MAIZE

ITS HISTORY, CULTIVATION, HANDLING AND USES

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COLLECTION

PROFESSOR OF ANIMAL HUSBANDRY
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Photograph by *Fred Coop of Pretoria*

GENERAL THE RIGHT HONOURABLE LOUIS BOTHA, P.C.

Prime Minister and Minister for Agriculture, Union of South Africa.

MAIZE

ITS HISTORY, CULTIVATION, HANDLING, AND USES

WITH SPECIAL REFERENCE TO SOUTH AFRICA

A TEXT-BOOK
FOR FARMERS, STUDENTS OF AGRICULTURE, AND TEACHERS OF NATURE STUDY

BY

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WITH FRONTISPIECE AND 245 ILLUSTRATIONS

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TO

GENERAL THE RIGHT HON. LOUIS BOTHA, P.C.

PRIME MINISTER AND MINISTER FOR AGRICULTURE

OF THE UNION OF SOUTH AFRICA

IN APPRECIATION OF HIS EFFORTS TO DEVELOP

THE MAIZE INDUSTRY

THIS VOLUME IS INSCRIBED

No other plant we grow will produce 3,172 lbs. of digestible food on one acre of land at so little expense. No other cereal crop yields the farmer so large a return for his labour as Indian Corn. It is the king of the cereals.

—DIRECTOR C. S. PLUMB.

PREFACE.

THE materials for this book have been collected during a period of three or four years, but the book itself has been written during a Term, and part of the Long Vacation of 1913, spent at the School of Agriculture, Cambridge, where the author has been studying inheritance of characters. He has endeavoured to adapt it to the needs of (1) the farmer; (2) students in the Schools and Colleges of Agriculture; (3) teachers in the country schools who are endeavouring to interest their pupils in Nature Study. He hopes, also, that it will interest others concerned with the maize industry in its various branches, e.g. commerce, manufactures, and the supply of agricultural implements, machinery, and fertilizers.

It is a difficult task to meet such diverse needs, and the result is necessarily open to criticism. The actual time available for its preparation has been too short, but if publication had not been completed before the author's return to South Africa, it would have been postponed indefinitely, and in the present stage of development of the local maize industry, there seemed to be a need for a book of this character.

The author is indebted to the following, among other gentlemen, for valuable assistance or contributions. The information on milling has been supplied by Mr. W. H. Horsfall of Aliwal North, and the chapter on the construction of silos by Mr. A. Morrison Hay, of the Public Works Department, Pretoria. For the

chapter on maize and maize products as stock food, the author has drawn largely upon *Feeds and Feeding*, by Professor W. A. Henry, from whom he once enjoyed the privilege of a valuable course of lectures. Much of the information on insect-pests has been furnished by his friend, Mr. C. W. Mally, Government Entomologist, Cape Town, whose work in investigating and fighting the pests of the maize crop, while stationed at Grahamstown, is well known and highly spoken of by Eastern Province farmers. Much of the information on the use of maize-harvesting machinery in America, has been taken from a bulletin specially dealing with the subject by Mr. Zintheo, of the U.S. Department of Agriculture. Much valuable information has been obtained from the writings of Professors T. F. Hunt, C. G. Hopkins, Bateson, and Punnett, Dr. E. M. East, and Dr. G. H. Shull. To many kind friends and correspondents the author is indebted for the native names in use in different parts of South Africa; and to Mr. R. T. A. Innes, Director of the Union Observatory, Johannesburg, for much valuable information on climatology.

The author's warmest thanks are due to his sister-in-law, Miss Florence Bolton, A.B. (Stanford), and to his wife, for patient and careful revision of manuscripts and proofs, without which it would have been impossible for him to have prepared the book for publication in the limited time at his disposal. He is also indebted to Mr. H. R. Mallett of Cambridge, for the preparation and revision of the Index at the last moment, and to Miss Pate of Cambridge and her staff, for their care and accuracy in copying the tables and bibliographical list, and typing the manuscript, and also for reading some of the proofs.

The author desires to express his thanks to those who have supplied photographs and blocks, or who have given permission for the reproduction of illustrations from other books and publications; where the latter have been used credit has been given at the foot of the illustration. Several drawings were specially prepared by Mrs. Burtt-Davy, and many of the illustrations have been reproduced from the *Transvaal* and *Union Agricultural Journals*, by the courteous permission of the Editor, Dr. Wm. Macdonald.

Grateful acknowledgment is made to those friends at Cambridge and elsewhere, especially to Professor R. H. Biffen, F.R.S., and Professor R. H. Punnett, for valuable suggestions and assistance, particularly in connection with the inheritance of characters; and to Mr. J. D. Anderson, M.A., and Dr. Nicholson, for assistance and information with regard to Hindoo and Persian names. Thanks are also offered to the Committees, Members and Secretaries of the Liverpool, Mark Lane and Baltic Corn Exchanges, for their courtesy in obtaining and supplying information, and particularly to Mr. Broomhall, Editor of *George Broomhall's Corn Trade News*, Mr. A. Grenville Turner of the Liverpool Corn Exchange, and Mr. H. M. Colebrook of the Baltic and Mark Lane Exchanges, for their valuable assistance.

JOSEPH BURTT-DAVY.

School of Agriculture,
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CHAPTER I.

IMPORTANCE AND HISTORY.

Heer, of one grain of maiz, a reed doth spring
That thrice a year five hundred grains doth bring.
—SYLVESTER, translation of Du Bartas' *Divine Weekes and Workes*, I. 3.

All around the happy village stood the maize-fields.
—*Hiawatha*.

Importance.

1. *Importance of the Maize Crop.*—Maize is one of the staple food crops of the world; the quantity produced is greater than that of any other cereal, and climatic conditions alone limit its more widespread cultivation. In those countries adapted to its production it is more extensively grown than any other grain. The total world's crop reaches the extraordinary figure of 1,085,700,000 muids (3,875,927,000 bushels, or 108½ million Colonial tons). Of this more than 75 per cent is produced in the United States, where the acreage is about double, and the total production about four times that of wheat. The whole of civilized Africa produces, at present, only about one per cent of the world's supply. The following figures show the comparative world's crop of the leading cereals for a single year:—

Maize	3,875,927,000	bushels.
Oats	3,532,470,000	,,
Wheat	3,428,998,000	,,
Rice	3,203,782,000	,,
Rye	1,432,395,000	,,
Barley	1,293,916,000	,,
	16,767,488,000	,,

The domestic consumption of maize in the United States is at the rate of 7·14 muids (25·5 bushels) *per capita* of popu-

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lation, which is said (*Hunt*, 1) to be the heaviest rate of consumption of any cereal by any people in the world; it is nearly twice as much, according to population, as the consumption in Europe of all the other cereals.

Maize is one of the easiest crops to grow, standing more rough usage than perhaps any other; a favourite Kaffir method of planting is to scatter the seed broadcast over the unbroken veld and then plough the ground; even with this crude treatment crops of $1\frac{1}{2}$ to 2 muids[1] of grain per acre are obtained.

FIG. 1.—A field of maize on the Demonstration Farms of Messrs. John Fowler & Co. (Leeds), Ltd., at Vereeniging, Traansvaal.

Davis (2), writing of maize and wheat in Argentina, points out that not only are they the two cereals requiring the least amount of capital, expense, and labour for their production, but that there is always an assured and immediate demand for them in the market.

The farm value of maize must not be calculated solely on the yield of grain, important as that is, for its total yield per acre of vegetable matter is larger than that of almost any other

[1] 1 muid = 200 lbs. avoirdupois.

farm crop. Maize produces a large quantity of "stover" (the stalk and leaves after the ears have been removed), which is of considerable use for winter-feeding stock if properly harvested; this should be taken into account in estimating the relative value of the crop. The husks, stalks, and cobs are also used for a number of manufacturing purposes, which are mentioned CHAP. I.

FIG. 2.—In a maize field in the Transvaal Bush-veld (Tzaneen, Zoutpansberg District).

in detail in a later chapter. As silage material, maize is one of the very best crops that can be grown, both on account of its heavier yield per acre and also because of the succulence and physical character of the plant, which render it peculiarly suitable to the process of ensiling.

We still hear South African farmers say that maize is a

CHAP. I. Kaffir crop, and that maize-growing does not pay the more ambitious white farmer. We hope to show in the following pages that, except where abnormal economic or unfavourable climatic conditions prevail, this is not the case when the crop is grown properly.

2. *What the American Farmer Thinks of It.*—In view of the fact that the United States produces 820,000,000 muids of maize per annum—three-quarters of the world's crop—and that this is not grown with cheap "native" labour, it may be well to look for a moment at the attitude of the American farmer towards the maize crop. In the United States it is a common saying that "Corn is King". "Corn" in America is maize.

The American farmer has earned the reputation of being a shrewd business man who does not conservatively stick to a crop whether it continues to pay or not, because his forefathers grew it; if anything, he is inclined to change too rapidly, and to "scrap" anything which he considers unprofitable. If maize did not pay he would soon drop it; but we find on the contrary that he has 108,750,000 acres under maize although, in 1906, his maize crop paid him only 5s. 11d. per muid, and in 1896 the farm price was only 3s. 1½d. per muid.

3. *Maize is the Leading Product of America.*—Mr. T. N. Carver (1), Professor of Economics in Harvard University, boldly states, and then proceeds to demonstrate, that maize is the *leading product* of the United States of America and maize-growing its leading industry. Not only is it grown more extensively than any other cereal, but the maize crop of the United States considerably exceeds in value that of wheat and cotton combined. No other American product or group of products equals it in value. In 1899 the value was greater by about £5,000,000 (five million pounds sterling) than that of all the products of the great iron and steel industry. It is the staple grain crop in most of the States of the Union, and its culture maintains a larger number of American people than any other industry. We hear much about the American wheat crop, but comparison of American crops of wheat and maize shows that where the total value to the farmer of a crop of wheat is \$9·07 (£1 17s. 10d.) per acre, the maize crop is worth \$14·56 (£3 0s. 8d.); or, if we add the value of the straw, stover, or fodder, the relative values are:

wheat, \$16·26 (£3 7s. 9d.) and maize, \$50·72 (£5 11s. 4d.) per acre. CHAP. I.

4. *Amount and Value of the United States Crop.*—The total production for all the North American States (not including Canada and Mexico) amounts to 2,927,416,000 (two billion, nine hundred and twenty-seven million) bushels, and the farm value, at a shade above 6s. 6d. per muid, is over £267,000,000. About 98½ per cent of this immense crop is wanted for domestic consumption and only the surplus 1½ per cent is exported; 1½ per cent of such a crop is no small quantity, however, for it amounts to over 12,000,000 (twelve million) muids.

The acre value of the maize crop in the United States varied in one year from 18s. 8d. on the poorer soils of South Carolina, to £4 9s. 4d. in Rhode Island, where more intensive agriculture is practised, and from £1 13s. 4d. to £2 10s. in the Corn-belt, and that was a year when the farm price of maize was only 35·7 cents per bushel (5s. 3d. per muid).

5. *American Maize is not Grown for Export.*—By far the largest part of the maize corn produced in the Corn-belt never leaves the farm on which it is grown, except in the form of a second product. Nearly every maize-grower finds it more profitable to turn the major part of his crop into beef or pork before it is sold. It is customary to buy up three-year-old steers, or flocks of sheep, raised on the Western stock ranges, to fatten on maize corn and stover through the winter; in the spring they are "finished off" on maize corn and green pasturage, and are ready for sale on the stock markets of Chicago and other Western cities, in June and July. Hogs are raised on the spare milk of the farm, and when older are allowed to follow the steers and pick out the undigested grain from the droppings, and are finally fattened off on maize and sent to market. A certain amount of the corn is eaten green as a boiled vegetable; some is ground into "corn-meal" for domestic use; only a small amount of grain is left to sell for manufacture or export. It has been well said that maize is and always will be the King of Crops, and the greatest of all cattle feeds.

6. *Maize is a White Man's Crop.*—Maize is essentially a white man's crop, and Prof. Carver (1) doubts whether it

CHAP. I.

"could be grown at all, as it is grown in the Corn-belt, if dependence had to be placed upon negro labour". The labour employed in that part of the country is entirely white, earning about £5 per month and board the year round. Yet that maize pays under these conditions is evident on all sides; it pays because it is a crop which can be handled almost entirely by machinery; because the soil is in good tilth; because the crop is kept clean; and, last but not least, because the farmer uses well-bred seed.

It is an instructive fact that in the American Maize-belt the enormous aggregate of the crop is made up of the products of a large number of small or moderate-sized farms, running from 80 to 300 acres in size, and worked mainly by the owners themselves or by tenants who pay cash rent. The reason for this, Prof. Carver (1) concludes, is that maize-growing requires a higher class of farming than any of the other staple crops, and cannot be so successfully carried on with hired labour alone. It requires such close and conscientious attention that it is doubtful if large farms, where the work is done by hired labour, can ever compete successfully with the smaller farms where the owner or renter does the work himself, or at least has it done under his immediate care and attention. With increased size of farm (as in the Western States), there is noticeable a general decline in the intensity of cultivation and consequent yield per acre, for good cultivation is essential to a good maize crop.

7. *Maize is the Staple Crop of South Africa.*—Maize is not only the staple food crop of the South African Kaffir, it has become an important item in the diet of the white people; but more than this, it has also become the staple cash crop of the South African farmer. In one of the writer's first Reports to the Director of the Transvaal Department of Agriculture, he stated that "Maize is a crop eminently suited to the Transvaal; every farmer grows it to a limited extent, and a vast quantity could be produced if he knew how to dispose of it. By the application of capital and the use of proper machinery, the maize crop can be made extremely profitable." Further observation and study not only confirm this view, but show that perhaps no country in the world is better suited to maize-growing on a large scale than South Africa; it has an

ample average rainfall, at the right season of the year, and phenomenally favourable winter weather for the natural production of the quality of grain most suitable for shipment. In fact the climatic conditions of a large part of the Orange Free State, Transvaal, Natal, Rhodesia, Basutoland, Swaziland, and the Transkei are all that could be desired for maize-growing.

8. *Future Possibilities of Development in South Africa.*—European corn brokers have recently referred to South Africa as the future maize granary of Europe. Maize will always be

FIG. 3.—Fields of maize, Government Experiment Farm, Potchefstroom, Transvaal. (Photograph by Fred Coop of Pretoria.)

the staple cash crop of South Africa. As its value for stock food becomes better appreciated, the local demand will increase, and in this connection Earl Grey's recent prophecy[1] of a coming shortage in the world's beef supply is suggestive. At the present time the country has only begun to show that it is possible to produce good maize. The traveller is impressed with the enormous areas of fertile land, suitable for growing maize, which are at present untouched by the plough, virgin sod like the American prairies. So far the average yield has been low; but it has been clearly demonstrated that, by means

[1] At the "South African Dinner," 1913.

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of good farming and good management, it can be trebled and even quadrupled. The present low yields are considered to just about cover expenses of production; if the yield were more than doubled, therefore, maize-growing should pay, provided prices hold good and cost of export remains low.

The exact acreage under maize in South Africa is not known, but it is grown on practically every occupied farm in the Transvaal Province. Many farmers are growing 200 to 1,000 acres each, and at least three have 6,000 acres under crop to maize. A good deal is also grown by Kaffirs, for their own use, both on native locations and on rented farms. The farms average about 5,000 acres each, but the area planted to

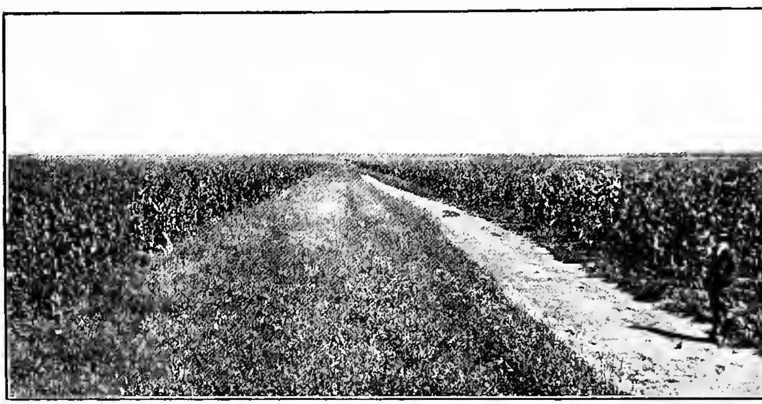

FIG. 4.—Five miles of maize fields at Vereeniging, on the High-veld of the Transvaal.

maize is often not more than 5 to 10 acres per farm, and sometimes less. There are 11,679 registered farms in the Transvaal, of which about one-half are occupied; allowing an average of 10 acres per farm, the total area in maize (outside of Native Locations) would be only 60,000 acres, and an average yield of four muids per acre gives, roughly, but 240,000 muids.

Only a very limited area of the Transvaal seems unsuited to the production of maize, but if we take into consideration only the farms at present occupied, and allow 250 acres of maize to every 1,000 acres of land, by raising the average production to merely 5 muids ($17\frac{3}{4}$ bushels) per acre, the

Transvaal alone ought to produce without difficulty 35,000,000 muids.

Owing to the dryness of the winter over the greater part of South Africa, the farmer is able to continue harvesting and shelling in the field up to the very day when he starts planting the new crop; in this respect he has an enormous advantage over the American farmer. The percentage of grain which is damaged by the weather is exceedingly small. The moisture content of the grain exported is some 5 per cent lower than that of the American-grown article. South Africa has, and is likely to have for many years, an excellent local market for a large part of her crop. Because she owns her own railroads she can carry her surplus to the coast at cost. With these great advantages in her favour, South Africa has good reason for optimism as to the future of her maize industry. There is good ground for the prophecy that South Africa is to become the maize granary of Europe.

9. *Relative Importance of the World's Maize and Wheat Crops.*—There is a popular idea that wheat is a more profitable crop than maize. This is due to the fact that in the inland provinces of South Africa the price of wheat is more than double that of maize, and the former yields a heavier crop than the latter. But if the wheat acreage were much increased the price would fall; present prices are quite abnormal, the average farm price in the United States during the last ten years was only 77 cents per bushel or 10s. 8d. per muid; when South Africa produces enough for local needs her wheat prices will probably fall to those prevailing in the States. The difference in average yield is due partly to the fact that wheat is at present grown on the best alluvial lands, and, in the Transvaal at least, practically all of it under irrigation, while much of the maize crop is produced on newly broken veld, and all of it as a dry-land crop. When the maize lands are in better "heart," the average yield will probably be doubled, and even now the best maize crops are nearly double those of wheat.

History.

10. *Origin of Maize.*—Researches into the history and geographical distribution of the maize plant show clearly that it originated in America.

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Darwin (2) considered that maize "is undoubtedly of American origin".

Humboldt (1) observes that maize was found by the European discoverers of the New World from the south of Chile north to Pennsylvania. Prescott (1) adds that he might have given its known range as to the St. Lawrence as "our Puritan fathers found it in abundance on the New England coast wherever they landed"; he cites as his authorities Morton, *New England's Memorial*, page 68 (Boston, 1826), and Gookin, *Massachusetts' Historical Collections*, chapter III.

Prescott (2) states that maize was "the great agricultural staple of both the northern and southern divisions of the American Continent; and which, after its exportation to the Old World, spread so rapidly there, as to suggest the idea of its being indigenous to it". . . . "The misnomer of *blé de Turquie* shows the popular error. Yet the rapidity of its diffusion through Europe and Asia, after the discovery of America, is of itself sufficient to show that it could not have been indigenous to the Old World, and have so long remained generally unknown there."

Alphonse de Candolle, the famous Swiss botanist and historian, who made a special study of the origin and history of cultivated plants, came to the conclusion, as long ago as 1855, that "maize is of American origin, and has only been introduced into the Old World since the discovery of the New. I consider these two assertions as positive." Twenty-seven years later he reiterated this view, and added: "The proofs of American origin have since been reinforced. Yet attempts have been made to prove the contrary, and as the French name, *blé de Turquie*, gives currency to an error, it is as well to resume the discussion with new data. . . . From all these facts we conclude that maize is not a native of the Old World. It became rapidly diffused in it after the discovery of America, and this very rapidity completes the proof that, had it existed anywhere in Asia or Africa, it would have played an important part in agriculture for thousands of years" (*De Candolle*, 1).[1] He concludes that circumstantial evidence points to New Granada as the original home of the plant, and suggests that the Chibchas, who occupied the table-land of Bogota at the

[1] Cf. Prescott (2) as quoted above.

time of the Spanish conquest, and considered themselves aboriginal, may have been the first to possess and cultivate maize. Some later botanists are inclined to consider, however, that it is of Mexican origin. CHAP. I.

The maize plant is not known to exist in a truly wild state, i.e. reproducing itself spontaneously from self-sown seed; no plant has been found which can be looked upon as the true parent form, unchanged by cultivation. Some botanists are inclined to think that maize is a descendant of the Teosinte plant of Mexico, *Euchlæna mexicana*, with which it can be hybridized; or that the two had a common prototype (*East*, 5).

11. *History*.—Maize has been cultivated by the inhabitants of North, Central, and South America since prehistoric times. The early American explorers found the Indians cultivating it; Columbus, writing to Ferdinand and Isabella of Spain, mentions maize fields eighteen miles in length. Hochelaga, which later became the city of Montreal, was situate in the midst of large maize fields when Cartier visited it in 1535 (*De Candolle*, 1). Hakluyt (1) quaintly and graphically describes the new cereal as "a corne called maiz, in bignesse of a pease, the eare whereof is much like a teasell". Maize-grain has been found in the Inca cemetery at Ançon, Peru, which is nearly contemporary with the discovery of America (*De Candolle*, 1). It was, even in those days, a staple crop from the valley of the La Plata to that of the Mississippi. Investigations show that it was grown by the Chibchas of New Granada, the Mayas of Central America, the Nahuas, and their successors the Toltecs and Aztecs of Mexico, and by the Incas in Peru.

De Candolle concludes that though these civilizations date at earliest from the beginning of the Christian Era, the cultivation of maize was doubtless still earlier.

After an exhaustive survey of the philological proofs of its origin, Harshberger (1) concludes: (1) that maize was introduced into the region now comprised in the United States, from two sources—from the tribes of Northern Mexico and the Caribs in the West India Islands; (2) that the Pueblos and Northern Mexican tribes derived maize from Central Mexico; (3) that tribal connections existed between the North and South American continents, and that an interchange of products was

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carried on by way of the Isthmus of Panama; (4) that the wild tribes living along the Andean system and in the El-Gran-Chaco and elsewhere used Peruvian loan-words for maize; (5) that South American words for maize extended throughout the Greater and Lesser Antilles and Florida, and that the Arawak word for Indian corn, adopted by Christopher Columbus, was used by tribes of that stock in the impenetrable and luxuriant Brazilian forests.

On the shores of the island of San Lorenzo, Peru, Darwin (1) found "the head of a stalk of Indian corn," embedded among shells and sea-drifted rubbish with some bits of cotton thread and plaited rush similar to those obtained in ancient Peruvian huacas or burial mounds. The stratum in which this was found had been elevated to a height of 85 feet above sea-level, and was itself overlaid by other strata, containing shells, etc., and having a thickness of over 85 feet, indicating great antiquity.

12. *Introduction into Europe.*—De Candolle (1) finds that maize was unknown in Europe at the time of the Roman Empire. Fée (1) states that from the year A.D. 1500 maize had been sent from America to Seville for cultivation. From Spain it was introduced into France and Italy, Turkey and other parts of Eastern Europe.

13. *Introduction into Africa.*—The wide distribution and extensive use and cultivation of maize on the African continent have led many to suppose that the plant was indigenous, or at least in use from time immemorial among the aboriginal peoples. But this was not so. Burchell (1), who visited what is now British Bechuanaland in 1812, makes no mention of maize in his account of the crops cultivated by the Bechuanas, though he notes its use and cultivation in Griqualand West, at the Mission Station at "Klaarwater" and at "Jan Bloems Kraal" in the Asbestos Mountains, in 1811. It was there grown for poultry food, but he also notes that "the half-ripe heads, when boiled, made a very agreeable and wholesome dish". He notes that it was planted in the first week in October and came into flower before the middle of December.

Visiting Burchell's old camp at Litakoon, Bechuanaland, in 1912, the writer met a native who remembered Moffat, and the introduction of maize into Bechuanaland by the missionaries; now it is one of their staple crops.

In the tenth century, according to Abn Zeyd Hassan and "Suleiman the Merchant," the Zeng peoples, the progenitors of the eastern branch of the Bantu-speaking races now south of the Zambesi, who were then located north of that river, in the country round Zanzibar, grew *millet*, which was their chief food (*Tooke*, 1). Giant millet or kaffir corn (*Sorghum vulgare*) appears to have been the former staple food-stuff of the natives of much of temperate South Africa. Northwards in the Bush-veld this was supplemented, and in places perhaps replaced by pearl millet or m'nyouti (*Pennisetum spicatum*), and still farther north, within the tropics, rapoko (*Eleusine Coracana*) was largely used.

Writing on the bearing of Bantu philology on early Bantu life, the Rev. Father Norton (1) states:—

"We find a tradition that sweet-reed and millet, or kafir-corn, were given to the first human couple; maize, on the other hand, was introduced in historic times by the Portuguese to the Becoana, to eke out their scanty list of cane, pumpkin, beans, melon. Our old centenarian told me that mealies appeared in Modderpoort district together with the missionaries."

Mr. Allister M. Miller of Mbabane, Swaziland, who probably knows as much, if not more, about Swaziland than any other man living, writes that from inquiries he made many years ago, he is of opinion that maize was introduced into Swaziland about the time the Hlamini clan, the conquerors of that territory, crossed from Tongaland, say the end of the eighteenth century. They do not call it by their word for "food," mabela, but by the Zulu words m'lungu, meaning "white man," or m'bila, the Zulu name for maize.

Maize would easily be carried from the north shores of the Mediterranean to the ports of Northern Africa, and probably reached the latter from Spain and Italy, with which countries there was much commerce in those days. In 1623 Caspar Bauhin referred to the occurrence of pod-maize (*Zea Mays* L. var. *tunicata* St. Hil.) in Ethiopia under the name of manigette.

But its introduction into other parts of the African continent is traceable to the Portuguese, who were great voyagers in the sixteenth century; they had colonies in Brazil and in the

CHAP. I. East Indies and had established settlements on the African coasts in 1450. It is instructive to note that in Angola maize was at one time known by the name "blé portugais" (Portuguese wheat), which suggests its source of introduction. They may have introduced it to West Africa with the object of furnishing food on the voyage across the Atlantic for the slaves whom they took from Africa to work their Brazilian plantations; one of the Brazilian names of the plant—*milho de Guine*—suggests this. Moodie (*Records*) mentions the following interesting fact under the date 1658: "As the season for sowing Dutch grain is past, he recommended that each farmer should sow a good quantity of mily, or Turkey wheat brought [to South Africa] from Guinea by the Hassalt".

Its introduction into South Africa may have taken place before the establishment of the Dutch Colony in 1650. Portuguese vessels calling at the Cape for water on the voyage to and from their East African and East Indian Settlements, probably left maize-grain with the Cape Colonists (or even earlier, with the natives) in trade for water, meat, and other commodities. This is suggested by the Afrikaans word for maize, "mielie" being undoubtedly a corruption of the Portuguese word *milho*, meaning grain.

We know how easily new plants of economic value spread among the native tribes of Africa, as witness tobacco, peanuts, rice, jatropha, colocasia, etc. Once the culture of maize was established at several points on the African continent, e.g., the Mediterranean shore, the Guinea coast, Cape Town, and Mozambique, the native population would soon distribute it throughout the Continent.

14. *Introduction into Asia.*—To the Portuguese voyagers, also, is probably due the early and rapid introduction of maize into India, China, Cochin, and other parts of the far East Indies, soon after the establishment of their East Indian settlements by Vasco de Gama at the beginning of the sixteenth century. Mendoza mentions (1585) among the plants observed by him in China, "the plant called maiz, which constitutes the principal food of the Indians in Mexico" (*Watt*, 1). Another route of introduction into Asia appears to have been by way of Turkey (and possibly also south Russia), Arabia, or Persia. The exotic character of the plant

is indicated by the absence of characteristic Asiatic names, the names now in use often combining an indication of the route of introduction with the vernacular for the particular corn of the country. CHAP. I.

A recent bibliographer (*Lacy*, 1) considers that though it is no longer a disputed question that maize is of American origin, "the possibility of its having been known in the East before the discovery of America by Columbus is by no means closed". She revives the alleged mention of *rous* (a name treated as synonymous with *blé de Turquie* or maize) by one of two Persian historians of the fifteenth century, of which Bonafous, in his monumental work on maize, admits that the translation "if it is exact, would leave no doubt that maize was known in the Old World before the discovery of the New". Bonafous finally dismissed the reference, having failed to trace it back, but Miss Lacy points out that this may have been due to an incorrect citation to Mirkond (1433-98) instead of to Khondemir (1475-1534), grandson of Mirkond, who wrote "at almost the same time as Mirkond . . . and whose best known work, the 'Khelassé-al-Akhbar,' is very nearly identical in subject-matter with Mirkond's *History of the World*, the 'Rauzet-al-safa'".

Quoting Mirkond, or perhaps Khondemir, Herbelot, to whom Bonafous refers as "Le célèbre orientaliste d'Herbelot," states that Rous, from whom Russia has taken its name, the eighth son of Japhet, son of Noah, sowed in all the islands of the River Volga, which empties into the Caspian Sea, "*le bled* which we call *de Turquie*, and which the Turks still call to-day, in their language, by the name of *rous* and *boulgar*". In this connection, however, it is instructive to note that the modern Persian names for maize are *ghendum*, *gandumi-makkah* (i.e. Mecca corn), and *haldah*.[1] The mere fact (if it should be proven a fact) that the name *blé de Turquie* was used in one place for *rous* (whatever that may have been) and in another for *maize* is no indication that the two were one and the same thing; for example, the word *corn* means wheat in England, maize in America, and the grain most commonly

[1] The word *haldah*, according to Meninski (*Lex. Arab., Pers., Turk.* 1780), was a name for "frumentum sarracenicum," i.e. Sarracens' corn, also pointing to its western origin.

used for food in several other countries, e.g. *Sorghum vulgare*, kaffir corn or Egyptian corn; the "corn" which Joseph's brethren went down into Egypt to buy was certainly not Indian corn or maize.

De Candolle (1) suggests that the rapidity of the recent distribution of maize in Europe, Asia, and Africa completes the proof, if further proof were needed, that had it previously existed in Asia or Africa, maize would have played an important part in agriculture for thousands of years, instead of being but a comparatively modern culture. As recently as 1832 maize was grown in India only as an ornamental plant in gardens, not as a regular farm crop for grain.

15. *Meaning and History of the Botanical Name.*—The botanical name of the maize plant is *Zea Mays.* The generic name *Zea* is derived from the Greek **Ζεια** or **Ζεα**, a sort of grain mentioned by Homer (Odyssey, 4, 41, 604) as used for feeding horses. The **Ζεια** of the Greeks was certainly not the maize plant, which was unknown to them; but when, in 1753, Linnæus was renaming all the then known plants in accordance with his new system of binominal nomenclature, he used many of the classical names of the ancients, often taking the risk of applying an old name to a new plant, where the former was appropriate or pleasing. Linnæus might, however, have adopted the generic name "Mays," already published by Tournefort in 1719, and followed in 1729 by Micheli who spelt it Mayz.

The *specific* name *Mays* was used by the earlier botanical writers, Matthiole (1570), Dodoens (1583), and Camerarius (1588) as being the name under which the plant was introduced from America. From their writings it was adopted by Linnæus. According to Prescott (1), Hernandez (1) derives the name maize from the Haytian word *mà-hiz*; this was the name used for it by the Haytians when Columbus visited the island in 1492.

16. *The Name Maize.*—Maize is an Arawak word, met with in many forms in South America and the West Indies, e.g. mahiz, marisi, marichi, mariky, mazy, maysi, etc. This name followed the introduction of the grain throughout Europe, and was adopted into many of the European languages, being variously spelled maiz, maize, mais, mays, mayz, or mayze.

The word *maize*, therefore, dating back to the introduction of the crop into the Old World, having been adopted into many languages, as detailed below, and forming part of the botanical name of the plant, has the highest claim to recognition as its universal vernacular name.

The following are the different forms in which it is in use in different parts of the world:—

Maiz (Portugal, Spain, Italy, Germany, Peru, Brazil, Uruguay, and Argentina); mais (Germany and Denmark); maïs (France); mays (Holland and Belgium); masé (Northern Africa), Maheende (Central Africa), Mahindi (Northern Africa), and Mihindi (Suahili), i.e. Indian corn or maize of India; mahiz (Hayti); marichi (Guiana); maysi (Cuba, Jamaica, and the Bahamas); maize (British Empire and the United States).

In English literature the word appears in the following forms: maith (doubtless the phonetic spelling of the Spanish pronunciation of *mahiz*), maix, maise, maiz, maize, maizium, mays, mayis, maijs, mayz, mayze, maes, maez, maze, mass.

The *e* is a comparatively modern suffix, which is not found in some English writers of the sixteenth and early seventeenth centuries, soon after the introduction of the grain into Europe. Du Bartas (1544-90), in his *Divine Weekes and Workes* (Sylvester's translation), writes:—

> Heer, of one grain of maiz, a reed doth spring
> That thrice a year five hundred grains doth bring.

Hakluyt (*Voy.*, 1600) and Dampier (*Voy.*, 1676) spell the word *maiz*, and Bacon, also, apparently throughout his writings, for we find it so in his *Natural History*, § 49; *Sylva* (1626); *Med. Rem. Wks.* (1626), and the earlier editions of Essay 33 "of Plantations," though in some modern editions the *e* has been added (perhaps in a pedantic effort to correct a "typographical error"). *Bailey's Dictionary* (17th ed., 1757) gives only the spelling *maize*, as does Murray's; the *Century Dictionary* has—"maize, formerly also maiz, mais, mayz, mays"; while the *Standard Dictionary* gives both maiz and maize, the former on the authority of the Philological Society.

Although *maize* is practically the only form in which the word occurs in modern English literature, there are several good reasons for dropping the *e* and adopting the spelling *maiz*:—

(1). Simplified spelling is a demand of the age, which should be complied with where there is good reason and authority.

(2). The *e* is unnecessary from the phonetic standpoint.

(3). The etymology of the word does not appear to provide for it.

(4). The form *mays* may, perhaps, have better claims to adoption from the etymological point of view, and is part of the botanical name of the plant, but is not in such general use in continental languages, and would be less easily adopted.

(5). *Maiz* is the form in use in Germany, Spain, Portugal, Italy, Peru, Brazil, Uruguay, and Argentina, as already noted.

(6). The authorities already cited seem ample. It remains for the literary and scientific public to decide whether the suggested change is sound, and whether it should be generally adopted.

17. *The Word Corn.*—*Corn* as used in American literature designates maize. The Saxon word "corn," Teutonic *korn* (whence Afrikaans "koren"), is the general term for any cereal, and is applied in any country to that cereal most extensively used there for human food; in England the words "corn" and the "corn trade" as generally used, refer to wheat, while in America they usually mean maize. Recent American writers on cereals are endeavouring to introduce the word "maize" as a substitute for "corn," as the South African Department of Agriculture is endeavouring to use it in place of "mielie".

The term corn or grain has been applied to maize in the following countries: United States and Canada (corn, Indian corn); Great Britain (Indian corn); Sweden (korn); Holland (Turks koren); Belgium (Turkisch koorn); Germany (Turkischer körn); Greece (Arabosite, i.e. Arabian corn); Formosa (fanmeh, i.e. foreign corn); Russia (Tureskorichljeb, i.e. Turkish corn); Japan (nan bamthbi, i.e. foreign corn); Italy (grano Turco, grano d'India, frumentum sarracenicum, grano Siciliano); Persia (gandumi-makkah, i.e. Mecca corn); Shangaan of N. Transvaal (mabele, i.e. kaffir corn).

18. *The Word Mielie.*—*Mielie* (often misspelled *mealie*) is the usual South African name, but is not known in

any other part of the world where maize is grown.[1] It is derived from the Portuguese word *milho*, from Latin *Milium*, the name for millet, a grain at one time much used for food by the inhabitants of Southern Europe. In Portuguese-speaking countries, milho is the term for any cereal used for human food. The name mielie was doubtless an early Africander-Dutch corruption of the word milho, as used by the Portuguese sailors who first left maize at the Cape on their way to the East Indies; it is significant that in Angola maize should have been known under the name of *blé portugais*. We may, therefore, look upon the word *mielie* as a colloquial form of the word milho, meaning any kind of grain used for food, rather than the name of the particular grain to which it has been applied locally and in modern times. It would be better to use the now universal word maiz or maize as the connection with the English word *meal* is remote. The forms in which the word milho are applied to maize are: milho grande (Portugal, Brazil); milho d'India (Portugal); milho da India, milho de Guine (Brazil); mielie and mealie (South Africa). Moodie (*Records*, p. 137, 1841) spells the word *mily*, and Damberger (*Travels*, p. 71, 1801) as *melis*.

19. *Other Vernacular Names.*—In other countries where millet was a staple cereal before the introduction of maize, the local word for millet was often made use of in naming the new cereal, thus: gros millet des Indes (France); durah-shami (Arabic), dourah de Syrie (Egypt), dourah being the Arabic name of millet; bari-joar (Panjab), bari-jowar (Oudh), Makka-jari (India), joar or juari being the general name in India for the great millet (*Sorghum vulgare*) and Makkai = Mecca (*Watt*), i.e. Mecca-joar or Mecca millet, indicating the route of introduction; jade sorgho (China); yuh-kau-liang (China), kao-liang being a Chinese name for *Sorghum vulgare;* mashela bahry, i.e. millet from the sea (Abyssinia).

On the other hand, where wheat was used more extensively, the local word for wheat was adopted in coining a name for the new cereal, thus we find: blé de Turquie or blé Turquet, blé de l'Inde, blé des Incas, blé de Guine, blé d'Afrique, blé d'Astrakan (France); blé de Rome (Vosges), blé de Barbarie

[1] The Dutch word for millet is *gierst*, for maize it is *mays* and *maïs*, and for Indian meal or corn meal, *maïs meel*.

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(Provence); blé d'Espagne (Pyrenees); blé portugais (Angola); Turkischer weizen (Germany); Turkische waitte (Gröningen); Turkse tarwe (Holland); misr-bogdag, i.e. Egyptian wheat (Turkey); trigo de Indias, trigo de Turkina (Spain); Turkish hvede (Sweden).

Several other names, included in the following geographical list, are in use in various parts of the world:—

Abyssinia: mashela bahry.

Africa (North): masé, mahindi.

Africa (Tropical): bekkolo (Galla), maheende, gafuli nosri, simsin (Darfour), kasoli (Uganda); matawe (Chikaundi of Kasemba Dist., N.W. Rhodesia); tjibakwe (Mashuna); umumbu (Matabele); mafluera (Kimwani, a coast dialect of Suahili; mafluera applies to both plant and grain); in Suahili language the fruit and plant are known as *muhindi*, the grain alone as *mahindi* (dim. *vihindi*, i.e. *hindi* = maize, singular la–, pl. = ma–), and the ear as *gunzi;* in the Makau language it is called *nakuo*, in all stages of growth, and in Nyasaland *chimanga;* in Angola it is known as mazza manputa or blé portugais.

Africa (South): maize (English); mielie (Afrikaans), anglicized into mealie; poone (Basutoland); lefeela, plural sefeela (Transvaal Basutos); sepeéla (Mapochs); shifake (Shangaan); shibakwe (Mashona); ma'ghea (phonetically ma'hea), plural, or le'ghea, one (Sapidi of Sekkukuniland); 'm-umbu (Matabele); semaka and monidi, plural mabidi (Bechuana): 'm-lungu (Swazi; in Zulu 'm-lungu means "white man"; its adoption by the Swazies may perhaps signify "white-man's corn". The Swazies now also use the word 'm-lungu for white man, in place of their own word 'm-lumbi); 'm-bila or 'm-beela (Zulu; this word is also used by the Swazies, in deference to the practice of the white man); sinjembani (Zulu for the dark red grains of the type of maize grown by natives in the early days). The growing maize plant is called by the Transvaal Basutos le'tlaaka, while the Shangaans, according to Rev. E. Creux, call it mabele, which is the recognized name for kaffir corn among most South African tribes; mihindi (Suahili). In the Transkei the following names are used, according to Archdeacon Woodrooffe, for many years Anglican missionary to the Transkeian natives (*Mally*, 5): um-bona, the common Xosa term for both the maize plant and the "fruit"; utiya is used by some of the Kaffirs and is synonymous; izikweba-sombona = green mielies, i.e. izikweba = ears, and sombona = of maize; um-pa = the cob after the corn has been stripped; in-tshatshoba = the flower of the maize plant; isi-gezenge = maize bread made from green maize; um-kupa = maize-bread made from dry maize.

Arabia: durah-shámi.

Argentina: maiz, pinsingallo (a pod-maize).

Australia: maize, Indian corn.

Austria: kukurutz.

Bahamas: maysi.

Belgium: mays, Turkisch koorn.

Bohemia: kukuřice.

Brazil: maiz, milho de Guine, milho grande, milho da India, zabemo, avati or abati. Special breeds have particular names, e.g. milho dourado and milho catete are flints, milho pipoca and milho perola are pop-corns.

Burmah: pyoung-boo.

Canada: corn, maize, Indian corn.

Ceylon: muwa.

Chile: maiz (Spanish); cua (Indian).

China: jade sorgho, yuh-kau-liang; yii-shu-shu.

Costa Rica: kup (Boruca); ep, ip (Terrabo); ain (Guatuso).

Cuba: maysi.

Denmark: mais.

Egypt: dourah shammy, dura shami or dourah châmy, dourah de Syrie.

Ethiopia: manigette (a pod-maize).

Fiji: sila-ni-papalegi.

Formosa: fanmeh.

France: maïs, blé de Turquie, blé de l'Inde, blé de Guinée, blé de Rome (Vosges); blé de Barbarie (Provence); blé d'Espagne (Pyrenees); blé des Incas; blé d'Afrique; blé Turquet; blé d'Astrakan; gros millet des Indes; maïs quarantain, maïs nain and maïs à poulet are pop-corns; maïs d'été is an early flint.

Germany: mais, maiz, Turkischer körn, Turkischer weizen, gemeiner maïs.

Great Britain: maize, Indian corn; Turkey corn (obsolete).

Greece: arabosite.

Guatemala: aima (Xinca Indian).

Guiana: marichi.

Hayti: mahiz.

Holland: mays, Turks koren, Turksche tarwe, Turkse tarwe; Turkische waitte (Gröningen).

Hungary: kukoricza (Magyar).

India: the numerous Indian dialects produce a number of separate names for the various crops grown. The name for maize in most general use—in one or other of its forms—appears to be makaī (Hindustani; Bihar); makkái (Panjab); makkā [1] (Tamil); makka-janar (Bengal); makká-sholâm (Madras); mukka-bhuta (Hindustani); elsewhere makkajári, mokka jonna, makî pyaungbú; an alternative name in Bihar is makaiya.

Where the joar, *Sorghum vulgare*, has been the staple cereal, its local name has been applied to maize, often with a qualifying adjective, thus: makka-janar (Bengal); bari-jowar (Oudh); bari-joar (Panjab); janara (Hindustani); janera [2] (in the west); junora (Patna); and makkajári, mokka jonna, junri and junala elsewhere.

Other names in use in India are: kukri (Panjab); goomdhān [3] (Assam); zonalu (Telugu); cholam (Madras); djagoung, mungari, and chhale.

Sir George Grierson (1) gives the following words applied in India to different parts of the maize plant:—

Stalks: dhattha to the west; thathera to the north generally; thathero (south Bhagalpur); dānt or dānti elsewhere. The stalks are used for fodder under the name makaï ke dānt (Gaya).

The Broken Stalk: lathēr (the north-west and in west Tirhut); nighās or nighesa (east Tirhut); no special name for this has been noted south of the Ganges.

[1] The *Madras Manual of Administration*, Vol. III, s.v. cholam, derives makkā from mecca, saying that mecca means the west generally. According to Sir George Grierson makkā is generally said to be derived from Skr. markataka, but the derivation from Mecca may or may not be true.

[2] Sir George Grierson gives a possible derivation of janēr as Skr. yavanāla, and says that Platts derives junhar, another name for joar, from Skr. jivana-dhāra.

[3] Dhān (Skr. dhānya) is the Assam word for rice. Mr. J. D. Anderson of Cambridge says that in Assam, where rice is a staple crop, the word dhān is used in the sense of *corn*, and that goom means hidden or secret, and so "strange" or "foreign," goomdhān meaning *foreign corn*.

Tassel: dhanbāl or dhanahra. CHAP. I.

Silk: bhūa (to the west); ghua (south-west Shahabad); san (Champaran and Gaya); monchh (Patna); moccha (South Munger); moch or mocha (Tirhut and South Bhagalpur); it is also called kesi.

Young Ear (when the grains begin to form but are not yet fit for eating): sancha.

Unripe Ear: duddha (to the west generally); dodha (Shahabad); khichcha or aju (Tirhut); dudhghottu (Gaya); duddha makaī (Sāran and Patna); dudhbhoro (South Bhagalpur); dant kamra (South Munger).

Ripe Ear and fit for eating: bhuttā [1] or bāl.

Roasted Ear: horha (generally); orha (to the east).

Dead-ripe Ears (grain hard and unfit for eating): pakthāïl.

Blind Ear (i.e. with no grain on it): bhorah or bhorha (north of the Ganges).

Ear with few Grains: pachgotiya.

Cob (after the grains are shelled off): lenrha (generally); lenruri (Shahabad); nerha (east Tirhut); baluri (an optional name in Patna and south-east Tirhut); balri (an optional name in south-east Tirhut and south Munger); khukhuri [2] or khonkhri (south-west Shahabad); haddi (south Bhagalpur).

Shelled Grain: gota or got.

Husk: balkhoïya or bokla (generally); khoïya (to the west); khoincha (east Tirhut); pataura (South Munger); pocho (South Bhagalpur); in Champāran another name is kalchoïya, and in south-west Tirhut balko or kosa.

Italy: maice, maiz; grano Turco or Granturco; grano d'India, grano Siciliano; melliga or melgone (Lombardy).

Jamaica: maysi.

Japan: nan bamthbi, sjo-kuso, too-kibbi, tomoro-koski, or tomorokoshi.

[1] Sir George Watt (1) says that the word bhuttā (Bengal and Bihar; Hindustani *but*, *mukka-bhuta*, elsewhere maki pyaungbú) may possibly be derived from bhukta or butta, to eat. Sir George Grierson says that it *may* be derived from Skr. bhrsta, *roasted*, which is suggestive in view of the method of cooking the young ears.

[2] The word kukri is used in the Panjab for some form of maize; and in south-west Shahabad khukhuri or khonkhri is the word for the maize cob after the grains have been shelled off. This suggests a connection with the Slav word kukuru (Turkey); kukurusa (Roumania); kukoricza (Magyar); kukurutz (Austria); kukurice (Bohemia).

Malaysia: djagoeng, jarung, cholam.

Maya: ixim.

Mexico: mais, maize (Spanish); cintli = ear, olote = grain (Aztec).

Paraguay: bisingallo (Guarany Indians).

Persia: ghendum; gandumi-makkah; haldah.

Peru: maiz (Spanish); sara or zara (Quichua Indian).

Portugal: maiz, milho da Indias, milho grande.

Roumania: kuku-rusa.

Russia: Tureskorichljeb.

Siam: hacpot.

Spain: el maiz, trigo de Turkina, trigo de Indias, zaras.

Sweden: Turkish hvede, korn.

Turkey: misr-bogdag, kukuru.

United States: corn, Indian corn, maize.

Uruguay: maiz.

According to De Candolle (1), there is neither Sanskrit nor Hebrew name for maize. There is no Greek or Latin name because the plant was unknown to the Greeks and Romans.

CHAPTER II.

CLIMATIC REQUIREMENTS.

The term climate, in its broadest sense, implies all the changes in the atmosphere which sensibly affect one's physical condition.—HUMBOLDT.

20. *Climate.*—The profits from the cultivation of the soil, and in relation to these the preference given to certain crops, depend perhaps more on the extent of the market for such products than on the quality of the soil and the climatic condition within the geographical area of agricultural production (*Davis*, 2).

Hann and Ward (1) define *climate* as meaning the sum total of the meteorological phenomena that characterize the average condition of the atmosphere at any one place on the earth's surface. That which we call *weather* is only one phase in the succession of phenomena whose complete cycle, recurring with greater or less uniformity every year, constitutes the climate of any locality.

21. *Factors which Limit Distribution.*—The known facts of distribution of maize as a crop lead us to inquire what factors limit that distribution. These have an important bearing on the question of the world's future supply, and more particularly on the problem of South Africa's future share in the world's trade.

Maize seems peculiarly sensitive to climatic variations, and these furnish the principal limiting factor of distribution of the crop. The variations referred to include temperature, sunshine, amount and incidence of rainfall, and length of growing season. Geographic features and the character of the soil are also important. Only when these several factors are suitably combined does the culture of maize become commercially successful; the absence of any one of them may limit production on a large scale.

It is important that we should understand the relation of these several factors to the maize crop. Speaking broadly, the most favourable conditions are long humid summers, hot days and warm nights, comparatively heavy, intermittent rains, with abundance of clear, sunshiny weather between. Hot, arid climates, hot and continuously humid and shady regions, and arid cool-temperate climates with short summer season, are, generally speaking, unfavourable to the commercial production of maize. Open plains or plateaus are therefore more suitable than forest country.

22. *Altitude.*—Altitude affects the growth of crops indirectly as it influences length of season, temperature, precipitation of moisture, depth, and richness of soil, etc.

Evidence collected by Harshberger (1) suggests that the maize plant came originally from tropical table-lands at a considerable altitude, probably above 4,500 feet.

Increase in elevation is accompanied by decrease in temperature and a steady shortening of the summer season, until, at very high altitudes, alpine conditions prevail; long before this point has been reached, however, it has ceased to be possible to produce maize. Davis (1) finds that in Argentina the decrease in temperature due to altitude is not a constant factor but varies according to the season of the year and the dryness of the air. The shortening of the season with increasing altitude has an immediate effect upon the crop in that the earliest autumn frosts, not falling regularly at the same date, are apt to kill the plants before the grain is ripe for harvest. The range of altitude within which a maize crop can be successfully grown largely depends on latitude; the nearer the Equator the higher the altitude, within certain limits, and the farther from the Equator the lower must be the altitude.

Humboldt records vast maize fields on the Mexican plateau (between the 15th and 30th parallels) at 8,680 feet. Near Lake Titicaca, Peru, at about the 16th degree of S. latitude, maize is grown successfully at 10,000 feet. In the Indian Panjab, between the 30th and 35th parallels, it is more extensively grown in the hill country at 7,000 feet and over, than in the valleys, where it is largely replaced by rice. In Baluchistan it is grown as a regular crop at 5,000 to 9,000 feet altitude. In the United States the major part of the crop is produced between the 35th and 45th parallels, and 82 per cent of it at an altitude between 500 and 1,500 feet; the proportion grown above 1,500 feet is only 4·4 per cent. Harshberger (1) points out, however, that this is partly due to the absence of large areas of tillable land at an elevation of 2,000 feet, for very fine maize crops are raised in North Carolina at 4,000 feet, between the 34th and 37th parallels. CHAP. II.

23. *Temperature.*—Careful investigations carried out in the United States fail to show any direct relation between actual temperature and yield of the maize crop. Maize is a tropical plant, susceptible to frost in all stages of its growth; but being an annual, it can be grown as a summer grain crop in warm-temperate climates, and as a fodder crop (not for grain) even in cool-temperate areas such as the south of England.

Dwarf, early-maturing sorts have been known to ripen seed in the south of England and even in Norway as far north as 63° 13′ (*Mueller*, 1). Martyn (1) states[1] that maize was cultivated in England in 1562, but that the seeds "rarely ripen in England. . . . Mr. Miller thinks that maize might be cultivated in England to advantage. But it can scarcely be expected to be grown here for the grain, except in favourable seasons and warm soils and situations. Yet as a fodder it might be of considerable service, if it were cut when just opening into ear, and given fresh to the cattle every day" (*Martyn*, l.c.). Of var. γ *Zea vulgaris*, Mill. (*Dict.*, n. 3), he says, "This ripens its grain perfectly well in England in as little time as Barley". But "Maize is seldom cultivated in England for use" (*Martyn*, l.c.).

Eighty-eight per cent of the American crop of 1897 was grown between July isotherms 70° and 80° Fahr. (*Brewer*, 1). The Argentine crop is grown with a mean January temperature of 75·78°, while that of the Transvaal Maize-belt is under 70° Fahr. The actual highest yields of the United States have been obtained between July isotherms 75° and 80° Fahr. (*Harshberger*, 1).

The average temperature of the maize-belt of Argentina is given as:—

[1] On the authority of Turner's *Herbal*, Part II, fol. 58 n.

CHAP. II.

1856-1875	62·9°
1876-1896	61·5°
1897-1900	63·1°

The maximum temperature is said seldom to exceed 95° Fahr., though it seems much higher owing to the excessive humidity. The maize zone lies between summer isotherms 71·6° and 78·8° Fahr., and annual isotherms 59° Fahr. and 68° Fahr.

TABLE I.

COMPARATIVE TABLE OF MEAN MONTHLY TEMPERATURES.

Place.	Alt. Feet.	Years.	November.	December.	January.	February.	Mean, 4 Months.
Transvaal—							
Vereeniging	4700	1903-10	67·97	69·63	70·34	69·24	69·29
Bethal	5580	1903-10	62·83	64·75	65·96	65·18	64·68
Pretoria (Arcadia)	4500	1903-10	69·18	70·78	71·54	69·64	70·28
Natal—							
Cedara		1903-4, 1907-8	68·2	69·6	72·0	70·75	70·14
Rhodesia—							
Bulawayo	4470	1898-1902	71·8	71·1	71·0	68·9	70·70
Bulawayo		1908-9	70·6	72·4	70·6	68·4	70·50
Salisbury	4810	1898-1902	69·6	68·2	69·4	67·6	68·70
United States of America—[1]							
Georgia		13 years	72·1	78·6	79·6	77·8	77·02
Iowa		18 years	59·8	69·3	73·6	71·6	68·3
Argentina—							
Mean of 13 stations		—[2]	69·12	73·54	75·78	74·59	73·25
Bahia Blanca		1860-83, 1897-1900	65·37	70·61	73·81	71·89	70·42
Goya		1876-1900	72·85	77·38	78·22	77·45	76·47
Paraguay—							
Mean of 2 stations		1892-1900	76·55	80·53	80·60	79·99	79·42
S. Europe—[3]							
Vienna	636	100 years	59·18	65·84	68·90	67·46	65·34

[1] The heaviest maize yields of the United States have been grown between July (=January) isotherms 75° and 80° Fahr.

[2] Various periods from 1855 to 1900.

[3] May to August inclusive.

In the Transvaal it is generally considered that the Lower Bush-veld (below 2,000 feet), though hotter, cannot compete with the High-veld in the production of maize; if this is actually the case it is probably due largely to the character of the soil, as there is a narrow strip of poor soil running through the Lower Bush-veld from north to south, and good maize crops are raised on either side of this belt at the same altitude. It may also be due in part to deficiency or irregularity of rainfall, and greater evaporation. CHAP. II.

TABLE II.

MEAN TEMPERATURES OF THE CEREAL BELT OF ARGENTINA.

November, December, January, and February.

Station.	Period.	November.		December.		January.		February.	
		C.	Fahr.	C.	Fahr.	C.	Fahr.	C.	Fahr.
Buenos Aires .	1856-1900	19·90	67·82	22·43	72·37	23·66	74·59	23·06	73·51
Bahia Blanca	1860-83 1897-1900	18·54	65·37	21·45	70·61	23·23	73·81	22·16	71·89
Tandil . .	1876-82	17·37	63·26	19·30	66·74	21·20	70·16	21·11	70·00
Viedma . .	1876-82	17·95	64·31	20·13	69·85	23·36	74·05	21·13	70·04
Rosario . .	1891-1900	20·78	69·40	23·73	74·71	24·70	76·46	24·33	75·79
Céres . .	1896-1900	23·15	73·67	25·68	78·22	26·61	79·91	26·83	80·30
Paraná . .	1896-9 1875-82	21·91	71·44	24·20	75·56	24·98	76·96	24·85	76·73
Concepcion del Uruguay .	1894-9	21·10	69·98	23·94	75·09	24·44	76·00	24·28	75·71
Hernandarias .	1877-92	22·82	73·08	25·11	77·20	26·23	79·23	25·33	77·59
Goya . .	1876-1900	22·69	72·85	25·21	77·38	25·68	78·22	25·25	77·45
Cordoba . .	1873-1900	20·87	69·56	22·97	73·34	23·44	74·19	22·74	72·93
Rio Cuarto .	1881-1900	20·98	69·76	23·36	74·05	23·96	75·12	23·07	73·52
San Luis .	1874-7	19·96		22·25	72·05	24·70	76·46	23·39	74·10
		268·02		299·76		316·19		307·53	
Mean of 13 stations .		20·62	69·12	23·08	73·54	24·32	75·78	23·66	74·59
				Paraguay.					
Asunçion .	1892-1900	24·78		27·09	80·80	27·20	80·96	26·95	80·51
Itacurubi del Rosario .	1892-9	24·72		26·83	80·30	26·80	80·25	26·38	79·50
		49·50 24·75	76·55	53·92 26·96	80·53	54·00 27·00	80·6	53·33 26·66	79·99

In the warmer coast-region of Natal, though there is less maize grown, the yields per acre are heavier than on the uplands; but this is probably due to increased fertility of the soil, and to longer growing season, rather than to actual increase in temperature.

TABLE III.

MEAN MONTHLY TEMPERATURES, TRANSVAAL.

Year.	1903-4.	1904-5.	1905-6.	1906-7.	1907-8.	1908-9.	1909-10.	Average.
				Bethal (5,580 feet).				
Nov.	—	63·9	63·3	61·6	62·3	63·3	62·6	62·83
Dec.	—	62·4	66·4	64·2	64·7	65·4	65·4	64·75
Jan.	—	66·0	69·8	66·1	67·0	62·9	64·0	65·96
Feb.	—	64·5	64·6	65·8	66·4	64·8	65·0	65·18
								258·72
								64·68
				Vereeniging (4,700 feet).				
Nov.	68·2	69·7	68·9	66·8	66·4	67·6	68·2	67·97
Dec.	73·4	65·9	71·1	68·6	68·8	70·4	69·2	69·63
Jan.	71·6	70·1	74·1	69·8	70·0	68·4	68·4	70·34
Feb.	70·5	69·4	68·6	69·0	71·4	67·6	68·2	69·24
								277·18
								69·29
				Pretoria (Arcadia) (4,500 feet).				
Nov.	68·6	71·1	69·6	67·1	68·5	69·8	69·6	69·18
Dec.	70·7	69·0	72·7	69·6	69·9	73·2	70·4	70·78
Jan.	71·4	72·2	74·8	71·0	72·2	70·6	70·0	71·54
Feb.	69·3	70·7	70·6	70·9	75·9	69·0	70·1	69·64
								281·14
								70·28

The above tables show the mean monthly temperatures of the four growing months for maize, November to February inclusive. In the case of the Transvaal stations the means are for the seven years 1903 to 1910 inclusive (*Innes*, 1), and are obtained by halving the sum of the mean daily maximum and the mean daily minimum. The Rhodesian figures are those given by Mr. Hutchins (1), and the Georgia figures are the means for thirteen years as furnished by Director Redding (1); the latter are for the corresponding summer months of May to August inclusive. The Iowa figures are from Bowman and Crossley (1).

24. *Night Temperature.*—Some writers (*Darwin*, 2; *Harshberger*, 1) conclude that the maize crop does not flourish where the nights are "cool," no matter how favourable the other

conditions. The term "cool" is relative, and may be misleading, for in those parts of the Transvaal where the maize crop thrives the summer nights are invariably cool. The director of the Union Observatory gives the following figures showing the mean daily temperature at 6 a.m. (the coolest hour of the night) at the Government Observatory, Johannesburg. CHAP. II.

TABLE IV.[1]

MEAN MINIMUM TEMPERATURES AT GOVERNMENT OBSERVATORY, JOHANNESBURG.

September, 1904—*March*, 1909.

Month.	Mean Daily Minimum Temperature, 6 a.m.					Mean, 5 Seasons, Sept., 1904—Dec., 1908.
	1904-5.	1905-6.	1906-7.	1907-8.	1908-9.	
September .	45·8	48·8	49·8	48·8	53·2	49·3
October . .	51·9	54·9	51·1	51·1	51·7	52·1
November .	57·4	54·5	53·0	54·2	55·6	54·9
December . .	54·2	57·5	55·2	55·9	57·8	56·1
January . .	56·8	59·8	57·6	56·4	57·7	57·6
February . .	56·6	56·1	57·8	57·7	56·1	56·8
March . .	53·5	53·5	56·6	54·1	55·2	54·6
7 Months' mean	53·7	55·0	54·4	54·0	55·3	54·5
Annual mean .	50·5 [2]	51·4	50·5	50·7	51·6	50·9

At Buenos Aires the mean minimum summer temperature (December to February) at 5 a.m. is 63·5° Fahr.

[1] Abstracted from Reports of Transvaal Department of Meteorology (*Innes*, 1).

[2] *N.B.*—The mean daily minimum is 1·7° lower than the mean temperature at 6 a.m.

The following tables, taken from the publications of the late Transvaal Department of Meteorology, Johannesburg (*Innes*, 1) show the mean daily minimum temperature over a series of years at Vereeniging (4,700 feet altitude), and Bethal (5,580 feet altitude), two of the most important maize centres of the Transvaal. Comparing the two tables we find that for the 880 feet difference in altitude we have an average difference in the annual mean of 1·2°, and in the 7 months' mean of 2·7°.

CHAP. II.

TABLE V.

MEAN MINIMUM TEMPERATURES AT VEREENIGING.

September, 1904—*March*, 1909.

Month.	Mean Daily Minimum Temperature.					Mean, 5 Seasons.
	1904-5.	1905-6.	1906-7.	1907-8.	1908-9.	
September	43·4	45·3	44·2	43·6	46·7	44·6
October	50·7	51·0	49·3	50·0	48·1	49·8
November	55·6	55·8	53·9	52·3	54·3	54·4
December	53·3	58·6	54·4	56·7	56·8	55·9
January	57·2	61·0	59·0	55·1	59·9	58·4
February	58·3	56·7	58·5	59·5	58·3	58·2
March	52·9	52·5	54·5	52·6	54·2	53·3
7 Months' mean	53·0	54·4	53·4	52·8	54·0	53·5
Annual mean	45·2	45·6	45·2	44·0	45·8	45·1

TABLE VI.

MEAN MINIMUM TEMPERATURES AT BETHAL.

September, 1905—*March*, 1909.

Month.	Mean Daily Minimum Temperature.					Mean, 4 Seasons.
	1904-5.	1905-6.	1906-7.	1907-8.	1908-9.	
September	...	41·1	42·3	42·5	45·5	42·8
October	...	47·7	47·0	46·4	46·6	46·9
November	...	51·4	50·3	50·2	51·7	50·9
December	...	54·8	53·0	53·6	54·0	53·8
January	...	57·4	56·7	54·6	52·8	55·4
February	...	53·2	55·7	53·8	55·6	54·6
March	...	49·2	52·5	50·5	52·7	51·2
7 Months' mean	...	50·7	51·1	50·2	51·3	50·8
Annual mean	...	43·9	43·8	43·1	44·9	43·9

25. *Frost.*—Late winter frosts have little effect on the South African maize crop, as they usually come at a time when there has not been enough rain to start the crop; but when they fall as late as the middle of October they may cause some damage. Early winter frosts are more dangerous;[1]

[1] On the Transvaal High-veld killing frosts are sometimes experienced as early as 28 March.

for on the high plateau of the Transvaal, at 5,000 to 6,000 feet elevation, the season is usually too short for late-maturing breeds of maize, and almost every year a proportion of the crop of medium-late sorts—such as *Hickory King*—is seriously injured. This is due to the sudden though temporary fall of temperature which frequently precedes the advent of the real winter by two or three weeks, when the frost is often sufficiently severe to injure the unripe grain. A remedy can be found in autumn tillage and earlier planting to bring the crop sufficiently forward to miss the frost; but too early planting often results in loss from cut-worms. When the South African maize crop is once ripe, frost does not injure it, and it can be left standing in the field to dry out, through the winter, without fear of injury. As there is considerable difference in the time required for the maturity of different breeds, the earlier-maturing sorts should be used at the higher altitudes; some of these yield rather less than the longer-growing sorts, and farmers are reluctant to drop the latter, even though they entail greater risk.

At lower altitudes, as along the coast of Natal, the Ubombo Range in Swaziland, and the adjacent portion of the Transvaal, the season between frosts is so long that two successive crops of maize-grain can be matured in the same year.

Temperature appears to have no direct effect upon yield per acre, but it does influence the maturing of the grain, and often in this way affects the yield of marketable grain, especially at higher altitudes and in the southernmost of the maize-growing districts of South Africa.

In Argentina frost is apt to cause a considerable loss of crop.

Where the crop has been thrown late, from one cause or another, the stalks may be cut just before the time when frosts are expected, and "stooked" in the field. This does not interfere with the proper filling out and ripening of the grain if the crop is not cut before the grain has begun to harden. Not only does this method enable farmers on the High-veld to save their crop from injury by frost, but it results in a saving of some 50 per cent of the feeding value of the "stover". At the suggestion of the writer this method was tried by several High-veld farmers in the Transvaal, during the very backward season of 1909-10, with excellent results.

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26. *Hail.*—No country in the world has such a perfect climate that the farmer is entirely free from worry, whatever his crop may be. On the whole the climate of South Africa is probably as nearly perfect as any; but it is not without drawbacks. Perhaps the chief of these is hail. The worst hailstorms usually fall in the months of November and December; on 16 November, 1909, hailstones weighing $4\frac{1}{2}$ oz. were reported from Germiston, and considerable damage was done to crops in the districts of Bethal, Ermelo, Standerton, Heidelberg, Marico, Rustenburg, Wakkerstroom, and the Witwatersrand. At this time of year the maize plant is still comparatively small; so long as it is not in tassel, a new crop of leaves may be produced and, though somewhat retarded in development, the crop usually recovers.

Fig. 5.—Effect of hail on the leaves of the maize plant.

Hailstorms coming in January are most likely to damage the maize crop. A storm of hail in the Glencoe District of Natal, on 21 January, 1908, cut the maize crop to the ground and injured it beyond recovery; but it is said to have been the heaviest hailstorm known in that district for forty years. Most damage is done when the main stem of the plant is broken by the hail, causing the development of *sucker shoots*, which do not bear good grain.

More frequently the injury is restricted to stripping the foliage into ribbons, sometimes leaving only the midrib (see Figs. 5 and 6) and sheath of the leaf to function in photosynthesis (¶ 69). If the storm occurs before the tassel appears, the plant may be able to throw out additional leaves, by which photosynthesis can be carried on; but if it has reached the stage shown in the above figure, no fresh leaves can form on the stem; there must then be some loss in weight of grain, inasmuch as all the starch must first be elaborated in the leaf before it can be deposited in the grain (¶ 69). CHAP. II.

It is a fortunate feature of the South African hailstorm that it is usually confined to a comparatively narrow strip, so that not all of any one farm is damaged, and as a rule the

FIG. 6.—Effect of hail on the stem and leaves of the maize plant.

same farm is rarely visited by hail two years in succession. There are, however, "hail-belts," in which hailstorms appear to recur almost yearly.

Apparently there is no reliable preventive for hailstorms; but insurance policies against damage from hail may be effected.

27. *Soil Temperature.*—The temperature of the soil has much to do with the successful growth of maize and other tropical crops. In cold soils germination and subsequent growth are retarded. Experiments conducted at Pretoria show that whereas maize planted in September and early October usually requires eight days to appear above ground, that planted at the end of December or early January will sometimes appear in three days; in each case the seed was well watered daily, so that lack of moisture was not the cause of retarded germination, which may therefore be attributed to low temperature of the soil.

Maize lands should be well drained, for wet soils are usually cold soils. It is largely on this account that maize germinates badly, and its growth, also, is retarded in water-logged soils. When water stands for any time on the maize lands, the foliage becomes yellow and the plants remain stunted. In cycles of droughty weather there is a tendency to plant the crops in low-lying ground which retains a certain amount of moisture; but when normal seasons return the crops in these lands suffer. It is better to apply the principles of dry-farming (i.e. good tillage) to the soil (see chap. IX.), in order to conserve the moisture, than to use undrained land in anticipation of possible drought.

28. *Moisture Requirements.*— Maize is, on the whole, a drought-resistant plant, but some breeds suffer more from drought than others, and these should not be chosen for regions where the average rainfall of the period from December to February inclusive is too light for the ordinary breeds. King (1) has found that in Wisconsin the maize plant abstracts from the surrounding soil 270 lbs. of water for each pound of dry matter grown, which is equal to a rainfall of 2·4 inches for each ton, or only about half the amount required (in Wisconsin) by oats and clover. But the maize plant requires a considerable amount of water *at certain stages of growth.*

In Illinois the growth of maize during one week in July has been found equal to 1,300 lbs. of dry matter per acre, which would require 1·5 inches of rainfall, according to King's experiments. At a time of such rapid growth the plant is apt to suffer from drought unless the soil is in the best physical condition (*Hunt*, 1).

An American writer points out that the curling of the leaves of the maize plant in July (equivalent to January in South Africa) is a bad omen to maize-growers in the drier districts. The time of the formation of the ear (January and February) is the critical period in the life of the plant, and lack of moisture at this time means curtailment of yield (*Bowman* and *Crossley*, 1).

29. *Rainfall.*—Though no direct relation exists between actual temperature and yield, rainfall, on the contrary, has a very direct bearing upon yield.

At the Illinois Agricultural Experiment Station a rainfall of 13 inches during the five growing months, produced 1,792 lbs. (practically 9 muids) of dry maize-grain per acre. The following year, with 22·5 inches during the same period, the yield (without fertilizer) was 5,264 lbs. (over 26 muids) per acre. The mean temperature was more favourable the first season than the second. The results indicate that the increase of 17 muids per acre was due to the additional 9·5 inches of rain, an average of 1·9 inches per month.

In the Corn-belt of the United States the most favourable condition is found to be a series of comparatively heavy rains during the growing season, but at considerable intervals, with clear sunshiny weather between, and followed by a warm, dry, ripening period. If the rainfall equals 11·5 to 12·0 inches in the three summer months corresponding to December, January, and February in the Southern Hemisphere, this should be adequate; of this, 4·5 to 5·0 inches should fall in January, when the ears are growing most rapidly. The average rainfall for these three months for thirty-nine stations through the Maize-belt of South Africa is 11·92 inches, while the average for January is 4·35, or 4·6 if we omit the three driest localities, which are really outside the Maize-belt. Heavy rainfalls and cloudy weather during the planting season (corresponding to October and November in South Africa and South America) are in North America found to decrease the yield. In South Africa a wet October and November prevents proper weeding and encourages early growth of weeds which withdraw moisture and plant-food from the young maize plants, thereby reducing the yield. But excess of moisture, as already explained (¶ 27), is injurious.

CHAP. II.

The average monthly rainfall for the four growing months of the maize crop, as recorded during thirteen years at the

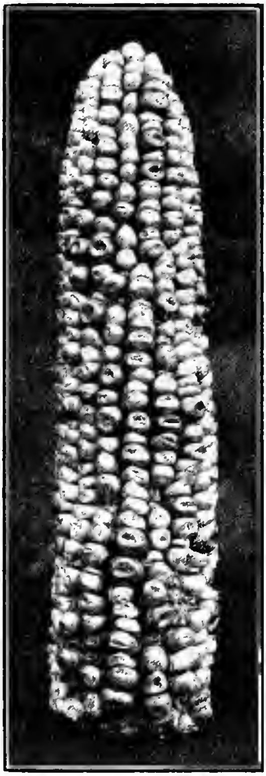

FIG. 7.—Grains which have been fertilized but not fully filled with starch, probably owing to drought.

FIG. 8.—Grains cracked from exposure to unfavourable weather conditions.

Georgia (U.S.A.) State Agricultural Experiment Station, was as follows (*Redding*, 1):—

Georgia.	South African Equivalent.	Rainfall.
May	November	2·91 in.
June	December	4·37
July	January	5·52
		12·80
August	February	6·06
		18·86

The rainfall of the Argentine Maize-belt ranges from 31·5 inches to 39·4 inches, but this is divided with fair uniformity between summer and winter. March is the rainiest month, and April is about as wet as February, which is unfortunate for the drying of the grain; this is one of the greatest drawbacks to maize-growing in Argentina. The winter is wet and frosty, which makes it difficult to get the grain into merchantable condition, and to store it satisfactorily; the consequent percentage of loss in Argentine cargoes during the ocean voyage is heavy. Even when the greatest care is exercised, the unfavourable climatic conditions are likely to handicap maize-growing in Argentina.

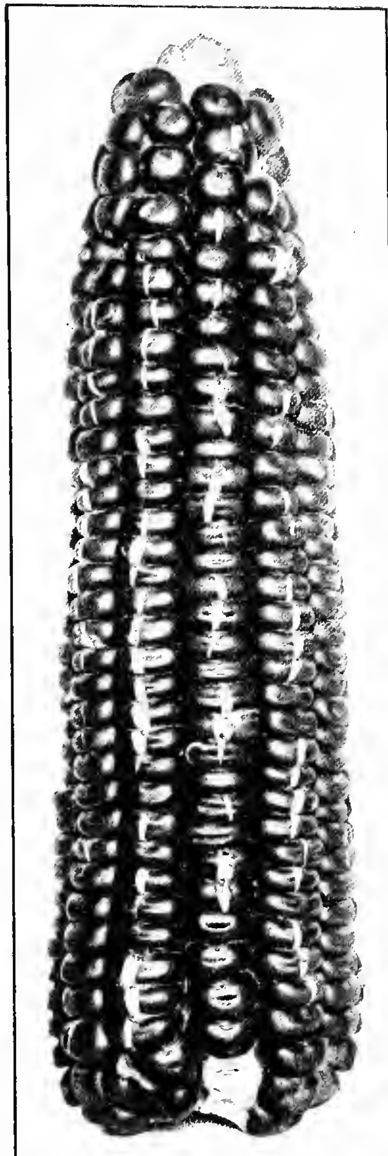

FIG. 9.—Grains cracked from exposure to unfavourable weather conditions.

The following table (VII), prepared with the courteous assistance of the director and staff of the Government Observatory, Johannesburg, shows that the summer rainfall conditions throughout a great part of South Africa are eminently suited to maize production. Certain areas must be excepted, however, such as the Cape Peninsula and the adjacent areas

Table VII.
RAINFALL OF SOUTH AFRICA.

Place.	Annual Rainfall.		November.		December.		January.		February.		March.		Rainfall, Dec., Jan., Feb., 3 Months.		Rainfall, November to March, 5 Months.		Period of Records.		Authority.
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Seasons.	No.	
Transvaal—																			
Pretoria, Government Buildings	25·32	82	4·15	12	3·90	13	5·49	14	3·91	10	3·16	11	13·30	38	20·61	61	1892-1908	17-18	Trans. Met. Dept.
Witwatersrand, Joubert Park	30·77	87	4·43	12	4·69	14	6·01	14	5·01	11	4·12	11	15·71	39	24·26	62	1888-1908	20-21	,,
Bethal (Dist.)	25·38	79	4·69	13	3·66	11	5·24	15	4·29	11	2·70	7	13·19	37	20·58	57	1904-5 to 1906-7	3	,,
Bloemhof (Dist.)	19·03	63	2·48	8	2·11	7	3·74	11	3·14	9	3·40	9	8·99	27	14·87	43		,,	,,
Ermelo (Eastern)	37·26	100	8·17	17	5·83	14	5·61	14	6·59	14	3·83	11	18·03	42	30·03	70	,,	,,	,,
Heidelberg (Dist.)	25·47	73	5·06	11	3·42	10	4·49	12	5·25	11	2·68	8	13·16	33	20·90	53	,,	,,	,,
Lichtenburg (Dist.)	19·73	66	2·20	7	2·57	9	4·41	14	3·97	10	2·56	9	10·95	32	15·71	49	,,	,,	,,
Potchefstroom (Dist.)	23·24	69	3·42	9	3·36	9	4·76	12	4·24	10	2·69	9	12·36	32	18·47	49	,,	,,	,,
Standerton (Dist.)	26·54	75	5·00	11	4·34	11	4·48	12	5·30	12	2·33	8	14·12	35	21·45	54	,,	,,	,,
Waterberg (Dist.)	23·84	57	2·79	8	4·37	9	5·12	11	5·00	10	2·57	7	14·49	30	19·85	45	,,	,,	,,
Zoutpansberg (Town of Pietersburg)	20·20	59	1·87	8	4·39	10	3·43	9	4·30	10	2·94	9	12·12	29	16·93	46	1904-7	,,	,,
Portuguese East Africa—																			
Lourenço Marques	27·27	66	3·50	9	3·73	8	6·06	8	5·21	7	2·78	7	15·00	23	21·28	40	1876-8,-91 1901-3-7	16	,,
Rhodesia—																			
Bulawayo	...	...	4·62	6·2	5·04	12	5·67	1·6	3·00	15·9	2·41	12·1	13·71	39·5	20·74	57·8	1897-8 to 1906-7	10	Rev. Father Goetz, S.J.
Salisbury	...	...	3·80	11·5	5·46	14·7	7·22	17·9	8·59	17·5	5·09	14·0	21·27	50·1	30·16	75·6			
Orange Free State—																			
Harrismith	27·62	68	4·23	9	3·58	9	3·96	10	3·30	8	3·34	8	10·84	27	18·41	35	1882-1908 (breaks)	12-13	Trans. Met. Dept.
Kroonstad	25·18	—	3·46	—	2·83	—	4·73	—	3·56	—	3·75	—	11·12	—	18·33	—	1880-1901	22	Sutton (Tr. S.A.P.S., XV).[1]
Bloemfontein	23·37	—	2·22	—	2·86	—	3·81	—	3·68	—	3·67	—	10·35	—	16·24	—	,,	20	,,

[1] *Transactions of the South African Philosophical Society*, Vol. XV.

Basutoland—																			
Maseru . . .	31·88	...	3·53	...	3·36	...	5·75	...	4·38	...	4·85	...	13·49	...	21·87	...	1891-1901	11	Sutton (Tr. S.A.P.S., XV).[1]
Natal—																			
Newcastle . . .	36·28	63	4·22	8	5·74	10	6·36	10	6·11	9	5·29	10	18·21	29	27·72	47	1894-9 1901-7	13	Natal Obser., per Trans. Met. Dept.
Dundee . . .	29·61	71	3·52	10	4·09	10	6·53	12	5·18	9	3·48	8	15·80	31	22·80	49	1896-9 1902-7	9 or 10	
Weenen . . .	25·83	76	3·45	10	3·55	11	5·34	12	4·11	9	2·89	11	13·00	32	19·34	53	1897-1907	10	,,
Estcourt . . .	28·39	69	3·04	8	4·69	11	5·52	11	4·94	10	3·64	10	15·15	32	21·83	50	1894-1907	14	,,
Maritzburg . . .	31·84	...	5·68	...	4·48	...	4·23	...	5·20	...	4·08	...	13·91	...	23·67	...	1858-67	10	Mann, Brit. Ass. Rep.
Maritzburg . .	34·86	124	4·56	17	5·78	18	6·41	18	4·88	14	5·34	15	17·07	50	26·97	82	1895-1907	13	Natal Obser., per Trans. Met. Dept.
Durban . . .	40·00	120	4·64	15	4·60	15	4·09	14	4·43	11	4·69	12	13·12	40	22·45	67	1883-5 1887-1907	23-24	,,
Cape Province—																			
Mafeking . . .	24·56	58	2·71	7	3·71	9	5·50	9	3·83	9	4·32	4	13·04	27	18·07	43	1887-1905	18	Trans. Met. Dept.
Bedford . . .	27·68	...	3·11	...	2·99	...	3·28	...	3·50	...	3·99	...	9·77	...	16·87	...	1880-1901	22	Sutton (Tr. S.A.P.S., XV).
Butterworth . .	30·36	...	4·36	...	2·84	...	3·59	...	3·47	...	3·44	...	9·90	...	17·70	...	1889-94	5·6	Buchan.
East London . .	24·43	...	2·66	...	2·11	...	2·29	...	2·16	...	2·65	...	6·56	...	11·87	...	1880-1901	22	Sutton (Tr. S.A.P.S., XV).
Fort Beaufort . .	22·39	...	2·61	...	2·12	...	2·68	...	2·70	...	3·33	...	7·50	...	13·44	...	,,	,,	,,
Graaff Reinet . .	16·26	...	1·66	...	1·60	...	1·78	...	1·91	...	2·78	...	5·29	...	9·73	...	,,	,,	,,
Herschel . . .	27·95	...	2·24	...	3·57	...	4·78	...	3·75	...	4·28	...	12·10	...	18·62	...	,,	19	,,
Humansdorp . .	25·79	...	2·65	...	1·95	...	1·72	...	1·58	...	2·37	...	5·25	...	10·27	...	,,	22	,,
Kingwilliamstown .	24·79	...	2·92	...	2·54	...	2·39	...	2·97	...	2·91	...	7·90	...	13·73	...	,,	22	,,
Peddie . . .	24·05	...	2·74	...	2·18	...	2·05	...	2·03	...	2·61	...	6·26	...	11·61	...	,,	21	,,
Queenstown . .	24·53	...	2·36	...	3·28	...	3·93	...	4·01	...	3·56	...	11·22	...	17·14	...	,,	22	,,
Oudtshoorn . .	9·44	...	0·65	...	0·46	...	0·68	...	0·83	...	0·99	...	1·97	...	3·61	...	,,	21	,,
Somerset East . .	26·22	...	2·78	...	3·03	...	3·30	...	3·34	...	3·49	...	9·67	...	15·94	...	,,	21	,,
Sterkstroom . .	22·50	...	2·27	...	3·20	...	3·28	...	3·64	...	3·51	...	10·12	...	15·90	...	,,	16	,,
Average . .	26·21	...	3·45	...	3·54	...	4·35	...	4·03	...	3·40	...	11·92	...	18·71	...	...	...	

[1] *Transactions of the South African Philosophical Society*, Vol. XV.

which have chiefly winter rains; the areas of very low rainfall such as the Karroo; areas where there is a deficiency in the spring rains, or where the intervals between rains are too great, as in parts of the south-western Transvaal and western Orange Free State; and the higher mountain ranges where, though the rainfall is ample, the growing season is too short.

30. *Sunshine.*—The maize plant is especially suited to the treeless grass-steppes of upland plateaux, and also thrives in *open* "bush" country. But it does not seem at home in humid, shady, tropical forests. Sagot (1) shows that maize does not thrive in the warm, damp climates where manioc (*Manihot* spp.) is grown, and De Candolle (1) supplements this observation by pointing out that forests are generally unfavourable to the production of *any annual* plants.

The latter view seems in harmony with the general geographical distribution of cereal crops in the tropics. Major Whitlock (1) observes that guinea corn (*Sorghum vulgare* var.), an annual plant, is the staple cereal of the natives on the plains of Nigeria, at about 1,400 feet above sea-level, from Lake Chad almost to the foot of the watershed plateau between the Benue and the Cross Rivers. South of this plateau, however, where the country is clothed with forest, no more guinea corn is seen, the natives subsisting entirely on yams and plantains. In parts of Uganda, also, bananas are more extensively grown for food than any cereal.

This is probably due, in the case of maize, to lack of sunshine. It is noticeable in South Africa that in cloudy seasons, like that of 1909-10, when there was nearly twice as much cloud as usual during the months of January and February, the maize crop is light. In continuous wet weather, pollination appears to be retarded; if the wet weather alternates with warm sunshine at short intervals, pollination can take place readily; nature has provided that the silks shall be receptive for a considerable period (sometimes as much as fourteen days if pollen is not applied earlier), while the pollen supply may last for two to three weeks through a natural irregularity in time of flowering of different individuals; in one plant, alone, pollen continues to fall for about four consecutive days.

31. *Influence of Climate upon Vegetative Characters and Time of Maturity.*—Careful study of the influence of climate

upon habit of growth is needed. The same breed appears to differ in size and in time of maturity at different altitudes and latitudes. Hunt (1) concludes that in the United States, as a general rule, a breed becomes one day later for each ten miles south or north of a given latitude, if the altitude is the same. This means that a variety which ripens two weeks before a killing frost in a given locality would only barely ripen if taken 140 miles away from the equator at the same altitude, the date of the first killing frost remaining the same.

He advocates that, in introducing new seed it should preferably be obtained from about the same latitude. Similarity of latitude may be a sufficient guide on a vast and nearly level plain like that of the Ohio valley; but where the topography varies as it does in South Africa, other factors than latitude and altitude influence the climate, and we doubt whether (with the present lack of knowledge of these controlling factors) South African farmers can make much practical use of the suggestion. A breed which matures in 90 days in Australia may take 100 or 110 days in the Transvaal. It is very noticeable that the same breed takes a longer or shorter time to mature in different years, according to the "season"; in a time of drought, growth is checked and flowering and fruiting are hastened, while in a rainy season, growth is continued much longer. Even within the Transvaal, and during the same season, the same breed, grown from the same lot of seed, is reported as having varied considerably in time of maturing in different districts. This is due partly, no doubt, to the condition of the soil as regards moisture at time of planting; in an air-dry soil such as is found over large areas during a great part of the spring, the seed does not germinate as quickly as in a moist soil. Allowance must also be made for the personal equation, different observers holding different views as to when the ear could be considered "mature" or safe from frost; lack of purity in strains of the same breed may also be a factor.

32. *Acclimatization.*—It is said that when a recognized breed has been grown for some time under diverse climatic conditions, it not only changes considerably in stature and time of maturity, but that these habits become more or less fixed so that, when taken back to the old conditions, the plant does not at once respond to the change. In this way different

strains of the same breed are supposed to be developed; they are said to become adapted to different conditions. The amount of such change, if it does occur, must be limited, however; within these limits it could be made use of in the acclimatization of new breeds, but it would not enable us to take a very late maturing sort suddenly from a tropical climate to a much higher altitude and colder latitude, and acclimatize it successfully; this would have to be done gradually and by intermediate steps, and with some breeds might not be successful even then. Little is known, at present, of the actual effect of climate upon the maize crop. If the facts are such as have been indicated, farmers would do well to make use of them, or at least to keep them in mind when purchasing seed-maize.

It appears clear that seed-maize from one climate takes some time to become acclimatized to another, and in the United States it has not been found desirable to take seed-maize from the rich alluvial plains of the Mississippi to the poorer soils of Virginia. For these reasons it is not desirable to buy bulk seed from hot, humid regions, at low altitudes, for cultivation in cooler and drier conditions at high altitudes. Nor is it desirable to obtain seed from deep, fertile soils for growth on thin, poor soils; one of the chief reasons that *Hickory King* has become such a favourite in South Africa is its ability to thrive on relatively poor soils and with rough treatment. But the converse may perhaps also be true, that it is not desirable to obtain bulk seed-maize from colder and drier climates and poorer soils for growth in hotter and more humid climates and on richer soils, because the quicker maturing habit will have been formed and the plant will not be able immediately to take advantage of the longer growing season and greater amount of plant food, and the resulting crop may be less than would have been the case with a breed already acclimatized to those conditions.

33. *Influence of Climate upon Varieties.*—The origin of the different varieties of maize is unknown, through lack of historical records, but it seems probable that there is some relation between climate and existing varieties. It is noticeable that those breeds grown in the most northerly parts of the United States and in Canada are mainly flints, while

in the Southern States dents are grown almost exclusively. CHAP. II.
Dents generally yield more heavily than flints, but take longer to mature; flints mature earlier, but as the yield is lighter they are grown only where others cannot mature owing to shortness of season.

It is said that a northern flint variety, after having been grown for several years in Illinois, changed under the influence of climate into a dent; but before concluding that this change was caused by change of climate it should be known whether any precautions had been taken against cross-pollination, for if crossing had taken place between the flint and a dent, the heterozygous grains might retain the flint appearance and would later produce dent grains, which, if selfed, would breed true.

Sugar maize is said to be rarely grown in the Southern States, but whether this is due to the climatic conditions being unfavourable for the production of sugar maize, or whether it may be due to the taste of the people, is not clear.

34. *Influence of Climate upon Chemical Composition.*—As the result of thirty-five analyses of dent maize grown in the Northern States, and forty-nine from the Southern, Hunt (1) concludes that there is no material difference in composition in maize grown in different parts of the country, over a very wide range of soils and climates. Analyses of Transvaal samples made by the Division of Chemistry of the Union Department of Agriculture tend to confirm this view (see chap. XIII.).

CHAPTER III.

GEOGRAPHICAL DISTRIBUTION.

To the wise man all the world's a soil.—Ben Jonson.

CHAP. III. 35. *Geographical Distribution.*—In the preceding chapter we have seen that maize requires a hot, sunny climate; it thrives best between the 40th parallels of latitude. Early ripening breeds are grown for grain in warm-temperate regions as far north as the 48th parallel in the northern hemisphere, and for fodder, still farther north, in the cool-temperate zone.

The value of maize as a cereal crop for man and his domestic animals has led to its world-wide distribution in the brief space of time since the discovery of America. Although, as already pointed out (¶ 10), maize was probably first grown in New Granada as a cultural crop, and has only been known in Europe since the beginning of the sixteenth century, to-day three times as much is produced in Europe as on the whole of the South American continent.

The countries mentioned in Table VIII are the leading producers of maize-grain; the figures given are for the year 1906, which was a record year for maize production in the northern hemisphere; they are taken from the *Year Books* of the United States Department of Agriculture (*U.S.D.A.* 7)[1] and other official publications, and are stated in United States standard bushels of 56 lbs. In the case of Mexico and the African continent, the figures are only approximate, through lack of precise data.

Maize is also grown, but to a lesser extent, in the Province of Quebec (Canada), Central America, the West Indies, Brazil, Paraguay, Bolivia, Chile, Peru, Nyassaland, Uganda, British

[1] The U.S.D.A. *Year Book* omits entirely the production of British India, which is larger than that of Mexico and Canada combined.

TABLE VIII.

THE WORLD'S MAIZE CROP OF 1906.

	Bushels.	Bushels.	Bushels.
North America—			
United States . . .		2,927,416,000	
Mexico		70,000,000	
Canada (Ontario) . .		23,989,000	
			3,021,405,000
South America—			
Argentina		194,912,000	
Uruguay		3,226,000	
Chile		846,000	
			198,984,000
			3,220,389,000
Europe—			
Austria-Hungary—			
Austria	18,177,000		
Hungary . . .	162,925,000		
Croatia-Slavonia . .	20,470,000		
Bosnia-Herzegovina .	8,900,000		
		210,472,000	
Roumania		130,546,000	
Italy		93,007,000	
Russian Empire—			
Russia proper, including Bessarabia and Southern Russia . . .	59,320,000		
Northern Caucasia .	11,181,000		
		70,501,000	
Servia		27,786,000	
Bulgaria		27,780,000	
Spain		18,714,000	
Portugal		15,000,000	
France		14,581,000	
			608,387,000
Asia—			
British India . . .			107,318,000
Africa—			
Egypt		30,000,000	
Natal (and Zululand) .		3,845,000[1]	
Orange Free State . .		Not stated.	
Transvaal		Not stated.	
Cape Colony . . .		3,200,000[2]	
Rhodesia		Not stated.	
Algeria		544,000	
Sudan (Anglo-Egyptian) .		300,000	
			37,889,000
Australasia—			
New South Wales . .		5,714,000	
Queensland . . .		2,233,000	
Victoria		661,000	
New Zealand . . .		653,000	
Western Australia . .		1,000	
			9,262,000
			3,983,245,000

[1] The 1901 crop is given by Harrison (1) as 1,351,045 muids (4,825,160 bushels).

[2] In the year 1894-5 the total crop of Cape Colony was given as 920,369 muids (3,287,032 bushels), (*Wallace*, 1).

CHAP. III.

East Africa, Madagascar, Mesopotamia, Ceylon, China, Japan, the Malay Archipelago, and New Caledonia.

36. *Distribution in the United States.*—The United States has 108,750,000 acres under maize and produces 75 per cent of the world's crop, but though maize is grown to a greater or less extent in most of the States of the Union, 58 per cent of the crop is produced in the comparatively small region comprising the seven central States of Iowa, Illinois, Nebraska, Kansas, Missouri, Indiana, and Ohio. These are known as the "Corn-surplus States," because they are practically the only States which grow more than is required for their own consumption. Their combined area is only about 268,000,000 acres, or 11½ per cent of the total area of the United States, and some 25,000,000 acres less than the area of the Union of South Africa *excluding* native territories. Only 18 per cent of the land of these seven corn-surplus States is planted to maize, but it produces 481,614,384 muids, or 58 per cent of the total crop of the country. The area of the Transvaal is approximately 71,000,000 acres; if only 18 per cent were under crop to maize, and if the average yield were only 5 muids per acre (only half the average of the Corn-belt), the Transvaal would be producing the respectable crop of 64,000,000 muids of maize.

TABLE IX.

STATISTICS OF THE MAIZE-SURPLUS STATES.

Corn-surplus States.	Square Miles.	Average planted to Maize.	Yield in 1906. Bushels.	Average Yield per Acre. Bushels.
Iowa	56,025	9,450,000	373,275,000	39·5
Illinois	56,650	9,616,886	347,169,585	36·1
Nebraska	77,510	7,325,000	249,782,500	34·1
Missouri	69,415	7,075,000	228,522,500	32·3
Kansas	82,080	6,750,000	195,075,000	28·9
Indiana	36,350	4,643,782	183,893,767	39·6
Ohio	41,060	3,325,000	141,645,000	42·6
	419,090	48,185,668	1,719,363,352	36·15

The maize zone of the United States may, for practical purposes of competition with other parts of the world, be considered as lying east of the 100th meridian. It occupies the rich, alluvial bottom lands of the rivers Missouri, Mississippi, Ohio, and their tributaries. West of this there are, roughly speaking, four zones of vegetation, none of which is likely to become a maize producer of importance, owing to the climatic and other conditions described below. A recent American authority has stated that this country has now reached a point where increased acreage will play a minor rôle in the future in the increased production of this great cereal (*Bowman* and *Crossley*, 1). CHAP. III.

37. *The Sub-arid Zone.*—The western portion of the States of South Dakota, Nebraska, Kansas, Oklahoma, and Texas, lying, approximately, west of the 100th meridian, is a sub-arid zone of prairie, nearly 200 miles wide, where, without irrigation, good crops grow only one or two years out of five. The eastern border of this zone roughly corresponds with the 2,000 feet contour, where the country begins to rise from the river basin towards the Rocky Mountains.

38. *The Rocky Mountains Zone.*—West of the sub-arid zone lie the Rocky Mountains, comprising pastoral and forest areas.

39. *The Great Basin.*—Between the Rocky Mountains and the Sierra Nevada of California, lies the Great Basin, at one time known as the "Great American Desert". Though the rainfall is scanty, this region is scarcely a desert in the ordinary sense of the word; it is largely covered with sage-brush and sparse grass furnishing grazing for stock. Crops are only grown where irrigation can be applied, and irrigated land grows lucerne more profitably than maize.

40. *The Pacific Slope.*—In the northern portion there is ample rain, but, as it falls principally in winter, the region is not well suited to maize-growing on a large scale. The irrigated lands can be more profitably planted to lucerne and fruit than to maize. A certain amount of sugar maize is grown for canning and eating fresh as "green corn".

41. *The Atlantic States.*—The North Atlantic States of Maine, New Hampshire, Massachusetts, and the New England States, have too short a growing season to produce large crops of maize. Sugar maize is extensively grown, however, for canning purposes, even in localities too far north to permit of the ripening of the grain. In New Hampshire maize is grown

in greenhouses for the very early market (*Rane*, 1). Virginia, North Carolina, and Georgia are the only ones of the Atlantic States which produce any quantity of maize grain. The immediate coast region of the South Atlantic States is not much of a maize zone, partly on account of the character of the soil.

42. *Canada.*—The Canadian climate, speaking broadly, is better suited to wheat than to maize. But a number of the earlier-maturing breeds are grown and ripen grain in the eastern portion of Ontario Province, and the southern part of the Provinces of Montreal and Quebec. Ontario has about 332,000 acres, and Quebec 33,000 under maize.

43. *Mexico.*—As is the case in most of the Latin-American countries, the agricultural resources of Mexico are by no means well developed. The topography and consequent climatic conditions stand in the way, but a good deal more could be done by the development of irrigation. The north-western States of Lower California, Sonora, and Chihuahua are very dry, the average (twenty-two years) rainfall in the case of Lower California being only 10·5 inches. In most parts of the country maize and beans (frijoles) form the staple article of diet. The principal maize areas are south of the States of Sinaloa, Durango, Nuevo Leon, and Tamaulipas.

In the drier States, such as Lower California, Coahuila, Durango, Nuevo Leon, and Yucatan, maize is mainly grown under irrigation, yet even in some of these, especially Sinaloa and Chihuahua, the maize area is considerable and is increasing. In others the crop might be doubled by irrigation. The strip of coast land is largely devoted to special tropical crops. The Maize-belt lies between this and the dry interior, at an altitude of 3,000 to 6,000 feet, where the climate resembles that of Southern Italy. Maize is the chief product of the States of Aguas Calientes and Colima. The estimated yields per acre range from 4½ to 14 muids (15 to 50 bushels). In some parts two crops a year are produced. In some States American capital, machinery, and enterprise are being applied with promising results to maize- and cattle-growing.

44. *Central America and the West Indies.*—Maize is grown to a limited extent throughout Central America, but though used as an article of diet, it does not form an important article of commerce, other tropical products paying better.

45. *Tropical South America.*—Maize is grown to a greater or less extent in all of the tropical South American countries, but statistics of production seem to be non-existent in most cases. Chile is reported to have had 63,100 acres under crop in 1908, and Uruguay 524,200 acres in 1907. Peru and Bolivia are also known to produce for their own consumption. In Brazil maize is grown in the more open parts, two crops a year being produced in some places. Flint breeds form practically the only variety grown, and the yield per acre is said to be higher than in the United States. The dense tropical forests which clothe the river valleys are unsuited to the production of maize, and there manioc largely takes its place.

46. *Argentina.*—Argentina is the most serious competitor with South Africa for the maize trade of the world, and the only country that she has to fear at the present time. In the season 1908-9 Argentina had 8,342,559 acres under maize, and her crop was 49,590,000 muids, or an average of nearly 6 muids per acre; on some farms 14 to 17 muids (50 to 60 bushels) are obtained.

The planting season extends from the middle of August to the middle of January, but the safest time is considered to be from the middle of September to the middle of December. Early planting gives the best yield when the season is favourable. The crop is drilled, not check-rowed; it is harrowed when the plants are 2 or 3 inches high, and hilled up by machinery when 12 inches high. Ninety per cent of the crop consists of a small flint type, much appreciated on the London and Liverpool markets; *Hickory King* and *Queen* have also been tried. There is a tendency to harvest before the crop is mature, in order to get the grain to the coast before the heavy rains begin (¶ 29). In some seasons locusts play serious havoc with the crop. The Provinces of Buenos Aires and Santa Fé are the largest producers.

47. *Possible Increase in the Argentine Crop.*—Fifty per cent of the total crop is exported, but it is likely that local consumption will increase owing to the enormous development of the meat-packing trade. However, with increased local demand, there will certainly be an increase in acreage under crop. During the five years 1905 to 1909 inclusive, the average annual increase in area planted to maize amounted

CHAP. III. to 78 per cent, the production 28 per cent and the export 33 per cent. Only about an eighth part (say 12 per cent) of the area suited to the production of the four crops, wheat, maize, linseed, and oats, is at present under cultivation. Of this, one-half is devoted to wheat and one-quarter to maize. Eight times the present maize acreage would be 66,000,000 acres, which at 6 muids per acre gives a potential crop of 396,000,000 muids. Unless the population in the country increases, this means a possible surplus of 198,000,000 muids for export. The importing countries consumed, in the year 1908-9, only about 49,689,180 muids. If the present rate of increase in Argentine maize exports is maintained, viz. 33 per cent increase in four years, it will take twenty-eight or perhaps thirty years for the export to reach the maximum indicated above. By that time local consumption in Argentina will probably have increased greatly, as it has done in the United States. Out of a crop of 850,000,000 muids (more than double the potential crop of Argentina) the United States exports only about 1·5 per cent or 8,500,000 muids. If the States continue to export 1 per cent, and the Argentine export falls to 1 per cent of her potential crop, the two countries will only export about 12,500,000, or one-quarter of the present world's imports, instead of *three-quarters*, as at present. This will leave ample opportunity for South Africa to supply 25,000,000 to 30,000,000 muids, while the Danube and South Russia can make up the balance. This estimate makes no allowance for increase in consumption by importing countries, which is steadily growing. Under these circumstances there seems to be plenty of room for the expansion of the South African maize trade.

48. *Europe.*—In the ten years from 1880 to 1890 the production of maize in the Austro-Hungarian Empire is said to have increased by 40 per cent, but during the last few years the maize acreage and production have been fairly uniform, and no great increase in future is to be expected.

Most of the crop is grown on the rich, alluvial plain soils of the Danube, Dnieper, and Dniester Rivers, Roumania, Hungary, and Bessarabia together furnishing over half of the European crop. This is largely exported from Odessa, Galatz, and Fiume; grain forms three-quarters of the export trade of Galatz.

In Roumania maize is the staple crop, and the staple food-stuff of the people; there are local distilleries which produce whisky from the maize.

Italy is the next largest producer with about 15 per cent of the European crop. The largest and richest agricultural area is the basin of the River Po, including the plains of Lombardy, Venetia, and Emilia. Part of the crop is shipped from Genoa and part from Venice; at the latter port the grain is stored in air-tight silos to await shipment.

49. *Asia.*—Very little information is obtainable as to the culture of maize among Asiatic peoples. Maize is grown in India, Ceylon, Persia, China, Japan, and the Malay Archipelago, but few statistics are accessible except in the case of India. The value of maize as a cereal crop is strikingly emphasized by its distribution in the latter country; though doubtless first introduced into the Portuguese Settlements of the East Indies early in the sixteenth century, the conservatism of the Indian peoples naturally stood in the way of its adoption as a regular crop. As recently as 1832, Roxburgh observed

TABLE X.

ACREAGE UNDER MAIZE IN INDIA FOR THE DECADE 1897-8 TO 1906-7, BOTH INCLUSIVE.[1]

	British India.	Native States.	Total.
	Acres.	Acres.	Acres.
1897-1898	6,414,732		
1898-1899	6,144,240		
1899-1900	5,195,472		
1900-1901	5,849,533		
1901-1902	6,198,063		
1902-1903	6,331,816	306,346	6,638,162
1903-1904	6,135,511	269,268	6,404,779
1904-1905	5,961,487	250,285	6,211,772
1905-1906	5,790,543	221,687	6,012,230
1906-1907	6,171,751	302,350	6,494,101
Average . . .	6,019,514	269,987	6,352,209

The distribution of the crop through the several Provinces is instructive; the highest yields per acre are obtained in the North-west Frontier Provinces; the lowest (as far as we have figures) in Bengal; but Bengal has by far the largest acreage.

[1] *Indian Government Publications*, 1.

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TABLE XI.

ACREAGE AND YIELDS OF MAIZE IN THE INDIAN PROVINCES.

Province.	Acreage Planted.	Yield per Acre.	Estimated Crop.[1] Muids.
Bengal	1,802,400	820 lbs.	7,389,840
Agra	1,454,497	1050 ,,	7,636,109
Panjab	1,195,849	1170 ,, irrigated 850 ,, dry 1001 ,, dry & irrigated 1007 ,, mean	6,021,099
Oudh	710,938	1050 ,,	3,732,424
N.W. Frontier	390,529	1841 ,, irrigated 745 ,, dry 1342 ,, dry & irrigated 1309 ,, mean	2,556,012
Bombay	157,079	850 ,, estimated	667,585
Central Provinces	135,852	850 ,, ,,	577,371
Upper Burma	106,700	850 ,, ,,	453,475
Madras	104,913	850 ,, ,,	445,880
Ajmer-Merwara	64,003	965 ,, irrigated 960 ,, dry 714 ,, dry & irrigated 880 ,, mean	563,226
Lower Burma	21,879	850 ,, estimated	92,985
Eastern Bengal	21,120	850 ,, ,,	89,760
Berar	2,116	850 ,, ,,	8,993
Sind	1,394	850 ,, ,,	5,924
Central India	1,269	850 ,, ,,	5,393
Assam	1,213	850 ,, ,,	5,155
Coorg	...	......	...
Native States	302,350	850 ,, ,,	1,284,987
	6,474,101		31,536,218

[1] Where the yield per acre varies between the irrigated and dry crops, and the crops fully irrigated and partly dry, the mean of these figures has been taken in calculating the yield. Where no yield per acre is given, the estimate has been made on the basis of the yield of the dry-land crop in the Panjab, which is probably a little on the low side.

that maize was "cultivated in different parts of India in gardens, and only as an ornament, but nowhere on the continent of India as an object of cultivation on a large scale" (*Roxburgh*, 1). In course of time native prejudice gave way before the unanswerable demands of hunger and a rapidly increasing population; Church (1) observes that in 1886 there were already in India 2,250,000 acres under maize. In another twelve years the area under crop had increased to

6,500,000 acres. Since then it has averaged about 6,352,000 acres per annum, with very little variation above or below, from year to year, indicating that it has probably reached its limit of geographical and economic distribution. Maize has now become a staple article of food in India, especially among the hill peoples. The average yield per acre ranges from 714 lbs. to 1,841 lbs. (i.e. from less than 4 muids to over 9 muids, the latter yield being obtained only under irrigation); the average production for all the States and Provinces is slightly over 5 muids per acre. Maize is grown more extensively in the hill country than on the plains, where it is largely replaced by rice; in the Panjab it is grown at about 7,000 feet altitude. In Baluchistan a dwarf breed is grown successfully at between 5,000 and 9,000 feet altitude, where it forms a staple food of the people (*Mueller*, 1).

It seems hardly probable that India, with its dense population and increasingly intensive agriculture, will become a maize-exporting country; it is more likely that she will be an importer, in exchange for some of the more costly articles of commerce which she produces in abundance.

50. *Australasia.*—The total Australian maize area is only about 385,000 acres, and the crop about 3,000,000 muids, of which New South Wales contributes roughly one-half and Queensland over one-third. The coastal belt appears to be best suited to maize cultivation; two crops may be grown each year on the low coast lands of South Queensland. The climatic conditions of the interior of the continent appear to be generally too dry for maize-growing on a large scale, and the irrigated lands are too valuable for lucerne and dairying, to be devoted to maize-grain growing. Only a small quantity is produced in New Zealand. In New Caledonia maize is the principal cereal grown; it is used for feeding horses (replacing barley and oats), work-oxen, pigs, and poultry, but not for human food (*Jeanney*, 1).

From the point of view of competition in the European trade, Australasia is not likely to be a serious competitor with South Africa, owing to the much greater distance from market, and the limited area available for maize production. Development of the Australian meat trade may lead to a larger consumption of maize, and to a steady import, in

CHAP. III. which case South Africa would be the nearest producing country.[1]

51. *North Africa.*—Egypt is the largest producer of maize in North Africa, having nearly 2,000,000 acres under crop, and producing some 8,500,000 muids. Maize is a staple article of diet, and a certain amount is imported annually. The Egyptian Sudan produces only a small quantity, an average of 84,000 muids per annum for the three years to 1908 inclusive. In Algeria, owing to lack of summer rains, maize occupies but a very limited area, almost confined to the Province of Oran (*Rivière* and *Lecoq*, 1), and the annual production is only about 125,000 muids.

52. *Tropical Africa.*—Excellent maize is grown in parts of Rhodesia, and this Colony is likely to become a very large producer. A small export trade has been started (valued at about £30,000 in 1912), through the port of Beira. The development of cattle-ranching on a large scale is likely to lead to greater local consumption; £60,000 worth of maize was imported from the Union of South Africa in 1912.

In Nyassaland a small quantity of maize is grown and there appears to be scope for development, but it is probable that more intensive crops such as coffee and cotton will prove more profitable for that Colony. On the uplands of British East Africa and the Uganda Protectorate maize-growing is on the increase, and it is possible that this region will become a competitor with South Africa for the export trade. The Suez Canal charges may, perhaps, more than offset the shorter sea-distance to Europe, but there seems to be a good opportunity for developing the trade with India, Ceylon, and China.

Comparatively little maize is produced in the remainder of tropical Africa, partly owing to the general lack of agricultural development, partly to the fact, already alluded to, that maize does not thrive in tropical forest country, and partly, also, to the depredations of the elephant and wart-hog. In Italian Somaliland, German East Africa, Madagascar, the Astove atolls, the Cosmoledo Islands, and Portuguese East Africa, small quantities are produced, but the coast conditions do not seem favourable to maize production on a large scale, and other tropical crops generally pay better.

[1] Since this was written Australia has imported 242,000 muids of South African maize in one season.

Maize seems to be almost unknown to many of the native tribes of equatorial Africa, probably for the reasons before given (¶¶ 21 and 30). It is grown by the Baambas to the west of Mt. Ruwenzori, and by the Unyoros of Uganda, but "bolu" (*Eleusine Coracana*) is said to be the favourite cereal of the latter people. In the Acholi country, millets appear to take the place of maize, except at a small Nubian settlement near the Nyama River, where a red kind of maize is also grown. A small quantity of maize is grown by the Bahoru at Katonia in the Ankole country east of Mt. Ruwenzori (*Dawe*, 1). Major Bright (1) states that maize is grown in large quantities in the plain around Kasenyi, on the west shore of Lake Albert, at about 2,170 feet elevation, where they are not troubled by elephants and wart-hogs.

In Nigeria maize does not appear to have yet supplanted the native cereal, guinea corn (*Sorghum vulgare* var.) (*Whitlock*, 1). In Portuguese West Africa a limited quantity of maize is produced, and in the Congo country it is used in the preparation of a beverage. In 1795 Mungo Park (*Travels*) found the natives at Pisania, on the Gambia, cultivating maize in considerable quantities. The French Sahara is too dry for maize-growing; water is plentiful in the country about Lake Chad, but the heat is intense and the rainfall very scant; during the rainy season (July to October inclusive), the mean fall is about 5·2 inches, while in the very wet year of 1908 it only reached 7·8 inches. In this region millet seems to be the staple cereal (*Tilho*, 1).

53. *South Africa.*—As a field for maize-growing, the Union of South Africa takes front rank, and for the farmer with energy and enterprise there awaits a rich reward in connection with this industry. A young, vigorous, and steadily (if slowly) increasing population provides an expanding local consumption, and the world's markets—owing to the excellent lines of communication linking South Africa with the older countries—lie within easy distance.

The climate of a large part of South Africa is peculiarly well suited to the easy production of enormous quantities of maize of exceptionally good quality, especially for manufacturing purposes. The rainfall is ample if the soil is cultivated properly. The possible planting season lasts for two months,

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as compared with a maximum limit of eighteen days in some of the maize-growing States of North America.

The moisture contained in maize exported from South Africa is some 4 per cent lower than that of the American-grown article, which minimizes danger of damage in transport, and puts a premium on South African grain for manufacturing purposes. Farmers in Argentina find their climate unfavourable to the proper conditioning of the crop for export (¶ 29).

Not all of South Africa is equally well suited to the production of maize. She has her Maize-belt just as the United States has her Corn-belt. The hot coastal zone and the dry Karroo and Kalahari regions are not well suited to maize-growing. The maize zone may be roughly defined as the country lying east of the 26th meridian, i.e., a line drawn between Algoa Bay, Bedford, Cathcart, Queenstown, Aliwal North, Wepener, Bloemfontein, and thence north to Lichtenburg and Zeerust. From this area the coast belt below 1,000 feet altitude, and the mountain region above 6,000 feet, should be excluded.

54. *Orange Free State.*—The Orange Free State, together with the adjoining native territory of Basutoland, is by far the largest producer and exporter of maize of any of the four Provinces of the South African Union. But of the total area of the Province less than $2\frac{1}{4}$ per cent is planted to this crop, and in the best producing Districts only $5\frac{1}{2}$ per cent. The largest acreage and best crops are found in the north-eastern Districts, where the rainfall is about 11 inches during the three growing months of December, January, and February. A considerable part of the crop is grown by natives, and the average yield is estimated at only 3 muids, or 11 bushels, per acre.

55. *Transvaal.*—Maize is grown more or less in every District and on practically every farm, but the principal Districts, in approximate order of production, are: Bethal, Heidelberg, Potchefstroom, Pretoria, Standerton, Ermelo, Middelburg, and Lichtenburg. Most of the Transvaal maize is produced on the High-veld, because the population is greater and more land is under cultivation. A good deal is also raised in the Upper and Lower Bush-veld, but chiefly by natives. The altitudinal range of the crop is from 600 feet at Komatie-poort, to over 6,000 feet in the Steenkampsberg and

Drakensberg; but the major part comes from the plateau between 4,000 and 5,500 feet. The south-western Districts are less suited to the production of the ordinary types of maize owing to low rainfall, short growing season, and often shallow soil. But it is probable that in time breeds will be developed especially suited to the climate and soil of that part of the country.

56. *Relative Yields of Transvaal Districts.*—The relative productiveness of a District cannot be determined from the actual number of bags of grain produced by it, for the simple reason that the areas of the different Districts are so enormously disproportionate; as an example we need only compare that of Bethal (384,000 morgen) with the Zoutpansberg, which is nineteen times its size (7,256,400 morgen[1]). The best method of comparison of relative productiveness is to reduce the yield to the average of some unit common to all, e.g. an acre, morgen, or square mile.

The writer has therefore reduced the maize yields of the Transvaal to the average per square mile, which is the most convenient unit to use in the present state of agricultural development. In the following table (XII) the Districts are arranged in order of productiveness.

If we considered only the total production of a District, we should have to give Lichtenburg first place with 191,405 bags, whereas in yield per square mile of veld she comes only sixth on the list.

The value of closer settlement and consequent improvement in cultivation of the soil are clearly brought out by the fact that the Witwatersrand goldfields produce more maize per square mile than any other District of the Transvaal. The Witwatersrand, comprising the Magisterial Districts of Johannesburg, Germiston, and Boksburg, is the most thickly populated area in the Transvaal; it covers only 556 square miles, a large part of which is occupied by mines, mine dumps, towns, and villages; yet in 1909 it produced 68,400 muids of maize, or 122·8 per square mile, almost doubling the yield of Bethal, the next largest producing District. The soils of the Witwatersrand are not as suitable for maize culture as those of many other parts of the country.

[1] 1 morgen = 2·1165402 acres.

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TABLE XII.

AREAS AND YIELDS OF TRANSVAAL DISTRICTS.

District.	Area.[1] Square Miles.	Morgen.[2]	Muids.	Average in Muids per Square Mile.	
				1908-9.	1909-10.[3]
Boksburg . .	270·57	81,814			
Germiston . .	102·03	30,852			
Johannesburg .	184·18	55,692			
Total Witwatersrand (excluding Krugersdorp)	556·78	168,358	68,399·5	122·8	122·8
Bethal . .	1,270·04	384,035	93,555·0	73·3	170·0
Heidelberg .	2,351·61	711,081	140,496·0	59·7	102·9
Standerton .	2,003·62	605,855	119,062·0	59·4	90·8
Potschefstroom .	4,904·15	1,482,918	190,653·3	38·8	58·7
Lichtenburg .	4,478·81	1,354,304	191,405·0	42·7	35·0
Wolmaransstad .	2,061·69	623,414	51,929·0	25·1	27·1
Middelburg .	5,028·98	1,520,664	106,796·5	21·2	37·1
Ermelo . .	3,003·43	908,178	56,751·0	18·9	36·0
Wakkerstroom .	2,197·76	664,559	39,123·5	17·8	20·9
Krugersdorp .	1,174·67	355,197	19,800·5	16·8	25·5
Piet Retief. .	1,615·93	488,625	25,100·0	15·5	31·5
Pretoria . .	6,641·54	2,008,272	73,486·5	11·0	37·6
Carolina . .	2,095·72	633,704	14,231·0	6·8	27·6
Bloemhof . .	3,193·53	965,661	19,754·0	6·2	7·9
Marico . .	3,636·89	1,099,724	18,423·75	5·0	8·1
Lydenburg .	10,176·84	3,077,276	43,239·5	4·2	6·9
Waterberg . .	15,625·77	4,724,925	64,242·0	4·1	6·9
Zoutpansberg .	23,997·78	7,256,455	65,868·0	2·7	16·1
Rustenburg .	9,730·73	2,942,381	25,617·5	2·6	9·4
Barberton . .	4,679·57	1,415,010	9,900·5	2·1	3·7
Total .	110,425·84	33,370,596	1,437,834·5	12·9	42·0

[1] Figures of area kindly furnished by the Surveyor-general of the Transvaal; statistics by the statician of the Department of Agriculture (*Joubert*, 1).

[2] 1 morgen = 2·1165402 acres.

[3] Estimated only. The actual crop was only about one-half of the expected, owing to a remarkably unfavourable season.

57. *Natal.*—Maize is produced in all parts of Natal, but the Midland Districts (2,000 to 3,000 feet altitude) are generally conceded to be the best for maize-growing. The coast-belt is better suited to sugar cane and citrus fruits than to maize, owing to the too rapid and luxuriant growth of weeds and consequent cost of cleaning the land; but the average yield per acre is 1¼ muids higher on the coast than "up-country".

TABLE XIII.

MAIZE PRODUCTION, NATAL, 1906-7.

Magisterial Divisions.	Acreage under Maize.	Total Produce. Muids.	Yield per Acre. Muids.
NATAL.			
Coast—			
Lower Umzimkulu	1,012	5,064	5·0
Alexandra	4,180	27,250	6·8
Umlazi	782	4,576	5·9
Inanda, Indwedwe	1,631	10,417	6·5
Lower Tugela, Mapumulo	748	4,939	6·6
Totals	8,353	52,246	Average 6·1
Midlands—			
Impendhle	1,089	5,968	5·9
Alfred	1,291	6,142	4·9
Ixopo	7,319	35,670	4·9
Richmond	9,882	59,230	6·0
Umgeni and Camperdown	16,087	73,488	4·5
New Hanover	8,908	49,113	5·6
Lion's River	4,983	22,398	4·7
Umvoti	10,132	34,287	3·4
Krantzkop	2,242	8,837	4·0
Totals	61,933	295,133	Average 4·9
Uplands—			
Underberg	1,098	4,980	4·4
Polela	925	4,290	4·6
Bergville	3,229	14,758	4·5
Estcourt	8,763	48,377	5·5
Weenen	1,018	4,963	4·9
Klip River	6,498	25,317	3·9
Umsinga	992	4,670	4·8
Dundee	8,372	34,190	4·1
Newcastle	9,012	37,468	4·1
Vryheid, N'Gotshe	1,722	6,960	4·0
Utrecht	1,934	7,896	4·1
Paulpietersburg	1,650	6,218	3·9
Babanango	788	2,596	3·3
Totals	46,001	202,683	Average 4·3
ZULULAND.			
Coast—			
Eshowe	...	...	...
Mtunzini	474	2,070	4·4
Lower Umfolosi	53	265	5·0
Hlabisa	...	...	...
Ubombo	...	...	...
Totals	527	2,335	Average 4·7
Inland—			
Nqutu, Nkandhla	29	116	4·0
Emtonjaneni	907	2,919	3·2
Mahlabatini	...	...	...
Ndwandwe	...	...	...
Ingwavuma	...	...	...
Totals	936	3,035	Average 3·6
Grand Totals for the Province	117,750	555,432	Average 4·7

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Districts favourable for wattle-growing do not seem to be well suited to maize; the rainfall and lack of sunshine are perhaps too great, or it may be that maize is not equally profitable and is therefore neglected where wattle is grown. Although the Uplands produce a considerable quantity (only 90,000 muids less than the Midlands), they seem better adapted to stock-raising than to agriculture.

Camperdown and Richmond Districts are considered the

TABLE XIV.

MAGISTERIAL DISTRICTS OF NATAL ARRANGED ACCORDING TO PRODUCTION.

Division.	Acres.	Square Miles.	Yield per Square Mile in Muids.
Upper Umkomanzi—Richmond	332,800	520	114·0
Camperdown	235,520	368	100·2
Umgeni	233,600	365	
New Hanover	332,800	520	94·4
Alexandra	428,800	670	40·7
Umvoti	550,400	860	39·9
Ixopo	624,640	976	36·5
Lion's River	403,200	630	35·5
Dundee	605,440	946	35·4
Newcastle	698,880	1092	34·3
Estcourt	1,164,800	1820	26·5
Inanda, Indwedwe	283,520	443	23·5
Klip River	920,960	1439	17·6
Krantz Kop	366,720	573	15·4
Bergville	704,000	1100	13·4
Alfred	364,800	570	10·8
Paulpietersburg	395,520	618	10·0
Lower Umzimkulu	341,760	534	9·5
Umlazi	320,000	500	9·1
Impendhle	448,000	700	8·5
Weenen	400,000	625	8·0
Polela and Underberg	774,400	1210	7·6
Umsinga	394,240	616	7·5
Lower Tugela	289,920	453	6·8
Mapumulo	172,800	270	
M'Tunzini	239,360	374	5·5
Emtonjaneni	414,720	648	4·5
Utrecht	1,310,720	2048	3·8
Vryheid, N'Gotsche, and Babanango	2,729,600	4265	2·2
Lower Umfolosi	656,000	1025	·2
Nqutu	400,000	625	·08
Nkhandla	487,680	762	

best part of the Maize-belt of Natal ; the rainfall at Manderston is about 30 inches. One of the pioneer maize-growers of this part of Natal, famous for his large-sized *Hickory King*, has only 220 acres under maize, but has harvested as much as 3,581 muids in one season, or an average of 16·28 muids per acre, while 10 acres averaged 22 muids ; it has been his ambition to get a crop of 4,000 muids from his 220 acres. He started maize-growing twenty-five years ago, and the first season only produced 5 muids per acre. Good farming and the regular use of bone-meal have brought up the producing power of the land from a non-paying to a profitable yield. CHAP. III.

In Table XIII the acreage given for the various Magisterial Divisions excludes the Boroughs of Ladysmith, Newcastle, and Dundee, and the townships of Greytown, Verulam, Utrecht, and Vryheid. Those divisions of Zululand for which there are no returns have a few hundred acres put under maize by Europeans, but altogether for local consumption (*Harvey*, 1).

58. *Cape Province.*—The Cape Province produces less maize in proportion to total area than any of the other Provinces. The lack of summer rains in the south-western portion, the old "Western Province," renders that part of the country but poorly adapted to maize culture. In the Karroo and North-western Districts of the Province the total rainfall is too low to produce good crops of maize. In some of the Eastern Districts, on the other hand, especially the Transkei, the climate is favourable to the production of excellent maize crops. In these Districts, however, there does not appear to have been the same rapid increase in production that is noticeable in some other parts of South Africa ; in fact, in the twelve years from 1895 to 1907 the production fell in the District of Victoria East from 28,000 muids to nearly one-third, while in King William's Town District it fell off 15 per cent. In other Districts, however, the production increased, and in two or three cases it doubled and trebled.

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TABLE XV.

MAIZE PRODUCTION, CAPE COLONY, 1906-7.

Districts.	Area in Acres.	Area in Square Miles.	Estimated Yield. Muids.		Average per Square Mile.
			1894-5.	1906-7.	
Komgha	342,400	535	13,651	38,722	72·4
East London	428,800	670	20,480	40,556	60·5
King William's Town	807,040	1261	84,706	71,705	56·9
Stutterheim	428,800	67	...	33,547	50·0
Bathurst	373,760	584	...	23,653	49·0
Stockenstroom	200,320	313	11,674	13,056½	41·7
Alexandria	615,040	961	...	39,329	40·9
Victoria East	241,920	378	28,260	10,740	28·4
Fort Beaufort	545,920	853	13,722	17,314	20·3
Cathcart	634,240	991	...	18,276	18·4
Knysna	621,600	815	...	10,624	13·0
Aliwal North	613,760	959	...	11,645	12·1
Queenstown	1,232,000	1925	17,315	22,990	11·9
Humansdorp	1,235,200	1930	9,817	19,777½	10·22
Albany	1,066,240	1666	...	14,967	9·0
Wodehouse	1,254,400	1960	...	11,009	5·6
Mafeking	2,345,600	3665	...	12,870	3·5
Herschel	...	693	32,880	...	...
Glen Grey	...	825	27,860	...	...
Bedford	...	1200	13,277	...	...
Oudtshoorn	...	1630	11,228	...	...
Peddie	...	619	9,704	...	...
Somerset East	...	2900	8,576	...	...
Graaf Reinet	...	2651	7,859	...	...
				415,780	

Addendum.—The possibilities of Rhodesia have been referred to in ¶ 52. Average yields of ten (and even twenty) bags of maize, year after year, are reported. It is stated that about one-third of the whole of the Mazoe Valley country could be planted to maize and that in the Kafue Valley of N.W. Rhodesia there are vast stretches of level alluvial soils, suitable for maize, recalling the level plains of the North American Corn-belt. The total area of Rhodesia is approximately 250,000,000 acres; if only one-fiftieth part were planted to maize, and yielded on the average only 7 muids per acre, the country would be producing 35,000,000 muids.

CHAPTER IV.

BOTANICAL CHARACTERS.

Day by day did Hiawatha
Go to wait and watch beside it
. . . .
Till at last a small green feather
From the earth shot slowly upwards,
Then another and another,
And before the summer ended,
Stood the maize in all its beauty,
With its shining robes about it
And its long, soft, yellow tresses.
And in rapture, Hiawatha
Cried aloud, "It is Mondamin!
Yes, the friend of man, Mondamin!"

—*Hiawatha.*

'Tis sweet . . . to . . . scent the breathing maize at setting day.

—COLLINS.

59. *Botanical Relationship.*—Maize belongs to the group of Monocotyledons, and the family Gramineæ, or Grasses; it is the type of the tribe Maydeæ to which the genera Euchlæna, Coix, and Tripsacum also belong. Of these, Euchlæna (Fig. 10) is its nearest relative, and the only one with which it is known to hybridize. Some botanists are inclined to consider Euchlæna as the prototype of Zea, for the latter is not known in a truly wild state. Montgomery considers that Zea and Euchlæna may have had a common origin, and that in the process of evolution the pistillate spikes in teosinte were probably developed from the lateral branches of a tassel-like structure, while maize was developed from the central spike (cf. Fig. 40) (*Bowman* and *Crossley*, 1). CHAP. IV.

60. *Description.*—The maize plant (Figs. 11 and 12) is a tall, annual, monœcious grass, with stout, erect, solid stem, and broad leaves; the staminate flowers form a terminal panicle; the pistillate flowers are arranged in a densely-crowded spike,

CHAP. IV.

FIG. 10.—Teosinte, *Euchlæna mexicana*, a near relative of the maize plant, and the only species with which it is known to hybridize.

the "ear," terminating a short lateral branch and closely enveloped in leaf-sheaths called the *husk*; the long styles, exserted in anthesis, form the *silk* or beard. CHAP. IV.

61. *Plant Structure.*—All plants are living organisms, which feed and breathe in order to grow and multiply their kind. Their food-material consists of water, several of the

FIG. 11.—Maize plants in the Transvaal.

chemical substances of which the soil is composed, and carbon which is obtained from the air.

Plants are built up of a vast number of *cells* of different forms (Fig. 13); the cell is a microscopic sac usually consisting of a cell-wall surrounding a jelly-like mass called *protoplasm* (Fig. 13C). The cell-wall is a colourless membrane composed

CHAP. IV.

of *cellulose;* as it surrounds each cell, cellulose forms a large part of the substance of the higher plants. Protoplasm is the *living* substance of the plant, and comprises various minute, differentiated bodies, some of which (*the chloroplasts*) contain a green colouring matter (*chlorophyll*), and are present

FIG. 12.—Flowering plants of maize (*Zea Mays*). A, Tassel. B, Leaf-blade. C, Leaf-sheath (the stem is entirely surrounded by the sheath). D, Ear surrounded by husks. E, Silk exposed for some days. F, New silk just appearing (Photograph by D. W. Macdonald).

in such enormous quantities that they cause the whole plant-surface to appear green.

In the more highly-developed forms of plant life the cells are not massed together promiscuously, but are associated in groups forming bands, plates, or cylindrical masses called *tissues* (Fig. 14). The tissues of such plants become differentiated into groups, forming *organs* which have different duties to perform. Of these organs the most important are the *root*, *stem*, and *leaf* which are connected with nutrition and growth, and the *flower* which contains the reproductive organs of the plant. The life-cycle of the maize plant begins with the fertilization of the egg-cell in the ovule by the male germ cell, as described in ¶ 78, by which a new plant-being is brought into existence. The new cell, formed by the union

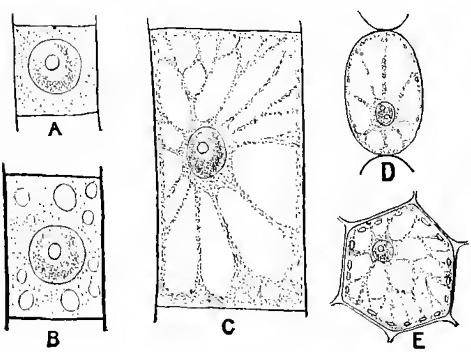

FIG. 13.

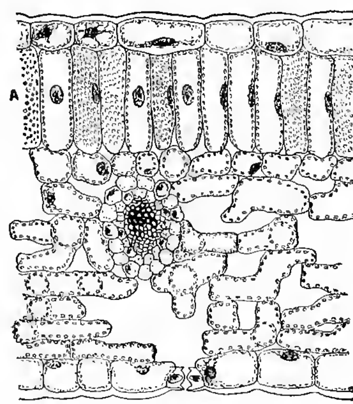

FIG. 14.

FIG. 13.—Plant cells, as seen under a high-power microscope, showing strands of protoplasm, nucleus, nucleolus, etc. A, B, young cells; C, an older cell, from the developing maize root; D, cell from the hair of Tradescantia; E, parenchymatous cell from the cortex of Ranunculus. (From Sir F. Darwin's *Elements of Botany*, Cambridge University Press.)

FIG. 14.—Transverse section through a leaf (of hellebore), showing tissues and cells. From above downwards are seen the upper epidermis, the palisade cells, the spongy tissue (in which a vascular bundle is seen), the lower epidermis (in which is shown a single stoma opening into a large intercellular space). Note that the chloroplasts are arranged along the cell walls, especially in the palisade tissue (A). (From Sir F. Darwin's *Elements of Botany*, Cambridge University Press.)

of the two germ-cells, develops by cell-growth and repeated cell-division (*somatic* division) into a seed.

62. *The Seed.*—The seed consists of an *embryo* plant and a mass of reserve food-material known as endosperm, wrapped in two protective seed-coats, the outer or *testa* and the inner or *tegmen*. In the case of maize and other grasses, the seed is further surrounded by the *pericarp* or envelope of the grain

CHAP. IV. or fruit, which in many kinds of plants encloses more than one seed, but in grasses and some other plants only one. We may therefore define the seed as a miniature living plant and its food-supply, wrapped in a protective envelope. The production of seed is a provision of nature to enable a living plant to remain dormant during a period when climatic conditions, as, for example, an intensely cold winter or a long, dry summer, are unfavourable to its existence as an *active* organism.

63. *The Embryo and Endosperm.*—The embryo (Fig. 15B) is the vital part of a seed; it is a living, though dormant, plant-in-embryo. The embryo comprises all the essential

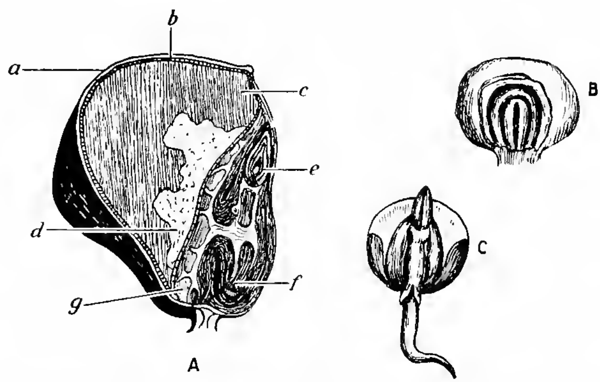

FIG. 15.—Embryo and endosperm of maize. A, Section through maize grain showing relative position of embryo and endosperm. *a*, hull; *b*, aleurone layer; *c*, horny endosperm; *d*, white starchy endosperm; *e*, plumule; *f*, radicle; *g*, scutellum. B, Embryo removed. C, Germinating embryo.

organs of growth, i.e. the *radicle* which develops into the root of the plant; the *cotyledon* or *seed-leaf;* and the *plumule* or young shoot, which develops into stem and leaves. In maize and other grasses the growing embryo absorbs the endosperm through a special organ, the *scutellum* (so named from its shield-like shape), which in maize can readily be seen with a low-power microscope. The embryo of the maize-grain lies to one side of the endosperm (Fig. 15A); as the grain stands on the ear, the embryo is on the upper side of the grain, i.e. facing toward the tip of the ear, its position being indicated by an oval depression in the grain.

The endosperm (Fig. 15*c*) consists of a store of prepared food-material which the growing embryo absorbs for use in the formation of new cells and tissues, in developing a root-system with which to absorb food-materials directly from the soil, and a leaf-system capable of photosynthesis (¶ 65). CHAP. IV.

The seeds of some plants (e.g. the castor-bean and the

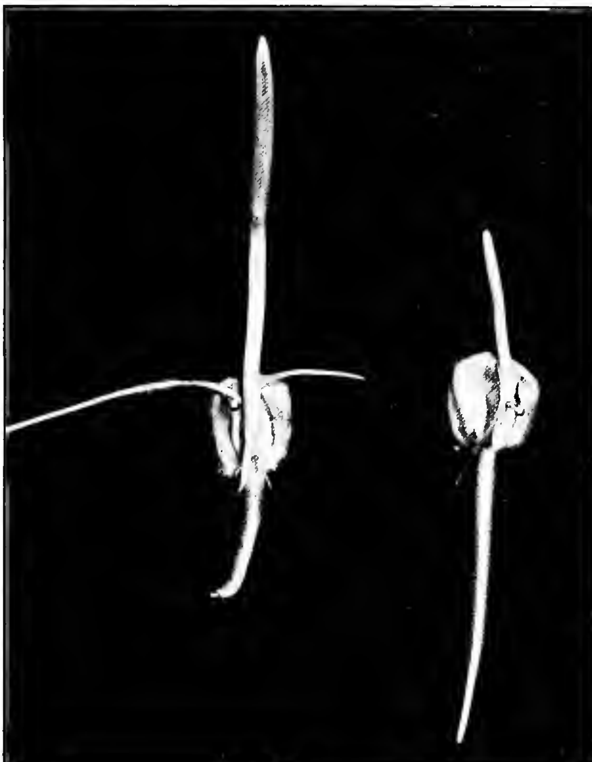

FIG. 16.—Germinating maize grains, showing developing shoot, primary root, root-hairs and adventitious roots. (¶ 66.)

lucerne) contain no endosperm, but store in the cotyledons a supply of food-material for the use of the growing seedling; such seeds are sometimes spoken of as ex-albuminous, in contradistinction to the albuminous or endosperm-bearing seeds.

64. *Germination.*—The commencement of growth in a

CHAP. IV. hitherto dormant seed is known as germination (Figs. 15C and 16). A seed will not germinate until it comes under the influence of favourable conditions, and may lie dormant for many years until such conditions supervene; these conditions vary with different sorts of plants, but all include: (1) moisture; (2) heat; and (3) sufficient air for the growing plantlet to breathe. The seed of the maize plant will retain its vitality for two or even three years; but after the first year there is a marked decrease in vitality, and after two years maize is considered practically useless as seed; this is independent of any question of injury by weevil or grain moth, and may, perhaps, be connected in some way with the presence of a considerable quantity of oil in the embryo; this oil readily turns rancid at high temperatures.

Experiments conducted at the Botanical Experiment Station of the Department of Agriculture, Pretoria, show that it requires from three and a half to eleven days after sowing the maize-seed for the seedling to appear above the ground. The difference in time of germination is largely influenced by the warmth of the soil; but it is evident that temperature is not the sole controlling factor, and that associated with it is the degree of moisture of the soil. Depth of planting also affects germination, deep planting tending to delay it; very shallow planting (i.e. less than 2 inches) has in South Africa a similar effect, perhaps because the surface soil is more rapidly affected by drought. The germinating embryo depends on the endosperm for its supply of food-material until it has developed a root- and leaf-system (¶ 63). In germination the radicle grows downwards or earthwards, and is therefore said to be *geotropic;* the plumule upwards or away from the earth, and it is therefore called *apogeotropic.*

If the seed be turned upside down so that the radicle is forced to commence growth upwards and the plumule to grow downwards, they quickly bend round until they have regained their normal positions; this is shown in Fig. 17.

65. *The Maize Seedling.*—The seedling stage (Fig. 18) of the maize plant is in many respects the most critical in its existence. While it is small it is more seriously affected by the depredations of insect pests (chap. X.), and is more sensitive to fluctuations in the weather conditions. It is obvious that

if it has only one or two leaves, and these are eaten off by a caterpillar, the plant will suffer more than when it has six leaves, some of which will be able to function and repair the damage done while the others are being devoured. If the root-system only penetrates to a depth of 2 or 3 inches, the young plant is more likely to suffer from a temporary drought than if its roots are tapping a supply of soil moisture at a greater depth. It is highly desirable, therefore, that the seedling should be encouraged to get beyond this critical

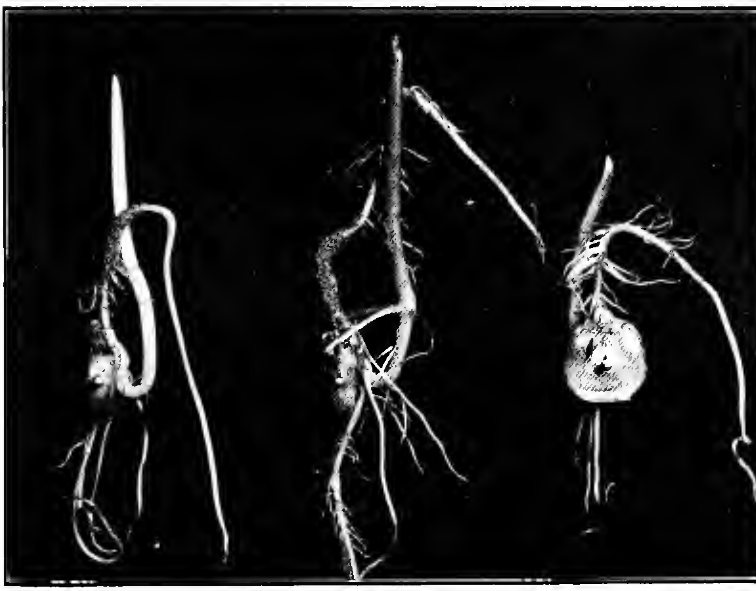

FIG. 17.—Maize-grains planted upside down, showing geotropism of the root and apogeotropism of the shoot.

stage as quickly as possible; this is one important reason for the use of artificial fertilizers in South Africa (chap. VIII.).

After the seedling has developed a root- and leaf-system of its own (Fig. 18), growth is rapid if suitable conditions prevail. Conditions favourable to rapid growth include warmth and moisture of the soil, sunshine, and a suitable tilth of soil to prevent water-logging. At the Geneva (New York, U.S.A.) Experiment Station, growth of the maize plant has been measured and found to range from 3 to 18½ inches per week;

CHAP. IV. a growth of 5 inches has been recorded on one day under specially favourable conditions in Iowa, and in Illinois an increase of growth equal to 1,300 lbs. of dry matter per acre was recorded in a single week.

66. *The Root and Its Functions.*—The root is the part of the plant which grows downward into the soil for the purpose

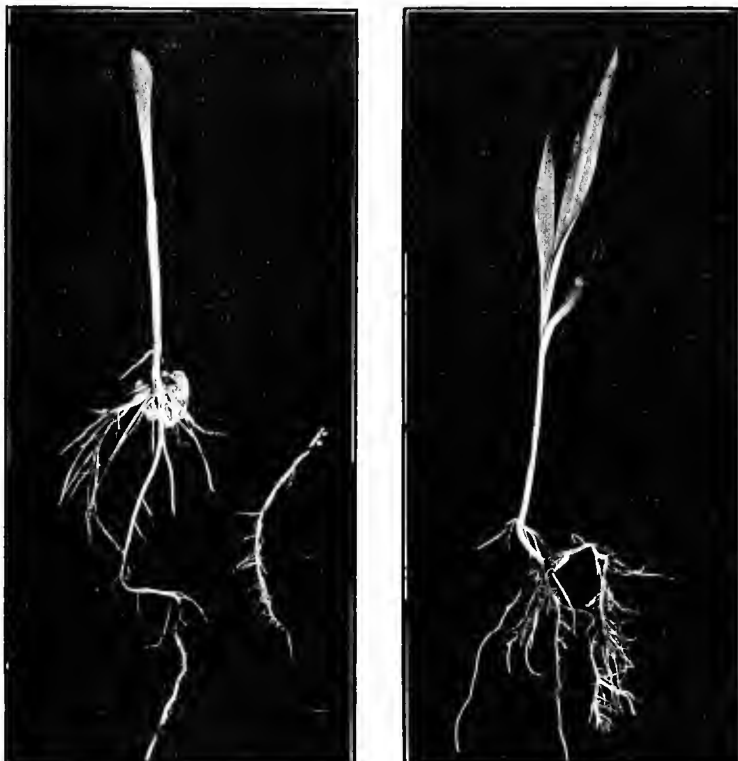

Fig. 18.—Maize seedlings at two stages of growth, the youngest on the left.

of anchorage and absorption of food materials; it does not bear leaves nor reproductive organs. The water held in the soil dissolves the carbonates, nitrates, and other salts which occur in the soil. Dilute solutions of these are drawn in through the minute *root-hairs* (Fig. 16) on the younger roots, and are carried up into the plant, where they are chemically changed into the various compounds on which the plant lives and grows. The plant gets most of the elementary constituents of its food in this way. CHAP. IV.

Maize is a surface-rooting plant. The majority of its permanent roots usually start at about 1 inch below the surface of the soil, regardless of the depth of planting (*Hunt*, 1). The general tendency of the roots is to spread horizontally, near the surface, for 1 or 2 feet all round, and then to turn abruptly downward. As a rule the horizontal roots occur within 4 inches of the surface. Hunt (1) found that in young plants one to six weeks old, by far the largest part of the root-system occurred at a depth of 2 to 4 inches from the surface. He concludes that the distribution of the roots is probably dependent more upon a proper supply of oxygen and water than upon temperature of the soil.

Maize roots have been measured 8 feet in length (not depth). They have been traced to a depth of 4 feet and slightly over, but as a rule most of the root-mass occurs within the first 2 feet of soil. The following measurements have been recorded :—

Height of plant ½ inch, root 8 inches long.
,, ,, 3 inches, root 13 inches long.
,, ,, 5 inches, root 11 to 24 inches long.

The joints (*nodes*) at the lower portion of the stem, above the surface of the soil, are often provided with roots, few or many in number, called *adventitious* or "brace-roots" (Fig. 23), some of which grow downward till they reach the soil, and then appear to assist in anchoring the plant. These adventitious roots are more plentiful in some of the less improved Tropical American breeds (e.g. *Cusco*, *Mexican*, etc.) than in many of the more highly-bred North American sorts. In some breeds they occur at a considerable distance up the stem ; it seems probable that in such cases the plants are accustomed to grow on river banks, subject to floods which carry a deep deposit of river mud, and into which the "brace-roots" may penetrate.

From the above description of the root-system we draw the following conclusions : *First*, that the maize plant being a surface feeder requires that its food supply shall be within a short

CHAP. IV. distance of the surface; *second*, that deep cultivation while the

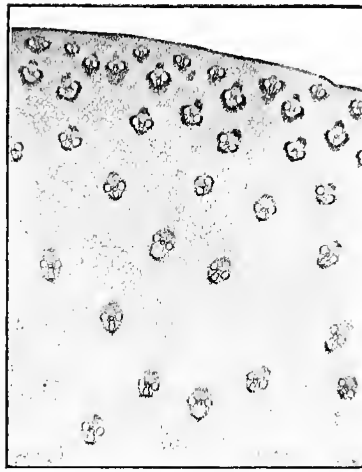

FIG. 19.—Part of a transverse section of a maize stem, showing mass of pith, with scattered vascular bundles, more numerous near the stem-wall. (From Cavers' *Practical Botany*, W. B. Clive.)

plants are growing is likely to prune off the surface-roots and thus reduce the absorptive power of the plant; *third*, that

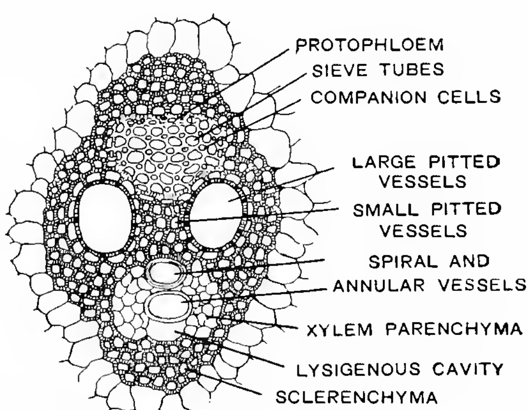

FIG. 20.—Transverse section of vascular bundle of maize. (From Cavers' *Practical Botany*, W. B. Clive.)

surface-rooting weeds interfere with the supply of moisture and plant-food required by the maize crop.

67. *The Stem and Its Functions.*—The stem grows upward and bears the leaves and inflorescences (Fig. 12). It is built up of a series of lengths or *internodes* connected by joints or CHAP. IV.

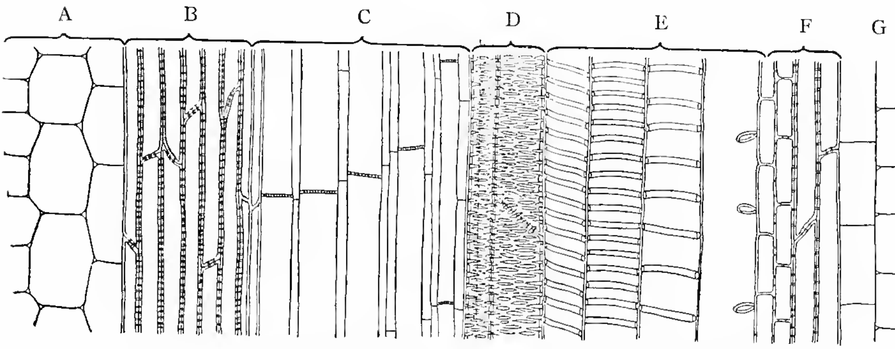

FIG. 21.—Part of a radial longitudinal section of stem of maize, showing one of the vascular bundles. A and G, parenchyma of the ground tissue; B and F, sclerenchyma; C, phloem; D, pitted vessels of the xylem; E, spiral and annular vessels. (From Cavers' *Practical Botany*, W. B. Clive.)

nodes. In many grasses it is hollow, but in the maize plant it is filled with *pith*, which consists largely of cellulose. The hard outer portion or stem-wall contains numbers of fibres called *vascular bundles* (Fig. 19), through the woody part

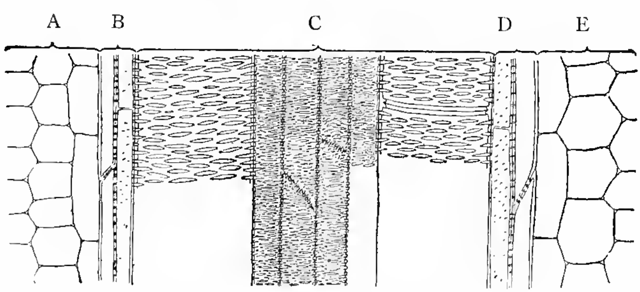

FIG. 22.—Part of a tangential longitudinal section of stem of maize, showing one of the vascular bundles. A and E, parenchyma (ground tissue); B and D, sclerenchyma; C, xylem—note the large pitted vessel on either side, and the small pitted vessels in the middle. (From Cavers' *Practical Botany*, W. B. Clive.)

(*xylem*) of which the solution of water and food-material absorbed by the roots travels upward to the leaves. As in other grasses the stem-wall is well supplied with silica, which aids

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in maintaining it in an erect position. Because they differ from the stems of other families of plants, the stems of grasses are usually spoken of as *culms*.

The stem or culm of the maize plant is extremely variable in height, ranging from 1½ to 30 feet in different breeds and in different climates; the usual range in South Africa is from about 5 to 14 feet. At the Botanical Experiment Station, Pretoria, in 1907-8, the maximum height[1] was 6 feet 6 inches (2 plants), and the minimum 3 feet, while the average of 313 plants was 5 feet 4 inches. The circumference of an average stem ranges from about 3 to 4½ inches between the first and second nodes, in a dent or flint maize.

The internodes are channelled on alternate sides, next the leaf blade, and on the side where the branch or ear may occur.

The histology of the maize stem has been studied by Dr. Cavers (1), whose illustrations of the tissues are reproduced here (Figs. 19 to 22), by kind permission. Figs. 19 and 20 show transverse sections through one of the lower internodes, and 21 and 22 longitudinal sections.

The function of the stem is to carry food materials from the roots to the leaves, and then to other parts of the plant, and to raise the leaves and inflorescences into the air and light, to facilitate photosynthesis (¶ 69) and pollination (¶ 73).

68. *Sucker-shoots.*—The maize plant often produces sucker-shoots (Fig. 23), especially when planted thinly; these are branches which arise from the lower nodes near or below the surface of the soil. Some breeds have a much greater tendency to sucker than others; the tendency appears to be specially strong in cross-bred plants. These suckers often produce tassels bearing both male and female flowers (Fig. 24), which sometimes develop small, round grains. As a rule suckers do not bear proper ears; they are, therefore, undesirable in crops grown for grain, because they take food and moisture from the soil and give no return except the fodder. Some breeds bear several branches from nodes higher up the stem, but as a rule the stems are unbranched except for the suckers and the shanks of the ears, for the shanks are in reality only short branches.

[1] Of a cross between *Iowa Silver-mine* and *Wisconsin* white dent.

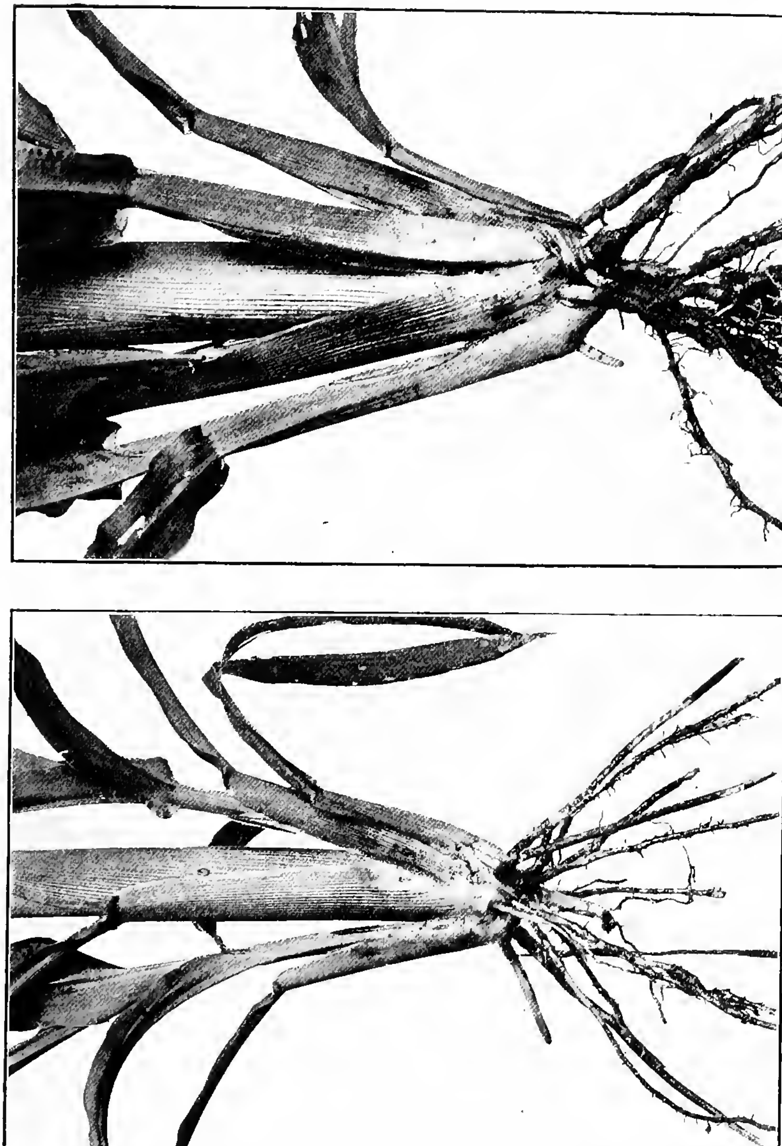

Fig. 23.—Base of young maize plant, showing adventitious roots and sucker-shoots.

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69. *The Leaf and Its Functions.*—The leaves are borne on the stem around which the sheath (Figs. 12C and 25), or lower portion of the leaf, is closely wrapped; the broad upper portion which spreads away from the stem is called the *blade* (Figs. 12B and 26C). At the junction of sheath and blade there is a projection which clasps the stem, and which is called the *ligule* (Figs. 25 and 26). To a certain extent the ligule of the maize plant checks the entrance of water and soil, which might start decay between the sheath and the stem.

FIG. 24.—Tassels of sucker-shoots, bearing small round grains as well as the normal male spikelets.

The leaf blade of the maize plant is long, broad, and flat, with wavy margins; the mid-rib is broad and strong (Fig. 5). The surface is usually more or less rough with scattered, adpressed white hairs (Fig. 25), which may be short or longer. The cuticle is found by Wager (1) to form a thin layer on both surfaces, with practically no difference in thickness in the different breeds.

In the dent variety of maize the number of leaves on a stem usually varies from 12 to 18, but as the lower leaves die off before maturity, it may happen that only about 12 function

at one time; 15 is usually considered a desirable number. CHAP. IV.
The average number for 313 plants[1] at the Botanical Experiment Station, Pretoria, in 1907-8 was 10·3, the maximum being 14 (on 3 plants only) and the minimum 6 (on 2 plants only). Leaf measurements were made of these 313 plants, the sixth from the base was selected as the most fully de-

FIG. 25.—Leaf sheath and base of blade, showing ligules, and hairs on blade.

veloped; the maximum width was 5·25 inches, the minimum 2·5 inches, and the average 3·8 inches.

The total external leaf-surface of a single maize plant has been measured, at the Missouri State Experiment Station, and found to equal 24 square feet. An acre often carries over

[1] Of a cross between *Iowa Silver-mine* and *Wisconsin* white dent.

CHAP. IV. 8,500 maize plants, which, with 24 feet of leaf-surface each, would yield a total of 204,000 square feet, or 4·68 times the area of the soil covered by the crop.

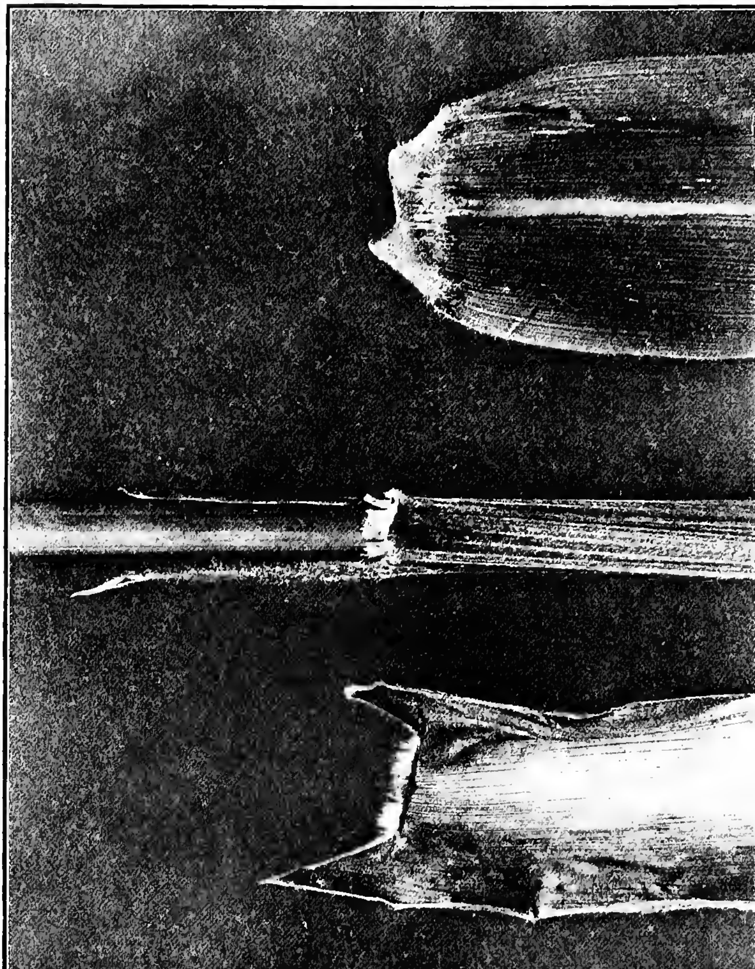

FIG. 26.—Leaf sheath. A, Sheath wrapped round stem, showing unusually long auricles. B, A sheath removed and opened, showing shorter auricles, with ligule between them. C, Blade removed, showing ligule at base (stem end).

The following method of measuring the leaf-surface of maize has been recommended by some of the Agricultural Experiment Stations in the United States:—

Select an average-sized leaf.

Take the width at 3 inches from the ligule.

Take the width at 6 inches from the tip of the leaf. CHAP. IV.
Take the average of these two measurements and multiply by the length of leaf between the two points of measurement.
Add the area of the isosceles triangle formed by the 6 inches left at the tip.
Multiply by 2 for the two surfaces.
Multiply by the number of leaves on the plant.

The leaves absorb air into their tissues through microscopic openings called *stomata* (Figs. 14 and 27). At the suggestion of the writer, Mr. H. A. Wager (1), of the Transvaal University College, Pretoria, kindly undertook to determine the number of stomata on the maize leaf. He found that on the under surface they varied from 75 to 126 per square millimetre, and on the upper surface from 60 to 97. Carbon-dioxide (CO_2) is one of the gases of which the air is composed, and consists of the two chemical elements *carbon* and *oxygen*. When the air comes in contact with the chloroplasts (¶ 61) in the leaf-cells, in the presence of light and moderate warmth, the carbon-dioxide is decomposed, and some of the oxygen is given off into the air. The carbon is retained, and, combining with the water and chemical substances obtained from the soil through the roots, various complex organic compounds are formed. This chemical action takes place chiefly during the day-time, and only in the presence of light, and is therefore called *photosynthesis*. The new compounds are used in the building up of tissues required for the increasing growth of the plant.

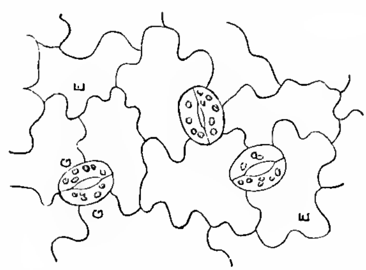

FIG. 27.—Three stomata with surrounding epidermic cells (E). G, G, guard cells of a stoma. From Sir F. Darwin's *Elements of Botany* (Cambridge University Press).

All of that enormous quantity of starch required to fill out the endosperm of the maize grain must first be chemically formed in the leaf before it is carried to the grain on the ear, where it is finally deposited. The importance of the leaf in the life-history of the plant is thus evident; *it is a chemical laboratory in which the various elements of plant-food are separated out from the compounds in which they originally occur, and are re-united into such forms as can be made use of by the plant.*

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Maize plants poor in leaf-surface, through lack of food or water, or from insect-injury, damage by hail, or undue shortness of growing season, cannot manufacture and store as much starch, and therefore fail to develop as much weight of grain as those with a proper proportion of leaf. It does not necessarily follow, however, that the larger the leaf-surface the

FIG. 28.—Tassel of *Odessa* maize.

greater the amount of seed produced. *Beyond a certain point* (which perhaps varies in different varieties or breeds), the amount of seed produced appears to decrease in inverse ratio to the increase in leaf-surface.

After the food-materials are used up, the surplus water in which they were dissolved and carried is *transpired* or given off from the leaf-surface, and is replaced by a fresh supply drawn up from the roots. Frank (1) notes that a single maize plant can pass off into the atmosphere 31 lbs. weight of water in 147 days of growth. This is less than the amount lost by some other plants, e.g. :— CHAP IV.

The maize plant can lose	31 lbs.	in 147 days.
The hemp ,,	60 ,,	in 140 ,,
The sunflower ,,	147 ,,	in 140 ,,

The rate of transpiration is greater in light than in darkness. In the maize plant it has been found to vary in the following ratio :—

In darkness . .	97
In diffused light .	114
In direct sunshine	785

There is thus a stream of water constantly passing away from the soil into the air, through the leaves of the plant; it soon drains the soil dry unless replaced by rain or irrigation. It has been found that 500 tons of water (containing salts in solution) is required to form one ton of dry matter (*Bowman* and *Crossley*, 1).

The leaves are arranged *distichously*, i.e. in two opposite rows, but there is no uniformity as to the direction in which the rows point.

FIG. 29.—Young ear showing silks ready for first pollination; the husks have developed leaf blades, showing the homology of husk and leaf sheath.

70. *The Inflorescence.*—The maize plant is *monœcious*, i.e. it bears the reproductive organs in separate flowers on the same plant (Fig. 12). The *staminate* or *male*

CHAP. IV. flowers are usually borne by themselves in the terminal inflorescence called the tassel (Fig. 28). The *pistillate* or *female* flowers are usually borne on one or more lateral inflorescences (Fig. 12D) called *ears*, at the ends of short branches arising from the nodes of the stem; the young ear is characterized by its long beard-like styles called *silks* (Figs. 29, 30, 31, and 32). Monœcism is not always complete, i.e. the separation of male and female flowers into different inflorescences on different

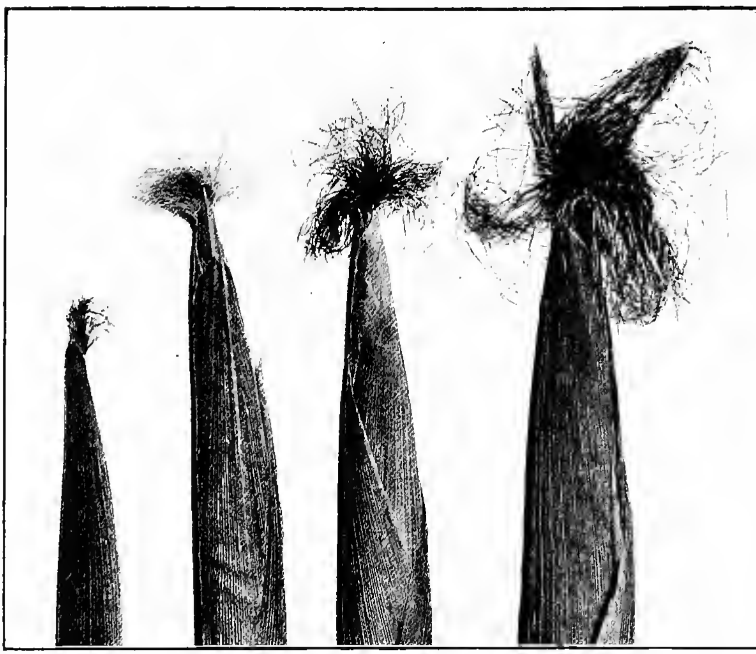

FIG. 30.—Young ears showing silks at different stages of development.

parts of the same plant is not constant; bisexual tassels are frequently met with on sucker-shoots (in the dent breeds at least) (Figs. 33 and 34); in some cases also, the tassel of the main stem bears the two kinds of flowers (Fig. 35); this is said to be especially the case in pod maize, a breed rarely seen in South Africa. Bisexual ears are occasionally, though rarely, met with (Figs. 36 and 37). Where mixed inflorescences occur, stamens and pistils may be found in the same spikelet, and the writer has even found hermaphrodite florets (i.e. with stamens and pistils in the same floret), but in those cases one or other organ was abortive. CHAP. IV.

Monœcism in maize facilitates *cross-pollination* and *hybridization*, though the only other species with which maize can hybridize, as far as we are aware, is the Mexican Teosinte,

FIG. 31.—Young ear with fully developed silk.

Euchlæna mexicana (Fig. 10), of which hybrids have been obtained by Harshberger.

71. *Barren Plants.*—One of the causes of low yield of grain is the occurrence of barren plants, i.e. plants which though bearing tassels produce no ears, or ears without grain. Cases are reported from America of 60 per cent of barren

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stems in a crop of maize. This subject has been much discussed by maize breeders, but it is still a moot point whether the tendency to produce barren stems is an inherited character. Some writers, e.g. Hunt (1), maintain that "if it were an hereditary characteristic the fact that the stalks are barren would tend to eliminate them". If barren stems were *abso-*

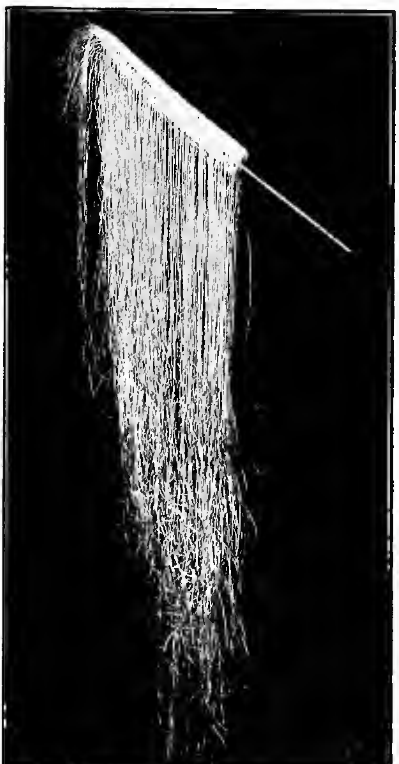

FIG. 32.—Young ear with husks removed to show silks. Note that the silks at the tip of the ear are not yet fully grown.

FIG. 33.—Bisexual tassel of a sucker-shoot.

lutely barren, in the strict sense of the word, this would be true, but the fact that they produce tassels and pollen lends colour to the view that they may tend to reproduce their kind.

The percentage of barren stems on a given soil is said

FIG. 35.—Bisexual tassel on main stem. B, Branch of same. enlarged.

FIG. 34.—Bisexual tassel (bearing small ears) of sucker-shoot.

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(*Hunt*, 1) to vary with the thickness of planting and the season, and barrenness does not seem to be a variety characteristic, but rather the result of environment. The subject needs further investigation as a possible cause of low yields in South Africa.

Sometimes the maize plant bears *ears* which are barren

FIG. 36.—Bisexual ear.

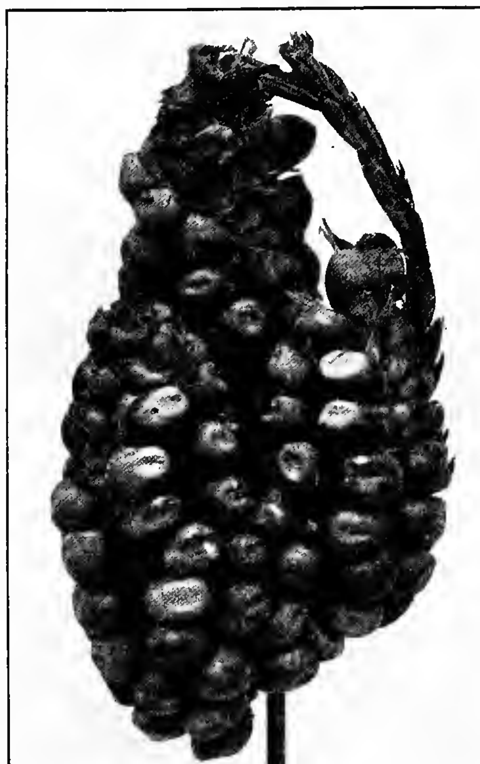

FIG. 37.—Bisexual ear.

owing either to the destruction of the silk by the larvæ of certain moths (Fig. 38) or to failure to produce silks even when the ovules are developed (Fig. 39).

72. *Flowering Period.*—Considerable difference is noticeable in the time taken by different breeds to reach the flowering stage; it usually requires nine to twelve weeks. This is

an important point for the farmer. A breed which *ripens off* too quickly *after* flowering will not have time to form and store enough starch to produce a heavy crop of grain; but if the shortening of the time of growth takes place between germination and flowering, it may, perhaps, not have such an effect on the yield. The shortest period between germination and flowering noted by the writer has been sixty-four days. Variation in this respect may be due in part to difference in CHAP. IV.

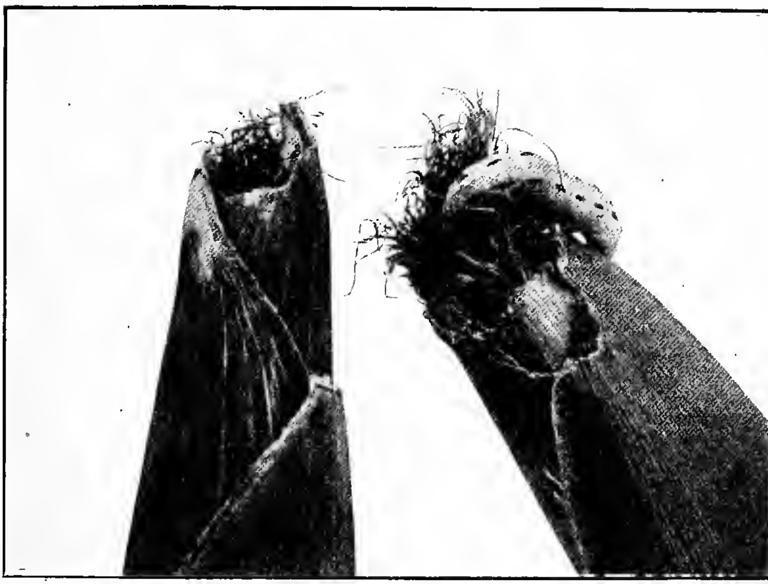

FIG. 38.—Silks injured by larvae.

amount and time of rainfall. If the grain is planted early in the season germination and growth are retarded because the temperature of the soil is not sufficiently high. In South Africa, drought in December and January sometimes checks vegetative growth and hastens flowering. But soil-moisture and temperature will not account for all of the differences noticed.

Within the same breed the flowering period of individuals varies greatly; the extremes noticed are fourteen and twenty-

CHAP. IV. one days. This is partly due to variation in the character or composition of the soil within a few feet of surface area; partly, perhaps, to variation in vigour between the individual plants; and perhaps largely to the occurrence of different

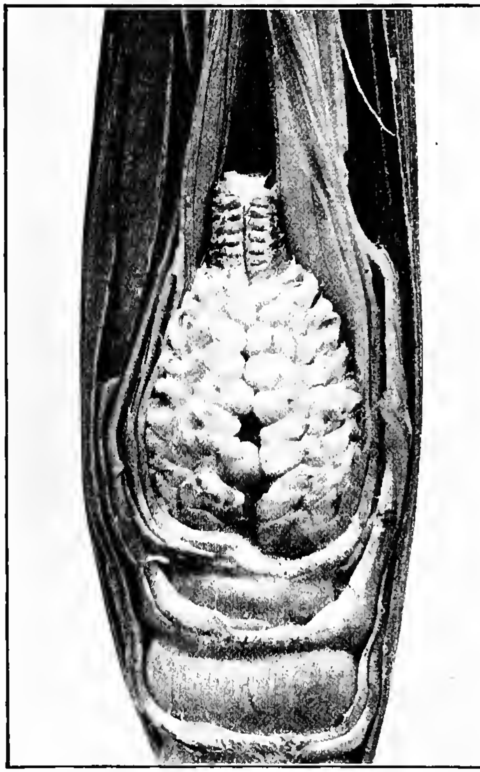

FIG. 39.—Blind ear, on which the silks have failed to develop.

strains in an ordinary commercial breed; a well-bred strain may be expected to show greater uniformity in time of flowering. Yet there seems to be a definite relation between the time of flowering and the time of ripening.

TABLE XVI.

VARIATION IN TIME OF FLOWERING.

Breed.	Date Sown.	First Flowers.		Last Flowers.	
		Appeared.	Days.	Appeared.	Days Later.
Arcadia Sugar	20 Aug., 1910	9 Nov.	81	Dec. 2[1]	23
Louisiana	27 Sept., 1910	8 Dec.	73	Dec. 25	17
Black Sugar	,,	30 Nov.	64		
Hickory King	15 Oct., 1910	30 Dec.	77		
Yellow Dent	,,	27 Dec.	74		
King of the Earliest[2]	9 Dec., 1907	11 Feb.	64		
White-cap Dent[2]	,,	,,	64		
Yellow Hogan[2]	,,	,,	64		
Wealth of Nations[2]	,,	12 Feb.	65		
Hawkesbury Champion[2]	,,	,,	65		
Hundred-day Bristol[2]	,,	14 Feb.	67		
Skinner's Court 10	3 Oct., 1907	17 Dec.	75		

[1] Ears were ready for boiling on 11 December, and these were not from the earliest-flowering plants.

[2] Grown without irrigation; *Skinner's Court* 10 was irrigated.

An investigation conducted at the Botanical Experiment Station, Pretoria, in which careful records were obtained from thirty-eight different breeds or strains of maize (see Table XVII), resulted as follows:—

Aggregate time taken from appearance above ground to period of flowering . . . . 2,125 days.
Aggregate time taken from date of appearance above ground to ripening of seed . . . . . . 4,256 days.

From the figures in Table XVII we conclude that the period of flowering occurs, roughly speaking, half-way between the first appearance of the plant above ground and the ripening of the seed. Hence a farmer should be able to foretell approximately the date at which he may reasonably expect his seed to be ripe and safe from frost. It is possible, however, that results obtained in one district may not be repeated in another, and it is therefore desirable to obtain records of the results obtained by farmers in different parts of the country.

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TABLE XVII.

CORRELATION OF FLOWERING AND RIPENING PERIOD.

Breed.	Days after Sowing.		Corrected for Date of Appearance above the Ground.	
	Flowering.	Ripening.	Flowering.	Ripening.
Brewer Yellow Dent	61	112	53	104
" "	63	115	57	109
Cuban Giant	61	110	53	102
"	61	115	54	108
Snowflake	60	110	52	102
"	58	109	52	103
King Philip (flint)	67	108	59	100
" "	59	113	54	108
Queen of the Prairie	61	110	53	102
" "	59	113	53	107
Early Mastodon	63	122	54	113
"	62	125	57	120
Sanford	60	113	52	105
"	59	115	53	109
Compton Early	59	108	51	100
"	59	113	53	107
Improved Early Canada	56	105	50	99
Wills Gehu (flint)	54	87	49	82
Wills Dakota (flint)	54	87	49	82
Champion White Pearl	67	117	59	109
King of the Earliest	66	115	58	107
" "	58	113	52	107
Yellow Horsetooth	72	128	63	119
Chester County	67	128	60	121
"	58	115	53	110
Eureka	65	128	59	122
New England 8-row	67	128	60	121
Yellow Botman	65	125	60	120
Hickory King	66	128	60	122
Boone County	65	128	60	123
"	64	128	59	123
Pride of the North	58	113	52	107
Sheepstooth	67	128	61	122
Thoroughbred w.f.	62	125	57	120
Wisconsin w.d.	62	128	57	123
Golden Dent	65	128	59	122
Iowa Silver-mine	65	128	59	122
White Flint	67	128	61	122
White Cap y.d.	59	115	53	109
Tuscarora	59	113	53	107
Red Cob Fodder	75	131	...	...
	2,555	4,808	2,223	4,420
Deduct Wills Gehu and Wills Dakota	108	174	98	164
	2,447	4,634	2,125	4,256

The only exceptions are the two earliest flint breeds, and here the figures would seem to indicate that earliness is produced by the hastening of the period between flowering and ripening. CHAP. IV.

73. *The Spikelet.* — The tassel consists of numerous branches (Fig. 40) bearing more or less *distichous* rows of staminate *spikelets* (Fig. 40A) which are arranged in pairs, one *pedicellate* (stalked), the other *sessile* (without a stalk). Each spikelet consists of a pair of protective, sheath-like bracts, called *glumes* or "empty glumes" (Fig. 41*d*), which enclose two florets. Each floret consists of a pair of thin bracts, the lower or outer of which is called the *valve* (called also "flowering glume" by some botanists), and the upper or inner the *palea*.

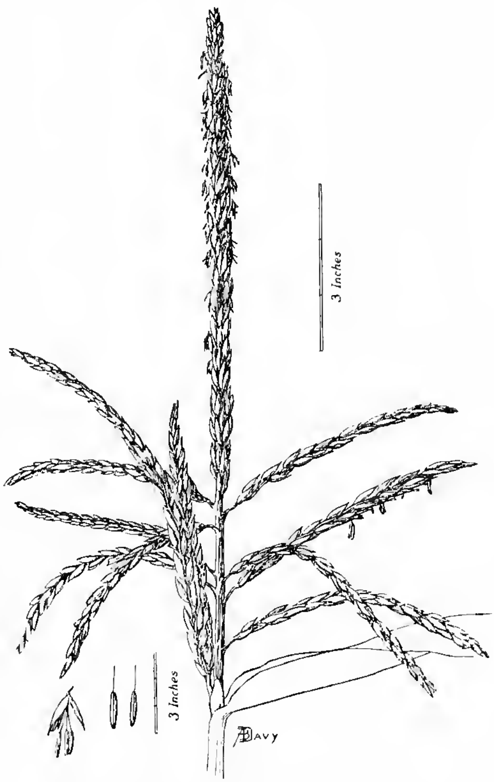


Fig. 40.—Tassel of sugar maize, with male spikelet and stamens enlarged

Enclosed within the valve and palea of each floret, when in bud, are three *stamens* (Figs. 40 and 41); there are thus six stamens to each spikelet. When the flowers open, the stamens are *exserted* (pushed out). Each stamen is composed of a long and narrow *anther* hanging freely at the end of a fine, slender thread, the *filament*. Each anther consists of two sacs, attached side by side, and having an opening, a *pore*, at the lower end, for the emission of the minute, dust-like,

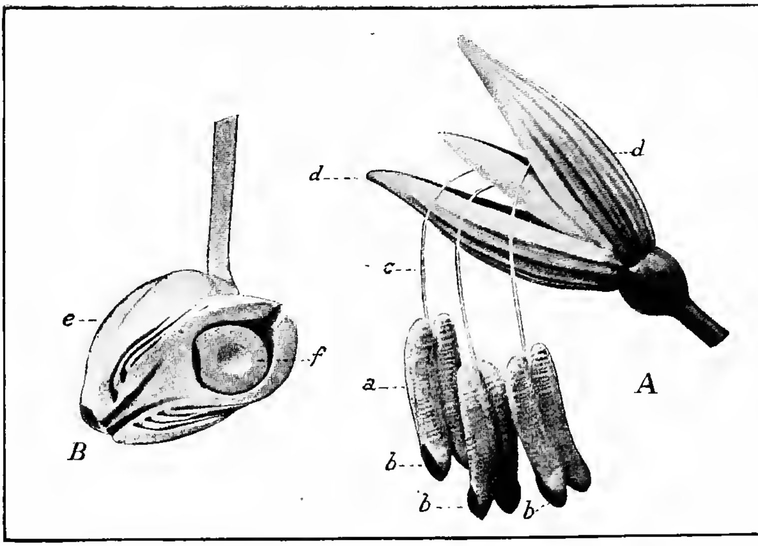
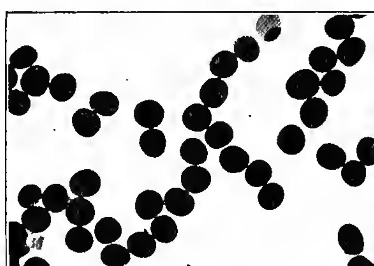


FIG. 41.—Spikelets of the maize plant (much enlarged). A, male spikelet. B, female spikelet. *a*, anther; *b*, pore; *c*, filament; *d* and *e*, glumes; *f*, ovule. (After De Vries, from models by Brendel, Berlin.)



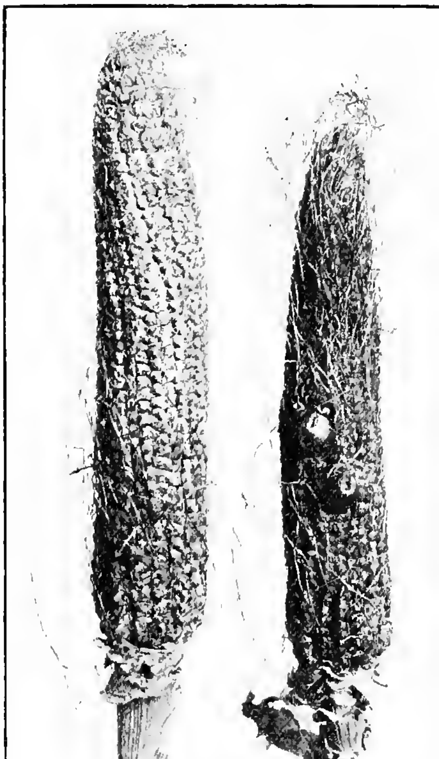
A

B

C

FIG. 42.—Pollen grains of maize (much enlarged). A, normal shape of living grains; B, shrunken, "dead" grains; C, dead grains moistened and allowed to dry again.

yellowish *pollen* (Fig. 42), which is the medium of sexual reproduction. At the base of the anthers are minute organs, called *lodicules*, which at the time of flowering become turgid and press open the valve and palea, allowing the stamens to protrude and scatter their pollen. CHAP. IV.



A B

FIG. 43.—Effect of complete or partial lack of pollination. A, Barren ear due to protection from access of pollen. B, Two ovules were fertilized, probably by pollen which caught on the husks before the bag was placed on the ear.

Both glumes and anthers vary in colour from pale green, through cream, salmon, etc., to deep magenta. Often the glumes are striped longitudinally with magenta or pink.

74. *The Pollen and Its Vitality*.—Pollen is the fine cream-coloured or golden dust which may be seen flying in clouds from the tassels when they are shaken on a still morning. It

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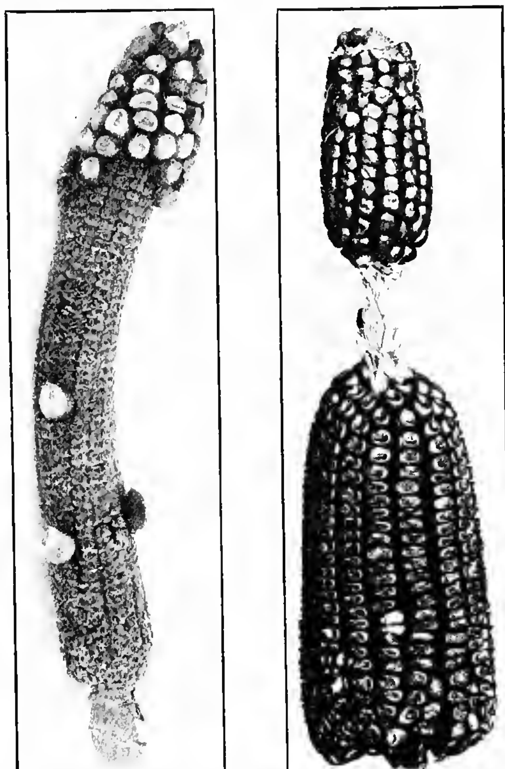
has a peculiar, heavy, sweet, lasting odour. Pollen is essential to the fertilization of the pistillate flowers and consequently to the development of the grain; without it no grain can be formed. This may easily be demonstrated by tying a clean paper bag tightly over a maize ear, before the silks develop,



A B

FIG. 44.—Effect of partial pollination. A, Pollen was applied artificially after most of the silks had ceased to be receptive. B, Imperfect pollination, possibly due to temporary injury to silks by insects.

and leaving it so covered until after the silks have dried up (Figs. 43 and 44).

Pollen "dust" is composed of an enormous number of roundish grains (Fig. 42). Each individual grain is a separate cell, consisting of a cell-wall of usually two layers or coats, surrounding a mass of protoplasm; within the cell are two smaller bodies called *nuclei*, one being known as the *vegetative nucleus* and the other as the *generative nucleus*. CHAP. IV.

The writer has counted 636 spikelets on a tassel of sugar maize, containing in all 3,816 stamens, while the more robust "field corns" (i.e. dent and flint varieties) may carry about 7,200 stamens. The pollen grains produced in one anther

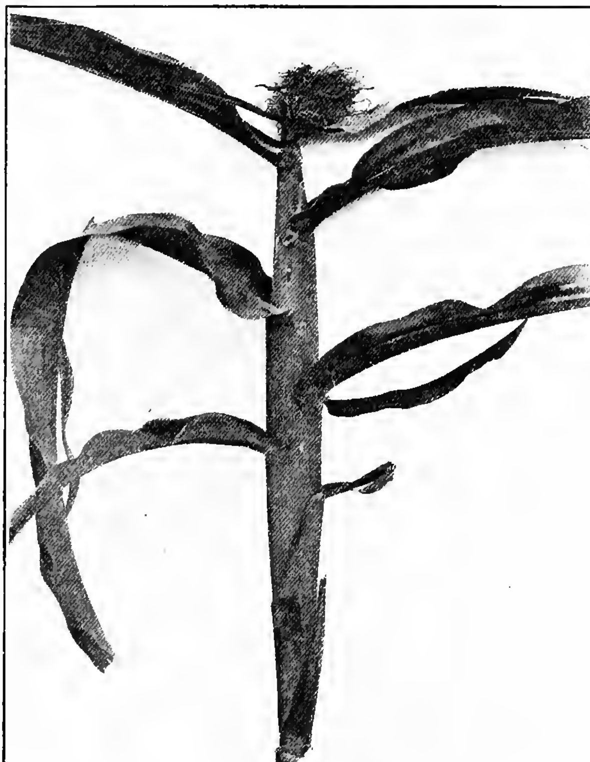


FIG. 45.—Young ear showing homology of husks.

have been counted and found to average about 2,500 each. At this proportion the tassel of sugar maize referred to would contain 9,500,000 grains of pollen. It has been estimated that a tassel of field maize will produce 18,000,000 grains, and especially vigorous plants from 30,000,000 to 60,000,000.

An average ear of sugar maize produces from 250 to 350 grains of corn; *Hickory King* about 400; some of the more

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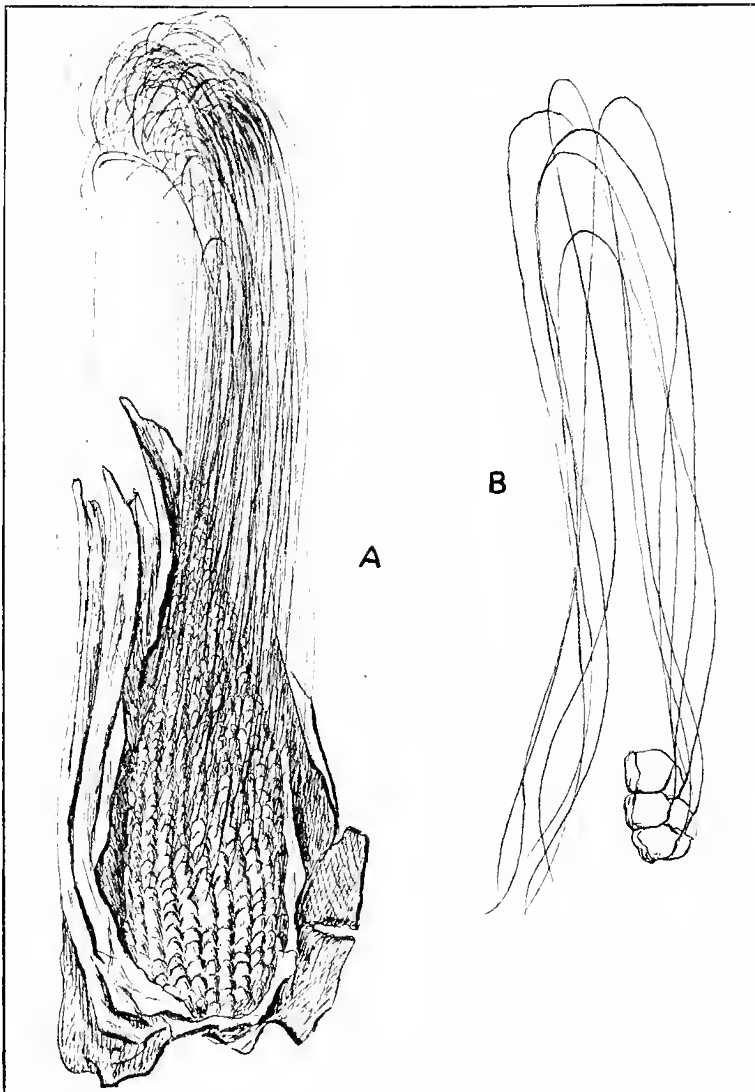

Fig. 46.—A, Young ear showing ovaries and styles ("silks"). B, Ovaries and silks enlarged.

productive breeds from 1,100 to 2,800. Allowing for a production of 1,000 ovules (¶ 75) requiring pollination, and a minimum of 6,000,000 grains of pollen available, we have 6,000 grains of pollen for every grain of corn. As only one is actually required, there is abundance to spare for the bees and chafers, and for waste. The amount of waste must be enormous, yet we often find large numbers of ears incompletely CHAP. IV.

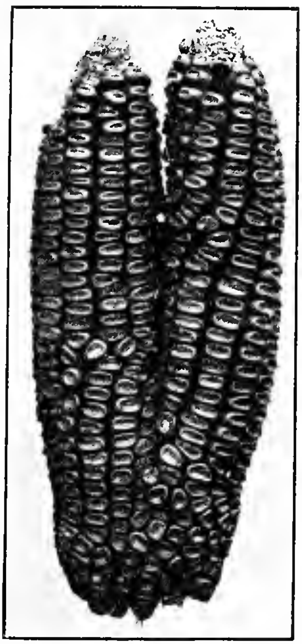

FIG. 47.—Two-lobed ear.

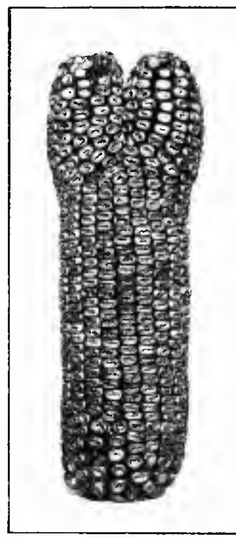

FIG. 48.—Bifid ear.

fertilized, probably through having been receptive at a time when little pollen was available in their vicinity.

Maize pollen retains its vitality for seven or eight days in the Eastern United States ; in the dry climate of South Africa it keeps well for three days, but after five days most of it is no longer viable.

75. *The Young Ear.*—The ear is situate at the end of a much shortened branch, which develops leaf sheaths forming the *husk* of the ear (Fig. 45). It is composed of a more or

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less cylindrical or tapering core, the *cob*, bearing from 4 to 48 rows of immature grains or *carpels* (Fig. 46).

Though the maize ear has a solid core, it is in reality made up of two or more connate, two-rowed *spikes* which have grown together, or failed to separate, during their early de-

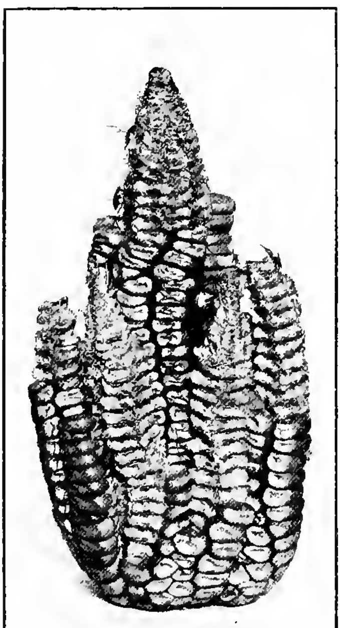

FIG. 49.—Branched ear of *Hickory King*.

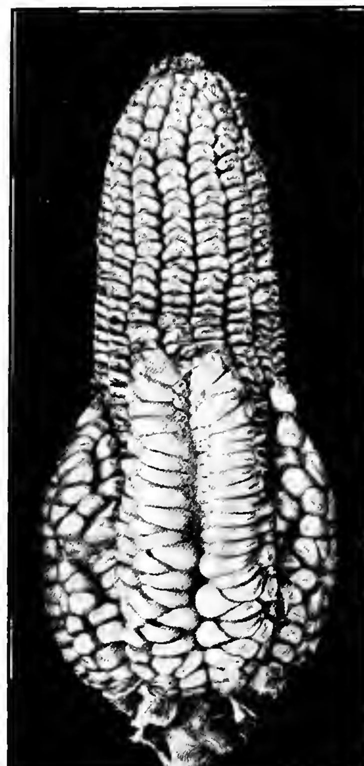

FIG. 50.—Branched ear of *Ladysmith*.

velopment. Each spike bears at the nodes two two-flowered spikelets, as on the tassel, but the lower floret of each spikelet is abortive, leaving only a pair of carpels to develop at each node; this accounts for the uniformity in the development of rows of grain in pairs. Lobed and branched ears are frequently met with (Figs. 47, 48, 49, and 50).

The carpel consists of a roundish body called the *ovary*, and a long, slender, soft thread called the *style* or "silk" (Fig. 46). Each ovary contains a minute egg, called the *ovule*, which, on fertilization by the nucleus of the pollen-grain, develops into a *seed*. CHAP. IV.

The cob does not complete its growth lengthwise before the first silks are ready for pollination. If the growth of the plant is checked through lack of sufficient moisture or plant-food, or inclemency of the season, the tip of the ear fails to grow out, and the cob, instead of being almost cylindrical, may remain tapering in shape through lack of development.

In "pod maize" (variety *tunicata*) the glumes are large, completely enclosing the ovary and persisting around the ripe grain (Fig. 51). In the varieties usually under cultivation, however, the glumes, valve, and palea (¶ 73) of the female flower cease to function, and are reduced to small rudiments around the base of the carpel.

The position of the ear on the stem varies greatly in individual plants according to the particular node from which the shank (¶ 81) is developed, and according to the length of the several internodes below it. Some positions are more desirable than others (see chap. V.).

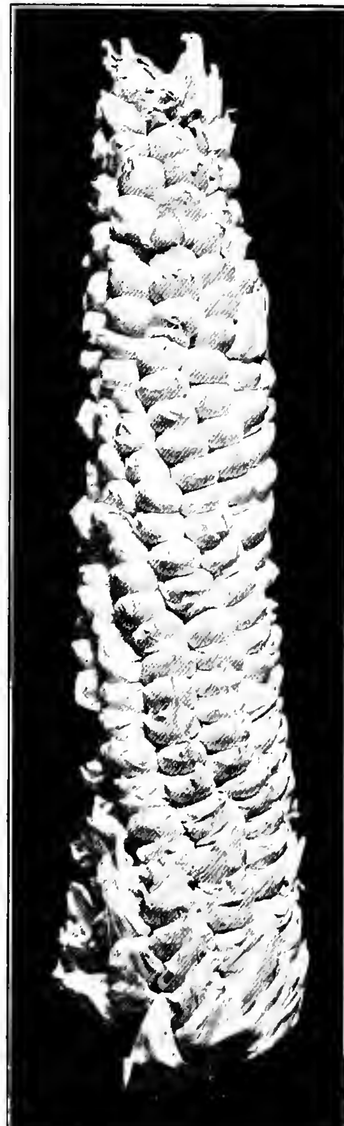

Fig. 51.—Pod maize (*Zea Mays* var. *tunicata*).

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76. *The Silk.*—The style or "silk" is a long, terete, hollow tube, bifid at the end (Fig. 52A) and it contains a viscous substance. When receptive, the silk is exserted from the apex of the ear to receive the pollen, and may then become 6 to 12 or more inches in length. After pollination the silk dries up, but persists. If pollination is prevented or is incomplete, the silk continues to grow to an unusual length, and remains green much longer than otherwise. Under a lens the silk is seen to be covered with short, branched hairs, on which the pollen grains are caught.

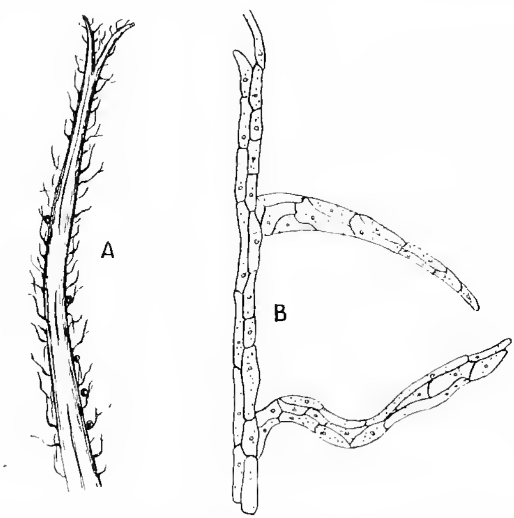

FIG. 52.—The style or silk (much magnified). A, Showing bifid end, and pollen grains caught among the hairs. B, Hairs magnified, showing cells and nuclei.

The silks do not all mature at the same time; those at the base of the ear develop first (Fig. 32); then those from a little higher up, and finally those from the tip. It takes about a week for all the silks on an ear to mature (Figs. 30 and 31). This progressive development appears to be one of nature's ways of ensuring the pollination of at least some of the ovules. It sometimes happens that there is not sufficient pollen available at the appearance of the earliest or latest silks, which results in the production of incompletely filled ears or "nubbins"; but such a shortage of pollen is not likely to occur throughout the whole period of development of the silks.

If the silk be injured, the proper fertilization of the ovule may be prevented, with consequent reduction in yield of seed.

77. *Pollination.*—Unless a pollen-grain reaches the style no seed will be formed (Fig. 43). The maize plant is *anemophilous*, i.e. wind-pollinated. The pollen is very light and is carried for long distances by the wind; there is thus danger of cross-pollination if two sorts of maize are planted near to each other—400 yards is considered a safe distance though some writers recommend half a mile. Because it is so light, and easily carried by a breath of air, very little pollen usually reaches the silks of the same plant which produces it; it is carried by the least puff of wind to the plants beyond. The writer has observed cases in which the pollen fell directly on to the silks below, on a very still evening; but such cases appear to be rare in nature; and as a rule the arrangement of the leaves is such that they partially protect the silks from such a contingency.

The maize tassel is much visited by bees, which collect the heavy-scented pollen for food for their young larvae. But the bees do not visit the silks, and are not, therefore, direct agents in pollination, and the amount of pollen produced is so great that the little taken by the bees is not likely to have any effect on the crop of grain. In South Africa at least three sorts of beetle also visit the tassels, to feed on the pollen (see chap. X.), without affecting the yield.

An experiment was conducted at the Botanical Experiment Station, Pretoria, to determine the receptivity of silks to pollen at different stages of development, with the following result: Application of pollen on the first day of appearance of the silk resulted in the fertilization of only 14 ovules, situate toward the base of the ear. Of the ear pollinated the second day, about half of the ovules were fertilized, the upper part of the ear being bare of grains. The ear pollinated on the third day was three-fourths covered with grain, the extreme butt and the tip having no grains. From this we conclude that if pollen is not available by the third day, the earliest silks to develop may not be fertilized.

78. *Fertilization.*—When a pollen grain is caught among

CHAP. IV. the stigmatic hairs of the silk or *style*, it begins to grow. The pollen grain takes up moisture from the stigma and begins to swell; a tube, called the *pollen tube*, pushes out from one side of the pollen grain, penetrates the silk, and grows down its whole length till it reaches the ovary at the base (Fig. 53).

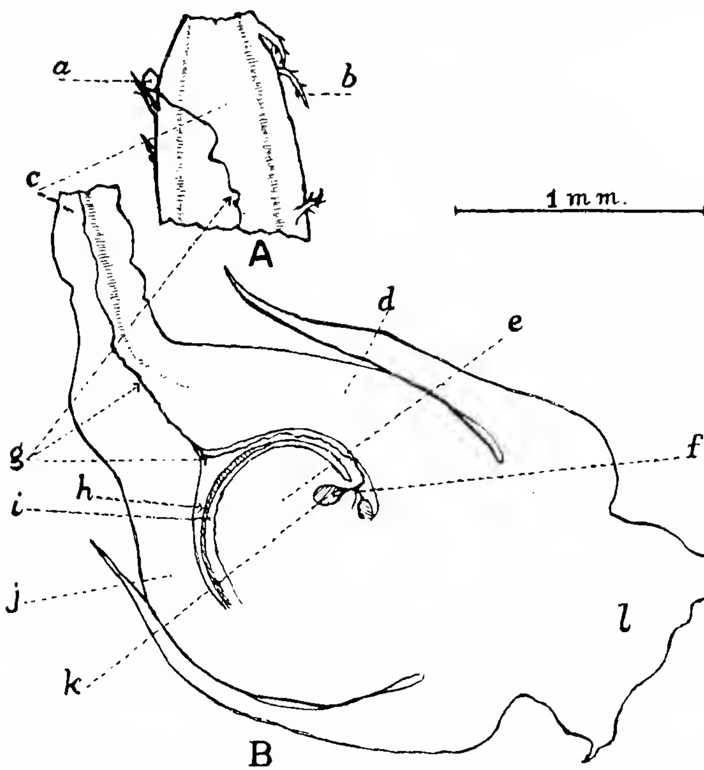

FIG. 53.—Diagram showing course of pollen tube through style to ovule. A, Section near outer end of style, showing pollen grain (*a*) and pollen tube (*g*). B, Section through base of silk and through ovule (*e*). (After drawing by C. S. Ridgway, in Duggar's *Southern Field Crops*, New York, The Macmillan Co.)

Into this tube the contents of the pollen grain, including the nuclei, pass. During growth the vegetative nucleus becomes gradually disorganized and is lost in the protoplasm. The generative nucleus, however, has divided and formed two nuclei. On reaching the ovary, the pollen-tube enters the embryo-sac, and discharges its two nuclei; one of these fuses with the nucleus of the egg-cell to form the embryo (Fig. 54); fertilization is then accomplished. The other male nucleus fuses with the two fused female polar-nuclei; from these the *endosperm* is developed. Cell-growth and cell-division then commence, and are continued until the mature seed is developed.

The *chromosomes* of maize are small and difficult to study, and scarcely anything is known of their behaviour during the maturation division (*East*, 6).

79. *Dichogamy.*—According to Kerner (1), most monœcious plants, including maize, are *protogynous*, i.e. the female flowers are receptive before the pollen of the same plant is shed, thus necessitating cross-pollination. If protogyny were complete, the very first plant in a field, which developed female flowers, would, in consequence, fail to propagate its kind, unless accidentally pollinated from a still earlier plant in a neighbouring field; but there would always be one plant in a district that was earliest of all, and which would therefore fail to develop grain. This habit would act to some extent as a check to any natural tendency to increased earliness in maturity.

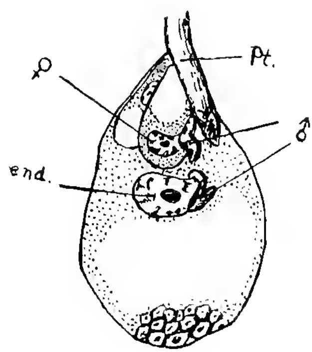

FIG. 54.—The embryo-sac in maize at the time of fertilization. *Pt.*, pollen tube which has just discharged the two male nuclei, ♂; ♀, egg-cell which, after union with one of the male nuclei, forms the embryo; *end.*, nucleus of the endosperm, with which the second male nucleus may unite. (After drawing by F. E. Lloyd in Duggar's *Southern Field Crops*, The Macmillan Co.)

If all the plants in a field flowered on exactly the same day, and all were completely protogynous, there would be no pollination except from other and earlier-planted fields, and those of the first planting would always fail to develop grain. But this is not the case. As already pointed out (¶ 72), there is a great difference in time of flowering with individuals in the same field, due to many causes, e.g. individual characteristics, difference in depth of planting, variation in soil fertility, soil texture and soil moisture, etc. The flowering period in any one field or plot may thus extend over ten days or three weeks.

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Protandry is the opposite of protogyny, i.e. the anthers shed all or part of their pollen before the female organs of the same plant are receptive. The very earliest pollen shed will, in such a case, be entirely wasted unless there is a protogynous plant in the vicinity which is receptive at the same time.

Plants of *Black Sugar-maize* in Pretoria, which matured pollen on 14 December, 1907, did not have any receptive stigmas till the 16th, 17th, and even later. In some instances the tassels had shed *all* their pollen before any silk appeared.

As far as the writer has been able to determine, from observation of Transvaal maize fields, protandry is the rule in South African maize. And Shamel (1) states that in America "in most varieties the pollen matures before the silks". On this account well-filled butts are more frequent than well-filled tips.

At the Botanical Experiment Station, Pretoria, no case of protogyny was observed among seventeen plants under observation for time of relative maturity of pollen and silk.

Relative Time of Appearance of Silk.	Number of Plants.
3 days later than the pollen	3
2 ,, ,, ,, ,,	2
1 ,, ,, ,, ,,	4
Same day as the pollen	8

In another experiment, however, with another variety of maize (a yellow flint, *Wills Gehu*), every one of twenty-six plants under observation was protogynous.

Plants of *Arcadia Sugar-maize* which developed silks on 9 November, 1910, had no anthers exserted until the 11th, while others had no anthers till the 13th. In some cases the tassels appear long before the anthers; the writer has a note of one vigorous plant of *Louisiana Hickory* on which the tassel first appeared on 25 November, but there were no anthers until 8 December, i.e. thirteen days later, the silks appearing on the same day.

It seems probable that protogyny is a breed characteristic. It appears to be constant in *Arcadia Sugar-maize* and in *Wills Gehu* (yellow flint), while protandry is the rule in

Black Sugar, *Hickory King*, *Louisiana Hickory*, and many other dent breeds. This matter is more fully discussed elsewhere (*Burtt-Davy*, 25). CHAP. IV.

80. *Form for Describing the Maize Plant in the Field.*—The following is a convenient form for use in recording the vegetative characters of selected plants in the field or the breeding plot. It can be printed off on to record cards of uniform size for subsequent filing. By marking off the character which is present, much time is saved which would otherwise be spent in writing out the cards. For instance in (*c*), if the plant is in silk at the time of taking the notes, put a mark, thus √, over the word "silking," or, if it is ripe, then over the word "ripe". More space must be allowed for the writing than is here indicated:—

(*a*) Name of breed..Date of record.........
(*b*) Where grown... Date of planting.........
(*c*) Maturity of plant; silking; roasting ear; partly dented or glazed; fully dented or glazed; nearly ripe; ripe.
(*d*) Height of stem: average of ten plants.........feet.........inches.
(*e*) Stem; straight; medium; zigzag.
(*f*) Stem circumference at middle of internode between second and third node from ground.........inches.
(*g*) Stem circumference at middle of internode below main ear.........inches.
(*h*) Number of ears on 100 stems.........
(*i*) Number of barren stems in 100 plants.........
(*j*) Position of ear; in middle of stem; above the middle; below the middle.
(*k*) Direction of ear; pointing upwards; horizontal; pointing downwards.
(*l*) Length of shank; distance from node to base of ear, average of ten plants........ inches.
(*m*) Husks; abundant; medium; scanty.
(*n*) Husks; tight; medium; loose.
(*o*) Number of leaves; average of ten plants.........
(*p*) Width of leaf-blades on ten plants: maximum.........inches; minimum .. ..inches; average.........inches.
(*q*) Length of leaf-blades on ten plants: maximum.........inches; minimum ....inches; average.........inches.
(*r*) Length of tassel; average of ten plants.........inches.
(*s*) Number of branches of tassel; average of ten plants.........
(*t*) Additional notes.......... ....

81. *The Shank.*—The shank is the stalk on which the ear develops. It is a much-reduced lateral branch, arising from a node on the main stem, and, like the stem, having nodes and internodes, the latter much shortened. Each node of the branch gives rise to a leaf, and in some cases to one or more distinct secondary ears (Fig. 55); this may produce silks, but

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appears rarely to develop grain; occasionally, however, fully developed secondary ears are produced (Fig. 56). A variation of one to twelve inches in length of shank has been noted. Very long shanks are undesirable because they allow the ear to hang too far away from the stem, which often results in its breaking off prematurely.

FIG. 55.—Four secondary ears developed from the nodes on the shank of a single ear.

The diameter of the shank also varies; it may be "*large*," i.e. nearly the diameter of the cob; "*medium*," i.e. half the diameter of the cob; or "*small*," i.e. one-third the diameter of the cob.

82. *The Husk.*—The husk of the ear consists of the leaf-sheaths which arise from the nodes of the shank (Fig. 39);

their homology is clearly indicated by the fact that often a diminutive leaf-blade, varying greatly in length, is developed at the end of each sheath of the husk (Fig. 45). Sometimes the husks are tightly wrapped around the ear; in other cases they are loose and baggy, giving a deceptive appearance of size to what may be only a small or medium ear.

In some cases the husks entirely cover the ear, and even extend a long way beyond it; in other cases they may be so short that the tip of the ear protrudes beyond them; the latter is an undesirable character, as it allows birds and insects to damage a good deal of the grain at the tip of the ear (Fig. 164).

FIG. 56.—Secondary ear developing from a node of the shank.

83. *The Mature Ear.*—The number of ears which a maize plant can bear varies considerably with the variety and breed, and also varies according to the richness or poverty of the soil and length of growing season.

The tendency to produce more than one fully developed ear on a plant (Fig. 57) may be seen in any maize field. But it is not the usual thing, in South Africa at least, for more than one *good* ear (on a dent breed) to develop fully and to mature grain. Some varieties naturally develop more ears; e.g. cases of ten or more ears on a flint breed have been reported, and one plant has been known to produce twenty-three ears; pop-corn has been known to produce twelve to nineteen ears; and six to fourteen have been reported for dent maize. But Hunt (1) points out that in the United States, dent breeds

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produce but one ear under ordinary conditions of culture; "*no two-eared dent breed has ever been produced which has become extensively grown or widely popular*". It seems reasonable that it should be easier for a plant to develop one large ear than two or more small ones, and it is better from the farmer's point of view, for it costs less to harvest one good

FIG. 57.—Maize plants developing two ears.

ear than to pick two small ones from each plant. The mature ear consists of a central pithy core, called the *cob* (Fig. 43) on which the grains are borne. The ear varies in length from ½ an inch to 16 inches, but 4 to 9 inches is a usual range in early and medium-maturing sorts, and 9 to 14 inches in the later sorts, such as white *Horsetooth*. Occasionally we have an early maturing sort which develops a long ear, e.g. *Chester County*. CHAP. IV.

The circumference of a mature ear at 2 inches from the butt should average 3 inches in an ear 4 inches long, or 7½ inches in one 10 inches long. The weight at harvest may vary from 3 to 18 ounces or more, but in time it may lose in drying from one-half of 1 per cent up to 35 per cent.

In shape the ear may be *cylindrical* (of uniform circumference) throughout its entire length, or more or less *tapering*.

The *butt* or base varies in shape and size. In a normal ear it should be of the same diameter, and have the same number of rows of grain as the main part of the ear, but this is often not the case. If the entire end of the *cob* is exposed, with the butt-grains at right angles to the axis of the cob, the butt is described as *even*. It may be rounded at the end and show the marks of the tightly-clasping husks on the grain, when it is called *compressed*. If there is a greater space between the rows at the butt than on the rest of the ear, it is *open*. It may be *expanded* by additional rows of grain, or *enlarged* without having any extra rows.

The cavity formed by a rounded butt may be shallow and broad, of moderate depth and diameter, or deep and of small diameter.

The apex of the ear is called the *tip*. The tip may be entirely covered with grains ; it is then described as *filled*. The tip grains may be scattered or in rows, or the tip may be bare through exposure, from lack of pollination or of adequate covering by the husks, or from ravages of ear-worm or birds, or through drought or lack of plant-food. If a central grain projects from a filled tip it is called *capped*. In shape the tip may be rounded or flattened.

The spaces between rows are called *sulci*. The smaller the number of rows, the greater the tendency to width of sulci. But if the grain is well shaped, the sulci will be narrow even when the rows are few.

84. *The Cob.*—The cob (¶ 83) varies greatly in shape and circumference. If the latter is over 4½ inches it is described as "*large*," if from 3½ to 4½ inches as "*medium*," and if 3½ inches or under as "*small*". The cob increases in length during the growing season of the plant. In colour, the chaffy

8

glumes on the cob may be blood-red or white. Forms intermediate in colour occur, but this may be the result of cross-pollination. As a rule, colour of cob is a fixed characteristic of a breed, e.g. in true *Hickory King* it is always white. White-grained breeds should have white cobs; coloured chaff discolours the mill-products.

85. *Number of Rows of Grain.*—The rows of grain on a cob vary in number from four to about forty-eight, but as a rule they range from eight to twenty in the breeds grown in South Africa. We have met with four-row and six-row ears, but these appear to be due to some abnormal condition, which has retarded the development of some of the rows. Odd numbers of rows occur very rarely; such irregularity is probably due to injury of one of the spikes of carpels during the stage of development. It often happens that a pair of rows fails to develop fully, both rows stopping short without reaching the apex; this may, perhaps, occur to only one of a pair of rows (Fig. 83B). Sometimes one or two rows on one side of an ear fail to develop through lack of pollination (Fig. 62), probably owing to the silks having been unable to protrude properly. Ears are sometimes found in which the grains are so scattered that the number of rows cannot be traced (Fig. 84A); sometimes this breaking up of the rows occurs throughout the whole ear; and sometimes it is confined to one part of the ear, most commonly to the butt.

Each breed has its characteristic number of rows, e.g. *Hickory King* has 8, *Louisiana Hickory* 10, *Hickory Horsetooth* 12, *Arcadia Sugar-maize* 12, *Black Mexican* 8.

In some breeds, however, the number of rows is not yet definitely fixed, e.g. *Iowa Silver-mine*, as grown in South Africa, has 14, 16, or 18. This is, perhaps, due to crossing with other breeds or with different strains of the same breed. In some cases the percentage of a given number of rows is found to be distinctly higher than in others, as shown by the following cases, which suggest crossing:—

Rows.	Ears, Per cent.	Breed.
14	24·00	Iowa Silver-mine.
14	32·58	Ladysmith.
16	57·00	Iowa Silver-mine.

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Breed.	Ears. Examined.	Rows. 14-row. Per cent.	16-row. Per cent.	18-row. Per cent.
Iowa Silver-mine	—	24	57	19
Ladysmith	89	32·5	45	22·5

Increase in number of rows is often accompanied by a corresponding decrease in the breadth of the individual grains. But this is not always the case; much depends on the thickness of the cob; the grains on a 16-row ear are sometimes broader than those on a 12-row ear of the same breed, if the cob of the former is thick while that of the latter is thin.

Increase in number of rows means a larger number of grains, but it does not necessarily follow that it is accompanied by increase in amount of grain produced. In *Golden King* (yellow dent), the best 14-row ears gave more grain than the best 12-row, but some of the 10-row also gave more than the 12-row. In *Yellow Horsetooth* (yellow dent), the ten best 14-row ears also gave more grain than the corresponding 12-row ears, but the ten poorest ears of the latter gave more than the ten poorest 14-row ears. In *Yellow Hogan* (yellow dent), the seven best 14-row ears gave more grain than the seven best 16-row ears (*Burtt-Davy*, 18).

The same number of rows does not give equally good returns in all breeds alike. Each breed seems to have an optimum number, which gives the best results in weight, shape, and size of grain, above or below which deterioration commences.

In some breeds the rows occur in distinct pairs; the rows are then described as *distichous*.

86. *Twisted Rows.*—The occurrence of a twist in the rows, either to left or right (Figs. 58 and 59), is a common feature. It is often confined to the upper portion of the ear, but may start from near the base. It is an undesirable character, as it tends to the development of irregular grains. This twisting appears to be in some way associated with the development of the number of rows. Out of a number of cases examined the following figures were obtained (*Burtt-Davy*, 18):—

Row numbers.	Left twist.	Right twist.	Ears examined.
14	17 = 59·6 per cent	12 = 41·4 per cent	29
18	12 = 60·0 ,,	8 = 40·0 ,,	20
16	Rows very straight, no twist.		
	29 = 59·3 per cent	20 = 40·7 per cent	49

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87. *Number of Grains per Ear.*—The number of grains per ear varies to some extent with soil, seasonal rainfall, etc., but apart from this, there appears to be a definite relation between the number of grains and the breed. *Hickory King* in the Transvaal ranges from about 350 to 400; *Iowa Silvermine* runs from 800 to 1,100. Burton (1) reports a case in

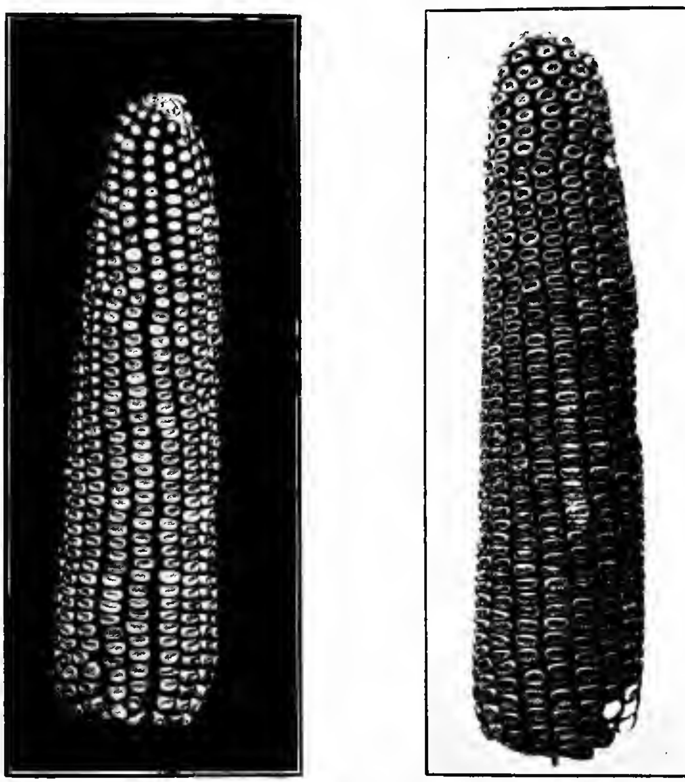


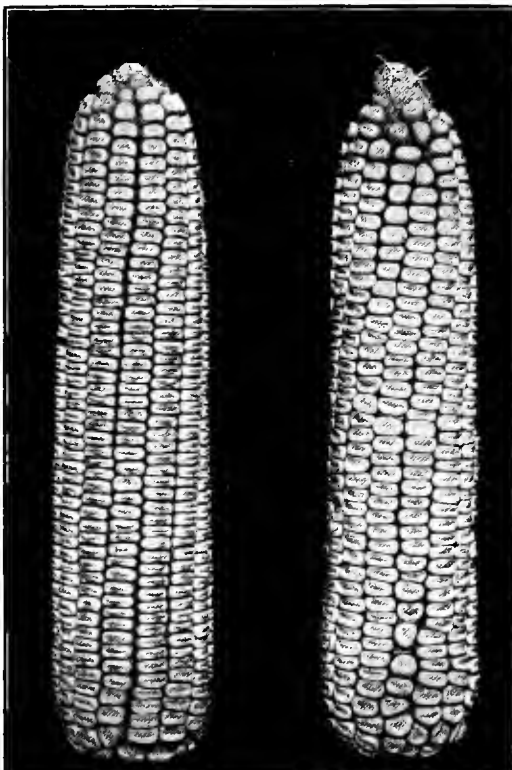
FIG. 58.—Left-hand twist of rows.

Aliwal North Division, Cape Colony, S. Africa, of an ear bearing 2,828 grains; this was one of eight ears from the same plant, but the name of the breed was not stated.

88. *Proportion of Grain to Ear.*[1]—The proportion of grain to ear is exceedingly variable, not alone as between breeds and under different conditions of growth, but also in the same

[1] i.e. percentage by weight of grain and cob.

breed grown under similar conditions. In the United States it is said that 86 or 87 per cent of grain per ear may be considered a fair proportion. In Transvaal-grown samples examined, the percentage has usually been much lower, averaging only 82·13 per cent. CHAP. IV.



A B

Fig. 59.—Right-hand twist of rows.

There does not appear to be any connection between *high yield* of grain per ear and percentage of grain on the ear. The heaviest yielding breed sometimes gives the lowest percentage of grain, while the one giving the highest percentage of grain may give a relatively low yield; but it does not follow that the breed giving the highest percentage of grain gives actually the lowest yield.

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American growers lay much stress on high percentage of grain to ear, because a great deal of maize is there sold on the cob, and buyers prefer strains which, when shelled, will bag up well. The growers admit, however, that the *proportion of grain to cob is of less importance than the actual weight of grain per ear.* In South Africa, where maize is sold, entirely, off the cob, the question of percentage does not appear to be of great importance.

89. *Form for Describing the Ear.*—The following is a useful form for recording the characters of typical ears in order to determine from year to year whether any change is taking place or whether they are remaining true to type. Owing to the difficulty of keeping specimen ears for any length of time, a written record is desirable. For definition of terms, see preceding paragraphs under each head.

This form can also be used to advantage by students in agriculture. In this case each student should have two or more ears of each of the five varieties of maize, or of five different breeds of the same variety. Ten ears of a given variety or breed are none too many for a thorough study. Ears of other varieties or breeds, showing the characters here mentioned, should be shown for the guidance of students.

The character present may be marked by a √ across the word.

Name: Variety..................... Breed...
Date of: (*a*) Record......... (*b*) Sowing......... (*c*) Harvest.....................
(*a*) Colour of grain: white; yellow; golden; red; purple; blue; or black.
(*b*) Colour of cob: white; light red; deep red.
(*c*) Surface: smooth; medium; rough; very rough.
(*d*) Sulci: absent; apparent; narrow; distinct; very distinct.
(*e*) Pairs of rows: distichous; not distichous.
(*f*) Number of rows: at ¼ length from butt.........; from tip.........
(*g*) Direction of rows: straight; right twist; left twist; irregular.
(*h*) Grains: very loose; loose; firm.
(*i*) Grains: regular; mosaic-like; uneven.
(*j*) Grains: upright; sloping; imbricated.
(*k*) Ear: cylindrical; cylindraceous; slowly tapering; tapering.
(*l*) Butt: even; shallow rounded; moderately rounded; deeply rounded.
(*m*) Butt: depressed; compressed; depressed-rounded; depressed-compressed; enlarged; expanded; open.
(*n*) Tip: sides of cob exposed; end exposed; end covered; capped.
(*o*) Juncture of shank with ear: large; medium; small.
(*p*) Extreme length of ear; maximum.........inches; minimum.........inches; average of ten.........inches.
(*q*) Circumference of ear at 2 inches from butt: maximum.........inches; minimum.........inches; average of ten.........inches.

(r) Circumference of ear at 2 inches from tip: maximum.........inches; minimum.........inches; average of ten.........inches.
(s) Weight of ear: maximum.........oz.; minimum.........oz.; average of ten.........oz.
(t) Weight of cob: maximum.........oz.; minimum.........oz.; average of ten.........oz.
(u) Percentage of grain: maximum.........; minimum.........; average of ten.........
(v) Circumference of cob at 2 inches from butt:.........inches.
(w) Ratio of circumference of cob to that of ear:.........

90. *The Grain.*—The grain of maize and other grasses is often spoken of as a *seed*, but it is in reality more than a seed, it is a whole *fruit*. It is a peculiar form of fruit, for the pericarp or outer covering of the fruit is completely united with the *seed-coat*. This special form of fruit is called a *caryopsis*.

The caryopsis of the maize plant comprises the following parts:—the *hull*, which is the combined pericarp and seed-coat; lying immediately under the hull is a layer of cells known as the *aleurone* layer (Figs. 15A and 60). The hull and aleurone layer together enclose the main mass of the grain. This consists of two distinct parts, the *endosperm* and the *embryo* (Fig. 15). The grains are arranged with the embryo side towards the tip of the ear; when the ear hangs down, the embryo is then on the under side of the grain.

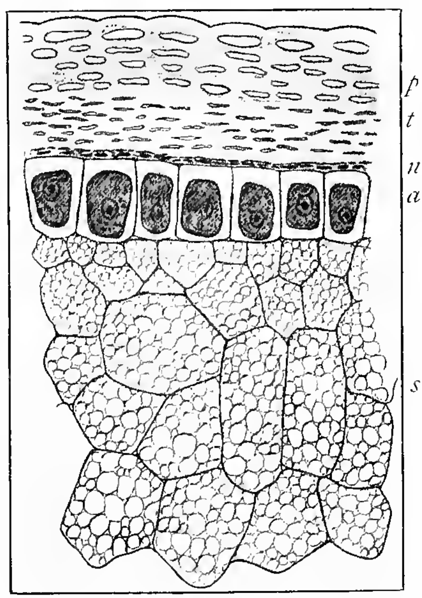

FIG. 60.—Enlarged section through hull of maize grain. *p*, pericarp; *t*, testa or seed coat; *n*, perisperm; *a*, aleurone layer; *s*, endosperm. (From Passmore and Webber.)

The grain may be firm on the cob or movable. Movable grains may, sometimes, be due to the ear being not fully mature when gathered, or to lack of adequate moisture at the time of ripening off. The grain may be set on at right angles to the surface of the cob, or it may slant towards the tip.

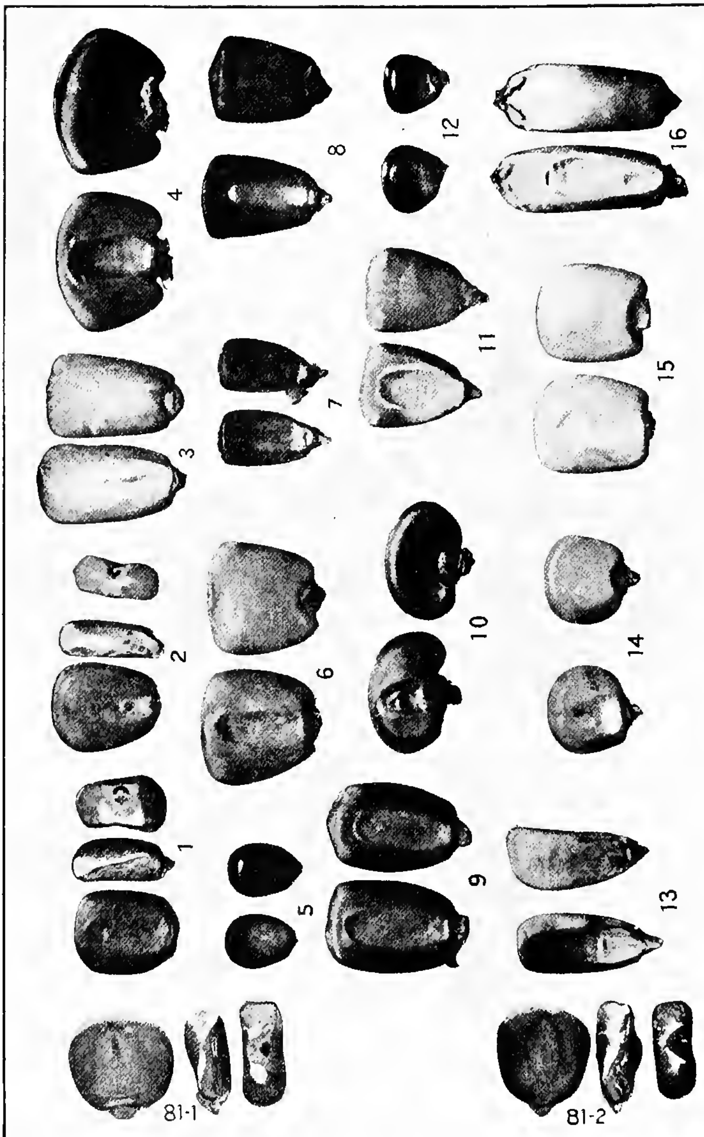

Fig. 61.—Variation in shape of maize grains. (From U.S. Department of Agriculture *Year-book.*)

The shape of the grain varies greatly (Fig. 61). In most breeds it is flattened and more or less wedge-shaped, with an indented apex (Dent maize); in one variety it is spheroidal or conical (Flint maize); in Pop maize it is distinctly and sharply beaked; in Sugar maize, when dry, the grain is much wrinkled owing to absence of starchy endosperm. CHAP. IV.

Depth and Breadth of Grain.

The depth (or length) of the grain varies greatly, and is said to be a quite constant character in different breeds. Breadth and thickness of grain, on the other hand, are not considered so constant.

Each of the five cultural varieties of maize (Pop, Flint, Dent, Flour, and Sugar) contains three well-defined sub-types, based on the relative breadth and depth of the grain. Thus:—

Group A—Grain broader than deep.
Group B—Grain as broad as deep.
Group C—Grain much deeper than broad.

According to Sturtevant (2) these depend on climatic conditions; the A group grows in short-season climates, the C group in long-season climates, while the B group is intermediate. A climate suitable for the C group will, naturally, also suit the other two groups, but they may not prove as profitable, and would therefore be less desirable. Deep grain appears, therefore, to indicate a long growing season, and *vice versa*; if this is constant, one should be careful not to select seed-maize having too deep a grain to suit the particular altitude or rainfall.

Shape of Grain.

(*a*) If broad above, tapering to a slender base with straight sides, the grain is described as *straight cuneate*.
(*b*) If the same general shape, but with rounded edges, it is *curved cuneate*.
(*c*) Broad above, narrower below, connected by straight lines, *truncate cuneate*.
(*d*) Long and uniformly narrow above, only tapering to a more or less broad base, *shoe-peg form*.
(*e*) Short, and as broad at base as at summit, *rectangular*.
(*f*) Slightly rounded at corners, both above and below, *round-cornered*.

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Apex of Grain.

(*a*) *Roof-shaped* at one edge, i.e. convex at one and flat at the other.
(*b*) *Shingled*, i.e. overlapping like shingles on a roof.
(*c*) *Flat* or *square*, corners not rounded at summit.
(*d*) *Rounded*, corners rounded at summit.
(*e*) *Rostrate* or *beaked*, with long, sharp, tapering projection.
(*f*) *Mucronate* or *pointed*, with small, sharp point at summit from embryo side.
(*g*) *Dented* (only in dent breeds), with an indentation of varying size and form.

Indentation of Grain.

(*a*) *Round dimple*, rounded or cup-shaped and quite smooth.
(*b*) *Long dimple dented*, i.e. longer than broad, and quite smooth.
(*c*) *Creased*, i.e. edges pressed towards each other, leaving a small space between and the edges parallel.
(*d*) *Pinched*, the edges pinched closely together and projecting upward and forward.
(*e*) *Rough*, with any rough, jagged, or beaked projection from the summit.
(*f*) *Bridged*, with a fold across the centre.
(*g*) *Crumpled*, or wrinkled, as in sweet maize.

91. *The Hull.*—The *hull* or outer covering of the ripe maize grain (Figs. 15 and 60) is hard and shiny. It comprises the *pericarp* of the fruit together with the *testa* or seed-coat (with which it is united), and the *perisperm*, a layer of tissue beneath the testa and surrounding the endosperm (Fig. 15). Of these three tissues the pericarp forms the larger part of the hull of the ripened grain.

The hull can be easily removed from the aleurone layer for study, by soaking in hot water for about fifteen minutes.

92. *The Aleurone Layer.*—Lying immediately beneath the hull, between the perisperm and endosperm, is a tissue composed of a single row of comparatively large cells, rather regular and rectangular in transverse or cross section (Fig. 60). This tissue is called the *aleurone layer;* it comprises 8 to 14 per cent of the grain.

Webber (2) has shown that the blue, purple, and black colour of the soft flour and sugar varieties of maize lies in the aleurone layer. In yellow maize, however, the yellow colouring matter is not confined to the aleurone layer, but penetrates the endosperm. In some of the red-grained breeds of maize, and in the red-striped *Cusco*, the red colouring matter is confined to the pericarp, which accounts for the fact that red maize is sometimes produced from white seed.

93. *The Endosperm.*—This is the mass of tissue lying below the aleurone layer, but above and partly surrounding the embryo. It comprises about 73 per cent of the whole grain. Its function is that of a reserve store of elaborated plant-food for the use of the young seed-plant before it is able to absorb food materials from the soil or to elaborate them in the leaf.

As seen in section, the endosperm shows a variation from translucence to opaque snowy whiteness. Hopkins (3) reports a difference of 2 per cent more protein in the corneous than in the white endosperm ; Hunt (1) questions whether this may not be due to lack of complete separation from the aleurone layer in the samples analysed. The latter author points out that there is no material difference in structure noticeable under the microscope, which has led to the suggestion, not positively proven, that the difference between them is a difference in density analogous to the difference between snow and ice.

The relative proportion and arrangement of the translucent or corneous and the white endosperm have been used in part to differentiate between the five varieties of maize.

94. *Form for Describing the Grain.*—This may be used to advantage for the same purposes, and in the same manner, as the form for describing the ear.

For the use of students in agricultural botany, twenty-five to thirty grains should be given of each of the five varieties, or of five breeds of one variety. For determining the points in (*l*) to (*p*) inclusive, a number of grains should be soaked in hot water for thirty minutes, or in cold water for twenty-four hours. For measuring the grains, a sheet of cross-ruled paper can be used to advantage for marking off distances, which can then be measured accurately by a scale divided to 32nds of an inch, or preferably to millimetres.

Name: Variety....................Breed..
Date of (*a*) record......... ; (*b*) sowing......... ; (*c*) harvest...... ..
(*a*) Weight: ten average grains in duplicate (*a*)...... .. ; (*b*).........
(*b*) Length: ten average grains in duplicate (*a*)......... ; (*b*).........
(*c*) Width: ten average grains in duplicate (*a*)......... ; (*b*).........
(*d*) Thickness: ten average grains in duplicate (*a*)......... ; (*b*).........
(*e*) Ratio of width to length: divide length of ten grains by width of ten grains (*a*)......... ; (*b*).........
(*f*) Ratio of thickness to width: divide width of ten grains by thickness of ten grains (*a*)......... ; (*b*).........

(*g*) Shape: flat; spheroidal; conical.
(*h*) Shape (side view): straight cuneate; rounded cuneate; curved cuneate; truncate cuneate; shoepeg; rectangular; round cornered.
(*i*) Apex: roof-shaped; shingled; rostrate; mucronate; rounded; flat; dented.
(*j*) Indentation: round dimple; long dimple; creased; pinched; rough; bridged; wrinkled.
(*k*) Colour: white; cream; yellow; golden; red; blue; purple; black; striped; mottled; mosaic.
(*l*) Place of colour: endosperm; aleurone layer; hull.
(*m*) Character of endosperm: corneous; partly corneous; farinaceous; sugary.
(*n*) Proportion of corneous endosperm (in dent variety): large; medium; small.
(*o*) Embryo size: large; medium; small.
(*p*) Sketch of longitudinal cross-section: show arrangement to scale, of embryo, and of corneous and white endosperm.

95. *Tubular Glands in the Embryo.*—Dr. C. Stuart Gager (1) describes the occurrence of true glands of the tubular and sub-racemose type in the tissue of the scutellum, formed by invaginations of the glandular epithelium of the latter. The significance of these glands, as in harmony with the theory that the scutellar epithelium is principally an organ of secretion, is indicated by the author.

96. *Apogamy.*—Collins (4) has described a case in which the staminate flowers were replaced by young leafy and root-forming maize plants.

Addendum.—Since this chapter went to press the writer has seen a paper by Prof. Emerson (1) of Nebraska, in which he describes and illustrates a family of maize in which the ligule and auricle were absent. He refers to a similar condition in oats reported by Nilsson-Ehle (1) and Hurst (1). Prof. Emerson notes that in the case of non-auriculate leaves, the sheath and the lower part of the blade are rolled somewhat closely about the stalk, and that the leaf as a whole assumes an upright position nearly parallel with the stalk, the tip of the leaf curving away gently if the blade is long and the mid-rib sufficiently flexible. "Whether the absence of the ligule proper is disadvantageous to the plant is somewhat questionable. . . . My own observations on liguleless corn are to the effect that the inside of the sheath is more often discoloured, as if from incipient decay, than is the case when a well-developed ligule is present. In no case, however, have I found decay of the stalk or leaf sufficient to be of any material injury to the plant—not even during the past summer when the plants were grown near Boston, where they were exposed to moister conditions than is usually the case in Nebraska." CHAP. IV.

He concludes that it is the absence of the auricle that makes the leaves stand so erect. "It is the triangular shape of the auricle that makes possible the immediate flattening out of the leaf blade at the termination of the cylindrical sheath, and that allows the blade to bend abruptly away from the stalk while the sheath still clasps it."

CHAPTER V.

INHERITANCE OF CHARACTERS AND IMPROVEMENT BY BREEDING.

'Tis often seen adoption strives with nature, and choice breeds a native slip to us from foreign seeds.

—SHAKESPEARE.

And he gave it for his opinion, that whoever could make two ears of corn . . . to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together.

—*Gulliver's Travels.*

Necessity for Improvement.

CHAP. V. 97. *The Object of "Breeding".*—Plant breeding is the application to crops of the principles applied in improving breeds of live stock. No breed of domesticated animals or plants is perfect in all respects; each one has its good and its weak points. There are therefore two primary objects which the breeder keeps in view in order to produce satisfactory results: (*a*) *maintenance* of quality and type, by the elimination of the unfit and untrue to type; (*b*) *improvement* of the type by the substitution of desirable for undesirable characters.

To allow the poor types in a herd or crop to propagate their kind always results in race deterioration. To allow only the strongest and best to mate and propagate means, on the other hand, race maintenance and also, within certain limits, race improvement.

"In the herd of cattle to destroy the strongest bulls, the fairest cows, the most promising calves, is to allow those not strong, nor fair nor promising, to become the parents of the coming herd. Under this influence the herd will deteriorate, although the individuals of the inferior herd are no worse than their own actual parents. Such a process is called race-degeneration, and it is the only race-degeneration known in the history of cattle or men. The scrawny, lean, infertile herd is the natural offspring of the same type of parents. On the other hand, if we sell or destroy the rough, lean, or feeble calves, we shall have a herd descended from the best. . . .

"In selective breeding with any domesticated animal or plant, it is possible, with a little attention, to produce wonderful changes for the better. Almost anything may be accomplished with time and patience. To select for posterity those individuals which best meet our need or please our fancy, and to destroy those with unfavourable qualities, is the function of artificial selection. Add to this the occasional crossing of unlike forms to promote new and desirable variations, and we have the whole secret of selective breeding. This process Youatt calls the 'magician's wand' by which man may summon up and bring into existence any form of animal or plant useful to him or pleasing to his fancy" (*Jordan*, 2).

To accomplish the best results possible from breeding, it is necessary (*a*) to understand something about the manner in which characters are inherited from the parent; (*b*) to be well acquainted with the characteristics and variability of the plants or animals with which one is dealing; and (*c*) to understand clearly what characters are required by the market, or are in other ways desirable or undesirable.

98. *The Necessity for Improvement of Crops.*—South Africa produces good maize and has established a good name in the maize market, thanks to the assistance rendered by the several Governments. There is no difficulty in selling the maize of South Africa; the difficulty is to supply the demand. There is even danger that, unless the output is increased, she may lose the market that she has gained, for Europe requires a steady and dependable supply; irregularity of supply tends to discredit the crop with the merchant, and reacts unfavourably on the producer.

South Africa *must produce more* if she is to become the "maize granary of Europe". Increased production depends upon three things: (1) more intensive cultivation of the area now under crop; (2) a larger farming population to increase that area; (3) increase of the yield per acre by scientific maize-breeding.

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Intensive cultivation means greater profit; if we can produce 600 muid bags of maize from 50 acres, *the profit per bag* is much greater than if we get only 300 bags from the same acreage, for the rent of the land and first costs of ploughing, harrowing, and cultivating are the same in each case.

Through breeding we may further increase the production by developing drought-resistant or early-maturing sorts adapted to regions now outside the Maize-belt.

With low yields, maize-growing ceases to be profitable when prices also are low; but if we double and treble the yield per acre, prices may fall much lower and still yield a good profit. The remedy for low prices lies not in restrictive fiscal legislation, but in reducing the costs of production by increasing the yield per acre and improving the quality of the crop.

99. *Need for Increase in the Yield per Acre.*—Hartley states that good farmers in the United States frequently grow from 75 to 100 bushels of maize per acre. An American bushel of maize on the cob weighs 70 lbs.; 75 bushels or 100 bushels would, therefore, be equivalent to 26 or 35 muid bags per acre. An American bushel of shelled maize must weigh (by statute) 56 lbs., which would be equivalent to 21 to 28 muid bags per acre. Maximum yields are, of course, higher. A certain Pennsylvania farmer has been known to harvest no less than 100 bushels (23 muids) per acre during twelve successive years (excepting only two seasons), and in 1902 his average yield over 90 acres was 130 bushels or 36·4 muids. The Transvaal records are pretty good, for, at Tzaneen in the Zoutpansberg District, the Department of Agriculture has produced 35½ muids (127 bushels of shelled maize) per acre, of *Austin Colossal* yellow dent, and at the Government Experiment Farm, Potchefstroom, 35 muids (125 bushels) of a white dent. There seems reason to expect, therefore, that given proper treatment of the crop, and with heavy-yielding varieties and well-bred seed, good farmers in the Transvaal will raise an average of 20 muids (71 bushels) per acre; it is an ideal worth working toward! A few farmers[1] have already done this, but they are still too few to affect the

[1] Messrs. Hutchinson and Shaw, and Messrs. Reynolds Brothers, of Zandbaken, Standerton District, have obtained averages of 19¾ and 20 muids per acre over areas of 30 acres or more.

average yield, which is estimated at between 4 and 5 muids (800 to 1,000 lbs., or 14·28 to 17·9 bushels).

This is astonishingly low as compared with the 22½ to 24 muids obtained (without manure) in the United States. Even assuming that the soils of the South African Maize-belt are perhaps not as rich as those of the United States Corn-belt, there is still much too great a discrepancy between the average yields of the two areas ; it has been clearly demonstrated on the Government Experiment Farms, and on many private farms as well, that average yields of 10 and 12 muids (35½ to 42½ bushels) per acre over hundreds of acres can be secured without undue expense.

But good as the American yields are as compared with those at present obtained in South Africa, American breeders find it is possible still greatly to improve them. Mr. C. P. Hartley, corn expert of the United States Department of Agriculture, writes (*Hartley*, 3):—

"It is possible within a few years to double the average production of maize per acre in the United States, and to accomplish it without any increase in work or expense. It is not to be understood from this statement that it is desirable to double the present maize crop, but that it is desirable to produce the same yield on a smaller number of acres and with less labour. If 60 bushels (a bushel of maize on the ear is calculated at 70 lbs. weight) are raised on 1 acre instead of on 2 acres, the labour of ploughing, harrowing, planting, cultivating, and harvesting is greatly reduced. The demand controls the quantity that should be grown. To meet demands the producers of the United States have, during the ten years previous to 1914, averaged in round numbers 2,000,000,000 bushels of maize yearly. In producing this amount a little more than 82,000,000 acres have yearly been devoted to maize-growing. The *average* production . . . for the past ten years has been less than 25 bushels per acre, but from the best estimates that have been made the conclusion is unavoidable that half of those who grow maize harvest less than 25 bushels per acre. Twice this quantity is a fair crop, three times 25 bushels is a good crop, and *four times 25 bushels per acre are frequently produced.*

"The lines of improvement that will most easily and quickly double the present production per acre are as follows: (1)

CHAP. V. improvement in the quality of seed planted; (2) improvement in the condition of the soil; (3) improvement in methods of cultivation."

In the present chapter we shall deal with the first of these three points; the others are discussed subsequently.

100. *The Cause of Poor Yields.*—Poor yields are not as a rule traceable to any single cause, but are due to a combination of causes, such as poor farming, poor seed, mixed strains, etc.

Good seed is seed bred with reference to certain definite requirements and possessing high germinating power.

Well-bred seed usually has a higher germinating power than ordinary seed of the same age, kept with equal care. If the germination is poor the stand will be poor; every ear should yield at least 8 ozs. of grain; every 400 failures in germination therefore reduce the possible yield by at least *one muid* of grain. Since 8,800 seeds will plant 1 acre, 400 poor seeds cause a loss of 4·5 per cent; but very few average samples of seed-maize will show so high a germination as 95·5 per cent. Of some seed planted only 80 per cent germinates; this means, of course, that 20 per cent of the seed was unsound in one way or another. A 20 per cent failure in germination would mean a loss in some cases of 3 muids per acre, in other cases more.

Poorly-bred seed, moreover, is apt to produce barren stalks and small ears yielding perhaps only 3 ozs. of grain apiece. A plant that does not produce 8 ozs. of grain is not giving an adequate return for the time and care bestowed upon it, nor for the space that it occupies. A good plant, yielding 8 ozs. and more of grain, takes up no more space, and requires no more scuffling or other attention than a poor one, and it costs as much to harvest the one as the other. It is plainly evident that it is unprofitable to grow crops from poor seed.

The difficulty is to know beforehand which seed is going to produce a poor plant and which a good one. The object of this chapter is to help the farmer to determine these points.

Studies of South African maize crops carried out by the writer have shown that, although the average yield per acre is exceedingly low, the average weight of grain per ear is comparatively high. This is a most encouraging fact for it shows that the crops have inherent possibilities of improvement.

Out of 93 ears of *Hickory King* (grown at Vereeniging in 1908), which were carefully weighed, the 10 poorest (Nos. 231-80) averaged 7 ozs. of grain apiece (Table XIX). A full stand of 8,712 plants averaging 7 ozs. of grain apiece would give 19 muids per acre. The crop at Vereeniging in 1908 only averaged approximately 6 muids per acre, on 3,500 acres, while on the best land it ran to about 10 muids per acre. Allowing 10 muids in this case, for the purpose of discussion, how can we account for the other 9 muids, equivalent to 47 per cent of the crop which an average yield of 7 ozs. of grain per ear should give? And what has become of those ears which averaged as much as 8·87 ozs. of grain per ear? It seems incredible that 47 per cent of the stand should fail completely to yield any return, or that the remaining 53 per cent should give an average of only 7 ozs. of grain per ear when the average of 93 ears is 7·90 ozs.! A yield of 10 muids would give the absurdly low average of 3·67 ozs. of grain per ear, with a full stand, while one of only 6 muids would be equal to only 2·20 ozs. per ear. CHAP. V.

This matter needs thorough investigation, including a large number of careful counts and weighings, for it is a state of affairs which should be altered. Whether the low yield is due to the imperfect stand, or to the low average of grain per ear, or whether partly to one and partly to the other, there is certainly great need for improvement. If the stand is so poor that 47 per cent of the plants fail to grow, or to bear ears, it should be possible to secure better stands. If a stand of 53 per cent bears an average of only 7 ozs. of grain per ear, it is clearly possible to improve that average, when we consider that a number of ears give 8·78 ozs., and the average of 93 ears is 7·90 ozs. A stand is never perfect; some allowance must always be made for vacant places due to misses in planting, accidents in harrowing and cultivation, destruction by hail, cutworm, stalk-borer, and cranes, losses in harvesting, etc. These losses often amount to 25 per cent, but just how many bearing stalks constitute an *average* stand has yet to be determined.

101. *Importance of a Perfect Stand.*—From what has already been said it is evident that there are two things essential to securing the heaviest possible yields of maize: (*a*) a

CHAP. V. perfect stand of plants; (*b*) large ears, with a heavy yield of grain per ear. Deficiency in either of these two requisites will spoil the results obtained from the other.

The influence of incomplete stands on total yield is one cause of loss which does not receive sufficient attention. The writer has made a careful examination of different maize stands, in various places, counting the number of bearing plants in a given area, and estimating the yield. The method adopted was to measure off 100 yards at various points which seemed to show an average stand. The plants in the row on either side of the measured strip were counted, omitting such as, through injury by stalk-borer or smut, were not likely to develop any grain. Where these fields were planted in continuous rows 3 feet apart, allowing 3 feet width of soil surface for each plant, the average number of plants in each 100 yards was multiplied by 48·40, which gives the approximate average per acre. The results obtained showed that the stands vary from 90 *per cent down to* 25 *per cent* of the possible perfect stand. Following are the details of some of the examinations which were made on different farms:—

No. 1. *Yellow Horsetooth.*—Messrs. Reynolds Bros., Zandbaken, Val Station, Standerton District. Main crop planted 36 × 22 inches, equalling 5·5 square feet per plant, or 7,920 plants per acre for a full stand. Average of two rows, 130·5 plants per 100 yards, or 6,216·4 per acre, equalling 79·5 per cent of a full stand. At an average of 8 ozs. of grain per plant the yield should be 3,158 lbs., or 15·79 muids per acre.

No. 2. *Yellow Horsetooth.*—Messrs. Hutchinson & Shaw, Zandbaken, Val Station, Standerton District. Main crop planted 36 × 22 inches, equalling 5·5 square feet per plant, or 7,920 plants per acre. Four rows averaged 132 plants per 100 yards, or 6,375·6 per acre, or 80·5 per cent of the full stand. At an average of 8 ozs. of grain per plant the yield should be 3,194·4 lbs., or 15·97 muids per acre.

No. 3. *Golden King.*—Messrs. Hutchinson & Shaw. Planted 36 × 22 inches, equalling 5·5 square feet per plant, or 7,920 plants per acre. Four rows averaged 113·5 plants per 100 yards, or 5,480·6 per acre, which is 69·2 per cent of a full stand. At an average of 8 ozs. of grain per plant the yield should be 2,746·7 lbs., or 13·73 muids per acre.

No. 4. *Hickory King.*—Messrs. Hutchinson & Shaw.

Planted 26 × 22 inches, equalling 4 square feet per plant, or 10,890 plants per acre. CHAP. V.

An average of six rows carried 136 plants per 100 yards, or 6,577·5 plants per acre, equivalent to 60·4 per cent of a perfect stand. At an average of 6 ozs. of grain per plant (the ears produced were smaller than those of the *Yellow Horsetooth*), this should give 2,466·5 lbs., or 12·34 muids, per acre. About 2 per cent of the crop was affected with smut of the tassel, *Ustilago Maydis.*

No. 5. *Hickory King.*—Government Stud Farm, Standerton. Check-rowed, 3 feet by 2 feet 8 inches, equalling 8 square feet per hill, two plants being planted on each hill. A full stand, therefore, would have 5,445 hills, or 10,890 plants. Six rows averaged 90 hills per 100 yards, or 8,668·4 plants if each hill carried two plants, but on account of the number of suckers it was not practicable to determine the actual number of individual plants; this is equivalent to 79·6 per cent of a full stand. At an average of 8 ozs. of grain per hill, i.e. 4 ozs. of grain per plant (the ears were small), the yield should be 2,178 lbs., or 10·88 muids.

No. 6. *Wisconsin White Dent.*—Government Stud Farm, Standerton. Check-rowed, 3 feet by about 2 feet 8 inches, equalling 8 square feet per hill, two plants per hill. A full stand should give 5,445 hills, or 10,890 plants. Five rows averaged 88 hills per 100 yards, or 4,259 hills per acre, equivalent to 77·8 per cent of a full stand. Number of plants per hill not counted. At an average of 8 ozs. of grain per hill this stand should yield 2,118 lbs., or 10·65 muids per acre. In this stand 2·65 per cent of the plants in some rows were affected by maize-smut in the tassel, and 11·3 per cent of the plants were injured by stalk-borer.

No. 7. *Early Leaming.*—Government Stud Farm, Standerton. Check-rowed, 3 feet by about 2 feet 8 inches, equalling 8 square feet per hill of two plants, or 5,445 hills, or 10,890 plants, per acre. Six rows averaged 93 hills per 100 yards, or 4,500 hills per acre, or 82·6 per cent of the full stand. At an average of 8 ozs. of grain per hill the yield should be 2,250 lbs., or 11·25 muids per acre.

No. 8. *Yellow Hogan.*—Government Stud Farm, Standerton. Check-rowed, 3 feet by about 2 feet 8 inches, equalling 5,445 hills, or 10,890 plants per acre. Six rows averaged 101 ears per 100 yards, or 4,888 hills per acre, equivalent to 89·3 per cent of a full stand. At an average of 8 ozs. of grain per hill this stand should yield 2,444 lbs., or 12·22 muids per acre.

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TABLE XVIII.

SUMMARY OF PERCENTAGE STANDS.

Variety.	Estimated Yield in Muids.	As the Stand Stood.	On a Full Stand.	Loss.
	Per Cent.			
1. Yellow Horsetooth .	79·5 at 8 ozs. per plant . =	15·79	19·8	4·0
2. ,, ,, .	80·5 ,, ,, . =	15·97	19·8	3·8
3. Golden King . .	69·2 ,, ,, . =	13·73	19·8	6·1
4. Hickory King . .	60·4 ,, ,, . =	12·34	20·4	8·1
5. ,, ,, . .	79·6 at 8[1] ozs. per hill . =	10·88	13·6	2·7
6. Wisconsin White Dent	77·8 ,, ,, . =	10·65	13·6	3·0
7. Early Leaming . .	82·6 ,, ,, . =	11·25	13·6	2·3
8. Yellow Hogan . .	89·3 ,, ,, . =	12·22	13·6	1·4
Average	77·37 Average	12·85		

[1] This figure may be on the low side, but we find that where the plants are crowded together in hills, the ears are smaller and the average yield per ear less than when planted in continuous rows; it is doubtful, however, whether the difference in results obtained by the two methods of planting is quite as great as the difference here allowed.

Messrs. Hutchinson and Shaw kept count of the yield from these several fields and found that they averaged very close to the estimate which had been made of them, except in one case of subsequent damage to the crop.

In a number of rows tested promiscuously in different fields, in another part of the country, the stand percentage was found to average 65·1 per cent, ranging from 53 per cent to 93 per cent. Where much damage has been done by hail, the stands (in individual rows) ranged from 19 per cent to 54 per cent and averaged only 38·4 per cent. Planted 3 feet 4 inches between the rows and 1 foot 6 inches in the rows, a full stand would carry 8,712 maize plants, which on an average of 7 ozs. of grain per ear (not an excessive amount to expect) should produce 19 muids per acre. A stand of 65·1 per cent carries 5,671 plants which with the same weight of grain per ear should yield 12·4 muids per acre, while a stand of 38·4 per cent would produce only 7·31 muids.

Poor stands may thus mean a loss of eight bags, or 64s. per acre, even where the crop has been considered a good one.

It appears also that, on fairly well-farmed land, losses may be equivalent to nearly 25 per cent of the stand. CHAP. V.

102. *Importance of Increasing the Size of the Ears.*—We have seen that a stand of only 38·4 per cent of the possible, would produce 7·31 muids per acre if the ears *averaged* 7 ozs. in weight.[1] But as this yield is about twice the estimated

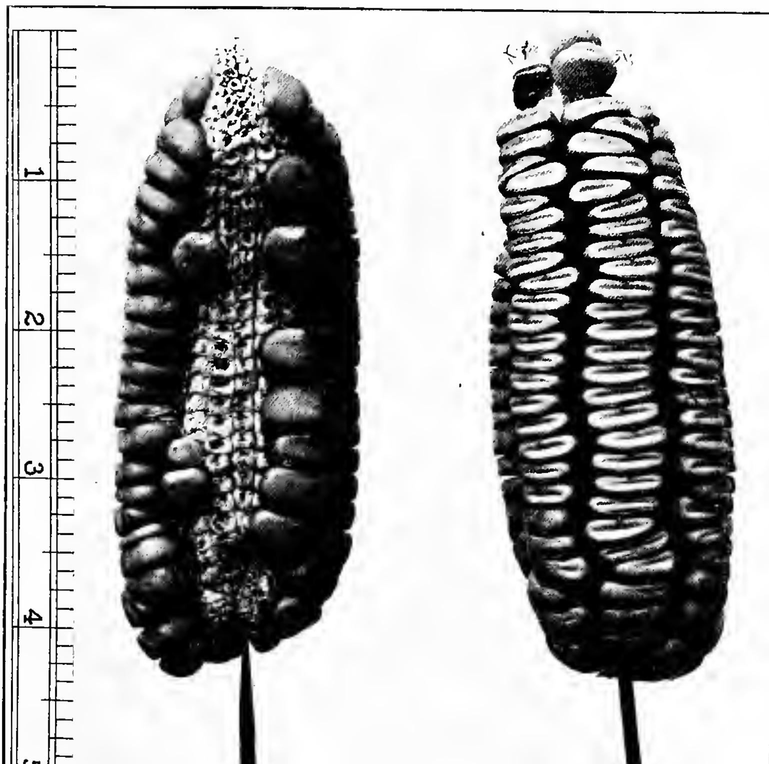

Fig. 62.—"Nubbins" of *Hickory King;* one cause of poor yields; 4½ inch nubbins weighing 2½ to 3 ozs.

average for the Transvaal, we are forced to conclude, in the absence of other likely reasons, that the low yields are due, in part at least, to small ears, the average weight of grain of which does not exceed 3½ ozs. per ear. In view of the

[1] Only 7 ozs. is allowed in this case, since the yields were lighter than those near Standerton.

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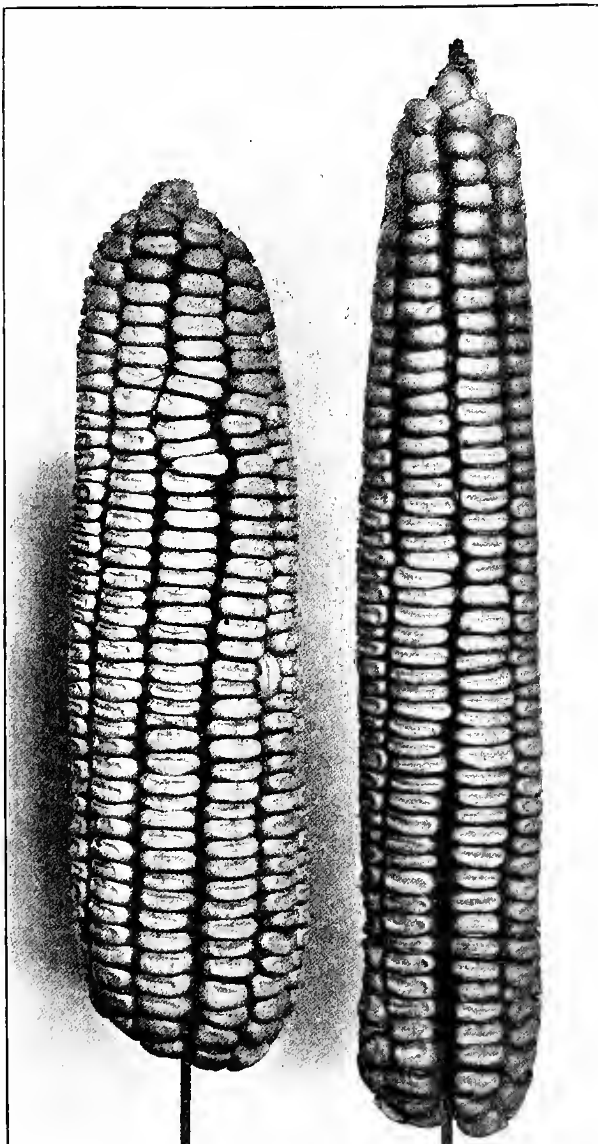

A B

FIG. 63.—Desirable and undesirable types of *Hickory King*; the shorter ear (A), 8 inches long, has a deeper grain and gives a heavier yield than the longer ear (B), 10 inches long, which has shallow grain.

fact that 8 ozs. of grain per ear is a common return, and that ears yielding 15 ozs. of grain are not unknown, an average of $3\frac{1}{2}$ ozs. is absurdly low, and suggests great possibilities for improvement.

"Nubbins" such as are shown in Fig. 62, must tend to bring down the yield enormously.

103. *Average Weight of Grain per Ear.*—Such variations in weight of ear indicate that the composition of the average lot of seed-maize is very unsatisfactory. A difference of 12 ozs. between the extremes is much too great; no stockman would breed 800 lbs. bullocks when he could produce 2,000 lbs. animals with the same amount of care and feed. Although it may not be possible to bring the average up to the maximum, still by breeding, the average can be greatly improved, and the production of the $2\frac{1}{2}$ to 4 ozs. nubbins (Fig. 62) which are so plentiful in South African crops at present, can be minimized. The following tables (XIX to XXIX) show the weights and yields of grain of 1,684 ears of maize grown at Vereeniging, Transvaal, in 1908, and selected for seed. They were carefully studied and weighed, at the end of the dry season when the grain was as dry as possible.

104. *Need for Increase in the Weight of Grain per Ear.*—Allowing for losses to the extent of 25 per cent from external causes, misses, etc., we should still have 6,534 bearing plants to an acre, an average of one to every $7\frac{1}{2}$ square feet of soil surface. As is shown in the preceding tables, the average weight of grain from a medium-sized ear of *Golden King* in 1908 was 7·397 ozs.; this was determined by weighing 250 ears which had been picked for seed, but from which all the best ears had been removed for use on the breeding plot, leaving 150 medium-sized ears. On well-farmed land, 10 muids of shelled grain per acre is not an uncommon average yield without manure. To produce 10 muids would require only 4,326 plants yielding 7·379 ozs. each, or less than two-thirds of the plants left on the acre. How are we to account for the remaining 2,208 plants? At 7·379 ozs. each they should produce an additional 1,020 lbs., or 5 muids of grain, which would increase the yield per acre by 50 per cent. There are three possible explanations: (1) that the average yield of grain per ear is much lower than 7·379 ozs.; (2) that

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TABLE XIX.

ANALYSIS OF YIELDS OF 134 EARS OF *HICKORY KING*.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Per-centage of Grain.	Number of Rows.	Average Number of Grains per Ear.	Notes.
Hickory King, S. 2.							
	Ozs.	Ozs.	Ozs.				
41 to 50 .	6·36	·93	5·43	85·37	8, 10	—	
51 to 60 .	6·85	1·28	5·57	81·31	8, 10, & 12	393	
61 to 70 .	5·54	·94	4·60	83·03	8, 10	—	
	18·75	3·15	15·60	249·71	—	—	
Average, 30 ears	6·25	3·05	5·20	83 23	—	—	
Hickory King (Narrow Grain), V. 8.							
141 . .	10·125	1·00	9·125	—	—	—	
146 . .	10·00	1·10	9·00	—	—	—	
147 . .	11·12	1·40	11·12	—	—	—	
148 . .	10·40	1·40	9·00	—	—	—	
149 . .	10·80	1·50	9·70	—	—	—	
150 . .	11·00	1·64	9·36	—	—	—	
151 . .	14·50	3·00	11·75	80·70	—	—	
152 . .	10·65	1·10	9·65	—	—	—	
153 . .	11·50	1·20	10·25	—	—	—	
154 . .	10·90	1·10	9·90	—	—	—	
155 . .	9·95	1·30	8·60	86·42	—	—	
	120·945	15·74	107·455	—	—	-	
Average, 11 ears	10·99	1·43	9·77	88·90	—	—	
Hickory King, V. 7.							
144 . .	10·35	1·65	8·70	84·05	8	—	
145 . .	11·50	1·40	10·10	87·82	8	400	
146 . .	10·00	1·20	8·80	88·00	8	—	
147 . .	10·10	1·30	8·80	88·11	8	384	No loss.
148 . .	10·50	1·75	8·75	83·33	8	336	
149 . .	10·60	1·10	9·50	89·62	10	490	
151 . .	10·25	1·75	8·50	82·92	10	—	
152 . .	10·10	1·25	8·85	87·62	10	—	
153 . .	9·50	1·25	8·25	86·84	8	—	
154 . .	10·20	1·70	8·50	83·33	8	400	
155 . .	10·50	1·60	8·90	84·76	8	368	
158 . .	9·85	1·60	8·25	83·75	8	—	
162 . .	10·75	1·30	9·45	87·90	10	—	
	134·20	18·85	115·35	1,111·05	—	2,378	
Average of 13 V. 7 ears .	10·32	1·45	8·87	86·00	—	396	
201 to 210 .	8·98	1·225	7·755	86·36	12	—	Discards.
211 to 230 .	9·19	1·21	7·98	86·83	10	—	Do.
231 to 280 .	8·066	1·064	7·002	86·81	8	—	Do.
	36·556	4·949	31·607	346·00	—	—	
Average of 93 V. 7 ears .	9·139	1·237	7·902	86·50	—	—	
Average of 24 ears (141-62)	10·63	1·44	9·28	—	—	—	
Average of all	8·29	1·19	7·12	85·85	—	—	

TABLE XX.

ANALYSIS OF YIELDS OF 100 EARS OF *NATAL WHITE HORSETOOTH.*

Natal White Horsetooth, V. 14.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percentage of Grain.	Number of Rows.
	Ozs.	Ozs.	Ozs.		
1 to 10	12·68	2·98	9·70	76·50	14
11 to 20	13·08	3·07	10·01	76·53	14
21 to 30	14·47	3·78	10·69	73·88	14
31 to 40	13·24	2·96	10·28	77·64	14
41 to 50	15·18	3·56	11·62	76·55	14
51 to 60	16·23	3·84	12·39	76·34	14, 16, 18, 12
61 to 70	13·80	3·26	10·54	78·37	16
71 to 80	14·54	3·32	11·20	77·03	12
81 to 90	14·00	3·45	10·55	75·36	12
91 to 100	14·05	3·45	10·60	75·42	12
	141·27	33·67	107·58	763·62	—
Average . . .	14·127	3·367	10·758	76·362	—

TABLE XXI.

ANALYSIS OF YIELDS OF 123 EARS OF *LADYSMITH.*

Ladysmith, V. 6.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percentage of Grain.	Number of Rows.	Number of Ears.	Notes.
	Ozs.	Ozs.	Ozs.				
132 to 145	10·55	—	—	—	16	14	
146 to 155	12·00 & over	(1·76)	10·24	(88·33)	16	10	10 best.
1 to 13	9·17	—	—	—	12	13	
156 to 169	10·60	—	—	—	16	14	
170 to 181	9·01	—	—	—	16	12	
183 to 193	10·09	2·11	7·97	78·99	18	11	
195 to 219	8·69	1·48	7·21	83·00	—	25	Estimate of cob based on ears 183 to 193.
183 to 197	12·05	2·11	9·94	82·49	18	15	
221 to 228	9·75	—	—	—	20	8	
229	12·70	—	—	—	22	1	
—	12·00 & over	—	—	—	14	—	
—	17·00	7·46	—	332·81	18	—	
	116·61	7·68	35·36	—	—	123	
Average	10·60	1·86	8·84	83·20	—	—	

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TABLE XXII.

ANALYSIS OF YIELDS OF 150 EARS OF *IOWA SILVER-MINE* AND 10 EARS OF *CHESTER COUNTY*.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Per-centage of Grain.	Number of Rows.	Average Number of Grains per Ear.	Notes.
Iowa Silver-mine, V. 9.							
	Ozs.	Ozs.	Ozs.				
1 to 10 .	9·11	1·71	7·400	81·23	16, 14, & 18	—	Much grain lost.
10 to 20 .	10·55	1·86	8·690	82·37	16, 14	—	
21 to 30 .	9·62	1·86	7·760	80·66	16, 14, & 12	—	Some grain lost.
31 to 40 .	9·56	1·83	7·730	80·85	16, 14, 18, 20	—	Some loss of grain.
41 to 50 .	9·94	1·77	8·170	82·19	16	—	Do.
51 to 60 .	9·36	1·58	7·780	83·12	16	—	
61 to 70 .	8·12	1·41	6·710	82·63	16	—	Do.
71 to 80 .	8·92	1·56	7·360	82·51	14	—	Do.
81 to 90 .	7·35	1·46	5·890	80·13	12, 18, & 14	—	Much loss of grain.
91 to 100 .	8·20	1·39	6·810	83·05	12, 14	—	
	90·73	16·43	74·300	818·74	—	—	
Average of 10	9·07	1·64	7·430	81·87	—	—	
Iowa Silver-mine, S. 4.							
1 to 10 .	5·51	1·03	4·48	81·30	16	664	10 poorest.
11 to 20 .	7·34	1·46	5·88	80·11	16	702	
21 to 30 .	8·91	1·69	7·22	80·80	16	—	10 best.
31 to 40 .	6·53	1·16	5·37	82·23	16	640	
41 to 50 .	8·27	1·11	7·03	85·00	16	—	Not true to type.
	36·56	6·45	29·98	409·44	—	2,006	
Average .	7·312	1·29	5·996	81·888	16	668	

Chester County, V. 4.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percent-age of Grain.	Notes.
	Ozs.	Ozs.	Ozs.		
11 to 20 . .	9·28	1·546	7·734	83·34	10 best ears.

TABLE XXIII.

ANALYSIS OF YIELDS OF 110 EARS OF *CHAMPION WHITE PEARL.*

(A breed closely allied to *Iowa Silver-mine.*)

Champion White Pearl, V. 5.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Per-centage of Grain.	Number of Rows.	Notes.
	Ozs.	Ozs.	Ozs.			
1 to 10 .	7·62	1·47	6·15	80·71	14	
11 to 20 .	7·99	1·45	6·45	81·85	14	Ears poor and broken.
21 to 30 .	8·67	1·53	7·14	82·35	14	Some loss of grain.
31 to 40 .	7·74	1·43	6·31	81·52	14	No loss of grain.
41 to 50 .	8·68	1·54	7·14	82·26	14	Slight loss of grain.
51 to 60 .	7·50	1·62	5·88	78·40	14	Ears very broken.
61 to 70 .	8·52	1·62	6·90	80·99	16	Ears a good deal broken.
71 to 80 .	8·12	1·49	6·63	81·65	16	A little grain lost.
81 to 90 .	10·26	1·74	8·52	83·04	16	Very little grain lost.
91 to 100	8·39	1·53	6·86	81·76	16	Do.
	83·49	15·42	67·98	814·53	—	
Average of 100 .	8·35	1·54	6·80	81·45	—	
101 to 110	6·65	1·42	5·23	78·65	12	

TABLE XXIV.

ANALYSIS OF YIELDS OF 170 EARS OF *YELLOW HORSETOOTH.*

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Per-centage of Grain.	Number of Rows.	Notes.
Yellow Horsetooth, 12-row, V. 1.						
	Ozs.	Ozs.	Ozs.			
81 to 90	10·15	2·04	8·11	79·90	12	
91 to 100	9·90	1·67	8·23	83·13	—	
101 to 110	10·65	1·79	8·86	83·19	—	
111 to 120	12·06	2·09	9·97	82·67	—	
121 to 130	10·67	1·81	8·86	83·03	—	
131 to 140	10·15	1·79	8·36	82·36	—	
141 to 150	9·55	1·79	7·76	81·26	—	
	73·13	12·98	60·15	575·54	—	
Average of 7	10·45	1·85	8·593	82·22	—	
Yellow Horsetooth, 14-row, V. 2.						
31 to 40	12·96	2·25	10·71	82·64	—	Best.
48 to 57	9·85	2·27	7·58	76·95	—	Light.

CHAP. V. after allowing for a loss of 25 per cent of the stand from the various causes mentioned before, one-third of the remainder are barren; (3) that each of these causes is partially accountable.

Barren Stalks.—An examination of many maize crops shows that there is a small percentage of barren stalks, but that this is not likely to equal anything like 33 per cent of the standing crop.

TABLE XXV.

ANALYSIS OF YIELDS OF 352 EARS OF *YELLOW HOGAN*.

Yellow Hogan, V. 3.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percentage of Grain.	Number of Rows.	Notes.
	Ozs.	Ozs.	Ozs.			
1 ...	10·50	1·90	8·60	81·90	16	Cob white.
2 ...	10·30	1·90	8·40	81·55		
3 to 14	9·08	1·54	7·54	83·04	14	Do.
15 to 24	9·45	1·50	7·95	84·13	12	Do.
25 to 34	8·00	1·38	6·62	82·75	12	Do.
35 to 41	7·67	1·38	6·29	81·99	12	Do.
42 to 151	—	1·60	—	—	—	
151 to 190	—	1·425	—	—	—	
192 to 201	7·85	1·31	6·54	83·31	12	Red cob.
202 to 208	6·08	1·21	4·87	85·01	14	
209 to 216	8·44	1·40	7·04	83·56	14	
217 to 222	8·30	1·40	6·88	83·10	14	
223 to 226	8·90	1·43	7·47	83·99	14	
227 to 232	9·98	1·41	8·50	85·81	14	
233 to 242	10·80	1·85	8·70	82·87	14	Best 10.
243 to 252	10·57	1·77	8·80	83·25	14	
253 to 262	9·82	1·40	8·42	85·74	14	
263 to 272	9·48	1·65	7·83	82·60	14	
273 to 282	8·44	1·44	7·00	82·94	14	
283 to 292	7·66	1·34	6·32	82·51	14	
293 to 307	10·10	1·73	9·20	83·99	16	
308 to 314	8·88	1·67	7·21	84·63	16	
315 to 324	9·13	1·60	7·53	82·48	12	
325 to 334	10·59	1·94	8·65	81·68	12	
335 to 344	9·46	1·90	7·56	79·91	12	
345 to 349	6·92	1·56	5·36	82·11	12	
350 to 352	8·90	1·53	7·37	82·81	14 & 12	
	225·30	42·165	186·65	2077·66	—	
Average of 25 lots .	9·01	1·56	7·46	83·10	—	

Nubbins.—It also shows that in most crops there is a considerable proportion of "nubbins," i.e. small ears (cf. Fig. 62)—often only 2 to 4 ozs. weight—which are imperfectly developed owing to inadequate pollination, or other causes. A three-quarter stand of 6,534 bearing plants per acre, yielding 10 muids of shelled grain, shows the low average of 4·89 ozs. of grain per ear, which is only 66 per cent of the average weight of the 150 medium ears mentioned above (p. 137), and is only 48 per cent of the average weight of 100 selected ears. CHAP. V.

TABLE XXVI.

ANALYSIS OF YIELDS OF 200 EARS OF *GOLDEN KING*.

Golden King, V. 13.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percentage of Grain.	Number of Rows.	Notes.
	Ozs.	Ozs.	Ozs.			
101 to 110 .	11·64	2·37	9·27	79·64	12	
111 to 120 .	11·94	2·21	9·73	81·49	12	
121 to 130 .	11·54	2·11	9·43	81·71	12	
131 to 140 .	12·12	2·18	9·94	82·01	12	
141 to 150 .	12·80	2·38	10·42	81·40	12	
151 to 160 .	13·30	2·41	10·89	81·88	12	10 best 12-row.
161 to 170 .	13·09	2·37	10·72	81·89	14	
171 to 180 .	13·90	2·33	11·57	83·24	14	10 best 14-row.
181 to 190 .	12·71	2·22	10·49	82·59	14	
191 to 200 .	11·43	2·25	9·18	80·31	14	
Total of 100 Selected Ears	124·47	22·83	101·64	816·16	—	Selected for breeding plot.
Average of 100 Medium-sized Ears . . .	8·74	1·6475	7·0925	81·15	12	Nos. 1-100 selected for bulk seed.
50 do. . .	9·402	1·7000	7·7020	81·92	14	Nos. 201-50 do.
50 do. . .	9·828	1·778	8·050	81·91	10	Discarded.
100 Selected Ears . . .	12·447	2·283	10·164	—	—	Nos. 101-200 selected for breeding plot.
10 Best Ears	13·90	2·33	11·57	83·24	14	Nos. 171-80 selected for breeding plot.

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Table XXVII.

ANALYSIS OF YIELDS OF 370 EARS OF *WISCONSIN*.

Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Per-centage of Grain.	Notes.
Wisconsin, S. 1.					
	Ozs.	Ozs.	Ozs		
1 to 10 . .	7·9	1·33	6·375	80·79	
11 to 20 . .	9·375	1·843	7·875	84·00	10 best.
	17·275	3·173	14·250	164·79	
Average . .	8·6375	1·5865	7·125	82·395	
Wisconsin × = *Skinner's Court* 2.					
1 to 10 . .	7·34	1·47	5·87	79·97	
11 to 20 . .	8·70	1·60	7·10	81·61	
21 to 30 . .	9·10	1·82	7·28	80·00	10 best.
31 to 40 . .	8·00	1·51	6·49	81·12	
41 to 50 . .	7·55	1·37	6·18	81·85	
	40·69	7·77	32·92	404·55	
Average . .	8·140	1·550	6·580	80·91	Selected ears.
51 to 150 .	7·791	1·440	6·351	80·23	100 large ears, bulk.
151 to 250 .	6·175	1·130	5·045	81·70	100 medium ears, bulk.
251 to 350 .	4·981	·922	4·058	81·47	100 small ears, bulk.
	27·087	5·042	22·034	324·31	Apices infertile, apparently from lack of pollen.
Average of 350	6·772	1·260	5·508	81·08	

It has been amply demonstrated by American maize-growers that the tendency to produce barren stalks can be reduced by careful selection, and that the average yield of grain per ear can be very greatly increased by breeding. The figures in Table XXX (p. 147) show the yield per acre for every ounce of average weight of grain per ear on a 75 per cent stand of 6,534 plants per acre.

These figures are somewhat startling. We are not prepared to say that an average yield of 23 muids can be obtained on any one South African farm without manure, even with the best of seed and of good management ; but

TABLE XXVIII.

CHAP. V.

ANALYSIS OF YIELDS OF 100 EARS OF *SKINNER'S COURT* 10.

Skinner's Court 10.						
Selection Numbers.	Average Weight of Ear.	Average Weight of Cob.	Average Weight of Grain.	Percentage of Grain.	Number of Rows.	Notes.
	Ozs.	Ozs.	Ozs.			
1 to 10 .	10·10	2·15	7·95	78·71	14	
11 to 20 .	7·95	1·85	6·10	76·73	16	
21 to 30 .	9·20	2·00	7·20	78·26	16	
31 to 40 .	10·30	2·40	7·90	76·70	16	
41 to 50 .	9·84	2·22	7·62	77·43	16	Grains deep.
51 to 60 .	10·95	2·31	8·64	78·90	14	10 best; grains deep.
61 to 70 .	9·85	1·95	7·90	80·20	14 (8) & 12 (2)	Grain deep.
71 to 80 .	9·55	2·18	7·37	77·17	18	
81 to 90 .	9·44	2·13	7·31	77·43	12	
91 to 100 .	9·04	1·86	7·18	79·42	14	
	96·22	21·05	75·17	780·95	—	
Average .	9·62	2·105	7·517	78·09	—	

25 per cent appears to be an ample allowance for losses by pests, etc.; we should aim to secure a 75 per cent stand and an average yield of at least 6 ozs. of grain per plant, which would give 12 muids per acre. The writer confidently believes that this standard will be reached, and the figures given in Tables XIX to XXIX seem sufficient warrant for the assumption.

All the defects referred to can be largely remedied by combining breeding with good farming; the tendency to produce barren stalks can be reduced by careful selection; misses in planting will be reduced by greater uniformity in shape and size of seed; the tendency to produce "nubbins" can be removed almost entirely by breeding; and the effect of cutworm and stalk-borer are minimized by careful management.

The tendency for like to produce like is found not only among animals but among plants. It is well known to all farmers that poor, weedy sheep, cattle and horses, reproduce their kind; and "nubbins" will generally reproduce the same sort of plant that bore them. When the poor-quality parent-

TABLE XXIX.

SUMMARY SHOWING COMPARATIVE YIELDS OF GRAIN FROM 1,684 EARS OF TRANSVAAL-GROWN MAIZE.

	Number of Ears Weighed.	Number of Rows per Ear.	Number of Grains per Ear.	Average Weight of Ears in Ounces.			Average Weight of Cobs in Ounces.			Average Weight of Grain per Ear in Ounces.			Percentage of Grain to Ear.		
				10 Best.	10 Worst.	Av. of all.	10 Best.	10 Worst.	Av. of all.	10 Best.	10 Worst.	Av. of all.	10 Best.	10 Wors.	Av. of all.
Natal White Horsetooth, V. 14 .	100	12-18	—	16·23	12·68	14·13	3·84	2·98	3·37	12·39	9·70	10·76	78·37	73·88	76·36
Golden King, 14-row . . .	90	14	—	13·90	9·40	12·10	2·33	1·70	2·17	11·57	7·70	9·93	83·24	80·31	81·99
,, 12-row, V. 13 .	160	12	—	13·30	8·74	11·72	2·41	1·65	2·19	10·89	7·09	9·54	82·01	79·64	81·32
,, 10-row . . .	50	10	—	10·59	9·42	9·83	—	—	1·78	—	—	8·05	—	—	81·91
Natal Yellow Horsetooth (dent), 14-row, V. 2	20	14	—	12·96	9·85	11·40	2·25	2·27	2·04	10·71	7·58	9·15	82·64	76·95	79·79
Natal Yellow Horsetooth (dent), 12-row, V. 1	70	12	—	12·06	9·55	10·45	2·09	1·79	1·85	9·97	7·76	8·59	83·19	79·90	82·22
Ladysmith White, V. 6 . .	120	12-20	—	12·00	8·69	(10·60)	(1·76)	1·48	(1·86)	10·24	7·21	(8·84)	(88·33)	82·49	(83·20)
Yellow Hogan, V. 3 . . .	200	14 & 12	432 to 728	10·80	6·08	9·01	1·85	1·21	1·56	9·20	4·87	7·46	85·81	79·91	83·10
Chester County, V. 4 . . .	10	18, 16, & 20	—	10·50	7·50	9·28	1·54	1·07	1·37	8·95	5·95	7·73	85·27	79·39	83·34
Hickory King, V. 7 . . .	93	12, 10, & 8	395, Av.	10·32	8·06	9·14	1·45	1·06	1·24	8·87	7·00	7·90	86·83	86·00	86·50
,, S. 2	30	12, 10, & 8	393, Av.	6·85	5·54	6·25	1·28	·94	1·05	5·57	4·60	5·20	85·37	81·31	83·23
,, V. 8 (narrow grain, apparently a cross) . . .	11	—	—	14·50	9·95	10·99	3·00	1·30	1·43	11·75	8·60	9·77	86·42	80·70	88·90
Iowa Silver-mine, V. 9 . .	100	16, 14, & 12	—	10·55	7·35	9·07	1·86	1·46	1·64	8·69	5·89	7·43	83·12	80·13	81·87
,, S. 4 . .	50	16	670, Av.	8·91	5·51	7·31	1·69	1·03	1·29	7·22	4·48	5·99	85·00	80·11	81·89
Skinner's Court 10 . . .	100	14 & 16	—	10·95	7·95	9·62	2·31	1·85	2·10	8·64	6·10	7·57	80·20	76·70	78·09
Champion White Pearl . .	100	14 & 16	—	10·26	7·50	8·35	1·74	1·62	1·54	8·52	5·88	6·80	83·04	78·40	81·45
,, x Hickory King	10	12	—	6·65	—	—	1·4	—	—	5·23	—	—	78·65	—	—
Wisconsin White Dent, S. 1 .	20	—	—	9·37	7·90	8·64	1·84	1·33	1·58	7·87	6·37	7·12	84·00	80·79	82·39
Skinner's Court 2 (Wisconsin x Iowa Silver-mine . . .	350	12, 14, & 16	—	9·10	7·34	8·14	1·82	1·47	1·55	7·2	5·87	6·58	81·85	79·97	80·91
	1,684	—	—	11·04	8·28	9·78	2·03	1·54	1·75	9·08	6·62	8·02	83·52	79·79	82·13

TABLE XXX.

YIELD PER ACRE FROM A 75 PER CENT STAND, AT VARIOUS AVERAGE WEIGHTS PER EAR.

Average Weight of Grain per Ear.	Yield from a 75 per cent Stand (6,534 Plants) in Muids per Acre, omitting fractions.
Ozs.	Muids.
1	2
5	10
6	12
7	14
7·7	15
9	18
10	20
11·5	23

Thus every single ounce of grain added to the average weight of ear produced makes a difference of 2 muids of grain per acre.

plants are in the majority, as is generally the case in ordinary maize crops from unselected seed, they cross with the good ones and cause deterioration. The obvious remedy is (1) to save only the best ears for seed, and (2) to plant this seed entirely away from the rest of the crop so that the plants may not be cross-pollinated by inferior strains.

It is true that large heavy-yielding ears do not always produce good ears in the next generation, but this is often due to the effect of previous cross-breeding with inferior plants, which continues to show in the second and even the third generation.

It seems reasonable to expect that by using only the ten best ears of the crop for seed, we shall be able to breed up a strain that will eventually average a yield of 11·57 ozs. of grain per ear, which on a 75 per cent stand will give 23 muids per acre. There may be some adverse factors to contend with, which are not yet fully understood, and which may delay the attainment of this desired end; but South Africa can undoubtedly do much better than at present.

In tests made during 1908 the average difference in weight of grain per ear from the ten best ears, as compared with that obtained from the ten poorest ears, was 2·68 ozs., while the range of difference was from ·97 oz. to 4·33 ozs. Though

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2·68 ozs. is not a great increase, yet on the basis of 6,534 bearing plants it means an increase of 5½ muids of grain per acre· This increase is 137 per cent of the estimated present average yield of 4 muids per acre.

But there is no reason why we should be content even with an increase of 2·68 ozs. of grain. Some breeds show an average increase for ten ears of 4·33 ozs. per ear; we should therefore aim at adding this to the average for the crop. An average increase of 4·33 ozs. per ear is equivalent to 1,764 lbs. (8·82 muids) of grain per acre.

105. *Percentage by Weight of Grain and Cob.* — Where maize is sold *on the cob* for feeding to stock, or for seed, as is often the case in the United States, the amount of grain which can be obtained from a bushel or muid of ears is of great importance; as this proportion varies, the price also will fluctuate.

The following table shows the range of variation in proportion of grain to ear in selected ears of certain breeds:—

TABLE XXXI.

PERCENTAGE OF GRAIN TO EAR.

Variety.	No. of Ears Weighed.	10 Best Ears.	10 Worst Ears.	Average of 100 Ears.
		Per Cent.	Per Cent.	Per Cent.
Hickory King, V. 7	93	86·83[1]	86·00	86·50
,, ,, V. 8	11	86·42	80·70	88·90
Ladysmith, V. 6	120	88·33[2]	82·49	83·20
Yellow Hogan, V. 3	200	85·81	79·91	83·10
Chester County, V. 4	10	85·27	79·39	83·34
Golden King, 14-row	90	83·24	80·31	81·99
Yellow Horsetooth, V. 1, 12-row	70	83·19	79·90	82·22
Iowa Silver-mine, V. 9	100	83·12	80·13	81·87
Champion White Pearl, V. 5	100	83·04	78·40	81·45
Yellow Horsetooth, V. 2, 14-row	20	82·64	76·95	79·79
Skinner's Court No. 11	350	81·85	79·97	80·91
Skinner's Court No. 10	100	80·20	76·70	78·09
Natal White Horsetooth, V. 14	100	78·37	73·88	76·36
Total	1,364	1,088·31	1,034·73	1,067·72
Average	105	83·57	79·59	82·13

[1] The maximum for a single ear was 89·62.
[2] There is a possible error in this figure.

Owing to the lateness of the season when the weights were taken, the dryness of the ears and the looseness of the grain, there was a certain loss of grain from a few ears. This was greater in some breeds than in others. In all cases, however, care was taken to select the least broken ears for weighing, and in many cases there was no loss from those that were weighed; at most it would not exceed half an ounce of grain, which would not alter the percentage of grain to ear by more than about ·67 per cent. Making due allowance for this, the percentages are considerably below those which American growers consider fair (¶ 88, p. 117).

106. *Effect of Depth of Grain on Yield.*—One of the principal factors, and perhaps the most important, in the production

A B

Fig. 64.—Increasing yield by increasing depth of grain (in *Arcadia Sugar-maize*). A, old type; B, improved type.

of heavy yields of grain, is the depth of the grain (cf. Fig. 64). Even an eighth of an inch added to the diameter of an ear, when the cob remains of the same thickness, makes a marked difference in the amount of grain carried on that ear.

In seed selection, therefore, this character is of great importance. To measure the relative depth of grain of each ear, when handling several thousand ears, is a most tedious process, and if some readily detected character can be found which is correlated with depth of grain, it will be a useful guide. One of the results of the writer's recent investigations has been the

CHAP. V. discovery that this character is often (in fact in nearly all the cases that have fallen under his observation) correlated with

FIG. 65.—Rough-grained type of *Hickory*; a desirable type for selection. Rough ears of this type generally have a longer grain (in South Africa) than the smooth type. The ear is *not* well bred, for the tip tapers too much, the sulci are too wide, the grains are uneven and the rows are irregular, but it is a useful type to start with.

roughness of the indentation of the grain (cf. Fig. 65), whereas very smooth grains (as in Fig. 67B) are often very shallow.

107. *Increasing Yield by Increasing the Number of Rows at the Butt and Tip.*—Loss of grain also occurs through breeding ears with *even*, instead of *rounded*, butts (Fig. 66) and with badly covered tips. It has been completely demonstrated that these defects can be removed by breeding. CHAP. V.

108. *Effect of Width of Sulci on Yield.*—Loss in weight of grain is often due also to wide sulci, as, for example, in the ear shown in Fig. 65, although this is not a bad case, and far worse specimens are often met with. The sulci should be as narrow as possible. The ears shown in Fig. 67 are not

A B

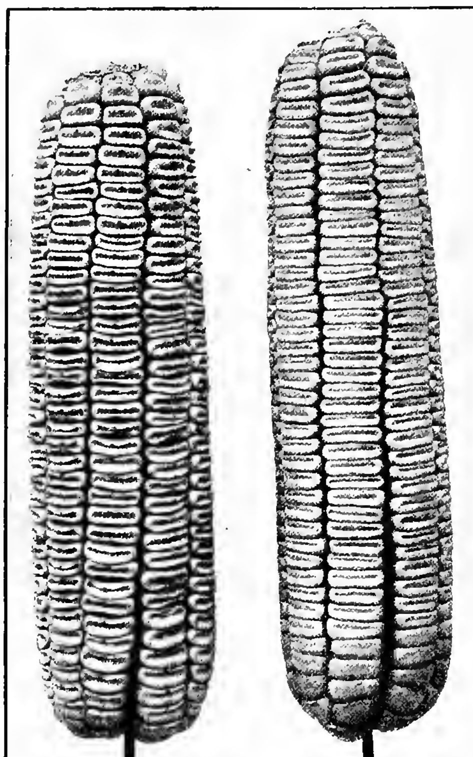
FIG. 66.—Increasing yield by increasing the number of rows around the butt. A (rounded butt) has a row of grains more than B (even butt).

quite perfect in this respect, but nearly so. Narrow sulci may be produced in two ways: (1) by the development of wedge-shaped grains so that the empty space, such as is produced by straight-sided grains, is filled with grain. This is the right type to breed. (2) By the development of shallow grains which are not long enough to form wide sulci. This is the wrong type to breed, because more weight is lost by the shallowness of the grain than is gained by the closing up of the sulci.

109. *Effect of Shape of Grain on Yield.*—The shape of the grain has a marked effect on yield; the grain which combines

CHAP. V. depth (¶ 106) with the shape which allows the least waste of space between rows, is obviously the one that will give the best yield, other things being equal. The ideal shape for this purpose is known as the wedge-shape (cf. Fig. 68 and ¶ 108).

110. *Effect of Number of Rows.*—It does not always follow that increase in number of rows of grain on the ear is accom-



A B

FIG. 67.—Result of breeding for reduction of sulci; *Doyle Hickory*.

panied by increase in amount of grain produced. Cases illustrating this point have been mentioned in chapter IV. (¶ 85).

One number of rows usually predominates in a breed, thus in *Iowa Silver-mine* it is the 16-row, of which there were 57 per cent, while of the 14-row there were only 24 per cent in certain cases examined. It does not follow, however, that the

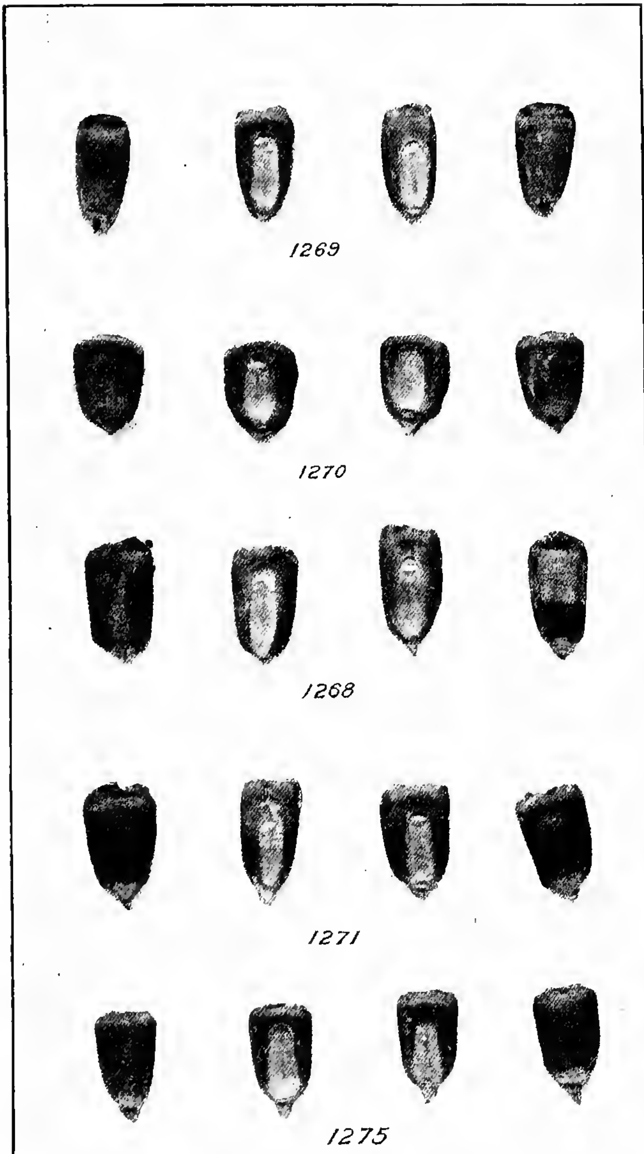


FIG. 68.—Variation in shape and size of grain in the same breed (*Reid*); No. 1271 approaches most closely to the ideal.

CHAP. V. type with the predominating number of rows is the one most suitable for propagation.

The number of rows may either exceed or fall below that of the type; the whole gamut (from 8 to 24 or more) may be found in one breed. It does not necessarily follow that an 18-row *Iowa Silver-mine* is not an *Iowa Silver-mine*, nor that a 10-row *Hickory* is some other breed. But it is found that either below or above a certain number in any one type, deterioration takes place; in *Iowa Silver-mine*, for example, the ears bearing 12, 18, and 20 rows respectively, prove undesirable for propagation, entirely apart from the question of the number of their rows.

111. *Effect of Diameter of Cobs.*—There is a popular idea that a thin cob is a highly desirable characteristic of a good type of maize, and a certain amount of simple selection on this basis has been carried out by South African farmers. In reality increase in the amount of grain is generally accompanied by increase in the *size* of the cob on which it is borne, not only in length but also in diameter. The writer's investigations show that increased yield of grain, by actual weight, is usually accompanied by *increase* in average weight of cob. The *longest* ears, however, do not always carry the greatest amount of grain. Heavy yield does not depend entirely either on large ears or on thin cobs.

Of two ears of *equal* circumference the one with the thinnest cob is the most desirable, because it carries more grain. But a thick ear with deep grain on a thick cob is infinitely more desirable than a thin ear with shallow grain on a thin cob (Fig. 63). An ear of *Golden King* 9¼ inches long produced only 8 ozs. of grain, while an ear half an inch *shorter* produced 10·25 ozs. of grain, or 2¼ *ozs. more than the long ear. This was due entirely to the depth and weight of the individual grains.* The *cob* that produced the most grain was half an inch shorter than the other, but it was *half an inch greater* in circumference, and weighed ¾ oz. more. On a half-stand of only 4,200 bearing plants per acre this difference means an increase in yield of 3 muids per acre in favour of the thicker cob.

112. *Need for Earlier-ripening Breeds.*—An important point for consideration in the Transvaal and Orange Free State, and in the Uplands of Natal, is early maturity. On the

High-veld thousands of bags of maize are lost each year by early autumn frosts. Early spring sowing on deeply ploughed land reduces the risk of loss from this cause, but with every precaution in that direction, there is still need for earlier ripening sorts. These could be planted after the last safe date for putting in the later-maturing crops and, in this way, the total acreage for the season could be increased, for at best the planting season is short in many parts of the High-veld. Early maturing sorts would also enable the farmer to replant in cases where the first crop has been destroyed by cutworm, etc.

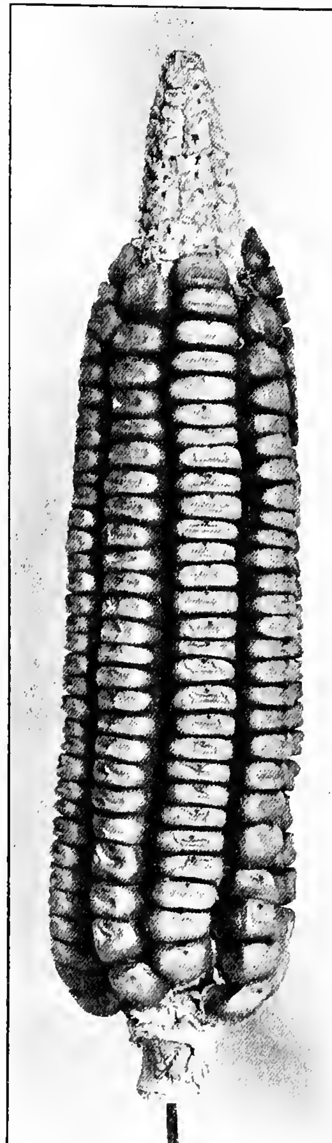


FIG. 69.—Shortening the growing season of *Hickory King*; a new 120-day type. (The bare tip is due to having given hand pollination once only.)

Unfortunately we find that early maturity is often correlated with relatively light yield. Within certain limits, however, it should be possible to correct this, that is to say, to increase the yield of the earlier maturing sorts, by careful breeding.

The Transvaal Department of Agriculture was successful in introducing and acclimatizing several sorts which take less time to mature than *Hickory King*, and these are becoming popular with farmers. Among them may be mentioned *Iowa Silver-mine*, *Chester County*, *Reid*, and *Minnesota Early*.

But the new importations do not meet the requirements of

CHAP. V. all parts of the country, and it is desirable to breed earlier-maturing strains for particular localities and special needs. That it is possible to do this has been demonstrated by the writer, who grew a *White Horsetooth* which produced a ripe ear in 97 days, and a *Hickory King* which ripened in 120 days (Fig. 69).

Although it is fully recognized that the heaviest yields of grain cannot be expected from the earliest-maturing breeds, early planting will, in many districts, do much towards minimizing loss from early frost, and there are many other parts of the country where an early maturing sort will be welcome, if for nothing else than to supplement the main crop, and thus increase the acreage.

113. *Drought Resistance.*—Although the South African climate is in the main admirably suited to maize-growing, there are districts towards the border of what we may call the Maize-belt, where the crops often suffer from the occurrence of droughty periods of perhaps twenty-one days of cloudless weather without rain. For such regions more drought-resistant breeds are required than are necessary for districts of more even rainfall.

Cultivation of many breeds, side by side, has shown a marked difference in constitutional ability to withstand drought. This difference can be made use of by breeders and emphasized. It is possible that great resistance to drought will be found correlated with lower yield, but if it enables us to produce even 6 muids to the acre where none could be grown before, it will serve a good purpose.

114. *Disease Resistance.*—Undoubtedly the parasitic diseases which affect all farm crops tend to reduce the yield, for if they do not destroy the host plant outright, the parasites use up some of the food material of the host, or interfere with photosynthesis. An important line of improvement, therefore, in cases where we cannot keep the parasite in check by cultural methods and the use of fungicides, is to breed strains which will be more or less immune against attack.

This has been successfully accomplished with some crops in some countries. But the problem is not always an easy one, and in the case of some diseases has so far failed.

Attempts were made in Java to render the maize grown there less subject to chlorosis (¶ 371) by crossing with teosinte (*Euchlæna mexicana* var. *luxurians*), with a view to adding to the maize plant the greater fertility and greater resistance to chlorosis of the teosinte. The results were not satisfactory; the first generation of hybrids resembled teosinte chiefly, but were uniform and intermediate in kind, while in the second generation all of the original characteristics had disappeared and still only intermediate forms were obtained. In the third and fourth generations marked chlorotic symptoms occurred while the fruitfulness and ear characteristics were still intermediate (*Exp. Sta. Rec.*, Vol. XXVI, p. 40, 1912).

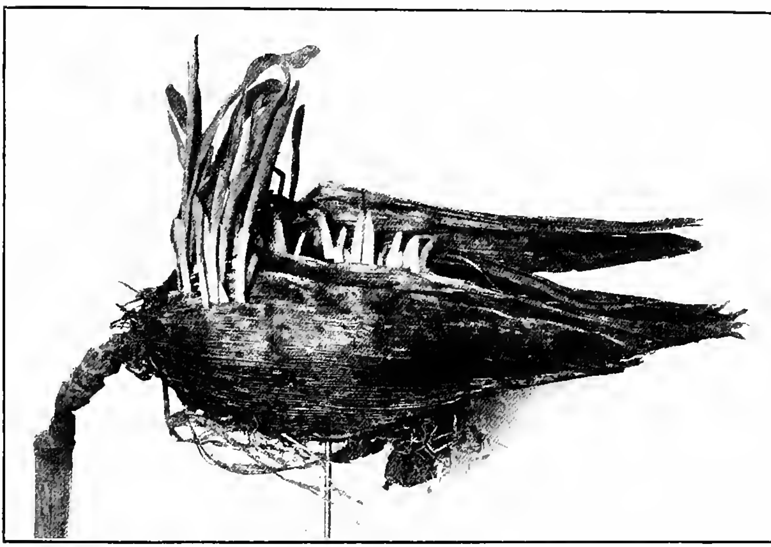


FIG. 70.—Result of weak stalk. The weakness of the stalk allowed the ear to fall to the ground before harvest; the grain then germinated with the late rains. By breeding stouter stalks this can be avoided.

115. *Loss from Weak Stalks, Shanks, or Cobs.*—The development of strains with exceptionally thin cobs and shanks sometimes results in loss. If the cob is very thin, it is apt to break in two before harvest, and part of the ear is lost. If the shank or stalk are very thin they break off with the increasing weight of the ear, often before the main crop is ripe; such ears fall to the ground and become food for rodents, or the seed germinates (see Fig. 70) and is worthless.

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116. *Necessity for the Production of Pure Seed.*—As a rule it is not desirable to export mixed grades of grain, such as mixed yellows and whites, or dents and flints. The merchant may not object, because he can always sell *cheap maize*, but the farmer is always paid less on the ground of mixed quality.

We can only avoid having mixed grain to sell, by growing pure seed. To secure this we must *plant pure seed* and take he necessary precautions to prevent it becoming crossed.

It is also necessary to reduce to a minimum the percentage of small and misshapen grains. This can be done only by the use of well-bred seed, combined with good cultivation.

If a herd of dairy cows contains some poor milkers, many moderately good, and only a few very good ones, the yield of milk and consequent profit are undoubtedly less than if all of the herd were good milkers; it costs as much to feed and look after a poor milker as a good one; a wise dairyman therefore weeds out the poor animals and buys or breeds better-class stock. It is the same with farm crops; investigations made by the writer show that even the best maize crops are usually very *impure* or heterozygous, containing many different strains; the analyses of these crops, some of which are summarized in Tables XIX to XXIX, show that the different strains of which each so-called breed is composed, vary greatly in relative productiveness. This difference in yield power is heritable.

A plant which gives a poor yield occupies as much soil surface as one which gives a heavy yield, so that it is a waste both of time and of money to use seed of a poor-yielding strain when we can grow something better.

117. *Other Desirable Points.*—There are many other points in which the maize crop may be improved. For example, scientific maize-breeders have demonstrated that it is possible to greatly change the average chemical composition of the maize-grain in starch-content, protein-content, oil-content, amount of horny endosperm, etc., to meet special trade requirements. By elaborate methods of selection and breeding, immense improvements have been effected in the United States, representing a monetary value of millions of dollars to the producing States, and amply repaying what at the time appeared to be very heavy expenditure for scientific investigation.

The following table (*Hopkins*, 2) shows the variation in results obtained on a breeding plot at the Illinois Experiment Station from seed-maize with a 7-year pedigree. CHAP. V.

TABLE XXXII.

VARIATION IN COMPOSITION AND YIELD OF DIFFERENT EARS SELECTED FOR BREEDING.

Field Row No.	Protein in Seed Ear.	Weight of Ear Corn in Crop.
	Per Cent.	Lbs.
1	12·06	91·0
2	12·17	86·0
3	12·19	98·5
4	12·26	99·5
5	12·31	77·0
6	12·40	118·0
7	12·66	116·0
8	12·83	54·5
9	12·90	107·0
10	15·78	103·0
11	12·93	87·0
12	12·90	127·5
13	12·72	113·0
14	12·45	123·5
15	12·32	103·5
16	12·31	92·0
17	12·23	85·5
18	12·18	117·0
19	12·07	140·5
20	12·06	97·0
Average . .	12·59	101·9

The protein-content varied in the parent ears from 12·06 to 15·78 per cent and the weight of ear-maize in the crop from 54·5 lbs. to 140·5 lbs.

Such improvements are also needed in South Africa, and would help her to meet the requirements of particular markets, especially when she develops her own factories for the local manufacture of articles now imported by her. The question of protein-content is of especial importance to compound managers as well as to stock feeders; it is believed that a higher proportion of protein would materially affect the efficiency of the native workers on the mines.

118. *Necessity for Development of New Breeds.*—After testing in South Africa scores of the best breeds of maize grown in the United States, Canada, Mexico, Bolivia, Chile, Peru,

CHAP. V. Argentina, France, Italy, the Balkans, India, Australia, Egypt, Somaliland, Nyassaland, and all the breeds and strains commercially grown in different parts of South Africa, the writer has reached the conclusion that none of them gives the best results which it is possible to obtain under South African conditions, and that it is necessary to breed improved types which will meet the varying conditions of different parts of the country, and combine high yield with market requirements. A good market has been established for South African maize, and the country must see to it that it is kept supplied with a steadily increasing quantity of grain suited to its various demands.

Inheritance of Characters.

119. *Fluctuations.*—There are some plant-characters, such as relative height of stem, number of leaves, size of leaf, length of ear, etc., which are not stable, but are more or less influenced by conditions of environment such as richness or poverty of soil, sufficiency or lack of moisture, temperature, and sunshine. These have been termed *fluctuations*, and "we have no valid reason for supposing that they are ever inherited" (*Punnett*, I, p. 133). Such variations have also been called "*acquired characters*". They are not to be confused with mere *mutilations*, due to borer, hail, smut, etc., which are not known to be transmitted.

120. *Heritable Characters.*—There are other characters, such as colour and shape, flintness or dentness of grain, which are not dependent for their manifestation on the influence of environment. These are transmitted from parent to offspring. When such a character affects the vegetative part of a plant, as for example the height of the stem, number or breadth of leaves, etc., it may be difficult to tell whether it is a fluctuation or a heritable character, except by growing it on for one or two generations.

121. *Importance of a Knowledge of the Laws Governing the Transmission of Characters.*—Improvement by scientific breeding must depend on a knowledge of the laws and methods of the transmission of characters from parent to offspring, inasmuch as such knowledge will (1) prevent the selection of parents unfitted to produce definite desired results; and (2)

enable us to "fix" a new type when we get it. "Choose your parents" is the axiom of the successful breeder. It is true that considerable success has in the past been achieved by empirical mating; but it does not advance the farmer far, and at best it is but a slow, risky, and expensive means of attaining the desired end. CHAP. V.

The fact that maize is the basis of the agricultural wealth of a large country makes it eminently desirable that every fact about the inheritance of its characters should be learned as soon as possible. "It is only through the application of such knowledge that the present arbitrary and, in a way, unscientific methods of its improvement as an economic crop will be placed upon a definite and orderly basis" (*East* and *Hayes*, 1).

Certain phases of the question of inheritance are of definite practical agricultural interest, as, for instance, the possibility of increasing the yield of a farm crop. Other phases which are the subject of investigation by students of genetics may seem, on the surface, to be of less importance, or to have no bearing at all on practical problems. But it should be borne in mind that all problems in genetics, even though they appear to be of scientific interest solely, bring us nearer to the complete understanding of the transmission of those characters in our live stock as well as in our various crops, which are of definite importance from the financial point of view.

122. *Inheritance of Characters in Maize follows Mendelian Law.*—Different students and writers have shown from time to time that *the maize plant behaves in accordance with Mendel's laws of the inheritance of characters.* As the result of extended investigation by East and Hayes (1), these authors conclude that in the behaviour of the maize plant there is no conclusive evidence of (1) failure of segregation of the male gametes; (2) selective fertilization; and (3) partial gametic coupling; and that aberrant ratios such as have occasionally been reported (e.g. *Correns*, 3) may be due to modification by other unknown characters possessed by the parents.

"When Mendel's Law of Heredity was rediscovered in 1900, it was the general belief that it covered only a few isolated cases. Many apparent exceptions were cited. One by one, however, these exceptions have been found to yield to interpretation by simple extensions of the Mendelian nota-

CHAP. V. tion when fully understood. *In our experience*, as reported here, *no exceptions to Mendelian interpretation have been found.* Such exceptions may exist, yet it seems as unwise to say that Mendel's Law is not general as to conclude at once that it can be made to cover every possible case. One may say that Mendel's Law has covered so many cases that its generality is rendered highly probable, although insufficient genetic investigation has been accomplished to place it on equal terms with any of the great laws of physics and chemistry. Yet some of the great laws of chemistry were accepted when surrounded by seeming exceptions. Some of these exceptions have been cleared up by such recent advances as the Ionic Theory and the Phase Rule; some still remain.

"Is it not probable that other like generalities will be found in biology, which, although they may entirely change our general conception of the fundamental action of Mendel's Laws, will nevertheless leave the facts upon which it was based as useful and practicable as have been left the facts of chemical recombination in definite and multiple proportions, in the light of the Electron Theory" (*East* and *Hayes*, 1).

123. *Reproduction and Transmission of Characters.*—As already explained (¶¶ 74, 77, and 78) the higher types of plants, like animals, bear male and female organs of reproduction, and the formation of a new maize plant depends on the fertilization of a female cell by a male cell. Reproduction is effected by the union of the nucleus of the pollen grain (¶ 78) of the male flower with the nucleus of the egg-cell in the ovule of the female flower. These sexual cells, viz., the pollen grain and the egg-cell, are known as *gametes* or "marrying cells". By the fusion of the nuclei of the gametes a new cell is formed, known as the *zygote.* The zygote gives rise—by repeated cell-division, called *somatic division*—to the complete adult plant, bearing new germ-cells, which subsequently ripen into gametes, thus completing the life-cycle of the plant.

Since the gametes are the only connecting link between successive generations, each gamete carries the power of reproducing the parental characters. *If the parents are alike, and are pure-bred* (¶ 125), *the progeny will be like them.* Selection in breeding is based on the principle *that union between two of a kind produces the same kind, provided the strain is pure.*

When we plant seed of *Hickory King* maize we expect to harvest a crop of white *Hickory King*, and when we plant seed of *Yellow Horsetooth* we expect to harvest *Yellow Horsetooth* grain; in other words, we recognize that in plants, as in animals, certain characters are inherited from the parent and again transmitted to the offspring, from generation to generation. This is such a general rule that it is the exceptions to it which cause remark.

124. *Mechanism of Transmission.*—Although it is the gamete which carries the power of reproducing the parental characters, it is not yet known what part of the cell mechanism actually takes part in the process. As it is the nuclei of the two cells which unite in fertilization, they must be associated with the process of transmission. It has been suggested frequently that the chromosomes of the nucleus are the actual conveyors of the separate characters, but many botanists and geneticists see objections, apparently insurmountable, to the "chromosome theory" as it has been called, and the subject is still one of investigation. In the case of maize the small size of its chromosomes makes their study difficult, and little is known about them.

125. *The Zygote.*—The term zygote was originally applied to the single cell produced by the union of two gametes (¶ 123). But since this cell, by growth through *somatic division* (¶ 123), develops into a complete plant bearing the characters of the original zygote, the term is often extended to the plant developing from that zygote.

As the zygote may be derived either from gametes which are alike as regards contained characters, or from gametes which are dissimilar, they may be either pure-bred or cross-bred. The pure-bred zygote, formed by the union of two similar gametes, is called a *homozygote;* that derived from the union of dissimilar gametes is called a *heterozygote.*

126. *The Homozygote.*—The homozygote is the progeny of parents similar in character, it is therefore like them as regards those characters which are common to the two parents, and its progeny are also like them and continue to breed true.

It is probable that, strictly speaking, there is no such thing as a regularly domesticated plant which is homozygous (i.e. pure-bred) for all its characters. We usually use the term with

CHAP. V. reference to the most striking or important characters, and speak of a plant as being homozygous for this or for that character.

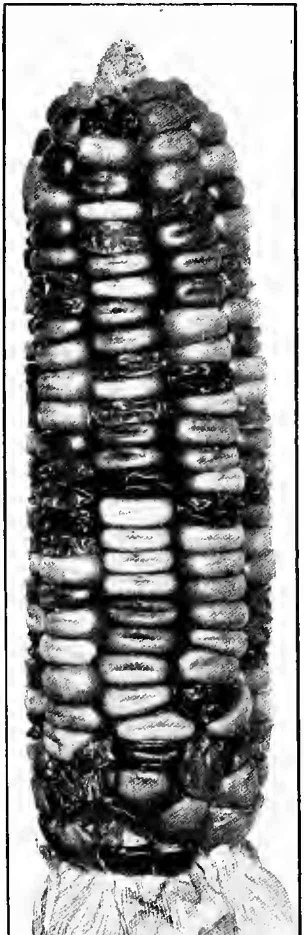

FIG. 71.—A heterozygous ear of the F_2 seed generation of a cross between black wrinkled and white dent (¶ 127).

127. *The Heterozygote.*—The heterozygote is formed by the union of gametes bearing the two characters of an *allelomorphic pair* (¶ 129). It is the progeny of parents which are dissimilar in some, or all, characters, and may be either exactly like one parent, or may have derived some visible characters from each parent, in which case it will not be exactly like either, i.e. in all its main characters.

The progeny of a heterozygote are unlike; some are more or less like one, and some like the other parent, while some are unlike either.

128. *Unit-Characters.*—We learned from the preceding chapter that in maize the two gametes or sexual cells, which unite to form a zygote, often come from separate plants. These two plants may belong to different breeds, having different characters. We know from experience that if a white dent breed is fertilized with pollen from an ordinary pure-bred yellow dent breed, the resulting grain (i.e. of the first generation) will be yellow dent, but that in the following generation some grains on one and the same ear will be white and some yellow; or that if we cross a sugar breed, having wrinkled grain, with pollen of a flint breed having rounded grain, the resulting grain will be round and flinty. That this is due not merely to what has sometimes been called "prepotency of the

male parent," is shown by the fact that if the process is reversed, i.e. if we make the *reciprocal* cross by taking the pollen from the wrinkled sugar-maize, this being then the male CHAP. V.

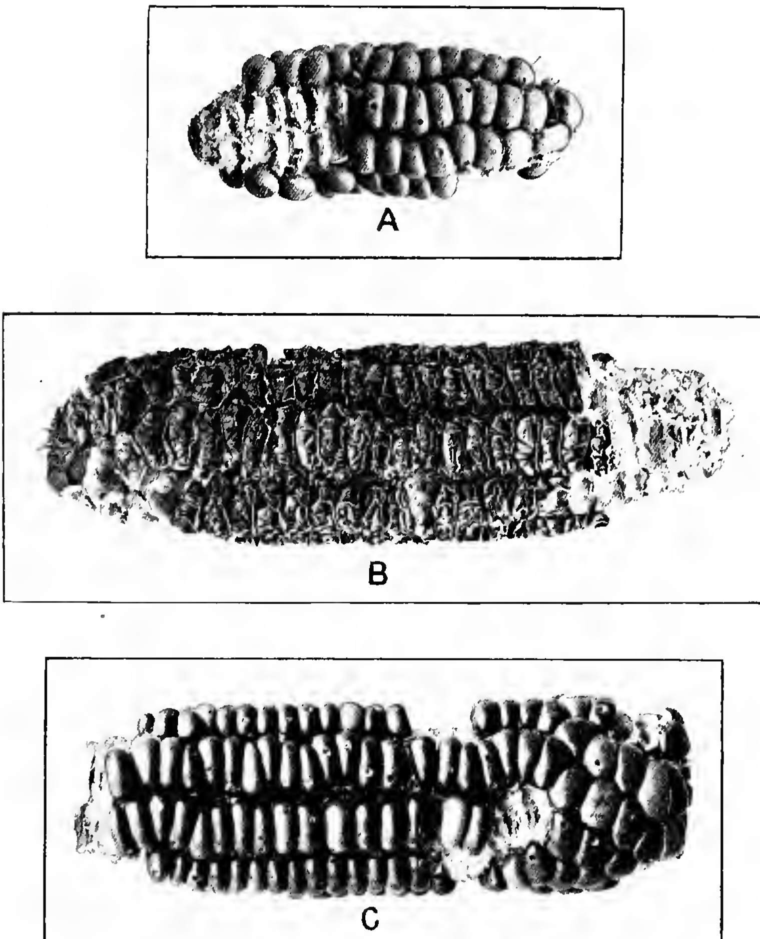

FIG. 72.—Dominance of one character from each parent, after crossing. A and B, parental ears of *Arcadia Sugar-maize*. A, White Flint; B, Black Sugar; C, Black Flint (F_1 seed generation from cross A ♀ × B ♂).

parent, the result is just the same as in the case of the direct cross, i.e. the resulting (the first or F_1) grain is round and

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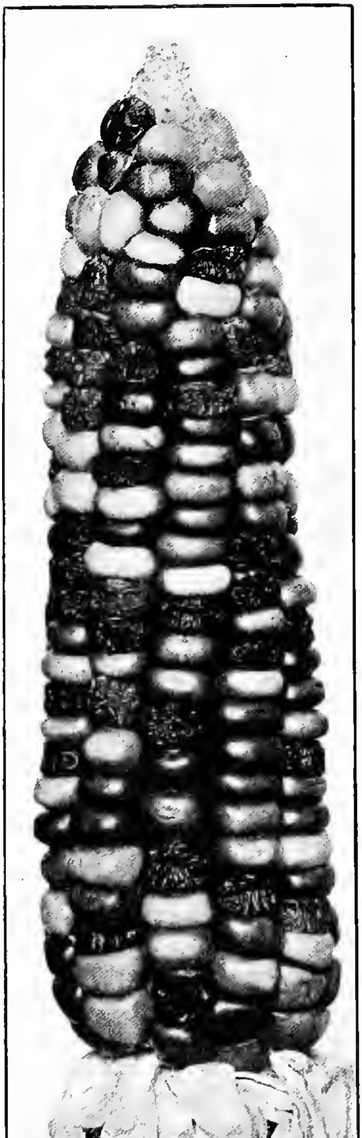


FIG. 73.—Segregation of characters in the F_2 seed generation. If the separate grains are planted and selfed they produce the nine types shown in the three following figures.

flinty. In the following (i.e. the second or F_2) generation of either the direct or the reciprocal cross, however, some grain is wrinkled and some, on the same ear, is round and flinty.

If, as a matter of further experiment, we cross a pure white flint breed (Fig. 72A) with a pure-bred black wrinkled breed (Fig. 72B), the result is still more interesting and instructive. In the first seed generation *all* the grains are *black flints* (Fig. 72C). But in the second seed generation *four* kinds of grain occur on the same ear (Fig. 73); two of them are like those of the two grandparents (i.e. the original parents used in the cross), and two (a *black flint* and a *white wrinkled*) different from either grandparent. It is evident, therefore, that the characters we have been studying in this case, i.e. blackness and wrinkledness, whiteness and flintness, may be *segregated* or separated from each other by crossing, and either transmitted independently (or re-united) as separate and independent units; they are, therefore, called *unit-characters*. The individual character of any species of animal or plant is made up of *many separate unit-characters*, and the difference between races, breeds, varieties, or species depends on the presence or absence of one or more such characters. CHAP. V.

"The demonstration that there exist definite and separable

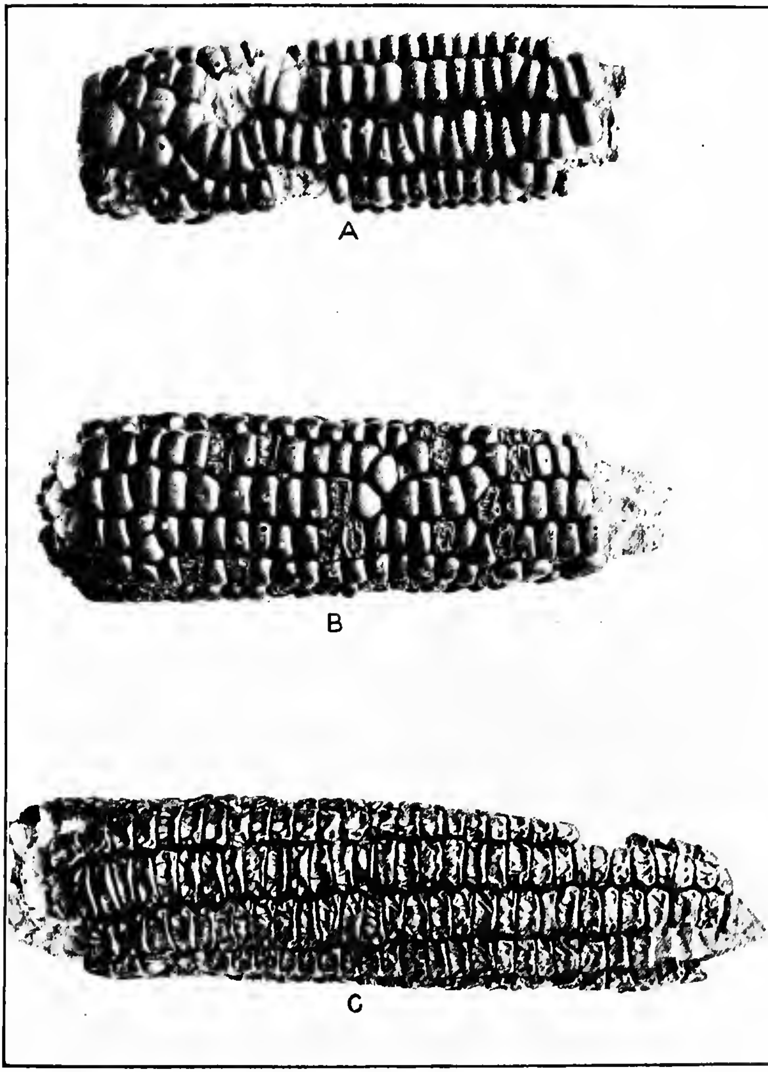


FIG. 74.—Segregation of characters in the F_3 seed generation; A, B, and C, all-black ears.

CHAP. V. unit-characters . . . is the first great debt that science owes to Mendel" (*Lock*, 1).

Segregation of unit-characters derived from the union of two dissimilar gametes cannot take place in the first (F_1) generation because only *one* zygote is formed by the union of two gametes. However if the gametes are dissimilar, the zygote is heterozygous, and in the second (F_2) generation, segregation of unit-characters does take place among the *many* newly-formed gametes of the heterozygote.

Segregation of unit-characters takes place prior to the separation of the two germinal nuclei in the pollen tube (¶ 78), since the two germinal nuclei of any pollen grain always bear the same allelomorph (¶ 129) (*Lock*, 1, p. 121).

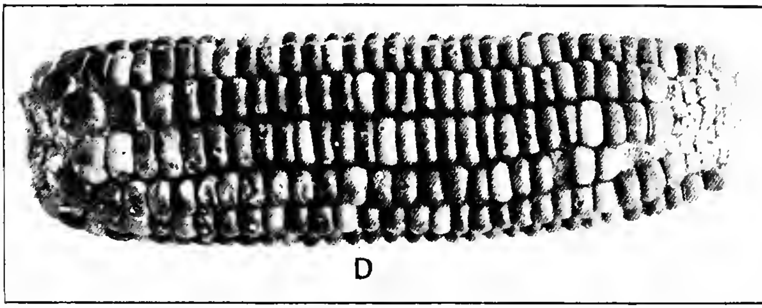
The completeness of the segregation may be still further demonstrated by planting all of the grains from the F_2 ear and *selfing* each plant. The progeny (the F_3 seed generation, borne on the F_2 plant generation) will, if there are enough of them, consist of *nine* distinct types of ear (Figs. 74, 75, and 76) as follows:—

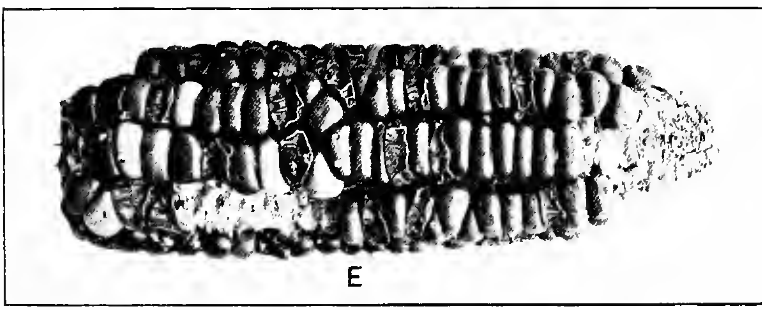
(*a*) The white wrinkled grains produce *only* white wrinkled (Fig. 76G); they are therefore recessive (¶ 129) both for whiteness and for wrinkledness, and will breed true. These are called *extracted recessives.*

(*b*) The white flints will produce *two* sorts of ear: (1) a *few* ears bearing all white flint grains (Fig. 76 I) some of which will probably breed true in the following generation; if they do, they will be pure dominants (¶ 129), called *extracted dominants;* and (2) more ears producing both white flint and white wrinkled grains (Fig. 76H) approximately in the proportion of 75 per cent of the former and 25 per cent of the latter, or 3 to 1.

(*c*) The black wrinkled grains will produce *two* sorts of ear: (1) with all black wrinkled grains (Fig. 74C) some of which will probably breed true in the following generation, in which case they will be pure dominants, also called extracted dominants. (2) Some ears will be borne which produce both black and white wrinkled grains (Fig. 75F), in the proportion of 75 per cent of the former to 25 per cent of the latter.

(*d*) The black flints will produce *four* types of ear: (1) ears like the parent ear, carrying black flint, black wrinkled, white flint, and white wrinkled grains (Fig. 75E); (2) ears with black flint and white flint grains (Fig. 75D); (3) ears CHAP. V.





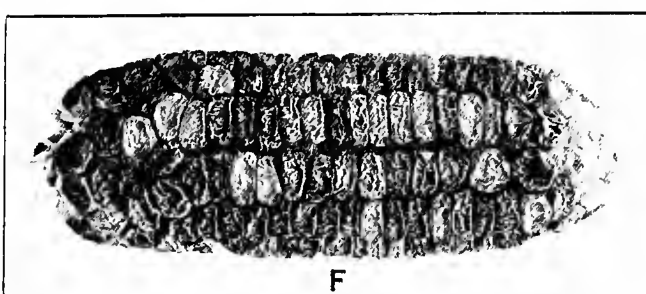


FIG. 75.—Segregation of characters in the F_3 seed generation; D, E, and F, black-and-white ears.

with black flint and black sugar grains (Fig. 74B); and (4) a few all-black flint ears (Fig. 74A); a few of these latter may breed true, being pure dominants for both blackness and flintness.

CHAP. V.

129. *Allelomorphic Pairs of Unit-characters.*—A plant either possesses a particular unit-character or does not possess it; it is either tall, or it is not tall, its grain is either blue or it

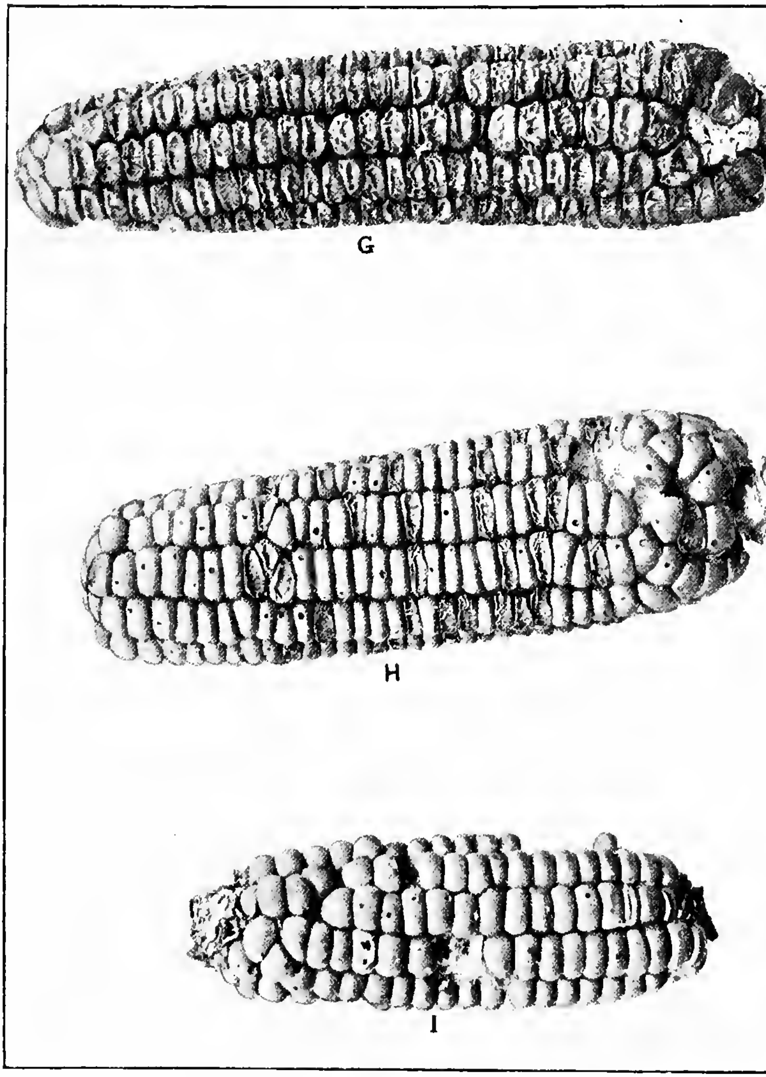


FIG. 76.—Segregation of characters in the F_3 seed generation; G, H, and I, all-white ears.

is not blue. If it is not blue, it may be white, cream, or some other colour; if it is not tall, it may be short or medium-sized. These facts have led to the concept of pairs of opposite unit-characters, known as *allelomorphic pairs*, either one, but not both of which, can be present in any *gamete*. Any one *allelomorphic pair* consists *only* of its *two allelomorphs*, i.e. characters which will not unite in the same gamete; but a *gamete* may include any number of characters which are *not allelomorphic*, i.e. not opposed to one another. The *zygote*, on the other hand, can carry both, since it is composed of two gametes each of which may contain either one of the two allelomorphs. But where each of the two parents possesses the opposite one of an allelomorphic pair of characters (e.g. blackness and absence of blackness), *both* of these allelomorphs cannot appear in the F_1 heterozygote with the same strength with which they appear in the parents; it is found that one of the two unit-characters *always* appears (Fig. 72C) to the exclusion of the other, e.g. when we crossed yellow- and white-grained types of maize the resulting grain was yellow.

The one unit-character which appears in the first filial (F_1) generation is called *dominant*, because when present it masks the other; the other is called *recessive* because it always recedes, or gives place to the dominant, when the latter is present. Bateson (1) has pointed out that dominance of certain characters is often an important but never an essential feature of Mendelian heredity; it is only a subordinate incident of special cases.

We sometimes meet with cases in which two colours appear to *merge* in the F_1 progeny, e.g. when blue- and yellow-grained breeds of maize are crossed together, the result is green; this latter is probably not a case of "incomplete dominance," but the temporary merging of two dominants belonging to different allelomorphic pairs.

From the examples cited in preceding paragraphs we learn that: (*a*) the characters of *both* parents are transmitted to the offspring, even though the two parents are very dissimilar; (*b*) if the parents are dissimilar their immediate progeny cannot be like each of them in all particulars;[1]

[1] Other experiments show that this also holds true when two *similar* parents are mated, if they are heterozygous (¶ 127), i.e. themselves the progeny of dissimilar parents.

CHAP. V. (*c*) that where unit-characters are opposed to each other, i.e. belong to an *allelomorphic pair*, only one of them appears in the immediate progeny; this does not mean that the two merge, for they segregate again in the second generation; (*d*) that parents markedly differing from each other in characters which are not allelomorphic, will, if mated, produce in the second generation offspring in which these characters will be united in combinations differing from those of either parent.

Cross-breeding is based on the principle that the union between two dissimilar plants or animals will produce something dissimilar to either, though combining some of the characters of each, as in the case of the black flint maize produced by crossing a black wrinkled with a white flint, described in ¶ 128.

"The complete segregation of the two allelomorphs in *equal* numbers of the germ cells of a heterozygote constitutes the first and most important section of the generalization known as Mendel's Law. The second part of the law refers to the fact that, as a general rule, separate pairs of allelomorphs segregate quite independently of one another" (*Lock*, 1). In other words, the gametes formed by a heterozygote contain in equal numbers the pure parental allelomorphs completely separated from one another; and if the cross-bred plant is heterozygous in respect of more than one pair of allelomorphs, then all *possible* combinations of these allelomorphs occur in equal numbers of gametes.[1]

130. *Dominant and Recessive Allelomorphs.*—The following characters in maize have been found to behave as Mendelian dominants and recessives respectively:—

Dominant:	*Recessive:*
Starchiness of endosperm.	Wrinkled (i.e. non-starchy) endosperm.
Flintness of endosperm.[2]	Dentness of endosperm.
Colour of endosperm (e.g. yellow,[3] red, purple, or black).	Absence of colour; in a starchy grain this shows as white; a non-

[1] But allowance should be made for such exceptions as occur in the case of coupling and repulsion of characters (¶ 132).

[2] In some cases observed by the writer; East and Hayes illustrate cases in which the F_1 grains were intermediate in character, and in the F_2 the flint was recessive in proportions indicating a dihybrid composition.

[3] There is a second yellow endosperm character which behaves as though its appearance were dependent on the presence of a factor for colour; in the absence of this second factor the endosperm is white.

Dominant:	*Recessive:*
	starchy grain becomes translucent and horn-coloured or creamy.
Development of "pods" around the grain.	Nakedness of grain.
Red colour of cob.	Absence of red, i.e. white.
Red silk.	Greenish white silks with or without red hairs, and white silks.
Red pericarp.	Colourless pericarp.
Green leaves.	"White" leaves, i.e. absence of chlorophyll. In this case the heterozygous plants have striped leaves.[1]
Tendency of the ear to split at the base into 2-rowed sections.	Normal type of ear.
Fasciation of the ear.	Normal shape of ear.
Presence of ligule and auricles.	Absence of ligule and auricles.

131. *Interaction of Unit-characters.*—In some cases we find that a dominant character is present, although it does not appear; to such cases the term "imperfect dominance" has sometimes been given, because it has been thought that they were cases in which the so-called "Law of Dominance" did not apply. It has been found, however, in several instances that the failure of the dominant character to appear is due to the absence or presence of some other factor on which its appearance or non-appearance depends. The phenomenon is known to occur in sweet-peas and other plants, and also among animals.

The character of flintness is present in some breeds of sugar-maize, but is unable to appear owing to the *absence* of white starch in the endosperm. In some breeds of maize two kinds of yellow colour are present in the endosperm; one of these depends for its appearance on the presence of a factor (C) for colour, though what this factor is, is not yet known; the result in this case is that by crossing two whites we obtain a yellow if each of the parents carries one of the requisite factors; this has sometimes led to the supposition that a dominant white was present (i.e., that the yellow colour was recessive). That this is not really the case is demonstrable, for by adding the factor for colour the two together are dominant over white.

[1] East and Hayes observe that several races exist in which the striping is apparently homozygous and the race breeds true.

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East and Hayes have shown that two white breeds of maize (Pc and pC), which show not the slightest trace of colour, may bring together the two factors P and C necessary for the full development of purple colour. They also refer to cases in which, owing to the presence of a certain factor, the red or purple colour of the aleurone layer is inhibited from appearing. Such cases are different from mere absence of the colour, for the colour factor is present even though not visible. The following results are obtainable by crossing between an allelomorphic pair where such an inhibiting factor is concerned:—

Male Parent.	Female Parent.	Inhibiting Factor (Present P or Absent A).	F_1 Seed.
Purple	White	A	Purple
Purple	White	P	White
White	Purple	A	Purple
White	Purple	P	White

132. *Repulsion and Coupling of Characters.*—This subject is too complex to be discussed at length here, and we cannot do better than quote a few extracts from Professor Punnett (1, pp. 81-8). "A few cases have been worked out," he says, "in which the distribution of the different factors, to the gametes, is affected by their simultaneous presence in the zygote. And the influence which they are able to exert upon one another in such cases is of two kinds. They may *repel* one another, refusing, as it were, to enter into the same gamete; or they may *attract* one another, and, becoming linked together, pass into the same gamete, as it were, by preference." In the cases of repulsion cited by him, "*the original cross was such as to introduce one of the repelling factors with each of the two parents*". But "*when both of the factors are brought into the cross by the same parent, we get coupling between them instead of repulsion.* The phenomena of repulsion and coupling between separate factors are intimately related, though hitherto we have not been able to decide why this should be so. Nor for the present can we suggest why certain factors should be linked together in the peculiar way that we have reason to suppose that they are during the process of the formation of

the gametes. Nevertheless the phenomena are very definite, and it is not unlikely that a further study of them may throw important light on the architecture of the living cell." CHAP. V.

East and Hayes report a case in which perfect coupling occurred between red cobs and red pericarp colour in their R_1 red (¶ 144), and another case in which the red pericarp colour of R_3 (¶ 144) was completely coupled with red silks; "Coupling is proved by the fact that red silks occur *without* red pericarp in other combinations". Emerson has reported (cf. *East* and *Hayes*, 1) cases in which certain red colours of maize are absolutely coupled in their inheritance, while in other cases spurious allelomorphism occurs.

133. *Xenia.*—When an ear of pure-bred white-grained maize is crossed with pollen of a pure-bred yellow-grained breed, the resulting grain is yellow, and the same result is obtained with the reciprocal cross. As this is the F_1 seed generation, and as *all* the cross-bred grains are yellow, this is not a case of segregation of a unit-character (¶ 128), but is the visible effect of the second male nucleus on the endosperm; it is called *xenia*. The term was originally proposed by Focke (1) to express the supposed influence of foreign pollen on maternal tissue. But Guignard (1) and Nawaschin (1) found that the endosperm is in reality a part of the filial generation, formed by the development of the endosperm nucleus after fusion with the second male nucleus of the pollen cell; this disposed of the only authentic examples of xenia as originally defined, and there is no further reason to use the word in that sense. But as the phenomena remain the same, the term is still used to express them.

Xenia, in the modified sense of the word, affects not only the colour, but also the chemical composition, of the endosperm; if wrinkled sugar maize is crossed with pollen of a starchy breed, the resulting grain is starchy (whether flint or dent). East and Hayes (1) find that when a flint (starchy) breed is crossed with a dent breed (also starchy) the resulting grain is intermediate, i.e. partial xenia shows in that the resulting grain may carry a slight, though often almost indistinguishable, crease.

It will be noticed that in the cases cited it is the *dominant* factor, whether carried by the male or the female parent, CHAP. V. which behaves as xenia; the reciprocal cross, in which the *recessive* allelomorph is brought in by the other parent, whether male or female, does not materially alter the endosperm. Xenia is therefore not due to the influence of *sex*, but is the immediate manifestation of the dominant character, in the F_1 seed.

Correns (1), Webber (2), and East and Hayes (1) observed several cases in which xenia occurred in only one half of the endosperm. The last two authors suggest that these rare phenomena are probably similar in nature to the gynandromorphs occurring in insects. They report having grown a number of them to see if the tendency was inherited, but without positive results. The present writer has met with a few

FIG. 77.—Grain showing part starchy and part wrinkled characters.

cases in which both the starchy and the wrinkled characters appeared side by side in the same grain (Fig. 77). These occurred on heterozygous F_2 ears, and it was therefore not possible to say definitely that they were due to xenia, but this seems to be the most probable explanation of the phenomenon.

Experiments by East and Hayes confirm the observation of Correns that in every case where xenia may be expected to occur, the seeds showing xenia were always hybrids. This fact was assumed to prove that the second male nucleus (¶ 78) always bears the same characters as the one that fuses with the egg-cell to form the embryo, and that for this reason Mendelian segregation of the gametes must have occurred previous to the division of the pollen nucleus.

It is clear that when a female flower carrying a *dominant* character such as flintness, or colour of the endosperm, is crossed with pollen from a breed carrying the *recessive* allelomorph, it may be impossible to detect that a cross has taken place. CHAP. V.

There are cases, however, in which the recessive allelomorph does modify the dominant, behaving as xenia. In some breeds of dent maize, where there is a large area of crown starch (see chapter XIII. ¶ 608), the yellow when crossedwith white becomes somewhat lighter, xenia appearing as a cap of lighter colour than the homozygous yellow. In some breeds, e.g. *Chester County*, the modification of colour varies in degree; some grains have a distinct white cap, others are quite unchanged, and among the remainder numerous intermediate shades occur (Fig. 78B). Where the crown starch is plentiful in the white-grained female parent, xenia may only affect the body of the grain, leaving the white crown-starch unchanged (Fig. 78A).

When yellow-grained breeds of flour corn (var. *amylacea*) are crossed with pollen of white-grained breeds of the same variety, the lighter colour of the heterozygote is not confined to the cap, but extends throughout the endosperm. "In this case difference in colour is always great enough to be noticed by a careful observer, in either cross" (*East* and *Hayes*, 1).

In the flint and pop varieties, having corneous endosperm, colour occurs as xenia, as a rule, only when the female parent carries the recessive character. But even here, East and Hayes have found exceptional cases in which a few heterozygous yellows were distinguishable from homozygous yellows when the female parent bore the dominant character.

Both red and purple colour of the aleurone layer are completely dominant, and xenia occurs only when they are transmitted by the male parent.

East and Hayes also find that in the case of Pc or pC, as described in ¶ 131, purple appears as xenia when either of them is the female parent. The writer has found what appears to be a similar case, in the second (i.e. paler) yellow colour which occurs in some breeds of maize, but further evidence is required to demonstrate the actual facts of the case.

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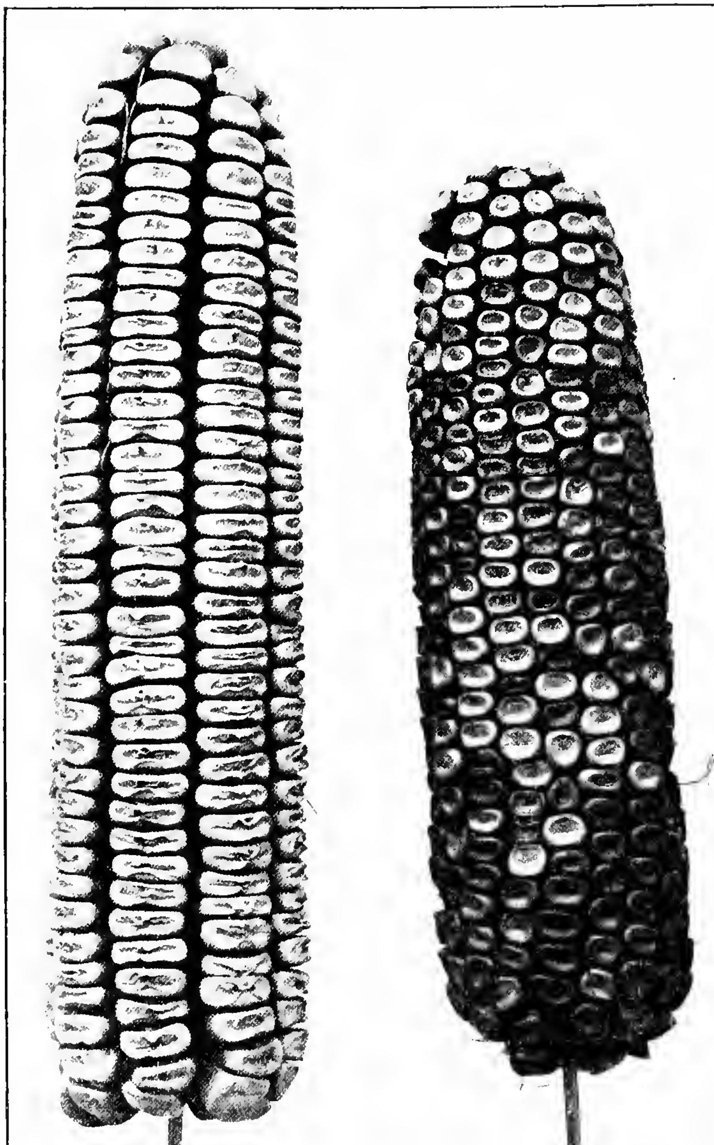

A B

FIG. 78.—Xenia. A, effect of "yellow" pollen on white *Hickory King* (the yellow colour is indicated by the dark shade in the sulci). B, effect of "white" pollen on yellow *Chester County*.

When a purple is crossed with white, the resulting grain may be white. Xenia results when an inhibiting factor (¶ 131) occurs to prevent the appearance of colour. East and Hayes's explanation of this phenomenon shows that it does not, as has been suggested, indicate dominance of whiteness. These authors also found cases in which the purple is not fully inhibited, and then a *light* purple results, whichever parent carries the colour.

Our knowledge of xenia in maize may be summarized as follows:—

(1) *When the parents of a heterozygote differ in a single visible endosperm character in which dominance is complete, the pollen only produces xenia when it carries the dominant allelomorph.*

(2) *When the parents differ in a single visible endosperm character in which dominance is incomplete, the pollen produces a modifying effect on the visible strength of the dominant allelomorph.*

(3) *When each parent carries one of two characters the union of both of which is necessary to render the other visible, the pollen also produces xenia when it carries the factor necessary to render visible the dominant allelomorph borne by the female parent.*

(4) *When the pollen parent bears the recessive allelomorph, full xenia does not result, though in some cases a partial effect may be produced.*

Xenia does not appear to affect the shape or size of the grain, as these are plant characters; in crosses between two dent breeds of the same colour, but which differ in shape and size of grain, no difference has been detected in the first ear produced.

From the foregoing it is clear that though xenia, i.e. the effect of pollen on the F_1 seed generation, may in some cases be useful as an indication that crossing has taken place, the absence of xenia *cannot be relied upon to indicate that crossing has not taken place*; *in many cases, therefore, the hand-picking of seed-grain is useless* as a means of entirely eliminating the effect of crossing.

134. *Splashed Purple Colour of Aleurone Layer.*—The cause of the occurrence of *splashed* purple colour in the aleurone layer has long been a subject of speculation and investigation,

CHAP. V. and various theories have been proposed to account for it. Webber (1) thought that it might be due to mosaic development of cell descendants of the endosperm nucleus and of the second male nucleus. East and Hayes, on the other hand, attribute it to incomplete dominance caused by other factors, arguing that if it were due to mosaic development the same cause would act in the case of heterozygous yellow endosperm, whereas "such cases have never been reported".

135. *Gametic Segregation.*—The heterozygous maize plant obtained by the crossing of male and female gametes produces flowers, and these develop new gametes, approximately 1,000 female (egg-cells) and several thousand times as many male (pollen grains). The new gametes are formed by the division of a primitive cell into pairs of daughter cells; this process is constantly repeated till the requisite number is reached.

In this cell-division for the formation of new gametes, the constituent dominant and recessive characters of any one allelomorphic pair (such as yellowness and absence of yellowness) both of which were present in the heterozygous mother cell, do not pass into the daughter cells in combination, but the dominant passes into one gamete (e.g. either a pollen grain or an egg-cell) and the recessive into the other (e.g. either an egg-cell or a pollen grain), so that each gamete contains only one of an allelomorphic pair of characters, i.e. it is *pure* for that character.

As regards any one allelomorphic pair of characters, e.g. yellowness and absence of yellowness, a heterozygous plant produces gametes of only two kinds, dominant (yellow) and recessive (non-yellow) and produces them in equal numbers; thus the heterozygous maize plant would produce approximately 500 ovules carrying the dominant, and 500 the recessive character, while of its pollen grains one half (say a million) would contain the dominant and an equal number the recessive. But we find that a heterozygous parent does not produce an equal number of dominants and recessives; instead we get for every three showing the dominant only one showing the recessive character. Let us see why this is.

136. *The Reason for Segregation in Definite Mathematical Ratios.*—We have seen that half of the pollen grains of a heterozygote contain the dominant character and half the

recessive (¶ 135), and that the same applies to the ovules. The chances are therefore equal that if the heterozygote is self-pollinated, as much pollen containing the dominant character will fall on "dominant" silks as pollen containing the recessive character falls on "recessive" silks, the result being progeny homozygous for the dominant and for the recessive characters respectively. But there is equal probability that some pollen with the dominant character will fertilize ovules bearing the recessive character, and vice versa, the net result being the same in either case, i.e., the production

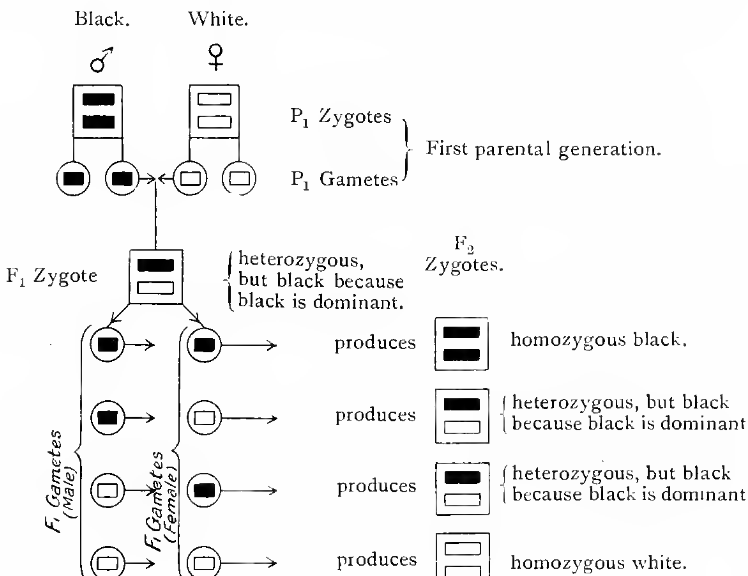

FIG. 79.—Diagram to illustrate segregation of characters.

of a new heterozygote. Thus the chances are equal whether the progeny will be heterozygous or homozygous. In practice we find that about 50 per cent of the progeny of a heterozygote are also heterozygous (if the total number is sufficiently large); the other 50 per cent are homozygous, one half of them being like the dominant grandparent and the other half like the recessive grandparent. But as all the heterozygotes contain the factor which is dominant, and as the essential feature of dominance is that it masks the presence of the recessive, we

CHAP. V. find all of the heterozygotes (i.e. 50 per cent of the total) as well as half of the homozygotes (i.e. an additional 25 per cent of the total, making *75 per cent in all*), *showing the dominant character*. This explains why we get *three* dominants to *one* recessive in the F_2 generation. This is illustrated in Fig. 79.

This is known as a *monohybrid ratio* because only one pair of allelomorphs is concerned.

The occurrence of definite mathematical ratios is a useful guide in the breeding of animals and plants, as it indicates the dominant and recessive factors, respectively, and which of the progeny of a heterozygote will breed true.

137. *The Monohybrid Ratio.*—The notation usually adopted to indicate this ratio is 1 : 2 : 1 or 25 : 50 : 25 per cent, which indicates that there is 1 dominant homozygote to 2 heterozygotes and 1 recessive homozygote; it is often referred to as the 3 : 1 ratio, because there are three zygotes in which the dominant character is visible, to one in which it is absent. This ratio is due to the fact that where only one allelomorphic pair (Aa[1]) is concerned in the cross, there are only four possible zygotic combinations of the characters involved, i.e. AA, Aa, aA, and aa.

If, instead of selfing the heterozygote Aa it is re-crossed with either of the homozygous parental types (AA or aa) we naturally get a different ratio, for the homozygous parent carries only one of each of the allelomorphs; if Aa is crossed with AA for instance, it produces AA and aA in equal proportions; or 50 per cent homozygous for the dominant character, and 50 per cent heterozygous. Or if Aa is crossed with aa it produces Aa and aa in equal proportions; or 50 per cent heterozygous, and 50 per cent homozygous for the recessive character.

138. *Dihybrid Ratios.*—Where, however, *two* allelomorphic pairs (e.g. Aa and Bb) enter into the cross, there will be sixteen possible combinations of their four allelomorphs. When gametic segregation takes place in the heterozygote AaBb, the chances of B being distributed to a gamete containing A, or a, are equal; hence the gametes containing B will be of two sorts, AB and aB; so, also, the gametes without B will be of two sorts bA and ba, and these will be produced in equal

[1] A convenient notation, A = the dominant; a, the recessive allelomorph.

numbers. The heterozygous plant therefore gives rise to ovules comprising equal numbers of gametes of the four different types AB, Ab, aB, and ab, and also to pollen grains comprising the same four types. When the heterozygous plant is self-pollinated, an ovule of any one of these four types has an equal chance of fertilization by a pollen grain containing any one of these four types. The result is mechanically demonstrable by the "chess-board" method of plotting, as shown in Table XXXIII. Each of the four terms AB, Ab, aB, and ab of the gametic series, is first written four times horizontally across the table, from left to right; it is then written four times vertically, from top to bottom, care being taken to follow the same order. In this simple mechanical way all the possible combinations are represented, and in their proper proportions.

The following are the possible combinations in which the gametes would segregate in a dihybrid:—

Table XXXIII.

DISTRIBUTION OF GAMETES IN A DIHYBRID.

{ AB AB	{ AB Ab	{ AB aB	{ AB ab
{ Ab AB	{ Ab Ab	{ Ab aB	{ Ab ab
{ aB AB	{ aB Ab	{ aB aB	{ aB ab
{ ab AB	{ ab Ab	{ ab aB	{ ab ab

Summary:

AABB	= 1 AB
AABb + AAbB	= 2 ABb
AAbb	= 1 Ab
AaBB + aABB	= 2 AaB
AaBb + AabB + aABb + aAbB	= 4 AaBb
Aabb + aAbb	= 2 Aabb
aaBB	= 1 aB
aaBb + aabB	= 2 aBb
aabb	= 1 ab

Thus there are nine cases in which both dominants (A and B) meet; three contain the dominant A, without B; three contain B without A, and one carries the two recessives *a* and *b*, without either dominant. This gives the ratio:—

9 : 3 : 3 : 1 :
or 56·25 : 18·75 : 18·75 : 6·25 per cent.

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When this ratio is met with in a heterozygous family, we conclude that we are dealing with a *dihybrid.*

The following example of a dihybrid cross (ear 1,157) between a white wrinkled and a red starchy maize is taken at random from among the writer's records:—

TABLE XXXIV.

ANALYSIS OF A DIHYBRID CROSS BETWEEN WHITE WRINKLED AND RED STARCHY MAIZE.

	Starchy.		Wrinkled.		Total.
	Red.	White.	Red.	White.	
	15	7	7	2	31
	16	6	10	1	33
	18	3	8	3	32
	17	9	4	1	31
	16	8	4	4	32
	19	4	4	4	31
	19	4	6	3	32
	14	9	5	2	30
	14	7	7	1	29
	18	5	6	2	31
	19	4	7	0	30
	17	7	4	3	31
Total	202	73	72	26	373
Average per row	17	6	6	2	31
Per cent	54·16	19·57	19·30	6·97	—
Mendelian expectation	56·25	18·75	18·75	6·25	—

139. *Trihybrid Ratios.*—Crosses are met with in which a third factor, which we may designate as C, has an influence on the second factor B, so that when the two meet they produce colour, but when *either* is absent, the appearance is the same as though *neither* was present. In such cases we get the ratio 48 : 9 : 7. By growing on the seven recessives we find that they are not homozygous, but consist of 3 B, 3 C and 1 abc, the latter only (i.e. $\frac{1}{64}$ of all) a pure recessive; the actual ratio is therefore :—

48 : 9 : 6 : 1

or

75 : 14·0625 : 9·375 : 1·5625 per cent.

When three allelomorphic pairs (e.g. Aa, Bb, and Cc) enter into the cross, there are sixty-four possible combinations of these characters. In such a cross the results will be :—

ABC	27			
ABc	9			
	— = 36 AB			
Abc	3			
AbC	9			
	— = 12 Ab	= 48 with A		
aBC	9			
	— = 9 BC			
aBc	3			
abC	3			
	— = 6 B or C	= 15	,,	BC, B, or C
abc	1	1	,,	abc
	64	64		

The distribution of the gametes is shown in Tables XXXV, XXXVI and XXXVII following.

Table XXXV.

DISTRIBUTION OF THE GAMETES IN A TRIHYBRID CROSS.

ABC ABC	ABC ABc	ABC AbC	ABC Abc	ABC aBC	ABC aBc	ABC abC	ABC abc
ABc ABC	ABc ABc	ABc AbC	ABc Abc	ABc aBC	ABc aBc	ABc abC	ABc abc
AbC ABC	AbC ABc	AbC AbC	AbC Abc	AbC aBC	AbC aBc	AbC abC	AbC abc
Abc ABC	Abc ABc	Abc AbC	Abc Abc	Abc aBC	Abc aBc	Abc abC	Abc abc
aBC ABC	aBC ABc	aBC AbC	aBC Abc	aBC aBC	aBC aBc	aBC abC	aBC abc
aBc ABC	aBc ABc	aBc AbC	aBc Abc	aBc aBC	aBc aBc	aBc abC	aBc abc
abC ABC	abC ABc	abC AbC	abC Abc	abC aBC	abC aBc	abC abC	abC abc
abc ABC	abc ABc	abc AbC	abc Abc	abc aBC	abc aBc	abc abC	abc abc

The above "chess-board" is classified in Table XXXVI following:—

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TABLE XXXVI.

CLASSIFIED SUMMARY OF TABLE XXXV.

							Per Cent.		
AABBCC		1	—	—	—	1	1·5625		
AABBCc + cC		2	—	—	—	2	3·125	4	
AABBcc		1	—	—	—	1	1·5625		
						4			
AABbCC	+ bB	1	1	—	—	2	3·125		
AABbCc + cC	+ bB	2	2	—	—	4	6·250	8	16
AABbcc	+ bB	1	1	—	—	2	3·125		
						12			
AAbbCC		1	—	—	—	1	1·5625		
AAbbCc + cC		2	—	—	—	2	3·125	4	
AAbbcc		1	—	—	—	1	1·5625		
						16			
AaBBCC	+ aA	1	—	1	—	2	3·125	8	
AaBBCc + cC	+ aA	2	—	2	—	4	6·250		
AaBBcc	+ aA	1	—	1	—	2	3·125		
AaBbCC	+ bB + aA	1	1	1	1	4	6·250		
AaBbCc + cC	+ bB + aA	2	2	2	2	8	12·500	16	32
AaBbcc	+ bB + aA	1	1	1	1	4	6·250		
AabbCC	+ aA	1	—	1	—	2	3·125		
AabbCc + cC	+ aA	2	—	2	—	4	6·250	8	
Aabbcc	+ aA	1	—	1	—	2	3·125		
						48			
aaBBCC		1	—	—	—	1	1·5625		
aaBBCc + cC		2	—	—	—	2	3·125	4	
aaBBcc		1	—	—	—	1	1·5625		
aaBbCC	+ bB	1	1	—	—	2	3·125		
aaBbCc + cC	+ bB	2	2	··	—	4	6·250	8	16
aaBbcc	+ bB	1	1	—	—	2	3·125		
aabbCC		1	—	—	—	1	1·5625		
aabbCc + cC		2	—	—	—	2	3·125	4	
aabbcc		1	—	—	—	1	1·5625		
						64	100·0000	64	64

TABLE XXXVII.

SUMMARY OF TABLE XXXVI.

		Per Cent.	
ABC	27 =	42·1875	
AB	9 =	14·0625	
AC	9 =	14·0625	
A	3 =	4·6875	
			48 = 75·0
BC	9		9 = 14·0625
B	3 =	4·6875	
C	3 =	4·6875	
abc	1 =	1·5625	
			7 = 10·9375
			64 = 100

It is conceivable that there might be other interactions of factors in a trihybrid combination of this character, which would give quite different Mendelian ratios; for instance if A were only visible in the presence of C we should have a ratio of— CHAP V.

36 AC : 21 B : 3 A : 3 C : 1 abc

of which A and C might conceivably give the same appearance as abc, giving an apparent ratio of 36 : 21 : 7.

Bateson gives the following scheme by which the number of types, and the ratios in which each will appear, is given for any number of pairs of factors, one factor of each pair being dominant and the other recessive.

$$
\begin{aligned}
4 &= 3 + 1 \\
16 &= (3 + 1)^2 = 3^2 + 3 + 3 + 1 = 9 + 3 + 3 + 1 \\
64 &= (3 + 1)^3 = 3^3 + 3 \cdot 3^2 + 3 \cdot 3 + 1 = 27 + 27 + 9 + 1 \\
256 &= (3 + 1)^4 = 3^4 + 4 \cdot 3^3 + 6 \cdot 3^2 + 4 \cdot 3 + 1 \\
&= 81 + 27 + 27 + 27 + 27 \\
&\quad + 9 + 9 + 9 + 9 + 9 + 9 \\
&\quad + 3 + 3 + 3 + 3 \\
&\quad + 1.
\end{aligned}
$$

So in general

$$
\begin{aligned}
4^n = 3^n & \\
+ 3^{n-1} + 3^{n-1} + & \ldots\ldots \; n \text{ times} \\
+ 3^{n-2} + 3^{n-2} + & \ldots\ldots \; \tfrac{1}{2}n(n-1) \text{ times} \\
+ 3^{n-3} + 3^{n-3} + & \ldots\ldots \; \tfrac{1}{6}n(n-1)(n-2) \text{ times.} \\
+ \text{etc.} &
\end{aligned}
$$

140. *Inheritance of Colour.*—There are several different colours in the maize grain, and also in the vegetative part of the growing plant, which behave as separate allelomorphic pairs, transmissible independently. In a few cases coupling of allelomorphs appears to take place. Owing to the different behaviour of these several colours it will be convenient to discuss them separately.

141. *Yellow Endosperm.*—Yellow colour of the endosperm and its absence behave as an allelomorphic pair.

Shull, East and Hayes, and the present writer have found two kinds of yellow each of which behaves with its opposite as an independent allelomorphic pair. One of these (the darker yellow) gives the Mendelian ratio 1 : 2 : 1; the other (the paler) gives the ratio 9 : 3 : 3 : 1. In some cases the latter is so faint as to be easily overlooked in a poor light, and has been mistaken for a "dominant white". If non-yellows breed true

CHAP. V. in the F_3 generation, they are usually considered pure (*East and Hayes*, 1), but if the absence of yellow is due to the absence of a factor on which the appearance of colour depends, they may, even though heterozygous, continue to breed white until crossed with another white carrying the complementary factor, when yellow will appear. The relative amount of soft and horny starch contained in the seed is one cause of varying intensity of the yellow colour in F_2 crosses between yellow and white.

East and Hayes appear to have found six shades of yellow in the progeny of a cross between yellow and white maize, for they observe that "in the case of the two yellow colours in the maize endosperm, the intensity of the yellow decreases in the following order:—

$Y_1\,Y_1\,Y_2\,Y_2$
$Y_1\,y_1\,Y_2\,Y_2$ or $Y_1\,Y_1\,Y_1\,y_2$
$Y_1\,Y_1$ or $Y_2\,Y_2$
$Y_1\,y_1$ or $Y_2\,y_2$
$y_1\,y_1\,y_2\,y_2$ [i.e. pure white ?]"

The present writer has found six shades of yellow in the F_2 seed generation, and ten shades in the F_3 seed generation after crossing with white. The two yellows already referred to are involved in the production of these shades, and there is a distinct break in the gamut of tints between what appears to be the palest of No. 1, and the darkest of No. 2.

142. "*White Starchy*" *Endosperm.*—This was shown to be a Mendelian dominant by Correns in 1901, and confirmed by Lock in 1904, and later by the writer and by East and Hayes working simultaneously though unknown to each other. East and Hayes found that dominance was complete; in no case was there the slightest difference between the homozygous and the heterozygous seeds in either outward appearance or in the character of the starch cells when examined microscopically.

143. *Inheritance of Characters which Affect the Growing Plant.*—The characters which we have been discussing are those which affect the endosperm, and are therefore visible in the daughter seeds of the ear that has been crossed, i.e. the first new generation. There are other characters, however, affecting the growing plant, which do not show in the seed. These will be discussed seriatim.

144. *Pericarp Colour.*—The colour of the maize-grain is sometimes found in, and confined to, the pericarp; in such cases this is readily demonstrated by soaking the grain in water until the pericarp can be peeled off without removing the aleurone layer. The red striped *Cusco* flour corn is a case in point; we also meet with sporadic cases of red ears appearing unexpectedly in crops of white breeds, which, on examination, prove to be cases of red pericarp colour.

The pericarp of the grain belongs to the parental, and not to the filial, generation; it is part of the female plant parent. The pollen grain therefore does not produce xenia in the pericarp. Thus if a white breed is crossed with pollen of a breed with red pericarp colour, the resulting grain (F_1 seed generation) will not show the red colour, though this will appear in the second (F_2 seed) generation.

The present writer has found four distinct red pericarp colours, and East and Hayes describe five, which they call R_1, R_2, R_3, R_4, and R_5.

R_1.—An ordinary dark red pop-corn; glumes of male florets sometimes reddish, but neither cobs nor silks red. Crossed with white it gave 75 R and 22 W ears in the F_2 generation, the reds being all dark and the whites showing no trace of colour. The writer has met with a red pop, answering to this description, in South Africa.

R_2.—A dark mosaic red, occurring as irregular red stripes radiating from the point where the silk was attached. A similar red occurs in South African maize.

R_3.—A dirty red colour, more abundant at the base of the seed and almost wanting at the summit; it appears to be coupled with red silks. The dye occurs in small amounts. "It is almost certain that this red forms an allelomorphic pair with its absence, that is entirely independent of R_1, R_2, and R_4."

R_4.—A rose-red, which "develops only in the presence of light, hence the ears with thick husks show the colour but faintly. When the husks are stripped away and the ear matures in full sunlight, the colour appears over the entire ear as a bright rose-red." Red was not present in other parts of the plants grown. A rose-red answering this description occurs also in South Africa, where it threatens to give some trouble to growers.

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R_5.—A rose-red resembling R_4, but occurring in lesser amounts, and on thick-husked ears only detected by very careful examination. It behaves with its absence as a separate allelomorphic pair to R_4.

R_6.—Is a dark red pericarp colour of sugar maize, from an ear of unknown parentage, found by the writer in South Africa. The combined red colour and wrinkled endosperm tend to give the impression of dried raisins.

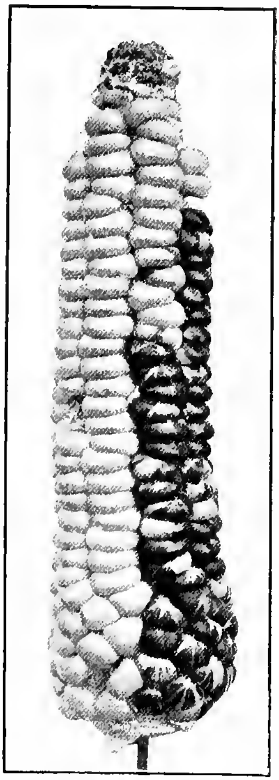

FIG. 80.—Somatic variation in pericarp colour.

145. *Somatic Variation in Pericarp Colour.*—Cases not infrequently occur in which an ear in a crop of white develops red pericarp on one side, or part of one side, of the ear, and white, or white striped with red, on the other side or part of that side (Fig. 80). Such cases have been attributed by East and Hayes to bud variations similar to those which occur in perennial garden plants, and also, though less frequently noticed, in annuals. In such cases the plant due to produce a red ear varies somatically so that one part of the ear becomes red and the rest white or striped. In a case which they record, this variation was transmitted by the seeds.

146. *Silk-colour.* — Maize silks vary from almost colourless, through cream and green, to dark red. Sometimes the style itself is red, sometimes only the hairs on the style. Sometimes the colour of the silk is coupled with that of the pericarp, and perhaps also with colour in the glumes. But redness of the silk occurs commonly when the cob and pericarp are not coloured. According to East and Hayes, study of the transmission of this colour character is obscured by the action of the bag over the ear to be hand-pollinated, which prevents the full development of the

red colour by shutting out the light, so that it is difficult to tell whether the F_1 silks which are selfed are full red, or only red-haired.

147. *Red Cob-colour.*—Experiments conducted by the writer (and it appears, simultaneously by East and Hayes (1)), show that red cob-colour is dominant to white cob-colour, and behaves as a simple monohybrid. These authors suggest that "it is not beyond probability" that dihybrid reds may be found in an extensive series of crosses. Cob-colour is not necessarily coupled with red endosperm colour, for red cob-colour is not infrequently found in a white-grained breed, e.g. *Hickory King*, which normally produces white cobs. Many yellow-grained breeds have red cobs, but white-cobbed ears are often found amongst them; other yellow-grained breeds normally have white cobs, but red-cobbed ears are occasionally found amongst them. East and Hayes record a case in which perfect coupling occurred between red cobs and red pericarp colour.

148. *Glume Colour.*—The glumes often carry red colour, and vary considerably in the amount of redness present; sometimes it is confined to very narrow or broader streaks along the nerves. Glume colour appears to be correlated with colour in other parts of the plant, for East and Hayes state that they have not yet found a plant which has red glumes and yet shows no red colour in other parts of the plant, though one has been found that is pure for red glumes and yet shows no red in other parts with the exception of the silks.

149. *Development of "Pods".*—Pod maize (Fig. 51) when crossed with breeds free from pods, behaves as a simple Mendelian monohybrid. The podded character is dominant, and appears in the F_2 generation in the proportion of 3 to 1; the extracted recessives breed absolutely true (*East* and *Hayes*, 1).

150. *Inheritance of Ligule and Auricles.*—Emerson (1) finds that absence of ligule and auricle behaves as a recessive to presence of these organs, and that they are transmitted as a single hereditary character. Four liguleless plants, crossed with unrelated normal-leaved plants, produced 103 F_1 individuals, all with normal leaves. Twelve of the latter were selfed, and produced 748 F_2 plants, of which 572 had normal leaves and 176 had no ligules, or practically a 3 : 1 ratio. Counting together all families in which both types of leaf occurred, he

CHAP. V. obtained a total of 672 normal-leaved and 221 liguleless-leaved plants; to have given as nearly a 3 : 1 ratio as possible the respective numbers would only have to be changed to 670 and 223.

151. *Physical Condition of the Starch.*—Presence and absence of starch, as we have already seen, behaves as a Mendelian allelomorphic pair; the presence of starch is a filial character, and shows as xenia in individual seeds. East and Hayes find, however, that the physical condition of the starch behaves as a plant character affecting the whole ear:—

"The characters which give the flint or the dent appearance to maize are transmitted as plant characters to the entire ear and not as endosperm characters to the seed. They conform to the essential feature of Mendelism by showing segregation; and they are due to the action of more than one transmissible character. The question remains, can any or all of these characters be named? Our experience suggests that the proportion of corneous starch to soft starch depends partially upon size and shape of the pericarp, and upon the number of rows per ear. . . . There is also some relation between the size of the plants and the amount of soft starch in their seeds. . . . Relationship between the physical character of the starch and shape of pericarp is much more intimate than it is between the former and size characters. . . . The shape of the pericarp depends somewhat on the number of rows, as the greater this number the more the seeds are crowded together and thus lengthened. . . . These relationships may simply be correlations and not direct causes of the proportion of corneous starch to soft starch that exists in various strains of corn. But even if they were directly concerned, they could not account for the large number of differences in varieties, for none of the correlations are sufficiently high. Many other characters, the exact nature of which is unknown, must be concerned in the matter. The simplest interpretation . . . seems to be the interaction of independent allelomorphic pairs, of the nature reported by Nillson-Ehle (1) and East (4) in earlier papers."

152. *Size Characters.*—Among size characters are included: height of plant, number and length of internodes, thickness of stem, breadth and length of leaf, length of sheath, length of ear, number of rows per ear, thickness of cob, size of seed, etc.

In the maize plant the factors which interact to cause the transmissible differences in the size of the organs are very complex, as has been pointed out by East and Hayes, who refer to the consequent difficulty of working out in detail their inheritance.

"It is perfectly obvious to one familiar with the maize plant that it is almost impossible to work out in detail the inheritance of the complex factors that interact to cause the transmissible differences in the size of the organs.

"That size characters are complex in themselves is shown by the numerous varieties grown commercially. They each vary from their own means, but different variety means in height are found all the way from two and one half to fourteen feet, with but little actual difference between the most similar strains. Further to complicate matters, all size characters respond to environmental stimuli, and these non-inherited fluctuations obscure the analysis of pedigree cultures in a still greater degree.

"For these reasons we do not attempt to analyse our results further than to say that *they do show segregation in every case. And segregation is held to be the important and essential feature of Mendelism. Therefore we believe that size characters Mendelize.* . . . But in size characters dominance is probably very incomplete or absent. . . ."

"*Several genes for the same character may exist in the germ cells of one organism, the number being limited possibly by the number of chromosomes.* The limited number of cases, thus far found, presumably is due to the fact that few size characters have been investigated, for nowhere would these phenomena be so likely to occur as in quantitative characters. . . . Several independent allelomorphic pairs may produce the same somatic character."

"A heterozygous combination presumably produces half the effect of a homozygous combination. Then as dominance becomes less and less evident the Mendelian classes vary more and more from the formula $(3 + 1)^n$ and approach the normal curve of error $(\frac{1}{2} + \frac{1}{2})^n$. When there is no dominance and open fertilization, a state is reached in which the curve of variation simulates the fluctuation curve, with the difference that the gradations are heritable. The heritable variations are always more or less obscured, however, by the ever present fluctuation."

TABLE XXXVIII.

FREQUENCY DISTRIBUTION OF HEIGHTS OF MAIZE PLANTS IN A CROSS (AFTER EAST AND HAYES).[1]

No.	Class Centres in Inches for Heights of Plants. 51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	A	S.D.	C.V.
5	3	2	4	5	11	17	17	18	10	6	4	–	–	–	–	–	–	–	–	–	–	68·22 ± ·426	6·49 ± ·324	9·51 ± ·421
6	–	–	–	–	–	–	–	–	–	–	–	–	1	2	2	13	14	16	14	8	3	101·18 ± ·400	5·07 ± ·283	5·01 ± ·279
(5 × 6) F_1	–	–	–	–	–	–	–	–	–	–	5	4	3	9	9	6	5	4	4	7	–	94·53 ± ·740	8·21 ± ·519	8·68 ± ·553
(5 × 6) – 1 F_2	2	1	3	6	3	5	10	10	22	16	10	7	11	13	6	10	8	4	4	2	–	81·00 ± ·685	12·76 ± ·486	15·75 ± ·684
(5 × 6) – 2 F_2	–	–	–	2	–	2	4	2	6	5	12	8	12	6	5	8	3	10	8	2	2	88·33 ± ·802	11·78 ± ·567	13·34 ± ·675
(5 × 6) – 8 F_2	2	–	–	–	4	4	12	7	9	13	12	15	10	8	8	1	1	1	–	–	–	79·46 ± ·621	9·55 ± ·438	12·02 ± ·559
(5 × 6) – 14 F_2	–	1	2	4	2	7	8	17	21	11	27	24	16	9	11	10	5	4	2	–	–	81·24 ± ·513	10·28 ± ·364	12·65 ± ·450

No.	22	25	28	31	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79	82	85	88	91	Total
No. 54	–	–	–	–	–	–	–	–	–	–	–	–	2	6	10	17	24	26	21	14	14	7	3	1	145
No. 60	←	–	–	–	–	–	→[2]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100
(60 – 5 × 54)F_1	–	–	–	–	–	–	–	–	–	–	–	–	–	←	–	–	–	–	–	–	–	→[2]	–	–	55
(60 – 8 × 54)F_1	–	–	–	–	–	–	–	–	–	–	←	–	–	–	–	–	–	–	–	–	–	→[2]	–	–	26
(60 – 3 × 54)F_1	–	–	–	–	–	–	–	–	–	–	–	←	–	–	–	–	–	–	–	–	–	–	→[3]	–	30
[3](60 – 5 × 54)F_2	–	–	–	–	–	2	2	1	8	18	26	44	95	117	126	92	59	31	22	3	3	–	–	–	649
[4](60 – 8 × 54)F_2	–	–	–	–	–	1	–	1	5	6	13	13	35	29	36	27	21	20	9	6	4	1	1	–	228
[5](60 – 3 × 54)F_2	–	–	–	–	–	5	15	13	32	31	68	60	72	34	47	14	13	5	–	–	–	–	–	–	409

[1] Distributions giving figures for plants grown side by side in same season.
[2] Extremes were measured and number of plants counted. All strongly convergent around the central classes.
[3] Grown from five different ears.
[4] Grown from two different ears.
[5] Grown from three different ears.

"In considering experiments in the inheritance of size characters in maize, we must remember that fluctuations are present, and that often many genotypes are present in one parent."

153. *Inheritance of Height of Plants.*—The results of East and Hayes's investigations, as far as described in their paper (1), show segregation from the lowest class range of the shorter parent to the highest class range of the taller parent, but they do not consider these segregates as pure types, and "their behaviour in further generations is still problematical". In every case the comparative size of the coefficient of variation was at least 50 per cent higher in the F_2 generation than in the F_1 generation (see Table XXXVIII). The F_1 generation is not intermediate between the two parents, but is nearly as high as the taller parent. This fact, they point out, is not to be regarded as in any way connected with dominance, but is due to the increased vigour of the maize plant which comes from crossing, as pointed out by East (3) in a previous paper.

FIG. 81A.—Inheritance of size characters. *Hickory King*, 8 to 9 feet high. (Type used to produce cross shown in Fig. 82 and grown the same season.)

An entirely different case has come under the observation of the writer, in the F_1 progeny of a cross between *Hickory King* (Fig. 81A) and *Wills Gehu* (Fig. 81B).

The relative height is shown by the walking-stick which stands alongside, at the same relative distance from the camera as the stem of the plant, in each case.

In this case the F_1 plants, Figs. 82A and B, show the dwarf habit of the *Wills Gehu* parent, and little, if any, increase

FIG. 81B.—Inheritance of size characters. *Wills Gehu*, 4 to 4½ feet high. (Type used to produce cross shown in Fig. 82 and grown the same season.)

FIG. 82A.—F_1 plant progeny of cross between types shown in Fig. 81; plants 4½ to 5 feet high.

in vigour due to crossing was noticeable, such as was met with by East and Hayes. The same result was obtained with the reciprocal cross, showing that in this case the short habit is dominant. CHAP. V.

154. *Inheritance of Abnormal Dwarfness.*—Abnormally dwarf forms, 1½ to 3 feet high, sometimes appear, possibly as examples of "reversion" or of "mutation". East and Hayes

FIG. 82B.—F_1 plant progeny of cross between types shown in Fig. 81; plants 4½ to 5 feet high.

find that segregation takes place in their inheritance, in the proportion of three normal to less than one abnormal, but the number of cases studied was perhaps inadequate to determine whether it was a case of Mendelian dominance.

155. *Inheritance of Length of Ears.*—Ear length does not show the increased vigour, according to East and Hayes, due to heterozygosis, that is seen in the heights of the plants. They conclude that there is scarcely a doubt that the greatly

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TABLE XXXIX.[1]

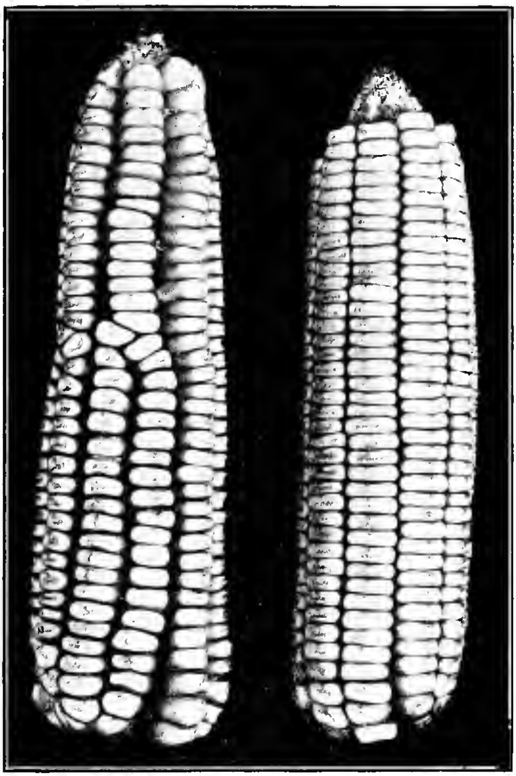
FREQUENCY DISTRIBUTION OF LENGTHS OF EARS IN CROSS (60 × 54).

No.	Class Centres in Cm. for Lengths of Ears.																	A	S.D.	C.V.
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
No. 60 . .	4	21	24	8	—	—	—	—	—	—	—	—	—	—	—	—	—	6·6 ± ·073	·81 ± ·051	12·27 ± ·783
No. 54 . .	—	—	—	—	—	—	—	—	3	11	12	15	26	15	10	7	2	16·8 ± ·121	1·87 ± ·088	11·13 ± ·531
(60 − 5 × 54) F_1	—	—	—	—	1	12	12	14	17	9	4	—	—	—	—	—	—	12·1 ± ·121	1·51 ± ·088	12·48 ± ·722
[2] (60 − 5 × 54) F_2	—	—	4	5	22	56	80	145	129	91	63	27	17	6	1	—	—	12·7 ± ·058	1·99 ± ·037	15·67 ± ·296
[3] (60 − 8 × 54) F_2	—	—	1	10	19	26	47	73	68	68	39	25	15	9	1	—	—	12·9 ± ·076	2·25 ± ·053	17·44 ± ·413
[4] (60 − 3 × 54) F_2	—	—	2	5	17	33	33	33	27	21	13	10	11	12	1	2	1	12·6 ± ·128	2·81 ± ·087	22·30 ± ·744

[1] From East and Hayes (1); No. 60 and F_1 generation grown in 1909, F_2 generation in 1910.
[2] Grown from five ears.
[3] Grown from two ears.
[4] Grown from three ears.

increased variability in F_2 (see Table XXXIX) is the direct result of segregation. CHAP. V.

156. *Inheritance of Size and Weight of Grain.*—East and Hayes conclude that segregation occurs in the progeny of ears heterozygous for size and weight of grain.



B A

FIG. 83.—Inheritance of row numbers. A, 10-row *Hickory* (Louisiana). B, *Hickory* with 10 rows below and 8 above.

157. *Inheritance of Row Numbers.*—The number of rows of grain in an ear varies according to the breed. In some breeds it is more definitely fixed than in others, e.g. *Hickory King;* many of the flint breeds are normally 8-rowed and rarely exceed that number when pure-bred; in these cases an ear carrying more than 8 rows is considered untrue to type,

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but it is doubtful whether any commercial maize crop grown breeds entirely true in regard to row numbers. That this is traceable, in part at least, to fluctuating variability, seems to be indicated by the following cases of irregularity :—

Not infrequently ears are met with in which two or four rows cease before reaching the tip (Fig. 83B).

That such cases may be dependent on nutrition, as affected by variation in the character of the season, is suggested by the fact that in the season 1910-11 the writer found ears bearing two more rows on the upper (tip) portion of the ear than on the lower portion; the weather was dry during the early part of the season, which tended to check development, but was wet during the latter part of the season. The possible connection between the season and such cases requires further investigation before we can definitely connect them as cause and effect.

In some cases, as shown in Fig. 84B, it is clear that a pair of rows has been dropped; this is unusual, however. More frequently one row of each of two pairs has stopped (Fig. 83B).

Many cases have come under the writer's notice, in which two ears borne on the same plant produce different row numbers; in thirty-three plants of *Arcadia Sugar-maize* each bearing two fully-matured ears on one culm, twelve plants bore an equal number of rows on each ear; fourteen plants had more rows on the lower ear than on the upper; on seven plants the largest number was borne on the upper ear; in most of these cases there were but two extra rows, but in a single case there were *four* more. The actual results obtained are shown in Table XL.

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TABLE XL.

ROW NUMBERS IN A FAMILY OF *ARCADIA SUGAR-MAIZE*.

Plants with Two Ears.

Plant No.	Upper Ear. Number of Rows.	Lower Ear. Number of Rows.
1	8	12
2	10	10
3	10	14
4	10	12
5	12	12
6	10	8
7	10	8
8	10	12
9	12	12
10	8	10
11	8	12
12	12	12
13	12	12
14	10	12
15	12	12
16	12	12
17	12	12
18	12	10
19	12	14
20	10	12
21	8	10
22	10	10
23	10	8
24	12	10
25	8	12
26	12	12
27	12	10
28	12	10
29	10	10
30	8	10
31	10	12
32 3 ears.	upper no grain middle 8	8
33	10	12

Class.	Upper Ear.	Lower Ear.	Number of Plants.	Number of Plants in each Class.
As many rows in lower as in upper . . .	12	12	8	12
	10	10	3	
	8	8	1	
More rows in lower than in upper	12	14	1	14
	10	14	1	
	10	12	6	
	8	12	3	
	8	10	3	
Fewer rows in lower than in upper . . .	12	10	4	7
	10	8	3	

TABLE XL (*continued*).

SUMMARY.

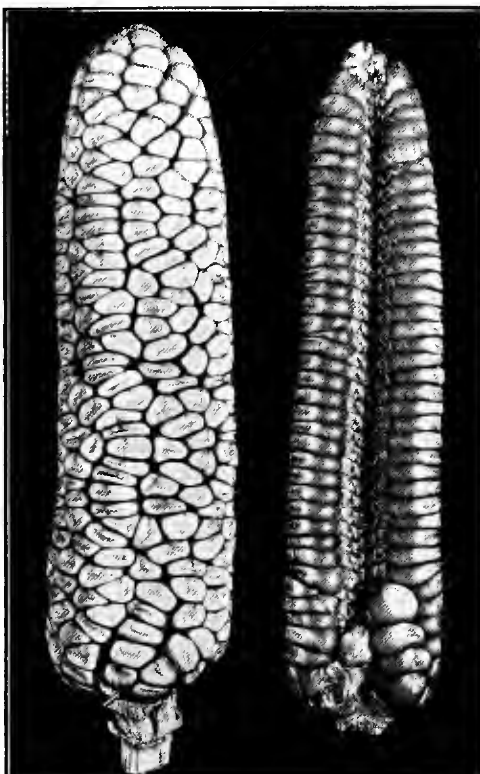
Upper Ear.	Lower Ear.	Number of Plants.
8	8	1
	10	3
	12	3
10	8	3
	10	3
	12	6
	14	1
12	8	0
	10	4
	12	8
	14	1
—	—	Total 33

The total number of ears producing any given number of rows was as follows:—

Rows.	Ears.
8	11
10	23
12	30
14	2
—	Total 66

A few ears are also met with in which the grains are scattered promiscuously, in mosaic fashion, over the ear (Fig. 84A), so that the number of rows can only be determined by cross-sectioning the cob.

Experiments conducted by the writer show that the cross between an 8-row and an 18-row breed results in the production of an intermediate form in the F_1 generation. Of thirty-nine cross-bred F_1 ears examined, only two produced the same number of rows as either parent, while nearly 75 per cent produced either 12 or 14 rows, i.e. more than one, and less than the other, parent; as regards these two row numbers, the cross and the reciprocal cross produced nearly the same proportions, the 18-row ♀ × 8-row ♂ giving 71·5 per cent, and the 8-row ♀ × 18-row ♂ 76 per cent. The cross was made between No. 904, an 8-rowed white dent, and No. 905, an 18-rowed yellow dent, both pedigree ears as regards colour and row numbers, which bred true when selfed (*Burtt-Davy*, 27). The results obtained are given in Table XLI. CHAP. V.



A B

FIG. 84.—Undesirable types for seed. A, Mosaic arrangement of grains. B, Failure to develop two pairs of rows: a 4-rowed ear.

Eighty-nine ears from a commercial crop of *Ladysmith*, studied by the writer, gave the following figures:—

Row Classes	14	16	18
Number of Ears	29	40	20
Percentages	32·58	44·94	22·47

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TABLE XLI.

INHERITANCE OF ROW NUMBERS IN CROSS-BRED MAIZE.

1063 ex 905 (18-row ♀) × 904 (8-row ♂) Yellow Grain with Light Yellow Caps.
1064 „ do. do. Yellow Grain with White Caps.
1066 „ 904 (8-row ♀) × 905 (18-row ♂) Do.
1067 „ do. do. Do.
1068 „ do. do. Do.

Separating the two crosses, we have the following figures :—

18-row ♀ × 8 row ♂

Parent Ear No.	Rows.					Total Ears.
	8	10	12	14	16	
1063	0	1	4	2	1	8
1064	0	2	4	0	0	6
Total . .	0	3	8	2	1	14
Per Cent .	0	21·4	57·1	14·3	7·2	= 100

8-row ♀ × 18-row ♂

Parent Ear No.	Rows.					Total Ears.
	8	10	12	14	16	
1066	1	2	3	1	0	7
1067	0	2	4	3	0	9
1068	1	0	3	5	0	9
Total . .	2	4	10	9	0	25
Per Cent .	8	16	40	36	0	100

Summary.

Parent Ear No.	Rows.					Total Ears.
	8	10	12	14	16	
18 × 8	0	3	8	2	1	14
8 × 18	2	4	10	9	0	25
Total . .	2	7	18	11	1	39
Per Cent .	5·1	18·1	46·2	28·2	2·6	100

East and Hayes find that two distinct kinds of irregularity of row numbers occur: one a physiological fluctuation which is not inherited, and one a definitely inherited character, or possibly a set of characters. CHAP. V.

"The non-inherited fluctuations are always present, while the inherited irregularity may be present or absent. The latter kind has been isolated in several varieties [breeds], the most conspicuous being the *Country Gentleman* [sweet] corn. . . . Since the inherited irregularity can only be distinguished from the fluctuation by breeding, and then with difficulty owing to the obscuring effect of the latter, it is difficult to come to any conclusion regarding the method of its transmission when dealing with mixed strains. It could undoubtedly be determined by careful work with a cross of which *Country Gentleman* formed one of the parents. We have not made such a cross, but observations of large commercial cultures of *Country Gentleman* lead us to believe that irregularity is a Mendelian dominant, although it may not act as a simple monohybrid. . . . The one fact that stands out clearly is that *if the percentage of irregular ears increases much over 4 per cent in a commercial progeny row culture, the whole culture must be discarded to eliminate the undesirable 'blood'.*"

The results obtained by them, to the F_3 generation, are shown in Table XLII following:—

TABLE XLII.

INHERITANCE OF ROWS IN A MAIZE CROSS.

No.	Gen.	Rows of Parents.	Row Classes.								
			8	10	12	14	16	18	20	22	24
No. 8 dent . .	P	12	—	3	54	36	12	2			
No. 54 sugar .	P	8	89	25	7						
No. 8 × 54 . .	F_1	12	1	6	14						
(8 × 54) – 1 .	F_2	12	9	22	16	1					
(,,) – 5 .	F_2	12	1	3	16	1					
(,,) – 1 – 1 .	F_3	10	—	15	87	4					
(,,) – 1 – 2 .	F_3	8	20	38	50						
(,,) – 1 – 2a	F_3	10	61	48	54						
(,,) – 1 – 3 .	F_3	10	32	75	15						
(,,) – 1 – 3a	F_3	8	5	20	27	1					
(,,) – 1 – 5 .	F_3	12	—	33	158	26	3				
(,,) – 1 – 6 .	F_3	12	4	36	109	8	2				
(,,) – 1 – 10	F_3	8	Very irregular, mostly 8-rowed								
(,,) – 1 – 13	F_3	10	96	43	8						

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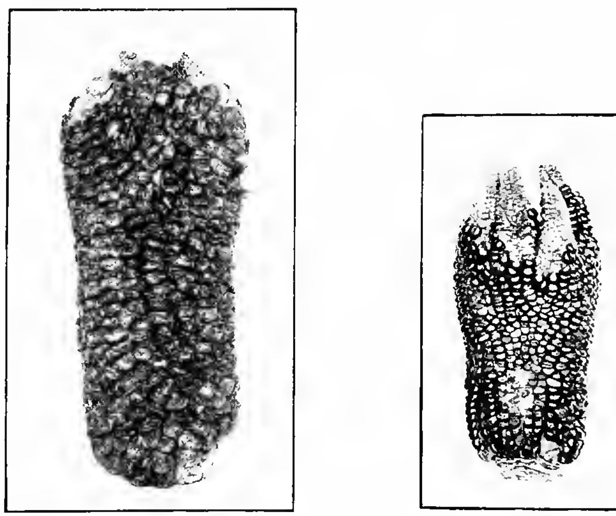
158. *Four-rowed Ears.*—The writer has occasionally found in both flint and dent breeds, ears with only 4 or 6 rows (Fig. 84B). The occasional presence at the base of the ears of the beginnings of additional rows, suggests that they are cases of failure to develop certain pairs of rows. East and Hayes associate the condition with the tendency commonly met with in ears of 8-row flint breeds, to split at the base into 2-rowed sections. Their investigations indicate that the tendency to the abnormality is dominant to the normal condition.

159. *Inheritance of Fasciated and Lobed Ears.*—Flattening,



A B

Fig. 85.—A, Fasciated ear. B, Lobed ear.

fasciation, and lobing of the tip of the ear (Fig. 85A and B) are not infrequently met with, and flattening and fasciation are more common in some races than in others; in the Transvaal flattening is common in strains of *Chester County*.

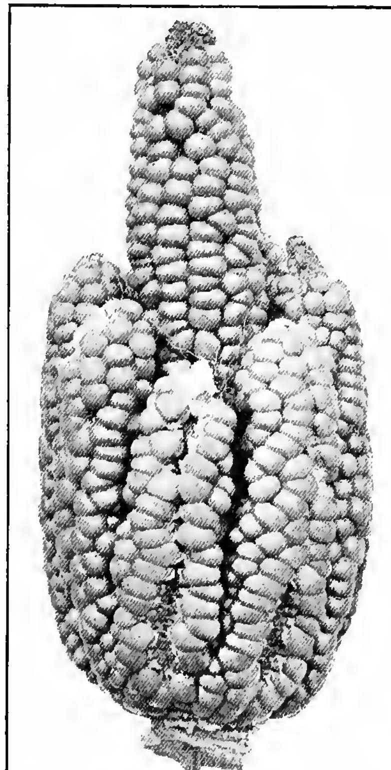
East and Hayes have studied the inheritance of this abnormality and find that it is a dominant character, alternatively inherited, and that it is difficult to tell the pure normal ears by inspection, but that they appear to breed true when isolated.

160. *Inheritance of Laterally Branched Ears.*—Laterally branched ears (Fig. 86) are occasionally met with. Attempts

made by East and Hayes and by the writer to study the inheritance of the tendency have not been very successful. But East and Hayes conclude that the character is transmitted and does segregate, for both normals and abnormals are produced in the F_2 generation. Such ears are undesirable, especially as they produce irregular grain, and they should not be used for seed purposes.

161. *Striped Leaves.*—Races of maize occur, as, for example, *Zea Mays* var. *japonica*, in which the leaves are green, with white stripes (they are deficient in chlorophyll), but which breed true, the striping being apparently homozygous.

But East and Hayes record cases in which the striping indicates a heterozygous condition; the dominant form in this case is fully green. Plants without chlorophyll died, when only a few inches high, from lack of the power of assimilation; these were considered by the authors as "probably homozygous recessives".



A

FIG. 86.—Laterally branched ear.

162. *Difficulties Encountered in Studying Inheritance in Maize.*—The investigation of the inheritance of characters in the maize plant is not as simple a problem as might at first appear.

(*a*) The amount of pollen produced is so great that it is continually present during the flowering period, in the air of the maize field; it adheres to the clothes and hands of the breeder, or to the leaves and stems of the plant, and is easily

CHAP. V. transmitted from them to the silks of plants which are to be kept pure. In spite of all possible precautions, seeds of unknown paternal ancestry do creep into the cultures. With tassels bagged three days before any pollen was ripe, it was found that stray pollen was already present, and though old, a certain percentage was viable, although East and Hayes conclude that the possible error from this source would be only one to about 10,000. But in the bagging of the silks there is also a chance of enclosing foreign pollen; the same investigators have found that about one ear in five would have one or more grains so crossed, even when the greatest care was taken.

They conclude that in this work there is a possibility of an experimental error of five or six seeds out of the 200 to 800 produced on an ear; this is to be considered as a maximum and not the probable error, the latter being less than one seed per ear. As they well observe, however, "the determination of a probable error in a mass of data is not sufficient in genetic work; an actual error, in which a single seed of unknown paternity becomes the ancestor of a pedigreed line, is sufficient to upset all inductions drawn from the data".

(*b*) The small size of the chromosomes makes them difficult to study.

(*c*) And, finally, maize seed is rather delicate; when properly matured and dried it remains in fairly good condition for only three seasons; seed older than this is almost worthless, and there is even a possibility of the results from second year seed being distorted.

All these factors add to the difficulty of carrying out investigations.

Methods of Plant Breeding.

A man should be very careful in the selection of his parents.

—HEINE.

163. *A Few General Principles.*—In plant breeding it is necessary to carefully decide upon an ideal and to work steadily and persistently toward it. We must remember that it takes several generations of the plant to acquire and fix a desired character, and that any deviation from the original aim

may involve us in complications difficult to unravel. With our present knowledge of genetics, the safest course to follow is to work step by step, building up the new type, one character at a time, rather than to attempt to add two or three characters at once. CHAP. V.

Promiscuous or aimless crossing, and crossing which is not followed by rigorous selection, is worse than useless, for it spoils an established breed only to produce a mongrel race. Vacillation in breeding is equally unproductive; success is then mere chance, and we work like men lost on the veld, wandering sometimes forwards, sometimes back on our tracks.

In order to breed intelligently and to good purpose, it is necessary not only to know what we want, but also how to attain it, which involves a close and thorough study of each breed. In the case of maize, our ideal should include not only the colour and shape of the grain and ear, but also the average yield of grain from each ear, and the average stand of plants per acre.

Briefly, we may say that there are three things essential to the development of pedigree stock, whether of animals or plants: (1) start with the best stock you can get; (2) propagate only the best (which implies also the elimination of the unfit); (3) improve by crossing, when you know how to obtain and fix the desired character.

164. *Methods of Plant Breeding.*—The methods employed in the breeding of plants are much the same as those used with domestic animals—horses, cattle, sheep, pigs, or poultry. The fundamental point, after the determination of the desired type, is the continuous mating (i.e. without interruption) of those parents, both male and female, which most nearly approach that type.

In the breeding of plants three principal courses are followed: (1) selection, (2) cross-fertilization, and (3) hybridization. Inbreeding necessarily follows any one of these three methods.

Selection may be roughly defined as the choice of suitable parents for the production of a strain of the desired type. They may belong to the same or to different breeds. Selection implies that there is a choice of characters to select from.

It is necessary to resort to selection and inbreeding to

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obtain pure strains from mixed ones, and to propagate pure strains when one has them.

By rigid selection we avoid the production or propagation of new forms; by cross-breeding we encourage it.

By *cross-fertilization* we mean crossing plants of different "varieties," breeds, or races of the same species as, for instance, two kinds of maize. This will be discussed more fully a little farther on.

The strict definition of the term *hybridization* implies breeding from two parent plants belonging to different species or genera as, for instance, wheat and rye. It is of little or no practical importance in the improvement of farm crops, and need not be further discussed here.

165. *Selection of Parents.*—The first step in breeding is to secure well-bred stock. This does not always mean the importation of fresh strains, unless the latter offer decided improvement over the old; if the breeds already acclimatized in the country are satisfactory as regards *breed characteristics*, it is sometimes better to use them as a basis for improvement than to rely entirely on something the adaptability of which to local conditions has not been proven. As Hartley (5) tersely puts it: "Under extremely difficult conditions of growth, teosinte and the buffalo will thrive better than improved types". But local strains are often so mongrel (i.e. heterozygous) in character that it would take years of patient toil, and much expense, to breed them pure; in such cases we must rely on the importation of fresh stocks. Whichever course we follow, we must select the parents best fitted to produce the desired type of offspring.

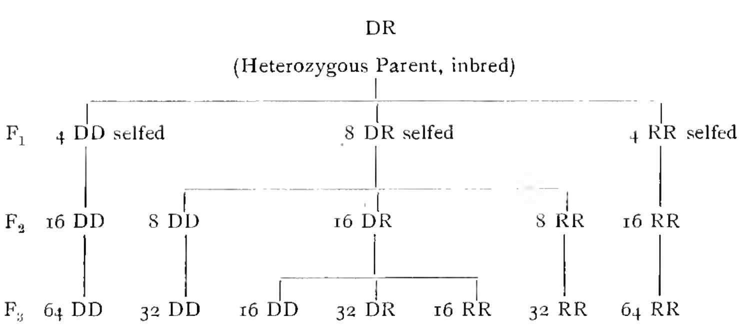
Sheep farmers, who start with a highly-bred stud flock of acclimatized animals, do not take long to build up a large flock if they are good sheep farmers. But the best of them find it comparatively slow work to grade up a mixed flock. So it is with maize. If we can start with pure, high-bred, acclimatized seed, we gain enormously in time, for all that is then necessary is to maintain the purity, and continue the improvement already started. But at the present time it is impossible to meet the demand for pure high-bred seed, acclimatized to each maize-growing district in South Africa.

In the selection of parents care is taken that both are as true to type as possible. The usual result of mating like with like, is to produce like, *provided always that the strains are pure;* the last point is essential. There are exceptions to this rule, due to the interaction of other factors (¶ 131) which we need not discuss at the moment as they do not affect the principle; we refer to such cases as the crossing of two white-grained breeds of maize, which sometimes results in the production of purple grain; and the crossing of two dwarfs, which in some instances results in the production of tall plants.

It is equally important to remember that by crossing the unlike we usually produce unlike, at least in the second generation.

Selection can carry us to a certain point, but no farther; it isolates characters and eliminates the unfit, but it cannot *add* characters which are not there. This is accomplished by cross-breeding. "Any permanent improvement that is made by selection is merely the separation of one of the extreme biotypes. When an extreme line is entirely separated, however, selection of *its* extreme fluctuations causes no change (or at least no permanent change) of type, because there is almost complete regression to the mode of its line" (*East*, 2).

166. *Effect of Inbreeding.*—Strict inbreeding gradually leads to the isolation of the homozygous type, as was pointed out by Mendel, and as is demonstrated in the following diagram, for which the writer is indebted to Professor Punnett:—



This gives, in the F_3 generation, 112 DD (pure extracted dominants), 112 RR (pure extracted recessives), and only 32 DR (heterozygotes). This scheme supposes that each plant of the progeny produces but four offspring and that chances

CHAP. V. are equal for the development of progeny of homozygous and heterozygous parents.

But as Shull (1), East (2), and others have pointed out, in maize "self-fertilization, or even inbreeding between much wider than individual limits, results in deterioration". Again: "Although a study of the injurious effects of self-fertilization was not the aim of the investigation, it was immediately apparent in the smaller, weaker stalks, fewer and smaller ears, and the much greater susceptibility to the attacks of the corn-smut (*Ustilago Maydis*). The results were almost as marked when the chosen parents were above the average quality, as when they were below it, which in itself refutes the idea that the injurious effect is due to the accumulation of deficiencies possessed by the chosen parents" (*Shull*, 1).

"Inbreeding in maize gives the same effect as lack of nutrients, while cross-breeding gives the opposite effect. There is retardation or acceleration of cell division, respectively. . . . It is an established fact, although the cause is unknown, that crosses between nearly related types are more vigorous than either of the types alone" (*East*, 2).

Collins (2) calls attention to the fact, however, that while it is fully recognized that isolating the pure strains or biotypes will very greatly reduce their vigour and yield, yet by making a combination of the proper strains, so isolated, it is believed that the degree of fertility of the cross will reach that of the most productive plants in the original mixed strain, and that an increase of the total yield can be obtained in this way. He also quotes an experiment of Dr. Shull, in which two self-fertilized strains which were separated from a common stock in 1904, and continuously self-fertilized since that time, were reciprocally crossed in 1907. In 1908 the yields of these reciprocal crosses were compared with each other, with the self-fertilized plants, and with cross-bred stocks of the original breed. *The yield from the cross-pollinated seed was 30 per cent greater than that from the self-pollinated ear, and 2 per cent greater than the average of the original cross-bred stock.*

By this means it is found possible to isolate a homozygous type, the individuals of which, when mated, are as vigorous and productive as the original mongrel heterozygote, but without its objectionable features.

Inbreeding, then, has no permanently injurious effect on the breed. CHAP. V.

167. *Improvement in Yield by Use of First-generation Crosses.*—The facts mentioned in the last paragraph indicate the possibility of utilizing the added vigour gained by crossing. The suggestion of making practical use of this fact was made by Prof. W. J. Beal, as long ago as 1876, but no advantage appears to have been taken of the idea until quite recently, when it was again brought forward by Shull (1), East (2), and Collins (2). Increases of 51 per cent over the normal crop have recently been obtained in this way in the United States.

In the case of maize the beneficial effect is noticeable mainly in the first season, and is said to disappear gradually. In the case of wheat, Professor Biffen finds it applies only in the F_1 generation. The principle, therefore, involves a new cross each year; this fact accounts for the loss of vigour and productiveness which new breeds often show when grown on a commercial scale.

Difficulties in the use of first-generation crosses in farm practice have been met with, but will doubtless be overcome in time.

168. *Fundamental Points of Seed Selection.*—The fundamental points in seed-maize selection are those which affect yield and quality; briefly they include:—

1. Depth of grain;
2. Shape of grain;
3. Thickness of grain;
4. Narrowness of sulci;
5. Length of ear.

The following points are of lesser importance, but should not be neglected:—

6. Shape of ear;
7. Straightness of row;
8. Regularity of grain in the row.
9. Covering and regularity of the butt;
10. Covering and regularity of the tip;
11. Thickness of the cob.

169. *Correlation of Characters.*—It is well known among breeders both of plants and animals that certain characters in an individual plant are more or less related to each other, and

are inherited together. When one of such characters is present in an individual, another character is almost certain to be present which is correlated with it. These correlations may be of several kinds; Webber (3) divides them into four groups, which he has termed Environmental, Morphological, Physiological, and Coherital.

By environmental correlation he means to indicate relation to physical conditions or environment, such as to soils of varying degrees of fertility. Such correlations include increase in number of grains with increase in height of culm, etc. They "are merely the expression for equality or conformity to condition of luxuriance. Strictly speaking, these are not correlated characters, and their consideration is of little or no value to the breeder."

He defines morphological correlations as those cases where a variation in one character is the primary cause for variation in another character, e.g. where the relationship between the characters is similar to that which exists between size of germ and oil-content of maize-grain.

Physiological correlations include such cases as the reduction in yield of fruit and seed in inverse ratio to excess of leaf-production, as in some races of tobacco, or of wood as in the case of certain fruit-trees.

Coherital correlations include "those characters which are not related to each other in any direct or causal sense, but which are inherited as single unit-characters". Such cases include the naked grain of certain races of oat correlated with large number of flowers in a spikelet.

It is of practical importance to the breeder to understand the correlations of the characters with which he deals. It is essential to a proper selection of parent plants that he should not only pick out those bearing good ears, but that he should also study the habit of growth of the plant, its stem, leaf, and flowers, for these have an important influence on the production of good grain, and their precise relationships should be accurately determined and defined.

"As yield is the character of paramount importance, and as this character can now be determined only by laborious field tests, it is of the utmost importance that careful consideration be given to plant characters that may be correlated to yield. Discussions along this line have been almost wholly confined to characters of the ear. A careful tabulation of yields as compared with other ear characters, covering six years' work with four varieties, embracing in all more than 1,000 ear-to-row tests of production, indicates that no visible characters of apparently good seed-ears are indicative of high-yielding power. It is reasonable to expect, however, that a careful study of the entire plant in connection with its environment will reveal such characters" (*Hartley*, 5).

170. *Desirable Stalks.*—The stalk represents the individual plant, and corresponds to the individual animal, the form and size of which are so carefully selected by stock-breeders.

For a grain-maize (i.e. apart from the question of ensilage), a desirable stalk should have no suckers or off-shoots, should have well-developed roots, be thick at the base and gradually taper to the top, and bear a good ear; this should be a little below the middle point of the stem to reduce the danger of blowing down in a strong wind. For the same reason the stalk should not be too high; even in the Low-veld of South Africa it is doubtful whether a height of more than 8 feet is desirable.

171. *Desirable Leaves.*—To produce the large amount of starch which is stored in a full ear, a large leaf surface is necessary; 14 to 16 blades is a good number, and, on well-grown plants, the blade of the middle leaf should be from 4 inches to 6 inches across.

172. *Desirable Ears.*—The shank of the ear should not be more than 4 inches or 5 inches long; individual plants produce shanks of 9 inches to 12 inches, which is an undesirable character.

An ear of cylindrical shape, well rounded at each end, gives the largest percentage of grain to cob; its grains are also more uniform in shape. The number of rows should be uniform and typical of the breed (8, 10, 12, etc.); the rows should be straight and with little space between; the grains should fit together compactly and be firm on the cob, and should be uniform in shape and length on all parts of the ear.

It is sometimes suggested that it would be desirable to save seed from plants bearing two or three ears, in order to develop a more productive race. Experience shows, however, that with most breeds it is preferable to grow one good ear

CHAP. V. on a plant rather than two medium or poor ones; few plants seem able to develop two really good ears, and much energy is wasted in the attempt, which might better be devoted to the production of one *good* ear per plant.

The weight of the husked ear can be taken as a fairly good guide to the relative yield of grain. In some breeds, however, the heaviest ears do not *always* give the greatest weight of grain, though such exceptions seem rare. Certain ears of *Wisconsin × Iowa Silver-mine*, weighing 10·95 ozs., gave 8·64 ozs. of grain, while those of *Yellow Hogan*, weighing only 10·80 ozs., gave 9·20 ozs. of grain, the difference in percentage of grain to ear being 5·81 per cent in favour of the *Yellow Hogan*. Other similar cases have come under the writer's observation. It is quite possible, however, that such differences are not constant. American experiments show that the production of a large number of well-bred but medium-sized ears is more profitable than the attempt to produce abnormally large ears.

In endeavouring to improve the yield by breeding, we may start with the moderate aim of a 75 per cent stand and an average of 8 ozs. of grain per ear. If this is attained it will give 6,534 plants (planted 40 × 18 inches), and 16 muids of shelled grain per acre.

Some local breeds show strong tendency for the sheath of the ear not to cover the end of the cob. This is a bad defect, and should be bred out. It leaves the uppermost ovules and silks exposed to weather and insects, with resulting loss of grain.

The most desirable character of a seed-ear is its power to reproduce abundantly a good quality of ears, but this can only be finally determined by comparative growing tests.

173. *Desirable Cobs.*—"Selecting for small cob results in reducing the size of the ear, and it is also an easy matter to reduce the size of the cob to such an extent that the pressure of the kernels causes the ear to break" (*Hartley*, 5).

But it is important that the cob should not be too thick, or it will not dry out quickly, when it is apt to discolour the grain.

174. *Desirable Grains.*—To again quote Hartley (5): "Length is a very desirable character for the grains of maize

to possess, as it is by increased length in proportion to the diameter of cob that the percentage of grain is increased. Soft, chaffy grains, though long, or grains with prolonged chaffy caps, are not desired. It is much better to select for increased length of kernel than to select for small cobs." The most desirable shape of grain, he adds, is that of a wedge having straight sides and edges. This shape admits of the grains fitting together so compactly that little or no space is wasted. "The germ, the most nutritious portion, and the portion in which is located the embryo plant, should be large, smooth, and firm."

This American ideal excludes such broad types of grain as the broad Natal *Hickory King*, and yet *Hickory King* is con-

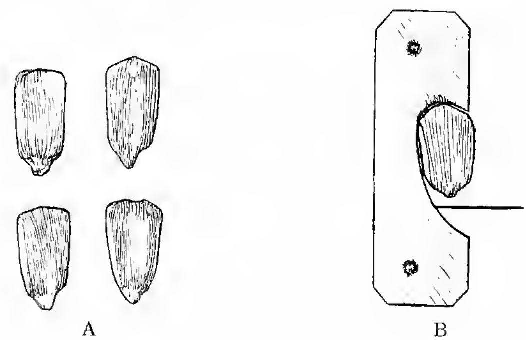


Fig. 87.—A, Desirable shape of grain. B, Device for standardizing grains.

sidered one of the best selling types on the local South African market. But it does not necessarily follow that *Hickory King* is the most profitable type to grow. We need further information on several points in this connection before we can form a definite opinion as to the breed that will pay best. *If* we can get the best price, combined with good yield, from the broad *Hickory King*, that may be the best type for us to grow. But if we get, say, 10s. a muid for *Hickory King*, yielding 12 muids per acre, and only 9s. per muid for some other variety yielding 15 muids per acre, it will pay better to grow the 9s. variety, for it will sell for 15s. per acre (or £7 10s. per ten acres) more than the *Hickory King*.

175. *Fancy Points.*—There are some points made use of in judging maize at shows which are good in their way, but which

CHAP. V. are not known to be of practical value in the selection of parent ears for breeding purposes; these include such fancy points as well-covered tips, perfectly straight rows, very thin cobs, etc. On this question we may think over the words of Dr. Hopkins of the Illinois State Agricultural Experiment Station:—

"There is some danger of corn breeders making too much of what might be called fancy points in selecting seed ears. We would learn the facts which are facts and not base our selections too much upon mere ideas and opinions. For example, it is not known that ears whose tips are well filled and capped with kernels are the best seed ears. Indeed it is not improbable that the selection of such seed ears will cause the production of shorter ears and a reduced yield per acre. It is true that the percentage of shelled corn from a given ear is the greater, the greater the proportion of corn to the cob, but our interest in that percentage is very slight compared to that of yield per acre, and perhaps for the greatest possible yield of shelled corn per acre it requires that the ears shall have good-sized cobs. Possibly the corn which shall ultimately surpass all others for yield per acre will have tapering and not cylindrical ears. These are some of the points regarding which men have some ideas and opinions, but as yet we have no *definite facts* and we shall need several years more to obtain absolute knowledge regarding some of these points. Let us base our selections of seed-corn first upon known facts and performance-records, and secondly upon what one may call his 'type' of corn."

176. *Methods of Selection.*—The attempt to practise plant breeding without sufficient knowledge of either the science or the practice has led to disappointment and failure in many cases. One mistake has been the buying of prize bags of shelled seed at agricultural shows, irrespective of the pedigree of the seed. Now prize bags of shelled maize generally contain the largest grain the farmer is able to find; the largest grain is often borne on the smallest ears and therefore does not represent high crop-producing power; the largest grain does not always produce good ears and good yields. Prize maize may have been sifted from bulk grain, shelled in the field, and often consists of the tailings which pass over the riddles; it is sometimes produced by a very indifferent crop!

Again, too much reliance has been placed upon seed-maize taken from the biggest ears from the bulk crop. Big ears are more likely to reproduce their kind than big seed, and this is better than no selection; but the farmer soon finds that it does not bring him beyond a certain point. This is because the *ears in the ordinary bulk field have been cross-bred with inferior strains.* In an ordinary commercial field of maize the proportion of good, typical ears is very small. Not long ago the writer went through a South African field of what looked like a good maize crop, running probably ten bags to the acre. In the course of about an hour he could find only two plants, in the best parts of the field of 15 acres, which could be considered ideal for seed purposes. And though this was much superior to the ordinary crop of the country, he *could not find* 100 *plants* in an acre that were worth picking for seed. An acre carried over 8,000 plants, and at this rate there would be 80 poor plants to every good one. As the maize plant is usually not self-pollinated, but depends on cross pollination, it is probable that every plant in that field was crossed with pollen from one or more of the many poor plants with which it was surrounded. Deterioration in the quality of the seed produced must inevitably have followed. Such deterioration might not show in the ear produced that year, but it would show in the following crop. Deterioration is constantly taking place where breeding is not practised.

It is not only big ears that produce heavy yields. A big ear is better than a little one, but big ears often produce small, light grains; medium ears with deep heavy grains usually produce the heaviest yield per acre.

In practical plant breeding, three processes are usually followed in the selection of maize for the breeding plot:—

(*a*) Field-selection of original mother plants;

(*b*) Selection of ears in the seed-store;

(*c*) Selection by continuous performance-record in the breeding plot.

177. *Importance of Care in Selection.*—Selection should not be done carelessly, nor be left to the ignorant. Hand picking by Kaffirs may be better than no selection, but it will not carry forward the work of improvement. One season's careless handling of the seed crop may undo all the good which has been accomplished in three or four years. The man who is

CHAP. V. selecting must know thoroughly what points to select, and this knowledge depends on an intimate acquaintance with the laws governing the transmission of characters. The day of empirical selection has passed; it can no longer be left in the hands of the ordinary farm labourer.

178. *Field Selection of Parent Ears.*—If we select only from among harvested ears, we cannot tell whether the mother plant was vigorous or weakly, tall or short, leafy or sparsely leaved, subject to rust or rust-resistant, or whether a particular ear has grown at the right place on the stem, or has had a desirable shank. All these points and many others have a definite bearing on the future yield of the crop to be grown, for they are correlated with characters directly concerning yield. Field selection is obviously most important.

Good ears cannot come from poor plants any more than good wool from poor sheep! And the one is as likely to propagate its kind as the other. A sheep with a poor constitution would not be used in a good stud flock. No more should the grain from a maize plant with a poor constitution be used for seed purposes, for it will not produce a heavy crop. It is not sufficient to select all the largest ears at harvest to be used for the seed plot. The large ear does not always come from a plant desirable in other respects. In breeding for wool, a sheep farmer does not base his selection of his stud sheep solely on the amount and quality of the wool. A shapely body and robust constitution also take an important place in the list of characters which make up a desirable stud sheep. Plants like animals are living things with varying degrees of vigour. As with live stock, it is important that we make a similar study of desirable points in selecting our parent seed plants. In order to produce good crops we must begin with the mother plant in the field, and that plant must be vigorous, must have plenty of leaf surface, produce large ears, and possess other qualities correlated with the characters which our standard demands.

Having in mind the standard of stalk, leaf, ear, and shank, it is necessary to select 100 to 500 plants which come as close as possible to that type; these should be marked conspicuously so that they will be found at harvest time. A field of from 15 acres to 30 acres should be chosen for this purpose. The time when the selection is made will depend partly on the object sought; if this be early maturity it will be desirable to go through the field when the *first tassels and silks* appear, marking all the earliest plants, provided they are desirable from other points of view. It will also be desirable to repeat the process when the first plants begin to ripen, because it does not seem to be the case that the earliest plants to mature are always the earliest to flower; this point needs further investigation, however. For ordinary selection for yield and quality the best time is probably when the ears are well developed, and before the leaves have turned brown; at this stage the breadth and colour of the leaf can be observed to good advantage.

By systematically walking through a field, row by row, and tying labels on the desirable plants, it does not take long to mark off 500. The principal points to be observed in field-selection are :—

1. General vigour of the plant.
2. Leafiness of plant and width of leaf.
3. Size of ear.
4. Straightness and strength of stem.
5. Stem broad at base, tapering gradually.
6. Ear borne about middle of stem.
7. Shank of ear short.
8. Husks compact and firm on ear.
9. Apex of ear well covered with the husk.
10. Freedom from rust and smut.

Where early maturity is desired, as on the extreme High-veld, this can also be taken into account.

Each selected plant should be marked with a conspicuous label which will not be lost sight of when the leaves turn brown at harvest. For this purpose sized cloth labels prove least satisfactory; they quickly blacken, lose the "size" and become indistinguishable, losing entirely the figures written on them. Our best results have been obtained with ordinary brown paper parcel-labels, numbered with ordinary black or blue pencil. But even these are too much like the dry maize leaves and husks in colour to be easily seen at harvest; and when a label is tied near the tassel away from the leaves, CHAP. V. both tassel and label will disappear in many cases by the breaking off of the tops of the culms.

At harvest all the marked plants that can be found are cut by hand and removed before the rest of the crop is harvested. The ears are hand-husked and stored until they can receive personal attention. By that time they should have dried out thoroughly, so that reliable comparative tests of weight can be made.

The ears should be allowed to ripen well on the stalks; the stalks of the selected plants might be harvested and shocked by themselves to avoid delaying the rest of the harvest. When thoroughly dry, careful selection of the ears must be made, only forty or fifty of those which come closest to the ideal being retained for the breeding plot. These should be weighed separately, and a record kept of the total weight and of the weight of shelled grain from each.

179. *Seed-room Selection of Ears.*—The 500 ears selected in the field are weighed in bulk and then laid out on benches in the seed-room. All small, distorted, or otherwise undesirable ears are at once discarded, their total weight being taken, as a check. Field selection cannot be so perfect that none but desirable ears will be harvested. In a test case of five breeds selected in the field, the following proportions were retained as suitable for the breeding plot:—

	Per Cent.
Yellow Hogan	80
Yellow Horsetooth	65
Hickory King	61
Golden King	59
Ladysmith	56

It is doubtful whether in ordinary selection of large ears at husking it would be possible to obtain even 10 per cent of desirable ears from an *ordinary* crop. And then one would not have the advantage of knowing that they came from robust and otherwise desirable parents.

Of the 300 or so ears left, a more critical study is made. One hundred of the best are reserved for the centre of the breeding plot and the remainder shelled off at once to be used for the end rows.

After some practice the selection of the best 100 ears can easily be made by eye. When increased yield per acre is the primary consideration, the points on which selection is made can be reduced to the following:—

1. Size and weight of ears;
2. Depth of grain;
3. Closeness of rows (i.e. narrow sulci);
4. Regularity of rows;
5. Regularity of grain;
6. Shape of ear, and character of tips and butts;
7. Yield of grain per ear.

FIG. 88.—Selecting seed-maize: the final selection.

All these points have a direct bearing on the yield per acre.

The final selection consists in classifying the picked 100 ears into groups of ten each, according to depth of grain and size and weight of ear, etc. (Fig. 88). The weights of each group of ten are then taken; they are arranged in a row, with the twenty best ears in the centre, the next best next, and so on, the poorest of the 100 occupying the two ends of the row.

In the final selection too much reliance must not be placed on weight or size of ear. The writer has frequently found that

CHAP. V. the smaller of two ears gives the greater weight of grain. This is due to the fact that there is an immense difference in the depth of the grain on different ears of the same variety. Other things being equal, the greater the length of the individual grains the greater the yield per acre. It is bulk of grain that is sought, not size of ear; the latter is important only as it aids to produce the former. It is true that the ear, as well as the vegetative characters of the plant, give an indication of its capacity; but it is the individual grain which carries the embryo plant, and as the grain is, so will its progeny be, except always for such changes as may be brought about by the influence of environment or cross-pollination.

The ear must be taken into account only in connection with the grain that it bears.

180. *Character of the Grain.*—Therefore, after the subdivision by size, weight, and other external characters, it is necessary to examine carefully the character of the grains of each ear, and to re-arrange the ears in accordance therewith; it is surprising to find how great a range of variation occurs in respect to the size and shape of the grain within the limits of one breed (see Fig. 68). This comparison is best accomplished by taking six grains from each ear, two from a point about one-third from the tip, two from the same distance from the butt, and two from the centre. These six grains are laid on the table at the foot of the ear from which they are taken. Comparison is then made of the grains from all the ears, especially in regard to uniformity, length, shape, thickness, and size of embryo. It is important to consider uniformity of grain, for if—as is often the case—the grains on the upper part of the ear are shorter than those on the lower part, the weight of grain must obviously be less than if they were longer. After careful study of the grains, the ears must be arranged accordingly, even at the expense of size and weight; in some cases a compromise may be made with advantage, but this can only be done effectively by persons having a thorough knowledge of the subject.

In the case of the ten best ears of each breed, full notes are taken of the length, circumference, and character of each ear; samples of the grain from each are retained for reference the following season, in order to determine whether the characters for which the ear was selected are being transmitted or whether they are only of a temporary nature. If any one or more ears show fluctuating variability as regards such characters, the progeny of those ears can be discarded next season.

The object of placing the very best ears in the centre, and the worst of the 100 on the outside, is that the same sequence may be preserved in the breeding plot. By this means, and as the grain from each ear will be used to plant only one row of the plot, the grain from all of the best ears will be removed as far as possible from danger of pollination by plants derived from poorer ears. In this way the tendency to deterioration, through cross-pollination with poor plants, is reduced to a minimum.

After this the ears are shelled by means of a hand-sheller; the cobs of each ten are weighed separately; the weight of cob deducted from the weight of ear previously taken gives the weight of grain. Being in groups of ten the average weight of individuals in a group can be determined at a glance.

Each ear is shelled into a paper bag (half-pound bags with folding flap have been found satisfactory) and numbered with a consecutive number from 1 to 100, preserving carefully the same sequence as that of the final selection. The packets of each breed are then placed in separate boxes, the highest number at the bottom, and carefully labelled ready to be taken to the breeding-plot at planting time. This completes the work of selection for the season.

181. *Selection by Continuous Performance-record.* — This consists in the strict and continuous selection of parent ears from among the best progeny of the best plants which have year after year given the best performance-record in the direction desired (i.e. yield, early maturity, drought resistance, etc.). An idea of the method practised is given in Table XLIII following, which shows the sort of record kept each year of the performance of certain strains grown in the breeding plot of the Illinois State Experiment Station. Selection for the following year would be made of those ears which give the best record in this analysis. It is noticeable that the nine best ears[1] are those in the centre of the table, which come from the centre of the breeding plot, and that the best result of all

[1] As regards protein-content, for which the ears were selected.

CHAP. V. is obtained from the centre row (No. 10). This indicates inheritance of good characters, for in the breeding plot the best ear was planted in the centre of the row, the two next best on either side, and so on, to prevent crossing of the best with the poorer plants.

TABLE XLIII.

PERFORMANCE-RECORD OF BREEDING PLOT, 1901.

ILLINOIS EXPERIMENT STATION.

(Breeding for High Protein.)

Field Row Number.	Relative Weight of Ear Corn in Crop (Average of 200 Plants per Row).	No. of Ears per Acre (on an Average of 8,000).	Weight per Acre (on an Average of ½ lb. per Ear).	Protein in Seed-ear.	
	Lbs.	No.	Muids.	Per Cent	
1	91·0	7,280	18·2	12·06	
2	86·0	6,880	17·2	12·17	
3	98·5	7,880	19·7	12·19	
4	99·5	7,960	19·9	12·26	
5	77·0	6,160	15·4	12·31	
6	118·0	9,440	23·6	12·40	
7	116·0	9,280	23·2	12·66	
8	54·5	4,360	10·9	12·83	
9	107·0	8,560	21·4	12·90	
10	103·0	8,240	20·6	15·78	Nine best plants.
11	87·0	6,960	17·4	12·93	
12	127·5	10,200	25·5	12·94	
13	113·0	9,040	22·6	12·72	
14	123·5	9,880	24·7	12·45	
15	103·5	8,280	20·7	12·32	
16	92·0	7,360	18·4	12·31	
17	85·5	6,840	17·1	12·23	
18	117·0	9,360	23·4	12·18	
19	140·5	11,240	28·1	12·07	
20	97·0	7,760	19·4	12·06	
Average	101·9	8,148	20·37	12·59	

182. *Method of Propagation.*—Difficulty has been experienced by growers in propagating the seed-maize after it has been selected, and some have been so discouraged by the results of cross-pollination, that they have given it up. It should be remembered that it takes three years, at least, before material improvement can be expected. The difficulty is largely due to the small amount of seed available as the result of the first selection. The following method has been found satisfactory.

First Year's Selection.—Let us suppose that only twenty good ears, coming up to our ideal, have been selected this

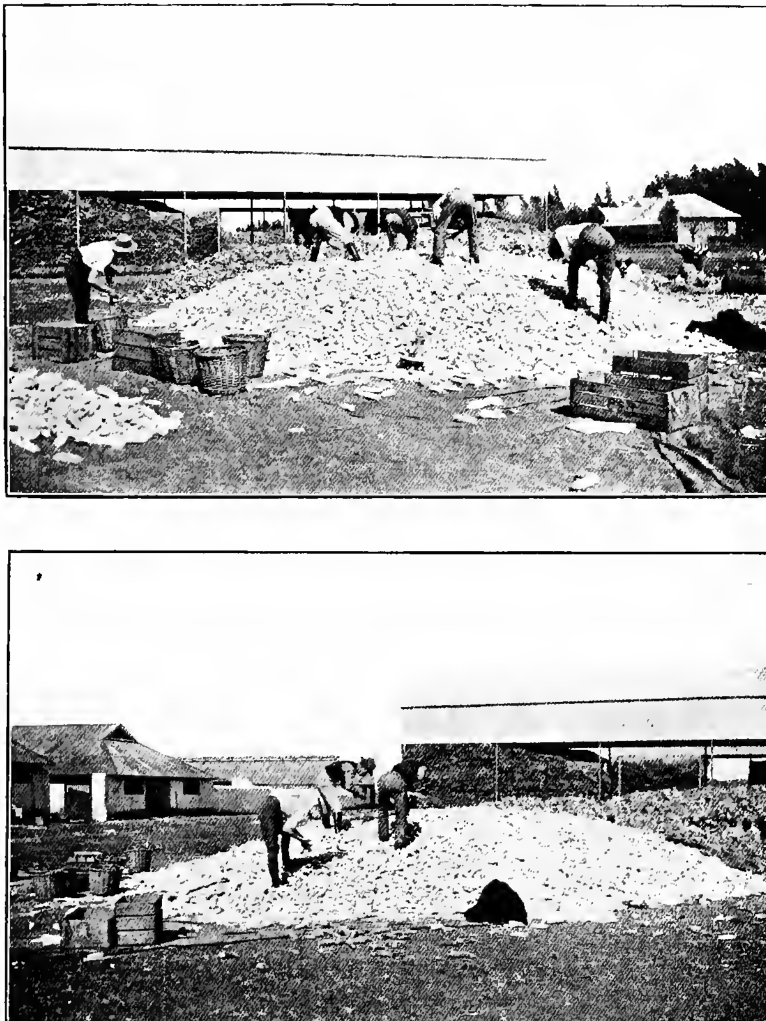


Fig. 89.—Selecting the best ears from the bulk plot.

season; what are we to do to prevent this progeny being crossed by plants in the same field grown from unselected seed? The best plan is to plant the seed in a square of, say,

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70 yards by 70 yards (an English acre), at one corner of the field where the bulk of the same breed is grown. This should be, preferably, on the side nearest the homestead or road, so that the plot may be watched. This is called the *breeding plot* (¶ 183). The rest of the field is planted with the best of the seed which is not considered suitable for the breeding plot.

Second Year's Selection.—The three outer rows of the breeding plot (which have been most exposed to crossing with the plants in the bulk field) are harvested with the bulk crop. The rest of the breeding plot is harvested separately, and any nubbins or undesirable ears are rigidly discarded. From the remainder the twenty best ears are again selected and planted in the breeding plot. The remainder are used for what is known as the propagation plot, which may vary in size from five to ten acres or more, according to the amount of seed available. The propagation plot is planted around the breeding plot, and forms a buffer between it and the bulk plot. The best ears selected (Fig. 89) from the bulk plot are used to plant the current season's bulk plot.

Third Year's Selection.—At harvest time the three outer rows of the breeding plot are harvested with the propagation plot, and the three outer rows of the propagation plot are thrown in with the bulk crop. The remainder of the breeding plot is harvested separately, and any nubbins and undesirable ears are discarded; from the balance the twenty best ears are again selected for the next season's breeding plot, and the remainder are used to plant the propagation plot.

The remainder of the propagation plot is harvested separately; nubbins and objectionable ears are discarded, and the best of the balance is used to plant the bulk fields.

Thus in the third and subsequent years the bulk fields are supplied entirely from twice selected seed from the propagation plot, while the propagation plot is itself supplied from the breeding plot.

In the fourth and subsequent years the work is continued as in the third year; it must always be maintained, for though there is a maximum beyond which "selection" alone cannot carry one, deterioration takes place with remarkable rapidity when selection ceases.

The fundamental principle of the method described above is the rigid elimination of undesirable types, which may appear owing to reversion, and the mating together in the breeding and propagation plots of the most desirable types. CHAP. V.

183. *The Breeding Plot* should be so selected that the soil will be typical of that on which the main crop will be grown. The same preparation should be given as for the main crop, no extra care or fertilizer being used. The object is to find out which plants will give the best results under normal conditions; if they do well, then they may be expected to do better on well-fertilized soils.

It is absolutely necessary that the plot should be isolated at least 400 yards from any other sort, or from strains of the same sort, flowering at the same time. Any stray plants from previous plantings must be carefully rogued out before they have a chance to tassel.

The rows should be 200 or more yards long and of exactly the same length. The seed should be planted on the principle of one row to each ear. After removing the tips and butts from the selected ears, the rest of the grain should be planted in a single row. It is better to drill the seed than to check-row it, as it is difficult to isolate suckers from main stalks when more than one plant occupies a place. Each row should be numbered consecutively and labelled with a stake at the end. With the seed left over from the rows three or four border rows may be planted all round the breeding plot to protect the plot to some extent from depredation.

184. *Devices to Prevent or Detect Cross-pollination.*—As a means of minimizing the amount of cross-pollination between breeds of maize grown near to each other on similar soils, the following devices, among others, have been resorted to at the Botanical Experiment Station, Pretoria; none of them, however, has been entirely successful.

Planting one week and two weeks apart was tried. Several of the breeds tested were new to us, and their relative time of flowering in that climate was not known, so that some of the later-sown flowered earlier than those planted before them. The danger of cross-pollination was minimized by bagging and hand-pollination, but the number of plants of each that could be treated this way was small, and the amount of seed

CHAP. V. saved was therefore limited. It was also found that in some cases in the same breed there was a difference of nearly two weeks in the time of flowering. This experiment demonstrated clearly that close planting, even allowing two weeks between plantings, cannot be relied upon to prevent cross-pollination.

By planting first an early-maturing breed, and two weeks later a late-maturing breed, a certain degree of immunity may be secured. But there would be little practical advantage in this, except where it is necessary to plant several breeds in close proximity, for the farmer usually desires to plant all his late-maturing maize first, and afterwards that which takes less time.

The use of rows of sorghum and kaffir-corn to separate the different sorts has proved unsatisfactory on the Transvaal High-veld, the maize having come into flower before the sorghum was tall enough to afford any protection.

Detasselling is perhaps the most satisfactory method of deeling with the problem. But there is a certain amount of fluctuating variability as regards time of flowering, and variability will be still more pronounced where the strain is heterozygous for this character. In practice this means that detasselling must be repeated (in the same row) two or perhaps three times within a week or ten days, and that great vigilance must be exercised to detect individual plants which flower later than others, and prevent pollen scattering from their earliest anthers.

Covering the plots with cheese-cloth was tried at the Government Experiment Farm, Potchefstroom, as a means of isolating the breeding plots, but was not found satisfactory.

185. *Production of New Types by Artificial Cross-pollination.*—The popular idea of cross-breeding maize is that by crossing two sorts the result will be a hybrid combining the characters of the two parents. This may be the case with the first ear obtained by the cross, but it is not always the case in the progeny of the first generation. Experience shows, moreover, that even where it does occur, the second generation from the cross produces a great deal of variation, more particularly with monœcious plants like maize, and unless scientifically guided efforts are made, this variation will continue from generation to generation for an indefinite period. We have already discussed the reason for this mixture of characters, and how it may be avoided or made use of.

Cross-breds of unknown pedigree are difficult to deal with, and it may take years before they yield any desirable progeny. They should, therefore, be avoided, and the work of improvement should be started with well-bred seed.

Where it is desired to *add new characters* to a breed which does not already possess them, cross-breeding must be resorted to. The actual process of crossing is easy, but to isolate and fix the desired type is an entirely different problem. Crossing produces such varied heterozygous combinations that endless confusion results, and it requires knowledge of the laws of inheritance, and infinite time and patience, to produce order out of chaos. Therefore *cross-breeding should only be practised or permitted where the effect of crossing is understood, the object sought is well known, and the method well planned.*

186. *Reciprocal Crosses.*—Where it is desired to transmit a definite unit-character from one breed to another, it appears to be immaterial which breed furnishes the male and which the female parent; the results in the F_2 generation are usually the same in either case.

187. *Method of Cross-pollinating.*—Cross-pollination is a comparatively simple matter. The silks of the plant to be pollinated must be carefully protected from the access of any stray pollen (Fig. 90); and the pollen of the male plant must be carefully collected so that it will not be mixed with stray pollen of other plants in the neighbourhood. The pollen is then shaken on to the silks and the latter are again covered up until all danger from stray pollen is over. It should be remembered that the pollen is light and easily carried by the wind; when the field or plot is in tassel, the air may be charged with pollen grains, so that difficulty is experienced in preventing contamination of the silks with stray pollen.

188. *Collecting the Pollen.*—The tassel should be covered with a paper bag, an ordinary 2 lbs. grocer's bag, of *thin* but tough brown paper, is found satisfactory. This is tied tightly round the stem below the lowest branches of the tassels. The bag should not be placed on the tassels until the first anthers appear on the terminal branch of the tassel, otherwise the anthers are apt not to develop properly. In the Transvaal, much of the pollen is found to lose its vitality after the third day.

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FIG. 90.—A new breed of maize in process of development. (Courtesy of the South African Railways Publicity Department.)

The tassels may appear before the silks, and sometimes even shed all their pollen before any silk appears (¶ 79). CHAP. V.

The appearance of the tassels is by no means uniform in individuals of the same variety. This is an important point in connection with the work of detasselling, for it makes it necessary to go through the breeding plot three or four times, at different dates, to effectually prevent self-pollination.

189. *Covering the Silks.*—This is done by means of paper bags similar to those used for covering the tassel (¶ 188). The ear should be covered just before the silks first appear, to prevent contamination with stray pollen. The ear may be left for four days or a week before the pollen is applied, in order to allow all the silks to develop. For pollination, the bag is removed and a good dose of pollen shaken on to the silk, care being taken that it reaches all the silks. The bag is then replaced quickly to avoid contamination with stray pollen. The first attempts at hand-pollination are not always satisfactory, but excellent ears may be obtained as a result of skill gained by experience and practice.

The silks may appear either before or after the tassels. Not all the silks mature at the same time; those from the ovules lowest on the cob appear first. Sometimes fresh silks continue to appear over a period of seven days. A single hand-pollination, effected when the silks first appear, is therefore inadequate; nor is it sufficient to repeat it on two successive days; this results in the lower half of the cob being well-filled while the apex remains undeveloped. Three pollinations, at intervals of three days between each, generally prove the most effectual, but by this means greater risk of contamination is incurred.

In some cases, and in the same breed, the silks appear before the tassels. When such an individual happens to be the earliest to flower in a field, it may fail to develop seed; this tendency is therefore unlikely to be propagated to any great extent.

190. *The F_1 Plants.*—Three or four hundred grains will be obtained from a single successful crossing. If the parents differ in colour of endosperm, it will sometimes be possible to tell which grains have been crossed and which selfed accidentally, and the latter can be discarded. But F_1 seed should be

CHAP. V. planted in an isolated breeding plot and each resulting plant should be carefully selfed. By this means it will be possible to detect the results of accidental crossing with stray pollen, and to prevent its spread to the other plants of the cross.

The ears produced by these plants will show segregation in the seed, if the characters involved in the cross are seed characters, and from them selection of the desired grains can be made.

191. *The F_2 Plants.*—The F_2 plants must also be grown by themselves, and selfed. If the desired character is recessive, it will be possible to isolate it and commence propagation. But as our knowledge of the individual unit-characters is at present imperfect, it is desirable to grow the plants on for another generation, and self them, in order to eliminate any undesirable character which may not have appeared. If the F_3 generation breeds true, the new type may be considered fixed and we may proceed to propagate.

192. *Improvement by Breeding is Slow at First.*—At best, improvement by breeding is a tedious process, and the man who is not prepared to be patient, methodical, and persistent, should not undertake it. The writer has known men who started out well, with no little expenditure of time and money, but who, seeing no visible results, gave it up in disgust after the first year. As has been said, visible results cannot be obtained during the first few seasons. It is probable that there is not a pure pedigree commercial crop of maize in South Africa to-day, and very few elsewhere, for maize is a remarkably heterozygous mixture. Before we can hope to make definite progress, we must purify the strains we wish to improve. Hitherto time has been largely taken up with trying out breeds suited to different parts of the country. Now that we have formed definite ideas on this subject, we can devote our attention to their *improvement by breeding*.

Addendum.—Arrangements have been made by the *Agricultural Supply Association, Limited*, P.O. Box 1148, Johannesburg, to supply pure-bred seed of heavy-yielding strains of maize especially suited to the High-veld of the Transvaal and Orange Free State.

CHAPTER VI.

JUDGING AND SELECTION FOR EXHIBITION.

Send forth the best ye breed.

—KIPLING.

193. *The Object of Exhibiting at Agricultural Shows.*—The agricultural show does not exist solely nor primarily for the purpose of winning and awarding prizes. Unfortunately there are too many people who exhibit merely for the sake of prize-winning, having in view either the value of the prize itself, or the advertising of their seeds and other farm products. Those who take all the prizes year after year discourage others who have not equal facilities for preparing special exhibits, but whose work is, nevertheless, worthy of a prize; therefore the number of prizes which can be drawn by any one exhibitor in any section should be limited. CHAP. VI.

The main object of the agricultural show should be educational: the farmer should be able to learn from the exhibits (1) the need for, and the means of, improving his own crops, (2) the relative merits of new breeds, and (3) where to obtain good seed. He may not realize the need for improving his methods and seed until he sees that other farmers' results are better than his own, and an agricultural show should be the best place for him to see this.

We agree with the American writer who says that exhibits arranged with respect to the ready comparison of typical samples of different breeds, offer one of the most effective methods of diffusing knowledge with regard to the characteristics of different breeds.

The main points enumerated in this chapter are already familiar to maize judges of experience, but are given here for reference. Owing to the short time usually allotted to judg-

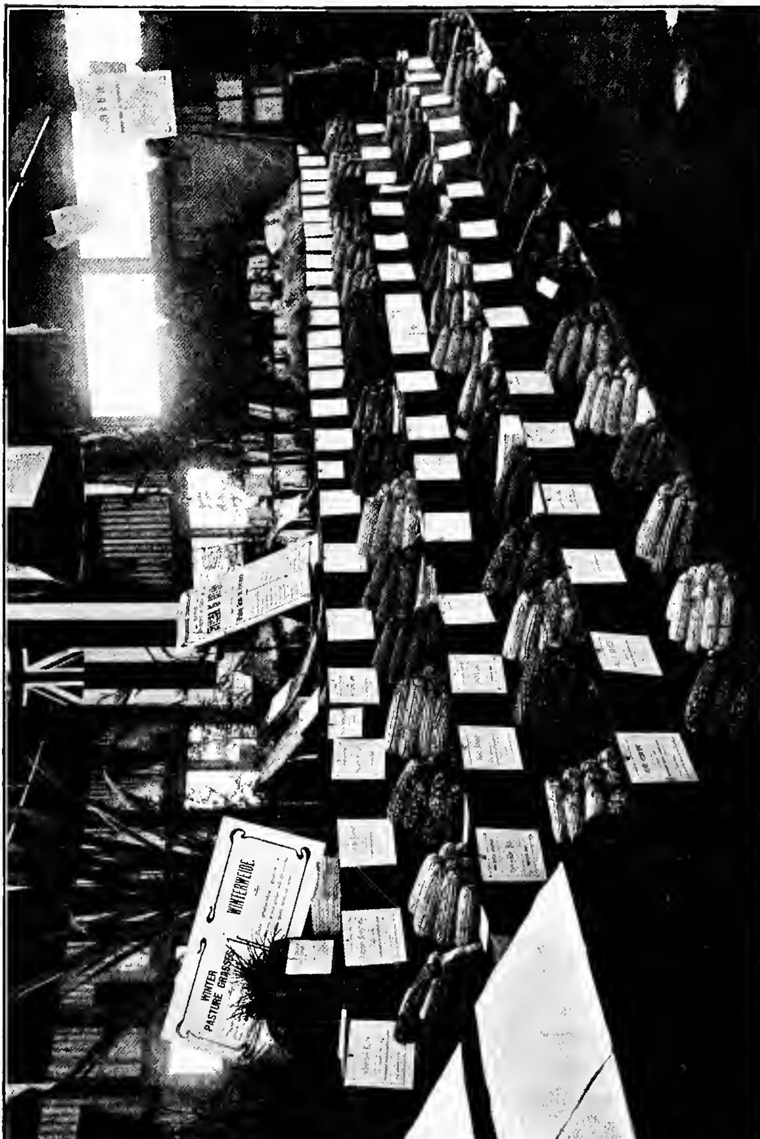

FIG. 91.—Exhibit of the Division of Botany, Transvaal Department of Agriculture, at the First South African Maize and Citrus Show, Johannesburg, 1910.

ing at local shows, certain of the details can be taken into consideration only where competition is very close. CHAP. VI.

194. *Rules Governing Maize Exhibits.*—The following rules are based on experience gained at leading South African shows :—

(1). Each entry must be accompanied by a certificate giving as nearly as possible the date of planting and date of harvesting of the crop and name of the district in which it was grown. These certificates must not be seen by the judge till after the judging.

(2). No exhibit may be entered in more than one class.

(3). An exhibitor may receive only one prize in any one class.

(4). An exhibitor is barred from exhibiting in more than three classes in any one of Sections I to III inclusive. This allows each exhibitor to show an early, medium or main-crop, and a late breed in each section. (At some American shows an exhibitor may enter only in *three classes* in all.)

(5). Every exhibitor may enter for all classes in Section IV (special prizes), but may only take *two prizes* in this section; should he obtain more awards he will have the option of choosing which two prizes he will take. All awards will count as points in the aggregate for the Grand Championship.

(6). Where there is but one entry in a class a prize shall be awarded only if the judge considers the exhibit deserving of recognition.

(7). In such a case the judge shall decide whether a first, second, or third prize shall be awarded.

(8). *Grand Championship.*—The Grand Championship Prize will be awarded for the highest number of points obtained by any exhibitor. Points will be given as follows: Commended, $\frac{1}{4}$ point; highly commended, $\frac{1}{2}$ point; third prize, 1 point; second prize, 2 points; first prize, 3 points; championship of first prizes in a section, 4 points extra. The last-named provision is made to prevent mere number of entries from scoring over quality of exhibit. An exhibitor A who makes three entries in each of the Sections I to III inclusive, and who obtains six first prizes, would score 18 points; another exhibitor B who enters in only one class in each of the three sections may obtain the first prize and the championship in

CHAP. VI. each section; unless the championship counted for more than 3 points, B would score no more points than A, although the quality of his exhibit was superior as evidenced by his taking three championships. The aim of agricultural shows should be to encourage *quality rather than number of exhibits* from any one exhibitor.

(9). In the event of a tie, the judge must decide as to the general relative merits of the two tieing exhibits and award the championship to the one which in his opinion is the best. If taken in an absolutely mathematical sense, the counting of points may result in an injustice to the best exhibit. It is obvious that if an exhibit wins prizes against severe competition, it is more worthy of a championship than one which has no competition.

(10). The exhibits must have been harvested during the twelve months immediately preceding the show.

(11). Exhibits must not, be treated unfairly by removing poor, cross-bred, injured, or otherwise undesirable grains and replacing them by good ones. Any unfair or tricky occurrences bar the exhibitor from all entries and all privileges of the show. One, or not more than three, grains may be removed by the exhibitor from one or more sides of each ear, in order to decide whether the ear is fit for exhibition.

(12). "Grooming" of the ears in such a manner as to allow of their best possible presentation, is strongly recommended; e.g. shanks of ears should be neatly removed with a pocket knife, and loose silks should be carefully taken off.

(13). Exhibits must be delivered to the stewards of the produce section two clear days before the opening of the show. They must be carefully labelled both *inside* and outside of the bag or box, for it often happens that the outside label is torn off in transit, and the owner is then traced with difficulty. The inside label should bear the name and address of exhibitor, the date of forwarding, and the section and class in which the entry is made. It is best to tie this on to at least one of the ears, or inside the mouth of the sack of shelled grain.

(14). All exhibits are subject to necessary handling by the judge, but remain the property of the exhibitor, and may be secured by him immediately after the show is declared closed and the awards have been made.

(15). Professional maize breeders, seed dealers, or expert judges will not be allowed to compete except in classes specially arranged for them.

(16). A bag of shelled maize shall weigh 203 lbs. gross.

(17). A bag of ears must be contained in a full muid maize sack, and must weigh about 100 lbs.

(18). An ear of maize is a cob with the grain still attached, but with the husks removed.

(19). In classes in which the breed is not specified, each entry must be conspicuously labelled with the name of the breed, or the entry will be disqualified, and the name of the breed, as given by the exhibitor, should be printed in the show catalogue.

195. *The Prize-list.*—It is important that the growing of recognized standard breeds of maize be encouraged; the offering of prizes for specific named breeds is doing much to permanently improve the maize industry of South Africa. The custom of allowing one recognized breed to compete with another in the same class (except for a championship) should not be allowed, except in certain special cases indicated farther on in this chapter.

196. *Classification.*—The proper classification of exhibits is essential to the educational value of a show, and to successful judging. In the classification of maize two main points should receive consideration :—

(1) The exhibition of ears selected for seed, by which the would-be buyer can determine by whom and where the best seed maize is grown in his particular district, province, or country. In this section there are usually two subsections, (*a*) the ten-ear and (*b*) the single-ear competitions. It is sometimes argued that this section has no value to the practical farmer because "anyone can grow ten good ears in his back garden". This, however, is not the case. To produce ten really good exhibition ears from a small plot is almost impossible, owing to the much greater danger of imperfect pollination, attacks by insect pests, etc. The ten-ear and single-ear competitions are essentially educational; through them a farmer learns what to select for seed.

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(2) The exhibition of the commercial article—the maize-grain—by which the merchant and manufacturer are enabled to learn where and by whom are grown the best qualities for their particular classes of trade.

Two distinct score-cards are required for the judging of these sections.

197. *Sections.*—The following sections are found suitable for South African shows:—

Section I.—Shelled maize for market or export. One muid (203 lbs. gross) of shelled maize, each bag to be accompanied by one full bag (to weigh about 100 lbs.) of ears from the same crop; these ears to be taken into consideration by the judge in making the awards.

Section II.—Seed-maize; ten ears selected for the breeding plot.

Section III.—Best single breeding ear.

Section IV.—Special prizes.

As far as possible all of these sections should be represented in every prize list, in districts where maize is a staple crop.

198. *Classes.*—The following is a list of classes suitable for maize shows. It is usually only the central shows which are able to offer such a complete list as is here given; very few district shows need include all of the classes, for only a few of the breeds named are grown in any one district.

Section I.—Seed-maize: Ten Ears Selected for the Breeding Plot.

Entrance fee, 5s. per class.

Prizes (in each class): 1st, £2; 2nd, £1; 3rd, 10s. Championship (of all classes in this section), £3.

Dent Breeds (white).

Class.

1. *Hickory King* (8-row).
2. 10-row *Hickory* or *Louisiana.*
3. 12-row *Hickory* or *Hickory Horsetooth.*
4. *Salisbury White*, *Mazoe*, or *Brindette.*
5. *Mercer.*

Class.

6. *Iowa Silver-mine.*
7. *Boone County.*
8. *Ladysmith* or *Champion White Pearl.*
9. *Natal White Horsetooth.*
10. Any other white dent breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Dent Breeds (yellow).

11. *Eureka.*
12. *Yellow Hogan.*
13. *Chester County.*
14. *Reid.*
15. *Yellow Horsetooth* or *German Yellow.*
16. *Golden Beauty.*
17. *Minnesota Early.*
18. *Golden Eagle.*
19. Any other yellow dent breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Flint Breeds (white).

20. Any white flint breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Flint Breeds (yellow).

21. *Yellow Botman.*
22. *Yellow Cango.*
23. *Wills Gehu.*
24. Any other yellow flint breed. (In this class entries *must* be labelled with the name of the breed or the exhibit will be disqualified.)

Flour corn or Bread-mielies.

25. *Brazilian Flour corn* or *South African Bread-mielie.*

Sugar maize.

26. Any breed of sugar maize. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Pop-corn.

Class.

27. Any breed of pop-corn. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Section II.—Best Single Breeding Ear.

Entrance fee, 2s. 6d. per class.

Prizes (in each class): 1st, £1; 2nd, 10s.; 3rd, 5s.; Champion Ear (the best ear of all the first prize ears), £2.

Dent Breeds (white).

28. *Hickory King* (8-row).
29. 10-row *Hickory*.
30. 12-row *Hickory* or *Hickory Horsetooth*.
31. *Salisbury White*.
32. *Mercer*.
33. *Iowa Silver-mine*.
34. *Boone County*.
35. *Ladysmith* or *Champion White Pearl*.
36. *Natal White Horsetooth*.
37. Any other white dent breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Dent Breeds (yellow).

38. *Eureka*.
39. *Yellow Hogan*.
40. *Chester County*.
41. *Reid*.
42. *Yellow Horsetooth* or *German Yellow*.
43. *Golden Beauty*.
44. *Minnesota Early*.
45. *Golden Eagle*.
46. Any other yellow dent breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Flint Breeds (white).

Class.

47. Any white flint breed. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Flint Breeds (yellow).

48. *Yellow Botman.*
49. *Yellow Cango.*
50. *Wills Gehu.*
51. Any other yellow flint breed. (In this class entries *must* be labelled with the name of the breed, or the exhibit will be disqualified.)

Flour corn or Bread-mielies.

52. *Brazilian Flour corn* or *South African Bread-mielie.*

Sugar maize.

53. Any breed of sugar maize. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

Pop-corn.

54. Any breed of pop-corn. (In this class entries *must* be conspicuously labelled with the name of the breed, or the exhibit will be disqualified.)

SECTION III.—SHELLED MAIZE FOR MARKET OR EXPORT.

One muid (203 lbs. gross) of shelled maize; each entry must include one full bag (to weigh about 100 lbs.) of ears from the same crop. These ears will be considered in judging the sample.

Entrance fee, 5s. per class.

Prizes (in each class): 1st, £3; 2nd, £2; 3rd, £1; championship (of all classes in this section), £5.

White "Flat".

55. *Hickory King.*
56. *Natal White Horsetooth.*
57. Any other flat white dent breed.

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Yellow "Flat".

Class.

58. Any flat yellow dent breed.

White "Round".

59. Any round white breed.

Yellow "Round".

60. Any round yellow breed.

Section IV.—Special Prizes.

Entrance fee, 20s.

Every exhibitor will be allowed to enter for all classes in this section, but may take only two prizes; should he get more awards in this section, he will have the option of choosing which two prizes he will take. All awards will count as points in the aggregate for the Grand Championship Prize.

61. Five muids of shelled "Choice White Flat" maize, suitable for export (any breed), with one bag of ears of seed-maize of the same breed, each bag to weigh about 100 lbs.

    Each entry must be accompanied by a certificate signed in the presence of the Field Cornet or the Resident Justice of the Peace, stating that the exhibitor has produced at least 500 muids of the same breed of maize on dry lands, during the past season, and that this particular exhibit was grown without irrigation.

First prize . . .	£10
Second prize . . .	£5
Third prize . . .	£3

62. Five muids of shelled "Choice Yellow Flat" maize, suitable for stock food or for export (any breed), with one bag of ears of seed-maize of the same breed, each bag to weigh about 100 lbs.

    Each entry must be accompanied by a certificate signed in the presence of the Field Cornet or the Resident Justice of the Peace, stating that the exhibitor has produced at least 500 muids of the same

Class.

breed of maize on dry lands, during the past season, and that this particular exhibit was grown without irrigation.

First prize . . .	£10
Second prize . . .	£5
Third prize . . .	£3

63\. Five muids "Choice Yellow Round" maize, suitable for export (any breed), with one bag of ears of seed-maize of the same breed, each bag to weigh about 100 lbs.

Each entry must be accompanied by a certificate signed in the presence of the Field Cornet or the Resident Justice of the Peace, stating that the exhibitor has produced at least 500 muids of the same breed of maize on dry lands, during the past season, and that this particular exhibit was grown without irrigation.

First prize . . .	£10
Second prize . . .	£5
Third prize . . .	£3

64\. Five bags of ears of *Hickory King* seed-maize (grain on the cob). Each bag to weigh about 100 lbs.

First prize . . .	£10
Second prize . . .	£5
Third prize . . .	£3

65\. Five bags of white seed-maize on the cob, of any one breed (except *Hickory King*). Each bag to weigh about 100 lbs.

First prize . . .	£15
Second prize . . .	£10
Third Prize . . .	£5

66\. Five bags of yellow seed-maize on the cob, of any one breed. Each bag to weigh about 100 lbs.

First prize . . .	£15
Second prize . . .	£10
Third prize . . .	£5

199\. *Championships.*—Championships are a great stimulus to keen competition, if properly arranged and managed. But

CHAP. VI. at some local shows in South Africa the whole purport of a championship seems to have been misunderstood, and the mistake has been made of calling for separate entries for the championship, thus turning it into a distinct class, which is uncalled for and undesirable. The aim and object of the championship is to determine which is the best exhibit in *any* class in the whole show; experience proves that if separate entries are called for, for the championship, the end aimed at is defeated, for the majority of exhibitors will not make separate entries, nor pay two fees, on the chance of securing the championship.

200. *Principles of Judging.*—Although each Province and District specializes in particular breeds of maize, and though the ears produced in each may differ in size, etc., the principles underlying maize judging are the same for all conditions, and these must be clearly understood in order to judge successfully. It is not merely a question as to which is the best exhibit in its class, on a particular show, but whether the exhibit compares favourably with a definite standard. This standard should be the one recognized by authorities as embodying all of the qualifications of the best maize. Therefore the judge must be thoroughly familiar with the points on which maize is judged, and with the standards which have been set for each breed. A printed "standard of perfection" is a useful guide; such a standard cannot be final, but will grow or be modified from year to year as the various breeds are improved or altered.

A well-arranged score card is of great assistance in maintaining a judicial balance. But the judge should bear in mind that there are no absolute rules which can be reduced to writing by which maize samples can be properly judged, independent of that intuitive perception of good and bad points which in a good judge accompanies experience. The score card may easily be abused if it is used in a strictly mathematical sense, for there are certain points which cannot be reduced to precise figures, and which will be neglected in the effort to do so. If the score card is slavishly followed, a wrong decision will result. On this account the use of the score card is sometimes condemned, though it is usually not the score card but the lack of comprehension on the part of the judge which is to blame. The judgment of the person who is comparing the exhibit must enter into the score, and experience should guide him in marking each point on the card. There are some men who are born judges, who can intuitively judge by eye without the aid of a score card; there are a few who even claim to find the score card a hindrance, because their perception and summarizing of points go together so quickly; but we believe such men are rare.

There are so many points in an exhibit, that one may easily place undue value on those which can be seen at a glance, such as length of ear, uniformity, narrow sulci, good colour and good tips, to the neglect of such important points as shape and depth of grain, circumference and shape of ear, yield per ear, percentage of grain to cob, and the like. To the average judge of maize, the score card is of great assistance in just such cases.

201. *Methods of Judging.*—The aim in judging is to determine which is the best exhibit, by careful comparison with a uniform standard scale of points. It is desirable to keep the separate scores of different exhibits side by side for comparison, and the most convenient way to do this is to have a printed score card of uniform size and shape. In scoring any point, it is useful to have the exhibits which have already been judged also laid out side by side, so that at any time a comparison of scores already made may be easily and quickly noted. Where there are many entries and the scoring is at all close, it is well to refer from time to time to the score previously given for the same point in the other exhibits. Unless this is done, it is difficult for the judge to keep clearly in mind the exact "cut" made on a point in previous cases.

The stewards, judge, and assistants should use care not to injure the ears, which should be handled as little as possible, and should not be broken. If damaged by falling, the loss of grain will affect the percentage of yield.

Good light is necessary in order to detect poor colour of grain and cross-bred grains. A convenient table is essential to good judging; it should be of such a height that the judge can see both tips and butts without handling the ears, and so that he need not stoop unduly to examine them. The judging table should be of such size and so arranged that

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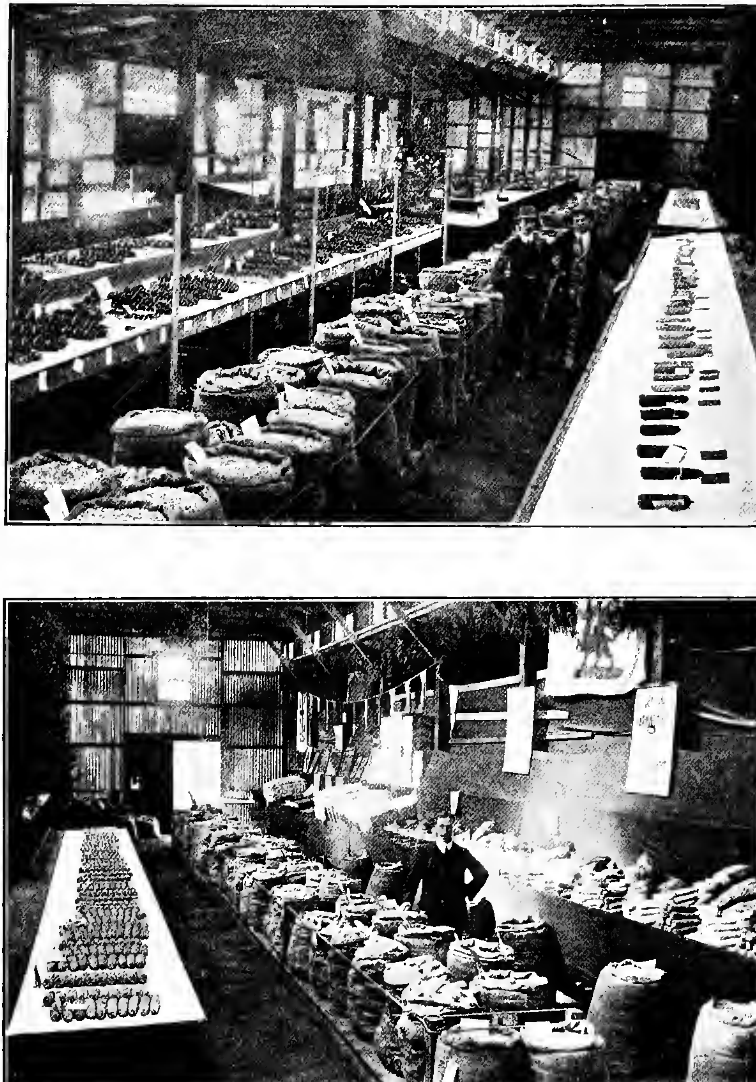

FIG. 92.—Maize Exhibits at the First South African Maize and Citrus Show, Johannesburg, 1910.

the ten ears of each exhibit can be laid out side by side for comparison.

An exhibit of ten ears is desirable, as it facilitates scoring of points and rapid calculation of averages. Rapidity of movement is essential to success in judging a large number of entries; ten minutes should be long enough for any one exhibit of ten ears, except for determination of percentage of grain to cob and total yield of grain. To judge a sample accurately in ten minutes means that all unnecessary moves must be omitted. The eye must be trained to judge accurately at first sight.

After the other points have been determined in any one sample, a competent assistant should follow to shell off and weigh up the ears to determine percentage of grain to cob. For this purpose the five alternate ears of the ten are weighed and shelled, the weight of shelled grain is taken, and the percentage determined.

202. *Judging Maize for Seed.*—The aim in judging seed-maize is to determine which is the best sample for *seed* purposes. The *best* seed-maize is that which will produce the heaviest yield per acre of grain, of the best quality for feeding or for manufacture. Such a type will, obviously, be the most profitable to grow. The competing exhibits are carefully compared with the standard recognized as embodying all of the qualifications of the best seed-maize. These qualifications include points

(1) which ensure good yield, e.g. size, uniformity, and shape of ears, straightness of rows, well-filled butts and tips, shape of grain, yield of grain per ear, percentage of grain to cob, etc.;

(2) which ensure a perfect "stand" or crop in the field, e.g. uniformity in shape of grain, size of embryo, percentage and vigour of germination;

(3) which ensure good condition for consumption or export, e.g. maturity, soundness, dryness, etc.;

(4) trueness to type and breed characteristics in shape, colour, etc.;

(5) the value of the sample for feeding or manufacturing purposes as evidenced by the comparative percentage of protein, oil, starch, etc.

CHAP. VI. Shamel points out that these standards have been developed and arranged by experienced growers, breeders, and judges to such a degree that a sample which comes up to these standards has been found (1) to give the best yield; (2) to have the greatest degree of vitality; (3) to be the most profitable seed to grow, and consequently (4) to command the highest price as seed. It is recognized, however, that not enough is yet known about the correlation of characters to say that the standards are perfect.

203. *Desirable Characters for Breeding Ears.*—A casual glance at an ordinary harvested crop of maize ears conveys but little idea of the degree of variation among them. It is surprisingly difficult to find ten uniform ears in a heap of many thousands from an ordinary crop.

Much remains to be done in the thorough scientific study of the maize plant to find out which visible characters are associated ("correlated") with the invisible characters to which we owe yield and quality. That such visible characters exist is well known among stock-breeders; an experienced dairyman buying a milch cow looks for one with a long, thin tail, prominent "milk" veins, good udder, and with a certain type of body and head. It is not probable that a thin tail has any direct connection with the supply of milk, but experience shows that a thin-tailed cow is usually a better milker than one with a thick coarse tail. So with plants; there are visible characters which may be correlated with the invisible. Experience shows that certain characters of the ears are in certain breeds associated with heavy yields. A study of these correlations has led to the framing of score cards for judging.

204. *South African Score Card for Seed-maize.*—The following score card has been successfully used by the Department of Agriculture of the Union of South Africa. It has been carefully prepared by comparing and testing the various score cards in use in the United States. It differs from any one of them in that greater stress is laid on weight of grain per ear than on proportion of grain to cob; it is the yield of grain that is important, irrespective of the amount of cob.

SCORE CARD FOR JUDGING MAIZE EARS.

Show.................................... Date ....
No. of Exhibit.......................... Class..............Breed..............
Name and Address of Exhibitor...

Disqualify any exhibit of white maize which has a red cob.
If any exhibit is conspicuously deficient in one or more of the eight last-named points, those particular points should be taken into consideration first.

SCORE.	POINTS. Possible.	Award.
1. Length of ears. (Measure and compare with standard of perfection; add the total sum of the deficiency, and for each inch cut 1 point)	10	
2. Sulci, i.e. space between rows. (Cut 1 for sulci $\frac{1}{8}$ inch wide or over, ·75 for $\frac{1}{16}$ to $\frac{1}{8}$; ·5 for $\frac{1}{32}$ to $\frac{1}{16}$) . .	10	
3. Shape of grain. (This depends partly on the breed; it is usually desirable for the grain to be wedge-shaped, and even in *Hickory King* it should be longer than broad; take particular note of the *shoulders* at top and bottom of the grain. Allow ·5 for every ear having well-shaped grain)	5	
4. Length of grain. (This must depend on the breed standard; a well-grown *Hickory King* may be $\frac{11}{16}$ inch long; and a good *Yellow Horsetooth*, *Eureka*, *Reid*, or *Iowa Silver-mine* should reach $\frac{3}{4}$ inch; cut 1 for every ear having short grain) . . .	10	
5. Uniformity of grain. (Place one grain from each ear side by side; cut 1 for every grain which is not uniform with the majority)	10	
6. Yield of grain. (Carefully shell and weigh the grain from half the ears in each exhibit; take the average weight per ear, and for each $\frac{1}{2}$ oz. below standard cut 1 point)	10	
	55	
If exhibits score at all closely on the above six points, the following eight additional points should be taken into consideration:—		
7. Trueness to type or breed characteristics. (Cut ·5 for each ear not coming up to standard in this particular)	5	
8. Shape of ear and straightness of rows	5	
9. Uniformity of exhibit	5	
10. Covering of butts	5	
11. Covering of tips	5	
12. Colour of grain. (Cut for variation in shade or tint) .	5	
13. Size of embryo	5	
14. Market condition (i.e. dryness and soundness of ear and grain and firmness of grain on the cob; the grains should be free from decay and should be well filled, not shrivelled nor chaffy)	10	
N.B.—Some breeds, e.g. *Ladysmith*, *Boone County*, and *Iowa Silver-mine*, have naturally rough grain; no cut should be made for roughness unless it is clearly due to lack of condition; cut 1 for every ear out of condition.		
	100	

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205. *Length of Ear.*—Standards at best are but approximate, and especially is this true in regard to length of ear. Change of altitude and latitude affect development, so that it is necessary to vary the standard for length of ear of the same breed, according to the part of the world (e.g. America or South Africa) or even according to the part of the same country (e.g. the Transvaal or Natal), in which it is growing. Seven and a half to 8½ inches is the usual length for ears of *Hickory King* in the United States. We have been able to grow ears of this breed 11½ inches long, and it may be necessary to fix the South African standard higher than that of the States. The difference is perhaps due to crossing and subsequent selection over a period of years. Variation of season also affects length of ear, so that it will not do to take the measurements of a single season as a guide in setting the standard. But variation of season need not affect the use of the standard in judging. In an unfavourable season it may happen that no exhibit comes up to standard length; then all exhibits lose alike on this point, and, at the most, length of ear only affects the score by 10 per cent.

Very long ears are usually produced only when the season is long and particularly favourable, for long ears appear to require a relatively long season for full development. It is probable that the majority of the longest ears in a crop were produced on late-maturing plants, therefore we may reasonably expect that if in seed selection we pick the very longest ears we may be developing a late-maturing strain. This may be counteracted, to some extent, by selecting from among the long ears those that have the most perfect tips.

In measuring ears take the full measurement from extreme butt to tip. This can be done best by the use of the foot-rule held in both hands, one end even with the butt the other end over the tip of the ear. Add together the deficiency and excess of length of each of the ten ears, as compared with the standard, and cut one point for each inch so obtained.

206. *Sulci or Spaces between Rows.*—A wide space between rows means waste of space that should be filled by the grains, and therefore means loss of grain. There are two places at which waste space must be looked for—

(1) the *sulci* or spaces between the rows of grain on the surface of the ear;

(2) the space between the tips of the grain, especially noticeable with sharply-pointed grains.

The sulci are generally widest in broad-, shallow- and smooth-grained ears, and in those breeds having fewest rows. Cut 1 point for sulci $\frac{1}{8}$ inch wide or over; ·75 for $\frac{1}{16}$ to $\frac{1}{8}$ inch, and ·5 for $\frac{1}{32}$ to $\frac{1}{16}$ of an inch. But judgment must be guided by experience in this matter.

The space at the tips can be judged fairly well by the shape of the grain, but in close judging it is well to shell off a space 4 inches long and 4 rows wide, on the five ears that are to be shelled for determination of yield of grain. By examining the exposed ends and sides of the rows it is easy to determine the degree of loss of space; ·25 may be cut for each ear showing too much loss of space.

Reduction of width of sulci is well illustrated in Fig. 67 of *Doyle Hickory King*.

207. *Shape of Grain.* — Generally speaking, the wedge-shaped grain is the best type to breed to, because it necessarily furnishes the greatest amount of grain for the same size of ear.

The shape of the grain is influenced to some extent by the number of rows, for we find that ears bearing eighteen to twenty-four rows usually have wedge-shaped grain, while those with less than eighteen rows are apt to have broader, rectangular, or round-edged grains. This is not constant, however, for 10-row *Hickory* has more or less wedge-shaped grains. The question of the most desirable shape for each breed is largely a matter of experience. In South Africa the types have not yet been definitely fixed. The edges of the wedge should not be curved but straight.

The proportion of starch is much higher in a *thick* grain than a thin one, and the proportion of bran and waste lower, which appeals to the miller and merchant; therefore thick grains are more desirable than thin ones. By thick grains we mean thick in the direction of the main axis of the ear.

The tip of the grain should be thick, plump, and not sharply pointed. Grain with a thin tip has a relatively low oil- and protein-content, and usually a lower vitality.

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In scoring, ·5 is allowed for each ear having well-shaped grain.

208. *Length of Grain.*—The longer the grain, the greater the yield, but the shape varies with the breed, and the length should be in good proportion to the width. Breeders classify by shape of grain, having three groups of breeds:—

(*a*) Grain broader than deep.

(*b*) Grain as broad as deep.

(*c*) Grain deeper than broad.

Scoring should be based on the characteristic shape of the particular breed being judged, which implies a good knowledge of the different breeds: e.g. *Hickory King* is judged as *Hickory King*, and should not be cut because the grain is broad in proportion to its length; but even in *Hickory King* there is great variation in length of grain, and preference should be given to the exhibit having the longest grain, if true to breed characteristics.

209. *Uniformity of Grain.*—Take two grains from every ear at about one-third of the distance from the butt and place them on the table in front of the ear, with the tip of the grain pointing to the ear. The shape of the grain will vary with the breed (see Fig. 61), and its shape should be true to the characteristic of that breed. Whatever the shape and size of grain in the breed, the grains should be uniform on all parts of the ear, not only in shape and size, but also (in dent breeds) in the character of the dent and smoothness or roughness of the grain end. Thus on smooth ears all the grains should be smooth, and on rough ears all should be rough. Roughness of grain is not necessarily objectionable, for as a general rule we find that a smooth grain is usually shallow, while a more or less rough grain is usually deep; but roughness may be too pronounced, and an extremely rough ear is difficult to handle and makes husking a slower and more expensive process.

210. *Yield of Grain per Ear.*—Weigh together the five alternate ears of the exhibit, shell them carefully so that none of the grain is lost, and weigh the grain; calculate the average weight per ear by dividing by five, and for each half ounce below standard cut 1 point.

The percentage of grain to cob can then be calculated; this will depend partly on the condition of the ears, for ears that are thoroughly dry yield a greater percentage than those which are still wet. If the yield of grain per ear is obtained, there appears to be little—if any—advantage in scoring for percentage; it is the total weight of grain which we wish to increase, and whether it is borne on a thin or a comparatively thick cob is immaterial. Experience shows that very thin cobs do not give such heavy yields of grain as comparatively thick ones. CHAP. VI.

211. *Trueness to Type and Breed Characteristics.*—In live-stock breeding the desirability of keeping to uniform types is universally recognized. It is equally important in plant-breeding, but the principle is less rigorously applied because the types of farm crops are not so definitely fixed. Stock-breeding on systematic lines has been practised for many generations; maize-breeding on definite lines is much younger, and in some cases the types change as the breeds improve. But even in maize, standards have been set by Breeders' Associations, for the older and well-established breeds, and where this is the case it is desirable to adhere to them.

Variations of one sort or another are met with, more or less frequently, in most breeds of animals and plants; these are culled out by the careful breeder. If any such variation is likely to prove beneficial, the individuals showing it may be isolated and inter-bred in order to "fix" the new character, and by this means new strains, races, or breeds may be produced. *But it is not desirable to start new breeds unless their distinctive characters are clearly worth having*; there is far too much naming and propagating of novelties based on trivial or unstable characters. Such "new creations" often lead to bitter disappointment on the part of the grower; the farmer would be wise to await the verdict of a competent Breeders' Association before spending time and money over untried novelties, and the Show Committee should not include them in the prize list without good authority.

Selection to type is necessary to the preservation of the characteristics of the breed, and also to the development of that uniformity which is essential to the production of the best merchantable article. With maize it is not always easy to furnish a written description of the breed characteristics, which could be recognized by anyone unfamiliar with them; in judging this point experience is the best guide.

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In the case of breeds the characteristics of which are not yet definitely fixed, the grower must choose for himself since there is no established standard to guide him. Among the ears in his crop which show variation in characters there is usually one type which is better than the others.

212. *Shape of Ears.*—The shape of the ear affects the yield, quality, and uniformity of the grain. The object in view is the selection of the best shape of ear to produce the largest possible yield of shelled grain, and to ensure proper maturity under prevailing climatic conditions. The cylindrical ear is, on the whole, the best for these purposes, but some breeds are characterized by a more or less tapering ear, and where a tapering ear is a characteristic of the breed it should not be treated as a defect, nor should the exhibit be "cut" on that account. If the grower does not like a tapering ear he can discard that particular breed in favour of one with a more cylindrical ear, or he can begin to develop from the old breed a new one which will meet his particular requirements. But little is yet known as to the actual relative merits of the different ear-shapes.

The principal objection to a tapering ear is that the grains in the upper portion are usually much smaller than those on the rest of the ear, and an uneven sample is the result. It is sometimes found that two rows run only part way up the ear, or in other words are "lost" (Fig. 83); this is a defect, as it means loss of grain.

It is difficult to define the varying degree of tapering in different breeds, and here, again, experience rather than written rules must be the judge's guide.

Some breeds being grown in South Africa at the present time, e.g. *Chester County*, show a tendency to flattening or lateral compression of the ear which sometimes develops into a fasciation (Fig. 85A) of either the whole, or the upper portion, of the ear, and sometimes to a lobing or division of the apex into fingers (Fig. 85B). These features are undesirable, and all tendency towards them should be bred out by discarding ears which show flattening at the tip. A quarter point is allowed for each well-shaped ear in the exhibit.

213. *Straightness of Rows.*—Straightness of rows may be less important than size or shape of ear and depth of grain,

but although it may appear at first sight to be merely a "fancy point" (¶ 175), it has a bearing upon the yield and quality of the grain. An ear with twisted (Figs. 58 and 59) or irregular (Fig. 84) rows cannot carry as much grain of uniform quality as one of the same size but with straight, regular rows. Moreover, the tendency to twisted rows seems to be cumulative, and may develop into complete loss of rows, which tends to a reduction of yield and an unevenness of grain. CHAP. VI.

At the same time it has been observed that some otherwise well-bred strains develop a marked tendency towards slight twist in the row, and an exhibit should not be scored too heavily on this account, if it has depth of grain and other desirable characters.

214. *Uniformity of Exhibit.*—Uniformity of exhibit refers to uniformity in appearance, shape, size, colour, indentation, smoothness, etc., but not to the *kind* of shape or colour. The shape and size may be poor, but if the ears are alike they must be given full marks for uniformity; the poor shape and size will be scored down when those particular points are dealt with. In scoring for uniformity remove those ears which are distinctly different from their fellows; half a point is allowed for each of the remaining uniform ears.

215. *Butts of Ears.*—To some extent the shape and covering of the butt are breed characteristics, and in such cases allowance may be made for this fact. With most breeds, however, it is desirable that the rows of grain should be carried well over the butt (Fig. 66A) leaving only a narrow opening through which the shank passes to the cob. If the rows of grain end abruptly on a level with the end of the cob (Fig. 66B) the ear will not yield as much (other things being equal) as if they are well carried over. A *swollen* butt is an undesirable character, for large, poorly filled butts usually have unduly large and thick cobs; these dry out slowly, and delay harvest; in frosty parts of the country this results in damage to the grain. The shank should be medium in size, for large, coarse shanks break off with difficulty and delay the work of harvesting and shelling where the latter is done by hand. But the shank should not be too small (Fig. 70) or the ear will break off in the wind before the main crop is ready to harvest. Exhibitors at a show should trim out the shanks

CHAP. VI. with a penknife before sending in their exhibits, for if the shanks are left on, the appearance of the exhibit is spoiled and the judge is apt to mark down accordingly.

Well-filled butts are more frequently met with than well-filled tips, because the silks from the butt appear first and remain in a receptive condition until sufficient pollen is available for fertilization. The silks from the tip of the ear appear last, and it not infrequently happens that all the pollen has been shed before they appear. In most South African breeds the pollen is mature some days before the silks become receptive.

The following scores are allowed for butts :—

(1) For butts having the grains swelled out around the shank in a regular manner, leaving a concave depression, allow full marks.

(2) Grains swelling out but not in a regular manner : cut ·1.

(3) Grains not swelling out beyond cob but regular in size : cut ·2.

(4) End of cob covered, but grains flat, shallow, and irregular : cut ·3.

(5) For poorly covered butt : cut ·5.

216. *Thickness of Cob.*—The cob is merely the support which carries the grains, and the larger the cob—other things being equal—the greater the number of grains that can be carried upon it. A careful study of this point shows that the best yielding ears have thicker cobs than those which give poor yields, or, in other words, that thin cobs generally result in poor yields. But a very thick cob should be avoided, because it requires too long to dry out thoroughly and is more difficult to shell off in a hand-sheller.

217. *Tips of Ears.*—There should not be any projection of bare cob beyond the uppermost grains on the ear, because this indicates lack of pollination through irregularity in flowering or other defects in the parent. The tip of a well-bred ear should be regularly covered with uniformly-sized grains. The percentage of such well-covered tips will vary with the season, and in some seasons it may be difficult to find any so covered ; but if the scoring is uniform in this particular, all exhibitors will be affected alike and no injustice will be done. It is usually found that short ears are better filled than long

ones, and, other things being equal, it is preferable to select long ears which are not so well covered than uniformly short ears which are well covered. In judging, however, length of ear is dealt with independently and must not affect the scoring for covering of the tips. In a well-covered tip the grains should continue in straight rows up to the very end, and not be scattered irregularly; for irregular grains the tips should be scored down according to degree of irregularity. For every exposed or badly covered tip 1 inch long, a cut of ·5 may be made, while less is taken off for shorter exposed tips.

218. *Colour of Grain.*—Yellow grains on a white ear indicate crossing, whether the yellowness is dark or pale; this means either:—

(1) that the crop has been grown too near to a yellow breed; or

(2) that the seed used was not quite pure, containing some (perhaps only a few) yellow grains or white grains carrying a yellow "factor"; or

(3) that grains from a crop of yellow previously grown on the same ground have produced volunteer plants which have caused the crossing.

In the first case the yellow grains are usually most plentiful near either the tip or the butt, owing to the fact that the volunteer plants, or the neighbouring field of yellows, came into flower at the beginning or close of the flowering period of the white breed.

The effect of crossing a yellow breed with white pollen is not always as clearly marked as in the case of yellow on white; in some cases the whiteness on the yellow is quite imperceptible, in other cases it shows in the form of a white cap on the yellow grain. Some pure breeds have a normally white-capped grain, e.g. *White-cap Dent* and *Bristol 100-Day;* in such cases a white cap does not necessarily indicate crossing.

For one or two yellow grains on a white ear, or white grains on a yellow ear, a "cut" of ·25 points is made; for three or four such grains, ·5; for five or six, ·75; for seven or more, cut 1 point.

Missing grains are considered as having been crossed, for the judge has no means of telling that they were not removed by the exhibitor to prevent a "cut" for crossing. In practice

CHAP. VI. cut ·1 of a point for each missing grain, except for those grains (three only) (¶ 194, § 11) which have been removed by the exhibitor from near the centre of each ear to determine whether the ears were suitable for seed or exhibition.

Richness of colour is a point in favour of yellow maize, but some breeds are naturally paler than others, e.g. *Golden King* as compared with *Yellow Hogan*. Dullness of colour may be due to age, to damage in drying, or to harvesting before the grain was sufficiently dry.

219. *Size of Embryo.*—A small, poorly developed embryo gives a poor germination and a weak seedling, which is less capable of withstanding drought, insect attacks, etc. Most of the oil of the maize-grain is contained in the embryo, so that the larger the embryo, the higher the oil-content.

220. *Market Condition.*—By market condition is meant the best condition for marketing purposes. Condition includes dryness, firmness of grain on the cob, soundness, maturity, and freedom from injury or disease. Maturity is determined by the filling out of the grain. *Chaffy* ends usually indicate lack of maturity, but some breeds naturally have rough ends even when the grain is thoroughly mature, and a good knowledge of breeds is essential, to avoid mistakes in this respect. Loose grain usually indicates lack of maturity, but here again knowledge of breeds is necessary, because some of them naturally have a loose grain. By twisting the ear sharply in the hand (but not sufficiently to break it) it is easy to determine whether it is mature or not; if it remains rigid, it is generally ripe and dry, but if it yields to the twist it generally means that the cob is still moist; a cut of half a point (·5) is made for each ear not in condition. At agricultural shows held early in the season it is difficult to obtain thoroughly dry ears, and allowance must be made accordingly.

In the case of seed-maize the vitality of the sample is of very great importance; this can be determined by means of a germination test, but at an agricultural show there is not time to make such a test, which takes five days. To determine the viability of a sample of seed-maize, three grains are taken from each ear, one from near the butt, one near the tip, and one near the centre. These will germinate between wet blotting paper, or preferably on a plate of pure damp sand;

the grains are planted with the point downward and barely covered with the sand. They are arranged and marked in such a way that the particular ear from which any set of three was taken can always be determined, so that ears with a poor germination may be discarded. A small plate or saucer or a sheet of glass are used to cover the germinating grain to check evaporation, and if the test is made in cold weather it should be carried on in a warm room. Daily examinations should be made and a note taken of the sets which take longest to germinate. A germination of 97 per cent in five days is the usual standard.

221. *Colour of Cob.*—White maize should have a white cob. Yellow breeds of maize usually have red cobs. Some breeds of yellow, however, always have white cobs; this is particularly the case with most of the yellow flint breeds (*Cango*, *Botman*, *New England* 8-*row*, etc.) and with *Golden King*, *Hawkesbury Champion*, *Yellow Horsetooth*, and *German Yellow*. A red cob in a white breed or a white cob in a yellow breed, excepting in the cases noted above, is an indication of careless selection, and the exhibit is disqualified accordingly.

222. *Circumference of Ears.*—An exceptionally thin ear usually indicates shallow grain, and an abnormally thick ear indicates an unusually thick cob; both will have been scored down when considering depth of grain, uniformity of exhibit and yield of grain per ear, while the lack of proportion will have received further consideration in scoring for length of ear.

Where competition is keen it is customary to take into consideration the circumference of the ears as compared with their length. The standard is approximately as 7½ inches to 10 inches of length, or 8 inches to 12 inches, but this varies to some extent with the breed. As in the case of length of ear, the excess or deficiency of each ear as compared with the standard, are added together, but the cut made for each inch so obtained is only ·25. A mechanic's small steel tape, divided into millimetres, is applied at a point about one-third the distance from the butt. With a little practice these measurements can be taken with ease and some degree of rapidity, but it is slow work at best, and as it is of minor value it is usually omitted unless necessitated, as was said before, by close competition.

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It is best to measure the circumference in centimetres. The average can be converted into inches by the following table:—

TABLE XLIV.

FOR CONVERSION OF CENTIMETRES TO INCHES, IN MEASURING CIRCUMFERENCE OF EARS.

Centimetres.	Inches,	Centimetres.	Inches.
11·0	4·32	17·0	6·7
11·5	4·51	17·5	6·9
12·0	4·71	17·78	7·0
12·5	4·92	18·0	7·1
12·7	5·0	18·5	7·3
13·0	5·1	19·0	7·5
13·5	5·3	19·5	7·7
14·0	5·5	20·0	7·88
14·5	5·7	20·32	8·0
15·0	5·9	20·5	8·08
15·24	6·0	21·0	8·26
15·5	6·1	21·5	8·46
16·0	6·3	22·0	8·66
16·5	6·5		

223. *Standards of Perfection.*—Standardization of breeds is essential to good judging; where there are as many breeds as there are in maize it is impossible to carry their several measurements in mind without great risk of error. All the leading American breeds have been standardized. The word standard, as here used, is not intended to imply finality; probably no one of the recognized breeds is yet perfect or thoroughly fixed; as improvement takes place, standards gradually change. For the newer breeds, standards have yet to be established. The following provisional South African standards are given for the guidance of growers and exhibitors. Weight of ear refers to well-matured ears weighed[1] between July and October; weight per bushel varies with locality; the large, fine-looking Natal-grown *Hickory King* weighs less per bushel than the smaller Transvaal-grown grain.

[1] These weights exceed the figures for weight of grain per ear *plus* weight of cob, because they are taken from the best single ears available, whereas the weight of ear here given is the average of a number of ears.

PROVISIONAL STANDARD OF PERFECTION.—DENT BREEDS.

	Hickory King.	Iowa Silver-mine.	Boone County.	Natal White Horsetooth.	Ladysmith.
Ear:					
Shape	Partly cylindrical	Cylindrical	Cylindrical	Slowly tapering	Slowly tapering
Length	9 in.	10 in.	10 in.	12 in.	10·5 in.
Circumference	6·5 in.	7·7 in.	7·5 in.	8·5 in.	8·75 in.
Rows	8	14 or 16	16-22	14-18	14-20
Arrangement	Distinct	Pairs	Pairs	Pairs	Pairs
Sulci	Medium to wide	Narrow	Medium	Medium	Narrow
Butt	Even	Moderately rounded	Moderately rounded compressed	Even to shallow rounded	Even to shallow rounded
Tip	Regular rows of grain	Regular rows of grain	Regular rows of grain	Regular rows of grain	—
Shank	Small	Small	Medium	Very large	Small
Weight	10 oz.	17 oz.	17·5 oz.	22 oz.	18·5 oz.
Cob:					
Size	Very small	Small	Medium	Very large	Medium
Colour	White	White	White	White	White
Weight	1·45 oz.	1·86 oz.	—	3·84 oz.	1·75 oz.
Grain:					
Condition	Firm upright	Firm upright	Firm upright	Firm upright	Firm upright
Colour	Pearl white	Cream white	Cream white	Pearl white	Pearl white
Apex	Smooth to roughish	Very rough	Rough	Smooth	Very rough
Form of dent	Crease	Pinched	Pinched	Crease	Pinched
Shape	Broader than deep	Medium wedge	Medium wedge	Broad and shallow but thick	Deep wedge
Per cent to ear	87	90	86	78	88
Number per ear	400	800 to 1,100	1,000 to 1,100	750	800
Weight per ear	8·75	10 oz.	—	12·5 oz.	10·25 oz.
Weight per bushel: lbs.	53 to 62 lbs.	57 to 64½ lbs.	—	62	57½ to 62

224. *Judging Shelled Maize and the Accompanying Ears.*—Both quality and condition are taken into consideration in judging shelled maize. In a close competition it is impossible to give a just judgment without reference to thoroughly representative ears from the crop.

In the classes for commercial (shelled) maize there has been a good deal of divergence of opinion and practice as to whether tip and butt grains should be included or not, and owing to the loose wording of many prize-lists the decision of the judge has been a matter of bitter controversy. In

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some cases the best entries have been disqualified on this account.

Unless the prize-list clearly states that tip and butt grains are not to be removed, the exhibitor is entitled to remove them, and should do so. A good judge does not study the tip and butt grains, and it only makes it more difficult to determine the relative merits of the bulk of the grain (which is that from the centre of the ear) if the tips and butts are left

PROVISIONAL STANDARD OF PERFECTION.—DENT BREEDS.

	12-row Hickory or Hickory Horsetooth.	10-row Hickory or Louisiana.	Yellow Horsetooth.	Yellow Hogan.	Eureka.
Ear:					
Shape	Partly cylindrical	Partly cylindrical	Slowly tapering	Slowly tapering	Slowly tapering
Length	8·50 in.	8·5 in.	10 in.	9 in.	11 in.
Circumference	6·9 in.	6·9 in.	7·75 in.	7·25 in.	7·25 in.
Rows	12	10	14	12 or 14	16 or 18
Arrangement	Pairs	Distinct	Distinct	Pairs	Pairs
Sulci	Medium	Medium	Medium	Medium	Narrow
Butt	Even to shallow rounded	Even	Even, sometimes expanded	Even to shallow rounded, slightly enlarged	Shallow rounded, enlarged
Tip	Regular rows of grains	Regular rows of grains	Regular rows of grains	Regular rows of grains	Regular rows of grains
Shank	Medium	Small	Large	Small	Large
Weight	12 oz.	13·5 oz.	16·5 oz.	14 oz.	17·5 oz.
Cob:					
Size	Small	Small	Large	Small	Large
Colour	White	White	White	Red	Deep red
Weight	—	—	2·25 oz.	1·85 oz.	—
Grain:					
Condition	Firm upright	Firm upright	Firm upright	Firm upright	Firm upright
Colour	Pearl White	Pearl white	Yellow with light cap	Orange yellow	Deep yellow
Apex	Smooth	Slightly rough	Smooth	Medium smooth or smooth	Medium smooth
Form of dent	Crease	Crease	Dimple	Crease	Crease
Shape	Medium wedge	Medium wedge	Broad shallow wedge	Medium wedge	Medium wedge
Per cent to ear	—	—	82	86	—
Number per ear	500	450	625	650	900
Weight per ear	—	—	10·75 oz.	9·25 oz.	—
Weight per bushel: lbs.	63	55½-56	—	59½-64	62

in. Nothing is gained by leaving them in, and much precious time is saved if they are removed by the exhibitor; if he does not do it the judge or stewards must do it for him (when judging the sample), and they have more important work. CHAP. VI.

If the show committee considers that it is a fairer competition to have the tip and butt grains left in, *the fact should be clearly stated in the prize-list.* It does not appear that any

PROVISIONAL STANDARD OF PERFECTION.—DENT BREEDS.

	Chester County.	Leaming.	Reid.	Golden King.	Golden Eagle.
Ear:					
Shape	Slowly tapering	Tapering	Slowly tapering	Slowly tapering	Slowly tapering
Length	10 in.	8 in.	10 in.	8 in.	9 in.
Circumference	7 in.	7 in.	7 in.	7 in.	7 in.
Rows	16 or 18	16-24	18-24	10-14	16-20
Arrangement	Pairs or not	Pairs	Pairs	Distinct	Distinct
Sulci	Narrow	Medium	Narrow ($\frac{1}{16}$ or less)	Medium	Medium
Butt	Well rounded	Shallow rounded, compressed, expanded	Deeply rounded, compressed	Even to shallow rounded	Moderately rounded, compressed
Tip	Irregular rows of grains	Irregular rows of grains	Regular rows of grains	Regular rows of grains	Regular rows of grains
Shank	Small	Medium	Small	Large	Small
Weight	13 oz.	13 oz.	12·5 oz.	14 oz.	—
Cob:					
Size	Small	Medium	Medium	Large	Small
Colour	Deep red	Deep red	Deep red	White	Deep red
Weight	1·54 oz.	—	—	2·4 oz.	—
Grain:					
Condition	Firm upright	Firm upright	Firm upright	Firm upright	Loose upright
Colour	Deep yellow with lighter cap	Deep yellow	Light yellow	Dull yellow	Deep yellow
Apex	Smooth or medium smooth	Rough	Medium smooth	Smooth	Very rough
Form of dent	Dimple	Crease	Dimple	Dimple	—
Shape	Medium wedge	Medium wedge	Long wedge, shoulder square	Broad and shallow	Broad wedge
Per cent to ear	85·25	—	88	83·25	90
Number per ear	1,000	1,100	900	600	—
Weight per ear	9 oz.	—	—	11·5 oz.	—
Weight per bushel: lbs.	57-63½	59-66	—	61	—

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advantage is gained by this form of competition, and it certainly offers the temptation to exhibitors to remove at least *some* of their tip and butt grains. It must also be borne in mind that with modern shelling machinery, some of the tip and butt grains can be removed in the process of shelling. Is a farmer to be penalized for using such machinery?

PROVISIONAL STANDARD OF PERFECTION.—DENT, FLOUR, AND FLINT BREEDS.

	Golden Beauty (Dent).	Yellow Cango (Flint).	White Cango (Flint).	New England 8-row (Flint).	Brazilian Flour-corn (Flour).
Ear:					
Shape . .	Slowly tapering	Cylindrical	Tapering	Partly cylindrical	Tapering
Length . .	9·75 in.	11 in.	9 in.	11·75 in.	9 in.
Circumference	7 in.	6·5 in.	5·5 in.	5·5 in.	6·5 in.
Rows . .	12	12	12	8	14
Arrangement .	Pairs	Pairs at the butt	Pairs at the butt	Pairs	Distinct
Sulci . .	Medium	Medium	Medium	Medium	Narrow
Butt . .	Even	Even depressed	Even, slightly enlarged	Even, usually expanded	Even
Tip . .	Regular rows of grains	Regular rows of grains	Regular rows of grains	Regular rows of grains	Regular rows of grains
Shank . .	Medium	Small	Large	Large	Medium
Weight . .	13·5 oz.	12 oz.	8 oz.	10 oz.	9 oz.
Cob:					
Size . .	Medium	Medium	Medium	Medium	Large
Colour . .	Deep red	White	White	White	White
Weight . .	—	—	—	—	—
Grain:					
Condition .	Firm upright	Firm upright	Firm upright	Firm upright	Firm upright
Colour . .	Deep yellow paler cap	Orange yellow	Dirty white	Orange yellow	Milk white
Apex . .	Smooth	Smooth	Smooth	Smooth	Smooth
Form of dent .	Crease	—	—	—	—
Shape . .	Broad wedge, rounded corners	Flat sides, rounded above	Flat sides, rounded above	Flat sides, rounded above	Flat sides, rounded above
Per cent to ear	—	—	—	—	—
Number per ear . .	550	600	600	420	680
Weight per ear	—	—	—	—	—
Weight per bushel: lbs.	—	62-67	60-68	62-68	52½-62

SCORE CARD FOR JUDGING SHELLED MAIZE.

Show.................................... Date..................

No. of Exhibit.......................... Class...........Breed.................

Name and Address of Exhibitor...

SCORE.

N.B.—Some judges find it more convenient to allow only one point instead of five for each item on the score card; it makes no difference so long as either method is used consistently throughout.

	Points. Possible.	Points. Award.
Quality of Grain:—		
1. Length	5	
2. Shape	5	
3. Thickness	5	
4. Uniformity (in size, shape, and thickness)	5	
5. Colour (trueness to type)	5	
6. Shade and uniformity of colour	5	
7. Colour of cob	5	
8. Weight per bushel	5	
9. Chemical composition	5	
Condition of Grain:—		
10. Dryness	5	
11. Sweetness	5	
12. Soundness (freedom from decay)	5	
13. Plumpness (grain should be well filled not shrivelled nor chaffy	5	
14. Cleanness and freedom from rubbish	5	
15. Brightness	5	
Ears Accompanying Shelled Maize:—		
16. Length	5	
17. Sulci (space between rows)	5	
18. Trueness to type	5	
19. Shape and straightness of rows	5	
20. Firmness of grain on the cob	5	
	100	

NOTES.

Quality of Grain.—Quality refers to thickness, shape, size, uniformity, and colour of grain, weight per unit measure, and colour of chaff.

Length of Grain.—A deep grain gives a larger percentage of grain to cob than a shallow one.

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Shape of Grain.—A rather narrow, wedge-shaped grain gives a larger percentage of embryo to endosperm than a very broad shallow grain, and for some classes of trade the embryo is of more value than the starchy endosperm. But wedge-shaped grains should not have narrow tips.

Thickness of Grain.—A thick grain contains more starch in proportion to "hull" or "bran" than a thin one, and is therefore preferred for certain classes of manufacture.

Uniformity in thickness, in shape, and in depth of grain, improve the quality; these can be secured by good breeding.

Purity of Colour.—White grain must be at least 98 per cent white, and yellow grain 95 per cent yellow; all else is classed as "mixed". This applies to bulk shelled grain only.

Shade.—White grain should be pure white, free from black tips and brown blotches; cut for brownish tinge acquired in sun-drying. Yellow grain should be clear, deep yellow, and uniform in colour.

Colour of Cob.—White grain should not have red tips, which spoil the colour for certain manufacturing purposes; yellow grain should have white tips in *Golden King*, *Austin Colossal*, *German Yellow*, *Yellow Horsetooth*, and the standard yellow flint breeds.

Weight per Unit Measure.—This is usually given in standard bushels. The American Standard in all but two States is 56 lbs. of shelled grain. Although in South Africa grain is not sold by measure, it is desirable to take the weights per unit of measure, as samples vary greatly, and the weight gives some indication of quality and chemical composition, for the richer the grain in protein the heavier it usually is.

Chemical Composition.—The character of the endosperm can be determined to some extent by holding the grain to the light and by cutting it longitudinally parallel with the broad axis; the larger the amount of translucent *horny starch* the richer in protein. Inasmuch as most of the oil-content of the maize-grain occurs in the embryo a large embryo usually indicates a high oil-content.

Dryness.—Dry grain should not (on the High-veld) contain more than 12 per cent moisture. A parcel containing not more than 12 per cent will travel safely from South Africa to Europe.

Sweetness.—Sweet grain is free from mustiness or other objectionable smell. CHAP. VI.

Soundness.—Sound grain is free from decay, or the ravages of insects and *Diplodia* injury (Fig. 159).

Plumpness.—Plump grain is well filled, not shrivelled nor chaffy.

Cleanness.—This refers to freedom from bits of cob, chaff, and all extraneous matter.

Brightness.—A prime choice parcel of maize should be bright and shiny. Some breeds, e.g. *Golden King*, lack the lustre of others. Grain which has been harvested wet, and then dried out, often loses its brightness, and a dull sample (from whatever cause) is assumed to be due to harvesting when wet.

Condition of Shelled Grain refers to soundness, plumpness, sweetness, dryness, cleanness, and brightness. Soundness and plumpness are considered the primary points in studying condition; sweetness comes third, dryness fourth—for a sweet sample, but not quite dry, may dry out, but a dry sample that is musty will never get quite sweet again.

For grader's requirements, see chapter XII.

Twenty-five points may be reserved for the ears accompanying a sample of shelled maize. The points to be considered in this connection are those which particularly affect uniformity and the quality of the grain, i.e. trueness to type, shape, space between rows, straightness of rows and regularity of grain, and firmness of grain on the cob.

Length.—Length of ear affects the yield; other things being equal, the longest ears should have the preference provided they no not exceed the standard of length for the breed.

Space between Rows.—Wide space between rows is space wasted, and usually implies badly shaped grain.

Trueness to Type.—Unless the ears are true to type the sample will not be uniform.

Shape of Ears.—The more cylindrical the ear the more uniform the grain. Allowance must be made for breed characteristics in this respect, for the ears of *Leaming*, *Chester County*, and some other breeds are naturally tapering.

Firmness of Grain on the Cob.—If grain is loose on the cob it may mean that it is not as plump and well filled as

Fig. 93.—American students learning to judge maize.

possible. Observation of this point is the quickest and surest way to detect this defect. But the point is comparative only, for in some breeds the grain is always more or less loose; however, this does not appear to apply to breeds grown in South Africa. CHAP. VI.

Straightness of Rows and Regularity of Grain.—Unless the rows are straight and the grain is regular in the rows it will not be uniform.

225. *Judge's Computing Sheet.*—The following form has been found of great assistance in reducing the time required for judging exhibits. It was first designed for use with exhibits of ten ears, but by increasing the number of points from fourteen to twenty and leaving out the figures for possible award, it has been adapted for use with either ears or shelled grain:—

FORM FOR USE IN JUDGING MAIZE BY POINTS.

Date.., 191.....

Show..

Class..

POINTS.		ENTRY NUMBERS.													
No.	Possible Award.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
TOTAL . .															
Yield of Grain per Ear .															
Weight of Grain per Bushel .															
Average Length of Ear . .															

AWARDS.	NOTES.
1st Prize.	
2nd Prize.	
3rd Prize.	
Highly Commended.	
Commended.	
Special Prize.	

226. *Useful Form of Judge's Card.*—It is a great convenience to the judge, and is conducive to greater rapidity and accuracy in the granting of awards, if a convenient form of *judge's card* is used. The variety of judge's cards and note-

books is almost as great as the number of shows held; it includes plain notebooks, printed triplicating books, and printed cards. The card of which a facsimile (reduced in size) is given below, is one of the best for convenience and rapidity of handling. The actual measurements of the card are 10 × 6 inches. CHAP. VI.

Section.	..........................AGRICULTURAL SOCIETY. JUDGE'S CARD.	*Class No.*

Judge's Name ....
Class No.

No. of Entries in this Class...... ....

Entry No.......................	Entry No.......................
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,, ,, ...	,, ,, ...
,, ,, ...	,, ,, ...
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JUDGE'S REMARKS.	AWARDS.
	1st Prize No.....................
	2nd Prize No....................
	3rd Prize No....................
	H. Commended No...........
	Commended No. ....
	Champion ....
	...........................Judge.
Time Judged	.... } Stewards.
Date.............................	... .

Triplicating carbon-books are also useful; as soon as a class has been judged the steward tears out the two carbons, one of which is sent to the Secretary's office and the other to the Press room, while the original is retained for reference by the stewards and judge until all the classes have been judged.

CHAPTER VII.

VARIETIES AND BREEDS.

And whene'er some lucky maiden
Found a red ear in the husking,
Found a maize-ear red as blood is,
"Nushka!" cried they all together,
"Nushka! you shall have a sweetheart,
You shall have a handsome husband!"

—*Hiawatha.*

CHAP. VII. 227. *Botanical Varieties.*—The genus *Zea* comprises but a single known species, *Zea Mays* Linn. As is the case with most of the older cultivated plants, the species is very polymorphous. The various forms of maize are grouped under the ten botanical *varieties* described below. Of these, five only, flint, dent, flour, sugar and pop-corn, are regularly cultivated for their grain. Sturtevant (2) considered these and two other varieties to be distinct species, but later botanists have not followed him in keeping them separate.

1. ZEA MAYS L., var. TUNICATA St. Hil.; (*Zea cryptosperma* Bonaf., 1836; *Zea Mays* var. *vaginata* Sturt., 1884; *Zea tunicata* (St. Hil.) Sturt., 1894). Pod maize.
2. ZEA MAYS L., var. PRÆCOX Bonaf., 1836; (*Zea Mays* Lam., 1823; *Zea hirta* Bonaf.; *Zea Mays* var. *minima* Bonaf.; *Zea Mays* var. *rostrata* Bonaf.; *Zea canina* S. Wats., 1891; *Zea everta* Sturt., 1894; *Zea Mays* L., var. *everta* (Sturt.) Bailey, 1902). The pop-corns.
3. ZEA MAYS L., var. INDURATA (Sturt.) Bailey, 1902; (*Zea indurata* Sturt., 1894). The flint breeds.
4. ZEA MAYS L., var. INDENTATA (Sturt.) Bailey, 1902; (*Zea indentata*, Sturt., 1894). The dent breeds.
5. ZEA MAYS L., var. ERYTHROLEPIS (Bonafous) Alefeld; (*Zea erythrolepis* Bonaf., 1836; *Zea amylacea* Sturt., 1894; *Zea Mays* L., var. *amylacea* (Sturt.) Bailey, 1902). Soft maize or flour-corns.

6. ZEA MAYS L., var. RUGOSA Bonaf., 1836; (*Zea saccharata* Sturt., 1894; *Zea Mays* L., var. *saccharata* (Sturt.) Bailey, 1902). Sugar maize.
7. ZEA MAYS L., var. AMYLEA-SACCHARATA (Sturt.) Bailey, 1902; (*Z. amylea-saccharata* Sturt., 1886). The starchy-sugar corns. Grown by the San Pedro Indians of Mexico, and in Peru (*Sturtevant*, 2).
8. ZEA MAYS L., var. JAPONICA (Van Houtte) Koern.; (*Z. japonica* Van Houtte; *Z. vittata* Hort.). A small plant with foliage variously striped with white; grown for ornament.
9. ZEA MAYS L., var. GRACILLIMA Koern.; (*Z. gracillima* Hort. and *Z. minima* Hort.). A very dwarf, slender form with green leaves, sometimes cultivated for ornament.
10. ZEA MAYS L., var. CURAGUA (Molina) Alefeld; (*Z. Curagua* Molina). A robust green-leaved form, grown for ornament. Considered by Sturtevant (2) to belong to var. *præcox*.

228. *Pod Maize* (*Zea Mays* var. *tunicata* St. Hil.); (Fig. 51).—In this breed each grain is enclosed in a pod or husk formed by the enlarged glumes; the whole ear also has its usual coating of husks formed by the leaf-sheaths.

Vernacular names: Pod corn, cow corn, stock corn, forage corn, husk corn, primitive corn, California corn, Egyptian corn, Rocky Mountain corn, Oregon corn (United States); pinsingallo (Buenos Aires); manigette (Ethiopia); balg-maiz (Germany).

The grain is small and very flinty, often with a sharp beak, and is said to be particularly resistant to weevils. Dr. Sturtevant (2) notes that once his whole collection of maize breeds (an exceptionally fine one) was destroyed by weevils, except the pod maize. The plant is excessively leafy, and has a great tendency to sucker. The tassels are unusually heavy and are inclined to be grain-bearing.

Caspar Bauhin in 1623 referred to the occurrence of pod maize in Ethiopia, under the name of *manigette*. Sturtevant was inclined to look upon it as the aboriginal form of maize, but admitted that it may be an abnormal and proliferous state of the flint variety. Darwin considered that the aboriginal

CHAP. VII. form of maize *would almost certainly have had its grains protected in this way.* Sturtevant (2) points out that podded corn is less conspicuous than the naked kernels of cultivated varieties, and is looser on the cob, yet firmly attached. This favours both protection from, and distribution by, birds. As insect and bird depredation furnish the strongest barrier to the growing of wild forms of maize, these protective characters assume importance in the argument that pod corn is an aboriginal form. The property of floating upon water, which the podded kernels possess in strong degree, would also facilitate distribution in a state of nature, as also the moisture contained within the pod. But pod maize does not appear to have been found in the ancient cemeteries of Peru.

Pod maize is said to be cultivated by the Guaycurus Indians of Uruguay and Paraguay; elsewhere only as a curiosity, though it is occasionally found in maize fields throughout the United States, in Brazil, and South Africa.

229. *Pop-corn* (*Zea Mays* var. *præcox* Bonaf.). *Coyote corn; German: früher zwerg-mais.*—Characterized by the exceptionally large proportion of corneous endosperm (in the best breeds it comprises the whole endosperm) and the small size of the grains and ear. The grain is sharply pointed in some breeds.

The breeds of this variety are said to be more subject to sports and monstrous growths than those of any other, and the tendency to bear many ears to the stalk is highly developed. The grain has strong vegetative power, and possesses the property of germination, after drying, to a great degree (*Sturtevant*, 2). It has the property of "popping," which means the complete eversion, or turning inside-out, of the endosperm, through the explosion of the contained moisture and the swelling of the starch on the application of heat. The presence of a small amount of starchy endosperm does not greatly interfere with the property of popping, but when there is a large amount of starchy endosperm, the corn does not pop well, for only the corneous portion explodes, leaving the starchy portion unchanged.

Pop maize has been much cultivated by native tribes both in North and South America, and has been found illustrated in sculpture, or petrified, among Peruvian ruins (*Sturtevant*, 2). It is a favourite sweetmeat with Americans.

Golden pop and *Rice pop* have been introduced into South Africa, but at present scarcely any pop-corn is grown there. CHAP. VII.

A form of this variety was reported under the name of *Coyote corn* as having been found growing "wild" in Mexico, and was named *Zea canina* by Dr. Sereno Watson; subsequent investigations have shown, however, that it was a cross between pop-corn and some other variety, and there is no evidence that it was not an escape from cultivation.

230. *Flint Maize* (*Zea Mays* var. *indurata* (Sturt.) Bailey).—Recognized by the corneous (horny) endosperm completely enclosing the starchy endosperm; the latter does not reach the apex as it does in the var. *indentata*, a fact which may be demonstrated in a split grain; the horny endosperm varies in thickness in different breeds.

Most, if not all, of the earliest-maturing commercial breeds belong to the flint variety; in many places where they are grown, e.g. in Southern Europe, the growing-season is so short (forty to fifty days) that only a very small amount of grain can be produced and, as a rule, the flint breeds are relatively light yielders.

Flint maize is the type usually grown by native tribes, e.g. in South Africa, Egypt, Somaliland, Mexico, Honduras, Trinidad, Paraguay, and Brazil. Also ninety per cent of the Argentine crop, and practically all of that of South Europe, is flint maize. The greater demand for dent maize has relegated the flint breeds to a subsidiary place, mainly as catch-crops at the end of the season or for use in parts of the world where the growing-season is too short for dent breeds. Flint maize is grown in Canada as far north as 54° north latitude.

The grains of some breeds of flint maize, being smaller than those of the dents, are preferred in the European markets for feeding poultry, game, and stock, and command a slightly higher price than the dents.

The smaller-grained flint breeds grown commercially are known to the trade as "round" maize.

As flint grain is much harder than dent, it is less easily injured by weevil and grain-moth. It takes longer to dry out than dent, but when once dry, does not re-absorb moisture so easily, and is therefore better suited to a long sea voyage.

231. *Dent Maize* (*Zea Mays* var. *indentata* (Sturt.) Bailey).

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—Recognized by the indentation (or "dent") at the apex and the presence of corneous (horny) endosperm at the sides of the grain; the starchy endosperm extends to the apex. The horny endosperm varies in height and thickness in different breeds; this determines the character of the indentation, which is caused by the drying and shrinkage of the "starchy" endosperm at the summit of the grain, which is drawn in or together, as the grain dries; the horny endosperm is not affected in this way, which accounts for the fact that the flint breeds (in which there is no "starchy" endosperm at the apex) do not develop a "dent".

The breeds of dent maize are far more numerous than those of any other variety, and in the United States they are more extensively grown than any others, furnishing nearly all of the maize exported.

Dent maize is known to have been grown in Peru in 1650, and by some of the North American Indians in 1608. It is also grown by the native tribes of Mexico, Venezuela, and Brazil. The earliest-maturing breeds can be cultivated as far north as Ottawa, Canada (about 46° north latitude), but generally speaking the dent breeds are not so well suited as the flints to regions of short growing-season.

232. *Soft Maize* (*Zea Mays* var. *erythrolepis* (Bonaf.) Alef.). —This variety includes the flour corns or "bread mielies" and is recognized by the absence of corneous endosperm. The grain is soft, and although most of the breeds of soft maize appear to have been grown in tropical America, the grain does not keep well on account of susceptibility to weevil and grain-moth; it is therefore not well suited to cultivation in tropical and sub-tropical countries.

It is probably on this account that there are so few breeds of soft maize; Sturtevant describes only twenty-seven, some of which appear to be merely colour forms of others. Soft maize is used both for meal and for eating as "green mielies," but the feeding value is poor; both protein and fat-content are low. Two breeds are occasionally grown in South Africa, both having white grain, viz. *South African Bread Mielie* and *Brazilian* flour corn. *Tuscarora* and *Cuzco* have been tested in the Transvaal and abandoned; red grains are met with in both of these breeds.

The "mummy-corns" from Peru, Chile, and Arizona were largely flour corns. Flour maize is still grown by native Indians of Brazil, Mexico, Arizona, and other parts of North America, for their own consumption, but it is not much cultivated commercially.

233. *Sugar Maize* (*Zea Mays* var. *rugosa* Bonaf.). *French : maïs ridé ; German : Gekörnelte maiz.*—Well defined by the more or less crinkled, wrinkled, or shrivelled condition of the grains and their translucent, horny appearance. Sturtevant describes sixty-three sorts.

The cultivation of sweet maize in place of the "bread mielie" and the "field corns," for use as a green vegetable, is slowly gaining ground in South Africa, and seed can now be obtained from most of the local seedsmen. Until recently difficulty has been found in obtaining good seed in South Africa, as American-grown sugar maize loses its vitality in transit. Good sugar maize ears bring as much as 20s. per bag on the Johannesburg market at the very beginning of the season (November and December), and should pay well at the price.

Sugar maize is extensively used in the United States for canning, and in the State of Maine is grown as a field crop for this purpose, in localities which are too far north for the seed to ripen. A number of the early-maturing breeds ripen their crop as far north as Ottawa, Canada. Sugar maize is but little grown in the Southern States, and apparently improves in quality as it proceeds northward. The grain ripens on the cob even when plucked at an early stage of edible maturity (*Sturtevant*, 2).

234. *The Agricultural Breeds.*—Botanical varieties produce cultural "breeds" or "races". It is said that in 1814 there were only five breeds of maize known in the United States, viz., *Big Yellow*, *Big White*, *Little Yellow*, *Little White*, and *Gourd Seed ;* but by 1840 nearly forty breeds were recognized ; and at least one of those grown at the present day, viz., *Leaming*, originated before that date.

Sturtevant (2) in 1894 described over 500 cultivated breeds of maize ; to these many have since been added, while others have dropped out of cultivation. These 500 were grouped as follows :—

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	Breeds.
Pop-corns	25
Flints	69
Dents	323
Soft Maize	27
Sugar Maize	63
	507

The leading agricultural breeds are described in the following pages, but for a ready means of comparing their leading characteristics the reader is referred to the Standards of Perfection in the preceding chapter (¶ 223).

235. *Comparative Yield of Dent and Flint Breeds.*—Dent maize is, with few exceptions, a much better yielding variety than flint maize. Each variety has its place, but where dents can be grown they are, generally speaking, the most desirable. On this account the American farmer grows only dents, except in localities which do not suit them. The difference in market value is so small that it does not pay to grow a poor-yielding sort if another can be grown which yields a bag to the acre more. Hunt (1) clearly shows the superiority of dents, even in Pennsylvania where the climate is not so well suited to them as in some other parts of the States. As a result of a three years' test he obtained the following result:—

Variety.	Weight of Ear in Lbs.	Weight of Stover in Lbs.	Total Lbs.
Dent Maize	3,012	3,258	6,270
Flint Maize	1,750	1,691	3,441
Difference	1,262	1,567	2,829

The following yields were obtained at the Maine (U.S.A.) Agricultural Experiment Station, as a result of a three-year test:—

Variety.	Breed.	Total Crop per Acre Green.	Yield of Dry Matter per Acre.
Dent	*White Horsetooth*	35,195 lbs.	4,798 lbs.
Flint	*Local*	19,197 ,,	2,893 ,,
Sugar	*Early Crosby*	16,908 ,,	2,420 ,,

At the Cornell (U.S.A.) Station a dent breed gave 10 per cent more dry matter than a flint. CHAP. VII.

236. *Principal Breeds of Dent Maize Grown in America.*—The following are the twenty-five principal breeds of maize now grown in the "Corn-belt" of the United States:—

Yellows.—Leaming (the oldest known breed), Reid, Legal Tender, Riley Favourite, Golden Eagle, Shenandoah, Farmers' Reliance, Pride-of-the-North, Early Mastodon, Golden Row, Mammoth Golden, Willhoit, Cattle King, Kansas Sunflower, Minnesota 13, and Hildreth.

Whites.—Iowa Silver-mine, Boone County, White Superior, Silver King, Chases, Wisconsin No. 7, McAuley, Nebraska White Prize, and Iowa Ideal.

Nearly all of these have been tried in South Africa, and most of them have not proved satisfactory, indicating a difference in condition of climate or soil, or both.

237. *Other Dent Breeds Grown in America.*—In addition to the above, the following breeds are recommended by the several State Experiment Stations (at which they have been tested for the number of years stated), as suited to their varying climatic and soil conditions:—[1]

1. Adams Early (w.d.)—
   Colorado (1).
2. Albemarle Prolific (w.d.)—
   South Carolina (1, on thin upland).
   ,, ,, (2, on bottom land).
3. Blount (w.d.)—
   Alabama (Auburn Sta.) (4), 5 years.
4. Blount Prolific (w.d.)—
   New York State Sta. (2 e.).[2]
   North Carolina (3 g. and s.).[3]
   Texas (1), 3 years.
5. Boggs Home-grown—
   South Carolina (1, on bottom land).
   ,, ,, (5, on thin upland).
6. Boone County White (w.d.)—
   Illinois (1), 6 years.
   Indiana (4), 5 years.
   Kansas (5), 3 years.
   Nebraska (14), 2 years.
7. Boston Market (Sweet) (w.d.)—
   Massachusetts Hatch (4 e.).
8. Bradberry Improved (y.d.)—
   Georgia (7), 1-11 years.
9. Bristol 100-day (w.d.)—
   North Carolina (1 g. and st.).[4]
10. Burrill and Whitman (w.d.)—
    New York State Sta. (3 e.).
    Vermont (1 e.).
11. Burrill and Whitman Ensilage (w.d.)—
    Wisconsin (6).
12. Burr White (w.d.)—
    Illinois (3), 6 years.
13. Calico (mixed)—
    Nebraska (11), 2 years.
14. Champion Pearl (w.d.)—
    Vermont (3 e.).

[1] The numbers in brackets refer to the relative position which the particular breed occupies at the Station named; thus "*Albemarle Prolific*, South Carolina (1, on thin upland)" indicates that it is considered the foremost breed at that Station for that particular soil, where *Mosby Prolific* occupies only 6th place.

[2] e. = grown for ensilage.

[3] g. and s. = grown for grain and silage.

[4] g. and st. = grown for grain and stover.

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15. Champion White Pearl (w.d.)—
Arkansas (4), 2 years.
Illinois (2), 6 years.
Iowa (5), 3 years.
Utah (9), 10 years.
16. Champion Yellow Dent (y.d.)—
Kansas (7), 3 years.
Louisiana (3 g. and st.), 1 year.
17. Clarage (y.d.)—
Ohio (1 medium), 10 years.
18. Clark's Early Mastodon (y.d.)—
Louisiana (7 g. and st.), 1 year.
Utah (5), 9 years.
19. Clark's Iroquois (y.d.)—
Illinois (5), 6 years.
20. Cleveland Colossal—
New York State Sta. (4 e.).
21. Cocke Prolific (w.d.)—
Georgia (6), 1-11 years.
North Carolina (1 g. and s.).
22. Dakota Dent (y.d.)—
Wyoming (2).
23. Darke Co. Early Mammoth (y.d.)—
Ohio (5), 6 years.
24. Delaware Co. Dent—
North Carolina (2 g. and st.).
25. Early Butler (y.d.)—
Ohio (3 early), 10 years.
26. Early Cattle King (y.d.)—
Nebraska (12), 2 years.
27. Early Ripe Fodder, No. 152—
North Dakota (2).
28. Early Huron Dent (y.d.)—
Utah (7), 7 years.
29. Early Mastodon (y.d.)—
Arkansas (3), 2 years.
Texas (7), 3 years.
Vermont (5 e.).
30. Early Prolific (w.d.)—
Vermont (4 e.).
31. Early Thompson (y.d.)—
Kansas (1), 3 years.
32. Early White (w.d.)—
Kansas (3), 3 years.
33. Early Yellow (y.d.)—
Indiana (6), 5 years.
34. Early Yellow Rose (y.d.)—
Kansas (6), 3 years.
Nebraska (7), 2 years.
35. Edmonds (y.d.)—
Illinois (8), 6 years.
36. Ellis—
Tennessee (3 Fodder), 1 year.
37. Eureka (y.d.)—
Georgia (4), 1-11 years.
Massachusetts Hatch Sta. (3 e.).
38. Evans (y.d.)—
Vermont (6 e.).
39. Evergreen (Sweet)—
Wisconsin (8).
40. Experiment Station Yellow (y.d.)—
Alabama (Auburn Sta.) (3), 5 years.
41. Extra Early Huron Dent (y.d.)—
Ohio (4 early), 9 years.
42. Fargo Brothers Ensilage—
Wisconsin (5).
43. Farmers' Favourite (y.d.)—
Ohio (4), 3 years.
44. Fitzpatrick Improved (y.d.)—
Georgia (10), 1-11 years.
45. Fleming Yellow (y.d.)—
Indiana (3), 5 years.
46. Florida—
Tennessee (L. Fodder).
47. Forsyth (w.d.)—
Oregon (4 g. and s.).
48. Forsyth Favourite (w.d.)—
Texas (4), 2 years.
49. Gandy—
Louisiana (2 g. and st.), 1 year.
50. Garrick Improved—
South Carolina (2, on thin upland).
51. Golden Beauty—
Arkansas (1), 2 years.
Illinois (10), 6 years.
Iowa (6), 3 years.
Missouri (1), 3 years.
North Carolina (5 g. and st.).
Texas (3), 3 years.
52. Golden Beauty, Improved (y.d.)—
Tennessee (2).
53. Golden Cap (y.d.)—
Nebraska (5), 2 years.
54. Golden Dent (y.d.)—
Arkansas (6), 2 years.
55. Golden Dent, Improved (y.d.)—
Georgia (15), 1-11 years.
56. Golden Row (y.d.)—
Nebraska (4), 2 years.
57. Hartman (w.d.)—
Kansas (2), 3 years.
58. Hartman White (w.d.)—
Indiana Sta. (2), 5 years.
59. Henderson Eureka (y.d.)—
Ohio (3), 3 years.
60. Henry Grady (w.d. ?)—
Georgia (2), 1-11 years.
61. Hickory King (w.d.)—
Alabama (Auburn Sta.) (5), 5 years.
Arkansas (5), 2 years.
New York (1 e.).
Texas (5), 3 years.
Utah (10), 9 years.
Vermont (7 e.).
62. Hogue Yellow Dent (y.d.)—
Nebraska (1), 2 years.
63. Huffman (w.d.)—
Tennessee (4 Fodder).
64. Hughson Dent (y.d.)—
South Dakota (2).

65. Huron Pure Yellow Dent (y.d.)—
Oregon (3 g. and s.).
66. Iowa Gold Mine (y.d.)—
Nebraska (13), 2 years.
67. J. E. Lewis Prolific (w.d.)—
South Carolina (3, on thin upland).
68. Johnston & Stokes Giant Beauty—
North Carolina (3 g. and st.).
69. King of the Earliest (w.d.)—
Ohio (2 early), 9 years.
Utah (6), 10 years.
70. Leaming (y.d.)—
Arkansas (7), 2 years.
Illinois (4), 6 years.
Missouri (2), 3 years.
Nebraska (9), 2 years.
New Hampshire (1).
North Carolina (4 g. and st.).
Ohio (6), 4 years.
Texas (6), 3 years.
71. Leaming Cuppy (y.d.)—
Ohio (2 medium), 5 years.
72. Leaming Field (y.d.)—
Massachusetts (Hatch Sta.) (2 e.).
73. Leaming, Improved (y.d.)—
Tennessee (3).
74. Legal Tender (y.d.)—
Illinois (6), 6 years.
Iowa (2), 3 years.
Nebraska (3), 2 years.
75. Lenocher Homestead—
Iowa (10), 3 years.
76. Long Yellow Dent (y.d.)—
Utah (3), 5 years.
77. Loveland Dent (y.d.)—
South Dakota (1).
78. Madison County Red (y.d.)—
Alabama (Canebrake Sta.) 2 years.
79. Mammoth Cuban—
Iowa (7), 3 years.
80. Mammoth Golden Yellow (y.d.)—
Nebraska (10), 2 years.
81. Mammoth White Pearl (w.d.)—
Nebraska (15), 2 years.
82. Marlboro Prolific (w.d.)—
Georgia (1), 1-11 years.
Louisiana (6 g. and st.), 1 year.
83. Minnesota King (y.d.)—
Oregon (2 g. and s.).
South Dakota (4).
Wyoming (1).
84. Minnesota No. 13 (y.d.)—
Nebraska (19).
85. Missouri Leaming (y.d.)—
Ohio (1), 1 year.
86. Mosby (w.d.)—
Alabama (Auburn Sta.) (1), 5 years.
87. Mosby Prolific (w.d.)—
Mississippi (1).
South Carolina (6, on thin upland).
88. Moyer Improved (y.d.)—
Georgia (8), 1-11 years.
89. Murdock (y.d.)—
Illinois (7), 6 years.
90. Murdock (y.d.)—
Texas (2), 3 years.
91. Nebraska White Prize (w.d.)—
Iowa (9), 3 years.
92. Nebraska White Prize (w.d.)—
Nebraska (8), 2 years.
93. Normandy White Giant—
Wisconsin (4).
94. Northern White Field (w.d.)—
North Carolina (2 g. and s.).
95. North Star Yellow Dent (y.d.)—
Ottawa (Canada) (1), 3 years.
96. North-western Dent (No. 124) (w.d.)—
North Dakota (1).
97. Piasa King (w.d.)—
Missouri (3), 2 years.
98. Piasa Queen (w.d.)—
Nevada (2 st.), 1 year.
New York (5 e.), 1 year.
99. Pride of Kansas—
Kansas (4), 3 years.
100. Prairie Queen (y.d.)—
Vermont (8 e.).
101. Pride of the North (y.d.)—
Nebraska (18), 2 years.
Nevada (1), 1 year.
Ohio (1 Early), 8 years.
Oregon (1 g. and s.).
South Dakota (3).
102. Purdue Yellow Dent (y.d.)—
Indiana (1), 5 years.
103. Queen of the Field (y.d.)—
Utah (8), 10 years.
104. Queen of the North (y.d.)—
Utah (4), 7 years.
105. Red Cob Ensilage (w.d.)—
North Carolina (5 g. and s.).
106. Red Driver—
Louisiana (4 g. and st.), 1 year.
107. Reid Yellow Dent (y.d.)—
Iowa (1), 3 years.
Nebraska (2), 2 years.
Ohio (2), 2 years.
108. Riley Favourite (y.d.)—
Illinois (9), 6 years.
Indiana (7), 5 years.
Nebraska (17), 2 years.
Texas (9), 3 years.
109. Rural Thoroughbred—
Massachusetts (Hatch Sta.) (1 e.).

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110. Salzer Earliest Canadian Yellow (y.d.)—
Utah (1), 5 years.
111. Sander Improved (y.d.)—
Georgia (3), 1-11 years.
112. Sander Improved (y.d.)—
South Carolina (4, on thin upland).
113. Seckler Perfection (w.d. ?)—
Iowa (4), 3 years.
114. Shaw White (w.d.)—
Georgia (12), 1-11 years.
115. Shaw Yellow (y.d.)—
Georgia (11), 1-11 years.
116. Sibley Sheep Tooth—
Wisconsin (7).
117. Silver-mine (w.d.)—
Nebraska (16), 2 years.
118. Smedley Dent (y.d.)—
Wisconsin (3).
119. Smith Improved (y.d.)—
Georgia (13), 1-11 years.
120. Snowflake (w.d.)—
Georgia (Atlanta Sta.) (14), 1-11 years.
121. Snowflake White (w.d.)—
Nebraska (6), 2 years.
122. Southern Ensilage—
Wisconsin (2).
123. Southern Horsetooth—
Wisconsin (1).
124. Southern White Gourd Seed (w.d.)—
Texas (8), 3 years.
125. St. Charles (w.d.)—
Alabama (Auburn Sta.) (2), 5 years.
Missouri (4), 2 years.
126. Stones White (w.d.)—
Georgia (9), 1-11 years.
127. Stones Yellow Show Pad (y.d.)—
Georgia (16), 1-11 years.
128. Tatum Choice—
Mississippi (2).
129. Tennessee No. 3889—
Tennessee (1), 1 year.
,, (2 Fodder).
130. Virginia Horsetooth (w.d.)—
Vermont (9 e.).
131. Virginia White Dent (w.d.)—
Louisiana (1 g. and st.), 1 year.
132. Weekley Improved (y.d.)—
Georgia (5), 1-11 years.
133. Western Yellow Dent (y.d.)—
Iowa (8), 3 years.
134. White Cap Yellow Dent (w.d. and y.d.)—
Ohio (3 medium), 7 years.
135. White Dent (w.d.)—
Arkansas (2), 2 years.
North Carolina (4 g. and s.).
136. Whitmire Mountain Seed Corn—
South Carolina (3, on bottom land).
137. Wisconsin Early White (w.d.)—
Utah (2), 8 years.
138. Yellow Creole—
Louisiana (5 g. and st.), 1 year.
139. Yellow Speckled Dent (y.d.)—
Indiana (5), 5 years.

238. *Principal Breeds of Dent Maize Grown in South Africa.—White dents:* Hickory King, Louisiana or 10-row Hickory, 12-row Hickory or Hickory Horsetooth, Natal White Horsetooth, Iowa Silver-mine, Ladysmith, Boone County, and Salisbury White are the breeds most largely grown.

The following have been tested and discontinued: Large White, Late White Horsetooth (not the breed known by this name in Natal), Mayfield Earliest, Champion-of-the-North, Blount Prolific, Minnesota White, Ninety-day White, Wisconsin, Woods Northern, Improved Early Horsetooth, Virginia Horsetooth, Red-cob Ensilage, Cocke Prolific, Snow-white, McMackin Gourd-seed, Snowflake, McAuley, Silver King, and Sheep's Tooth.

Yellow dents: The principal sorts grown are: Yellow Horsetooth, German Yellow, Golden Beauty, Chester County, Eureka, Yellow Hogan, Golden Eagle, Reid Yellow Dent, Minnesota Early, Leaming, and Golden King.

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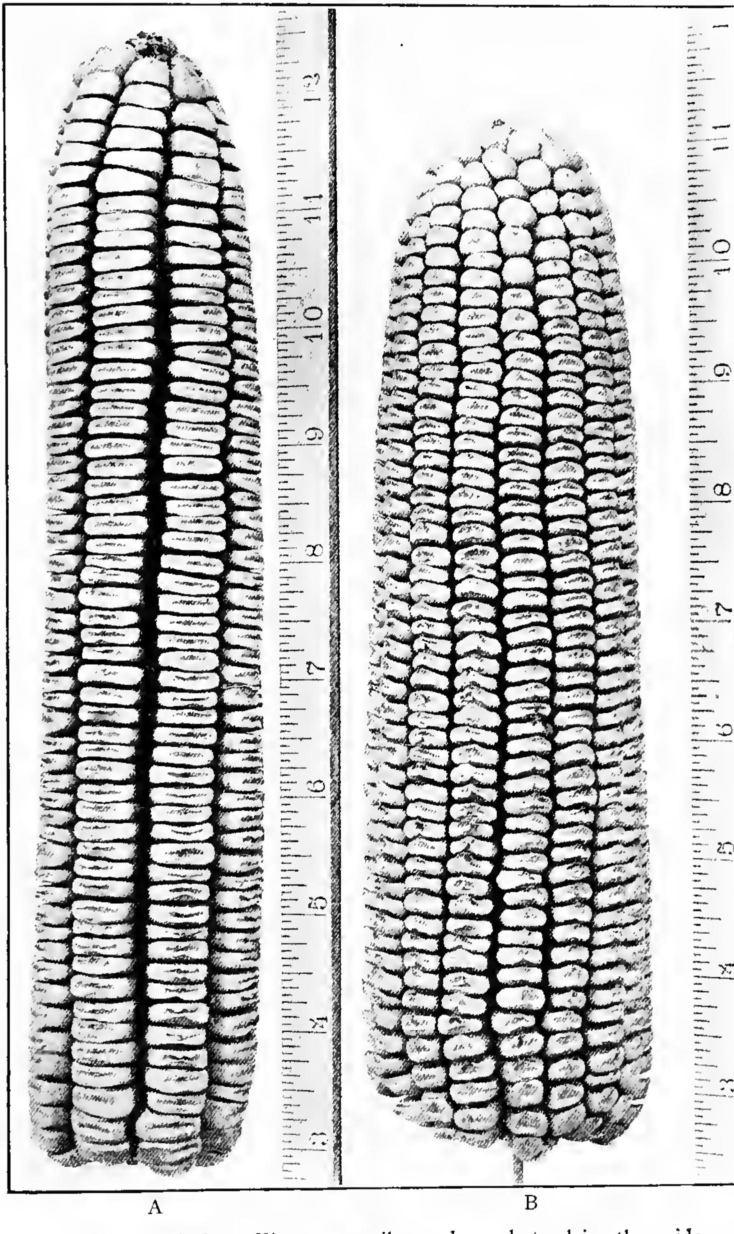

A B

Fig. 94.—A, *Hickory King*, unusually good ear, but sulci rather wide.
B, *Ladysmith*.

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The following have been tried and discontinued: Waterloo Extra Early, Late Mastodon, Yellow Butcher, Bloody Butcher, Wealth of Nations, King Early, Pride of the North, Improved Leaming, Legal Tender, Early Mastodon, Extra-early Huron, Minnesota 13, White-cap, Early Butler, Droughtproof, Austin Colossal, Bristol 100-day, White-cap, Brewer, Riley Favourite, Clarence River, Hawkesbury Champion, Iowa Gold-mine, Red Hogan, King-of-the-Earliest, Kansas Sunflower, Queen of the Prairie, Hildreth.

239. *Hickory King.*—Figs. 94A, 95, and 96. Class: medium late white dent; rows, 8; length of ear, 9 inches; circumference of ear at 2 inches from butt, $6\frac{1}{4}$ inches, from tip, $5\frac{1}{2}$ inches; grain, often as broad as deep, narrow crease-dented, roughish to smooth. First introduced into Natal before the War, thence into the Transvaal and Orange Free State; fresh introductions from the United States were made by the writer after the War.

Hickory King is the best known and most extensively grown breed in South Africa, although its average yielding capacity is lower than that of several other breeds. It is later in maturing than several other sorts grown, and is therefore better suited to Midland or Bush-veld conditions than to the Upland or High-veld climate. Generally speaking, it is not a good drought-resister, but is considered less particular about its soil-requirements than some other breeds, and is grown successfully on lighter, sandy soils, where *Boone County* fails. The grain is large and attractive in appearance, which probably accounts for the general popularity of the breed, and the cob is extremely thin, drying out quickly. The breed is typically 8-rowed, but there has been a good deal of inter-crossing with 10- and 12-rowed breeds, and there may also be a certain amount of fluctuating variability in this direction; but as a rule well-bred *Hickory King* is more constant in row numbers than other dent breeds. The 8-row character appears to be partly responsible for low yield, inasmuch as there is too great width of sulci when there is any depth to the grain; or when there is no loss of space between rows, the grain is shallow and apt to be too thin; these facts suggest that 10-row and 12-row types of *Hickory* should be better yielders, and breed tests show that this is the case.

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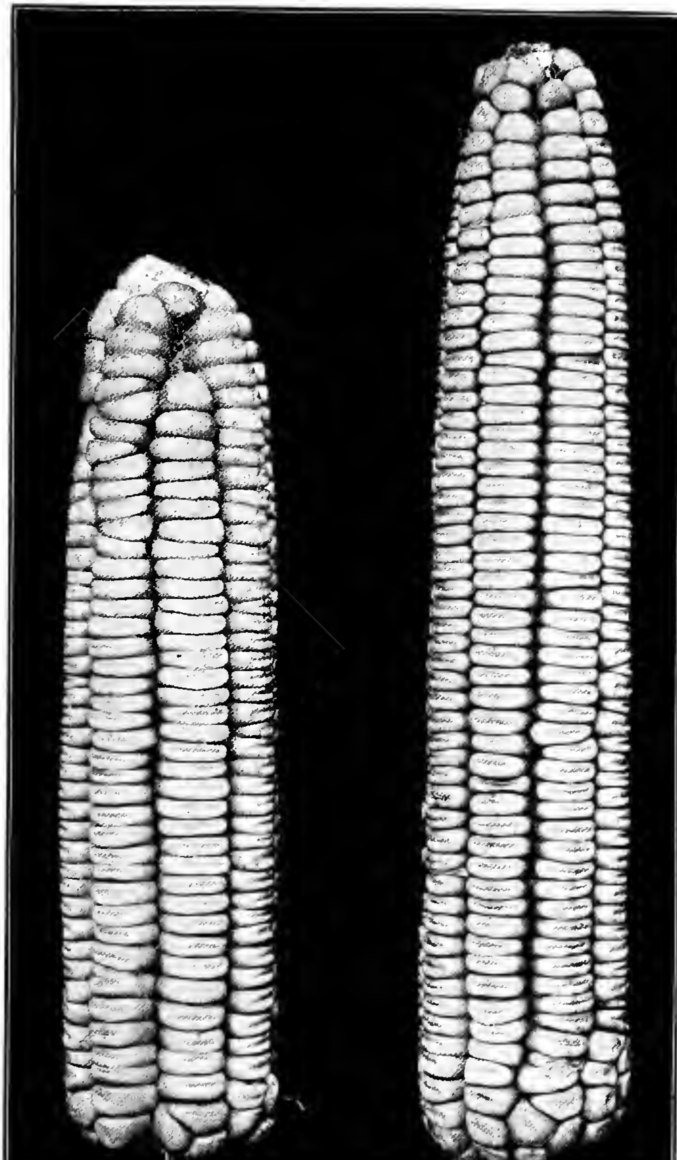

A B

FIG. 95.—*Hickory King*. A, defective tip. B, a good average ear.

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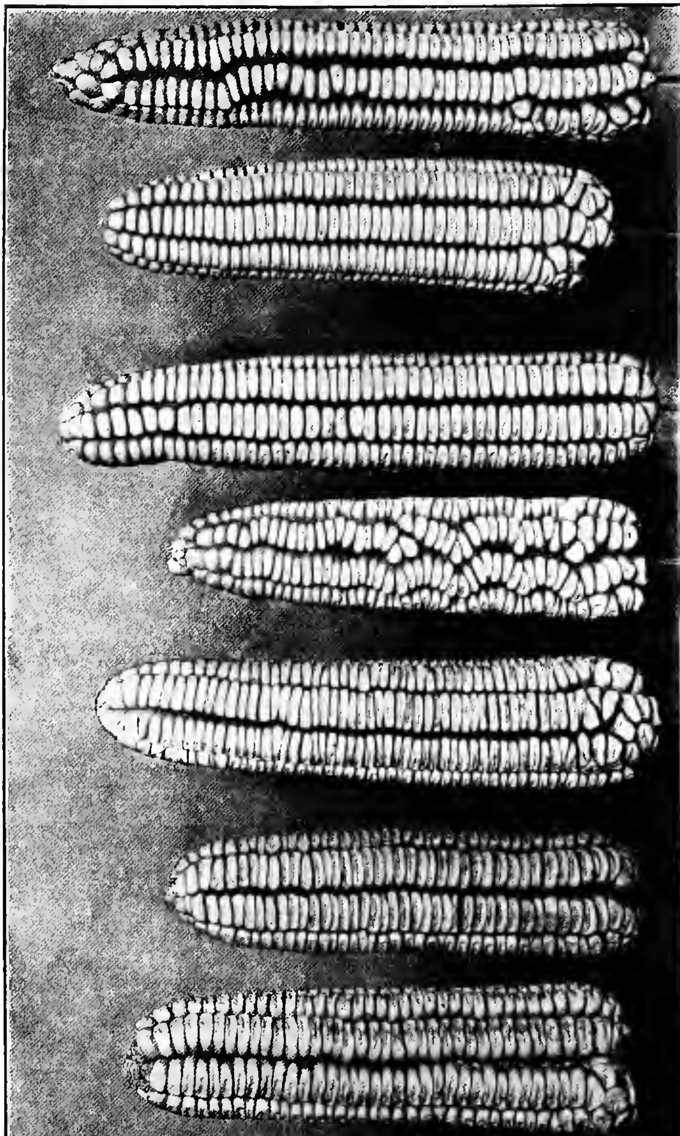

Fig. 96.—Variation in ears of *Hickory King*.

In spite of the lack of crowding, or possibly on account of it, there is a great tendency to irregularity in the rows. The frequent occurrence of an extra grain out of place (see Fig. 97), forming an irregular star, suggests the possibility that a larger number of rows is more normal. CHAP. VII.

The extensive cultivation of *Hickory King* has led to the accidental production of innumerable crosses, most of which appear to be useless, and none of which are definitely fixed. Of these *Ladysmith Hickory* (Fig. 97) is a promising type, characterized by the length of ear; it was found by the writer among some exhibits at the Ladysmith Show in 1912. Other probable crosses with *Hickory King* are referred to under the types which they more nearly represent.

240. *Hickory Horsetooth, or 12-row Hickory.*—Fig. 98. Class: medium late white dent; length of ear, 9 inches on the High-veld to $10\frac{1}{2}$ at lower altitudes; circumference of ear at 2 inches from butt, $6\frac{3}{4}$ to $7\frac{1}{4}$ inches, from tip, 6 to $6\frac{1}{4}$ inches; rows, 12; grain, deep wedge-shaped, broad crease-dented, smooth to roughish. Grown in the United States, both separately and in mixed stands of *Hickory*, and sometimes known as *Texas Hickory*.

At the Botanical Experiment Station, Pretoria, the writer isolated this type as likely to prove more productive than *Hickory King* owing to the greater depth and better shape of the grains, which allow greater yield of grain to the same size of ear. This type was subsequently propagated at the Government Experiment Farm, Potchefstroom; also by Mr. McLaren at Vereeniging, and by other Transvaal farmers. The writer has started selections of individual strains of this breed on several farms in the Transvaal and Natal; the yield is proving better than that of *Hickory King*. There is a tendency for the length of ear to fall to $8\frac{1}{2}$ inches, when close selection for well-covered tips is practised at expense of length, with consequent reduction of yield, and this should be overcome by selection.

Hickory Horsetooth varies in time of maturity, according to the character of the particular cross from which it has been segregated, and the part of the country in which it has been acclimatized. The strain grown at Potchefstroom has proved to be a late sort (i.e. later than *Hickory King*, and about the

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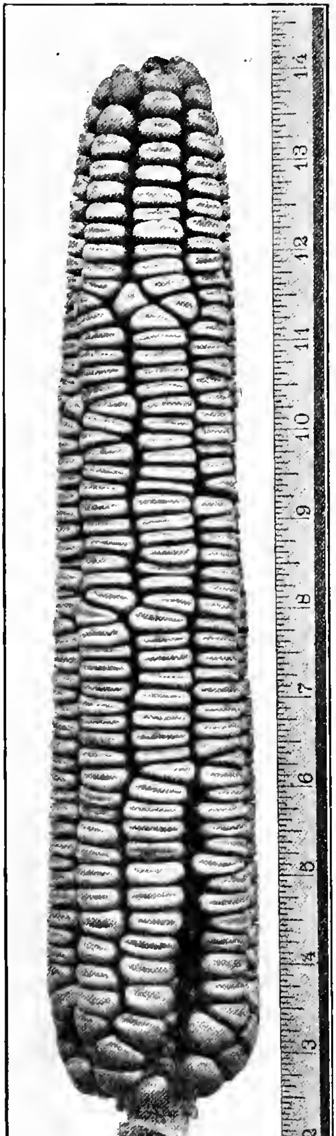

Fig. 97.—*Ladysmith Hickory*; a promising but unfixed cross-bred grown at Ladysmith, Natal.

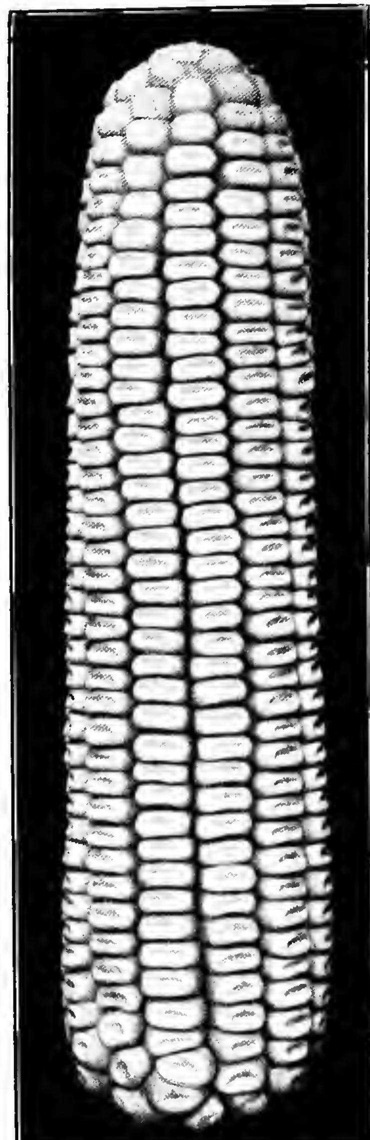

Fig. 98.—*Hickory Horsetooth*, or 12-row *Hickory*.

same as *Ladysmith*, *Yellow Hogan*, and *Golden Beauty*), but some strains grown on the High-veld are medium early.

Several different strains occur, due to the fact that the South African type has been isolated from other breeds, and variously crossed with such breeds as *Hickory King*, *Virginia Horsetooth*, etc.; some of these strains have been named, e.g. *Mercer*, *Noodsberg Horsetooth*, *Salisbury White*, etc.

241. *Salisbury White.*—Fig. 99. Class: late white dent; rows, 12; length, $8\frac{3}{4}$ to 9 inches; circumference at 2 inches from butt, $7\frac{3}{4}$ inches, from tip, 7 inches; grain, medium wedge-shape, broad crease-dented, smooth.

Appears to be a cross between 12-row *Hickory* and some other type, and not very different from *Hickory Horsetooth* except in length of ear and width of sulci. Said to have originated at Salisbury, and to be extensively grown in Rhodesia. Sometimes called *Mazoe* or *Brindette.*

242. *Noodsberg Horsetooth.*—Fig. 100. Class: late white dent; rows, 14; length, 10 inches: grain, deep wedge-shaped, shallow crease-dented, roughish.

This was exhibited at the Weenen County Show, Estcourt, Natal, 20 June, 1912, by two growers, Mr. C. How of Willow Grange and Mr. John Rencken, J.P. It is said to have originated on the Noodsberg from a cross between *Hickory King* and *Natal White Horsetooth.* Some farmers in that vicinity have called it the *Mercer*, but it is quite different from that breed; it is not unlike *Salisbury White* as grown in Swaziland. *Noodsberg Horsetooth* is said to breed true to type, and to be fairly drought-resistant; in spite of a bad season it had produced compact, well-covered ears.

243. *Mercer.*—Figs. 101 and 103. Class: late white dent; rows, 12; length, 9 inches; circumference, $7\frac{9}{16}$ inches at 3 inches from butt; grain, deep wedge-shaped with pinch-creased dent, roughish.

Originated as an accidental cross between *Hickory King* and "*North American Horsetooth*" (i.e. *Virginia Horsetooth*, Fig. 102), on the farm of Mr. W. Mercer, Cato Ridge, Natal. Mr. Mercer informs the writer that about the year 1904 he planted for comparative test with, and alongside, his *Hickory King* some seed of "*North American Horsetooth*" which had been introduced by Mr. Gavin of Umhlaas Road, Natal. Some

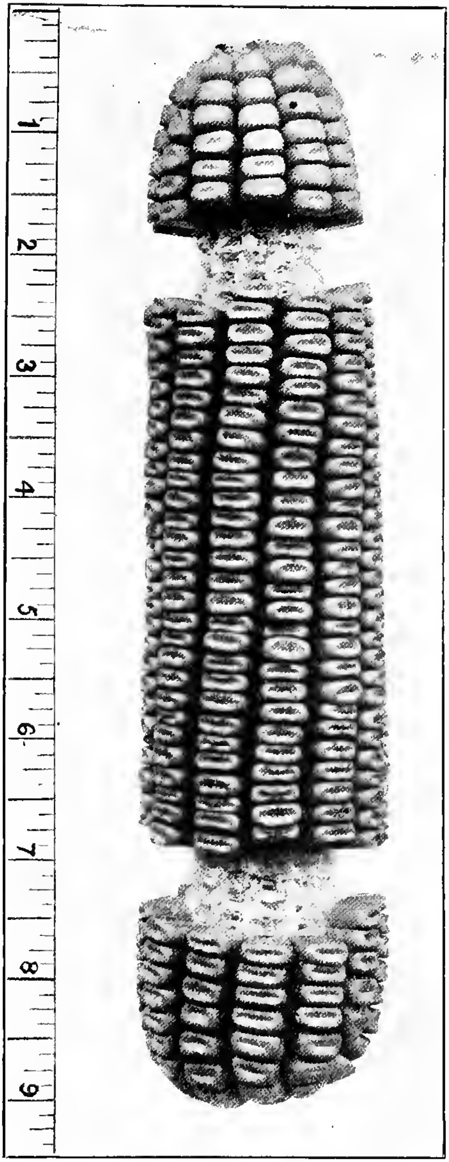

FIG. 99.—*Salisbury White*; specimen courteously furnished by the Department of Agriculture, Salisbury, Rhodesia.

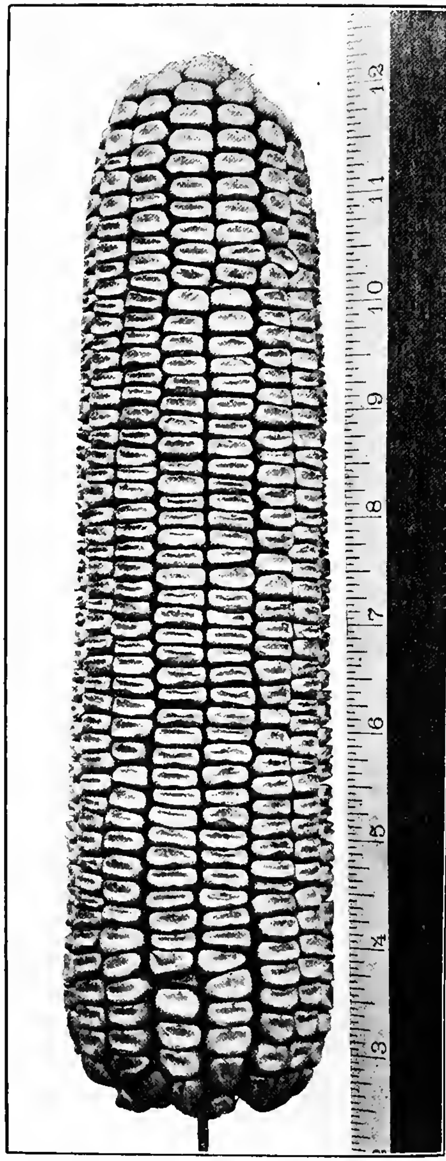

FIG. 100.—*Noodsberg Horsetooth*; a promising, unfixed cross-bred.

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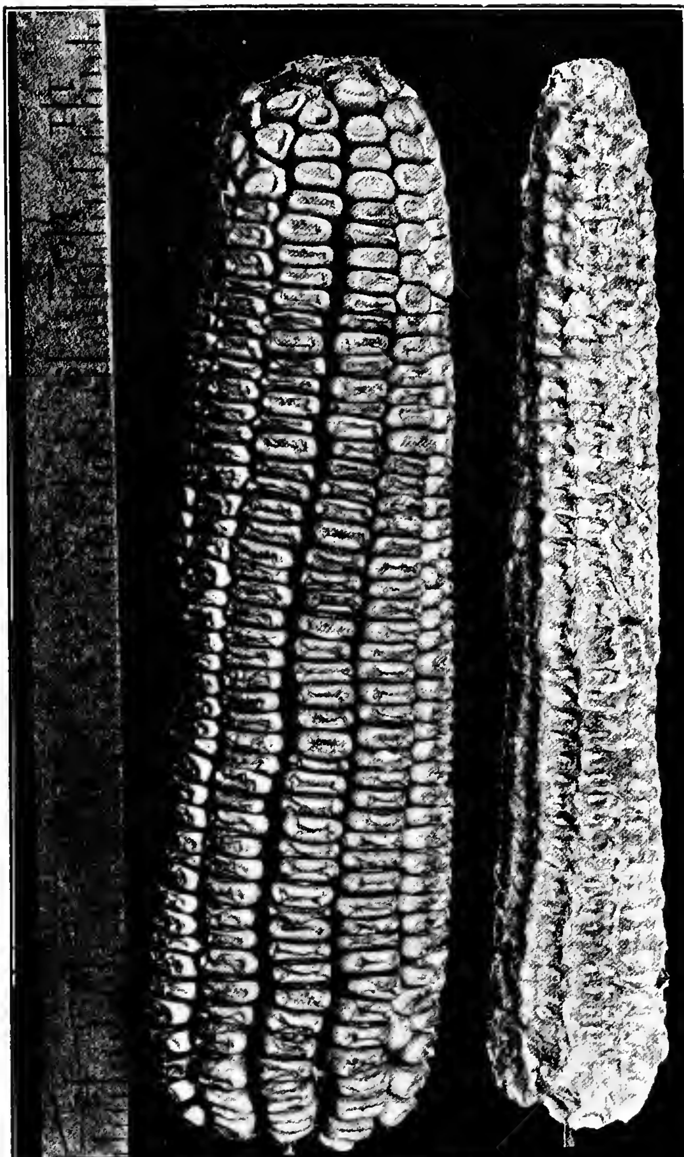

FIG. 101.—*Mercer*.

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two years later he found that his *Hickory King* crop produced a number of ears carrying 12 rows of grain of a much deeper

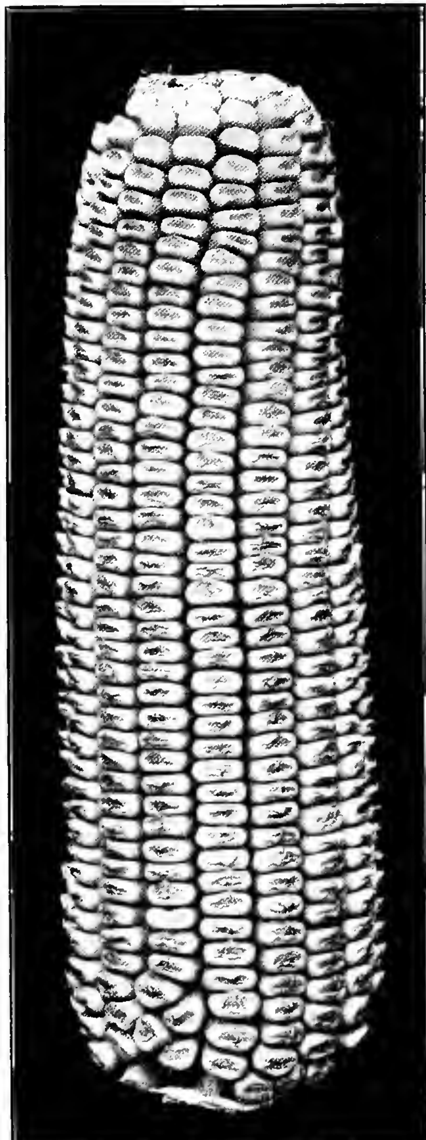

FIG. 102.—*Virginia Horsetooth.*

character than *Hickory King* and somewhat resembling the "*North American Horsetooth*". CHAP. VII.

These he selected and planted by themselves, with the result that he obtained from among the progeny both 8-row *Hickory King* and the deep-grained 12-row type, some ears also producing 10 rows. By continued selection of the 12-rowed, deep-grained ears his crop now produces mainly that type, although it still gives some 8- and 10-rowed ears.

Although the characteristic features are not yet fully fixed, the type is so distinct, and of such good quality, and is, moreover, proving such a good yielder (as is to be expected where the grain is of such depth), that it seems worthy of further attention, but it is only likely to suit localities with a long growing-season.

Description of ear No. 11,137, selected from Mr. Mercer's crop:—

Ear—
- Length—9 inches.
- Shape—Slowly tapering.
- Circumference, 3 inches from butt—$7\frac{9}{16}$ inches.
- Rows—12.
- Arrangement of rows—In pairs.
- Sulci—$\frac{1}{8}$ inch between pairs, less between the rows of a pair.
- Butt—Deeply rounded, slightly enlarged; rows regular, passing straight over.
- Tip—Regular rows up to the end.
- Shank—$\frac{3}{4}$ inch diameter.
- Weight—16·5 ozs.

Cob—
- Size—Medium; $4\frac{1}{4}$ inches circumference.
- Colour—White.
- Weight—2 ounces.

Grain—
- Condition—Firm upright; very rigid.
- Colour—Cream white.
- Indentation—Roughish.
- Form of dent—Pinched crease.
- Shape—Medium wedge.
- Length—$\frac{10}{16}$ to $\frac{12}{16}$ in.; the latter is the type for selection.
- Width at apex—$\frac{8}{16}$–$\frac{9}{16}$ inch.
- Per cent of grain per ear—87·1 per cent.
- Number of grains per ear—600.
- Weight of grain per ear—13·5 ozs.

244. 10-*Row Hickory*, or "*Louisiana*".—Figs. 104 and 105. Class: medium late white dent; length, $8\frac{1}{2}$ inches; circumference,

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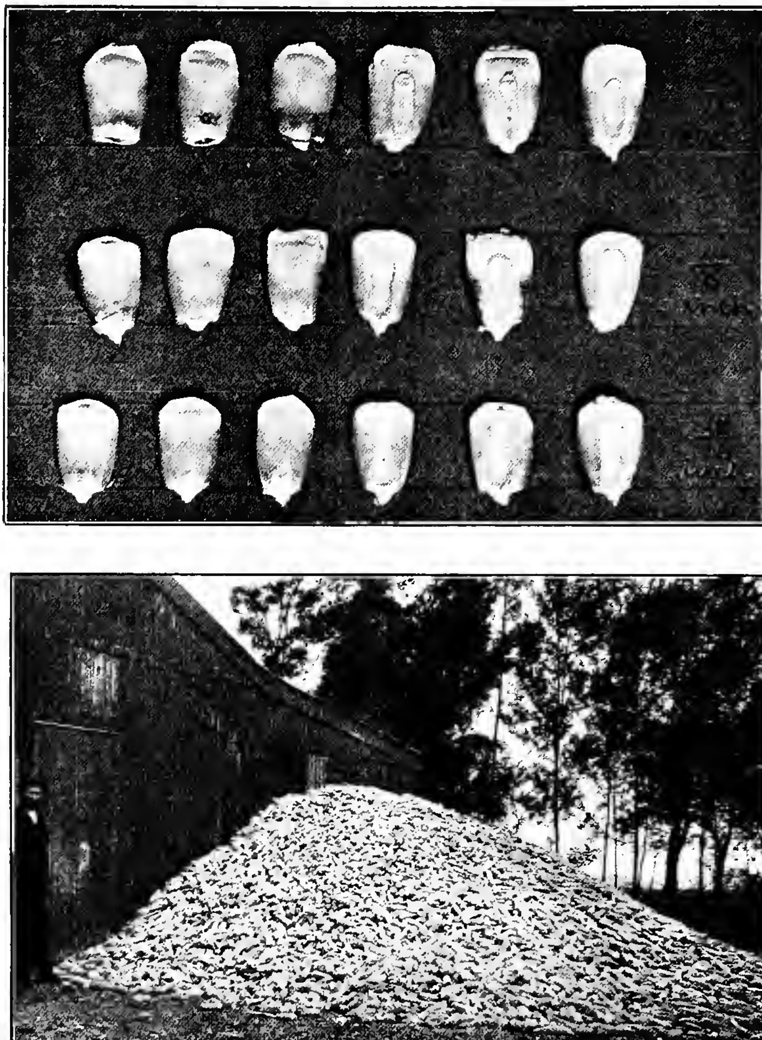
6½ inches; rows, 10; grain, medium wedge-shaped, deep crease-dented, slightly rough.

One of the types of *Hickory* grown in the United States and usually found segregating in fields of *Hickory King*, both



A

B

FIG. 103.—A, grains of *Mercer*: B, surplus crop after filling Mr. Mercer's barn (Cato Ridge, Natal).

there and in South Africa. The writer isolated a strain of this type some years ago, which now breeds fairly true though a CHAP. VII.

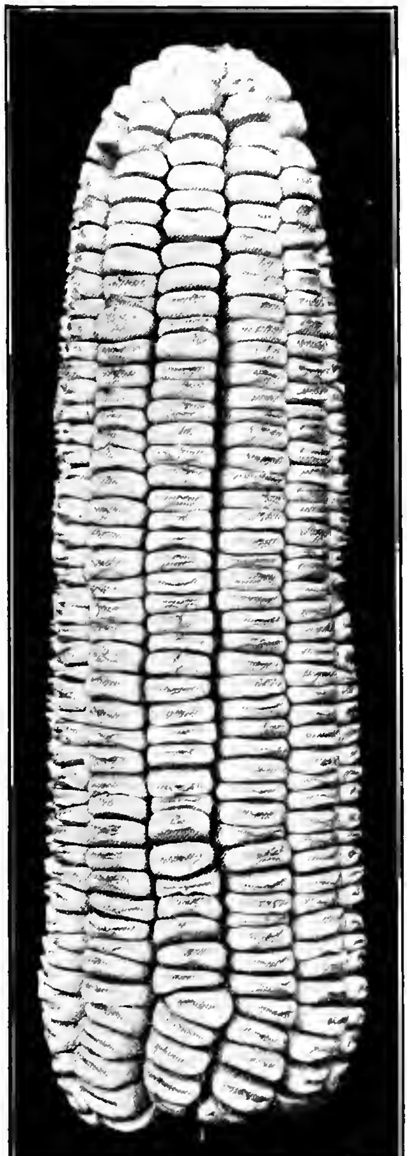


FIG. 104.—10-Row *Hickory* or "*Louisiana*

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certain amount of fluctuating variability occurs. The tendency is for the ear to be rather short and well filled, which is an advantage for the High-veld as it tends to hasten the time of maturity.

As the local market is still prejudiced in favour of a broad grain, it is a matter of opinion whether the broad-grained

A B

FIG. 105.—Two prize ears of 10-row *Hickory* at the Johannesburg Maize Show. A, grown by Reynolds Bros.; B, grown by Hutchinson and Shaw (Val Station, Transvaal).

10-row *Louisiana* type is not preferable to the narrower-grained 12-row of the *Hickory Horsetooth* (although the difference is but slight), especially on the High-veld, where the earlier-maturing habit of the former is in its favour. It may be possible to develop a *Hickory Horsetooth* with equally broad grain and earlier-maturing habit. Sometimes the 10-row grain is no broader than that of the 12-row, in which case the 12-row is preferable where the climate suits it; the 12-row produces a larger percentage of embryo than the 10-row, and at Potchefstroom the latter has been discarded in favour of *Hickory Horsetooth*. CHAP. VII.

245. *Iowa Silver-mine.* — Figs. 106 and 107. Class: medium-early white dent; rows, 14 or 16; length, 10 inches; circumference at 2 inches from butt, 7 inches, from tip, 6 inches; grain, medium wedge, pinch-dented, very rough.

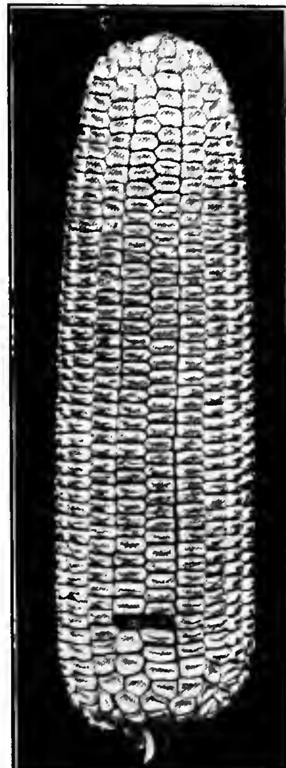

FIG. 106.—*Iowa Silver-mine*, a prize ear.

A drought-resistant, early-maturing breed, producing compact, heavy, rough ears. It does not seem suited to wet soils and climates, in which its behaviour is exactly the opposite of *Boone County* (Fig. 108). *Iowa Silver-mine* was introduced by the writer in 1905, from J. M. Thorburn and Co., New York, U.S.A.; it has given excellent results in the drier parts of the South-western Transvaal, in British Bechuanaland, the Orange Free State and near Aliwal North. It proves to be rich in protein and horny endosperm, and is therefore well suited for the manufacture of samp, and makes a nutritious mielie-meal if "whole-ground".

An improved strain of *Silver-mine*, known as *Johnson County*, was introduced by the writer a few years ago, and has been widely distributed and used to cross into the acclimatized strain.

A strain of *Silver-mine* from Illinois, U.S.A., was introduced into Natal some years ago, and is said to have become a favourite there, standing next to *Boone County* in point of yield.

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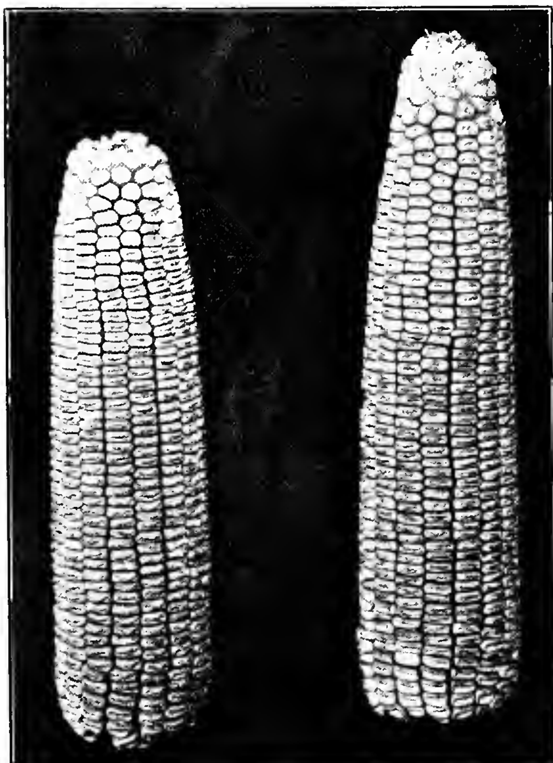
246. *Boone County.*—Fig. 108. Class: late white dent; rows, 16 to 22; length, 10 inches; circumference at 2 inches from butt, $7\frac{1}{2}$ inches, from tip, 6 inches; grain, medium wedge-shaped, pinch-dented, rough.

Introduced into the Transvaal by the writer in 1905 and previously into Natal from Indiana, U.S.A.



A B

FIG. 107.—Two prize ears of *Iowa Silver-mine* at the Johannesburg Maize Show. A, grown by W. A. McLaren (Vereeniging); B, grown by M. Geerdts (Boksburg), Transvaal; the tip of the latter is very defective.

It has been grown successfully, but to a limited extent, in the wetter parts of Natal, in the Eastern Transvaal (in warm, sheltered localities) and in Rhodesia, but the conditions most generally prevalent throughout South Africa do not seem favourable to this breed. According to Sawer it is found in

Natal to be hardy and resistant to rust, but a rank feeder, with extensive root system, yielding record crops only on rich, heavy vlei soil, and requiring 135 to 150 days to mature. CHAP. VII.

247. *Ladysmith.*—Figs. 94B and 109. Class: late white dent; rows, 14 to 20; length, $10\frac{1}{2}$ inches; circumference at 2 inches from butt, $8\frac{3}{4}$, from tip, $6\frac{3}{4}$ inches; grain, deep wedge, pinch-dented, beaked, very rough.

Grown by Mr. Walter Pepworth of Pepworth, near Ladysmith, and taken from his farm to Vereeniging by Mr. McLaren, who called it the *Ladysmith* for want of another name. It probably originated from *Champion White Pearl*, which it resembles in its beaked grain, and it is known by that name among many farmers in Natal. But it differs in other respects (larger size, later maturity, better yield, etc.) from typical *Champion White Pearl* as imported by the writer some years ago, and grown for several years at the Botanical Experimental Station, Pretoria, and the Government Experiment Farm, Potchefstroom.

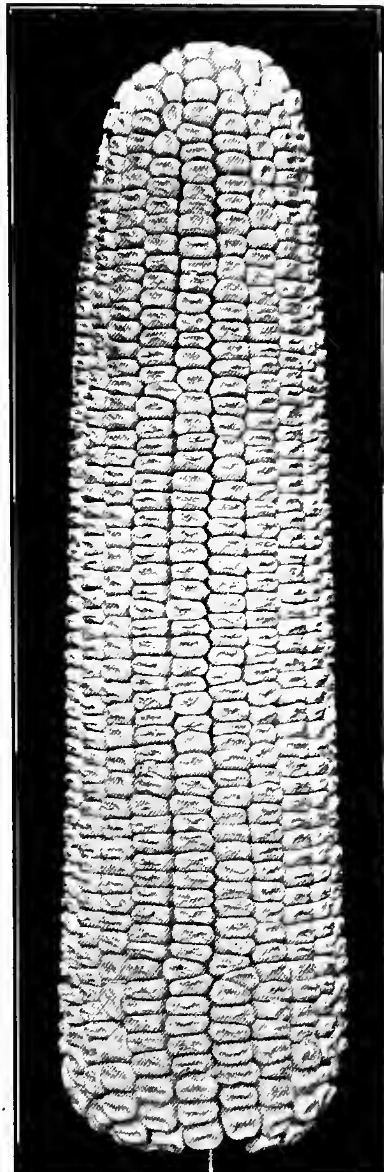


FIG. 108.—*Boone County.*

Ladysmith is a late-maturing breed, and best

CHAP. VII. suited to the Midlands and wetter parts of the Bush-veld. When planted *early* it has matured satisfactorily at Vereeniging, but cannot be recommended as a High-veld breed, nor for

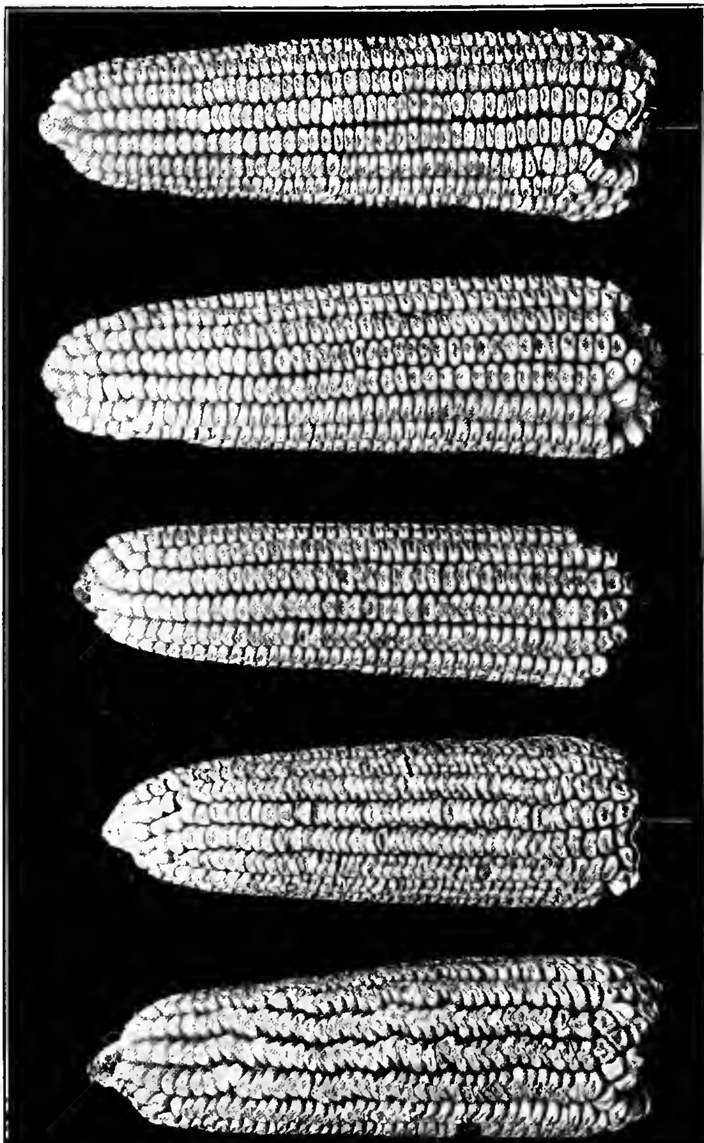


FIG. 109.—Variation in types of *Ladysmith*.

regions of low rainfall. *Ladysmith* has been discarded at Pretoria and Potchefstroom. *Champion White Pearl* is still grown.[1]

The grain is appreciated on the English market, for samp and grit manufacture, as it contains a large percentage of horny endosperm.

248. *Natal White Horsetooth.*—Figs. 110 and 111. Class:

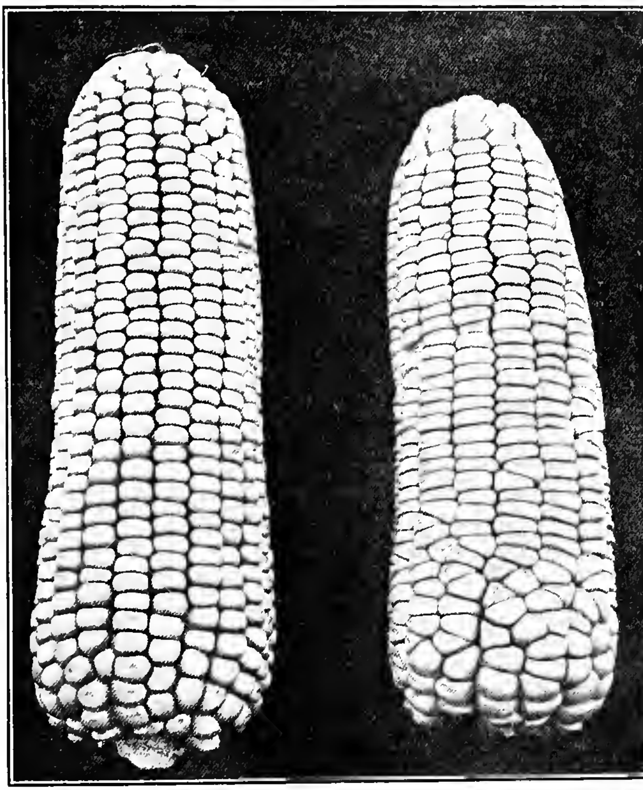


FIG. 110.—*Natal White Horsetooth.*

very late white dent; rows, 14 to 18; length, $10\frac{1}{2}$ to 12 inches; circumference at 2 inches from butt, $8\frac{1}{2}$, from tip, $6\frac{3}{4}$ to 7 inches; grain, broad and shallow, but thick, crease-dented, smooth; cob, very thick, drying slowly. Synonym: *Late White Horsetooth.*

According to Sawer it takes 140-150 days to ripen in Natal, but is a good drought resister and heavy cropper.

[1] Under the name *Potchefstroom Pearl*, which is a selected strain of *Champion White Pearl.*

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This breed has been grown for some years in Natal, but owing to its late-maturing and slow-drying habit its cultivation has not extended much to other parts of the country. It is one of the six best yielding breeds at Potchefstroom and has been grown successfully at Vereeniging, but is too late as a main-crop for the High-veld. The grain is floury, and valued for the manufacture of starch, cornflour, and mielie meal.

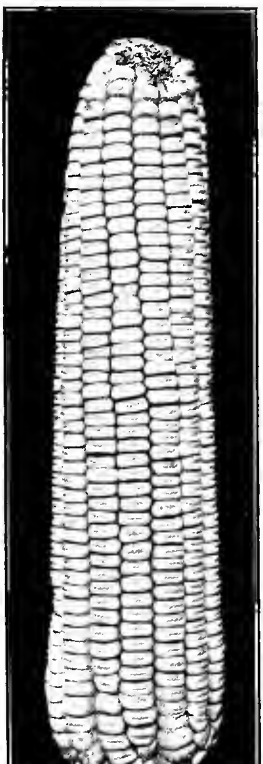

FIG. 111.—*Natal White Horsetooth × Hickory King.*

Crosses between *Natal White Horsetooth* and *Hickory King* are not infrequently met with; some of these have a narrower ear (Fig. 111), with thinner cob than the *Horsetooth*, while retaining something of its thickness of grain. The so-called *Mazoe* or *Brindette* grown in Swaziland may perhaps have some *Natal White Horsetooth* "blood" in it, though said to have been brought down from the Mazoe Valley, Rhodesia.

249. *Eureka.*—Fig. 112A. Class: medium or mid-season yellow dent; rows, 16 or 18; length, 9½ to 11 inches; circumference at 2 inches from butt, 7¼ inches, from tip, 5¾ to 6¼ inches; grain, medium wedge-shaped, crease-dented, medium smooth.

Introduced by the writer in 1905 from Peter Henderson, New York, U.S.A.; now widely distributed in the Transvaal, but apparently not equally suited to all climates and soils. Topped the list for yield at the Government Experiment Farm, Potchefstroom, for three years (1907-8 to 1909-10), and gave the highest average yield for six years. Valuable for stock-food and export.

250. *Chester County.*—Fig. 112B. Class: early yellow dent; rows, 16 or 18; length, 10 inches; circumference at 2 inches from butt, 6½ to 7 inches, from tip, 5¾ inches; grain, small,

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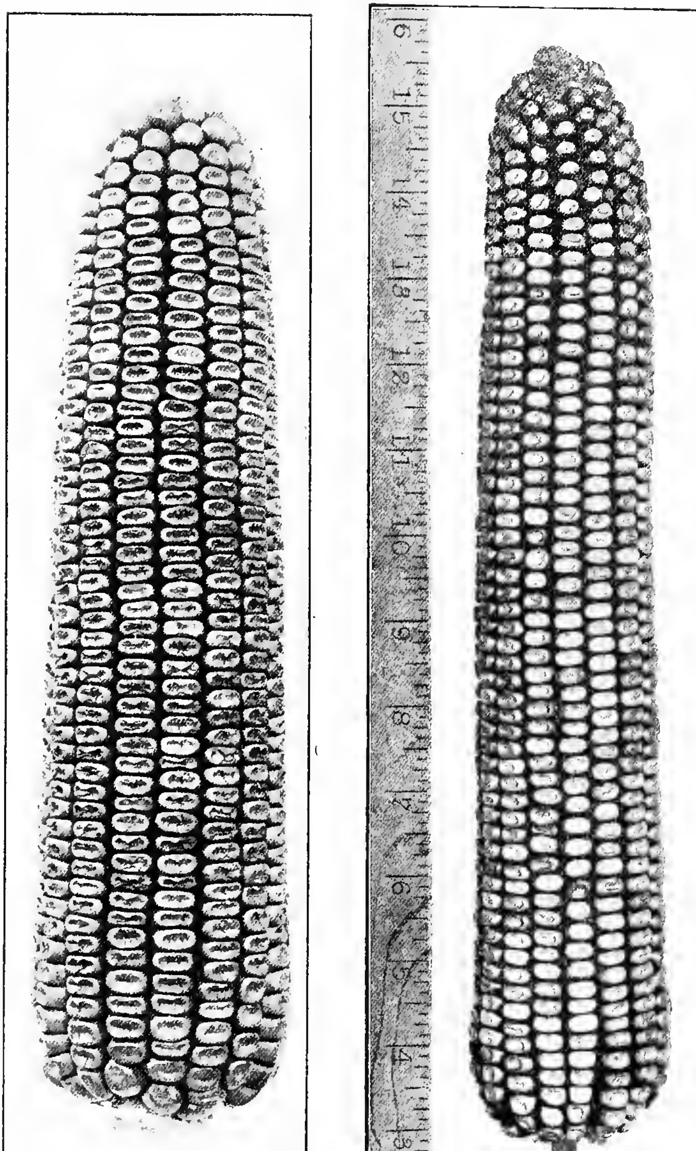

A B

FIG. 112.—A, *Eureka*; B, *Chester County*.

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deep, narrow wedge-shaped, thick, round dimple-dented, smooth or medium smooth, deep yellow with lighter cap.

Introduced by the writer in 1905 from Peter Henderson, New York, U.S.A., and now widely distributed. Valued for its early maturity, drought resistance, and heavy yield. Gave the heaviest yield at Potchefstroom in 1910-11, and the second highest average for six years. Is proving suited to the Uplands of Natal, which have hitherto been considered outside the Maize-belt, or only suited to flint breeds.

The small size of the grain is considered objectionable by some local buyers, but the grain is appreciated for stock-food on the European markets.

251. *Yellow Hogan.*—Fig. 113B. Class: late yellow dent; rows, 12 or 14; length, 9 inches; circumference at 2 inches from butt, $7\frac{1}{4}$ inches, from tip, 6 inches; grain, medium wedge-shaped, crease-dented, medium smooth or smooth, rich orange yellow.

Introduced by the writer in 1904 from P. L. C. Shepheard and Son, Sydney, N.S.W. At Potchefstroom *Yellow Hogan* beat *Eureka* for yield in 1905-6 and 1906-7, and came a close second in 1910-11; it stands third in the average for seven years.

252. *Golden Beauty.*—Fig. 113A. Class: late yellow dent; rows, 12; length, 12 inches; circumference at 2 inches from butt, $6\frac{1}{2}$ inches, from tip, $5\frac{1}{4}$ inches; grain, deep, broad wedge-shaped rounded corners, crease-dented, smooth to medium smooth, rich orange-yellow.

Introduced by the writer, in 1904, from Burpee, Philadelphia, U.S.A., but did not prove satisfactory in the Transvaal, and was subsequently discarded. Separately introduced into Natal where it has proved more satisfactory, and is grown in the Richmond District. A handsome ear, producing a fine, well-coloured grain.

According to Sawer, *Golden Beauty* takes 140 days to mature in Natal, proves a vigorous grower, is very drought and wind resistant and does not sucker; "a good general purpose breed, but rather slow for the High-veld".

253. *Yellow Horsetooth.*—Fig. 114. Class: medium-late yellow dent; rows, 14; length, 9 to 10 inches; circumference at 2 inches from butt, $7\frac{3}{4}$ to 8 inches; from tip, 6 inches; grain,

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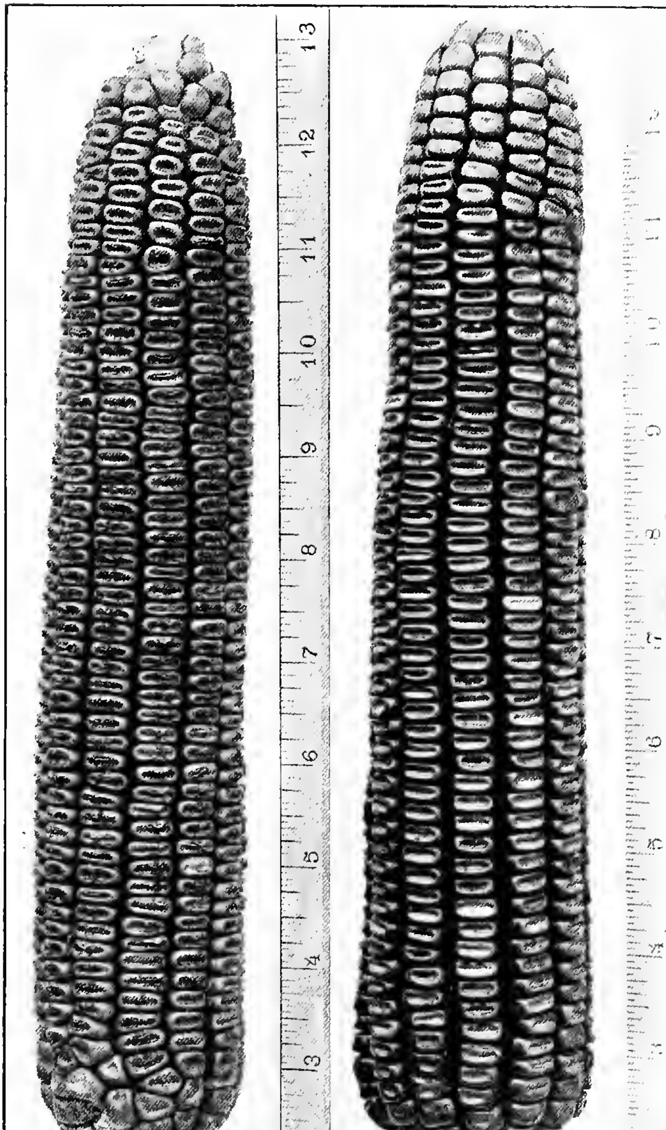

A B

FIG. 113.—A, *Golden Beauty*; B, *Yellow Hogan.*

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thick, shallow wedge, with shallow crease-dent; cob, large, white. Synonyms: *German Yellow Horsetooth; Natal Yellow Horsetooth; Bishop.*

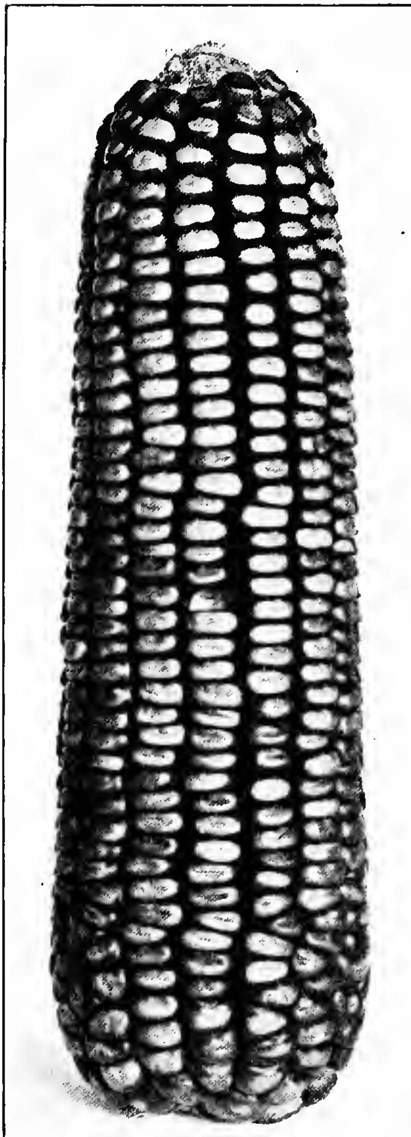

FIG. 114.—*Yellow Horsetooth* or *German Yellow.*

There are two types in South Africa, known respectively as *German Yellow* (Fig. 114) and *Natal Yellow, Horsetooth*; the former is apt to be earlier in maturing and more drought resistant than the latter, but both vary greatly in these respects, according to the part of the country in which they have become acclimatized, and the character of the other strains which have entered into their composition, for both are very impure. In some cases the type grown under this name is a mongrel flint, segregating each year into flints and dents, and in others it is a partial dent which segregates into dents and flints. We are not aware that any distinctive and pure strains have been isolated.

If planted early, *Yellow Horsetooth* does well on the High-veld, where it proves a good yielder both in grain and fodder.

The grain, when true to the dent type, is valued on the London market, both for manufacturing purposes and for the preparation of flakes.

254. *Reid Yellow Dent.*—Fig. 115. Class: medium-early yellow dent; rows, 18 or 20; length, 9-10 inches; circumference, 7 inches; grain, long wedge, dimple-dented, medium smooth (the rougher grains usually have greatest depth).

An early maturing and comparatively drought resistant type, giving good yields. Introduced by the writer from the United States, in 1909; gave excellent results at the Botanical Experiment Station, Pretoria, in 1909-10, 1910-11, and 1911-12; now being tested at Potchefstroom, where the returns have so far been good.

Reid Yellow Dent was originated in 1846 by Mr. James L. Reid, of Tazewell County, Illinois, U.S.A., as a cross between "*Gordon Hopkins*" of Brown County, Ohio, and *Little Yellow.* Its characteristics of shape, length and circumference of ear, filling out at tips and butts, size and shape of cob, and shape and indentation of grain, are said to have been strongly fixed by careful and intelligent selection, and are uniformly reproduced, and it is considered one of the most improved breeds of maize grown in the United States. The following are characteristics as recorded by Sturtevant and Myrick :—

Ear, $9\frac{1}{2}$ inches long, $6\frac{7}{8}$ inches (6·9 inches) circumference, $2\frac{1}{8}$ inches diameter, slowly tapering; rows, 18-20 in distinct pairs; sulci narrow, scarcely well defined; butt deeply rounded, very compressed, with diverging grains. Grains very firm on the cob, upright, broadly truncate-cuneate, tapering to a point by straight lines, $\frac{5}{16}$ inch broad, $\frac{1}{2}$ inch deep; long dimple-dented, smooth; tip grains conical; colour horn-orange with yellow cap. *Cob* red. *Shank* medium to small. *Season* reported as 118 days in Indiana.' According to Sturtevant this appears from the description to be the same as *Queen of the Field* from Iowa.

255. *Minnesota Early.*—Fig. 116. Class: medium-early yellow dent; rows, 16 or 18; length, $9\frac{1}{2}$ inches; grain, medium wedge, fairly deep, dimple-dented, medium smooth.

An early-maturing yellow dent introduced by the writer in 1909 from the United States; it gave promising results at the Botanical Experiment Station, Pretoria, in 1909-10, and is being tested further.

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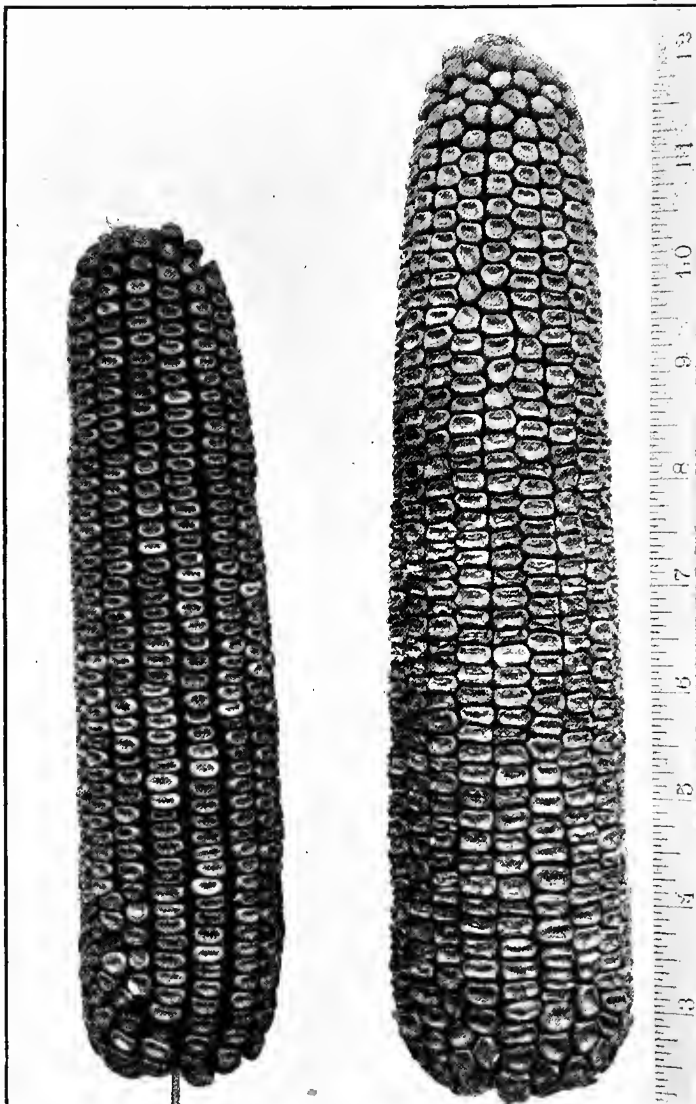


A B

FIG. 115.—Two types of *Reid Yellow Dent*, showing improvement by selection. B is the improved type.

256. *Star Leaming.* — Fig. 117. Class: medium-early yellow dent; rows, 16 to 20; length, 10 inches; circumference, CHAP. VII.

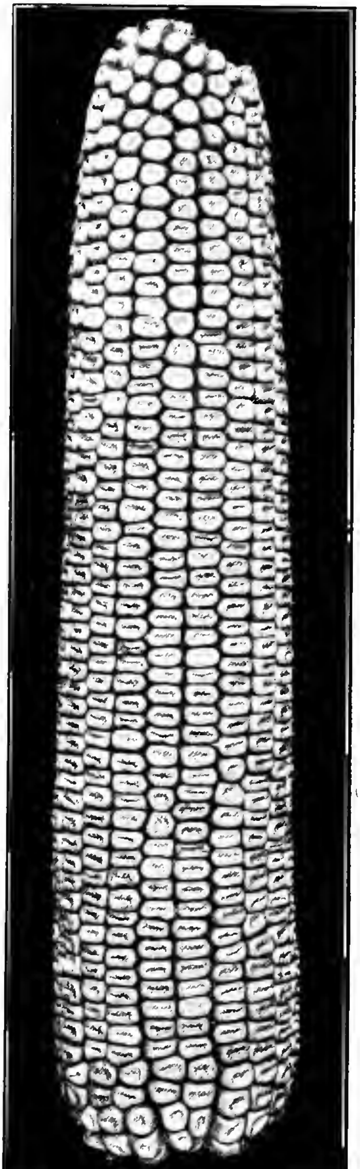


FIG. 116.—*Minnesota Early.*

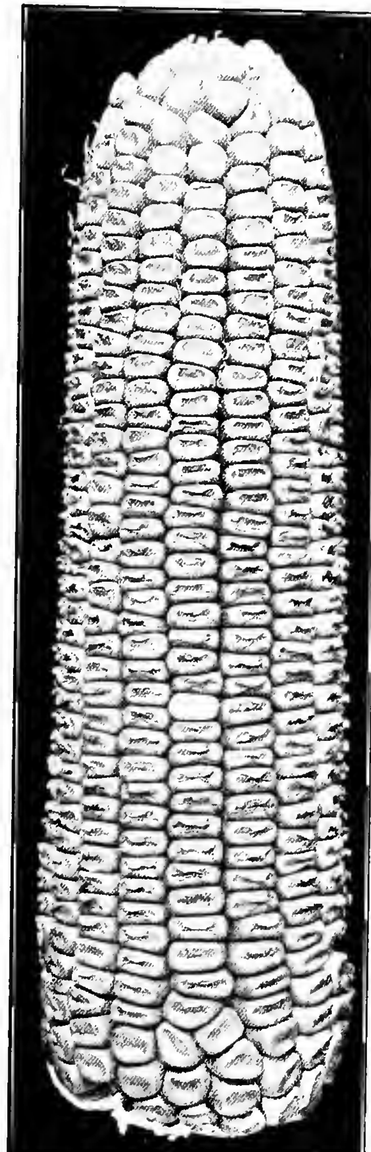


FIG. 117.—*Star Leaming.*

CHAP. VII. 7 inches; grain, medium wedge, crease-dented, rough. Introduced by the writer in 1904 from P. L. C. Shepheard and Son, Sydney, N.S.W. Proved particularly useful on the eastern High-veld.

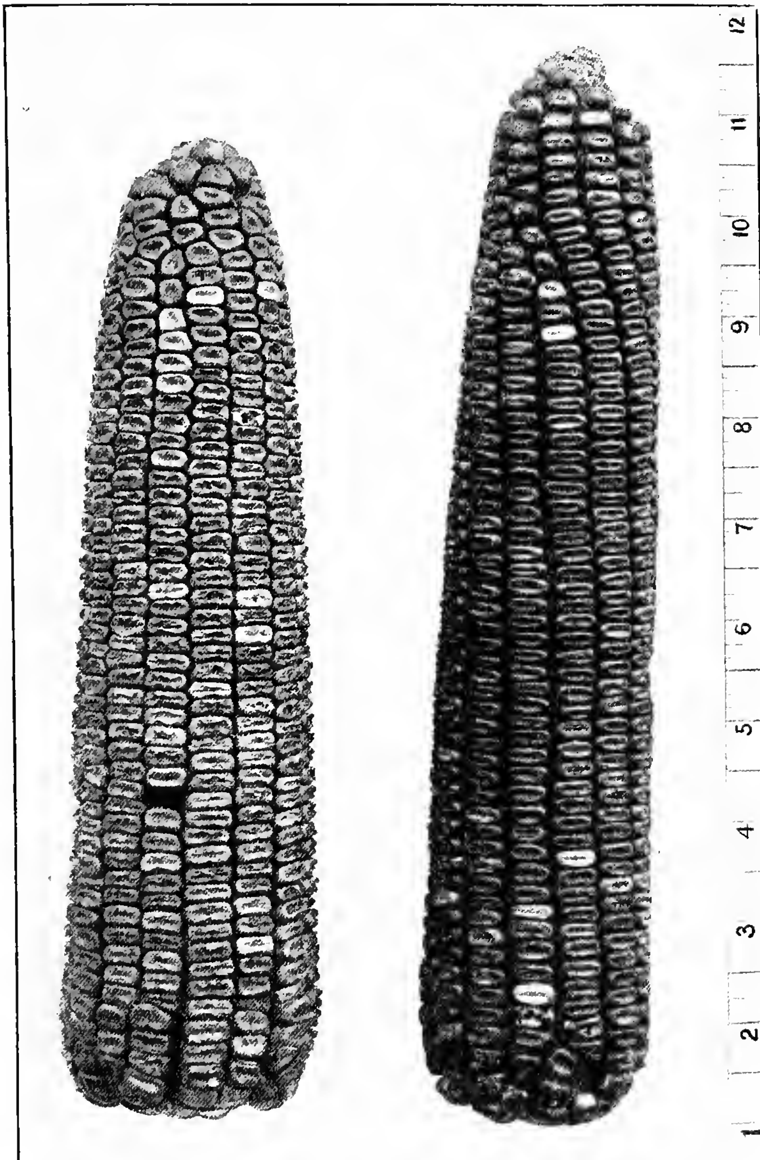
Leaming is one of the most extensively grown breeds of maize in the United States, and is said to have the most uniform characteristics of any yellow maize grown. It there proves adaptable, by selection, to widely different conditions of soil and climate. It was originated in 1826 from a common yellow sort growing on the bottom lands of the Little Miami River, Hamilton County, Ohio, by Mr. J. S. Leaming, and was selected by him towards a standard type for a period of fifty-six years. It is supposed to be the type from which many breeds of yellow maize have been developed, as most of the yellow breeds show some of its characteristics, and many of them can be actually traced back to *Leaming*.

The general characteristics of the *Leaming* group are: *Ear* tapering, $9\frac{3}{10}$ inches long, 7 inches circumference; butt rounding or moderately rounding, more or less compressed, with tendency to expand; rows in distinct pairs but mixed at tip, 16 to 24, with a tendency to reduction about the middle of the ear; sulci medium. *Grains* generally firm (sometimes loose) and mostly upright; generally wedge-shape with square-cut summits and nearly straight edges, long dimple to pinch-dented, horn-orange with yellow cap. *Cob* red, medium. *Shank* medium to large.

Sturtevant recognized five strains of *Leaming*, viz.: (1) *Early Leaming* (Illinois); (2) *Improved Leaming*; (3) *Leaming Yellow* (Ohio); (4) *Missouri Leaming*; (5) *Star Leaming* (Ohio). Of these *Early Leaming*, *Improved Leaming*, and *Star Leaming* have been tested at the Government Experiment Farm at Potchefstroom, but have now been discarded in favour of better yielding breeds. They were also distributed among farmers on the High-veld, where they have done well in some cases.

257. *Golden Eagle.*—Fig. 118. Class: late yellow dent; rows, 16 to 20; length, 10 to 11 inches; circumference, 7 inches; grain, broad wedge, dimple-dented, rough to very rough (or medium smooth, Fig. 118B).

Introduced from the United States, where it was originated by Mr. H. B. Perry of Illinois in 1871.



A B

FIG. 118.—*Golden Eagle*, as grown in Rhodesia; ears courteously supplied by the Department of Agriculture, Salisbury.

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In South Africa the cultivation of this breed appears to be mainly confined to Rhodesia, and even there (we are informed) the tendency is to discard yellows in favour of whites for export purposes. Reported (*Sawer*, 1) as a strong, gross feeder, requiring heavy and fertile soils.

258. *Principal American Breeds of Flint Maize.*—The following twenty-one breeds of flint maize are recommended, principally for grain production, by the Agricultural Experiment Stations of the States mentioned after their names, as reported by Hunt (1):—[1]

1. Angel of Midnight (r): Utah (tested ten years), Vermont, Wyoming.
2. *Canada yellow (y): Nevada (did not ripen grain).
3. Canada 12-rowed (y): Vermont.
4. Early Demand (o): Vermont.
5. French Squaw No. 32 (w): North Dakota.
6. *Gehu, No. 123 (y): North Dakota.
7. Golden Dewdrop (y): Utah (tested seven years).
8. *King Philip (y): Ottawa, Kansas, Oregon, South Dakota, Utah (tested nine years), Wisconsin.
9. *Longfellow (y): Ottawa, Vermont.
10. Long Yellow flint (y): Utah (tested ten years).
11. Milliken's Prize (y): Vermont.
12. *North Dakota (w): North Dakota (No. 148); Utah (tested seven years).
13. Orange County (w): Vermont.
14. Rideout corn (y): Wyoming.
15. *Sanford (w): New Hampshire, Vermont.
16. Smut-nose (w): South Dakota.
17. Squaw corn (w): Utah (tested seven years).
18. *Thoroughbred (w): Vermont.
19. Waushakum (y): Vermont.
20. White flint (w): Utah (tested ten years).
21. Yellow Flint Corn (y): South Carolina (on thin upland soil).

259. *Principal South African Flint Breeds.*—Flints appear to have been grown in South Africa long before the introduction of dents, and still persist in the Native Territories, and in districts of poor rainfall devoted mainly to stock-raising. The breeds principally grown were: *Botman* (both white and yellow); *Cango* (both white and yellow); *Repatriation* (yellow); *Bushman* (yellow); and "*Kaffir mielies*" (mixed white, red, blue, and yellow). The three first-named are now so mixed as often to be indistinguishable, except that difference in time of maturity is associated with the strains grown in one part of the country as compared with those of another. "*Bushman*" is rarely met with. The "*Kaffir mielie*" is probably a descendant of the old *Squaw* or "native" corn still grown in Canada, and a similar type has been received from Italian Somaliland. The natives are said to have a predilection for parti-coloured ears.

[1] Red = (r); orange = (o); yellow = (y); white = (w). Those marked with an asterisk have been tried in South Africa.

The Transvaal Department of Agriculture introduced and tested a number of the improved American and other sorts, some of which have been discarded as unsatisfactory, while others having proved superior to the older sorts already grown, have been widely distributed, and are now mixed with the old types. Among the best of these are *New England 8-row* (y) and *Rural Thoroughbred* (w). *Wills Gehu* (y) and *North Dakota* (w), introduced in 1909, matured in eighty-seven days at the Botanical Experiment Station, Pretoria, and gave a very fair yield for such a short season; a fresh consignment of seed was obtained and widely distributed among farmers for the season of 1910-11.

The early-maturing flints of South Europe, such as *Cinquantino*, *Odessa*, and *Bessarabia*, while maturing quickly (sometimes in forty to fifty days) give such poor yields as to be unsuited to the broad type of agriculture necessarily in vogue in a large part of South Africa. They seem better suited to the small farm areas of the south of Europe. Another drawback is their habit of bearing ears low down on the stem, which renders them particularly liable to injury by vermin and to damage by torrential summer rains. These breeds might be useful to plant late, where the regular crop has been destroyed by hail or locusts; but the difficulty would then be to obtain a sufficient quantity of seed at the moment when it is needed, as no one cares to grow for seed those breeds for which there will only be a demand in a bad season.

The following have also been tested:—

Yellow Flints.—Compton Early, Canada Early (8-rowed), Vilmorin Early, Vilmorin Early (long-eared), Henderson Large Yellow, Ninety-day, Longfellow, Improved King Philip, Harris Golden, Cinquantino, Odessa, La Plata, Argentina, and Sheppard Yellow Flint.

Red Flints.—Indian Pearl; the ears often carry white, red, and blue grains mixed.

White Flints.—Egyptian, Somali, and Western Beauty have been tried and discarded. Burlington Hybrid is grown to a very limited extent.

260. *Cango*, white.—Class: medium white flint; *ears*, 9 to 10 inches long; $5\frac{5}{8}$ inches circumference at tip, $1\frac{1}{2}$ inches diameter; slowly tapering; butt even; rows distinctly distichous

CHAP. VII. below, 8 to 10. *Grain* rather large, 6 lines broad, 4½ deep; roundish at apex, flattish at sides (sometimes classed as a "flat" in the trade), brownish white, embryo large. *Shank* medium. *Cob* thin, white. Medium early; 10th in average yield at Potchefstroom; useful breed for late districts. *Stem* medium short; tillers freely. Extensively grown throughout the country. Supposed to take its name from the Cango District, Oudtshoorn Division, Cape Province, whence it is said to have been brought north. A form of white flint with larger ears than the Botman, and with grains "flatly rounded on top," is described by Sturtevant as being grown at Rio Claro, on the uplands of Brazil, under the name *Milho catete;* it was distributed by American seedsmen between 1881 and 1884 under the names "*Hominy*," "*White Pearl*" (not *Champion White Pearl*), and "*Large White Flint*".

There is no demand for this class of maize on the London or Liverpool markets.

Cango and *Botman* are probably the types introduced by the Portuguese, from their Brazilian settlements, into the East Indies and China, and dropped at Mossamedes, Cape Town, and on the East Coast *en route.* An African-grown ear of white flint maize, received probably from the late Prof. MacOwan, Cape Town, about the year 1884, was classified by Sturtevant as *differing only in colour* from Chinese samples exhibited at the Centennial Exposition, and from the *milho dourado* grown at Rio Claro, in the Province of Goyaz, on the uplands of Brazil; Rio Claro is on the trade route from Rio de Janeiro to Matto Grosso and Bolivia. Colour we now know to be a most inconstant character, due to crossing; there are both white and yellow *Cangos* and white and yellow *Botmans.*

261. *Thoroughbred, Rural.—Ear,* 11 to 12 inches long, 2 inches diameter, depressed, very open, strongly distichous, often expanded at butt; rows, 8. *Grain* 6¾ lines broad, scant 4½ lines deep, rounded, dingy white. *Shank* large. *Cob* medium, white. Early to medium early. *Stem* medium short; growth fair. Introduced by the writer in 1905 from Thorburn, New York, under the name "*Thoroughbred White Flint*," but it appears to be the same as the standard breed known as *Rural Thoroughbred.* Widely distributed and favourably reported

on from the Heidelberg, Standerton, Bethal, and Carolina Districts. The "blood" of this strain has entered into the composition of much of the "*White Cango*" now grown, from which it is no longer kept distinct, and the name of *Thoroughbred* has been dropped.

262. *Cango*, yellow.—Fig. 119A. Class: medium-late yellow flint; *ear*, $8\frac{1}{2}$ to 9 inches long; circumference at butt, $5\frac{3}{4}$ to $6\frac{1}{4}$ inches, at tip, $5\frac{1}{4}$ to $5\frac{7}{16}$ inches; diameter, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches; cylindrical; butt even, slightly compressed; rows, 10 or 12. *Grain* medium, $4\frac{3}{4}$ to 5 lines wide, $4\frac{1}{4}$ to 5 lines deep, shallowly rounded above, flat on sides, colour golden yellow. *Shank* small. *Cob* thin, white. *Stem* medium-tall, robust, leafy, tillering; good drought-resister, well acclimatized. Medium late. Valued for maize hay, and at one time extensively grown in small plots.

263. *Wills Gehu.*—Fig. 119C. Class: early yellow flint; *ears*, 6 to $7\frac{1}{2}$ inches long; circumference at butt, $4\frac{3}{8}$ to 5 inches, at tip, $3\frac{5}{8}$ to $4\frac{5}{8}$ inches; diameter, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches; almost cylindrical to slowly tapering; butt even; rows, 12, 10, or 8. *Grain* 5 lines broad, 4 lines deep, shallow rounded above, flat on the sides (intermediate between "flat" and "round"), bright yellow. *Shank* large. *Cob* white. Described from ears imported by the writer in 1910 from the breeders, Oscar H. Will & Co., Bismarck, North Dakota. *Stem* short; inclined to stool; early maturing, ripened at the Botanical Experiment Station, Pretoria, in eighty-two days. Has given excellent results in British Bechuanaland and the semi-arid regions of the S.W. Transvaal and western Orange Free State.

264. *North Dakota.*—Fig. 119B. Class: early white flint; *ears,* 7 to 8 inches long; circumference at butt, $4\frac{1}{2}$ to 5 inches, at tip, $4\frac{1}{8}$ to $4\frac{1}{2}$ inches; diameter, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches; cylindrical to tapering; butt even; rows, 12 (rarely 8). *Grain* small, roundish, 4 lines broad and deep, shallowly rounded above, flattish on sides (intermediate between round and flat), greyish white. *Shank* large. *Cob* white. Described from ears imported by the writer in 1910 from the breeders, Oscar H. Will & Co., Bismarck, North Dakota, U.S.A. *Stem* short, inclined to stool. Early-maturing; ripe at Skinner's Court, Pretoria, in eighty-seven days, in 1910.

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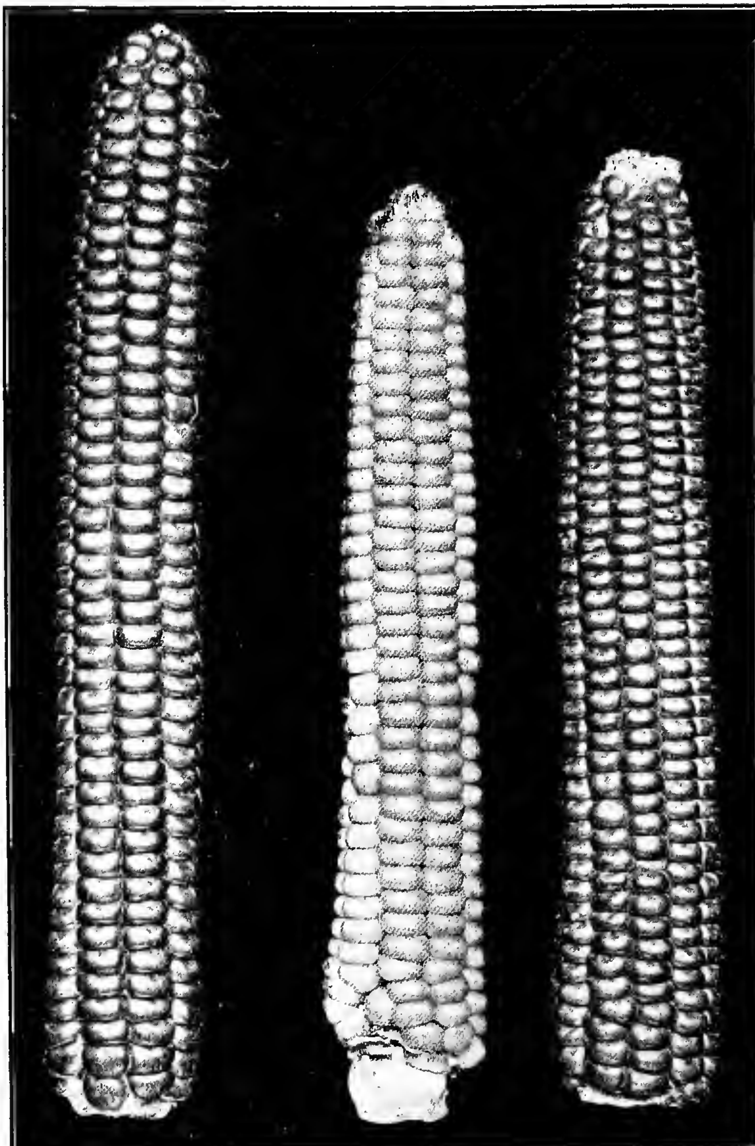
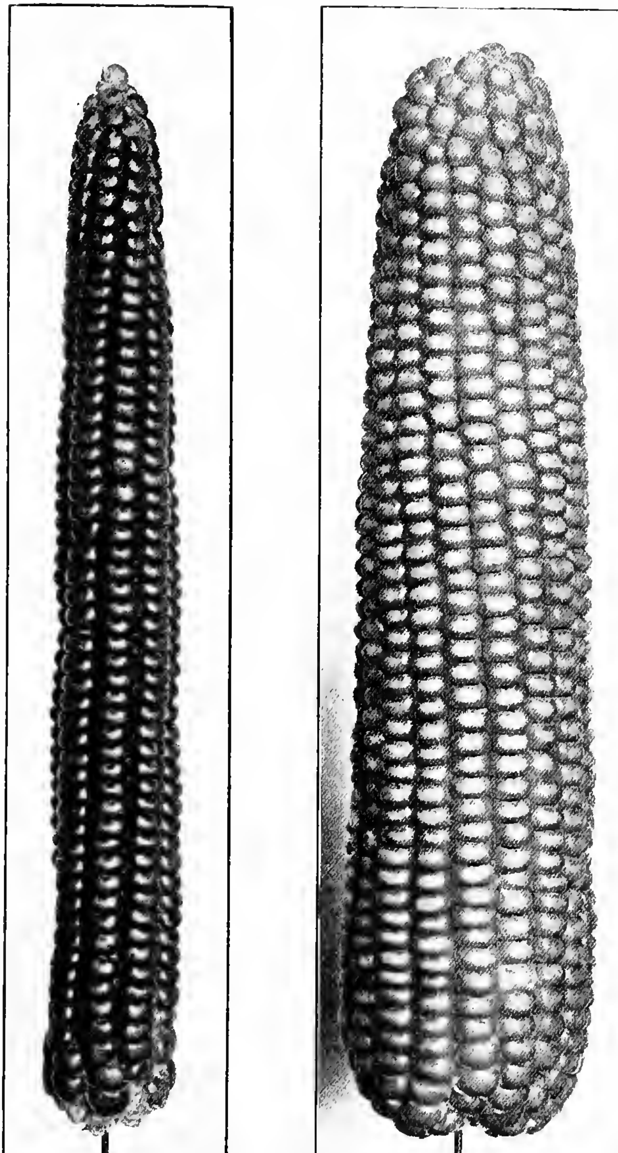


A B C

Fig. 119.—Three flint breeds grown in South Africa. A, *Yellow Cango*; B, *North Dakota*; C, *Wills Gehu*.



A B

FIG. 120.—A, *New England 8-row Yellow Flint;* B, *Improved Yellow Botman.*

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265. *Botman*, white.—Class: medium-early white flint; *ears*, $8\frac{1}{2}$ to 9 inches long; $5\frac{1}{2}$ to $6\frac{3}{8}$ inches circumference at butt, $5\frac{1}{8}$ to $5\frac{1}{4}$ inches at tip; $1\frac{1}{2}$ inches diameter; tapering to cylindraceous, even and slightly enlarged at butt; rows, 12, 14, or 16. *Grain* rather small, $4\frac{1}{2}$ lines broad and deep, rounded above, flattish on sides (classed as "round" in the trade), white. *Shank* variable. *Cob* thin, white. *Stem* medium height, tillering, leafy below. Early maturing, earlier than white *Cango* but less robust. One of the principal sorts formerly grown in small patches in the drier parts of the Western Transvaal and adjacent Bechuanaland, as far west as Kuruman. After seven years' trial at Potchefstroom it remains, as usual, at the bottom of the list as regards yield, a striking demonstration of the fact that new types developed by sound scientific breeding are superior to some of the older established and longer acclimatized breeds.

266. *Botman*, yellow.—Fig. 120B. Class: medium-early yellow flint; *ears*, 8 to $8\frac{1}{2}$ inches long; circumference, $5\frac{1}{2}$ inches at butt, $4\frac{5}{8}$ inches at tip; diameter, $1\frac{1}{2}$ inches; slowly tapering, even at butt; rows, 12 or 14. *Grain* $4\frac{1}{2}$ lines broad, $3\frac{3}{4}$ lines deep, rounded above, light yellow, said to be softer than that of *New England 8-row* and therefore preferred by the older residents of South Africa. *Shank* small. *Cob* slender, often found to be white, but the typical yellow *Botman* is said to have a red cob. Considered less drought-resistant than *New England 8-row*. Tillers freely. One of the principal sorts formerly grown by the smaller producers in the Transvaal and Orange Free State. Synonym: *Transvaal Yellow*.

267. *New England 8-row*.—Fig. 120A. Class: medium-early yellow flint; *ear*, 9 to 12 inches long; circumference at butt, $5\frac{1}{16}$ inches, at tip, $4\frac{1}{2}$ inches; diameter, $1\frac{1}{2}$ inches; a little enlarged at butt, but rarely depressed or expanded; rows, 8. *Grain* hard, 6 lines broad, $4\frac{1}{2}$ to 7 lines deep, rounded above, flat on sides (sometimes classed in the trade as "flat"), golden yellow. *Shank* large. *Cob* thin, white. Medium-early; *stem* medium height; plant stools freely; said to stand drought better than yellow *Botman*; one of the best of the flint breeds. Introduced by the writer in 1904 from Burpee, Philadelphia (No. 758·04). Subsequently grown and distributed by the Government Experiment Farm, Potchefstroom, and by Messrs. John Fowler & Co., at Vereeniging.

268. *Burlington Hybrid.*—Class: white flint; *ear*, $8\frac{1}{2}$ to 9 inches long; circumference, $6\frac{1}{4}$ inches at butt, $5\frac{3}{8}$ inches at CHAP. VII.

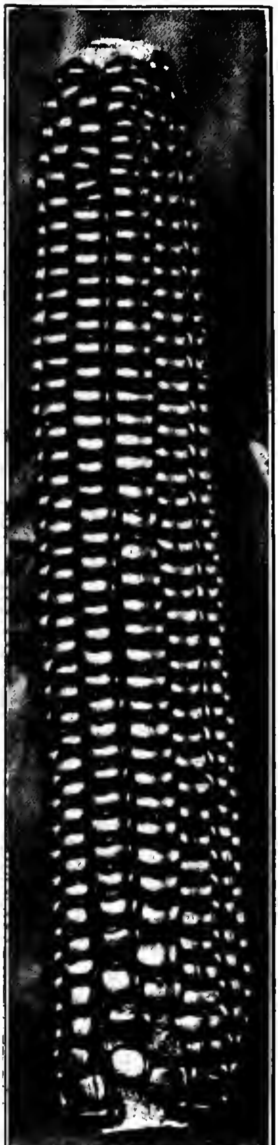


FIG. 121.—*Gillespie Yellow Flint.*

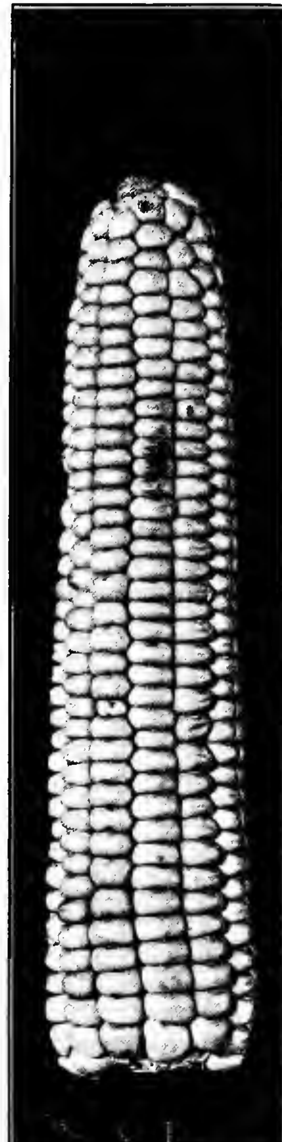


FIG. 122.—*Brazilian Flour Corn.*

CHAP. VII. tip; diameter, $1\frac{1}{2}$ inches; slowly tapering; butt even, enlarged and open; rows, 10. *Grain* 6 lines broad, 5 lines deep, thick, rounded above, flattish on sides, dusky white, embryo large. *Shank* large. *Cob* rather thick, white. *Stems*, 5 feet, not tillering, ears borne low; maturing fairly early. Ears from W. Gillespie, Rietpoort, Zandspruit, Transvaal, 1909, who grew it from seed obtained in Natal. Grown in Natal for some years; catalogued by Kirchoff, Howie, etc.; said to make a good table maize. Has been described as a hybrid between sugar and flint maize, but in South Africa it shows no sign of sugariness.

269. *Gillespie Yellow.*—Fig. 121. Class: medium yellow flint; rows, 12; length, $10\frac{3}{4}$ to 11 inches; circumference at 2 inches from butt, $5\frac{1}{4}$ inches, from tip, $4\frac{3}{4}$ inches; cob red; grain reddish. Selection towards a lighter coloured grain would be desirable from a commercial point of view.

A red-cobbed segregate obtained by Mr. W. Gillespie, Rietpoort, Zandspruit, Transvaal, and exhibited at the Johannesburg Maize Show, 1910.

270. *Indian Pearl.*—Class: parti-coloured flint. *Ears* long. *Cob* thin, white. *Grain* small, roundish, of high feeding quality, mixed dark red, purple, blue or pearly white on the same or on separate ears. Medium early; yield good to medium. *Stem* medium height, tillering freely, leafy, good for ensiling. Introduced by the writer in 1903 from Vilmorin, Paris (No. 639·03). Grown for some years at the Government Experiment Farm at Potchefstroom, and distributed, but now discarded. The strain has entered into the composition of other breeds, and occasionally crops out as a "reversion"; probably the source of the red colour in *Claret Sugar*. Probably one of the earliest forms introduced into the Old World, and of common parentage with the "*Squaw*" or "*Native*" maize grown by the Indians of the Northern United States and Canada.

271. *The Principal Breeds of Soft Maize or Flour Corn.*—Owing to their poor keeping quality in districts subject to weevil and grain moth, and their consequent unsuitability for export, the flour corns are now but little grown in countries of large maize production. There are, therefore, but few commercial breeds.

The old *South African Bread-mielie* differs but little, if at all, from the *Brazilian Flour Corn* of America. It is stated[1] that before the Boer War, there were two sorts of flour corn grown in the Transvaal: (1) the *Kaffir Bread-mielie* (known in Zulu as *u'hlanza-gazaan*), having a short stem, small ears, and white grain; and (2) the true *Bread-mielie*, with taller stem, larger ears, and dirty-white grain with red tips; this latter type is said to be most nearly approached by the sorts of bread mielie recently exhibited at local shows in the Transvaal.

A white flour corn was exhibited at the Johannesburg Maize Show, by Mr. Glass of Grahamstown, Cape Province, under the name *Glass's Early Flour Corn.*

272. *Brazilian Flour Corn.*—Fig. 122. Class: white soft maize; rows, 14; length, 9 inches; circumference, $6\frac{1}{4}$ inches; grain rounded above, with slight dent, and flat sides; cob large, white.

Probably the original type from which the old *South African Bread-mielie* was derived. Introduced by the writer in 1903 from the United States; chiefly grown for local consumption, especially on High-veld farms. Mr. F. le Roux of Oudehoutskloof, Volksrust, Transvaal, often exhibits it at local shows.

273. *Principal Breeds of Sugar Maize Grown in America.*—The following breeds are mentioned by Hunt (1) as having been recommended by three or more of the State Experiment Stations.

Early Sorts.—Cory, Marblehead, Crosby, Chicago Market, Early Landreth.

Medium Sorts.—Squantum, Maule XX, Stabler Early.

Late.—Ne-plus-ultra, Stowell Evergreen, Country Gentleman.

274. *Sugar Breeds introduced into South Africa.*—Several breeds have been introduced into South Africa by seedsmen and by the Transvaal Department of Agriculture. These include: Black Mexican (*T.D.A.*), Crosby Early (*T.D.A.*), White Cory (*Clark*), Landreth (*T.D.A.*), Stowell Evergreen (*Clark, Howie*), Country Gentleman (*Clark, Howie*), Golden Bantam (*T.D.A.*), New Cory (*Clark*), Cory Early (*Howie*), Marblehead (*Howie*).

Poor germination has generally been experienced with imported seed of sugar maize. To Mr. James Clark, seeds-

[1] e.g. by Mr. C. J. Morgan, at the Volksrust Show, 3 March, 1910.

CHAP. VII. man and florist of Pretoria, is due the credit of what was probably the first attempt to produce a distinctly South African breed of sugar maize. In one of his early catalogues (undated, but from internal evidence issued later than 27 September, 1904), he offers "*Clark's Favourite*" as a South African production.

275. *Clark Favourite.*—Mr. Clark issued the following account in the catalogue referred to above:—

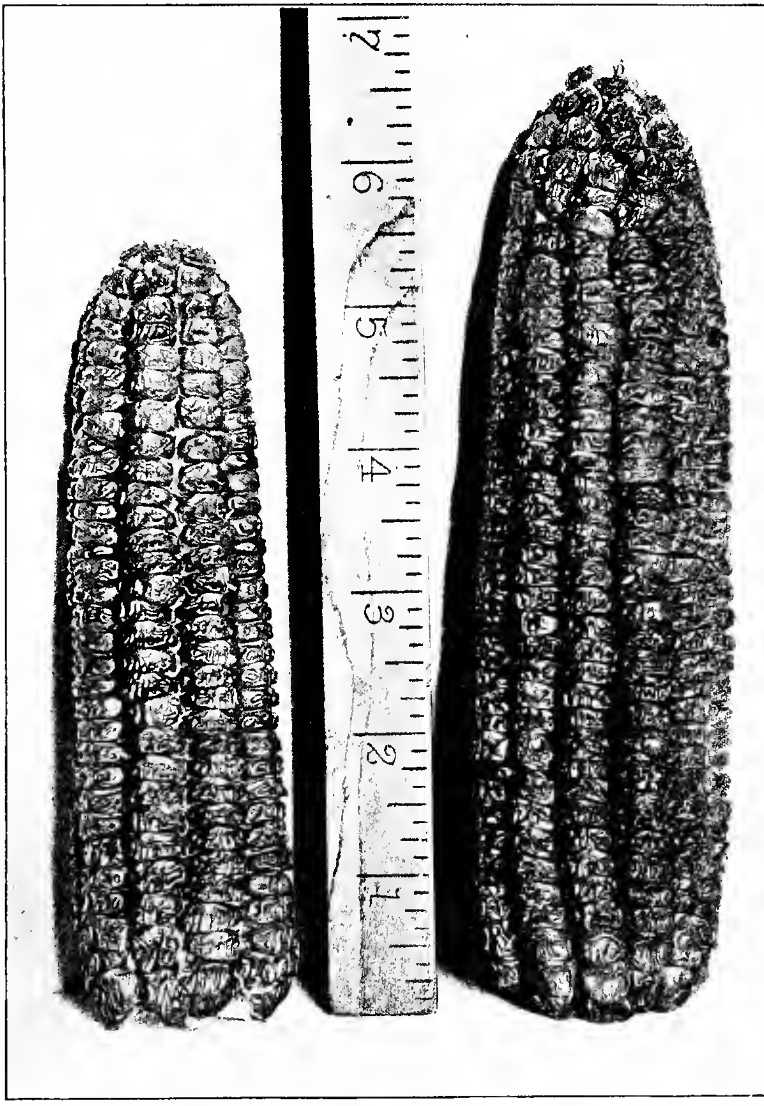
"*Sweet Corn: Clark's Favourite* (Early Sugar Corn).—For years I have been working to get a cross with our Bread Mealie; this I am pleased to say is a true cross with the Early Cory and Bread Corn. Clark's Early Sugar Corn is not only the earliest, but has a good-sized ear, white cob, very tender, sweet and nutritious; it also keeps a long time in good condition before hardening. In all-round good qualities it is the finest of all Sweet Corns; it grows to a medium height, and the ears are formed low and two or three on each stock. This is undoubtedly the most important Vegetable Novelty of this year [1904-5]. Stock very limited."

276. *Arcadia Sugar-maize.*—Fig. 123. In 1906 the writer obtained a few white sugar grains from a cross between *Black Mexican*[1] and a Transvaal white flint; in the season of 1907-8 these were propagated and bred true, producing ears of white sugar maize, without any admixture of black. The new breed has since been improved, and was distributed in 1911. It produces two good ears on a stalk; the ears are 12-rowed; planted on 20 August, 1911, it flowered on 9 November; ears were ready for boiling on 9 December, i.e. in 110 days; it was ready to harvest for seed on 4 January, or 137 days (*Burtt-Davy*, 8). Earlier-maturing strains producing larger ears have since been produced (Fig. 123B).

277. *Claret Sugar.*—Developed from a few grains selected by the writer from a *Black Mexican* cross grown in his garden in Arcadia, Pretoria. A dwarf, early-maturing sort, with pale claret coloured grains. Planted 8 November, flowered 6 January, ready for eating 6 February, i.e. ninety days. It seems likely that the red colour (an aleurone colour) was ob-

[1] Brought to South Africa in 1903 by Miss Florence Bolton, from the farm of Mr. B. Hayward of Pescadero, California, U.S.A.

tained by an accidental cross between *Black Mexican* and *Indian Pearl*. Breeds true. CHAP. VII.



A B

Fig. 123.—*Arcadia Sugar-maize*. Improvement by breeding. A, original type; B, improved type.

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278. *Union Sugar.*—Developed from a few grains obtained by the writer from a cross between an unnamed red sort and *Arcadia Sugar*, grown at the Botanical Experiment Station. The grains were obtained from the red ear, and are blood-red, and very deep (½ inch), giving an excellent bite. Probably contains some *Indian Pearl* strain. Breeds true.

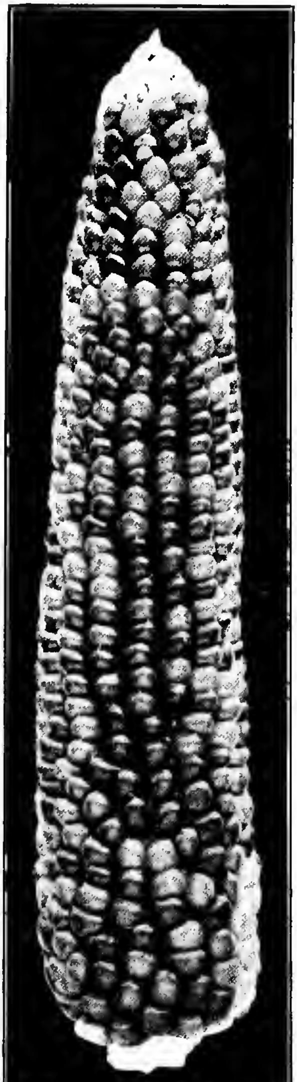

FIG. 124.—Pop-corn; a heterozygous F_2 (seed generation) ear (yellow and white).

279. *Golden Sugar.*—Developed from a few grains selected by the writer from a multiple cross grown in his garden in Arcadia, Pretoria. Grains shallow, but broad. Breeds true.

280. *Pop-corn.*—Fig. 124. Pop-corn is at present but little grown in South Africa, though the demand is increasing. Several breeds have been introduced from time to time from the United States and South Europe.

281. *Special-purpose Sorts.*—It is an axiom in agriculture that breeds adapted to particular classes of trade generally command a better price than ordinary general-purpose sorts, provided they are well grown, and that their production is not overdone. The manufacture of corn-flour, corn-flakes, silver-flakes, grits, semola, hominy, samp, and other special food preparations, calls for particular qualities of grain, which the climate of South Africa seems better fitted to produce than that of most parts of the world. But good "condition" (due to climate) is not the only requisite of the manufacturer, and it is

necessary to produce for him the *type* of grain called for by the market. One of the first requirements is a large percentage of endosperm in proportion to "bran" or "hull"; to secure this we should aim to produce a *thick* (not necessarily *broad*), long grain, instead of the very thin, flat type which is being grown so much to-day.

There is a large demand in Europe for a small, "round," flint maize suitable for feeding poultry, pheasants, etc. This commands from 6d. to 1s. 6d. per muid more than ordinary yellow flint maize. South African *Cango* and *New England 8-row* are too large for this trade, and are being classed as "Flats" instead of rounds by buyers for Europe. If South African farmers can grow the smaller type of maize, it may prove worth while as a catch-crop, provided the yield is satisfactory.

282. *Silage Breeds.*—In growing crops for silage, it is an object to get as large a yield of forage as possible from an acre of ground. For this purpose tall, leafy sorts which tend to sucker freely are preferred. Useful sorts are "*Red-cob Ensilage*," "*Indian Pearl*," and "*Sweet Fodder-corn*".

But it is difficult to obtain seed of breeds specially suited to silage production, as they are not regularly grown for seed. South African farmers do not care to grow their own seed of special silage maize, because of the danger of crossing with their grain crops. Most farmers, therefore, prefer to grow for silage the same sorts which are grown for grain, planting them closer in order to get the requisite yield. In America we find that it is mainly those States which are not grain producers which grow special sorts for silage; in the "Corn-belt" the ordinary grain sorts are used, but dents are always preferred to flints because of the greater yield.

There is a tendency to use as silage-crops, on the High-veld of South Africa, breeds which are grown as grain crops only at lower altitudes, such as *Natal White Horsetooth* and *Yellow Horsetooth.* The reason is that their season of growth being longer than the upland sorts, they continue to grow later in the season, and thus may produce a greater yield of green-stuff per acre than those breeds grown mainly for grain. But the percentage of ears to stalk and leaves is lower, and the percentage of water to dry matter is apt to be higher, requiring

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the handling and storing of a larger mass and weight of greenstuff in proportion to amount of dry matter and feeding value. It is not desirable to cut silage too green, and it is therefore doubtful whether it is desirable to use very late-maturing sorts even for this purpose.

283. *Classes Best Suited for Cultivation in South Africa.*—There is not, and probably never will be, any one breed or variety of maize which can be said, without reserve, to be the best for general cultivation throughout the Union, or in any one Province. Maize is sensitive to changes in climate or soil, and a breed which proves suitable in one district is not equally suited to all, owing to the great variations in altitude, temperature, moisture, and soil between different parts of the country.

Speaking generally, the dent breeds are the best for the main crop, as they usually give the highest yields, and are in greatest demand. The flint breeds are most suitable for localities where the rainfall is limited and the growing season short, or for planting after the last date suitable for dents, to increase the acreage under crop. On the other hand, the flint breeds are generally richer in protein than most of the dents, and are therefore more nutritious for stock-food; but on account of their lower yield they cannot be recommended for the main crop where dents can be grown satisfactorily. A certain amount of flint maize is useful on every farm, however. Yellow flints are more suitable than white, for the yellows have a better flavour, and are preferred for stock-food, though the yellow colour does not necessarily indicate higher feeding value. The oversea demand for white flints seems to be nil, while for yellow flints it is unlimited.

Hickory King is now more widely grown in South Africa than any other breed of dent maize. It is in special demand for the mines' trade, though it does not appear to command a higher price than any other well-grown breed of white dent, unless a glut in the market gives the buyer a choice. For the export trade, well-grown *Hickory King* has met with a favourable reception on the European markets, especially among manufacturers of grits, flakes, breakfast foods, etc., and among distillers and brewers. The higher price already obtained indicates that if the trade is carefully fostered by rigid grading and the exclusion from the "No. 1 white flat" grade of all but the very best, there is a possibility of securing increased demand and still better prices for the best *Hickory King*. *Ladysmith* and *Iowa Silver-mine* sell readily in Europe as "No. 2 flat white," and choice parcels as "No. 1". CHAP. VII.

For the grade known as No. 2, or fair average quality ("F.A.Q."), yellow dents are in demand for stock-feeding purposes, but yellow flints may be of equal market value if of good quality.

For the supply of the present markets, the course for the South African farmer to follow is clearly to produce:—

(*a*) A very "choice" (No. 1) grade of *Hickory King*, in order to increase the promising, though at present very limited, export trade in this class of maize.

(*b*) A good quality of white dent maize of the No. 2 grade, such as *Hickory Horsetooth*, 10-*row Hickory*, *Ladysmith*, *Boone County*, *Mercer*, or *Iowa Silver-mine*, for use on the mines and for export.

(*c*) A No. 2 quality of yellow dent maize, to be used for stock food locally and in Europe.

(*d*) A limited amount of yellow flint (where dents cannot be grown profitably) for feeding his own stock, and for export when the price warrants.

In the present condition of the market, farmers will probably find it better to limit their export trade to the first, second and third classes indicated above, though it is not improbable that the export demand for yellow flint will increase.

With the exception of choice *Hickory King* for export, and yellow maize for local stock food, it does not appear to matter what particular *breed* is grown so long as it meets the above general requirements. From the farmer's point of view, therefore, the question resolves itself into finding out which breed gives the best yield of maize of good quality under the conditions of climate and soil of his particular farm, and this depends largely on (1) the time taken by a breed to mature, and (2) length of growing season, which latter depends in turn on (*a*) altitude, (*b*) amount and (*c*) incidence of rainfall.

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284. *Relative Length of Growing Season.*—The time taken for the crop to mature varies greatly from year to year, according to the fluctuations of the seasons; in a dry, warm, sunny season the crop takes a shorter time than in a cold, wet, relatively cloudy season. Therefore no definite time limit for the ripening of the grain can be assigned to any variety or breed of maize; the time fluctuates with the season. Prof. Morrow, of the Illinois Agricultural Experiment Station, notes the following differences in the ripening of *Burr White Dent*:—

1888 in 135 days.
1889 in 144 and 156 days.
1890 in 130 days.
1892 and 1893 in 127 days.

Prof. Burrill, of the same experiment station, notes the following difference in time of reaching edible maturity in *Crosby Early* sweet maize:—

1888 in 62 to 64 days.
1889 in 83 to 85 days.
1890 in 79 days.

The season does not affect all breeds in equal degree, but there is a relative proportion between their times of maturity which can be used for classificatory purposes and as a guide to the adaptability of the different breeds to climatic conditions in different parts of the country.

The relative ripening period of the different breeds may be roughly classified as follows, the time referring to the period between appearance above ground and the time when the plant is safe from injury from early frost:—

Very Late	150 days and over.
Late	140 to 150 days.
Medium Late	125 ,, 140 ,,
Medium Early	110 ,, 125 ,,
Early	95 ,, 110 ,,
Very Early	85 ,, 95 ,,

The relative time of maturity for different breeds is shown in the following list, but the reader should understand clearly that such a list is only approximate, and that the relative position of different breeds varies in different districts and in different seasons. As a rough guide, however, such a list has its uses.

Very Lates (150 days and over), for early planting:—
- Natal White Horsetooth (White dent).
- Ladysmith (White dent).
- Salisbury White (White dent).
- Yellow Horsetooth (Yellow dent).

Lates (140 to 150 days), for early planting:—
- Hickory King (White dent); in parts of the Transvaal and Natal.
- Hickory Horsetooth (White dent).
- Yellow Hogan (Yellow dent).
- Golden Beauty (Yellow dent).
- Golden King (Yellow dent).
- Brazilian Flour Corn (White soft).
- Mercer (White dent).
- Boone County (White dent); in Natal.

Medium Lates (125 to 140 days), for main crop:—
- Hickory King (White dent).
- 10-Rowed Hickory or "Louisiana" (White dent).
- Yellow Cango (Yellow flint).
- German Yellow (Yellow dent).
- Eureka (Yellow flint).
- Boone County (White dent); in Transvaal.
- Golden Eagle (Yellow dent).

Medium Earlies (110 to 125 days), for main crop:—
- Iowa Silver-mine (White dent); in Natal.
- Reid (Yellow dent).
- Star Leaming (Yellow dent).
- White Botman (White flint).
- White Cango (White flint).
- New England 8-row (Yellow flint).

Earlies (95 to 110 days), for late planting:—
- Wills Gehu (Yellow flint, 85 days).
- North Dakota (White flint, 85 days).
- Chester County (Yellow dent).
- Thoroughbred (White flint).
- Transvaal Bread-mielie (Flour corn).
- Minnesota Early (Yellow dent).
- Iowa Silver-mine (White dent); in Transvaal.

285. *Breeds Suitable for the High-veld.*—On the extreme High-veld (5,000-6,000 feet) it is now generally recognized that *Hickory King* is too risky for the main crop owing to danger from early frost; many thousands of bags are annually lost from this cause. Where this is the case farmers would be well advised to discontinue growing it, except for *very early* planting, and to choose a sort which will supply one of the three other classes of merchantable grain mentioned in ¶ 283. *Iowa Silver-mine* is said to make as good a "mielie meal" as *Hickory King*,

CHAP. VII. for use on the mines. For the export trade, or for stock food, earlier maturing yellow dents, such as *Chester County*, *Reid*, or *Minnesota Early*, can generally be sown where the season is too short for *Hickory King*. The two early flints already referred to, *Wills Gehu* and *North Dakota*, prove particularly valuable for late planting.

For *Early Planting*.—Hickory King (w.d.); Hickory Horsetooth and 10-row Hickory (w.d.); Eureka (y.d.).

For *Main Crop*.—Iowa Silver-mine (w.d.); Chester County (y.d.); Reid (y.d.).

For *Late Planting*.—Wills Gehu (y.f.).

286. *Breeds Suitable for the Maize-belt of the Transvaal and Orange Free State*.—For the Maize-belt proper, lying (roughly) between 4,000 and 5,000 feet, the following seem most suitable:—

For *Early Planting*.—Ladysmith (w.d.); Yellow Horsetooth (y.d.); Yellow Hogan (y.d.).

For *Main Crop*.—Hickory King (w.d.); Hickory Horsetooth and 10-row Hickory (w.d.); Eureka (y.d.).

For *Late Planting*.—Iowa Silver-mine (w.d.); Chester County (y.d.); Reid (y.d.); Minnesota Early (y.d.).

For *Very Late Planting*, or as a catch-crop.—Wills Gehu (y.f.).

287. *Breeds Suitable for the Maize-belt of the "Midlands" East of the Drakensberg*.—For the lower-lying country east of the Drakensberg, 2,000 to 3,500 feet elevation, later-maturing breeds can be grown owing to the longer growing-season and larger rainfall.

For *Early Planting*.—Natal White Horsetooth (w.d.).

For *Main Crop*.—Hickory King (w.d.); Ladysmith (w.d.); Boone County (w.d.); Mercer (w.d.); Golden Beauty (y.d.); Yellow Horsetooth (y.d.). Yellow Hogan (y.d.) is worth trial, the quality of the grain being superior to that of either of the other two yellow dents named.

For *Late Planting*.—Eureka (y.d.) is worth trial.

288. *Breeds Suitable for the Coast-belt*.—This part of the country is suitable for the cultivation of late-maturing sorts when the incidence of the rainfall gives a long growing-season. *Boone County* (w.d.), *Ladysmith* (w.d.), and "*Yellow Dent*" do well. *Hickory King* and *Golden Beauty* are also grown.

At the Government Experiment Station, Stanger, the three following breeds stood out prominently in the breed tests of 1907:—

	Yield per Acre.
Ladysmith	5,100 lbs. = 25·5 muids.
Hickory King	4,260 ,, = 21·3 ,,
Golden Beauty	3,950 ,, = 19·75 ,,

289. *Breeds Suitable for the Semi-arid Western Region.*—The region west of a line drawn between Bloemfontein and Lichtenburg is with small exception too dry for any but short-season breeds. *Botman* (flint) is the breed which has been grown most extensively but it yields poorly; a white *Botman* is grown successfully at Grootfontein and Blikfontein on the Kaap Plateau. *German Yellow* (y.d.) is favourably reported on from parts of the Orange Free State, as fairly drought-resistant, early, and a good yielder. *Hickory King* is only safe in exceptionally favourable seasons and when planted early; 10-*row Hickory* (w.d.) is more suitable. *Iowa Silver-mine* and *Chester County* have given excellent results in the Wolmaransstad District. *Wills Gehu* (y.d.) and *Wills Dakota* (w.d.) should be especially valuable here.

290. *Breeds Suitable for the Upper Bush-veld.*—There is an enormous area of territory in the Northern Transvaal, west of the Drakensberg, which is at present but thinly settled by white people. It is a good cattle country and grows excellent maize in ordinary seasons. But the rains fall late and the growing-season is somewhat short. On the Springbok Flats, *Hickory King* (w.d.) has given good results, but *Hickory Horsetooth* is more promising. *Iowa Silver-mine* (w.d.) should do well and *Chester County* (y.d.) is worth trial.

291. *Breeds Grown in Rhodesia.*—*Hickory King*, *Salisbury White*, and *Golden Eagle* appear to be favourites, and do excellently in those parts of the country suited to maize growing.

292. *Relative Yields of Different Breeds in the Transvaal.*—The relative yields obtained in any one district do not necessarily apply, except in a very general way, to districts belonging to a different crop-zone or to localities having a different soil. Nor will the returns obtained during one or two years be a safe criterion as to the relative merits of differ-

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ent breeds. Seasonal conditions affect the various breeds differently, and as it requires a ten-year average of the various factors to determine the character of the climate, so also a ten-year average is desirable for determining accurately the relative yields of different breeds. But some breeds can be discarded after two seasons, and many before the expiry of ten years, so even without the full ten-year record a table of relative yields has its value.

Breed tests have been conducted on the Government Experiment Farm, Potchefstroom, since 1905-6, and the results are summarized in Tables XLV and XLVI.

TABLE XLV.

SUMMARY OF POTCHEFSTROOM BREED TESTS.

	Average Yield in Muids for		
	3 Years (1906-7 to 1908-9).	5 Years (1906-7 to 1910-11).	6 or 7 Years.
1. Eureka	25·79	24·1	21·75 (6)
2. Chester County	24·77	23·1	21·15 (6)
3. Yellow Hogan	23·27	21·3	20·59 (7)
4. Hickory Horsetooth	23·00	20·65	20·00 (6)
5. Natal White Horsetooth	23·83	22·10	19·73 (7)
6. Hickory King	25·14	21·9	19·53 (7)
7. New England 8-row	20·82	19·1	—
8. Iowa Silver-mine[1]	21·70	20·4	18·76 (6)
9. Champion White Pearl	21·50	20·0	18·72 (6)
10. White Cango	23·50	20·3	17·36 (7)
11. Yellow Cango	21·58	20·1	17·24 (7)
12. White Botman	18·6	16·4	14·73 (7)

The following brief notes giving some idea of the method followed in conducting these tests are taken from the Reports of Mr. Holm (1) and Mr. Bell (1):—

Definite comparative experiments with maize were commenced on this farm in the season 1904-5.

Breeds.—The crops were grown on land which had, during the previous year, produced mangels or potatoes, which received from 8 tons to 10 tons dung per acre, and about 300 lbs. of a

[1] The low position held by this breed at Potchefstroom is not maintained in some other parts of the country; it does not like low-lying, damp ground, and does better in localities with less soil-moisture.

Table XLVI.

RELATIVE YIELDS OF MAIZE BREEDS, GOVERNMENT EXPERIMENT FARM, POTCHEFSTROOM. Average yield for 6 years, 17·53 muids.

Breeds (in Order of Yield).	Class.	Division of Botany Record Numbers.	Origin of Seed.	Yield per Acre. 1904-5.	1905-6.	1906-7.	1907-8.	1908-9.	1909-10.	1910-11.	Average of 3 Years (1906-7 to 1908-9).		Average of 5 Years (1906-7 to 1910-11).	Average of All.		
				Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Muids.		Lbs.	Muids.	Years.
1. Eureka	Y. d.	1470/05	Henderson, New York	—	2,035	5,574	4,180	5,720	3,190	5,410	5,158	25·79	24·1	4,353	21·75	6
2. Hickory King (8-row)	W. d.	—	J. Moon, Natal	2,667	2,805	6,616	3,190	5,280	2,200	4,580	5,028	25·14	21·9	3,905	19·53	7
3. Chester County	Y. d.	1471/05	Henderson, New York	—	2,255	6,722	3,300	4,840	2,530	5,742	4,954	24·77	23·1	4,231	21·15	6
4. Horsetooth, Natal White	W. d.	—	Natal	3,200	2,365	7,042	3,080	4,180	2,695	5,060	4,767	23·83	22·1	3,946	19·73	7
5. Cango, White	W. f.	—	Transvaal	1,677	2,255	6,402	3,300	4,400	1,760	4,510	4,700	23·5	20·3	3,472	17·36	7
6. Hogan, Yellow	Y. d.	766/04	Shepheard, Sydney	4,730	2,915	5,922	3,640	4,400	1,925	5,300	4,654	23·27	21·3	4,119	20·59	7
7. Hickory Horsetooth	W. d.	—	Local selection	—	3,355	6,108	3,410	4,290	2,547	4,290	4,602	23	20·65	4,000	20·00	6
8. Austin Colossal	Y. d.	573/04	R. McNally, Randfontein	2,756	—	6,321	3,960	3,520	2,805	—	4,600	23	—	3,852·4	19·262	5
9. Horsetooth, Virginia	W. d.	1447/05	Thorburn, New York	—	2,970	5,689	3,850	4,070	1,980	—	4,536	22·68	—	3,711·8	18·555	5
10. Leaming, Star	Y. d.	1043/04	Shepheard, Sydney	2,172	2,695	6,509	3,190	3,740	3,135	—	4,479	22·4	—	3,573·5	17·8675	6
11. Golden King	Y. d.	1048/04	Shepheard, Sydney	2,970	2,475	6,134	3,300	3,740	2,530	—	4,391	21·95	—	3,524·83	17·6241	6
12. Bristol 100-Day	Y. d.	1218/05	Henderson, New York	—	3,025	5,549	3,660	3,960	2,695	—	4,389	21·94	—	3,777·8	18·889	5
13. Iowa Silver-mine	W. d.	1547/05	Thorburn, New York	—	2,145	5,308	3,630	4,080	2,365	4,985	4,339	21·7	20·4	3,752	18·76	6
14. Cango, Yellow	Y. f.	—	Transvaal	1,705	2,365	5,361	4,070	3,520	2,420	4,700	4,317	21·58	20·1	3,449	17·24	7
15. Champion White Pearl	W. d.	1448/05	Thorburn, New York	—	2,475	6,189	3,410	3,300	2,090	5,000	4,299	21·5	20·0	3,744	18·72	6
16. Butler, Early	Y. d.	1219/05	Henderson, New York	—	2,255	6,162	2,700	3,960	—	—	4,274	21·37	—	3,769·25	18·8462	4
17. Indian Pearl	Mixed f.	639/03	Vilmorin, Paris	2,172	2,695	6,508	2,750	3,520	1,815	—	4,256	21·28	—	3,243·33	16·2166	6
18. Horsetooth, Improved Early	W. d.	1472/05	Henderson, New York	—	2,805	5,897	2,750	3,960	—	—	4,202	21	—	3,853	19·265	4
19. New England 8-row	Y. f.	1471/05	Henderson, New York	—	—	6,161	2,592	3,740	1,760	4,840	4,164	20·82	19·1	3,818	19·09	5
20. 90-Day Australian	Y. f.	1277/03	Sydney, N.S. Wales	2,447	1,925	5,228	3,520	3,080	1,650	—	3,967	19·88	—	2,958·33	14·7916	6
21. Wisconsin	W. d.	1446/05	Thorburn, New York	—	1,925	5,095	3,300	3,520	—	—	3,971	19·85	—	3,660	18·30	4
22. Thoroughbred, Rural	W. f.	1546/05	Thorburn, New York	—	1,815	5,815	3,030	2,970	1,210	—	3,938	19·69	—	2,968	14·84	5
23. King of the Earliest	Y. d.	748/04	Burpee, Philadelphia	3,300	2,420	4,909	3,300	3,520	—	—	3,909	19·5	—	3,489·8	17·449	5
24. Drought-proof	Y. d.	1225/05	Maule, Philadelphia	—	2,145	4,588	3,410	3,300	—	—	3,766	18·83	—	3,360·77	16·8038	4
25. Botman, White	W. f.	—	Transvaal	2,392	1,815	5,549	2,420	3,190	1,760	3,500	3,719	18·6	16·4	2,946	14·73	7
26. Brazilian Flour Corn	W. s.	536/03	Thorburn, New York	3,080	2,090	5,922	1,650	2,970	—	—	3,514	17·57	—	3,142·40	15·7120	5
27. Woods Northern	W. d.	1472/05	Henderson, New York	—	2,145	4,588	2,750	2,970	—	—	3,436	17·18	—	3,113·25	15·5662	4
28. Huron, Extra Early	Y. d.	1473/05	Henderson, New York	—	1,815	3,521	3,080	2,420	—	—	3,007	15	—	2,709	13·545	4
29. Potchefstroom Pearl	W. d.	—	—	—	—	—	—	—	2,310	5,780	—	—	—	—	—	—
30. Lichtenburg White Flint	W. f.	—	—	—	—	—	—	—	—	5,640	—	—	—	—	—	—
31. Reid	Y. d.	—	—	—	—	—	—	—	—	5,380	—	—	—	—	—	—
32. Champion White Dent	W. d.	—	—	—	—	—	—	—	—	5,420	—	—	—	—	—	—
			Average	2,713	2,384	5,764	3,051	3,791	2,253	5,010	4,262	—	—	—	—	—
			Muids	13·56	11·92	28·82	15·25	18·95	11·26	25·05	21·31	—	—	17·53	—	—

phosphatic manure, but no manure was applied directly to the maize crop.

The first "comparative" trials were put down in the season 1904-5. More breeds were procured for the 1905-6 planting, but as they largely consisted of imported seed it would not be safe to take the results of the first year's growth as a basis of comparison. In this report, the comparative records are therefore dated from the season 1906-7. During that year and the previous two years the results, however, served a useful purpose in the determination of breeds which could be discarded.

The Seed.—Most of the breeds were procured by the Division of Botany from America, Canada, and Australia, but attention was also paid to local sorts from the best seed procurable.

It was soon seen that the results obtained in the first two years of experiment could not be regarded as strictly comparative, since the seed of most of the breeds was not acclimatized. This is a further reason for only dating these records from the year 1906-7.

The Cultivations.—As a general rule the land was deeply ploughed once after the potatoes or mangels were cleared. Such cultivations as "cultivating," "harrowing," and "rolling" were performed to procure a satisfactory tilth prior to planting. Immediately after planting the land was harrowed; subsequent cultivations generally consisted of one or two harrowings, one hand-hoeing, and one horse-hoeing.

In the year 1906-7, the breeds were planted with the ordinary "2-row planter," and a special series of plates was used to plant grains of such great diversity, equidistant, but it was found that this did not give as great accuracy as could be desired for experiment. Consequently, in succeeding years, the planting for this breed test was done by hand, the grains dropped in hills 3 feet apart in each direction, three to each hill.

In 1909-10 the trials were conducted on land consisting of a brown loam in a very good state of fertility.

The actual piece of land devoted to the experiment was of course selected for its uniformity, and to ensure results most favourable for comparison, two rows of each breed of maize were planted across the full length of the field, breeds of similar robustness and general character of growth being placed next to each other. CHAP. VII.

In previous years the trials had been conducted on check-row principles, the seed being sown in hills 3 feet apart in each direction; but in this year that system was discarded and the seed planted in continuous rows 3 feet apart.

"The field was watched throughout the season, and any blanks in the 'plant' due to borer, faulty germination, or other such accidental cause, carefully noted. Such blanks, of course, affect the yield, and as they are the result of accident, and not a characteristic of particular breeds, allowance must be made for them in comparative experiments. These allowances, and the fact that the most even stand in a field, even if not the best part, is certainly not the worst, together make the calculated yield per acre come out at a higher figure than is actually obtained over large areas. This, however, though giving a somewhat inflated appearance to the yield generally, does not affect the relative positions of the different breeds."

In harvesting, two stretches, each 22 yards in length, were selected out of the full length of the rows at places where the stand seemed to be the most even for all breeds. The ears from both rows of each breed were harvested from these two selected areas, shelled, the grain weighed, and the result calculated out to weight per acre, after the necessary additions for blanks were made. This makes a total of four chains length harvested for each breed.

The character of the season should be taken into account in comparing the yields. In 1905-6 two very severe droughts were experienced during the growing period, viz., in January and February, and it is probable that the medium-early breeds were most affected, as these droughts took place at a critical stage in their growth. Late breeds also suffered to some extent, but the early breeds did not appear to have been much affected.

The year 1906-7 was ideal for securing heavy yields. A good rainfall took place throughout the growing period, and at no stage of its growth did the crop suffer either from "drought" or a supersaturated soil.

The year 1907-8 was too dry in February, a critical stage in the crop's development, while in 1908-9, though a sufficient

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total rainfall fell during growth, the crop suffered during December from drought, and, later, from a water-logged soil and absence of sunshine.

In the season 1909-10 the crops suffered from drought in the early stages, were flooded out in December, recovered somewhat, and produced a fair crop.

In the last season (1910-11), owing to heavy early rains, the young plants made rapid growth and got an excellent start. Then came the drought, which reached, and continued at, its worst at the time when the majority of the breeds were at the most critical stage of growth, i.e. during the flowering period. Owing to this, in many cases imperfect pollination took place, which resulted in an abnormal proportion of small, badly-filled ears. Rain fell after this, but to the end of the season the fall was considerably below the average and quite insufficient to produce the best results.

The rainfall for the period 1906-7 to 1909-10 is given in Table XLVII following:—

Table XLVII.

RAINFALL AT GOVERNMENT EXPERIMENT FARM, POTCHEFSTROOM, 1906-7 TO 1909-10.

	1906-7.		1907-8.		1908-9.		1909-10.		1910-11.	
	Inches.	On Days.	Inches.	On Days.	Inches.	On Days.	Inches.	On Days.	Inches.	On Days.
July . . .	—	—	—	—	·64	4	0·36	2	—	—
August . .	—	—	—	—	·98	4	0·31	2	—	—
September .	·10	3	2·04	6	1·67	5	0·02	1	0·88	1
October . .	2·03	9	1·48	10	1·73	7	0·39	4	6·00	13
November .	3·93	10	3·96	10	2·64	9	2·81	10	1·62	7
December .	3·50	9	4·11	12	2·59	7	10·26	14	4·13	13
January . .	6·40	15	4·21	12	7·00	17	3·45	12	1·46	10
February . .	8·94	10	2·95	16	4·72	13	1·77	11	3·13	10
March . .	2·00	10	3·39	12	2·93	7	2·49	5	1·91	11
April . .	5·25	11	·02	1	·80	4	0·14	3	2·53	9
May . .	1·39	7	·06	1	1·21	6	0·15	3	2·68	9
June . .	0·2	1	·03	1	—	—	0·06	2	0·01	1
Total Rainfall .	33·56	—	22·25	—	26·91	—	22·21	—	24·35	—
Number of Days	—	85	—	81	—	83	—	69	—	84

These climatic conditions are reflected in the yields. In each year all the breeds were safe before frost occurred.

293. *Relative Yields of Breeds in Natal.*—The following report on breed tests carried on at Cedara, Natal, is furnished by Mr. Sawer (1):— CHAP. VII.

"In 1904-5 the variety tests were made in Block 1C of the variety section. The rows were 35 feet long and 3 feet apart, and there were two rows of each variety. Ten tons of farm-yard manure were ploughed in, and a mixture of 200 lbs. sulphate of ammonia, 400 lbs. superphosphate, and 100 lbs. potash chloride was spread broadcast and harrowed in. The same lots of seed from America, France, and England were used as in the previous year; also several lots from Dammann and Co., of San Giovanni a Teduccio, near Naples, Italy, and some two or three other lots. In all cases the seed was planted too late for the best results, the Brazilian and the Virginian Dent on 28 and 29 December, and all the others on 19 December, three weeks later than desirable. Some of the yields were good, but in all probability the general average would have been higher had the seed been planted earlier. The peculiarity of the 1904-5 season, to produce much stalk but comparatively little grain, was shown throughout. The following are the results in detail, arranged in order of grain yield":—

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TABLE XLVIII.

RELATIVE YIELDS OF MAIZE BREEDS AT GOVERNMENT EXPERIMENT FARM, CEDARA, NATAL, 1904-5.

No.	Variety.	Source.	Average Height Feet.	Yield. Grain.	Yield. Stalk, etc.
1	Hickory King (L.)	Trelawny Adams	7½	3,538	6,128
2	Boone County (L.)	Henderson (grown by W. Pepworth)	7	2,917	10,417
3	White Flint	Henderson, New York	6	1,719	6,771
4	Yellow Hogan	Hawkesbury Exp. Farm, N.S.Wales	7	1,614	6,406
5	Adams Early	Kilminster, Durban	4	1,510	2,838
6	Early Butler	Henderson	6	1,432	11,041
7	Longfellow	,,	6	1,354	6,328
8	Improved Leaming	,,	6	1,237	6,341
9	Improved Early Horsetooth	,,	7	1,224	8,346
10	Early Yellow Long Eared	Vilmorin, Paris	6	1,175	1,680
11	Early Mastodon	Henderson	7	1,172	12,578
12	Sugar Corn, Evergreen Late	Vilmorin	5	1,167	5,768
13	Early Minnesota	Dammann, Italy	5	1,167	3,633
14	Golden Beauty	Henderson	7	1,146	10,286
15	King Philip	,,	6	1,133	5,300
16	Rural Thoroughbred	,,	6½	1,120	9,895
17	Large Yellow Flint	,,	6	1,015	6,419
18	Southern Horsetooth	,,	7	1,015	4,297
19	Queen of the Prairie	,,	6½	976	7,526
20	Late White Horsetooth	Vilmorin	6	911	10,338
21	Six Weeks, or Quarantino	Dammann	4	911	1,953
22	Crosby Early Sweet Corn	,,	3½	898	6,706
23	White Cap Yellow	Henderson	6	885	4,948
24	Extra Early Huron	,,	6	794	4,414
25	White Early Pyrenean	Vilmorin	5½	791	1,706
26	Sweet Fodder	Henderson	4	755	2,995
27	King Philip Early White	Vilmorin	5	743	2,070
28	Compton Early	Henderson	6	729	4,674
29	Henderson Eureka	,,	7	716	11,783
30	White Pyrenean	Sutton, England	4	703	2,200
31	Pearl White	Dammann	5½	664	2,473
32	Extra Early Szekely	Vilmorin	4	664	1,068
33	Stowell Evergreen	Kilminster, Durban	5	651	6,627
34	Curagua	Dammann	6	612	4,805
35	Sugar Corn, Early Dwarf	Vilmorin	4½	586	1,549
36	Indian Corn Yellow	,,	5½	567	1,693
37	Ambra	Dammann	3	560	1,719
38	Seven Weeks, or Cinquantino	,,	4	547	2,317
39	Early Dwarf Sugar Cane	Sutton	3	531	2,578
40	Kansas King (in the husk)	Dammann	4½	521	6,016
41	Hickory King	Henderson	7	508	9,778
42	Extra Early Yellow	Sutton	4	504	1,354
43	Brazilian (L.)	C. Harding, near Estcourt	6	456	3,398

L. = local seed

TABLE XLVIII (*continued*).

CHAP. VII.

RELATIVE YIELDS OF MAIZE BREEDS AT GOVERNMENT EXPERIMENT FARM, CEDARA, NATAL, 1904-5.

No.	Variety.	Source.	Average Height Feet.	Yield. Grain.	Yield. Stalk, etc.
44	Late Bicolor Pearl . .	Vilmorin	5	443	12,174
45	Early Small Yellow Auxonne	,,	4	420	1,146
46	Evergreen Sweet . .	Henderson	4½	377	4,153
47	Extra Early Small Yellow	Vilmorin	3	266	846
48	Mastodon Improved . .	Dammann	7	182	963
49	Moor Early Concord . .	,,	3	156	911
50	King Philip, Early Brown .	Vilmorin	3	137	625
51	Iowa Silver-mine . .	Dammann	3	133	664
52	Japanese Striped . .	Sutton	3½	194	1,354
53	Perry Hybrid . . .	Dammann	3	104	443
54	Virginia Dent . . .	Henderson	6	39	9,127
55	Cuzco White . . .	Vilmorin	5	26	1,380
56	Mammoth	Dammann	5	26	364
57	Nanerotollo . . .	,,	1	20	26
58	Egyptian	,,	5½	13	1,536
59	Cuzco Red . . .	Vilmorin	5	—	3,125
60	Very Early August . .	,,	2	*	2,083
61	Adams Extra Early . .	Dammann	Failed		
62	Cory Early Red Cob . .	,,	Failed		
63	Iowa Gold-mine . .	,,	Failed		
64	Longfellow Yellow . .	,,	Failed		
65	Leaming Yellow . .	,,	Failed		
	Average of 60			768	4,496

* The ears were all destroyed by crows. The grain would perhaps have weighed 200 lbs. per acre.

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Table XLIX.

RESULTS OF MAIZE BREED TESTS, CEDARA, NATAL, 1905-6.

No.	Variety.	Source.	Average Height Feet.	Yield. Grain.	Yield. Stalk, etc.	Date of Harvesting.
1	Hickory King . .	Trelawny Adams	7	5,990	9,869	30 May
2	Virginia White Dent 1	Henderson	7	5,220	18,385	,, ,,
3	Early Mastodon .	,,	7	4,844	5,755	,, ,,
4	Boone County White .	,, through W. Pepworth	7	3,662	8,242	,, ,,
5	Yellow Hogan . .	Hawkesbury Ex. Farm, N.S.W.	7½	4,219	9,241	,, ,,
6	Mastodon Improved .	Dammann	8	4,206	7,214	14 ,,
7	Queen of the Prairie .	Henderson	8	4,140	5,443	,, ,,
8	Zulu Red, Zululand Mealie . . .	Rawlins	8	4,075	18,789	30 ,,
9	Golden Beauty . .	Henderson	9	4,010	6,745	14 ,,
10	Late White Horsetooth	Vilmorin	6½	3,906	15,729	30 ,,
11	Extra Early Huron .	Henderson	8½	3,737	5,013	14 ,,
12	Horsetooth and Hickory King, Greytown	Thresh	7½	3,633	8,507	30 ,,
13	Hickory King . .	Henderson	7	3,542	5,482	,, ,,
14	Improved Early Horsetooth . . .	,,	7½	3,515	5,469	,, ,,
15	Virginia White Dent 2	,,	6	3,411	4,662	,, ,,
16	Burlington Hybrid, Ingogo . . .	Panzera	7	3,398	4,453	3 ,,
17	White Cap Yellow .	Henderson	8	3,372	5,182	14 ,,
18	Japanese Striped .	Sutton	4	3,268	4,844	30 ,,
19	Southern Horsetooth .	Henderson	7½	3,255	12,696	,, ,,
20	Henderson Eureka .	,,	8½	3,255	5,560	14 ,,
21	Improved Leaming .	,,	7	3,216	3,776	,, ,,
22	Iowa Silver-mine .	Dammann	7	3,190	6,107	12 ,,
23	Large Yellow Flint .	Henderson	7	3,060	3,515	3 ,,
24	Horsetooth or Curagua, N.S. . .	Vilmorin	6½	3,008	11,042	30 ,,
25	Rural Thoroughbred .	Henderson	8	3,008	10,663	14 ,,
26	Early Butler . .	,,	7	2,956	4,779	3 ,,
27	Curagua . . .	Dammann	7¼	2,903	7,214	12 ,,
28	King Philip . .	Henderson	6½	2,786	4,375	3 ,,
29	Brazilian . . .	C. Harding	6	2,760	7,865	30 ,,
30	White Flint . .	Henderson	6¼	2,760	3,763	3 ,,
31	Evergreen Sweet .	,,	6½	2,760	3,620	12 ,,
32	Compton Early . .	,,	6½	2,708	3,685	3 ,,
33	King Philip Early Brown . . .	Vilmorin	6	2,682	6,797	12 April
34	Longfellow . .	Henderson	6½	2,630	5,651	3 May
35	Kansas King (in the Husk) . . .	Dammann	7	2,408	5,521	14 ,,
36	Mammoth . . .	,,	6¾	2,356	4,271	2 ,,
37	Small Yellow S. American, N.S. . .	Natal Agricult. Dept.	5½	2,356	4,219	30 ,,
38	King Philip Early Brown, N.S. . .	Vilmorin	6	2,253	4,948	12 April
39	Late Bicolor Pearl, N.S. . . .	,,	5	2,161	5,654	30 May

TABLE XLIX (*continued*).

RESULT OF MAIZE BREED TESTS, CEDARA, NATAL, 1905-6.

No.	Variety.	Source.	Average Height Feet.	Yield. Grain.	Yield. Stalk, etc.	Date of Harvesting.
40	Boone County White, N.S.	Henderson	6½	2,148	5,248	30 May
41	Indian Corn, Large Yellow	Vilmorin	5½	2,122	3,893	12 April
42	Perry Hybrid	Dammann	7	2,096	2,773	2 May
43	Sweet Fodder	Henderson	6	2,083	3,125	3 ,,
44	Late Bicolor Pearl	Vilmorin	5½	2,051	5,937	30 ,,
45	Moor Early Concord	Dammann	5¼	2,005	2,304	2 ,,
46	White Early Pyrenean, N.S.	Vilmorin	6	1,912	3,711	12 April
47	Crosby Early Sweet Corn	Dammann	5½	1,784	2,565	3 May
48	King Philip Early White, N.S.	Vilmorin	6	1,706	4,167	12 April
49	Sugar Corn, Evergreen, Late, N.S.	,,	5¾	1,680	4,844	2 May
50	Pearl White	Dammann	5½	1,667	5,768	30 ,,
51	Early Yellow, Long Eared	Vilmorin	5¾	1,653	2,044	12 April
52	Early Minnesota	Dammann	5½	1,627	2,395	2 May
53	Large Yellow, N.S.	Vilmorin	5½	1,615	3,503	12 April
54	White Early Pyrenean	,,	5½	1,615	2,825	,, ,,
55	King Philip Early White	,,	6	1,602	3,906	,, ,,
56	Sugar Corn, Evergreen Late	,,	6	1,588	3,633	2 May
57	Sugar Corn, Early Dwarf, N.S.	,,	4¾	1,536	2,109	12 April
58	Adams Early	Kilminster, Durban	5	1,475	2,457	,, ,,
59	Stowell Evergreen	,, ,,	6	1,424	2,361	,, ,,
60	Early Yellow, Long Eared, N.S.	Vilmorin	6	1,419	3,307	,, ,,
61	Ambra	Dammann	5¾	1,406	1,693	,, ,,
62	Egyptian	,,	6½	1,380	5,912	2 May
63	Seven Weeks, or Cinquantino	,,	6	1,380	2,773	12 April
64	Extra Early Dwarf Sugar Corn	Vilmorin	4½	1,380	2,526	,, ,,
65	Six Weeks, or Quarantino	Dammann	5½	1,328	1,901	,, ,,
66	White Pyrenean	Sutton	4½	1,315	2,330	31 Mar.
67	Early Szekely	Vilmorin	6	1,146	2,317	26 ,,
68	Early Small Yellow Auxonne	,,	5½	1,016	3,368	21 ,,
69	Austin Yellow Corn	Ferguson	6	989	2,486	30 May
70	Extra Early Yellow	Henderson	4¼	989	1,015	31 Mar.
71	Extra Early Szekely	Vilmorin	6	976	4,447	21 ,,
72	Extra Early Small Yellow	,,	5½	926	2,279	26 ,,
73	Early Small Auxonne	,,	6	871	3,385	21 ,,
74	Early Dwarf Sugar Corn	Sutton	3½	599	2,669	31 ,,
75	Very Early August	Vilmorin	1½	13	218	17 ,,

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294. *Third Season's Results, Cedara, Natal.*—"In 1905-6 tests were carried out on the same grounds as in the previous season, but as there were more varieties to be tested the ground had to be extended into Block 1D. This block in the previous season had been manured with 10 tons per acre of farmyard manure, and 200 lbs. superphosphates and 50 lbs. potash chloride. The whole ground was manured again in 1905-6 with 10 tons per acre of farmyard manure ploughed in, and 415 lbs. per acre superphosphate applied in the drills with the seed. The seed used was from the previous season's variety plots in all cases except those marked 'n.s.' which means new stock or newly imported seed, or with the words Zululand, Greytown, or Ingogo. The rows were, as before, 35 feet long and 3 feet apart, and the plants were 18 inches apart in the rows. There were two rows of each variety. The seeds were all planted on 9 December, about ten days later than they should have been, but the 1905-6 season was favourable to late sowing, so that no great harm was done by the delay. Some very fine yields were obtained: the average of seventy-five varieties was at the rate of 2,424 lbs. grain and 5,085 lbs. stalks, etc., to the acre, and the highest yield was only 10 lbs. short of 30 muids of grain per acre, or actually 106¼ bushels."

Table XLIX gives the results in detail.

295. *Relative Weight of Grain per Bushel of Different Breeds.*—The standard weight of a bushel measure of maize, in the United States, is 56 lbs. But there is great difference between the relative weight per bushel of the different breeds. The grain which weighs heaviest in the bag or bushel measure does not necessarily give the heaviest crop, in fact the reverse is generally the case; the flint breeds usually weigh heavier than the dents, but we generally find that they give fewer muids per acre of ground.

The weight per bushel varies with the degree of dryness, so that to make a reliable comparison between them, it is necessary to take all the weights at the same time. It would be more accurate to take them in conjunction with a moisture-test. The comparative weights per bushel of some leading South African breeds, taken at the Johannesburg Maize Show, July, 1910, are given in Table L.

TABLE L.

WEIGHTS PER BUSHEL OF SOUTH AFRICAN SHELLED MAIZE.

Breed.	Where Grown.	Weight per Bushel.
		Lbs.
Hickory King	Natal	53
" "	"	55
10-row Hickory (Louisiana)	Transvaal	55½
" " "	"	55½
Iowa Silver-mine	"	58
" "	"	57
Ladysmith	Natal	57½
Yellow Hogan	Transvaal	59½
" "	"	60
Chester County	"	60
" "	"	57
Leaming	"	59
Yellow Cango	"	62
New England 8-row	"	62
Gillespie Yellow	"	62
White Cango	"	60
Glass Early Flour Corn	Cape Province	55
Brazilian Flour Corn	Transvaal	52½
		18/1040½
Average for 18 samples		57·8
Lightest of all = Brazilian Flour Corn		52½
Heaviest Flint = Cango, New England and Gillespie Yellow		62
Lightest Flint = White Cango		60
Heaviest Dent = Yellow Hogan and Chester County		60
Lightest Dent = Hickory King		53
American Standard Weight		56

CHAPTER VIII.

SOILS AND MANURES.

The fundamental secret of continued success in farming is the maintenance of soil fertility.—Mr. RUNCIMAN, President of the Board of Agriculture.

Maize requires a better quality of land, and a higher grade of farming, than any other of the great staple crops.—Prof. T. N. CARVER.

By dung we are limited to the quantity of it we can procure, which in most places is too scanty. But by tillage we can enlarge our field of subterranean pasture without limitation.—JETHRO TULL.

CHAP. VIII. 296. *The Soil.*—Soil is the medium in which plants grow and from which they draw the chemical substances used in the processes of growth. Soils are produced by the weathering and decomposition of rocks. They vary in texture, and are described as stony, sandy, loamy, or clayey; a loam is intermediate between sand and clay.

Soils vary in chemical composition according to the nature of the rocks from which they have been derived, and may thus vary in the amount of plant-food which they contain. Ninety to 95 per cent of most of the fertile soils consist of the following substances: phosphoric acid, potash, lime, soda, magnesia, iron oxide, sulphuric acid, chlorine, silica, and alumina, which, however, do not usually exist in a free state. The remaining 10 or 5 per cent is made up of *humus* or decayed vegetable matter containing nitrogen. Sometimes a fertile soil has only 2 or 3 per cent of humus, while in other cases it may contain 25 and even 50 per cent. Nitrogen is also contained in rain-water, in varying amounts, and is further added to the soil by the action of nitrifying bacteria living on the roots of leguminose plants (¶ 311).

Both texture and chemical composition of the soil have an important bearing on plant growth.

297. *Chemical Elements of the Soil Required by Plants.*— All of the above-mentioned chemical substances of the soil occur likewise in plants, with the exception of alumina (oxide of aluminium), and this is always present in good soils, so that it may be said that all are requisite to plant growth. Some are always present in such abundance that there is no danger of their becoming exhausted. The supply of others, however, especially phosphoric acid, potash, lime, and nitrogen, is frequently insufficient for the production of good crops, and the deficiency has to be supplied by the farmer. Of these, nitrogen is the one which is most expensive to replace. CHAP. VIII.

All of the mineral substances found in the ash of plants must come from the soil; plants cannot get them in any other way. The carbon used in the structure of plant tissue is taken from the air. The hydrogen and oxygen come from the water in the soil.

298. *Soil Moisture.*—The chemical substances in the soil can only be made use of by the plant when they are dissolved in water, and water is capable of dissolving from the soil all the substances that it contains which enter into the food of plants; this explains why moisture is necessary to plant life. Dilute solutions of these substances are drawn in through the minute hairs which clothe the ends of the youngest rootlets, and are carried up into the plant, where they undergo a chemical change into the various compounds on which the plant feeds.

Soil has the power of absorbing and retaining water that passes through it, and also of drawing up water from below; the latter is known as capillary action, and is similar to the action by which the oil is "drawn" up into a lamp-wick. Good soils will frequently absorb and hold one-half or more of their own weight of water; some, much more, and those containing most humus will hold most water. Soils also absorb a small amount of moisture from the air. Even when a soil seems perfectly dry it still contains considerable moisture. Soils exposed to the direct rays of the sun or to drying wind give up much of their moisture by evaporation, and as the surface dries water begins to ascend from the lower strata by capillary action. When the soil is protected by a "mulch," evaporation is checked.

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299. *Conservation of Moisture by Tillage.*—South African maize-growers in the drier districts have often experienced loss of their crops, and have had to plant twice or thrice because the stands have "burned off" in a long drought following a good spring rain. Such loss may often be prevented—or greatly reduced—by good tillage. After a rain or after irrigation the surface of the soil is packed tight and a "crust" is formed. Through this crust capillary action is set up, and, as the water evaporates from the surface, more is drawn up from below, until the soil is dried out to a considerable depth. But if that crust is finely broken up, capillary action cannot take place; the fine soil on top forms a "mulch," evaporation is checked, and the soil moisture is left for the young plants instead of being drawn into the air.

300. *Dry-land Farming.*—By the conservation of soil-moisture, through the adoption of better tillage, it is probable that maize-growing may be extended considerably beyond the present western limits of the South African Maize-belt; just how far, has yet to be determined, but the practice of dry-farming methods would undoubtedly add greatly to the area at present under crop. Jethro Tull (1) says:—

"The well hoed earth, being open, receives and retains the dews; the benign solar influence is sufficient to put them in motion, but not to exhale them from thence. The hoe prevents the [growth of] turf, which would otherwise by its blades or roots intercept and return back the dews into the atmosphere, with the assistance of a moderate heat. So that this husbandry [i.e. dry-farming] secures Luserne from the injury of a wet summer, and also causes the rain-water to sink down more speedily, and disperse its riches all the way of its passage; otherwise the water would be more apt to stand on the surface, chill the earth, and keep off the sun and air from drying it: for, when the surface is dry and open, Luserne will bear a very great degree of heat, or grow with a mean one."

301. *Irrigation.*—Irrigation, also, might extend the area now planted to maize. But irrigated land is too valuable to be devoted to this crop except in the vicinity of good markets, where early "green mielies," for table use, command a sufficiently high price, or where climatic conditions do not permit maize to be grown otherwise; and then only if the cost of importation exceeds the local value of the crop.

302. *Available Plant-food.*—Some of the phosphoric acid, potash, etc., present in the soil is in a state of chemical combination in which the plant cannot make use of it for food, until a certain amount of "weathering" and decay has taken place through the action of moisture and air. Estimations of the *total quantities* of such salts present in the soil are therefore of comparatively little value, alone, as indications of its actual fertility or of its manurial requirements, without a knowledge of the amounts available as plant food at any one time.

303. *Recuperative Power of Soils.*—Soils are possessed of great recuperative power, and if the conditions are favourable the renewal of the available plant-food may take place with considerable rapidity. Under the action of moisture and air a process of "weathering" is constantly taking place, and the salts are thereby rendered soluble. This is one reason why summer fallowing often proves so beneficial. Even if the *available* salts had been quite exhausted before fallowing was resorted to, the soil would not long remain unproductive; the available plant-food would soon be restored by the action of moisture and air on the mineral matter.

304. *Character of South African Soils.*—As a general rule South African soils are not rich in the total amount of salts required by plants, as compared with those of many parts of the world. Yet the peculiar fact remains, as pointed out by Ingle (1), that *luxuriant crops are yielded by soils which, on analysis, appear to be extremely deficient in plant-food.* This is partly explained by the favouring influences of abundant sunshine and high temperature. In tropical and sub-tropical countries the processes of soil renewal appear to go on more rapidly than in other climates. Soils poor in available salts may, under these conditions, give the plants actually greater nutriment than soils containing a considerably larger percentage of salts under conditions less favourable (*Ingle,* 1).

305. *Soils Suitable for Maize-growing.*—Maize as a surface-rooting plant is quickly affected by change of climate (*Burtt-Davy,* 16). It is also sensitive to variations of soil—perhaps more so than other cereal crops. To succeed well it requires a good deal of moisture, but standing water or water-logged soils are injurious; to secure the best results the soil should be moist, but well drained. It should also be of

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good depth, for shallow soils require manuring sooner than deep ones. A friable soil which neither bakes nor cracks much in dry weather is desirable. The black "turf" soils of parts of South Africa are often rich, but in seasons of drought are apt to dry out too much, or in wet years to become water-logged. Red clay soils, also, give good crops in some districts. Some of the more sandy soils bear two or three crops and are then exhausted, or become so loose with cultivation that they blow away from the roots of the young maize plants.

There are some soils along the Drakensberg range of mountains which Prof. Watt (*Watt, R. D.*, 1) has found to contain so much of the ferrous iron compounds that maize and kaffir corn do not grow more than a few inches in height even in favourable seasons. Loamy soils, whether red or grey, with some admixture of sand, are among the best all-round soils for maize. In the Transvaal such are found largely in the Heidelberg, Standerton, Bethal, Ermelo, and Lichtenburg Districts, and on that large stretch of country known as the Springbok Flats. Deep, loamy, alluvial river-bottom soils, such as are found along parts of the Vaal River, Kaffir Spruit, the Crocodile, Hex, Marico, and other Transvaal streams, are admirably suited to maize-growing. The rich soils found in pockets along the foot of the eastern slopes of the Drakensberg produce some of the finest crops in the country, but only a short distance out on the plains beyond, there occurs a strip of ashy grey soil which seems unsuited to maize or almost any other crop.

306. *New* v. *Old Lands*.—A common practice in South Africa is to abandon maize lands after the third year, either because they are supposedly "worn out," or on account of weeds. New lands usually give poor maize crops. Experience at the Government Experiment Farm at Potchefstroom, the Government Stud Farm at Standerton, and the demonstration farms of Messrs. John Fowler & Co. at Vereeniging, all in the Transvaal, shows that the best crops may be obtained in the fourth and fifth year of continuous cultivation of the soil. As the land becomes well opened up to air and water, chemical changes take place in the soil which liberate the plant-food or make it available to the plant. There are a few places in the Transvaal where the soil does not

seem able to stand cropping with maize for more than three years, but in most cases the abandonment of the land at the third year means giving it up just when it should be producing the very best crops. At Vereeniging an average of 18 muids per English acre has been obtained over a field of 32 acres, without manure, on steam-ploughed land; this was the sixth crop of maize from the land, five having been in succession. On new lands the Vereeniging crop has been as low as 2½ muids per acre.

307. *Effect of Tillage.*—"Tillage is manure" is an oft-quoted saying attributed to Jethro Tull, but sometimes misunderstood. Prof. Morrow states that proper tillage of the soil increases its productive power; the ability of a soil to produce crops is often as directly increased by tillage as by the application of manures (*Morrow* and *Hunt*, 1).

Tillage is described by Jethro Tull (1) as "breaking and dividing the ground by spade, plough, hoe, or other instruments which divide by a sort of altition (or contusion), as dung does by fermentation. . . . Tillage (as well as dung) is beneficial to all sorts of land. . . . The finer the land is made by tillage, the richer will it become, and the more plants it will maintain." But it should not be concluded from this that good tillage makes it unnecessary to manure, for manure *adds* to the soil, while tillage only makes available what is already there. For a few years after the first breaking of the veld, land may continue to improve and yield better crops, under good tillage, but after that, deterioration begins.

The following are the principal reasons why cultivation makes soils more productive:—

(1) Stirring and pulverizing a hard, compact soil enables the roots of plants to penetrate more easily and reach a larger quantity of the salts which are to be converted into plant-food.

(2) It opens the soil to the weathering effect of air and water, which increases the supply of available plant-food.

(3) With very fine, loose soils tillage (and rolling) may make them more compact, increasing the capillary action.

(4) Surface cultivation, which keeps the surface soil loose and dry, forms a mulch, which checks evaporation.

(5) Tillage kills weeds, which otherwise rob the soil of food and water.

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308. *Effect of Continuous Cropping.*—It is well known that the crop-producing power of the soil is reduced to a point below that of profitable cultivation by continuous cropping with maize or any other cereal, even where the soils are rich in the constituents of plant-food. As the average soils of South Africa are not rich in these substances (¶ 304) they will the sooner become exhausted, unless steps are taken to renovate them. There has been a tendency in parts of South Africa to crop continuously over a long series of years, until the soil has become "sick" or "worn out". Continuous cropping means the annual removal of a certain amount of plant-food from the soil, without replacing any. Neither the greatest quantity, nor the best quality, can be produced by growing the same crop year after year on the same soil. Fortunately there are still large tracts of unbroken veld, but they cannot be drawn upon indefinitely; the time is rapidly approaching when there will be no more raw veld to be broken to the plough. When this time comes South Africa will be compelled to resort to some means of restoring the fertility of the soil.

This has been the experience in every farming country, until the lesson was learned and a more normal practice established. Where the soils are naturally poor in plant-food farmers should not wait until they are "worn out" before adopting a better method of treatment; it is easier and cheaper to maintain and add to what is already there than to undertake to renovate an already impoverished soil.

309. *Maintaining the Crop-producing Power of the Soil.*—Continuous cropping with a heavy-yielding crop like maize, will inevitably result in exhaustion of the soil unless steps are taken to maintain its crop-producing power.

Quoting Mr. Runciman,[1] the President of the British Board of Agriculture: "The fundamental secret of continued success in farming is the maintenance of soil fertility. This is where England excels. Her system of land tenure is often criticized, but it is a significant circumstance that it is associated with

[1] In a speech at the Government dinner given in honour of the American Commission on Agricultural Credit and Co-operation, July, 1913, as reported in *The Field*, Vol. CXXII, p. 128, 19 July, 1913.

the best and most enduring methods of husbandry known in any country."

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There is no need for South African farmers to become pessimistic on the question of soil exhaustion, if they will study the example of England in contrast with that of the United States; in the latter we find, according to Hopkins (6), thousands of acres of land practically ruined from an agricultural point of view, after but 200 years of farming; while on the other hand we learn from Mr. Runciman that "*the older England grows the richer become the average soils;* cases of impoverishment are few and far between". The English tenant-farmer is compelled, under the terms of his lease, to restore to the soil what he takes from it, and nothing ends a tenancy more speedily than evidences of exhaustive farming.

If proper steps are taken to maintain the crop-producing power of the soil, maize does not prove an exhaustive crop. Hunt (1) makes the following points—that (1) the amount of soil elements removed is small in proportion to the amount of foodstuff produced; (2) large quantities of organic matter are produced which when fed to live-stock make large quantities of organic manure to return to the soil; (3) the intercultural tillage required by the maize crop is beneficial to the soil.

Hopkins (5, p. 200) says that to return the maximum amount of organic matter to the land requires that the manure shall be applied to the soil before losses occur by fermentation and decay. "In ordinary farm practice more or less loss of organic matter is almost certain to occur unless the manure is applied to the soil within a day or two after it is produced." English farm practice is changing in accord with this view, largely owing, no doubt, to the effect of the dairy regulations which require that the manure shall be removed daily from the immediate vicinity of the milking sheds; dairy farmers now find it convenient to cart it direct to the land, and the results appear to be entirely satisfactory.

The best means of maintaining the crop-producing power of the soil on a maize farm, as at present demonstrated, are:—

(1) The use of stable manure and kraal manure wherever available. The available amount can be increased by the

CHAP. VIII. adoption of the best methods of preserving the fodder and stover of the crop, and conserving the manure.

(2) The ploughing-in of green-manure crops.

(3) The suitable rotation of crops in connection with stock-raising.

(4) The use of suitable artificial manures.

310. *Summer Fallowing.*—Where large areas are under crop on any one farm (as in many parts of the western United States and parts of South America and South Africa) it is not practicable to give the same amount of cultivation as would be possible on a farm of smaller area. It needs too large an investment of capital in machinery and draught animals, not to mention the difficulty of getting labour. But without cultivation weeds soon get hold of the land, smother the crop, and greatly reduce the yield. Under such circumstances summer fallowing may be resorted to with advantage. By summer fallowing we mean leaving a portion of the land without crop during the summer season, so that it may be cleaned of weeds. Crops of young weeds are allowed to grow, and are then ploughed under as "green manure," or harrowed off before they get too large to be pulled out or old enough to scatter seed. The latter point is of great importance, for there is much truth in the old proverb that "one year's seeding makes seven years' weeding".

Summer fallowing has been decried alike by practical farmers and writers on agriculture, because no immediate return is obtained from the land for a whole season. Another objection offered is that much of the plant-food may be leached out of the soil and carried away in the drainage water, if the lands have a steep slope and the rains are heavy. Experiments conducted by Mr. W. A. McLaren at Vereeniging, Transvaal, have shown, however, that summer fallowing was followed by an *increase* of 11 muids (2,200 lbs.) per acre in the maize yield, *without the use of fertilizers*. At one of the American State Experiment Stations the yield of wheat from a field cropped only in alternate years, during a period of ten years, was greater than from a field cropped every year during the same period, thus five crops gave a heavier yield than ten. Somewhat similar results were recorded by Lawes and Gilbert at Rothamstead, England.

If the total yield obtained by cropping in alternate years is equal to that obtained by cropping each year over the same period, the cost of production is reduced and the profit consequently increased. Unless the cost of fallowing and rent of the land (or its equivalent in interest) are heavier than the cost of production of a crop without fallow, fallowing will thus pay for itself while at the same time it cleans the land. CHAP. VIII.

Not only so, but the cost of cultivation is lessened by ploughing under two or more crops of weeds on the fallowed land before they have had a chance to seed. Where farms are large and land is cheap, there need be no loss of revenue, if each year only one-third or one-quarter of the land is kept in fallow and the rest under crop. For example, if 1,000 acres of arable land is all that a South African farmer can maintain each year, owing to lack of either capital or labour, or both, he might have 200 or 300 acres of it under fallow each year. During the comparatively slack season, from the end of December to the end of March, he could usually employ his draught animals and "boys" to cultivate these fallow lands. By this means he would save much of the time and expense which would otherwise have to be devoted to cleaning the crop during the following growing season.

311. *Rotation of Crops for Fertility Conservation.*—One of the cheapest and most profitable methods of resting the land after it has once reached good cropping condition (¶ 306) is to adopt a system of change or "rotation" in which some other crop than maize is grown every third or, even, second year. Some farmers grow potatoes the third year with the aid of commercial fertilizers, but for unmanured land the best kind of rotation for maize is a leguminose crop, such as cowpeas, kaffir beans, velvet beans, soybeans, peas, or peanuts (¶ 313). This rotation crop may be cut for hay or silage, or, better still, ploughed into the ground at the beginning of winter.

Practising rotation of crops is one of the best methods of checking the wearing-out of the land (*Burtt-Davy*, 15). The principal advantages of rotation are:—

(1) That as some crops require more of one kind of plant-food than others, an intermediate crop can be grown between two crops of a kind without interfering with the general fertility of the soil, and still allow time for the chemical changes which replace a certain proportion of the available salts required for

CHAP. VIII. the following crop. For example, a crop of wheat withdraws large amounts of phosphoric acid from the soil, but takes relatively small quantities of lime and potash, while a crop of beans requires a great deal of potash and relatively less phosphoric acid.

(2) Some crops are surface feeders while others root more deeply, drawing their food from the lower layers of the soil. By alternation of deeper with shallower rooted crops the available food supply is utilized to better advantage and made to last longer.

(3) Certain crops replace in the soil certain ingredients which have been removed by other crops, for instance such crops as lucerne and peanuts give back nitrogen.

(4) Rotation of crops helps to clean the ground of "volunteer" plants from the preceding crop, which, in the case of wheat, oats, and especially of maize, cause so much mixing or crossing of seed, with resulting loss to the farmer.

(5) As different crops require different treatment of the soil, a change enables the farmer more easily to clean the land of such weeds as are particularly injurious to a given crop. In the rotation the farmer can use crops which are known as "cleaning" crops.

The general results of rotation may be summarized as :—

(*a*) The production of crops of greater vigour and better yield. When crops of the same kind are grown continuously on the same land the crop becomes less vigorous and, consequently, more susceptible to attack by insect and fungous pests. Rotation disturbs the "balance of nature" in such a way that the pest dies from lack of its normal food or goes away to search for it elsewhere.

(*b*) The reduction of the manure bill.

(*c*) A principle of rotation is the division of the land into two to four portions, no two of which bear the same crop in the same season. A well-arranged rotation reduces the labour required at any one time, inasmuch as not all crops require to be planted, cultivated, or harvested at once.

The principal points to observe in planning a rotation are :—

(1) Have at least one leguminose crop in the rotation.

(2) Have at least one cultivated or "cleaning crop," or, in its place, a "smother crop" for weeds.

(3) Alternate shallow-rooting crops with deep-rooting crops. CHAP. VIII.

(4) Where there is danger of loss of plant-food from leaching of the soil owing to the slope of the land, plan to have a growing crop on the land all the summer.

(5) Bare summer fallow can be used to advantage if the weeds are allowed to grow during the rainy season and are ploughed in *before they seed.*

(6) Do not rotate cereals with cereals.

(7) Plan the rotation so as to have about the same amount of forage, hay, and roots each year.

(8) Unless it is thoroughly rotted, so that the weed-seeds which it contains are killed, apply the stable manure to the root crop (if one is used in the rotation) or to a rank-growing crop like maize.

312. *Organic Matter.*—By *organic matter* is meant matter composed of substances that are or have been living organisms, in contradistinction to the inorganic matter derived directly from rocks, metals, etc. Organic manures include farmyard manure and humus, which are valuable sources of plant-food, especially nitrogen. Humus and organic matter are not synonymous, for humus includes only that part of the organic matter which has passed the most active stage of decomposition and completely lost the physical structure of the materials from which it is made; it has thus become, as a rule, thoroughly incorporated with the soil mass (*Hopkins*, 5).

Beside returning plant-food to the soil, organic matter improves its mechanical condition; when it is in the proper state it may materially modify the water-content. Soil which has been manured with stable manure is usually moister than unmanured ground; this may be for some or all of four reasons:—

(1) It may absorb more rain-water;

(2) It may draw up more water from below, by capillary action;

(3) It may lose less water from the surface by evaporation; or

(4) It may lose less water by drainage.

Briefly, then, organic matter improves the texture of the soil, adds to its moisture-retaining power, and furnishes nitrogen.

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South African soils are frequently deficient in humus, and where this is the case organic matter must be added if good crops are to be obtained. This may be done by manuring with farmyard manure (¶ 309), or by ploughing into the soil some "green-manure" crop.

313. *Use of Leguminose Green-manure Crops.*—On sandy soils a leguminose crop, such as soybeans, velvet beans, cowpeas, or kaffir beans, proves very beneficial to the maize crop following. A greater yield of maize may be obtained on a poor, sandy soil from the use of a crop of this character, with the addition of a phosphatic fertilizer, than would be secured in two years where maize is grown continuously (*Watt, R. D.*, 2).

To the South African farmer a particularly important feature of crop rotation is the possibility it furnishes of adding humus (¶ 312) to the soil by ploughing in a growing crop, usually a legume, which at the same time adds one of the most expensive elements of plant-food, namely nitrogen, to the soil. The leguminose crop in the rotation (¶ 311 and 314) is often treated in this way, but a crop of any kind of green weeds may also be ploughed in to advantage, where humus only is wanted, and this may be done when the land is in summer fallow.

Hopkins (5, p. 199) definitely states that the *most important*, and least appreciated, method of maintaining or increasing the supply of organic matter in the soil is *by the use of green manures and crop residues.* A ton of clover ploughed under will add nearly *three times* as much organic matter to the soil as can possibly be recovered in the manure if the clover is fed; but with maize only one-tenth of the dry matter of the crop is found in the manure.

314. *Rotations with Maize in other Countries.*—A look at a few rotations practised elsewhere may be instructive. One in use in the Northern United States is :—

First year . . .	Wheat or rye.
Second year . . .	Clover or grass.
Third year . . .	Maize with farmyard manure, and with winter rye sown at the last weeding to furnish late pasture and winter feed.
Fourth year . . .	Oats.

In the State of Rhode Island two different rotations with maize have been practised on light and worn-out lands :—

(1) A four-year course .	Maize, potatoes, rye, clover.
(2) A five-year course .	Maize, potatoes, rye, grass and clover for two years.

In the State of Delaware the following rotation has been practised to advantage :—

First year . . .	Maize, followed by crimson clover.
Second year . . .	Cowpeas, followed by winter oats.
Third year . . .	Red or crimson clover.

In Louisiana, where the climatic conditions are more nearly like those of the warmer parts of South Africa, the rotation recommended by the State Agricultural Experiment Station is :—

First year . . .	Maize.
Second year . . .	Oats, followed by cowpeas.
Third year . . .	Cotton.

Another rotation practised in parts of the United States is :—

First year . . .	Wheat.
Second and third years .	Clover and pasture (or hay) grass.
Fourth year . . .	Maize (manured with farmyard manure).

In the Maize-belt of Illinois a twenty-year test was made with maize after maize, as compared with maize in a six-course rotation, viz., oats one year, clover three years, maize two years. The average increase the first year after clover was 5 muids 120 lbs., and the second year 4 muids 51 lbs. (*Hunt*, 1).

315. *Some Transvaal Rotations.*—No systematic plan of rotation has yet been adopted in the Transvaal. On the light sandy loams of some of the potato farms in the Standerton District it is customary to grow maize for two years in succession after potatoes. From 600 to 800 lbs. per acre of commercial fertilizer is applied to the potato crop ; the two maize crops which follow use the residue of the manure not required by the potatoes, and give crops varying from 20 down to 15 muids per acre. On these soils, however, it has been found that after six years' cropping a change is required, to add humus to the soil. Farmers are, therefore, conducting experiments to include green-manure crops in the rotation ;

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the kaffir bean, cowpea, and soybean have given the most promising results.

In the Standerton District ploughing in of teff for green manure has been tried.[1] The rapid growth of this grass makes it possible to get it in as a catch crop where other crops might not be practicable.

At the Botanical Experiment Station, Pretoria, experiments conducted to determine the effect of green-manure crops on subsequent crops of maize, wheat, and sunflowers all gave marked results in favour of the green-manured plots.

The Division of Tobacco and Cotton of the South African Department of Agriculture is conducting a series of rotation experiments at Rustenburg, Tzaneen, Barberton, and Piet Retief, in the Transvaal. These experiments are designed to determine the best rotation for the improvement of worn-out tobacco lands. The experiments include the following rotation :—

First year	Tobacco.
Second year . . .	Cotton.
Third year . . .	A leguminose crop such as velvet beans, cow-peas, peanuts, or soybeans.
Fourth year . . .	Maize.

It is intended to add to this a small cereal winter crop such as wheat, barley, or oats, on irrigated lands, to come between the tobacco and cotton, or between the legumes and maize crops. The experiments are not yet complete.

316. *The functions of manures* are twofold, restorative and additive; to maintain fertility and to increase it. *Restorative manures* are merely intended to replace in the soil those elements of plant-food which have been taken out of it by cropping. Restorative manures should be of a "complete" or general character, i.e. must contain all the fertilizing ingredients. Restoration is chiefly effected by farmyard manure. *Additive manures* should be adapted to the special requirements of the soils and crops to which they are applied; they may be, but are not necessarily, or usually, complete. As a rule, addition can only be made in the form of the so-called artificial manures.

317. *Manurial Requirements of the Maize Crop.*—Hunt (1) concludes that, as far as maize is concerned, the influence of the

[1] By Messrs. Reynolds Bros., Zandbaken, Val Station.

several ingredients of commercial fertilizers appears to be more dependent upon the soil than upon the crop. At the Government Experiment Farm, Ottawa, Canada, mixed horse and cow manure gave an average return during fourteen years of 14·32 tons of green silage per acre, as compared with 8·02 tons on the unmanured plots; of the artificial manures, phosphates, nitrates, and potash, mixed, gave the best result, viz. 11·97 tons per acre (*Canadian Government*, 1). At Koedoespoort, Pretoria, superphosphate and nitrates gave the best results. At Potchefstroom superphosphates alone and dung have given good crops. At Manderston, Natal, bone-meal is said to have given excellent results for a series of about fourteen years. CHAP. VIII.

318. *Does the Use of Fertilizers Pay?*—Experiments conducted at Vereeniging, under the direction of Prof. Watt, showed that on unmanured land an increase of 60 per cent in crop can be secured by the direct application of 150 lbs. of commercial fertilizer per acre, when drilled in with the seed. When 300 lbs. was applied *broadcast* the increase was very slight the first year, but it is probable that some effect would have been noticeable the second year if the test could have been carried on. On a certain farm at Manderston, in Natal,[1] 400 lbs. per acre of bone-dust was used the first year, and 200 lbs. every subsequent year, and excellent crops have been harvested for twenty-three years in succession. On poor soils at Koedoespoort, Prof. Watt obtained an increase of 11½ muids in two years through the use of artificial fertilizers. The net increase from the use of suitable manures has been found by Prof. Watt and Mr. Holm to amount to £2 or £2 5s. per acre; in one case the expenditure of 18s. 8d. per acre resulted in an added gain of £2 19s. 6d. per acre. It is evident, therefore, that it pays to manure if a suitable quantity of the right kind of fertilizer is used.

The kind of fertilizer will vary with the chemical composition and physical character of the particular soil, and this should be determined by analysis by a competent agricultural chemist before the farmer invests heavily in any chance manure offered, which may not at all suit his soil.

319. *Cost of Fertilizers in the Interior Provinces.*—One of

[1] Mr. John Moon's.

CHAP. VIII. the greatest hindrances in the past to the use of commercial fertilizers in the interior provinces has been their high cost, due to high rate of transportation inland. In view of the fact that South African soils are not as fertile as those of other countries competing for the maize trade, it is important to the farmer that the cost of fertilizers should be reduced to the lowest possible figure. It would result not only in an enormous increase in the output of crop, both for local consumption and for export, but in tremendous increase in the amount of fertilizer used and consequently in the increase of trade in that commodity.

320. *Residual Value of Manures.*—Farmyard manure and the chemical manures do not always yield up the whole of their component salts to the crop the first season. Prof. Watt (2) found in carrying out manurial experiments that the *residual value* of the fertilizers used is a matter of greater importance in the Transvaal than in almost any other part of the world. Phosphatic fertilizers, like superphosphate and basic slag, *may have a greater effect on the second crop than on that to which they are applied.* With the dry winter climate of the South African Maize-belt, even such a soluble manure as nitrate of soda has some residual value. A judicious use of maize fertilizers will give a profitable return, even from poor land, provided two years' results are taken into account. On some soils the use of 600 lbs. per acre of commercial fertilizer for a crop of potatoes leaves enough plant-food in the soil to afterward produce two excellent crops of maize in succession (¶ 315). Farmers[1] in the Standerton District of the Transvaal have obtained 20 muids of maize per acre the first year, and 15 the second year, after a potato crop which had been manured in this way.

321. *Stable and Kraal Manure.*—Organic manures, such as farmyard manure, are found to be among the best of fertilizers, perhaps because of the effect of the large amount of organic matter contained, on the texture of the soil (¶ 312). As already pointed out, the function of farmyard manure is chiefly restorative. The pasturing of cattle on the old maize fields undoubtedly has a beneficial effect on the soil, but is not an equivalent compensation for such a large amount of grain (over a ton per acre) as is removed from the land.

[1] Messrs. Hutchinson and Shaw, and Messrs. Reynolds Bros.

The Indiana (U.S.A.) Station (*Bull.* 55, p. 29) manured a series of plots which had grown maize continuously for five years, with about 50 tons per acre in two years, of fresh horse manure, no manure having been used either before or after. Comparing the manured with the unmanured plots, it was found that during twelve years the *average* yield was about 560 lbs. per acre, and on the last year of the twelve about 280 lbs. per acre, more on the former than on the latter. The total increase, due to the use of the manure, was about 33½ muids. CHAP. VIII.

At the Government Experiment Farm, Potchefstroom, Transvaal, the effect of a dressing of 8 tons of dung per acre had almost entirely disappeared in the third year following the application (*Holm*, 1), indicating that frequent applications, or larger amounts at a time, are necessary to produce satisfactory results. The quantity usually applied in the United States varies from 10 to 20 tons per acre.

Owing to the size of the farms and the sparseness of the white population in South Africa, the amount of stable manure produced is not sufficient to permit of its use on a large scale, and Holm (1) concludes that the comparatively small amount available on most South African farms can be more profitably used on other crops, such as mangels and potatoes, than directly on the maize crop. In the United States, even to-day, the supply of dung is totally inadequate to the demands of the field crops, and hardly more than is needed for the kitchen garden and a few "truck patches" near the farm-house.

The value of stable, and kraal, and other home manures, should not be underestimated. The farmer should endeavour to increase the supply of them rather than try to become independent of their use. But it would be just as unwise to so overestimate the value of home manures as to lead to the policy of ignoring altogether the aid of commercial forms of plant-food. Director Redding of the Georgia State Experiment Station (1) points out that the true farm economy is that which utilizes to the fullest every home resource and then supplements their use by the purchase of commercial forms of plant-food in the proportions demanded by different crops, and modified to some extent by the character and condition of the soils to be fertilized.

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322. *Artificial Manures or Commercial Fertilizers.*—The scarcity of farmyard manure has led to the manufacture and use of the so-called *Commercial Fertilizers* or *Chemical Manures.* Their principal function in the economy of the farm is to *increase* fertility, not to maintain it. They are obtained from natural deposits, such as the nitrate beds of Chile and guano from the Guano Islands or from caves, or are manufactured from bones, blood, and refuse of various sorts. Artificial manures are of two sorts, "general" or complete, and "special" or incomplete.

323. *Method of Applying Fertilizers.*—Experiments conducted on a large scale have clearly shown that the best method of applying the fertilizer to the maize crop is through the planter with the seed; this is usually done by means of the fertilizer attachment which can be bought with every good planter. Some commercial fertilizers are not so well dried as others and are apt to stick in the box of the machine unless watched; the result is that the machine may run for the greater part of a row without dropping any manure, and an uneven stand and growth will result.

One of the great advantages derived from the application of these fertilizers in the climate of South Africa is the stimulus which they give to the young seedling, enabling it to get a good start in life. Broadcast sowing of artificial manure generally benefits the weeds rather than the maize plants, for in the often dry spring of the South African Maize-belt it rarely gets washed down to their roots.

324. *Influence of Season on the Efficacy of Fertilizers.*—It has been found that fertilizers produce different effects on the crop in different years, and this has been traced to seasonal variations, such as difference in rainfall. In the United States it has been found that in dry seasons land manured with stable manure may give poorer returns than land which has had no manure at all. Also that the best results from the use of either stable manure or commercial fertilizers are obtained in seasons of good rainfall.

325. *Use of Lime.*—Lime is an essential constituent of good soils and is extensively used for the improvement of agricultural land. It is absorbed by the crop, being found in the ash of plants, but its specific action in promoting plant growth is

not well understood. Lime is not in itself a *manure*. It has a beneficial effect on the soil, and therefore on the crop. It encourages nitrification, rendering nitrogenous matter in the soil available to the growing plant. It also improves the soil texture, making heavy adhesive soils more friable and granular, and reducing their tendency to puddle, while it makes loose, sandy soils more compact and retentive of organic matter. Lime counteracts acidity of the soil, thus improving it for the development of nitrifying organisms, and is useful for sweetening freshly drained swampy lands. Lime hastens the decomposition of decaying matter, and may therefore be applied with stable manure to advantage. But continuous application of lime without the addition of real plant-food tends to impoverish the soil; there is a good old adage to the effect that "all lime and no manure soon makes the farmer poor".

For soils deficient in lime, maize is a good crop with which to apply it; in the United States it is used with this crop to a considerable extent, with apparently satisfactory results.

326. *Indication of Need of Lime.*—Many South African soils are deficient in lime, but others contain sufficient, and where that is the case the application of more would only be a waste of money. The farmer can tell whether lime will improve his crops or not: (1) by chemical analysis, which will show the percentage of lime (CaO) present; for agricultural crops 0·2 per cent is usually considered the minimum requirement; (2) by a test with neutral litmus paper which, if it turns red, will indicate acidity in very sour soils and the consequent need for lime; (3) by the excessive adhesiveness of clay soils; (4) by the character of the native vegetation (e.g. in South Africa the Vaalbosch (*Tarchonanthus camphoratus*) and *Salvia rugosa* generally occur on soils rich in lime); (5) by the persistent failure of certain crops, such as lucerne or sainfoin; (6) by experimental application—and this is probably the most reliable test—of a good dressing of lime on say one acre of a field of maize where the soil is uniform, and under conditions which make it possible to tell whether there is any increase of crop as a result of the application.

327. *Kinds of Lime.*—Commercial lime is not always of the same chemical composition. Two kinds are commonly met with in South Africa, *White* and *Blue* lime. Blue lime

CHAP. VIII. made from dolomite or "magnesian" limestone is found by experience to be unsuitable for agricultural purposes (*Vipond*, 1). White lime (calcium carbonate or carbonate of lime) is the sort recommended by agricultural chemists.

328. *Preparation of the Lime.*—For agricultural purposes lime is usually burned and slaked before using. To slake lime for use in the field, it is heaped and covered with earth to exclude the air; water is then poured on it; in a few days it "falls" into a fine powder suitable for spreading on the land. Full advantage of the lime dressing is obtained only if the lime is very fine in texture; if it is still coarse after burning and slaking it should be ground.

The Pennsylvania Station (*Rep.* 1902) shows that the continued use of *caustic* (i.e. *burned*) lime, tends to *exhaust or destroy* the fertility of the soil (see also *Hopkins*, 5 and 6). Both the Pennsylvania and Maryland Stations found that *ground limestone* gave better results in sustaining the productive capacity of the soil, than burned lime. Hopkins (6) cites results obtained in Germany and England favouring the use of the former as a more profitable and effective form than the latter.

329. *Method of Applying Lime.*—As lime is somewhat soluble and apt to be carried off in the drainage, it is best to apply it after the soil has been partly prepared; it is then spread broadcast and cultivated into the surface. The amount used should vary according to the texture and chemical composition of the soil. Half a ton per acre is often recommended, but on very heavy, sour soils a ton to the acre may not be too much. In the United States up to 4 tons per acre is sometimes used for maize, but ordinarily not more than 2 tons (*Hunt*, 1). The Agricultural Chemist of the Department or College of Agriculture should be consulted as to the amount to be used on any particular soil.

330. *Phosphatic Manures.*—Phosphatic manures, such as superphosphate, bone-meal, and basic slag, may have a greater effect on the *second* crop than on that to which they are applied. Where they are used on sandy soils a greater yield of maize may be obtained after a crop like cowpeas than would be got in two years where maize is grown continuously without fertilizer (*Watt, R. D.*, 2). The experiments at the

Government Experiment Farm, Potchefstroom, Transvaal, indicate (*Holm*, 1) that these manures greatly increase the yield, and that profits are obtained on the expenditure; from 3½ muids per acre without manure the yield was raised to 8 muids, an increase of about 133 per cent. CHAP. VIII.

331. *Superphosphate Alone.*—At Stanger, Natal, in 1903-4, the use of concentrated superphosphate, at the rate of 120 lbs. 5 oz. per acre, resulted in an increased yield of 4 muids 82 lbs. per acre (*Anon.*, 1). At Koedoespoort, Pretoria, in 1907-8, the increase was only 240 lbs. of grain per acre and in 1908-9, 360 lbs., and the net cash gain (at 10s. per muid) from the use of this manure only 5s. 4d. per acre (*Watt, R. D.*, 2). In the experiments at Potchefstroom, superphosphate proved the most profitable manure to use, the average yield for the three years being 14 muids 97 lbs. per acre, a gain of 300 per cent, and a net gain of £2 0s. 10d. per acre, estimating the value of the crop at 8s. per muid. The cost of the manure was 18s. 8d. per acre (*Holm*, 1).

332. *Bone-meal Alone.*—In the experiments at Potchefstroom no increase was obtained the first year from the use of bone-meal alone. But in the second and third years the yield was good. The average for the three years was 6 muids 164 lbs. per annum (*Holm*, 1), which is very low, showing that this manure when used *alone*, on this particular type of soil, did not supply the requirements of a good maize crop.

333. *Superphosphate and Bone-meal Mixed.*—Holm (1) concludes that a mixture of superphosphates and bone-meal is likely to give the best results of any artificial manure, especially in the first and perhaps also in the second year; after that only bone-meal need be applied. The mixing of bone-meal with superphosphate facilitates the sowing of the latter. An English Agricultural Chemist states that: "By mixing and allowing them to stand some little time before using, the action of the superphosphates on the bone-meal tends to increase the solubility of the phosphates in the bone-meal, which in a dry climate is an advantage". To get the best results, the bone-meal must be very finely ground; according to competent agricultural chemists, "the bulk of that offered on the South African market is too coarse". Such coarse particles may remain many years in the soil before they are rendered available for plant-food,

CHAP. VIII. and it is likely that chemical action eventually takes place which renders a part at least of their phosphate insoluble and therefore of no value as plant-food (*Holm*, 1).

Steamed bone flour is more readily soluble than bone-meal.

334. *Basic Slag Alone.*—At Koedoespoort, Pretoria, on sandy soils poor in lime, Prof. Watt found that a dressing of basic slag was beneficial to the leguminose crop grown in rotation with the maize (*Watt, R. D.*, 2). At Potchefstroom the average yield for three years with the use of basic slag was

FIG. 125.—Effect of basic slag on maize (cf. Fig. 126).

8 muids 106 lbs. per acre, and the net gain 17s. 5d per acre (*Holm*, 1).

335. *Nitrate of Soda Alone.*—This is a very soluble manure and is apt to leach out in the drainage, so that in some climates there is little or none left for the following year; but with the dry winters of South Africa some residual value may remain for the succeeding crop. Though an important element of plant-food, experiments show that the application of this manure is not always profitable. As it is one of the most

expensive of commercial fertilizers, the farmer should make sure that it will prove beneficial before going to the expense of purchasing. CHAP. VIII.

A three-year series of trials at the Government Experiment Farm, Potchefstroom, showed that the average yield of grain was only 30 lbs. per acre more (worth 1s. 3d.) with the use of nitrate of soda than without. As the cost of this manure was £1 0s. 1d. per acre, the net loss from its application was 18s. 10d. per acre. The amount used was 200 lbs. the first

FIG. 126.—Effect of growing maize without manures (on plot adjacent to that shown in Fig. 127).

year and 100 lbs. each year in the two succeeding years (*Holm*, 1). Similar results have been obtained with maize at Cedara, Natal (*Sawer*, 1), and with other cereals at Potchefstroom.

336. *Superphosphate and Nitrate of Soda.*—On poor sandy soils at Koedoespoort, near Pretoria, Prof. Watt obtained an increase of 500 per cent on his maize crop, the first season, on the plot on which nitrate of soda (200 lbs. per acre) and superphosphate (400 lbs. per acre) were used, as compared with that on which superphosphate was used alone. The second crop

CHAP. VIII. after the application of the mixed fertilizer was nearly double that obtained with the use of superphosphate alone. The total increase was more than 11½ muids per acre in two years, and the net value of the increase due to the use of the mixture was £2 16s. 3d. per acre, as against 5s. 4d. per acre gained by the use of superphosphate alone (*Watt, R. D.*, 2).

The conflicting results obtained with nitrate of soda at Koedoespoort and at Potchefstroom emphasize the fact already alluded to, that different *soils* require different manures to

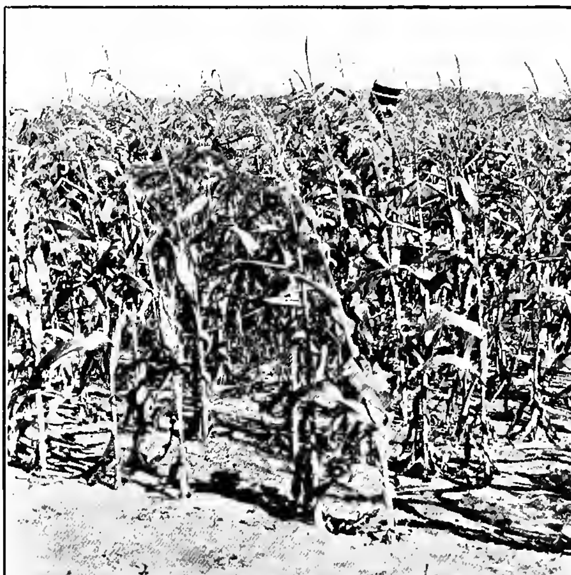

FIG. 127.—Effect of superphosphate and nitrate of soda mixed.

produce the same crop. They also point to the necessity for extended manurial experiments in different parts of South Africa.

337. *Manganese Compounds.*—Experiments conducted in Japan and Italy, and at Woburn, Grönigen, and Uitenhage (*Sutherst*, 1), have shown that manganese has a beneficial effect on certain crops and especially on maize. Large amounts of manganese salts are injurious to crops, and the manganic salts much more injurious than the manganous, but small amounts (50 to 60 lbs. per acre) are found to improve the crops.

Mr. Ingle (*Sutherst* and *Ingle*, 1) concludes that for the present it will be safer to assume that manganese exerts a "tonic" action, and that its application to a soil must not be regarded as at all an efficient substitute for the plant-food required, and usually supplied by means of artificial manures. In other words, it is probably better regarded as a medicine than as a food. CHAP. VIII.

Russel (2) observes that manganese is considered by

A

FIG. 128.—Effect of manganese compounds on maize; A, Effect of manganese dioxide.

Bertrand (1) to be a constituent of oxidases, and, therefore, necessary to the plant; minute traces only are required, larger quantities being harmful. A number of field experiments[1] have shown that manganese salts may act as manures. Bertrand classes them as "*engrais complementaires*".

[1] Numerous Japanese experiments are recorded in the *Bull. Coll. Agric.*, Tokyo, 1906 *et seq.*, and Italian experiments in the *Studi e Ricerche di Chimia Agraria*, Pisa, 1906-8.

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338. *Potassium.*—At Koedoespoort, Prof. Watt obtained an increase of 452 lbs. of maize per acre the first year and 360 lbs. the second year, after an application of 150 lbs. per acre of sulphate of potassium, but the net value of the increase due to manuring was only 5s. 5d. per acre. At Potchefstroom the use of sulphate of potassium (150 lbs. per acre the first year, and 75 lbs. in each of the two succeeding years) resulted in an average *loss* of 252 lbs. of maize-grain per acre, valued at 10s. As the cost of the manure was 16s. 1d. per acre, the

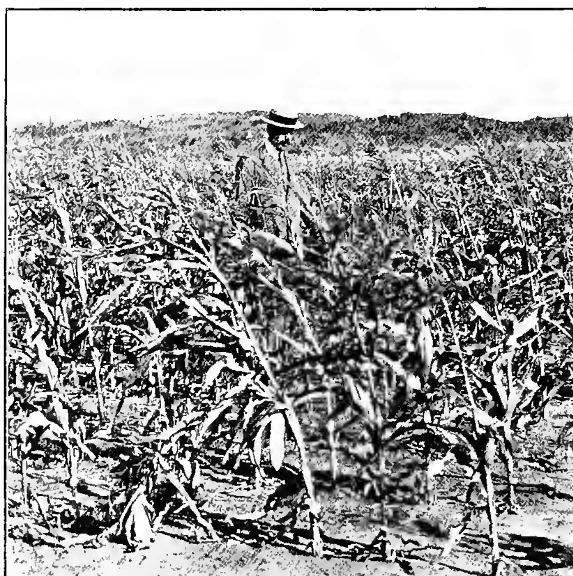

FIG. 129.—Effect of sulphate of potassium on maize (cf. Fig. 126).

total loss due to its use was £1 6s. 1d. per acre. As sulphate of potash is considered the least deleterious of all potassic manures, it has been suggested (*Holm*, 1) that it is not likely that either kainit or chloride of potassium ("muriate of potash") would give any better results; but it has been pointed out by an agricultural chemist that it is just possible that the property possessed by kainit of holding moisture—due to its sodium-chloride content—may prove it to be better than potassium sulphate *for such crops as are not injuriously affected* by the use of the salt, and this to some extent would apply to chloride of potassium also. He refers to the fact that in England it has been proved in many cases that potassium in the form of chloride (i.e. "muriate of potash") applied to potatoes is not so beneficial as when the potassium is applied in the form of sulphate, and in fact has caused deterioration in the quality of the crop, while kainit has given the best results. CHAP. VIII.

Addendum.—The writer is informed that in Rhodesia the "chocolate" soils prove best suited to maize, and produce heavy crops year after year without the application of manure. The "red" soils produce maize for about three years in succession, and then require a rest. The granite soils, though producing good tobacco, are found unsuited to maize-growing.

CHAPTER IX.

TILLAGE, PLANTING, AND CULTIVATION.

Two or three additional ploughings will supply the place of dung . . . if they be performed at proper season.—JETHRO TULL.

There ain't but one principle to follow in raisin' corn; keep it clean.—AN IOWA FARMER.

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339. *Time of Ploughing.*—In the Maize-belt of South Africa new lands, and lands which have been fallowed with a rotation crop, may be ploughed as early as is possible in the autumn (preferably in January, February, and March), in order to prepare a proper seed bed and to conserve the moisture for early planting. Old lands may with advantage be ploughed as soon as they can be eaten off by the cattle. In the Transvaal the lands should not be left unploughed any longer than can be avoided, and should be ready for planting as soon as good rains fall in September or early October, but in parts of Natal, on light, grey sandy loams subject to much washing, it is found desirable to leave the ploughing as late as possible before planting.

340. *Depth of Ploughing.*—Shallow ploughing causes the maize plant to suffer from drought in a dry season, and from waterlogging (on some soils) in a wet season. It has been demonstrated clearly during many years that, in the Transvaal and Orange Free State, deep ploughing conserves soil moisture. In very wet seasons it has also been demonstrated in Natal that deep ploughing enabled the surplus moisture to drain away better; on one farm it was shown that the only maize crop produced was on land which had been deeply steam-ploughed; on adjacent land, which had been ploughed to the ordinary depth of ox-ploughing, the maize crop had been either washed away or "drowned out".

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FIG. 130.—Primitive method of preparing land for maize, in Zululand.

FIG. 131.—Deep ploughing by steam, 12 furrows at a time by direct traction.

CHAP. IX.

Eight to nine inches is a good depth for ox-ploughing; but steam-ploughing to a depth of 12 to 15 inches generally gives better results. Deep ploughing is more necessary for maize than for wheat. On shallow soils, however, with an unfavourable subsoil, 6 to 8 inches is found sufficient.

"Whether it is done well or badly, ploughing is a slow business, and I think it is important that when it is done, it should be done well" (*W. A. McLaren*).

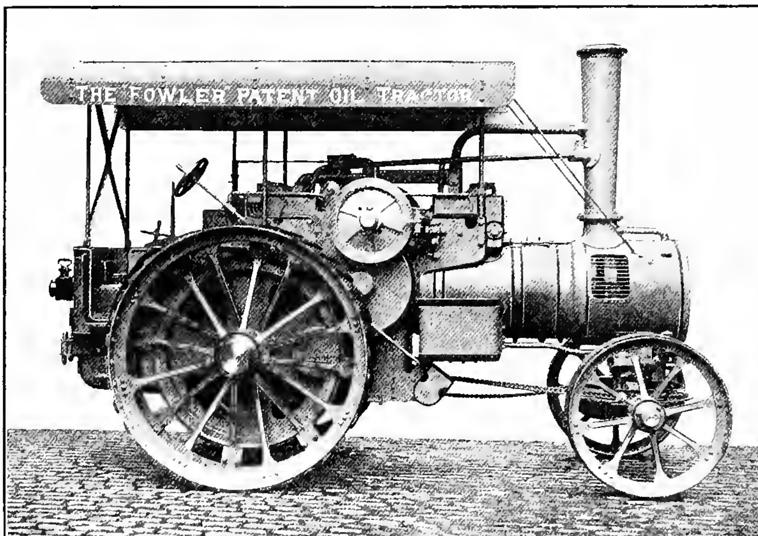

FIG. 132.—The "Fowler" direct traction engine (for oil or coal).

Subsoiling[1] is generally considered most effective where the subsoil is heavy.

341. *Different Soils Require Different Treatment.*—It has already been pointed out (¶ 307) that the object of tillage is (1) to improve the texture or physical condition of the soil so that the plant-roots may have the best chance to reach food and moisture; (2) to render the salts more readily available to the plant; (3) to retain the moisture of dry soils and remove surplus moisture from those that are too wet.

[1] Subsoiling has been described as a method of increasing the depth of ploughing by running a special "subsoil plough" in the bottom of every furrow made by the ordinary turn-plough (*Duggar*, 2).

Thus different soils will require different treatment to secure the best results. The difference in returns from applying uniform treatment to different soils can be deduced from the experiments conducted in Natal by Mr. Pearson, then Director of Agricultural Experiments at Cedara, as shown in the following table:— CHAP. IX.

TABLE LI.

EFFECT OF TREATMENT OF SOIL ON YIELD.

	Light Sandy Soil.	Soil of Less Open Texture.
Yield without Subsoiling	1945 lbs. = 9·725 muids	1640 lbs. = 8·20 muids
Yield with Subsoiling	1935 ,, = 9·675 ,,	1860 ,, = 9·30 ,,
Yield without Surface Cultivation	2001 ,, = 10·005 ,,	1860 ,, = 9·30 ,,
Yield with Surface Cultivation	1894 ,, = 9·47 ,,	2040 ,, = 10·20 ,,

The returns from the same treatment were practically reversed on the two soils. It is clear, therefore, that there are some soils in South Africa so light and sandy that they will not bear much cultivation; in fact, as Mr. Pearson states, the less such soils are disturbed beyond the ordinary ploughing, the better the results. In some cases in the Transvaal—such as certain lands along the Vaal River—the soil blows away if too much cultivation is practised. But such soils are exceptional; often they do not bear good crops for more than about three seasons.

342. *Preparation after Ploughing.*—Maize requires a deep, loose seed bed, though the soil need not be as fine as for wheat. To produce this, it is essential, in the climate of South Africa, that particular attention be paid to the after preparation of the seed bed. This will vary with different soils and in different districts; we can only speak here in general terms.

A well-known agriculturist has said that very much depends upon performing each tillage operation when the soil is in exactly the right condition; two hours of sunshine will often make the difference between success and failure in the operation of a tillage implement; compare the old couplet:—

He that by the plough would thrive
Himself must either hold or drive.

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Land becomes very hard and lumpy if left rough to dry out, but new land, broken at the end of the summer, may be

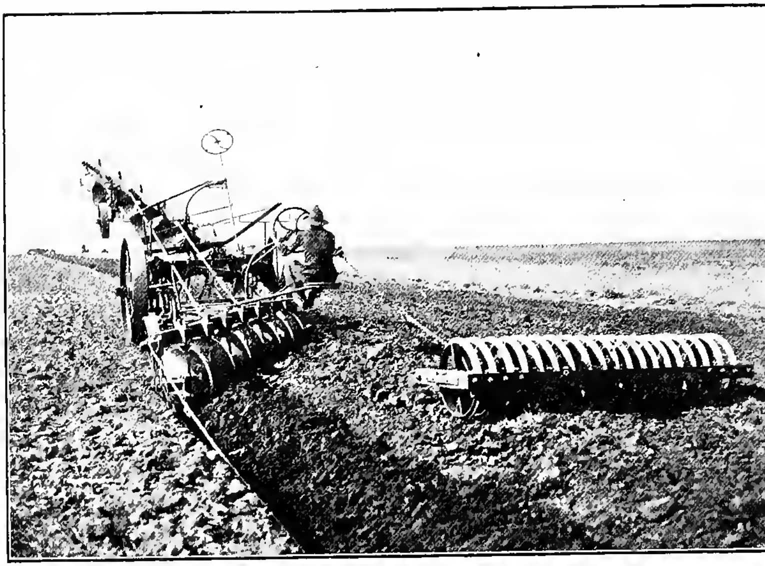

FIG. 133.—Disk cultivating; double-engine system.

allowed to lie fallow till the spring rains in order to "weather" and kill the sod. Old lands broken in summer may be pul-

FIG. 134.—Harrowing by steam; double-engine system.

verized at once and harrowed to produce a mulch and to conserve moisture for early spring planting.

After ploughing old maize lands, the stalks and roots lying in or near the surface should be gathered together by means

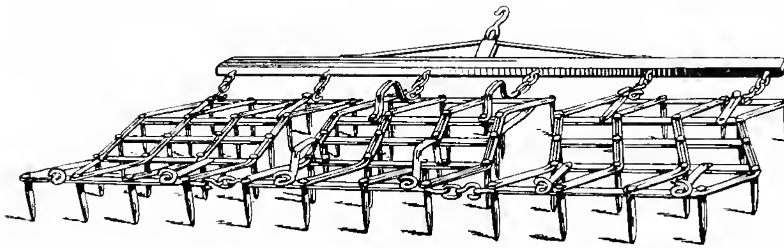

FIG. 135.—Zigzag harrow. (Courtesy of Messrs. Malcomess & Co.)

of the harrow and burned in heaps to kill the stalk-borers ("mest-worms") which are hiding through the winter in the hollow part of the base of the stem (cf. ¶ 407).

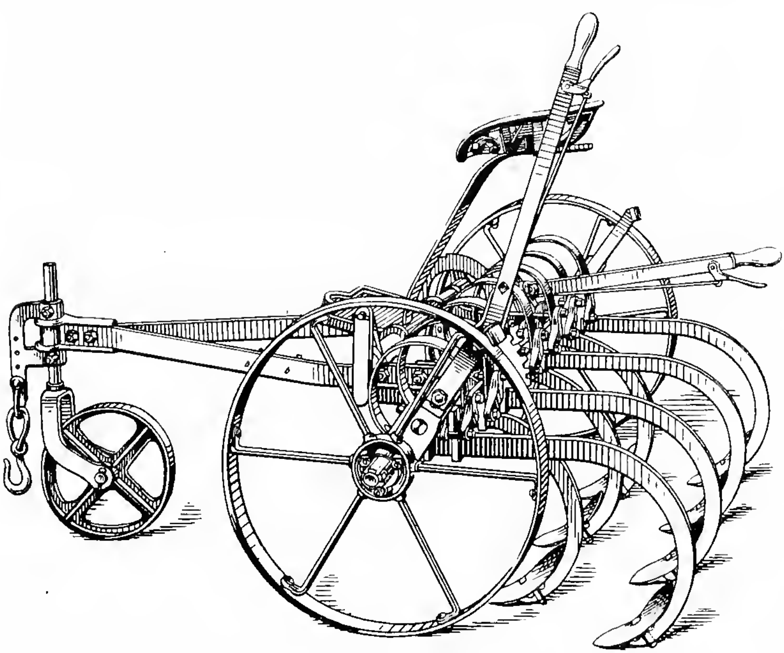

FIG. 136.—Riding cultivator. (Courtesy of Messrs. Malcomess & Co.)

Cross ploughing or cross cultivation are useful methods of treatment for closing up the air spaces by drawing together

CHAP. IX.

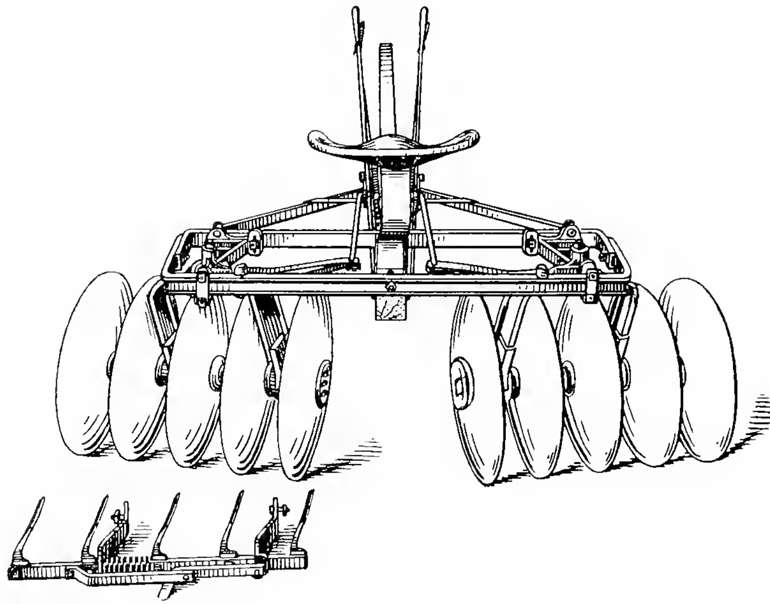

FIG. 137.—Riding disk cultivator. (Courtesy of Messrs. Malcomess & Co.)

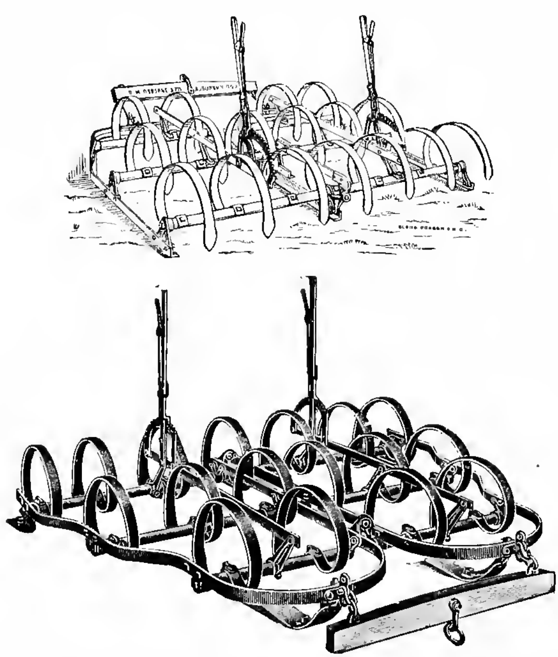

FIG. 138.—Spring-tooth harrows. (Courtesy of Messrs. Malcomess & Co.)

the sod. The implements used must necessarily vary with the character of the soil, but the plough, Martin cultivator, disk harrow, spring-tooth harrow, and zigzag harrow are the implements most in use. The Cambridge roller is a useful implement at times and on certain soils, but great care must be exercised not to use it unless the soil is sufficiently dry or otherwise fit; a roller may do much damage if used at the wrong time. CHAP. IX.

After planting it is desirable to harrow at least twice with the zigzag harrow or anti-clog weeder; this may be done when

FIG. 139.—Harrowing the young maize plants, Vereeniging, with zigzag harrow.

the maize plants are just up above the ground, and again while they are still quite young. The second harrowing should kill the first crop of weeds, but should not be given till the maize plants are well out of the ground, otherwise too many of the young plants may be pulled up; for the same reason this harrowing should be done across the drills, not along the rows; if it runs down the drills, a harrow tooth may pull out a large part of a row of maize; on some soils, it is true, harrowing with the rows is found preferable to harrowing across them.

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343. *Time of Planting.*—South African farmers have a distinct advantage in being able to plant for at least eight consecutive weeks, whereas in the Maize-belt of the United States the time is only three to four weeks: this means that with the same

Fig. 140.—Part of the gang of fifty-two "Champion" planters at work on Messrs. John Fowler & Co.'s demonstration farms at Vereeniging.

amount of labour we can plant double the acreage. The time of planting undoubtedly has an influence on the yield. Late planting does not allow the plants time to develop a full crop before the frosts set in, and is responsible for much loss. In good seasons late planting may give satisfactory returns, but one cannot depend on the seasons; to plant late is to "tempt Providence". On the other hand early planting means danger of injury from late frost. It also tends to induce ripening before the summer rains are over, with consequent injury to the grain. However, it has been shown on a large scale that in the South African Maize-belt seed can safely be planted and germinate before the rains begin, as early as 26 August. CHAP. IX.

FIG. 141.—Fowler's steam planter.

At Vereeniging (4,750 to 4,900 feet) large areas have been successfully planted during the last week of August. Here the season usually ends about 5 December, though in some seasons it has been successfully extended to 26 December. There are some disadvantages in planting very early (1) because the weeds do not start as soon as the maize plants, and when they do come they cannot be destroyed as easily by the harrow, on account of the size of the maize plants; (2) there seems to be more loss from cutworms and other insect pests. This difficulty can usually be overcome by clean cultivation and winter

CHAP. IX. ploughing of the maize fields. No actual planting calendar can be given which would apply equally to all parts of the country, for this necessarily varies with temperature and time of arrival of the spring rains, which vary greatly in different districts and different seasons.

Experiments conducted at the Government Experiment Farm, Cedara, Natal, gave the following results :—

TABLE LII.

EFFECT OF TIME OF PLANTING ON YIELD.

Maize	sown	22 Oct.,	1904,	yielded	720 lbs.	(3·6)	muids	of grain	per acre.
,,	,,	3 Nov.,	,,	,,	760 ,,	(3·80)	,,	,,	,,
,,	,,	15 ,,	,,	,,	1690 ,,	(8·45)	,,	,,	,,
,,	,,	27 ,,	,,	,,	1890 ,,	(9·45)	,,	,,	,,
,,	,,	9 Dec.,	,,	,,	1680 ,,	(8·40)	,,	,,	,,
,,	,,	21 ,,	,,	,,	600 ,,	(3·00)	,,	,,	,,

Plantings made on the same dates in successive years are not likely to show uniform results, for time of planting can have no direct bearing on the crop except as it is correlated with conditions of the weather and seasonal variations in the prevalence and effect of pests and diseases. At the same time it should be noted that observations of this character, conducted over a long series of years, with the same variety of crop and in the same locality, are of the greatest importance for localities having similar conditions. For every district there must be a time for sowing when weather conditions are, on the average, at the best for the production of good crops.

At the Government Experiment Farm, Potchefstroom, the usual time for maize planting is between 15 October and 7 November.

In parts of the Pretoria District (4,000 to 4,500 feet altitude) the usual time is from the occurrence of first rains, until Christmas. In this district the "planting rains" rarely come before 15 November, which throws the growing season so late that there is danger of early autumn frost catching the crop before it is mature; these frosts sometimes fall as early as 28 March. By ploughing the ground in January, February or March, and choosing the moister soils of the farm, planting can be started the following season independently of the spring rains, even as early as 1 September, and by deep planting (4 to 5 inches) and frequent harrowing, the seedlings do not suffer from the usually intermittent character of these rains. As a rule the occasional light frosts of early September do not seriously affect the young plants. At the Botanical Experiment Station, Pretoria (4,300 feet), planting commences on 1 November and continues until Christmas. CHAP. IX.

At Witbank, Middelburg District, Transvaal, one crop was planted as early as 26 August in 1909 and did not suffer from cutworm or stalk-borer.

On the eastern High-veld, where the rainfall is heavier, October is the general month for main crop planting, which continues till the middle of November. Planting at the Government Stud Farm, Standerton (5,000 to 5,500 feet), on well-prepared land, begins about 25 September and is continued till 25 October. At Bethal, 31 October is considered about the last safe date for planting *Hickory King*.

In the drier parts of the Waterberg and Western Zoutpansberg (3,500 to 4,000 feet) the rains usually fall late, and the commencement of planting is often delayed until the middle of December; but as the early frosts fall later here than at higher altitudes, the planting season for early maturing sorts may continue till the middle of January.

In the Lower Bush-veld of the Transvaal the planting season is independent of frost, but the rainfall being less than on the High-veld, and evaporation and transpiration greater, the season varies with the rainfall and must be so planned that the plants will secure about 13 inches of rainfall during the three principal growing months of the crop. In Rhodesia, according to Mr. Odlum, maize is planted as soon as sufficient rain has fallen to thoroughly saturate the soil. Sometimes this is in November, but more often not until December.

At Himeville, Natal, in the Underberg District, planting sometimes commences at the end of August, while at Cedara, in the Umgeni District, the end of November has been found the best time. At Manderston, Camperdown District, the ten days from 22 November to 1 December have given the best results.[1]

344. *Listing.* — Planting with a lister (Fig. 142) is a common practice in those parts of the United States in which the soils are friable and the rainfall scanty. It is claimed,

[1] According to Mr. John Moon.

CHAP. IX. says Shelton (1), that listed corn endures dry weather much better than that planted near the surface; that it gives increased yield; and that the labour of growing a crop is thereby reduced one-fourth to one-third. In 1888 "nearly or quite three-fourths of Kansas corn was raised by the method known as listing; which . . . consists of drilling the seed in the bottoms of deep furrows struck at the usual intervals, in ground not otherwise ploughed" (*Shelton*, 1). In experiments conducted at the Kansas and Oklahoma Stations, five out of eight trials of listed maize gave the best results, with an average yield of the eight trials 6 per cent greater than that

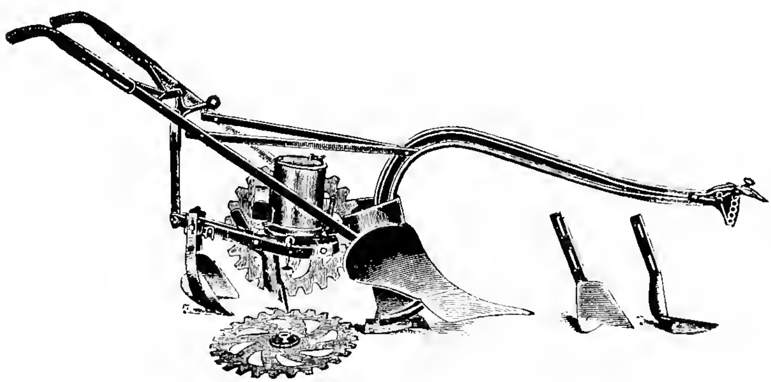

FIG. 142.—Combined lister and planter.

with surface planting; but at the Illinois Station the results were in favour of surface planting (*Hunt*, 1).

A few listing implements have been introduced into South Africa, but the writer has not yet seen the results of any trials conducted with them.

345. *Use of Planters.*—The use of planters is rapidly gaining ground. An implement dealer in a small country town of the Transvaal stated that in 1908 he sold nineteen planters, which was more than he had sold in the previous six years. In 1909 he sold fifty-one planters before the end of August; and there were two other firms in the same town who dealt in planters. This means progress. The great advantage of the planter lies in the uniformity in distance and in depth of planting, rapidity of work, and economy in labour. Many

planters are on the market, such as the Moline Champion, Deere & Mansur Improved, Black Hawk, Rock Island, Farmers' Friend, Hoosier, Bradley, and Planet Junior. The simpler the mechanism the better, where farm labour is inefficient and unskilled. CHAP. IX.

Some of these machines are furnished with centre-hole plates for the seed to pass through into the hopper, while the plates of others have edge-hole plates, i.e. the holes are in the form of notches in the edge of the plate. The general experience seems to be that for ordinary purposes, and with ordinary seed of variable size and shape, the centre-hole plate

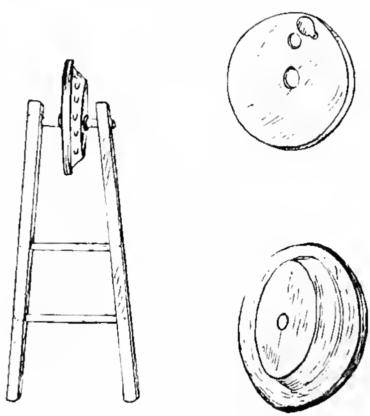

FIG. 143A.—A home-made hand planter for maize. (After Myrick, *The Book of Corn.*)

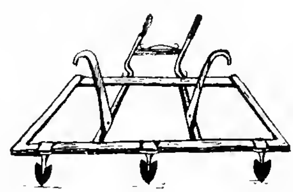

FIG. 143B.—Home-made marker for planting maize by hand. (After Myrick, *The Book of Corn.*)

does the best work, resulting in fewer misses in the row. It seems likely that the edge-hole plate would plant more evenly and accurately, provided the seed were very evenly graded and uniform, otherwise the centre-hole plate is preferable.

346. *Check-rowing* on small areas (up to, say, 200 acres) has an advantage in that it enables the farmer to cultivate both up and down and also across the field, and thus to get rid of a large proportion of weeds. But it takes a longer time, and on large areas the farmer may not have labour enough for this inter-cultural tillage. Moreover when check-rowing bunches four or five plants in a hill, the results appear

CHAP. IX. to be unsatisfactory (¶ 350) unless the surplus plants can be pulled or hoed out; this means extra labour and loss of time, and where maize is grown on a large scale it is doubtful whether the extra work would pay. If check-rowing is practised, care should be taken not to leave too many maize plants together; probably two will be found sufficient for any one "hill".

347. *Distance of Planting.*—Distance of planting affects

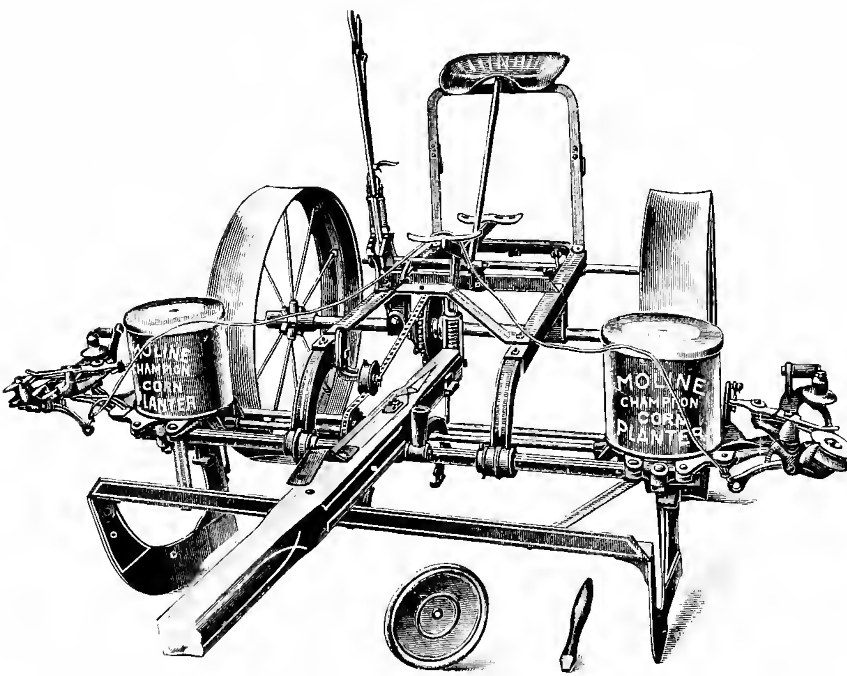

FIG. 144.—Maize planter, "Moline Champion".

the crop in several ways. Too close planting is injurious, because, in the first place, it reduces the amount of plant-food available for each plant, maize being a surface-feeder; in dry times it injuriously reduces the amount of moisture available to each plant; it also retards photosynthesis since less light is available to the leaves (¶ 69); finally it prevents proper weeding. On the other hand the plant does not require an indefinite amount of space, and if more than a certain optimum of soil space is allowed, the ground area lies waste. In brief, to secure the best yield, it is necessary that an acre should carry as many maize plants as possible without injury to one another. CHAP. IX.

It is obvious that as the richness and texture of the soil and the amount of available moisture vary tremendously, not only in different parts of South Africa, but also on the same farm, the optimum distance of planting will vary in different places, and even on the same farm. *There is no uniform distance suitable for the maize crop in all parts of the country.* Owing to the difference in amount and incidence of the rainfall in different seasons, a greater distance of planting would be desirable in some seasons than in others; but as the farmer cannot foretell the rainfall, he cannot vary his planting in anticipation, but should regularly adopt the average distance which his own records over a number of years have proved most satisfactory for a particular field.

Distance should also vary with the kind of maize grown; a large-growing sort naturally requires more plant-food, and therefore more soil and light space, than a small kind.

The farmer will find it to his advantage to carry out a series of distance tests on his own farm over a series of years and on different soils: a comparison of the *average* yields from each planting at the same distance will (if carried out long enough) give the optimum distance for that particular soil and locality. But a single test is not sufficient; it should be repeated for several years and the results should be compared carefully. In order to start an experiment intelligently, it is well to know something of the results obtained elsewhere, as a basis on which to start; a few such results have been given in the following paragraph.

348. *Distance Tests in the Transvaal.*—The following results (Table LIII) were obtained from an experiment conducted at the Botanical Experiment Station, Skinner's Court, Pretoria, on shallow red soil of poor quality. The breed used was *Hickory King* and only one grain was planted to each hill. It will be noted that at the greater distances the results were not satisfactory.

Further results (Table LIV) were obtained from a subsequent experiment conducted at the Botanical Experiment

Table LIII.

RESULTS OF DISTANCE TESTS ON YIELD OF *HICKORY KING*.

Distance.	Soil Surface Area per Plant.	Equivalent Number of Plants per Acre.	Yield of Grain.	Per Cent of Total Yield.
	Square Feet.		Lbs.	
3′ × 3′	9·0	4,840	100	15·36
3′ × 2½′	7·5	5,808	180	27·65
3′ × 2′	6·0	7,260	175	26·88
3′ × 1½′	4·5	9,680	196	30·10
			651	99·99

Table LIV.

RESULTS OF DISTANCE TESTS ON YIELD OF *IOWA SILVER-MINE*.

Experiment Number.	Distances.	Crop Harvested.		Equivalent Yield per Acre.	
		Ears.	Lbs.	Lbs.	Muids.
A.217	3′ 6″ × 1′ 6″	960	384	2,846	14·23
A.218	3′ 4″ × 1′ 6″	997	290	2,249	11·25
A.219	3′ 8″ × 1′ 6″	1,038	352	2,559	12·79
A.220	3′ 6″ × 1′	1,211	255	2,890	14·45 [1]
A.221	3′ 4″ × 1′	931	200	1,555	7·77

Experiment Number.	Soil Surface Area per Plant.	Equivalent Number of Plants per Acre.	Average Weight per Ear.	Possible Return if every Hill had borne a Plant, and every Plant one Ear up to the Average weight for that Distance. Total Weight per Acre.	
	Square Feet.		Oz.	Lbs.	Muids.
A.217	5·25	8,297	6·40 [2]	3,318·8	16·59
A.218	4·995	8,720	4·65	2,534·2	12·67
A.219	5·49	7,934	5·42	2,688·0	13·44
A.220	3·50	12,445	3·37	2,621·1	13·10
A.221	3·33	13,081	3·44	2,812·4	14·06

[1] Some plants evidently bore more than one ear.

[2] The largest ears gave the largest yield per acre, but the lowest yield per acre was not obtained from the plants which produced the ears of smallest average size (cf. experiments A.218 and A.220).

Station, on red soil, with *Iowa Silver-mine.* This breed was used, as it was already being grown for other purposes which would not interfere with the distance tests.

The plot was 56 yards long, and ten rows were grown at each distance. The distances chosen were based on the results obtained in the previous experiment.

From Table LIV it is obvious that the heaviest ears were obtained, in all cases except one, from the plants having the largest amount of free soil space per plant; in the one exception the difference is so slight that it does not affect the results. But in an experiment with sunflowers conducted at the Botanical Experiment Station a few years previously, it was clearly proved that the plants which produced the smaller heads gave a better crop than those which bore very large heads, because there were more of them.

We must therefore find out whether the reduced weight of ear, in cases of less soil space per plant, may not be compensated by the larger number of plants per acre. Table LIV shows that in the above experiment this was not the case. In Illinois, however, the smaller ears gave the heaviest total yield (¶ 350).

One of the factors which affects the maize yield is sunshine, and on this account distance *between* the rows may be of greater importance than distance *in* the rows. But this again is sometimes affected by the direction of the rows, especially in a cloudy, wet season; in such a season wide rows, running north and south, have an advantage over narrow rows running east and west.

At Vereeniging Mr. McLaren has tried various distances, and now usually plants 3 feet 4 inches between the rows, the grain being dropped on the average at about 1 foot 6 inches in the row, giving 5 square feet to each plant, or 8,712 plants per acre.

On some of the Transvaal soils it seems likely that 3 feet × 1 foot 6 inches, or 9,680 plants per acre, will give better results, but this requires further investigation.

349. *Distance Tests in Natal.*—At the Government Experiment Farm, Cedara, Natal, the following returns of yield of grain per acre were obtained:—[1]

[1] In 1904.

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TABLE LV.

RESULTS OF DISTANCE TESTS IN NATAL.

Distance in the Rows.	Rows, 2½ feet Apart.		Rows, 3 feet Apart.		Rows, 4 feet Apart.	
	Lbs.	Muids.	Lbs.	Muids.	Lbs.	Muids.
1 foot apart	1,880	9·40	1,908	9·54	1,696	8·48
1½ " "	1,702	8·51	1,744	8·72	1,510	7·55
2 feet "	1,632	8·16	1,592	7·96	1,290	6·45
2½ " "	1,580	7·90	1,458	7·29	1,174	5·87
3 " "	—	—	1,342	6·71	1,014	5·07
4 " "	—	—	—	—	864	4·32

Clearly the best distance, in that locality and soil and for that season, was 3 feet between the rows and 1 foot apart in the rows. It must be remembered, however, that unless such an experiment is conducted over a series of years, or on a large area, and an *average* taken, the variations which occur may be due to slight differences in soil, or to greater insect attack in some spots than others, these being usually restricted to patches and not uniformly distributed.

A farmer at Manderston, Natal,[1] informed the writer that he planted *Hickory King* 2 feet 8 inches × 14 inches, which is equivalent to about 14,000 plants per acre; this was on well-manured land. His crop when planted at this distance averaged 14 muids per acre which appears like a good yield; but this means that with a full stand of plants the average yield per plant would have been only 3·2 oz., which is very low, indicating either that an unusual allowance must be made for misses, grubs, etc., or that the planting was too close.

350. *Distances Tried in the United States.*—From accounts of experiments in the United States it would appear that the best crops are obtained at distances giving 11,000 to 12,000 plants per acre, but there, also, we find variation according to climate and richness of soil. Recent experiments have shown that the crop is apt to suffer if the plants are bunched, four or five together in a hill, and from this point of view continuous row planting seems to be superior to check-row planting. At the Missouri Station, the largest yield on poor land (36 bushels) was obtained from leaving only two stalks per hill, with the hills 3 feet 9 inches apart each way, or 6,480 stalks per acre; while

[1] Mr. John Moon.

on good land 70 bushels was obtained with four stalks per hill, the hills being the same distance apart (*Hunt*, 31). At the Illinois Station (*Bull.* 13, p. 410) close planting (23,760 plants per acre) gave smaller ears, 100 weighing only 39 lbs.; but a heavier yield of shelled grain (76 bushels) per acre, as compared with 5,940 plants per acre which gave large ears (100 weighing 66 lbs.) but only 55 bushels of shelled grain per acre.

351. *Planting Distance for Silage or Fodder Maize.*—When the object is to get the heaviest possible yield of fodder from each acre of ground, the plants may stand much closer together than when grain is to be harvested. At the Botanical Experiment Station, Pretoria, the rows are kept the same distance apart as when planted for grain, i.e. 3 feet 6 inches, in order to allow space for cleaning, for sunlight, and for leaf-development, but the seed is planted every 5 or 6 inches instead of 18 inches. But no definite rule can be laid down because so much depends on the local conditions of soil and climate, and the particular breed grown. The Pennsylvania and Michigan Stations found the most satisfactory distance to be rows 40 inches apart and single stalks 3 to 9 inches apart in the row.

In the Standerton District (Transvaal) some farmers[1] leave 3 feet between the rows, planting 10 inches apart in the row, and cultivate just as they would for grain; but they are not sure that 2 feet 6 inches × 10 inches might not give a better yield, though "if planted too thick the bottom leaves die," and the leaf is the most valuable part of the fodder. They use *Natal Yellow Horsetooth*, a vigorous grower, which could not be grown as thickly as some other sorts; they plant 14 to 15 lbs. of seed per acre.

352. *Effect of Thickness of Planting on Composition of the Fodder.*—The American Experiment Stations have found that where the crop has been planted thickly the protein content of the fodder is materially reduced and the percentage of crude fibre considerably increased; but when there is no greater variation in rate of planting than that of one grain every 6 to 12 inches, there is no material difference in the composition of the fodder (*Hunt*, 31).

353. *Number of Plants to an Acre of Ground at Different Distances* :—

[1] e.g. Messrs. Hutchinson and Shaw of Val Station.

TABLE LVI.

NUMBER OF PLANTS PER ACRE WHEN SOWN AT THE FOLLOWING DISTANCES, ALLOWING ONE PLANT PER "HILL".

Distance between Rows.		Distance in the Rows.																
Ft.	In.	1 0 Ft. In.	1 2 Ft. In.	1 4 Ft. In.	1 6 Ft. In.	1 8 Ft. In.	1 10 Ft. In.	2 0 Ft. In.	2 2 Ft. In.	2 4 Ft. In.	2 6 Ft. In.	2 8 Ft. In.	2 10 Ft. In.	3 0 Ft. In.	3 6 Ft. In.	4 0 Ft. In.	4 6 Ft. In.	5 0 Ft. In.
3	0	14,520	12,445	10,890	9,680	8,712	7,920	7,260	6,701	6,222	5,808	5,445	5,124	4,840	4,148	3,630	3,226	2,904
3	2	13,755	11,790	10,316	9,170	8,253	7,503	6,877	6,348	5,895	5.502	5,158	4,824	4,585	3,930	3,438	3,056	2,750
3	4	13,068	11,201	9,801	8,712	7,840	7,128	6,534	6,031	5,600	5,227	4,900	4,612	4,356	3,733	3.267	2,904	2,613
3	6	12,445	10,667	9,334	8,297	7,467	6,788	6,222	5,744	5,333	4,978	4,667	4,392	4,148	3,555	3,111	2,765	2,489
3	8	11,880	10,182	8,910	7,920	7,198	6,480	5,940	5,483	5,091	4,752	4,455	4,192	3,960	3,394	2,970	2,640	2,376
3	10	11,363	9,740	8,522	7,575	6,818	6,198	5,681	5,244	4,870	4,545	4,261	4,010	3,787	3,246	2,840	2,525	2,272
4	0	10,890	9,334	8,167	7,260	6,534	5,940	5,445	5,026	4,667	4,356	4,083	3,843	3,630	3,111	2,722	2,420	2,178
4	2	10,454	8,960	7,840	6,969	6,272	5,702	5,227	4,825	4,480	4,181	3,920	3,689	3,484	2,986	2,613	2,323	2,090
4	4	10,052	8,616	7,539	6,701	6,031	5,483	5,026	4,639	4,308	4,020	3,769	3,547	3,350	2,872	2,513	2,233	2,010
4	6	9,680	8,297	7,260	6,453	5,808	5,280	4,840	4,467	4,148	3,872	3,630	3,416	3,226	2,765	2,420	2,151	1,936
4	8	9,334	8,000	7,000	6,222	5,600	5,091	4,667	4,308	4,000	3,733	3,500	3,294	3,111	2,666	2,333	2,074	1,866
4	10	9,012	7,724	6,759	6,008	5,407	4,915	4,506	4,159	3,862	3,604	3,379	3,180	3,004	2.574	2,253	2,002	1,802
5	0	8,712	7,467	6,534	5,808	5,227	4,752	4,356	4,020	3,733	3,484	3,267	3,074	2,904	2,489	2,178	1,936	1,742

354. *Amount of Seed Planted per Acre.*—This varies greatly with the method and distance of planting, and with the breed of maize planted. If plates with suitable holes are used, a muid of *Chester County* will plant many more acres than a muid of *Hickory King*, because it contains so many more grains. It is usually estimated that 18 to 20 lbs. of *Hickory King* are required to plant an English acre (70 × 70 yards), or, in other words, that a muid will plant 10 acres.

355. *Depth of Planting.*—The rule with maize is to plant it just deep enough to ensure a continuous supply of moisture. In countries subject to periodic drought, like most parts of South Africa, deeper planting is required than in countries of more uniform rainfall. Deep planting allows the seed to remain in contact with moist soil; at the same time it takes longer and requires more effort for the plant to reach the surface. But there is a possibility of planting too deeply, and in the United States it has been found that too deep planting reduces the yield per acre, apparently because too many seeds fail in germination.

Deep planting does not appear to materially affect the depth to which the roots penetrate the soil, nor does it apparently affect the yield per individual stalk, which has been found to be the same at all depths tested.

Tests made at the Botanical Experiment Station, Pretoria, gave the best results with seed planted at depths of 4 and 5 inches. In drier seasons it seems probable that 6 inches would be still better. Seed planted at 8 inches, even, germinated well, though slowly.

Seed of the same breed, planted the same day, at different depths, at the Botanical Experiment Station, gave the following results. Sown 23 November, followed by a rainfall of 0·95 inch on the 26th, appeared above ground as follows:—

TABLE LVII.

EFFECT OF DEPTH OF PLANTING ON GERMINATION.

Depth.									
1-inch;	seedlings	first	appeared	above	ground	27	Nov.	
2- ,,	,,	,,	,,	,,	,,	27	,,	
3- ,,	,,	,,	,,	,,	,,	28	,,	appeared next best to 5 inches.
4- ,,	,,	,,	,,	,,	,,	30	,,	

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Depth.			
5-inch;	seedlings first appeared above ground	30 Nov.	germinated most evenly and looked best.
6- ,,	,, ,, ,, ,, ,,	30 ,,	only a few appeared.
7- ,,	,, ,, ,, ,, ,,	2 Dec.	
8- ,,	,, ,, ,, ,, ,,	2 ,,	

Germination was poorest (though growth was at first most rapid) in those planted at 1 inch; but these had made the least subsequent growth when examined a few weeks later. The most vigorous growth was attained by those planted at 5 inches.

This experiment should be repeated, for some at present unexplained factor affected the growth of those planted at 4 inches, which were less vigorous than those planted at 3 inches.

356. *Planting behind the Plough.*—This method is largely practised by Boers and natives, especially in breaking new veld, but the resulting crop is not as good as when the land has been properly prepared.

357. *Planting before Ploughing.*—This method is sometimes practised by natives, especially on sandy soils; it naturally results in an uneven stand, and in irregularity of germination, growth, flowering, and ripening, and is not the best method of producing a profitable crop; as a rule it is said to result in a crop of not more than 1½ bags per acre.

358. *After-cultivation.*—Maize requires a better quality of land and a higher grade of farming than any other of the great staple crops. One of the principal causes of low yields is the prevalence of weeds, such as pig-weed, mest-briede (*Amarantus paniculatus*), Bermuda quick or quagga kweek-gras (*Cynodon Dactylon*), uintjes (*Cyperus esculentus*), and the sweet grasses (*Chloris virgata* and *Panicum lævifolium*). Weeds rob the maize roots of moisture and plant food, and thus reduce the yield of grain. Their successful eradication is one of the most important problems the South African farmer has to face. Occasional fallowing of the soil and rotation of crops do much to reduce the weed crop. Frequent harrowing, while the weed seedlings are small, is one of the most economical and rapid methods of treatment. But the frequent use of the cultivator between the rows of a check-rowed field is far the best. Cultivation not only keeps the land clean but also helps to retain the moisture in the soil during dry spells, by maintaining a soil

Fig. 145.—Cultivating maize lands in Kaffraria.

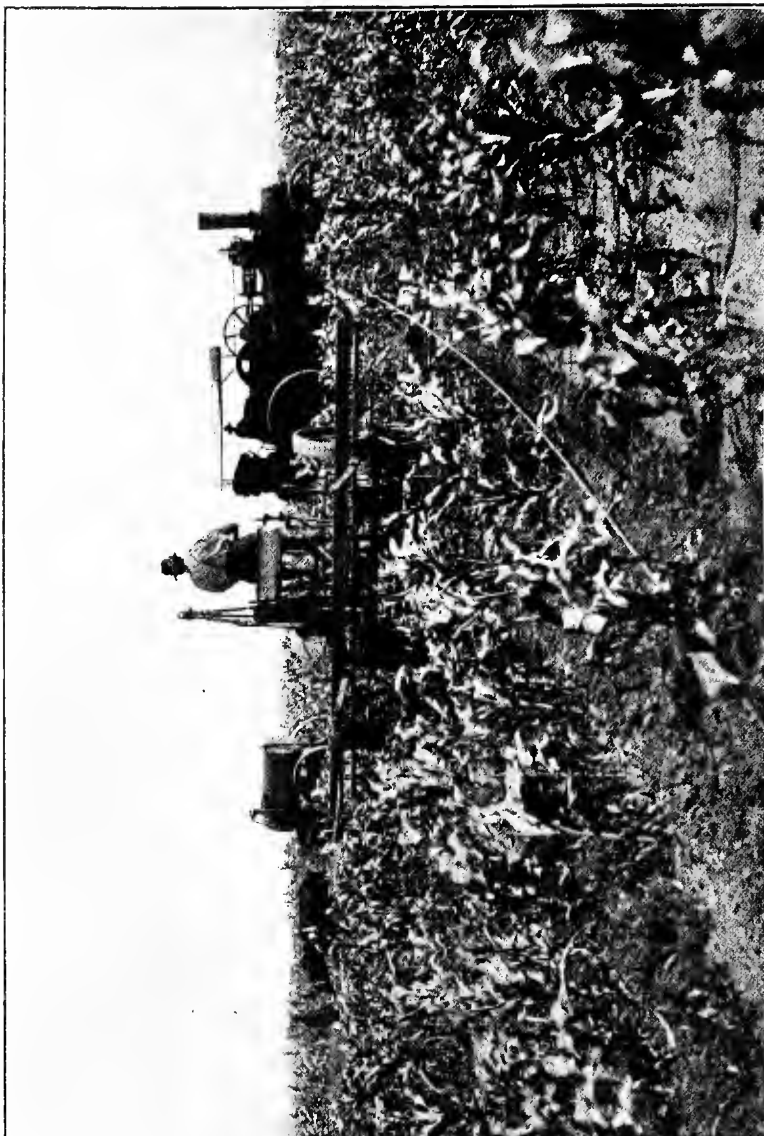

FIG. 146.—Steam-cultivating maize plants 36 inches high, with spring-tooth cultivators doing 6 rows at a time. (Courtesy of Messrs. John Fowler & Co., Vereeniging.)

mulch. Some South African maize-growers cultivate between the rows as much as eight times in a season. To keep the maize crop clean one must have the land in good condition before the crop is planted, and then keep working it, *never allowing the weeds to get a start.* This subject is more fully discussed in chapter X. CHAP. IX.

For these reasons the small maize farmers of the United States who give their crop thorough cultivation, obtain heavier returns per acre than those who grow maize on a larger scale and are unable to give it the same attention. Prof. Carver notes (cf. ¶ 6) that there is a noticeable general decline in the intensity of cultivation of the maize crop, with the increase in size of farm in the Western States. There is also a noticeable

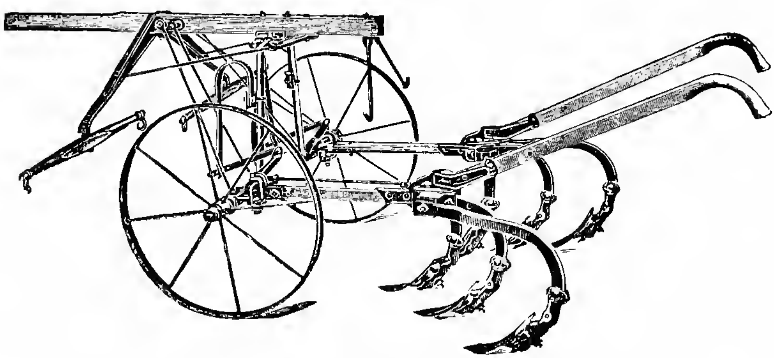

FIG. 147.—"New Western" cultivator. (Courtesy of Messrs. Malcomess & Co.)

decrease in yield per acre; that this is associated with the less intensive cultivation rather than to geographical reasons, is indicated by the fact that the highest average yields per acre are obtained in the *North Atlantic* States, quite out of the Maize-belt (¶ 41).

Care should be exercised in the use of the cultivator, for if it is set too deeply, or run too close to the plants, it may prune off a proportion of the roots, below the surface, which will probably reduce the yield below the potential; for this reason some American Stations recommend that after the first cultivation the implements should not be allowed to cut deeper than 2 inches; deep cultivation also tends to turn up a fresh crop of weed seeds.

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359. *Implements for Weeding.*—Many implements are in use in South Africa for cleaning the land of weeds and keeping a loose mulch on the surface after rains. Probably no one of these can be said to be the best implement for all classes of soil.

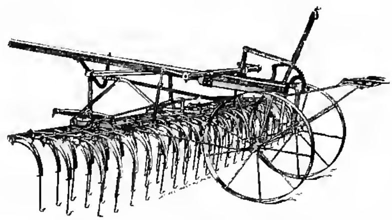

FIG. 148.—Anti-clog weeder.

The use of the ordinary zigzag harrow and the anti-clog-weeder have already been alluded to. Among others should be mentioned the Planet Junior, Collet, and Howard scufflers, which are in use at the Experiment Farm, Potchefstroom; the Martin cultivator and the Captain Kidd disk cultivator, both of which are in use at Vereeniging; and the Peg-tooth

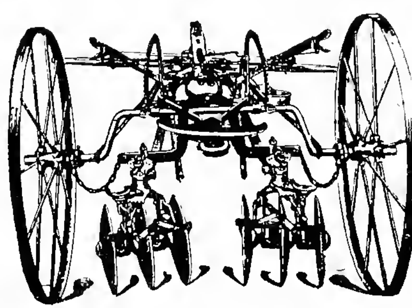

FIG. 149.—"Captain Kidd" cultivator. (Courtesy of Messrs. Malcomess & Co.)

cultivator used by farmers in the Standerton District.[1] The following are also in use in the Transvaal: The Hallock, Independent, Keystone-adjustable, Corn King, Dandy, Golden Rule, New Age, New Western, etc.

Where the crop is in danger of suffering from excessive

[1] e.g. Messrs. Reynolds Bros., Val Station.

moisture, it is useful to run a mouldboard plough down the rows to throw up the earth around the maize roots and form a shallow channel down which the surface water can run instead

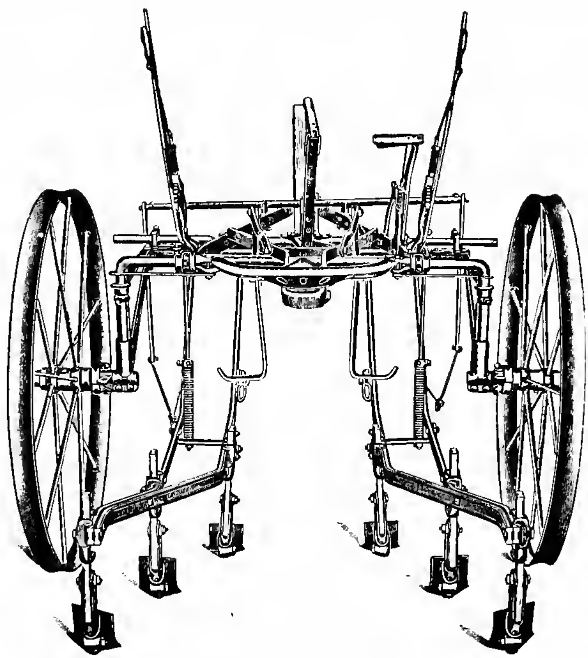

FIG. 150.—"Single Dutchman" cultivator. (Courtesy of Messrs. Malcomess & Co.)

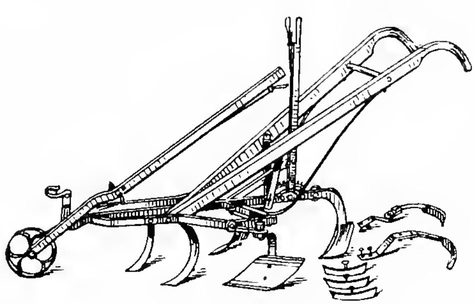

FIG. 151.—Adjustable cultivator. (Courtesy of Messrs. Malcomess & Co.)

of standing. The maize plant does not like stagnant water, and many a crop has been saved by this simple method of treatment.

CHAP. IX.

360. *Power.*—The usual source of power employed on the South African farm is the ox, most frequently the Africander breed. The argument generally used in favour of the ox is that he requires little artificial feed, and can be sold to the butcher when his draught days are over. This may have held good in the days of the 6,000-acre farm, and when the beef market was less critical than it is to-day. But when we think of the number of oxen required to haul a load or draw a plough, and consider that the same grass necessary to keep them might be making prime beef such as the trek-ox never

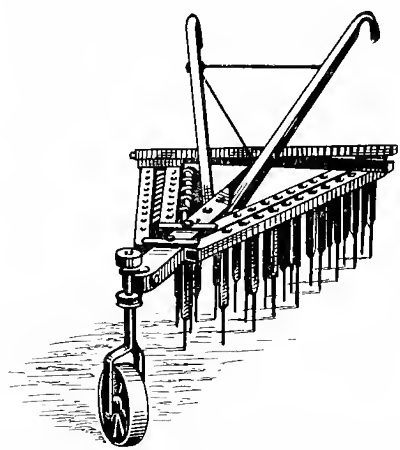

Fig. 152.—Adjustable Weeder. (Courtesy of Messrs. Malcomess & Co.)

can produce, we begin to question where the economy of the trek-ox comes in; he is, at best, a slow beast and an expensive form of power. When drawing the planter he makes crooked rows, and when drawing the cultivator through the growing maize he cuts out the plants in the bends which he made when planting, thus still further decreasing the yield; and he is so ponderous and so slow in getting over the ground that a larger number of planters and natives must be employed to cover a given area in the limited amount of time available for planting and cleaning, than would be needed if horses or good mules were used.

For the preparation of the land there is nothing to equal steam cultivation, and the best machinery and implements for steam ploughing are apparently those manufactured by Messrs. John Fowler & Co. (Leeds), Limited (Figs. 131 to 134, 141 and 153), whose extensive and long-continued demonstrations at CHAP. IX.

FIG. 153.—Steam-ploughing and subsoil packing the land at Vereeniging; double engine system. (Courtesy of Messrs. John Fowler & Co.)

Vereeniging have proved beyond doubt the efficiency of this form of power for maize-growing in South Africa. This firm is now putting on the market a direct-traction oil-tractor (Fig. 132), the "Fowler," which, if it proves adapted to South African conditions, is likely to greatly reduce the cost of machine ploughing.

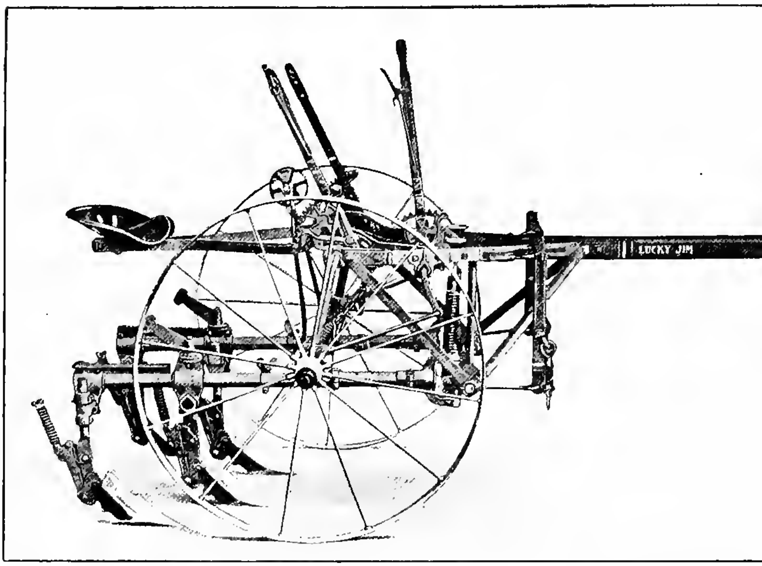

FIG. 154.—"Lucky Jim" weeder. An implement for cleaning the growing crop.

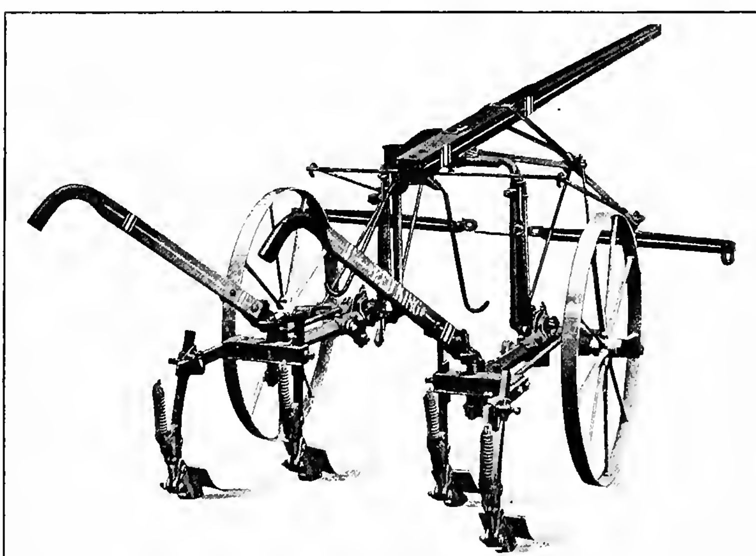

FIG. 155.—"Red King" cultivator. Another implement for cleaning the growing crop.

CHAPTER X.

DISEASES AND PESTS OF THE MAIZE CROP.

Every crop has its pest.
—Proverb.

Overgrown, through long years of peace and neglect, with grass and alien weeds.
—HAWTHORNE.

Plant Diseases.

SPEAKING broadly, maize in South Africa appears to be less seriously affected by disease than most crops; though the maize plant is the host of certain rusts and smuts, they do not appear—at present, at least—to materially affect the yield. The principal diseases are: brown rust (*Puccinia Maydis* Bereng), red rust (*Puccinia purpurea* Cooke), maize smut or "brand" (*Sorosporium reilianum* (Kühn) McAlp.), dry-rot (*Diplodia Zeæ* (Schw.) Lév.), and leaf scorch (*Helminthosporium turcicum* Pass.). CHAP. X.

361. *Brown Rust of Maize.*—This is a fungus, *Puccinia Maydis* Bereng (Fig. 156), which usually appears when the maize plants are in flower, or a little earlier. At first a few isolated brown pustules are to be seen on the leaves and, later, the leaves and sheaths are gradually covered with pustular areas, which bear both the uredo- and teleuto-spores. According to the Plant Pathologist of the Department of Agriculture, Union of South Africa, 'abundant teleutospore masses are formed on the leaves, sheaths, and stalks towards the close of the rust season, and the incubation period of its uredo-stage is of considerably shorter duration as compared with that of other cereal rusts, viz. five and six days instead of about ten days; this must aid in the rapid spread of the disease. The parasite is widely distributed, occurring practically wher-

CHAP. X. ever maize is grown, e.g. in the United States, France, Germany, Italy, India, and South Africa.

He (*Evans*, 3) notes that some breeds of maize "are far more susceptible than others; those varieties which have been longest in the country, e.g. *Transvaal Yellow*, seem to be affected most"; apparently this depends in part on seasonal conditions and the stage of development of the maize plant at the time these conditions prevail. In Rhodesia it has been stated that *Hickory King*, *Golden Dent*, and *His Excellency* were particularly susceptible. In the season 1905-6 over one hundred strains of maize were under cultivation at the Botanical Experiment Station, Pretoria, and brown rust appeared on nearly all of them, to a greater or lesser extent; *Transvaal Yellow* and *Egyptian* were very appreciably affected by it, but there was little damage apparent on the others.

Brown rust is also said to propagate upon the teosinte and sugar-cane plants.

A serious outbreak of rust in the maize crop of the Pretoria district in February, 1911, coupled with reports concerning the damage done elsewhere, especially in the Eastern districts of the Cape Province, in Rhodesia and in British East Africa, rendered an investigation of the life-history of the pest advisable, for in many instances a large proportion of the plants were so severely attacked that they set no ears. To quote directly :—

"The severe epidemic of the rust at the Botanical Experiment Station, Pretoria, was preceded by a heavy and most noticeable æcidial infection of *Oxalis corniculata* plants close by, and the probable association of these two rusts, the one with the other, was immediately suggested by Prof. J. C. Arthur's cultures of Uredineæ in 1904, in which he found that the æcidiospores of *Æcidium Oxalidis* Thuem., on *Oxalis cymosa* Small., when sown on maize produced the uredo-form of *Puccinia Maydis* Bereng.

"A collection of the infected *Oxalis corniculata* leaves was made and a number of healthy maize plants, growing in the greenhouse, inoculated with the æcidiospores thus obtained. In ten days all the inoculated plants were showing a profuse development of uredo-pustules of *Puccinia Maydis.* This result left no doubt as to the connection between the æcidium on *Oxalis corniculata* and the brown rust of the mielie. Thus

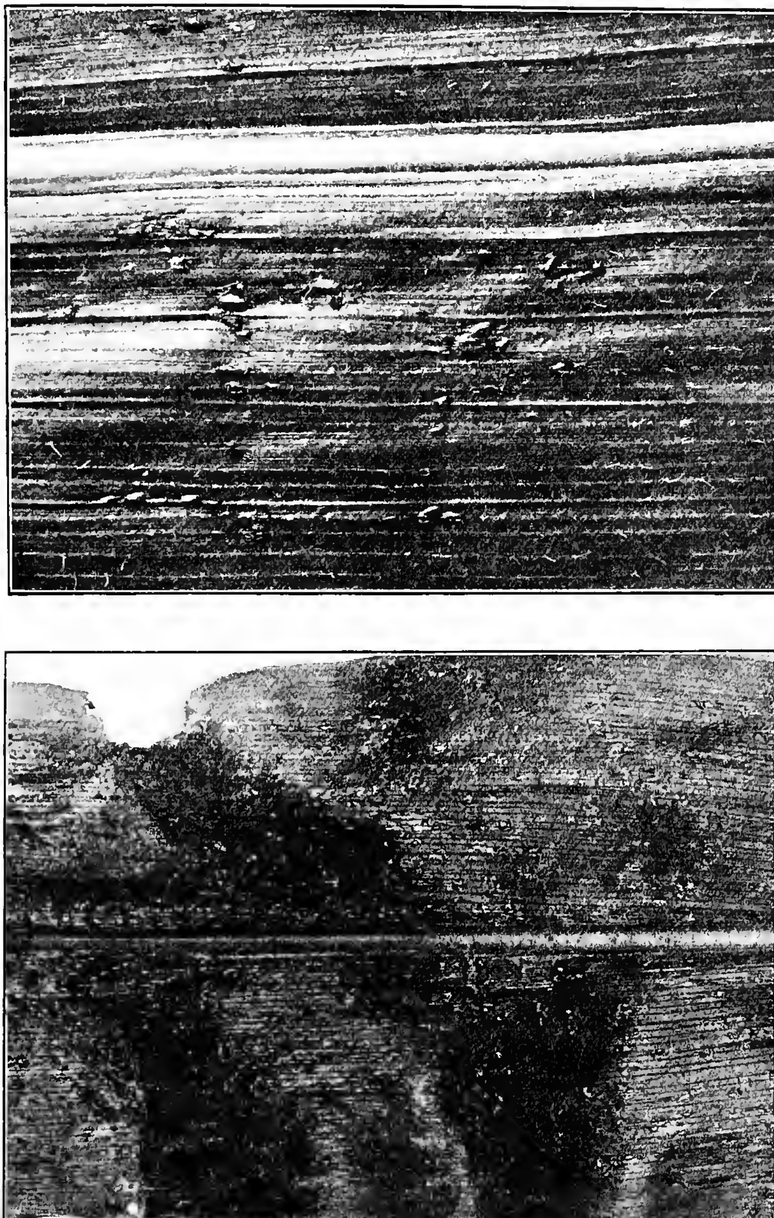

Fig. 156.—Brown rust of maize.

CHAP. X. it was evident that the little yellow sorrel, *Oxalis corniculata*, was in part responsible for the rust epidemics in the mielie; but whether it is the only host for the æcidial stage of the rust is a matter for further investigation. Strange to relate, the first Æcidium recorded on Oxalis was collected in South Africa as far back as 1876 by the late Prof. P. MacOwan on *Oxalis Bowiei* and was named and described by Von Thuemen as *Æcidium Oxalidis*. Whether this Æcidium is the same fungus as that which occurs on *Oxalis cymosa* and on *Oxalis corniculata* seems at present doubtful, although Arthur is of opinion that they are identical.

"My reason for regarding the Æcidium on *Oxalis Bowiei* to be different from that on *Oxalis corniculata*, is due to the fact that repeated inoculations of *Oxalis Bowiei*, *Oxalis setosa*, *Oxalis Smithii*, and *Oxalis corniculata*, have only resulted in the infection of the last-mentioned plant, whereas the others, which are endemic to the country, have always remained immune.

"Specimens of the artificially infected *Oxalis corniculata* leaves were submitted to Prof. P. Magnus of Berlin and the Æcidia were confirmed by him as being identical with *Æcidium Peyritschianum* Magn., which was collected on the same species of Oxalis in the Austrian Tyrol in the year 1893" (*Evans*, 4).

The brown rust has not hitherto been regarded as a serious pest of the maize crop in South Africa, but Mr. Pole Evans considers that before very long it will have to be reckoned with as one of its most serious enemies; "the more that maize is grown, the more the disease will manifest itself". He (3) does not suggest remedial measures other than "paying all possible care and attention to the cultivation of rust-resistant varieties, while those which show tendency to rust should be discontinued at all costs, as they are to a large extent responsible for the rapid spread of the disease," but he hopes "shortly to publish full details regarding the life-history of this rust".

362. *Red Rust of Maize.*—This is the fungus *Puccinia purpurea* Cooke; as far as observations in South Africa go it is at present confined to the Province of Natal. It is readily distinguished from the brown rust of maize by the discoloration produced in the leaf by the uredo-pustules, which are distinctly red, to blood-red (*Evans*, 4).

363. "*White Rust*" *or* "*Blight*".—In certain seasons the maize crop in some localities is affected by a disease which causes the plants to "whiten" and wither off prematurely as though frost-nipped; sometimes it becomes so serious that a large part, or it may be the whole crop, is lost. This trouble has been reported from the Transvaal, Orange Free State, Natal, and Rhodesia, under the name of "white rust" or "blight". Some farmers consider certain breeds to be more susceptible than others; inquiry shows, however, that in some cases *Hickory King* was affected and *Iowa Silver-mine* or *Yellow Horsetooth* on the same farm appeared to be less susceptible, while in other cases *Iowa Silver-mine* suffered and *Hickory King* was not affected. Whether this disease is due to fungus or bacterial causes does not appear to be yet known; the writer has observed that somewhat similar symptoms are sometimes produced by *drought*, and disappear when the crop has been irrigated. If drought should prove to be the cause of white rust, the incidence of the disease as referred to above would be explicable; the varying conditions of the soil might easily account for one field being affected while another, perhaps carrying a different breed of maize, remained healthy.

The occurrence and serious nature of this disease in Rhodesia were referred to by Mr. Odlum (4) in 1906, but he does not explain the cause of the trouble. He suggests, however, as a remedial measure, the breeding of "blight-resistant" strains; if drought is the cause, the breeding of "drought-resistant" strains would probably assist in some measure.

364. *Maize Smut or* "*Brand*".—This fungus parasite, *Sorosporium reilianum* (Kühn) McAlp.,[1] is conspicuous in one stage of its life-history as large, black, sooty masses on the tassel (Fig. 157) or the ear (Fig. 158); when it occurs on the leaves it appears generally in the form of black streaks. How long maize smut has been known in South Africa is not clear, but its occurrence in the Cape Province was commented on in June, 1906 (*Anon.*, 3). It is now a familiar phenomenon to almost every farmer throughout South Africa; the microscopic fungus-plant lives as a parasite within the tissues of the maize plant, and is only seen by the ordinary observer when it breaks

[1] Also known as *Ustilago Maydis* (DC.) Corda, and *Ustilago Mays-zeæ* Magnus (*Evans*, 1).

CHAP. X. out on the surface of the invaded parts as a black dusty mass. To quote Mr. Pole Evans (1, 2, and 3): "The black powder or smut consists of myriads of microscopic reproductive bodies, commonly known as spores. They serve to propagate the fungus and disseminate the disease, and correspond in function to seeds in the higher plants. Each spore is brown and spherical, and measures about one thirty-three hundredths of an inch in diameter. Under favourable conditions these spores germinate, and give rise to a number of secondary bodies, which are blown about by the wind.

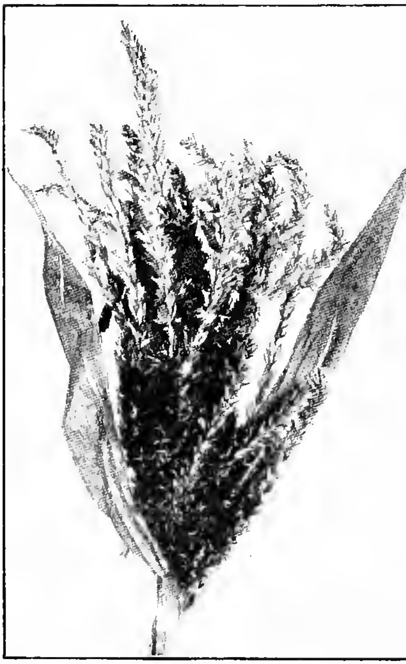

FIG. 157.—Maize smut or brand on the tassel.

"It is found that the spores germinate more readily, and also give rise to a larger number of secondary bodies, in fresh stable manure than in ordinary soil. Consequently, if a heavy dressing of fresh stable manure is applied to land infested with smut spores just before planting, the risk of infection will be much greater to plants growing in such ground, inasmuch as more secondary bodies will be produced than would have occurred in untreated land.

"As the secondary spores are able to infect all young and tender parts of the maize plant, their presence in the maize lands should be prevented as far as possible. This can best be done by removing and burning all smutted plants, by using *seed free from smut spores*, and by avoiding the use of fresh stable manure at the time of sowing."

This parasite is said to occur wherever maize is grown. It appears to be spreading in some parts of South Africa. In some cases in the Standerton District, Transvaal, it was found to affect 2 per cent of the plants in several crops of maize; 2 per cent on a 10 muid per acre yield means a loss of 2 muids from every 10 acres, or 20 muids from 100 acres, which at 8s. per muid amounts to £8. The general average of infected plants in the United States crops is said not to exceed 1 or 2 per cent; but Prof. Brewer reports having heard of cases of CHAP. X.

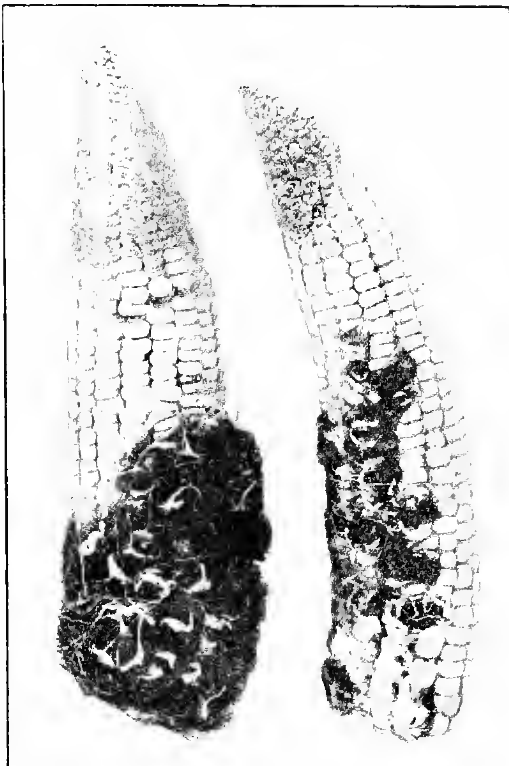

FIG. 158.—Maize smut or brand on the ear.

16 per cent, and Prof. Bessey states that in a garden where sugar maize had been grown for several years in succession, 66 per cent of the crop was destroyed by smut in one season (*Weed*, 1).

Maize smut is quite a different fungus from the smut of wheat, oats, etc.; it gains access to the plant in a different way, and is not controlled by dipping seed in bluestone or formalin solutions but by destruction of infected plants. Most people, CHAP. X. says an American writer, do not begin picking smutty ears until it is too late, when the sooty spores have already begun to be scattered by the wind and to infect the ground; if the work is begun earlier in the season, and all plants showing the small pustules on the young tender parts of the plant are gathered and burned, the enormous crop of spores which would otherwise be produced will be prevented from coming to maturity. The ear, when it is first affected, appears as a white malformed mass, sometimes the whole ear, sometimes a part only of the grains, being changed; the white mass gradually grows darker, finally becoming brownish-black and powdery; on the tassels the swellings are not so large, and on the stem and leaf their size varies greatly (*Weed*, 1).

"Where domestic animals are allowed to eat smut in the field they become the carriers of the spores, and their droppings, filled with the still living spores, become the centres of infection. No animal should be permitted to eat smutted corn, even though the owner be convinced of its harmlessness to the animal itself. The harm lies in the distribution of the spores, which are little, if at all, injured by passing through the alimentary canals of animals" (*Bessey, quoted by Anon.*, 3).

Many farmers believe that corn smut is injurious when eaten by cattle. Cases of death attributed to this cause are not common, however, and feeding experiments made by Professors Gamgee, Henry, and others, indicate that the amount of smut which cattle are likely to eat, under ordinary circumstances, would do little, if any, injury (*Weed, quoted by Anon.*, 3).

The only other known host plant of *Sorosporium reilianum* is teosinte (*Euchlæna mexicana*), which suggests the near relationship of the latter to *Zea Mays*.

365. *Leaf Scorch or Maize "Blight"*.— Leaf scorch or maize "blight," *Helminthosporium turcicum* Pass., is a fungus parasite common on the leaves of the maize plant in South Africa, "forming somewhat elongated, reddish-brown areas". It is said to commonly attack the plant also in Southern Europe, Queensland, and the United States. This fungus is sometimes discussed in the literature under the names *Helminthosporium inconspicuum* Cooke and Ellis, *Helminthosporium graminum* Rab., and "leaf-blight fungus". In the

United States this disease is considered to have "little economic importance" (*Hunt*, 1). CHAP. X.

366. *Ear-rots of Maize.*—In 1910 at Vereeniging and at Potchefstroom, and in 1912 at Ladysmith, Natal, the writer found maize ears affected with a fungus reminding him of *Diplodia Zeæ* (Schw.) Lév.[1] (Fig. 159) as it occurs in the

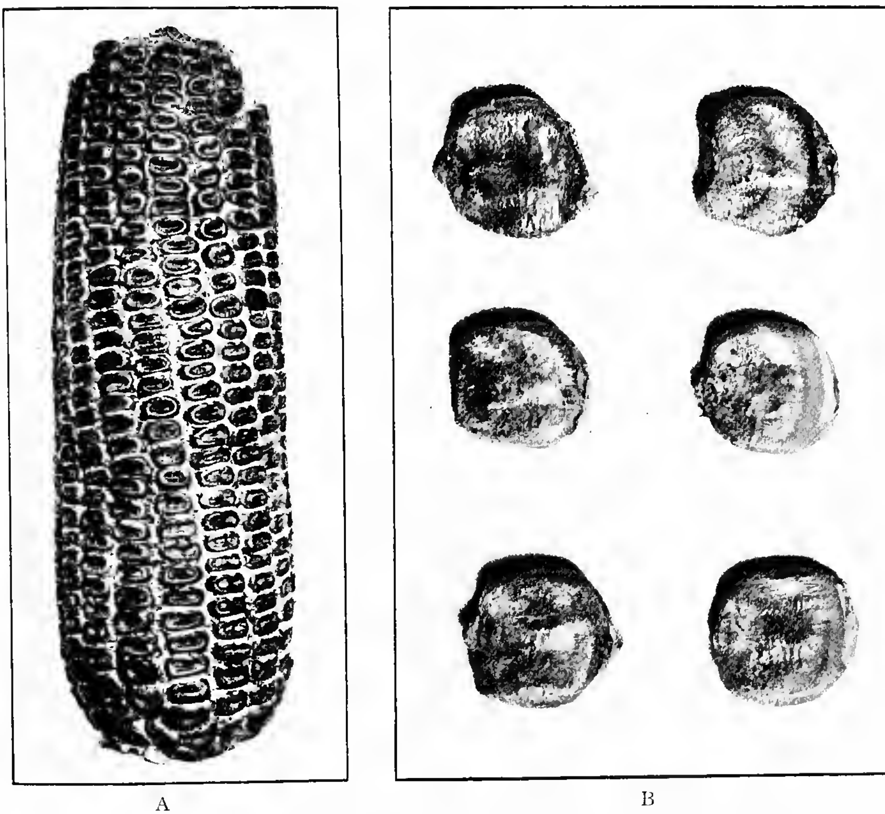

FIG. 159.—Dry-rot of maize, *Diplodia Zeæ* (Schw.) Lév. A, Ear showing white hyphæ; B, Grains showing small black fruiting bodies of the fungus.

United States. Subsequently these were so identified by the Acting Plant Pathologist in Pretoria. In the State of Illinois the annual loss from ear-rots is said to be from 2 to 4·5 per cent of the entire crop, representing a money loss of from

[1] Also known as *Diplodia Maydis* (Berk.) Sacc.

CHAP. X. $2,000,000 to $5,500,000. Ninety per cent of the rot is found to be due to *Diplodia Zeæ* (*Heald*, *Wilcox*, and *Poole*, 1). In Nebraska it has been found that there is a loss of weight on infected ears of over 50 per cent (*Burrill* and *Barrett*, 2).

This disease is shown in Fig. 159, and is very fully described and well illustrated by Burrill and Barrett (1 and 2),[1] who conclude that "in the case of the Diplodia disease, . . . the fungus perpetuates itself over winter on old diseased ears and old stalks," and recommend that all diseased ears be collected and burned, and that where fields are infected to any considerable extent, the stalks be deeply ploughed under or burned. "If the first suggestion is adopted and the second followed wherever necessity demands it," they consider that serious losses will be practically prevented.

In Illinois three species of *Fusarium* are found to be largely responsible for 10 per cent of ear-rot in that State; the characteristic rot of each species is described by Heald, Wilcox, and Poole (1).

Smith and Hedges (1) point out that there is little doubt that the manner of infection by ear-rots is from the soil into the roots, from these to the interior of the stems, and thence upward to the cobs, and finally to the grains, but that it is not unlikely that certain soil conditions may favour or hinder the root infection.

"Unquestionably the *Diplodia*, like the *Fusarium*, is a soil-organism persisting from year to year in infected fields, which for this reason should be staked off and planted to other crops than corn."

They further suggest that "it is also worthy of inquiry whether this fungus may not be the cause of the so-called 'cornstalk' disease prevalent among cattle in the West. It is also possible that to *Diplodia* should be referred the great number of deaths of negroes in the South during the past three years, from the so-called *pellagra* (Chap. XIV) following the consumption of mouldy corn-meal and mouldy hominy. This fungus (*Diplodia*) is also a cause of mouldy corn in Italy. The only other fungi we have reason for suspecting in this connection are species of Aspergillus" (*Smith* and *Hedges*, 1).

[1] See also Barrett (1).

367. *Dothiorella.*—A disease of maize is recorded as occurring in Cochin China, caused by a fungus of the genus Dothiorella (*Foëx* and *Berthault*, 1).

368. *Burrill's Bacterial Disease of Dent and Sugar Maize.*—A bacterial disease is reported as affecting the roots of young maize plants in some parts of the United States, but the writer is not aware that it has yet made its appearance in South Africa.

"The young plant is first affected in the roots. After midsummer the disease manifests itself also in the full-grown corn stalks, more particularly on the leaf-sheaths, by certain discoloured areas. Even the developing ears are often infected, showing a jelly-like disposition, occasionally becoming a mass of rotten slime. An attack upon the very young plant means the dwarfing of its growth and destruction of the crop. A lessened yield and valueless fodder are the only results of infection of the more mature stalk. The presence of the disease is noted to a greater extent some years than others. Means of prevention have not yet been carefully studied, but destroying affected parts is said to be the only sure way of absolute eradication. This disease is sometimes known as 'corn blight'" (*Illinois Station Bull.*, 5).

369. *Stewart's Corn Wilt.*—Another bacterial disease, in this case caused by *Pseudomonas Stewartii*, has been reported as destroying whole fields of maize in the United States. Affected plants are said to wilt and dry up, but do not roll up as when they suffer from lack of moisture. Young plants die in a few days, but older plants may live for some time after the first attack (*Bowman* and *Crossley*, 1).

370. *Yellow Foliage.*—Yellowness of leaves points to an unhealthy condition of the plant. It need not necessarily indicate the presence of a parasitic disease, but is often caused by a wet, cold soil, or the lack of sufficient sunshine, either condition interfering with the proper nutrition of the plant.

371. *Chlorosis.*—In Java the maize crop is said to be particularly subject to *Chlorosis*, i.e. absence of chlorophyll, which results in the development of white leaves. Cavers (1) notes that chloritic culture plants are easily obtained with maize, and that the condition is readily remedied by adding an iron salt to the culture fluid.

372. *Physiological Effect of Drought.*—Drought usually

CHAP. X. causes the leaves of the maize plant to curl up their edges in folding, and to assume a bluish- or in extreme cases whitish-green tint.

Weeds.

Rich soils are often to be weeded.—BACON.

373. *Weeds.*—A weed is a plant growing spontaneously where it is not wanted.

When newly-broken veld is used for maize, weeds are not very troublesome, and cleaning is then a comparatively small item in the cost of production. But in three years, or less, of continuous maize cultivation the land becomes foul and more time and labour are required to keep it clean. Cases occur where maize has been grown continuously for several years and where, owing to scarcity of labour, weeds have become such a pest that the yield is not more than one muid (200 lbs.) per acre.

The weed question does not appeal to the farmer who controls such large areas that he can plough up new lands for maize, year after year, and abandon the old to grass. But the number of those who have no more suitable unbroken veld available for cropping is yearly increasing; as the farms become divided into smaller holdings, and as it becomes necessary to crop the old lands, the weed problem is certain to become more acute. The farmer who has been used to the method of breaking new lands each year, already complains that under the changed conditions maize-growing is becoming unprofitable, and that as the new lands become exhausted South Africa will cease to be a maize-producing country. We do not agree with this pessimistic view; in other countries maize is grown profitably on old lands, lands which have been for centuries under the plough, and the same can be done in South Africa; it is only necessary to revise the methods to meet the changed conditions. In any case maize requires *cultivation* to give the best returns, and the cultivation of the lands for the purpose of cleaning them of weeds will, in addition to destroying the weeds, greatly increase the maize crop (¶ 307).

374. *Parasitic Weeds.*—Weeds may be profitably discussed under two heads, *Parasitic* and *Non-parasitic* weeds. Plant parasites in general are those which draw some, if not

all, of their food materials directly from the plant on which they grow, thus obliging the host to provide food for two, when it is constructed to feed only itself. Under this head come the smuts, which have already been discussed, as well as certain weeds such as the is-ona or witch-weed which are considered later (¶ 388). CHAP. X.

375. *Non-parasitic Weeds*, on the other hand, starve the young plants by robbing them of light and air, and indirectly of their provision of food and moisture. A farmer cannot profitably grow both weeds and maize on the same land at the same time; in ninety-nine cases out of a hundred one or the other will suffer, and that one will be the maize, inasmuch as a weed is a weed because it is usually hardier than the crop that it infects.

The principal non-parasitic weeds are of two sorts:—

(1) Those which are *Perennial*, or continue from year to year by means of a persistent root-stock which keeps alive, though often dormant, through the winter.

(2) The *Annual* weeds, or those which die in the winter and are reproduced again next year from seed scattered in the preceding autumn.

376. *Perennial Weeds.*—From one point of view perennial weeds are the most difficult to eradicate, but as they can be dealt with during the dry winter months, when other agricultural operations are largely at a standstill, they are, in a way, more easily disposed of than annual weeds.

The most pernicious perennial weeds are: Bermuda quick-grass (*Cynodon Dactylon*), and uintjes (*Cyperus esculentus* and *C. rotundus*). Two others also threaten to become troublesome in South Africa, viz., bindweed (*Convolvulus arvensis*) and sorrel (*Rumex Acetosella*), but up to the present time we have not met with them in the maize crops. Khaki-weed (*Alternanthera Achyrantha*) and bachelors' buttons (*Gomphrena globosa*) appear from their habit less likely to become injurious.

377. *Annual Weeds.*—The annual weeds grow, on the High-veld of South Africa, almost exclusively in the wet summer months. When the rains fall at sufficiently long intervals to allow the soil to dry out thoroughly, the weeds can be kept down with the horse-cultivator. It often happens, however, that the rains fall so continuously during the height

CHAP. X.

of the growing season, that the lands remain too soft for cultivation, over a long period, and the weeds are apt to get ahead of the maize crop unless other methods of treatment are adopted.

The principal annual weed-pests of the maize crop in South Africa are: mest-briede (*Amarantus paniculatus*), black-jacks (*Bidens pilosa* and *B. leucantha*), the sweet-grasses (*Chloris virgata* and *Panicum lævifolium*), goosegrass (*Eleusine indica*), stink-blaad (*Datura Stramonium* and *D. Tatula*), wild gooseberry (*Physalis minima*), Mexican marigold (*Tagetes minuta*) and *Nicandra physaloides*.

Many other annual weeds occur in the maize fields, such as rooinek (*Zinnia pauciflora*), burweed (*Xanthium spinosum*) and kaffir melons (*Citrullus vulgaris*), but they are less troublesome than those mentioned in the preceding paragraph.

378. *Volunteer Maize.*—Volunteer maize plants may be considered weeds in the sense of our definition. They cross-pollinate plants of the main crop, thus producing "mixed," and consequently inferior, grain. When volunteer plants come up between the rows, they are usually removed by the cultivator; but it often happens that they come up in the rows themselves, and it is then more difficult to eradicate them. When it is remembered that a single maize tassel may produce from 3,000,000 up to 30,000,000 grains of pollen, that these pollen grains are so light that they may be carried by the wind for a distance of a quarter of a mile, and that it requires only a single grain of pollen to fertilize one grain of maize, it is readily seen that much damage may be done by a single volunteer plant.

The appearance of volunteer maize is due to several causes, e.g. the planting of different breeds on the same land in successive years; the dropping of ears or of loose grains on the land at harvest; the dropping of undigested grain in the dung of animals working in the fields or pasturing on the stover.[1]

379. *How Weeds Spread.*—The question sometimes arises as to how weeds get into the lands, and how they spread so rapidly in spite of cultivation. It is often found in the first

[1] The Ohio Station found that 43 per cent of the dry maize grains which pass whole through the alimentary tract of cows will germinate, but none of those which have been ensiled.

season after breaking new veld that weeds appear which do not grow in the unbroken veld, such, for example, as Mestbriede, *Amarantus paniculatus*. This particular weed is greedily eaten by mules and other stock ; the seeds are hard and pass through the alimentary tract undigested, ready to germinate with the first favourable opportunity ; if the droppings of the mule or ox fall on land newly broken, the Amarantus seeds become buried in the loose soil and a seedling soon follows the advent of favourable weather ; but if it falls on hard, unbroken veld, the probability is that the Amarantus seed will be picked up by a seed-eating bird ; or it may lie on the hard ground, sprout with the rains, and fail to grow into a fully-developed plant because the soil is too hard for the roots to penetrate quickly, and in the meantime the grass and other veld plants choke it.

The seeds of other weeds, such as the sweet-grass (*Chloris virgata*), are carried by the wind and scattered broadcast over the veld ; they do not grow readily in the unbroken veld because the soil is too hard. But they will grow readily in loose, washed soil deposited along the roadsides, and soon develop seed ready to be blown across to any newly-ploughed lands in the vicinity. A few plants along a roadside will soon supply enough seed to cover whole fields.

Blackjacks and burweed are carried on the legs of the mules and oxen which plough and work the land, or which are turned into the waste lands to eat down the stalks. These animals also spread weeds such as stink-blaad (*Datura*), the seeds of which pass through their alimentary tracts undigested.

A South African farmer was once heard to remark that he would never turn cattle into his lands to eat his maize stalks because they would spread the seeds of weeds in their droppings. He might with as much reason argue that he would not use a gun because people have been killed through accidents with guns. Both guns and dung are necessary ; even the weeds brought in by the dung are valuable if turned into manure.

Perennial weeds, such as quick-grass (*Cynodon Dactylon*) and uintjes (*Cyperus*, spp.), are spread from one field to another by the plough, cultivator, or harrow, if these implements are not properly cleaned before they are transported from a weedy part of the farm to clean lands.

CHAP. X.

380. *Plant Less Maize and Produce More.*—The solution of the weed problem lies in planting only so much maize as can be well cultivated. A small acreage well cultivated gives better returns than a large area allowed to become weedy. In maize-growing it is the *high average yield* per acre which pays; a low yield per acre makes an unprofitable crop. Unless one can get a high average yield the cost of production takes too much out of the cash returns; *then* the farmer finds that "maize-growing does not pay".

381. *Cultivation.*—The South African farmer complains that it costs too much to keep the lands well cultivated and clean. The American maize-grower cultivates thoroughly though he has to pay more for his labour, yet he finds it profitable; the secret of this is the higher yield per acre which he obtains through clean cultivation. The average South African farmer says that he cannot get enough labour for clean cultivation; the American has less labour, and therefore plants only 90 or 100 acres to the South African's 300 or 400. Those successful South African farmers who produce 15 to 20 muids per acre, do so by dint of good cultivation; some give as many as eight cultivations in a season. Those who complain of having too little labour for more than four cultivations could give eight by halving their acreage. Where there is a small acreage, check-rowing may be practised; this allows the land to be cross-cultivated and facilitates clean cultivation.

The initial costs of ploughing, disking, harrowing, and cultivating an acre of ground are the same, whether the resulting crop is light or heavy; so that every additional 100 lbs. of maize from that acre means so much extra profit, or, in other words, reduces the cost of production per bag.

382. *Effect of Clean Cultivation of the Maize Crop.*—To demonstrate the value of cultivating the maize crop and keeping it free from weeds, an experiment was carried out at the Botanical Experiment Station, Pretoria, in 1905-6, on a piece of good black vlei land, which was weedy with sweet-grass, wild gooseberries, and mest-briede. *Transvaal Yellow* flint and *Hickory King* dent were used. The land was treated uniformly before planting and all the seed was planted on the same day; no manure was given in either case. No cultivation was done on

one half of the plot, which was about one-eighth of an acre in size (70 × 150 feet); the other half was cultivated and cleaned of weeds three times during the period of growth. CHAP. X.

The increase in yield on the cleaned plot was marked; the difference in total weight of stalks as cut was 75·7 per cent. In weight of cobs it was 57 per cent with the *Transvaal Yellow* flint and 70 per cent with *Hickory King*.[1]

383. *Harrowing.*—The cost of cultivation can be greatly reduced by the liberal use of the harrow both before and after planting, until such time as the maize plants are too large for the harrow. To be effective, the harrowing must be done as soon as a new crop of weed-seedlings appears, and while these are so small that the harrow will break their roots instead of merely passing over the weeds.

384. *Fallowing.*—In localities where the soil is apt to remain so wet, for a long period, that it is impossible to get on to it with the cultivators until the weeds are injuring the crop, some other method of treatment must be adopted. A season's crop of weeds comes from the seeds lying within the first few inches of soil. Those which lie deeper remain dormant till brought to the surface by the plough. It is obvious, therefore, that if all the surface weeds are killed, and no fresh crop of seeds is brought up from below by frequent ploughing, the cost of cleaning may be materially reduced. The principal weeds of the Maize-belt grow mostly in the summer, which facilitates the cleaning of lands allowed to lie *fallow* for a summer; during this time two or three crops of weeds are ploughed in or disked in, as fast as they come up, and before they go to seed. Weeds ploughed in in this way form a manure, adding humus to the soil. The resting of the land after two or three seasons' cropping with maize is also advantageous; land cannot be cropped continuously with the same crop, unless methods are practised which will replace some of the ingredients removed from the soil by that crop; fallowing and ploughing-in the weeds helps to renovate the soil (¶ 310).

385. *Rotation of Crops for Cleaning Purposes.*—A suitable rotation of crops assists in keeping the land clean (¶ 311); another crop, such as vetches, black medik, or teff, may be grown at a different season, or sown later than the maize crop,

[1] *T.A.J.*, Vol. V, No. 18, p. 450, January, 1907.

CHAP. X. and thus allow the land to be harrowed free of those kinds of weeds which are not affected by winter tillage. One of the advantages of a catch crop like teff is that it is a short-season crop, which allows the farmer time for a certain amount of summer fallowing, while it also enables him to get some cash return the same season, for his labour. Teff, velvet beans and some other crops are useful as "smother-crops"; if sown thickly they will sometimes clean the land by choking-out a crop of such weeds as grow more slowly than the smother-crop.

Mangels and potatoes are useful "cleaning crops" for maize, as the cultivation necessary for these crops greatly reduces the stock of weeds stored in the land. Cabbages would have the same effect, but it is said that a cabbage crop greatly reduces the subsequent crop of maize, possibly because of the poisonous nature of the decomposition products of the cabbage stem and roots.

386. *The Best Time to Kill Weeds.*—"The best time to kill weeds is just as the seeds are germinating, or while they are yet very small. When this is done, but little moisture is lost through them, and they render but little plant food insoluble. In the thorough and early preparation of the seed-bed many weeds are destroyed by killing them just as they are coming up. So, too, in the case of a grain field which is rolled after being seeded, and is then harrowed; the rolling hastens the germination of the weed seeds, and the harrowing then throws them out into a dry soil, which kills them. If such a field is again harrowed just after the grain is up, a second crop of weeds may be destroyed, and the yield made greater as a consequence. In the case of potatoes and maize it is very easy to destroy at least two crops of weeds before the maize or potatoes are large enough to cultivate, by harrowing before and just after the plants are up. This is very important, because it not only saves plant food for the crop, but it can be done so much more cheaply and rapidly with the broad light harrows and weeders than it can later with the cultivator" (*King*, 1).

387. *Weed Seeds do not all Germinate at once.*—"It must be remembered in handling soils to kill weeds that the seeds do not all germinate at once. The first harrowing which is done to kill weeds may itself bring up from below seeds which

were too deep in the ground to grow, or it may cover some seeds which were lying upon or too close to the surface to germinate, hence frequent cultivations for hoed crops are needful" (*King*, 1). CHAP. X.

388. *Is-ona, Witch-weed, or Rooibloem.*—The is-ona, witch-weed, or rooibloem, *Striga lutea* Lour. (Figs. 160 and 161),

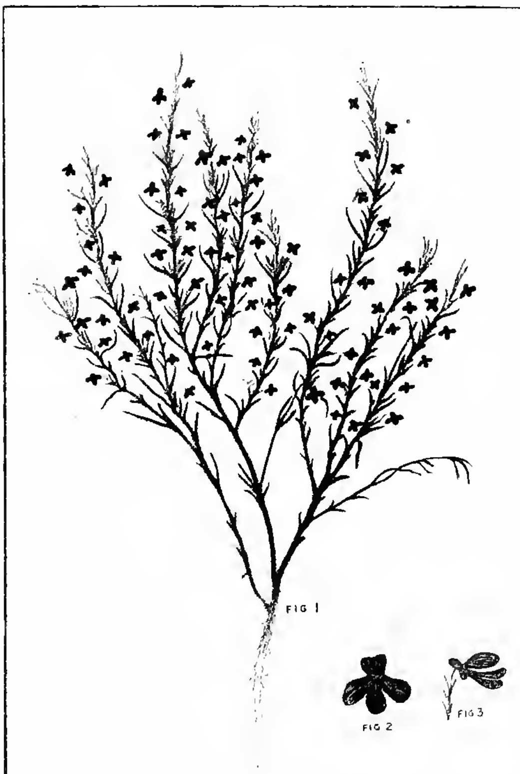

FIG. 160.—Rooibloem, *Striga lutea* Lour.

is one of the most troublesome pests with which the South African maize-grower has to deal. It is a small, branching, herbaceous plant, 6 to 9 inches high, bearing green leaves and bright scarlet and yellow flowers, and is a parasite on the *roots* of the maize plant, to which it is very destructive. It also grows on the roots of kaffir corn, sorghum, and sugar-cane, and has recently been found apparently attacking teff-grass and the pea-nut plant. The seeds are extremely small and light, CHAP. X. and are easily carried by the wind, blown away in the dust, or carried by flood-waters.

They may also be carried on seed-maize, especially if it is sent from place to place on the cob. In 1912 the writer got an ear of *Chester County* from a locality where is-ona occurs, and planted a dozen grains in his garden; the ear itself was taken into the garden and the grain was shelled off on the spot where it was planted; in the middle of January, following, there was a single plant of *Striga lutea* in flower at the foot of one of the plants of *Chester County*. This is the eighth consecutive year in which maize has been grown in this garden, and is-ona has never appeared there before.

Is-ona is known by several other names, e.g. soani, in Natal (see *Anon.*, 2); moloane, i.e. "fire-burner," by the Basutos of the Rustenburg District, Transvaal; fire-weed; rooibloemetje; rooi-bosje; mielie-gift; mielie-poison; the Zulu name *is-ona* indicates that the weed "bewitches" the maize, and supplies the English equivalent by which it is known (*Fuller*, 2).

Is-ona is particularly abundant in the warmer parts of the country, e.g. in Zululand, parts of Natal, and the Bush-veld of the Transvaal. It is occasionally met with on the High-veld Plateau, but does not appear to be really troublesome at the higher altitudes. It would not be wise to conclude, however, that the High-veld is immune; possibly it is only a case of time before it will be established there, and it will be well to take every precaution not to introduce it.

On the Springbok Flats, Waterberg District, Transvaal, there are five leading types of agricultural soil: (1) bright red, (2) grey sandy loam, (3) chocolate, (4) black turf, (5) black loam. It is stated by local farmers that is-ona does not thrive on the first two of these; on the other three it is very troublesome, but does more damage on the chocolate than on the black turf.

The first explanation of the parasitic nature of this pest appears to have been given by Mr. Claude Fuller (2) as early as 1900. He illustrated the mode of attack and the haustoria of the parasite, and showed that the seeds only germinate when a growing root of their host-plant approaches closely to them as they lie in the soil. Also that they are endowed with great longevity, remaining dormant in the soil probably six or more years, until the root of a suitable host-plant approaches CHAP. X.

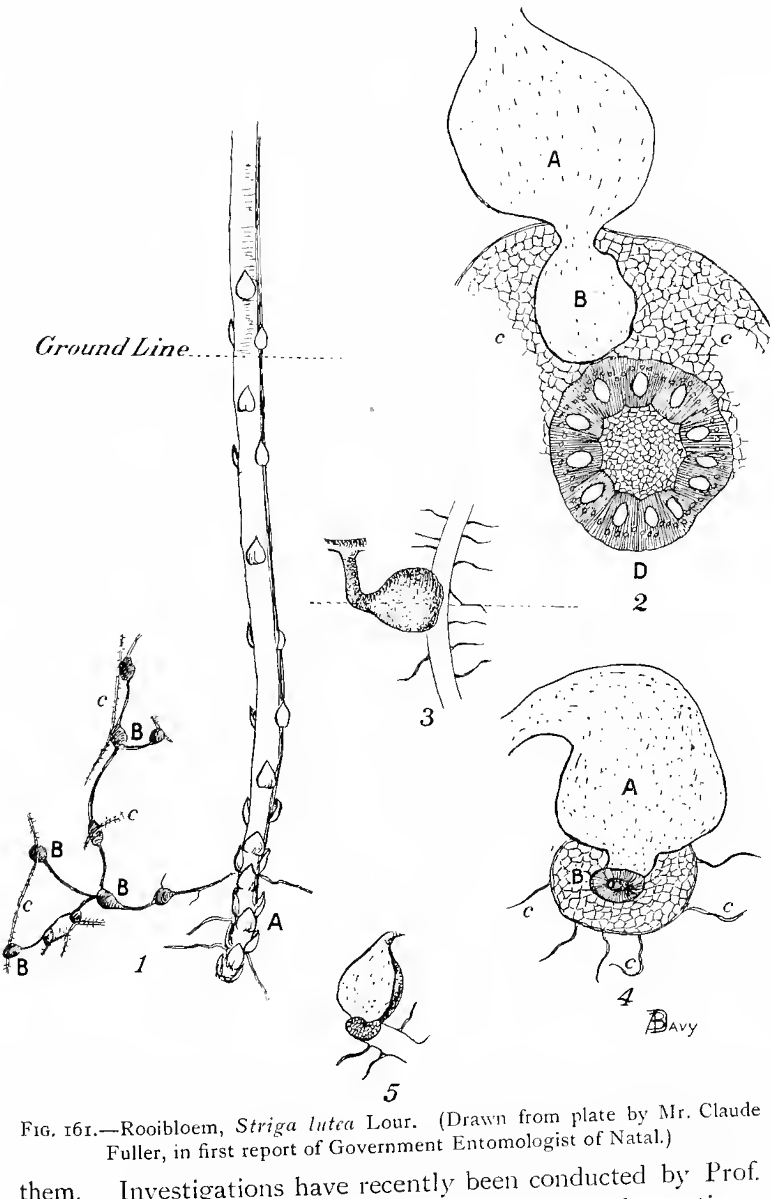

FIG. 161.—Rooibloem, *Striga lutea* Lour. (Drawn from plate by Mr. Claude Fuller, in first report of Government Entomologist of Natal.)

them. Investigations have recently been conducted by Prof. Pearson (1 and 2) which confirm Fuller's earlier observations.

CHAP. X. The anatomy, and the structure and development of the haustorium, of *Striga lutea* Lour., have recently been worked out by Miss Edith L. Stephens (*Stephens*, 1 and 2).

389. *Remedies for Is-ona.*—Discussing this pest in 1904 (*Burtt-Davy*, 1) the writer recommended that the farmer's main efforts should be directed towards *preventing the seeding of the is-ona plants.* "This can be done by hoeing them out wherever they are seen, before they form seed, and by keeping those places constantly cultivated so that the new growth may be killed before it has time to develop. If carried out thoroughly and persistently, this method cannot fail to be successful in the end. If, however, a single crop of the weed is allowed to scatter seed, all the previous work will be lost."

Further investigation of the life-history of this pest has emphasized the importance of this point.

390. *Early Planting.*—Early planting, if sufficiently early, also acts as a check, for in this way the maize plants become well established before the witch-weed has had time to injure them. In the Transvaal Bush-veld the is-ona plant rarely appears above ground until the end of January or the beginning of February. Unfortunately, however, this treatment is not always possible as it depends largely on the favourable nature of the season, and it is not recommended as a final remedy. In the Transvaal Bush-veld the rains usually fall too late to make it practicable (*ibid.*).

391. *Manuring.* — Stimulating the rapid growth of the young maize plant with fertilizers has a beneficial effect on the crop; but where the soil is full of is-ona seed it is not likely that there will be a good maize crop in any case, and it will be a waste of money to put manure upon such land. Where is-ona has not, however, taken a strong hold, heavy manuring with good kraal-manure or steamed bone-flour is likely to be beneficial, as it will produce a stronger growth of the maize plants, and may enable them to develop ears while supporting the parasite as well. But this is only a temporary expedient, making final eradication still more difficult and more remote, for it does not prevent the ground becoming more and more foul with the pest, and more and more heavily charged with its seeds (*ibid.*).

392. *Clear the Land of Is-ona Seed already there.*—On

land which has become infested with is-ona seed, attention should also be directed towards clearing the land of the seed already there. Attempts have been made to starve out the rooibloem by short rotations (one or two years) with leguminose or other crops; these attempts failed to secure the desired result, but demonstrated that the is-ona seed could remain dormant five or six years, and that it would be necessary to clean the land of is-ona seed before maize could again be grown successfully. Two methods of treatment suggest themselves, and are recommended by Pearson (2)—burning and the use of trap crops. (1) Burning: immediately after harvest the rubbish, weeds, and maize roots should be gathered into large heaps and burned *on the places where the is-ona has grown.* (2) Trap-crops: infected areas may be sown down to kaffir corn for silage or fodder; it is essential, however, that the crop be cut, and the roots ploughed in, *before the is-ona flowers*, otherwise the kaffir corn will only tend to propagate the pest.

393. *Buy Seed-maize from Clean Farms.*—As previously noted (¶ 388) is-ona seed may be carried on an ear of maize from an infected to a clean farm. There is less likelihood of its being carried with shelled maize which has been machine-cleaned, but it would be safer not to take unnecessary risks and to refuse to buy any seed from infected farms.

For his own sake the farmer should not allow the harvested maize ears to be laid on infected land, as they may carry the is-ona seed to clean lands.

Animal Pests of the Maize Crop.

394. *The Chacma Baboon.*—In some districts of South Africa, especially where rocky kopjes and kranses abound, the common Chacma baboon, *Papio* (*Chœropithecus*) *porcarius* (Bodd.), Fig. 162, sometimes does considerable damage to the ripening maize crop; "if a herd once takes to a mielie field it will not leave off its daily visits until every cob is destroyed". The general experience, however, is that baboons retreat before the advance of civilization; as closer settlement takes place, and vacant farms become occupied, the pest becomes less troublesome. On the open High-veld plateau one does not hear of damage done by baboons.

The baboon is a wily animal, most difficult to capture;

CHAP. X. various plans have been suggested by writers to the *Agricultural Journals* of the several South African Provinces, but none of them appears to have given uniformly satisfactory results. To quote the late Dr. J. W. B. Gunning, Director of the Transvaal Museum :—[1]

"They live in troops of ten, fifty, seventy, or even more, and their system of spying, and putting out sentries on the highest cliffs would compare favourably with that of any European army.

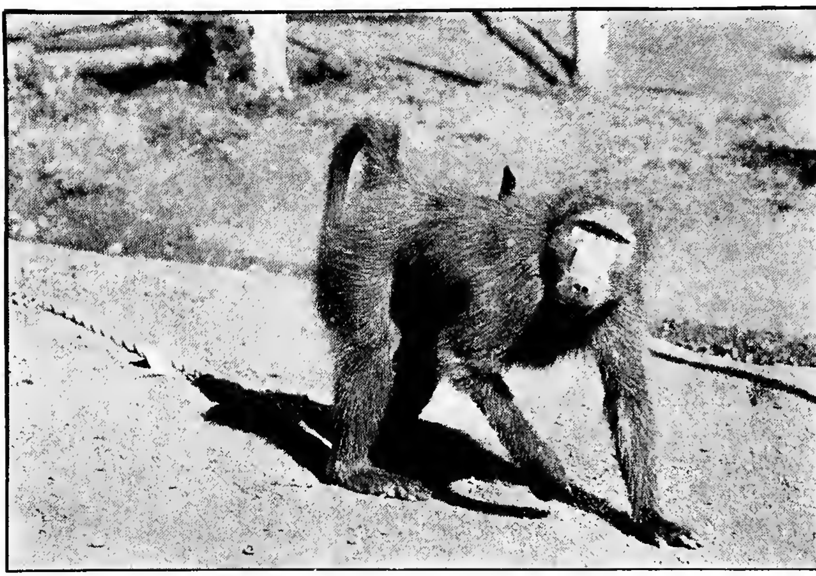

FIG. 162.—Chacma baboon, *Chæropithecus porcarius* (Bodd.). (From *Transvaal Agricultural Journal*.)

"I have tried poison in many ways. Mealies soaked in an arsenical solution and afterwards sun-dried so as to have the aspect of the original size of the corn, and thrown broadcast in places daily frequented by a troop of baboons, were left untouched. Whether the poison was detected and therefore the mealies discarded, or whether the baboons had noticed the human beings near by and therefore did not return to these places for some days, I cannot say; at any rate the mealies were not picked up and no damage done to the baboons. An

[1] *T.A.J.*, Vol. II, pp. 528-31, Plate CXXIII.

old remedy advocated by the early settlers was to make a hole in a pumpkin just big enough to let the empty baboon hand through; the baboon would then come and put his hand through the hole, fill it with pumpkin seed and would not be able to get his full hand back, nor would he think of letting the seeds go in order to withdraw his empty hand, and therefore would be caught. I can only say that I have never been able to catch any baboons in this or any other traps; I have found pumpkins with holes much wider than those made by myself, but the inside of the pumpkin had been eaten or carried off by the intruders.

"In captivity I have tried in vain to destroy baboons with strychnine. I remember one old dangerous specimen which I tried to poison with about fifteen grains of pure strychnine, hidden in a banana. The banana was eaten—almost swallowed whole without biting—in my presence and the baboon did not show the slightest trace of indisposition. I have made similar attempts two or three times with the same negative results. The animals had simply to be shot.

"Neither is it an easy task to approach a troop of baboons with a rifle, and even if one should be fortunate enough to kill one sentry by a well-directed and lucky shot, the troop will escape unharmed, and smarter sentries will be put out next time."

He concludes, however, that the rifle is the only means of destruction; the fight must be kept up continuously for a long time, before an old-established troop will be permanently driven away from its accustomed haunts. He advises the organization of large "drives," at frequent intervals, to surround the favourite haunts of a troop and exterminate it.

Lyddekker in his book, *On Mountain Excursions*, quotes Mrs. Martin (in *Home Life on an Ostrich Farm*):—

"No vegetable poison has the slightest effect on the baboon's iron constitution; and, indeed, if there exists any poison at all capable of killing him, it is quite certain that, with his superior intelligence, he would be far too artful to take it; and when the fiat for his destruction has gone forth, a well-organized attack has to be made on him with dogs and guns. He can show fight, too, and the dogs must be well trained and have the safety of numbers to enable them to face him; for in fighting he has the immense advantage of hands, with which he seizes a dog and holds him fast, while he inflicts a fatal bite through

CHAP. X. the loins. Indeed, for either dog or man, coming to close quarters with Adonis (as the chacma is ironically called by the Boers) is no trifling matter."

Mr. D. E. Hutchins, late Conservator of Forests, Cape Town, notes [1] that some years ago a troop of baboons was doing a good deal of damage in the Government timber plantations at Tokai, near Cape Town, by scratching up the pine seed as fast as it was sown. On a certain day a quantity of pine seed, poisoned with strychnine, was left within their reach, and the next morning seven baboons were found dead near a mountain stream ; after this the band forsook the pine seed for a time. Later they returned, but the seeds meantime had developed into seedlings which were left unharmed by the baboons. Mr. Hutchins concludes, however, that baboons " are so intelligent that I am doubtful whether it would be possible to destroy a whole troop with poison ; after one or two deaths they would either forsake the locality or learn to avoid the poison ".

Mr. P. Thomsen [2] makes this suggestion for ridding a farm of baboons :—

Near the drinking or sleeping places of the baboons sow a small patch of maize. Before the ears appear, begin scattering in the same neighbourhood a little maize grain at intervals of a day or two. When the baboons come to inspect the growing maize they will find the grain on the ground and eat it. After a time begin putting out a few ordinary sweets with the maize grains, and when these have been found to disappear make bonbons in the following manner: Boil some yellow sugar, as for ordinary sweets, and drop it in lumps on a stone slab to cool. When these have been eaten by the baboons, make more in the same way but add to the sugar, while it is still soft in the pan, some glass which has been well cleaned and then pounded fine. Drop this mixture, as before, on a slab to cool. Feed regularly for some time with these glass and sugar sweets, and gradually the baboons will cease to come to the field—the glass is sure to kill them.

Another method recommended [3] is to put out near the haunts of the baboons a number of little heaps of grain or pumpkin seed, each with a detonator or dynamite cap in it.

[1] *T.A.J.*, Vol. III, p. 385. [2] *T.A.J.*, Vol. III, p. 188.
[3] Mr. W. R. Life, of Rustenburg, Transvaal, in the *U.A.J.*

It is said that the inquisitiveness of the baboon will lead him to pick at or bite this bright object and so bring about his own destruction. The caps may also be laid on the twigs of wild fruit trees. It is as well to warn the natives of the nature of these attractive looking things. CHAP. X.

From another source[1] we get this idea for the use of arsenic :—

Cut the tops nearly off some prickly pear fruits, take out part of the seeds, put a small quantity of arsenic in their place, and close down the lid formed by the top of the fruit. Put these near a "krans" or other place where the baboons sleep, taking care to keep away all stock (including goats) as long as any of these poisoned fruits are left.

395. *Monkeys.* — Where bush-land on the sub-tropical coast-belt of South Africa is cleared for agriculture, the common monkey, *Cercopithecus pygerythrus* Cuv., is a source of much annoyance and loss, raiding the maize fields unless the latter are constantly guarded ; in some places piccanins are regularly employed for this purpose. Doubtless as more extensive bush-clearings are made on the coast the number of monkeys will be reduced ; but under existing conditions the coast-belt is considered less suitable for maize-growing than the midlands.

An effective method of poisoning is to boil arsenic with maize, mix it with sugar and put the mixture in places frequented by the monkeys. It is reported[2] that in this way one man killed fifty-five at one time.

396. *Hares.*—The jumping hare or spring-haas, *Pedetes caffer* (Fig. 163), hares, *Lepus capensis* and *L. ochropus*, and other rodents occasionally damage the maize crop, digging out the young plants in spring when green food is scarce, and eating the ears of low-cobbing breeds in the autumn. The jumping hare is usually shot at night by the aid of a lantern which attracts the attention of the animal when out feeding. Various other methods for ridding the farms of this pest have been recommended as follows :—

[1] Mr. G. L. S. Holland, in *T.A.J.*, Vol. III, p. 386.

[2] Mr. F. Oosthuizen, in *U.A.J.*

CHAP. X.

(1) Parboil some ears of green or ripe maize, break them into three or four pieces, slit down a row of the grains cutting fairly deep, widen out the slit a little, fill the cut with a small quantity of strychnine and squeeze the edges together again to prevent the strychnine from falling out. Lay the poisoned bait around the haunts of the jumping hares.[1]

(2) Scatter about the field tiny cakes, about a cubic centimetre in size, made of pollard or some attractive meal in which

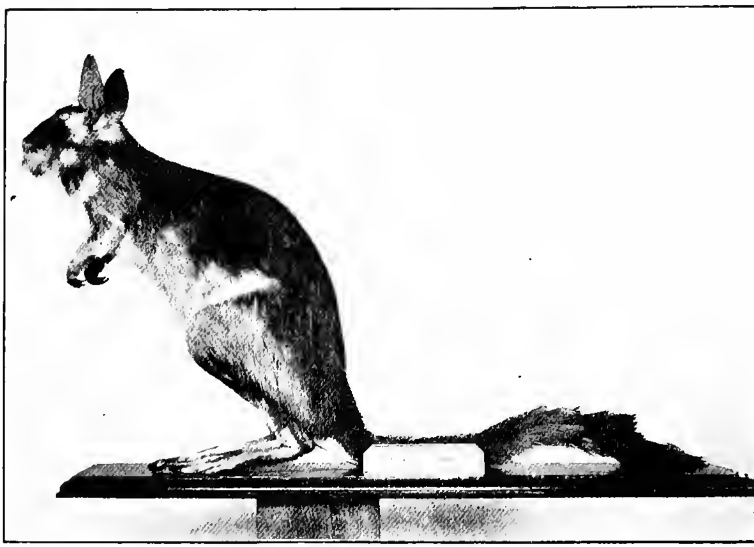

Fig. 163.—Jumping hare or spring-haas, *Pedetes caffer*. (Photograph from specimen in Cambridge University Museum of Zoology.)

has been mixed yellow phosphorus dissolved in carbon bisulphide (the cakes should not be too wet). Five hundred rabbits were reported killed at one time by this method.[2]

(3) A farmer[3] of the Orange Free State says that maize-grain cooked with arsenic is effective, but that the bait must be put out before the young maize plants come up, otherwise the hares will leave the grain in favour of the fresh green shoots.

(4) The same farmer has had great success in driving off the hares by watching carefully for the first signs of digging

[1] Mr. J. J. Keely, of Mosita, in the *U.A.J.*, January and March, 1912.

[2] Mr. J. van S. Wansbrough, of Holpan, Marico, Transvaal.

[3] Mr. N. A. Oberholzer, of Marseilles, Orange Free State, 23 Nov., 1911, in *U.A.J.*

for the young maize shoots. He harrows the land immediately and when the hares find that the ground has been disturbed they do not return. CHAP. X.

(5) Dissolve as much wolf-poison as can be held on the point of a knife, in a little boiling water, together with a large spoonful of sugar, stir into this a large cup of crushed maize and distribute the mixture in the fields.[1]

(6) To one dessertspoonful of Government red poison add three-quarters of a gallon of maize-grain, and make up to one gallon with water. Let it stand for twenty-four hours, then strew the mixture in the field, where the animals are likely to find it.[2]

397. *The Reed-rat.*—In Swaziland, Zululand, and other parts of the north-eastern region of South Africa, considerable damage has been done to growing maize by the reed-rat, *Thryonomys swinderenianus* Temm. It does not appear to be frequent in the Transvaal, but specimens are occasionally met with, and Dr. Gunning reports that whereas it was formerly scarce it now appears to be on the increase. The reed-rat is a large and destructive rodent; in November, 1910, a male reed-rat was killed on the farm "Busby," Lake Chrissie Ward, Ermelo District, weighing 11 lb., and measuring 20 inches in length to the root of the tail, and 19 inches in circumference. The reed-rat is hunted with dogs.

398. *The Porcupine or Yster-vark.*—The porcupine, *Hystrix africæ-australis*, does some damage to the maize crop of the Bush-veld, as it likes the young tender ears. On the High-veld there is no complaint of loss from this cause.

399. *Birds.*—Some damage is usually done to the young newly-planted crop through the depredations of birds, among which are the African rook or zwarte kraai, *Heterocorax capensis* (Licht.), and the blue crane or blaauwe kraanvogel, *Anthropoides paradisea* (Licht.), which dig up whole rows of grain, and appear to be the worst offenders.

It is said that the rook is a great evil-doer; "he delights in continually stealing maize, and does not, apparently, render any useful services. . . . The guinea-fowl [*Numidia coronata*], and blue cranes or kraanvogel [*Anthropoides paradisea* (Licht.)],

[1] Mr. W. L. de Wilde, Heidelberg, Cape Province, 4 Dec., 1911.
[2] Mr. A. du Plessis, of De Aar, Cape Province.

CHAP. X. though undoubtedly useful at times as destroyers of locusts and other insects, have got into the way of plundering maize and other crops."[1]

A farmer[2] of the Cape Province states that the crows dig up his mielies wholesale, as fast as the young plants appear above the ground. He tried shooting the crows and also employed small boys to scare them away, but while these methods were fairly successful after sunrise, the birds visited the fields before sunrise or just after daybreak, and with about 100 acres of maize to watch, it proved impossible to keep them on the wing. He tried with great success the use of arsenic,[3] in the following manner: An ordinary paraffin tin was half filled with maize which was boiled until the grains burst open; to this was added half a pound of the arsenic; the maize was well stirred until all the arsenic was absorbed, and was then strewn about the field.

FIG. 164.—Maize ear damaged by small birds.

The spurwing goose, sporen gans, or wilde makauw, *Plectropterus gambensis* (L.), is often seen on the fields of young maize in early spring, but although the writer has frequently watched he has never detected it digging up the grain or pulling out the young plants.

[1] Senator H. G. Stuart, of Elim, Winberg, Orange Free State, in *T.A.J.*, Vol. III, p. 187.

[2] Mr. Ben. Norton, Berlin, Cape Province, in *U.A.J.*

[3] As specially stocked by South African chemists, at 1/6 per lb., for bird-killing.

Some damage is done at times to maize standing in the field to dry off before harvest, by birds which pick out the grains at the ends of ears (Fig. 164) imperfectly covered by the sheath, and especially of ears standing upright on the stalk. Ears so damaged are more liable to injury from moisture which penetrates the end of the ear where the sheaths have been torn off. One remedy is to breed strains of maize having well-developed sheaths, and ears which hang down on the stem when ripe; selection of the very longest ears for seed purposes is apt to result in badly covered ears.

The birds which do most damage in this way are the Spermestinæ or bishop-birds, especially the southern pink-billed weaver or quela weaver, *Quelea sanguinirostris lathami* (A. Sm.), the red bishop-bird or roode kaffervink, *Pyromelana oryx* (L.), and the sakkaboola, long-tailed widowbird or flap, *Diatropura procne* (Bodd.).

In many parts of the country the natives erect in the fields wooden platforms thatched with grass, or in the treeless High-veld, mounds of turf sods, from which stones or lumps of earth are thrown with switches; they also adopt the old European country methods of beating empty tins and shouting to scare away the birds.

Insect Pests.

400. *Insect Pests of the Maize Crop.*—It is often stated that South Africa is peculiarly cursed with plagues, especially insect pests. On the other hand it requires only a glance at American literature on the subject to demonstrate that South Africa is more favoured than this great maize-producing country in its comparative freedom from insect pests. Hunt (1) says that there are 214 species of insects known to be injurious to the maize plant in the United States; this gives some idea of the difficulties with which other maize-growers have to contend as compared with the few South African pests described below. In addition to the cutworms, ear-worms, and stalk-borers with which we have to contend, the American farmer has to fight wireworms, white grubs, corn-root worms, corn-root web-worms, seed-corn maggots, click-beetles, flea-beetles, army worms, the corn-root louse,

CHAP. X. corn bill-bugs, and the chinch-bug, none of which occur in South Africa.

The insect pests of maize appear to multiply in greater numbers as the acreage under crop is increased. Some farmers, accustomed to the easy production of good crops of maize before maize pests were as troublesome as they now are, have been inclined to abandon the crop in favour of something else which they hope may be produced more easily. Speaking generally, the man who cultivates his land well and at the proper time, and who adopts ordinary methods of precaution, is not seriously troubled by insect pests, and this fact should be borne in mind by those who are inclined to be discouraged.

The most troublesome pests of the maize plant in South Africa are: (1) the cutworms, larvæ of several species of moth (Agrotis); (2) the stalk-borer, top-grub, or tassel-worm, the larva of the moth *Sesamia fusca* Hampson ; (3) the striped beard-grub or ear-worm, the larva of the moth *Heliothis armiger* Hubn. ; (4) the maize cricket, which feeds on the young silks ; (5) locusts (*Acrididæ*) ; and (6) the tok-tokje (*Psammodes Reichei* S.). All of these attack the growing plant.

401. *Methods of Combating Insect Pests of the Maize Crop.*—The maize crop appears to suffer most from insect attack either when it is grown on newly broken veld, which has for a long period lain in grass or weeds, or when it has been grown on the same land for several years in succession and has therefore become weedy.

Some of the weeds of the veld and of maize fields are the partial host-plants of certain insects which also live upon the maize plant. These weeds therefore serve to carry over the pest from one crop of maize to another. By preventing the growth of the weeds we interfere with the life-cycle of the insect ; hence the most effective preventives against such insect attack are short and systematic rotation of crops, together with clean culture of the maize fields and of the surrounding land.

Where the land is neither in grass nor maize for more than two years in succession, the attacks of insects are comparatively limited, except perhaps in the case of certain migratory ones such as locusts, whose increase in numbers has been brought about by special conditions.

402. *Cutworms, Agrotis* spp.—Cutworms are among the most troublesome pests with which maize-growers have to deal. They are largely responsible for the relatively poor yields obtained, because they destroy so many young maize plants, thus thinning the stand. They are particularly destructive to early planted maize; to delay planting in order to avoid them may seriously shorten the season and increase the risk of loss from frost before the crop is mature. The following notes have been kindly furnished by Mr. C. W. Mally, Government Entomologist, Cape Province, who informs the writer that much work has yet to be done on the systematic entomology and life-histories of these insects, of which there are probably six or seven species in South Africa.

Cutworms vary in colour; some are green to yellowish, while many are of a dirty greyish or light-brown colour. They are smooth (without hairs or spines) and greasy looking, often similar in colour to the soil in which they spend the day. Some feed day and night, but others rest during the day just below the surface of the soil or under logs, stones, bags, bark, or rubbish, and come out to feed at night. They feed for about two weeks before pupating, and remain in the ground in the pupal state for ten to fifteen days in warm weather, or longer in the cold season. The female moth which emerges from the chrysalis ("pupa"), flies about at dusk and lays eggs on any suitable weed or plant. The eggs hatch out in a few days and the young caterpillars at once begin to feed on any green thing accessible to them. A life-cycle may thus be completed in about six weeks, or longer in a cold season. There are at least two broods of cutworms in a season, but how many more is not yet known.

403. *Remedies for Cutworms.*—A large number of cutworm eggs may be destroyed by keeping the land clean of weeds, and by the winter burning of, or deep ploughing-under of, such haulms of harvested crops as are not eaten off by stock. Where the cutworms are bad, Mr. Mally has found the use of poisoned bait to be effective. This is prepared by dipping bundles of green-stuff into a strong mixture of Paris green (1 oz. to a bucket of water) or sprinkling them with a mixture made according to the following recipe:—

CHAP. X.

Arsenite of soda	1 lb.
Treacle or brown sugar	8 lbs.
Water	10 gals.

Dissolve the arsenite of soda and the treacle or sugar in the water.

Mr. Mally describes his method as follows:—

By cutting up any available green-stuff (lucerne, barley, oat-forage, cabbage, rape, young succulent weeds, etc.) into small bits, say half an inch in length, it can be moistened with the poisoned sweet and then scattered broadcast over the fields. If distributed evenly, and at frequent intervals, the cutworms are practically certain to find it before they find the growing crop. Their fondness for sweets induces the caterpillars to fully engorge themselves on the bait, a fact which makes their destruction certain. There is also no danger to stock, for the pieces of bait are so small that nothing but poultry can pick them up, and it is not likely that even they will get enough to injure them. But, as a precaution, poultry should be kept from the lands where the bait has been spread. Care should be taken not to make the bait too wet or it will not scatter well when broadcast. For the best results the bait should be distributed *a few days after the ground has been ploughed*, and all green succulent vegetation has been destroyed. The cutworms that are not crushed in ploughing will then be on the surface again, and on account of their long fast, practically all of them will be prowling around in search of food. In this way one application will probably be sufficient. If injury is noticed after the young maize plants appear, the application should be repeated.

Where infestation of a crop takes place from outside stretches of unploughed veld, Mr. C. French, Jr., Assistant Government Entomologist, Victoria, recommends (*French*, 1) running a flock of sheep in the infested paddock adjoining the crop, as the constant walking about of the sheep will destroy the cutworms.

Autumn and winter ploughing has some reducing effect by disturbing and exposing the hibernating larvæ to the weather and the attacks of insectivorous birds, and by destroying the food-plants on which they might feed in spring.

404. *The Maize Stalk-borer.*—The maize stalk-borer is variously known as the mielie stalk-borer, mielie grub, top-worm, or top-grub, and tassel-worm, and is often also called

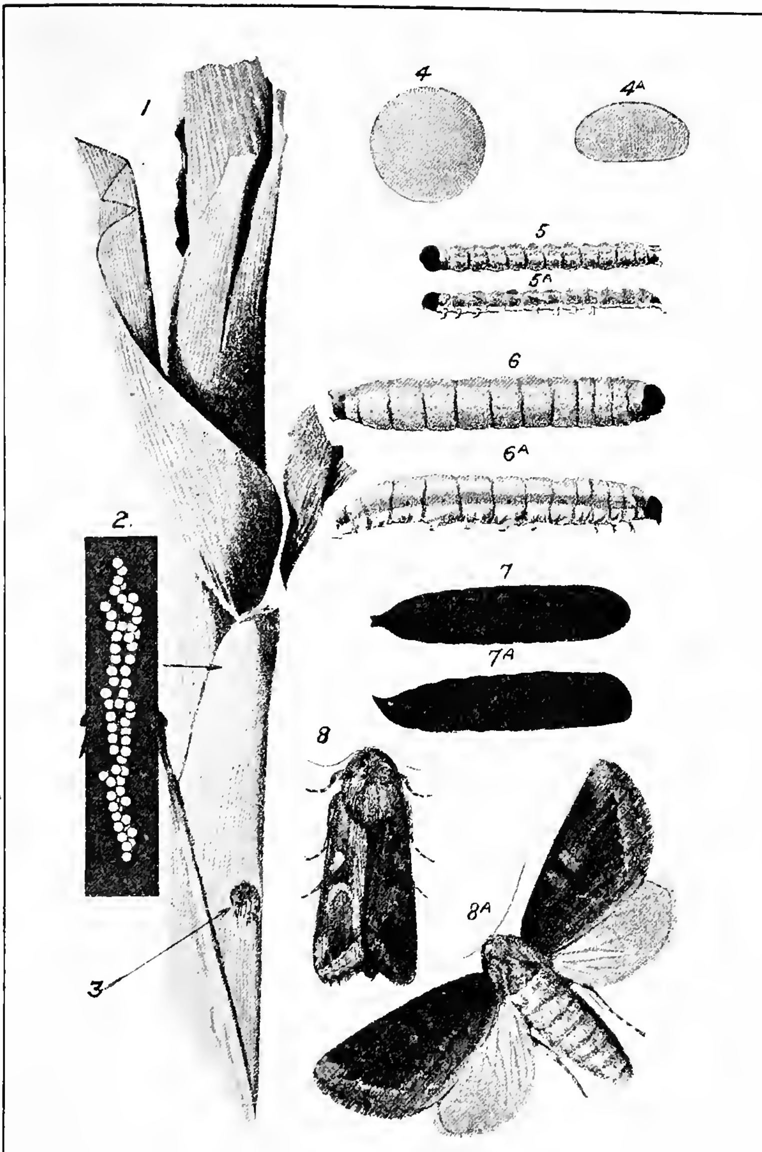

FIG. 165.—Maize stalk-borer, *Sesamia fusca* Hampson. (From coloured plate by McManus, illustrating article by C. W. Mally in *Cape Agricultural Journal*.)

CHAP. X. cutworm. Mr. Mally finds that two distinct insects with similar habits are known by the name stalk-borer, one of which is the larva of the moth *Sesamia fusca* Hampson (Fig. 165) which was ably described by Mr. Mally and beautifully illustrated by Mr. McManus, in the *Cape Agricultural Journal*, August, 1905, pages 159-68. This pest is well known to all South African maize-growers, and is responsible for the loss of anywhere from 25 to over 50 per cent of the maize crop, according to estimates made by Mr. Mally and Mr. Claude Fuller.

According to Mr. Mally the first evidence of the presence of the borers is the withering of the top of the young plant, which turns a brownish-red colour, as if scorched, due to the fact that the centre or "heart" has been eaten away. Although the centre of the plant has been destroyed, the outer leaves and roots do not always perish, but make an effort to recover. The leaves may become somewhat darker than in surrounding plants and in some cases "suckers" are thrown out later, so that in time the plant fills its place in the field. All such plants must be counted as loss, for they seldom or never produce ears; their only value is for ensiling or for feeding to stock as green fodder. The second brood of stalk-borers does not exert such a decided influence, because the plant is then strong enough to resist the attack, for the burrows of the insect (Fig. 165, 3) are not sufficiently large to prevent the flow of sap.

405. *Life History of the Stalk-borer.*— There are two broods of *Sesamia fusca* and three of the other species of stalk-borer, during the season. The last brood passes the winter as larvæ within the stalks or in the cob, and in late-harvested ears they are often found wrapped up between the husk and the ear. These larvæ pupate and then change into moths, which emerge between October and December. If maize plants are available, the female moths begin to lay their eggs almost immediately, but always at night, hiding during the day. These eggs are deposited in clusters under the edges of the leaf-sheaths, and hence are protected from destroying agents; they are faintly visible through the sheaths, and vary in number from 5 or 10 to over 100. The eggs hatch in seven to nine days. The young larvæ begin feeding on the maize-stalk at once, quickly eating their way towards the centre; "they are very careful to remain under the sheath all the while, and it

affords them perfect protection from rain or insecticides". When the food supply of one plant is exhausted, the larvæ leave it and search for fresh plants.

On reaching maturity, about the first week in January, the larva clears out a portion of the burrow which it has tunnelled into the stalk, prepares an opening through which the adult can escape (Fig. 165, 3), and then transforms to a dark-brown pupa, as shown in Fig. 165, 7, and 7A. It remains in the pupal stage from a fortnight to three weeks, and then transforms to the dark-brown moth. . . . After pairing, the female lays eggs and dies, thus marking the end of the first brood. The eggs for the second brood are deposited under the edges of the leaf-sheaths about the first of February, and may be found anywhere from the main stem well up to the tassel, preference apparently being given to the younger portions of the plant. The eggs hatch about the end of the first week in February, and the larvæ burrow into the centre of the stalk as before. They mature by the first of June, depending on the condition of the maize. They do not transform to pupæ at once, as in the first brood, but pass the winter as larvæ within the stalks, occurring anywhere from the cob down to the roots, much depending on the size of the plant. . . . Observations . . . lead me to believe that the moths do not travel far in search of food-plants and that they are content to stay in the first maize plant they find (*Mally*, 1).

406. *Parasites of the Stalk-borer.*—Mr. Mally has found a few natural parasites of the maize stalk-borer, but study of their habits led him to the conclusion that "while they do some good, they have not shown themselves able to keep the pest under control; hence we are forced to adopt artificial means to avoid serious loss".

407. *Burning the Stalks to Destroy the Stalk-borer.*—"From the brief sketch of the life-history of this insect it is apparent that there is no hope of destroying it during the summer by the use of insecticides, because all its transformations take place *within* the plant, and the moth itself is protected through being nocturnal. . . . Our main hope lies in the possibility of establishing a system of cultural methods which will enable us to *prevent* injury. . . . The fact that the winter stage of the insect is passed within the remains of its food-plant is its weak point, and gives a control measure in the destruction

CHAP. X. of the over-wintered stalks which, if carefully followed, makes it possible to prevent appreciable loss. The advisability of burning the stalks has often been suggested. . . . When the stalks have been left to dry up in the field they are of little value except as 'stalk-pasture' for cattle and horses. Since the moths do not emerge till spring it is an advantage to use the stalks for pasture, for it reduces the bulk to be handled in burning them. Their value as a source of plant-food in the soil must not be overlooked, but there is also the disadvantage that coarse material tends to augment the effect of drought in certain soils. The stalks are not [altogether] lost by burning, for the ashes remain and are readily available [as plant-food]. From the standpoint of value as stock-food or fertilizer the stalks can easily be turned to better advantage by means of the silo or by cutting them in time for 'fodder,' as pointed out later, and ultimately returning to the land as manure" (*Mally*, 1).

To destroy all the borers the maize stalks must be pulled or hoed out, after having been browsed by cattle, and be piled up in convenient heaps and burned; especial care must be taken to completely burn the stumps. It is not sufficient to let the fire sweep through the heap and then gradually smoulder away; the stalks and stumps around the edges must be raked up on to the centre of the burning mass, otherwise a few borers will remain alive. "It must be clearly understood that half-hearted work is of little use. The occasional stalks and stumps, which it seems hardly worth the trouble to clear up, may harbour enough borers to discredit the work when the young mielies are examined in the spring. The same is true of neglected spots or lands to be left fallow for the season. . . . Neglect is the strongest ally of the pests, for it provides them with a good base of supplies on which to gain strength for the next season's depredations."

Kaffir corn, sorghum, Johnson-grass, teosinte, and sugar-cane are recorded as additional host plants of the maize stalk-borer, and they should be treated in the same way as the maize stubble.

408. *Ploughing-under the Stalks.*—This method of treatment is frequently suggested, but Mr. Mally does not recommend it owing to the difficulty experienced in burying *all* of the stalks, and because those which are left on the surface are

enough to harbour a crop of borers for next season. Where steam-ploughing is practised, however, and the stalks are buried 12 to 18 inches below the surface, this is fairly efficacious, and in fact it seems the only practicable method where a farmer has between 1,000 and 6,000 acres under maize.

409. *Early and Late Planting to avoid Stalk-borer.*—Early planted maize may miss the stalk-borer, but is liable to destruction by the spring brood of cutworms, and if the area under crop is large, the application of poisoned bait may be impracticable. Late planted maize, on the other hand, is in the best condition for the second brood of borers (¶ 405) and to provide a supply of them to pass the winter, and is in danger from early frost. Moreover, as the emergence of the moths lasts over a period of four to six weeks, variation in time of planting with a view to avoiding the borer is of doubtful utility.

410. *Trap Crops for Stalk-borer.*—" A few rows of maize planted very early would render good service by attracting the moths so that the eggs for the first brood would be deposited on these few rows. It would be an easy matter to go over them, say once a week, to destroy the plants showing signs of withering. An early breed of maize is preferable for this purpose because it tends to grow more rapidly and so augments the effects of early planting. It must be remembered, however, that unless the trap maize is looked after carefully, it is a positive danger because it will be the means of saving the eggs from the earliest moths and ensure the greatest possible number of the first brood coming to maturity" (*Mally*, 1). Kaffir corn and sorghum appear to be more attractive to the stalk-borer than the maize plant, and might, therefore, prove more useful as trap crops.

411. *Ensiling and Shredding Maize as a Remedy for Stalk-borer.*—" For either ensilage or fodder the maize could be cut some time before the second brood of larvæ has matured. Although no test has been made, it is difficult to see how they could survive in the silo. They survive without difficulty in maize cut and dried in the ordinary way for fodder but they would stand little chance of escaping the shredder. In case the fodder was dried without shredding, the coarse stalks should be collected and burned before the middle of September,

CHAP. X. to prevent the escape of moths from larvæ that are not destroyed in tramping. The question of turning the crop into ensilage and fodder as preventive measures raises the whole problem of how best to utilize the maize crop when once it has been produced. A great many possibilities suggest themselves in this connection. For the present we must be content to follow the methods which promise the greatest measure of success under existing conditions" (*Mally*, 1).

412. *The Striped Beard-grub or Ear-worm, Heliothis armiger* Hubner.—According to Mr. Claude Fuller (1), Natal Government Entomologist, this insect feeds upon a variety of plants, but especially on maize and kaffir corn. The larvæ ("worms") vary in colour. Those which feed on kaffir corn heads are always dark, generally reddish, resembling the colour of the food-plant. Feeding on the silk ("beard") (Fig. 38) of the maize plant they may be green, brown, or reddish, according to the colour of the silk; hidden away in the ear they will at times be dark in colour, but more frequently of a pale-pinkish or pinkish-brown. In all cases, however, they are characterized by dark stripes running the full length of the body, and cannot readily be confused with the larvæ of the stalk-borer or the cutworms. The striped beard-grub usually pupates *in the soil*, though the pupæ are occasionally found in the maize stalk or ear (Fig. 166). There are probably three or more generations in a summer, the broods overlapping. They make their appearance earlier than the stalk-borer, the first sometimes as early as August, another about the end of January, and yet another during April and May. The early brood seems to do no conspicuous damage, but the caterpillars which feed upon the beards during February, often cause a lot of injury; the moths of this brood emerge during April and May; these are believed to lay eggs almost at once; the eggs soon hatch and the caterpillars feed and come to full growth and crawl into the soil to pupate, remaining there enclosed in little earthen cocoons, at depths varying from a half to two inches below the surface, and emerging as moths about the month of August in Natal, and perhaps rather later on the High-veld.

413. *Remedies for the Striped Beard-grub.*—From the above sketch of the life-history of this insect it is clear that the com-

mon practice of leaving the old lands unploughed until spring *encourages* the propagation of the beard-grub, whereas winter ploughing and cultivation of the land (before August) must destroy a large proportion of the insects which are pupating in the soil. To reduce the size of the first spring batch of moths must help greatly to keep down subsequent sets. CHAP. X.

FIG. 166.—Striped beard-grub pupa in sheath at base of ear.

Dipping or soaking the seed-maize in one or other of various preparations (e.g. saltpetre) is frequently recommended as a preventive measure against ear-worm and stalk-borer; such methods of treatment were tersely likened, by the editor of an American agricultural paper, to "advising a man to soak his feet to prevent his hair from falling out" (*Pacific Rural Press*, 14 May, 1904).

414. *The Maize Cricket.*—Writing to the *Cape Agricul-*

CHAP. X. *tural Journal* for May, 1907,[1] Mr. D. van Zijl, of Dichaking, Kuruman, British Bechuanaland, stated:—

"We are greatly troubled in these parts with a certain insect generally called corn cricket. As it causes an enormous amount of damage to growing crops, I should be very glad if any of your readers could suggest a remedy for this destructive insect. In December, during the first rains, they hatch out just like small locusts, and December being in this district the month for sowing and planting, the insects develop simultaneously with the growing crops, and start their work of destruction when the crops are in bloom. They climb up the mealie-plants, causing little or no damage to the stalks and leaves, but eating, within the space of a few minutes, all the grains of the mealie-cobs. They also consume the flowers of all creeping plants as pumpkins, water-melons, sweet melons, and beans, just when they make their appearance. Last January I had a splendid plot of beans, of which I expected a yield of 15 muids, but, as described above, no sooner had they come in flower than the corn crickets appeared on the scene, and all I reaped was 2½ muids. Even all shoots were destroyed by them; and this work of destruction is not limited to one year only, but goes on year after year with unabated vigour. I have tried several kinds of poison to kill the pest, such as Cooper's dip and Little's dip, and even wolf-poison. A strong solution of tobacco dip also failed to kill them. I should, therefore, be greatly obliged if you or any of your readers could advise me what to do to get rid of this pest."

The Assistant Entomologist, Cape Colony, replied:—

"We are not aware of any remedial measures having been used in this country against these insects. We would, however, recommend Mr. van Zijl to give a trial to poisoned bait as used against locusts. . . . The endeavour should be to ascertain the breeding spot of the pest and, as this is probably somewhere on the veld, the ploughing of the cultivated land probably preventing the escape of the young hatched from eggs laid there, the vegetation could be very effectively sprayed with the arsenic-soda-treacle solution, for instance, which should do excellent execution amongst the 'corn crickets'. This has been recommended for the destruction of a similar pest in Colorado. . . ."

415. *Locusts* (*Acrididæ*).—Shortly after the war the agricultural crops of South Africa were decimated by enormous

[1] Vol. XXX, No. 5, p. 599.

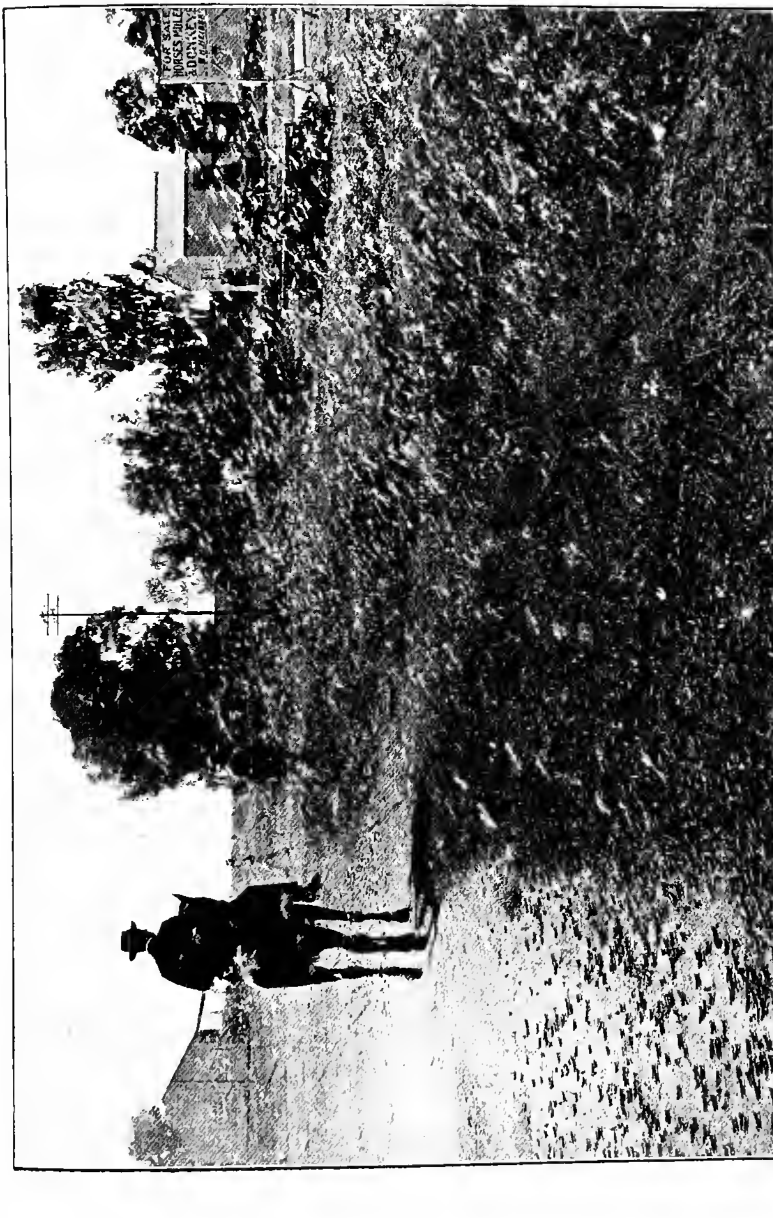

FIG. 167.—Locusts. (Photograph by Exton, Pietersburg, Transvaal; the streaks across the upper part of the plate are due to flying locusts.)

swarms of locusts (Fig. 167). These consisted of the common purple locust, *Acridium purpuriferum*, in the central and western parts of South Africa, and the brown locust, *Pachytilus sulcicollis* in Natal and the eastern districts of the interior Provinces. During the season 1906-7, the locust scourge was very severe in the northern, central, and western districts of the Transvaal. The wet, cool summer was partly responsible, as the crops were late in maturing, and the locust plague came at a time of year when, in a normal season, they would have been ripe and free from danger. One hundred and ninety-nine experimental crops being grown by Transvaal farmers in co-operation with the Division of Botany of the Department of Agriculture, were reported as having been destroyed by locusts. Locusts lay their eggs, a large number together, in the soil; they hatch out when weather conditions are favourable, i.e. after good spring rains have fallen, which not only help to hatch the eggs, but also bring on the grass and spring vegetation which the young locusts require for food. The young locusts are not able to fly for some time after hatching, and are therefore known as voetgangers (i.e. walkers). They feed voraciously, and not being able to travel far, are easily dealt with in this stage, if their breeding grounds are known.

Although the efforts of the Entomologists of the South African Locust Bureau, assisted by the locust birds, practically wiped out the scourge, there is always danger of fresh migrations from the North, and it is well to be prepared to combat the pest if it should reappear. After experimenting in various ways with the numerous remedies recommended, the Locust Bureau finally adopted the remedy tested and recommended by Mr. C. P. Lounsbury, Cape Government Entomologist. This consisted of a mixture of arsenite of soda and molasses or other syrup, which was sprayed on to the veld immediately surrounding the newly hatched swarms. In order to locate all the swarms before they developed wings and began to migrate, a corps of volunteer swarm-reporters was organized throughout the country. These gentlemen, located in every district, reported by means of franked post cards, and by wire, the laying of eggs, the hatching of voetgangers, and later the migration of swarms from one part of the country to the other. The Government stocked and distributed free to farmers supplies of spray-pumps and the components of the spray, and by means of public meetings and lectures enlisted their hearty co-operation. CHAP. X.

Much good work was also done by large flocks of locust-birds, the principal among which were (1) the true locust-bird, wattled starling or klein springhaan vogel, *Creatophora carunculata* ; (2) the small locust-birds or pratincoles, *Glareola pratincola* and *G. melanoptera* ; (3) the white stork, *Ciconia alba* ; and (4) the white-bellied stork, *Abdimia abdimii.*

416. *The Tok-tokje.*—Mr. Mally reports damage done to young maize plants in the Eastern Province, Cape Colony, by the tok-tokje, *Psammodes Reichei* S. :—

"The larva attacks wheat, oats, barley, and maize. It evidently tunnels along in search of food, and when it locates a stool of wheat or other grain it comes to the surface, so that it can just reach the base of the stem. It then pulls off the hard outer layers in little shreds and arranges them so as to form a protectionary cover for itself. It evidently feeds on the soft juicy inner layers of the stem, and when one stem is eaten off it makes for another one, the attacks usually being limited to the short basal joint. In a number of cases noted the larva had drawn the stem down into the burrow and devoured it almost entirely. The plant may be injured at any time during its growth, and there may, therefore, be a heavy drain on the crop in addition to that indicated at the time of ripening. In one instance a larva was found feeding on the maize roots. There was a very poor stand of maize in this field, and the farmer was inclined to think that these larvæ were the cause of it. He said that early in the season many of the plants seemed to die off, and that others were blown down, but in time recovered and regained an upright position. This is due to the fact that the larva feeds from the side which it finds first, and in that way destroys about half of the roots, and the remaining half support the plant sufficiently to enable it to make a short turn at the base and make fairly good growth ; but it always remains a stunted plant."

417. *Remedies for the Tok-tokje.*—Mr. Mally adds :—

"I doubt the practicability of trying to starve out the larvæ by clean cultivation, for they can go a long time without food. Frequent ploughing, harrowing, and rolling would be more likely to give good results, because the great majority of the

CHAP. X. larvæ would be injured, and thus destroyed. If the ground could be kept under constant cultivation, by adopting a system of rotation and the ploughing-in of green manure, so as to preserve its fertility, in place of exhausting it by constant cropping for a term of years and then letting it lie fallow for a time to recuperate—as is done in the present system—I believe injury from this pest would be almost entirely avoided. Cultivated lands apparently do not attract the beetles, and they therefore take to the native veld to deposit their eggs. But before we can hope to induce the farmers to go in for a system of rotation in place of the present practice of long fallowing, it will be necessary to show by means of demonstration farms that the intensive cultivation necessary to make rotation answer will pay them better than the present system of extensive cultivation. I am satisfied myself that an intensive rotation would be much more profitable than the present system, and would combine numerous other advantages—not the least of which will be the fact that it will open the way for a much larger farming population."

418. *Plant-lice* (*Aphides*).—Aphis or green-fly is commonly found on the maize tassels in some seasons, but does not appear to cause serious damage. A common opinion is that prevalence of green-fly coincides with drought; the writer has noticed, however, that in some seasons (e.g. February, 1913) it was abundant during a time of plentiful rains.

419. *Rose-chafers.*—Some species of Rose-chafer, notably *Porphyronota hebræ* and *Plæsiorhina plana*,[1] feed on the male flowers of the maize plant, probably on account of the pollen. These two chafers are particularly troublesome in eating holes in paper bags used for the collection of pollen in maize-breeding, the pollen escaping through these holes; from three to a dozen chafers will be found in one bag. They do not appear to injure the maize plant.

The common hive bee, *Apis mellifera*, also visits the tassels of the maize plant for the purpose of collecting pollen; on this account it is popularly supposed to effect cross-pollination, but during an extended series of observations the writer has never seen a bee carry pollen to, or even visit, the maize-silks, so that it is not at all probable that it is a factor in cross-pollination.

Weevils and grain-moths are dealt with in chapter XI.

[1] Both kindly identified by Dr. L. Péringuey, Director of the South African Museum, Cape Town.

CHAPTER XI.

HARVESTING AND STORAGE, AND PESTS OF STORED MAIZE.[1]

. . . when the Autumn
Changed the long green leaves to yellow,
And the soft and juicy kernels
Grew like wampum hard and yellow,
Then the ripened ears he gathered,
Stripped the withered husks from off them,
As he had once stripped the wrestler.

. . . .

And they called the women round them,
Called the young men and the maidens,
To the harvest of the corn-fields,
To the husking of the maize-ear.

—*Hiawatha.*

Now the broad fields of maize are cut and the maize-cobs garnered.

—CRAWFORD.

420. *Maize Harvesting.*—The usual method of harvesting maize in South Africa, before the acreage reached its present extent, was to pick the ears by hand as the stalks stood in the field, after the ears had become thoroughly sun-dried. Native labour, alone, has been employed for this work. But with increased development in agriculture, mining and manufactures, native labour is becoming scarcer and consequently more expensive, and the necessity for adopting other methods of handling the crop is becoming apparent. A case has been reported within the last few years where, when the new planting season came round, it found the last crop not entirely harvested, owing to lack of labour; another case came to the notice of the writer in which harvesting was only completed the day before the planting of the new crop was begun. CHAP. XI.

[1] Much of the information on the use of maize-harvesting machinery in America has been taken from a special bulletin of the United States Department of Agriculture (*Zintheo*, 1).

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Maize is less easily harvested than almost any other cereal crop, except perhaps the sorghums, because of its large size and hard stem. Whereas machinery has for a long time replaced hand labour in the harvesting of most cereals, it is only quite recently that the application of machinery to the harvesting of the maize crop has been practically and economically successful.

The method and time of harvesting depend to some extent on the uses to which the crop is to be put, e.g. whether it is required for grain only, or whether for grain and stover, fodder or silage.

The present method in general practice in South Africa, with local variations, is for native labourers to walk up and down the rows with sacks into which they put the ears as they break them from the shanks; the husk is opened by hand, and the ear dexterously removed with a twist. One great drawback to this method is the amount of labour involved in walking back and forth with the sacks between the picking place and the headlands where the ears are to be shelled.

Mr. W. A. McLaren, South African Manager for Messrs. John Fowler & Co. (Leeds), Ltd., has improved on this method by making the shelling machine accompany the pickers through the standing stalks (Fig. 179).

421. *Best Condition of the Crop for Harvesting.*—The stage of maturity of the crop affects the total yield of dry matter. Also the difference in nutritive value at different stages is shown by analyses to be considerable. It is, therefore, important to know the best stage of development at which to harvest maize intended for grain, stover, fodder or silage.

In some fodder plants the feeding value increases gradually up to a certain stage of growth, but begins to decrease *before* the plant reaches full maturity, which is due in part to the transfer of nutritive matter from the leaves and stems to the seed, and in part to the loss of some of the leaves themselves. In the case of the maize plant, however, both the total amount and the feeding value of the dry matter increase up to, or nearly up to, the stage of complete maturity. The Kansas Station obtained the following yields at different stages of maturity:—

	Yield per Acre.	
	Grain (bushels).	Fodder (tons).
Cut in the "milk" stage	35·5	2·4
,, ,, "dough"	51·0	2·4
,, when ripe	74·0	2·7

The experiments conducted by several other stations show general agreement with these results.

In some instances, however, the yield of the whole plant has been found to decrease slightly in weight of water-free substance, during the last one or two weeks of development, doubtless because of loss of leaves.

The plant, *exclusive of the ear*, may decrease materially in weight, owing to translocation of material to the grain. At the Iowa Station (*Bull.* 21) this decrease was found to equal 17 per cent of dry matter during the three weeks from the time most of the ears were dented (but leaves and husks still all green) until the plant was entirely ripe. This was perhaps partly due to loss of leaves, but chiefly to translocation of material.

When the maize plant is in full tassel it has developed one-third to one-half its weight of water-free substance. When it is in the roasting ear stage three-fourths to four-fifths of its dry matter has developed; when at the silage stage it has developed from three-quarters to nine-tenths of its dry matter (*Illinois Bull.* 31, p. 361; *Michigan Bull.* 154, p. 283; *Cornell Bull.* 4, p. 52). The greatest rate of growth in height precedes that of the development of dry matter (*Hunt*, 1).

The increase in percentage of starch and of soluble carbohydrates is rapid during the development of the ear, and there is a coincident decrease in proportion of crude fibre. After ripening there is a considerable loss of dry matter from the fodder, partly due, no doubt, to loss of the lower leaves in drying off. The Iowa Station found that two months after ripening, under ordinary field conditions, the crop had lost about *one-half* of the dry matter and more than half of the feeding value.

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We conclude, therefore, that the maize crop should not be cut very early, whether intended for grain, or for fodder or silage; nor, on the other hand, should it be allowed to stand

Fig. 168.—Maize crop ready for harvest (for grain only). (Courtesy of Publicity Department, South African Railways.)

in the field after ripening, if it is desired to obtain the maximum yield of *both* grain and fodder. When the grain is in the "dough" stage, or even a little harder, the plant makes excellent silage, especially if passed through a chaff-cutter.

422. *The Best Stage of Growth for both Grain and Stover.*—The total weight of grain increases up to the period of full maturity (*Hunt*, 1). When the plant is grown for ears alone, it is not only allowed to ripen, but the ears are allowed to remain on the standing stalks until they have become dry enough to be safe for storage, usually about a month after the maize is ripe, or after the first killing frost. But when the stover, as well as the grain, is to be harvested, it is well to allow the plant to become as ripe as is possible without risk of the leaves falling off before or during the operation of shocking. The ears should be all, or nearly all, dented or glazed, the husks dry, and the leaves from one-third to one-half green (*Hunt*, 1).

According to the Iowa Station "the *stover* of a crop of maize seems to reach the highest yield and the best condition for feeding at the stage of growth indicated by a well-dented kernel and the first drying of the blades. The *grain* of a crop of maize seems to reach the highest yield and the best condition for utility at the stage of growth indicated by a well-ripened ear and a few dry blades; and the best time for securing the crop with reference to the highest utility of *both maize and stover* would be found at a stage of ripening between the above."

The Wisconsin Station recommends the cutting of flint breeds for silage when just past glazing, and dent breeds when "well dented"; while the Vermont Station recommends that maize be allowed to stand before ripening as long as it is safe from frost. The Ohio Station found there was little difference in the yield of grain from maize left standing, or maize cut and shocked, provided it was sufficiently matured at cutting time.

In the field-curing of maize at the Colorado Station, large shocks lost 31 per cent of their dry matter, small shocks 43, and maize spread on the ground 55 per cent, largely because of the active fermentation in the seemingly dry and well-cured stalks. At the Oklahoma Station the outside stalks of maize shocks exposed to the sun, rain, and wind lost fully one-fourth of their feeding value as compared with the inner stalks. The average loss in dry matter at the Wisconsin Station, in ensiling maize, was 15·6 per cent and in field-curing the same fodder 23·8 per cent.

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"To sum up, *harvest maize for both grain and stover soon after the kernels are well dented and the blades begin to dry, but before the ears are thoroughly ripened. For silage, harvest flint varieties when just past glazing and dent varieties when well dented*" (*Farmer's Cyclopedia of Agriculture*).

423. *The best Stage of Growth for Fodder.*—It is usually considered that the fodder stage is reached when the lower leaves have turned yellow, but have not become dry, while the husks on the ears are still green; the grain should be fully glazed and practically mature. In this stage it has been found to give about the heaviest yield without loss of palatability, and to be in a suitable condition to "shock" without danger of becoming mouldy. Some farmers recommend that the stalks and the leaves above the ears should have begun to turn golden; but as the whole crop cannot be cut at once, it would probably be best to begin in the earlier stage of development, i.e. when the lower leaves have turned yellow, but the upper are still green.

When food of very high palatability is wanted, as, for instance, for young, growing stock, or animals being fattened for market, it is considered desirable to cut it rather earlier, i.e. when the lower leaves have just begun to turn and the ears are in the "roasting" stage (*Hunt*, 1).

Maize fodder cured in the field has been found to lose from 19 to 21 per cent of dry matter. The loss is nearly 5 per cent less if the fodder is cut in the "green-mielie" stage, than if cut when nearly ripe.

424. *Best Stage of Growth for Ensiling.*—The degree of maturity and the condition of succulence are the important factors in deciding when the crop is ready for ensiling. It is impossible to make a hard-and-fast rule on these points, as so much depends on local and seasonal conditions; local experience based on careful observation is therefore the best guide.

Generally speaking, maize for silage should be cut rather greener than for fodder, otherwise it does not pack so well in the silo, too much air is left in the mass and it is apt to mould. Hunt (1) describes the best condition as reached when many, but not all the ears have become dented in the grain, a portion of the husks dry, and the bottom three or four leaves dry, with the rest still green. Until this stage has been reached, it may be considered that the greener the maize, the greater the loss in the silo. He summarizes as follows the advantages of allowing the crop intended for silage to arrive at the stage of maturity indicated above:— CHAP. XI.

(1) Greater yield of water-free substance.
(2) Less total weight to handle.
(3) Less loss in silo.
(4) Superior composition.
(5) Greater digestibility.
(6) Greater palatability, resulting in a greater feeding value per acre at less cost.

The following table (LVIII) prepared by Prof. Hunt at the Cornell Station shows the influence of maturity upon weight of fresh and dry substance and loss in the silo.

TABLE LVIII.

INFLUENCE OF MATURITY ON YIELD.

Date of Cutting.	Green Matter per Acre.	Dry Matter.		Dry Matter in Silage: Loss per Acre.	Condition of Maize.
		Per Acre.	Per Cent Green Food.		
	Lbs.	Lbs.		Lbs.	
Aug. 10	19,200	2,672	13·1	752	In full tassel
" 16	20,800	3,144	15·1	502	Maize in silk
" 22	21,840	3,712	17·4	305	Grains fully formed
" 28	19,200	3,744	19·5	288	Grains in milk
Sept. 3	16,960	3,824	22·5	195	Grains still in milk
" 9	16,400	4,168	25·3	188	Grains past milk
" 14	14,720	4,536	30·8	125	Maize glazed

If put into the silo before the grain has reached the "glazed" or "roasting" stage, the silage is less nutritious than it would otherwise be and is apt to be unduly acid. If, on the other hand, it is allowed to get riper than the "glazed" stage, it is less likely to pack well, and mouldy spots or masses will be found among the silage. The *over-acid* condition is due to *excess of succulence*, and the *mouldy* condition to *lack of succulence*. A partial remedy for the first trouble is to wilt the maize more or less before putting it into the silo; for the mouldy condition, prevention is the best

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remedy—the maize should be cut rather younger. If, however, it has already become a little too old before it has been practicable to cut it, the condition may be improved by pouring a little water over the mass while the silo is being filled, or by adding a little succulent material—such as green lucerne, velvet beans, cowpeas or soybeans. The amount of wilting required for immature maize depends on the degree of succulence, and must be learned by experience; the younger the plants, the more they must be wilted.

425. *Frosted Maize.*—The value of maize for silage is reduced by freezing; but if the crop is cut and put into the silo immediately after being frosted, the value of the silage made from it, though reduced, is not seriously impaired; if, on the other hand, the maize is allowed to stand uncut for any length of time after being frost-nipped, it is greatly injured for feeding.

426. *Composition of the Maize Plant at Different Stages of Maturity.*—The following analyses made at the Maine Station (*Rep.* 1893, Pt. 2, p. 25) show the variation in composition of the maize plant at various stages of growth and have been generally verified at other stations (*Jordan*, 3, p. 211). The percentages (Table LIX) are those of water-free matter.

TABLE LIX.

INFLUENCE OF MATURITY ON COMPOSITION.

Stage of Growth.	Protein.	Sugar.	Starch.	Total Nitrogen-free Extract.	Fat.	Ash.	Crude Fibre.
Very immature . . (15 Aug.)	15·0	11·7	—	46·6	2·6	9·3	26·5
A few roasting ears . (28 Aug.)	11·7	20·4	2·1	55·6	2·9	6·5	23·3
All at roasting ear stage (4 Sept.)	11·4	20·6	4·9	59·7	3·0	6·2	19·7
Some ears glazing . (12 Sept.)	9·6	21·1	5·3	62·5	3·0	5·6	19·3
All ears glazed . . (21 Sept.)	9·2	16·5	15·4	63·3	3·0	5·9	18·6

Though there is nearly 6 per cent less protein at the glazed stage, there is an increase of nearly 17 per cent of nitrogen-free extract, and a decrease of nearly 8 per cent of crude fibre.

427. *Composition of Maize Fodder at Different Stages of Growth.*—Maize fodder varies in protein-content according to the stage of growth at which it is cut, as is shown by the following table (LX) extracted from Jenkins & Winton's (1) tables:— CHAP. XI.

TABLE LX.

INFLUENCE OF MATURITY ON COMPOSITION OF FODDER.

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Number of Analyses.
Fodder from flint breeds cut early	79·8	1·1	2·0	4·3	12·1	0·7	40
Fodder from flint breeds cut after kernels had glazed	77·1	1·1	2·1	4·3	14·6	0·8	10
Fodder from dent breeds cut early	79·0	1·2	1·7	5·6	12·0	0·5	63
Fodder from dent breeds cut after kernels had glazed	73·4	1·5	2·0	6·7	15 5	0·9	7
Leaves and husks cut green	66·2	2·9	2·0	8·7	19·0	1·1	4
Stripped stalks cut green	76·1	0·7	0·5	7·3	14·9	0·5	4
Silage	79·1	1·4	1·7	6·0	11·1	0·8	99

428. *Comparative Digestibility of Maize Fodder and Silage at Different Stages of Maturity.*—There is also a variation in the degree of digestibility, according to the stage of maturity at which the maize has been cut. Both with silage and fodder the digestibility is higher after the grain has glazed, or dented, than before. It has been found that the total digestible food value of the maize crop was 200 to 300 per cent greater in the fully mature crop than at the silking stage, and 36 per cent greater than at the time the ears were glazing (*Armsby, Pennsylvania Rep.* 1892).

	Maize Fodder.			Maize Silage.		
	Max.	Min.	Av.	Max.	Min.	Av.
Cut before glazing; thirteen experiments	71·4	53·6	65·7	77·8	56·6	67·4
Cut after glazing; ten experiments	74·2	61·2	70·7	80·2	65·2	73·6

CHAP. XI. Jordan (3, p. 212) gives the above summary of experiments on the digestibility of maize fodder and silage; the figures show the amount digested out of 100 parts of organic matter.

The average difference in favour of the more mature crop is thus 5 per cent in the case of fodder and 6 per cent in the case of silage.

429. *Feeding Value of Maize Fodder at Different Stages of Growth.*—The feeding value of maize fodder at different stages of growth, as determined by milk production, has been investigated by the Pennsylvania Station (*Rep.* 1892) and the Ohio State University.[1] The fodder was cut at three different stages of maturity: the roasting ear stage, the silage stage, and when ripe or nearly so. The weight of field-cured fodder increased with the stage of ripeness, the increase being greatest during the first interval. The percentage eaten was least in that cut early, though prepared with a feed cutter. Compared with the earlier cutting, the intermediate stage gave the greatest increase of milk and of live weight; compared with the later cutting the difference was less marked.

430. *Pulling.*—In the Southern United States there is a tendency for the maize leaves to dry up before the ears are sufficiently mature, and in consequence it has been customary to strip the leaves from the stalks while they are still green and the ears immature.

In the States "fodder pulling is effected, according to latitude and season, from the first of August to the middle or even the last of September. When the operator's hands are full of blades and he can hold no more, the quantity is termed a 'hand,' and is bound rapidly with a twist and hung on a broken stalk to cure. On gathering a day or so later, from three to four hands form a 'bundle,' which is, also, bound with a few twisted blades. The bundle weighs from 1¾ to 2 lbs. and forms the staple 'roughage' of southern draft stock" (*Myrick*, 1).

The Georgia Station (*Bull.* 23) finds that the practice is only expedient under the most favourable circumstances; but that where it is done, the best method is to strip the blades, from and including the ear-blade downwards, and in a week or

[1] D. A. Crowner, *Thesis*, 1896, quoted by Hunt (1).

ten days to cut off the stalks above the ear; this is more expeditious than the ordinary method and adds largely to the yield of stover.

The effect of this "pulling" on the yield of grain has been investigated by eight, at least, of the State Experiment Stations, and the general result shows a loss of 10 to 20 per cent of grain. The Florida Station (*Bull.* 16) finds that the "pulling" of fodder has the effect of loosening the husks in the ear before the grains become hard, thus promoting the ravages of weevils.

431. *Topping.*—This is a method which has been practised in some parts of the United States, when the stover is required to supply lack of food before the maize crop is ripe. The prevailing conditions in South Africa do not call for the practice of this method, because there is usually abundance of food at the time when the maize crop could be topped. In any case the practice cannot be recommended, for investigations show that topping results in a loss of grain which is "more than the feeding value of the fodder secured" (*Mississippi Bull.* 33, 1895, p. 63; *Pennsylvania Rep.* 1891, pp. 58-60).

432. *Methods of Harvesting for Grain.*—Briefly the following methods and devices for harvesting maize for grain are in vogue: (1) Husking the ears from the standing crop; (2) picking the ears from the standing crop with a "corn-picker"; (3) cutting the stalks by hand, with knives; (4) cutting with sled harvesters and similar devices, or cutting with (5) maize binders and (6) maize shockers.

433. *Husking by Hand from the Standing Stalks.*—When the crop is allowed to dry off as it stands in the field, as is most usual in South Africa, husking is easily done by the "boys" who harvest the ears; opening the husk with one hand and catching hold of the ear with the other, a sharp twist or bend breaks the ear from the node above the upper husk; the ears are dropped into a bag slung around the neck, and when this bag is full it is emptied into a sack common to three or four pickers, to be carried when full to the headland (Fig. 169); the sheller is moved from heap to heap.

434. *Cost of Hand-picking in the United States.*—From 300 replies furnished by farmers in different parts of the

CHAP. XI. United States, the following figures were obtained, as to cost and efficiency of picking by hand ;—

Yield of maize on the ear, average per acre	44 bushels.
Average quantity picked per man per day, 59 bushels, or at 70 lbs. per bushel of unshelled maize	4,130 lbs.
Cost per bushel for picking maize by hand, average . . .	$3\frac{1}{2}$ cents, $1\frac{3}{4}$d.

435. *Cutting Maize by Hand.*—A common method of harvesting maize in the United States is to cut the stalks by hand, close to the ground. The implement first used for corn-cutting was the hoe, but as this was rather heavy and awkward, the more progressive farmers substituted the *corn*

FIG. 169.—Harvested ears of maize carried to the headland ready for shelling.

knife. At first this was made from scythe blades, but these have been largely replaced by various sizes and shapes of factory-made knives. A short-handled, short-bladed scythe-like *corn hook* is much used in the States. In Natal the *cane knife* (Fig. 170) used by the coolies for cutting sugar-cane is now largely employed for maize-cutting, and its use has extended to the Transvaal. This tool is so constructed that the weight of the falling knife is almost sufficient to sever a stalk, which facilitates rapid work.

In America one man is able to cut and shock by hand about 34 shocks, 12 hills square, or nearly $1\frac{1}{2}$ acres of corn a day. The average cost for cutting by hand is reported to be 6·5 cents per bushel, or $1·50 (6s. 3d.) per acre. CHAP. XI.

436. *Does it Pay to Use Machinery for Harvesting the Maize Crop?*—As the result of an exhaustive inquiry into maize-harvesting machinery in use in the United States, Mr. Zintheo (1) concludes that by the use of the proper machinery in place of hand methods of harvesting the ears (leaving the stalks to waste), the farmer may considerably increase the net income from his maize crop, and still allow full price for the use of the different machines. But he also says that there is a limit beyond which it is not profitable for a farmer to invest in maize-harvesting machinery, and that the amount of work to be done by the machine each year should be carefully considered before a purchase is made. As a general rule "it is better not to invest in expensive implements unless there is sufficient work in sight to make them profitable".

FIG. 170.—Cane knife used for cutting maize.

The relative advantage of using machine or hand-labour depends in the first instance on the amount of work to be done; the U.S. Department of Agriculture finds that a farmer who has only 20 acres of maize to cut per year, and who does not intend to cut any for his neighbours, would lose money by purchasing a maize binder if he could hire one from a neighbour, or had sufficient labour to harvest his crop by hand; and further that it would require a cut of at least 80 acres per year before the investment in a corn binder would be profitable.[1] We have heard of a farmer on the Transvaal

[1] It is admitted, however, that this is a conservative estimate, for with proper care the life of the machine would probably be considerably longer than the

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High-veld having 200 acres under crop, who used a binder for one or two seasons and then "scrapped" it in favour of hand-labour; but he was exceptionally well situated as regards a steady supply of the best native labour, and this single case cannot be relied upon as a demonstration of the relative value of machine and hand-labour in South Africa.

"The farmer who would secure the full value of his corn crop should secure the fodder with as much care as he gives his clover hay, harvesting it at the proper period, and not allowing it to become ruined by rain or frost"; for South Africa we should have added: and drying-out by desiccating winds.

437. *Sled Harvesters.*—In the United States many home-made harvesting devices of the sled pattern have been made from time to time (cf. Figs. 171 and 172). These were adapted for cutting either one or two rows at a time, according to draught available and other requirements. With most of these sled harvesters the driver rode on the platform, and it was necessary for him to gather the stalks in his arms in advance of the cutting edge, to prevent them falling in various directions. This method proved very exhausting to the men, and the acreage which could be handled per man per day was reduced in consequence.

An improved harvester was designed, in which the stalks were collected on the platform by a guiding arm (Fig. 172), and it was only necessary for the driver to remove the stalks from the sled at intervals and to throw them on the ground. A further improvement was effected when, in order to reduce the draught, the sled was mounted on wheels. With this machine, two men sit on the platform, one facing each row, to guide the maize stalks against the cutting edge with one hand, and with the other hand and arm to collect the cut stalks on the tilting side-part or wing of the platform, holding the stalks against the leg, until enough have been collected to form a shock.

438. *Mechanical Harvesters.*—These simple devices, while

eight years used as a basis of calculation. "There is no doubt that in general *half the money spent for implements could be saved if they were given better care when in use, and when not in use protected in an implement shed, from wind, rain, sunshine, and farm animals.*"

an improvement over cutting by hand, were felt to be inadequate, and further improvements were effected to reduce labour. A later machine consists of two driving wheels, between which is mounted the frame for the driving mechanism and platform. It is drawn by one horse, which walks between the two rows that are being cut. The *dividers* pick up the lodged maize, CHAP. XI.

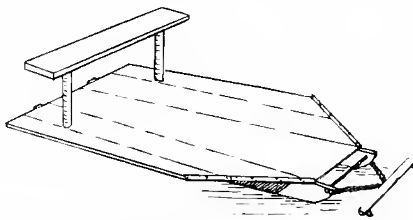

FIG. 171.—Device for cutting maize in the field. (After Myrick, *The Book of Corn*, Orange Judd Co.)

except such as lies in the row of maize away from the machine, and guide it to the cutting apparatus, which consists of two stationary side blades, above which is a movable sickle; this cuts the maize and deposits it horizontally on a platform elevated about 6 inches above the cutting apparatus. On the inner side is a guide chain, which helps in directing

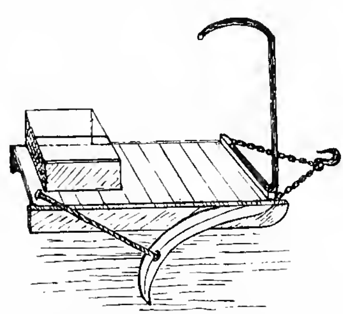

FIG. 172.—Another device for cutting maize in the field. (From *Transvaal Agricultural Journal*.)

the stalks of maize to the knife and the platform. The rear part of the machine is provided with a small wheel, above which is a tilting lever; by means of this lever the dividers in front can be raised or lowered to gather up the lodged maize until it comes in contact with the endless chain, and is thus carried backward to be cut and deposited on the platform.

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Machines of this type gather and cut the maize and drop it on the platform. When there is enough to start a shock, the horse is stopped and the shock is set up.

439. *Cost and Efficiency of Harvesters.* — The different forms of maize harvesters vary in price from \$5 (£1) to \$55 (£11), and " while their low cost is a great advantage, their degree of efficiency is not very high. The cheap sled harvesters can be used only when the corn stands straight, and the horse must walk rather fast in order that the work may be perfectly done. It is also hard work for the men to gather and shock the corn. The work of harvesting corn is such that only the best construction can withstand the strain for any great while, hence these machines are being used less than formerly."

The following figures indicate the cost and efficiency of these machines :—

Area of maize cut per day .	2 to 10 acres.	
Use of machine and repairs .	84 cents per day	18 cents per acre.
Twine	19 ,, ,,	4 ,, ,,
Expenses for one horse and man	\$2·75 ,, ,,	58·5 ,, ,,
,, of second man . .	\$1·75 ,, ,,	37·5 ,, ,,
Average area cut and shocked per day by two men and one horse, with sled harvester . . .		4·67 acres.
Area cut by one man with a knife		1·47 ,,
Cost of harvesting per acre		55 cents to \$2.
,, ,, ,, (average of all reports) .		\$1·18
Cost of harvesting by hand, per acre		\$1·50
Saving in favour of the machines		32 cents.

440. *The Maize Binder.*—The maize binder is a machine drawn, usually, by horses, and so designed that it will cut off the maize stalks near the roots, pick up any lodged plants lying across the rows, and bind the stalks into bundles. There are three different forms of maize binder, the vertical, the horizontal, and the inclined ; the last is a blend of the other two rather than a distinct type. These implements differ only in the *relative position* of their several parts, which are essentially the same in all. These are: the *dividers*, which pick up the lodged stalks, except such as lie *in the row* (i.e. in the direction in which the machine is travelling), and guide them to the *cutting apparatus* ; the latter consists of a serrated knife which passes to and fro across two stationary blades, one

attached to each jaw ; the stalks are collected on the binder CHAP. XI.

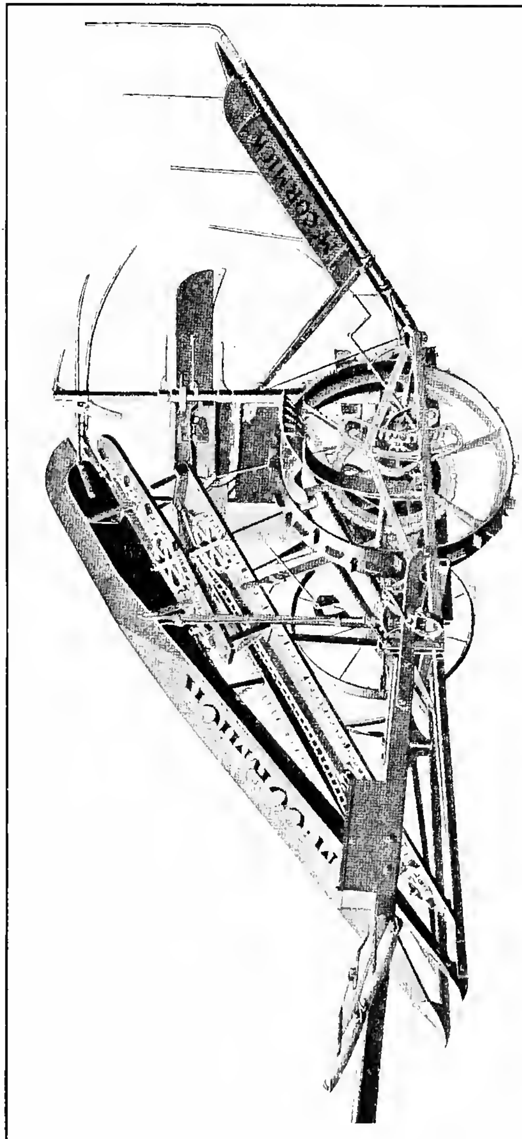

FIG. 173.—McCormick maize binder. (Courtesy of Messrs. Malcomess & Co.)

deck, where they are tied in bundles with twine ; each bundle

CHAP. XI. as it is tied is discharged on to the ground. Two or three men follow and shock the corn, i.e. set the sheaves up in the form of stooks or, as they are usually called, *shocks*.

Maize binders weigh from 1,400 to 1,800 lbs.; "generally speaking, those weighing in the neighbourhood of 1,500 lbs. have been most successful, this weight seeming to give the proper relation between driving power and durability".

"The corn binder is used to greatest advantage in fields where the corn is check-rowed, as it is possible to cut around a block, keeping the machine constantly in operation."

Fig. 174.—Maize binder at work in America.

"The corn binder is well adapted for cutting corn for the silo, as the bundles are bound into convenient size for handling, but this saving of labour is accomplished at the cost of twine."

441. *Estimated Cost of Using a Maize Binder.*—We have no available data as to the relative cost of harvesting by hand and machinery in South Africa, since harvesting machinery has not yet come into general use. We must therefore take American figures as a basis on which to work.

The following figures give some idea of the efficiency of the maize binder:—

Number of acres cut per day, average	7·73	
Number of horses used	3	
Number of men employed	3 or 4	
Lbs. of twine per acre cut, average	2·44	
Life of corn binders, average in years	8·17	
Acres of corn cut per binder, average (spread over 8·17 years)	668·77	
First cost of corn binder, average	$125	
Cost per acre cut, including price of machine, repairs, and interest on the investment, average per acre	29 cents, i.e.	1s. 2½d.
Cost of driver and team :		
per day	$3·55 ,,	14s. 9½d.
per acre cut	46 cents ,,	1s. 11d.
Cost of twine per acre	30·5 ,, ,,	1s. 3¼d.
Cost of shocking after a corn binder, per acre	44·8 ,, ,,	1s. 10¾d.
Total cost of harvesting maize with a corn binder, per acre	$1·50, ,,	6s. 3d.

"The cost of cutting corn with the corn binder is therefore the same as the cost of cutting corn by hand, and 32 cents per acre higher than the cost of cutting with a sled harvester. This extra cost of cutting with the corn binder over the cost of cutting with the sled harvester may be attributed to the cost of the twine and the interest on the investment in the higher first cost of the machine.

"One disadvantage in the use of the corn binder is that it knocks off more or less ears of corn, which either have to be picked up by hand, at a cost of about 10 cents (5d.) per acre, or left to waste or to be found by the cattle after the field is cleared."

442. *The Maize Stubble Cutter.*—When the maize is cut high with a corn binder, the farmer may have difficulty in getting rid of his stubble. In order to obtain a clear field and to have the corn stalks cut close to the ground, an attachment to the corn binder has been invented. This is a knife, attached to the under side of the machine; it floats on the ground, cutting the stalks even with the surface. The cutter has a drawing, slanting cut against spring resistance, which makes a clean cut. When this attachment is used, the binder is usually set to cut higher. The stubble may be ploughed in, and if cut when sappy, will decay quickly and form humus in the soil. By cutting the stubble in this way the ground may be more thoroughly prepared for the next crop, and the stubble and roots buried more deeply, with consequent destruction of the stalk-borer, if present.

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443. *Draught of Maize Binders.*—The average draught of a maize binder is about the same as that of a 6-foot wheat binder. It therefore requires the same number of animals to draw it, i.e. the equivalent of three good horses. Draught tests made by the United States Department of Agriculture show the following results:—

	Lbs.
Draught of maize binder *with* stubble cutter	437
,, ,, ,, *without* stubble cutter	420
Draught of stubble cutter	17

444. *Shocking Maize.*—When the maize is cut before the stalks are dry, it must be put up in *shocks* (Fig. 175) in the

FIG. 175.—Shocking maize in America.

field, to allow it to cure properly. In the United States the shocks vary in size from 36 hills to the shock, i.e. collected from an area 6 hills square with check-rowed maize, to 256 hills from an area 16 hills square; but a common size is 144 hills or 12 hills square, which at a minimum of 2 stalks to the hill is at least 288 stalks. The smaller-sized shocks are common in the North Atlantic States, where it is found more difficult to properly cure the stover if the shocks are larger. In the North Central States 10 and 12 hill shocks are common: 10 × 10 hills of check-rowed maize would be equivalent to about 30 feet of continuous row-planting, for 10 rows, or 30 square feet if the rows are 3 feet apart.

A common method of building shocks is to tie together the tops of four hills, as they stand, uncut, and then to cut and shock around them the rest of the hills in the square ; this is called the four-saddle method. Another way is to use a three-legged wooden horse as a temporary support. "In either case the shock is built around the support with great care, to prevent it from being blown over by heavy winds or damaged by rain. In some cases the maize is tied into small bundles which are set together to form the shock ; more commonly the stalks are gathered as cut, and set up, an armful at a time. Where the wooden horse is used, the shock is built about it by leaning the first bundles or armfuls against a pair of projecting arms formed by inserting a stick through a hole bored at right angles to the horse. When the shock has been set up the stick is withdrawn, the horse removed, and the shock tied lightly near the top or left without tying, as the case may be. A rope with a hook at one end is sometimes used to draw the tops together before tying.

In the South African Bush-veld, where sticks are easily obtained, stakes are driven into the ground at suitable intervals, in rows through the fields, and the cut stalks are stood around the stake until a shock of suitable size is made, which is finally tied with a strip of bark from the "mimosa" thorn (*Acacia horrida*). Strips from the fresh green leaves of the New Zealand flax (*Phormium tenax*) are also useful for this purpose.

In the United States it takes about a month for shocked fodder to cure properly. After this the shocks are gathered together and stacked to prevent loss from frost and winds, or are husked by hand if it is not intended to feed the grain with the fodder.

445. *The Maize Shocker.*—Maize shockers have the advantage over binders in that they require the work of but one man, as the machine does the shocking of the maize bundles. Maize shockers cost about as much as binders and weigh approximately the same. But the shock is not so easily loaded on a wagon, for the whole shock must be loaded at once, requiring some form of loading device or horse-power derrick, whereas the individual sheaves made by the binder can be loaded with a pitchfork.

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Number of acres cut per day, average	4·7
Number of horses used	3
Number of men employed	1
Total cost of harvesting maize with shocker, per acre	\$1·06, i.e. 4s. 5d.

"The wear and tear is less than on a corn binder, and the life of the machine ought to be greater. . . . A corn shocker arranged to load the shocks on a wagon, would no doubt prove the cheapest method of harvesting corn for the silo. *The general verdict of farmers who have used both the corn binder and the shocker, is that the shocker is the preferable machine for harvesting corn.*"

446. *A Maize Shock Loader.*—A loading device for handling the shocks adds greatly to the value of the shocker, for with it the maize can be more cheaply handled. "An improved loading device which can be carried along with the wagon or left in the field and driven about independently, is mounted on four wheels, and consists of an adjustable vertical mast on which is a horizontal steel cross-arm. On this is mounted a travelling block fitted with pulleys through which a rope passes. To the end of this rope a horse is hitched to lift the load. For loading corn shocks a grapple fork is used; this is slipped under the shock, the grapple arms are closed, and with the pull of the horse the shock is lifted up on the wagon and laid on its side or stood on end; the grapple arms are released by simply turning the handle of the fork. This machine was originally designed to load corn shocks, and it easily handles two shocks per minute, and will bear a stress of 2,000 lbs. It can also be applied to many other uses, such as loading hay, manure, small grain, dirt, lumber, telephone poles, and other heavy objects."

447. *Husking Shocked Maize by Hand.*—When the maize is cut before it is dead ripe or dry, it must be husked after the crop has cured. Where large acreages are grown, the *Combined Husker and Shredder* is used to advantage, but where the acreage is small and labour plentiful and cheap, husking may be done by hand.

A correspondent writing to the *Rhodesian Agricultural Journal*, under date 13 May, 1910, describes the method of husking adopted by him, as follows:—

"I give each native a piece of hard pointed stick about

5 to 6 inches long, with a string round two notches in the centre. The stick is held in the palm of the right hand with the point between the thumb and forefinger, the string being round the middle finger; the mealie, still on the stalk, is grasped in the left hand, the point of the stick is inserted at the top of the cob, the forefinger and thumb grasping the husk, a sharp tug pulling half of the husk away, the remaining half comes away easily, and a sharp twist detaches the cob. The straw is then carted away and stacked alongside the wire kraals for winter use, to be fed to the cattle at night. I cart the cobs after this fashion; the large, medium and small cobs are bagged separately. The large cobs are placed at the farther end of the mealie hock, the medium-size in the centre, and the smaller ones near the door for immediate use.

"I may say the above methods are the quickest I have yet seen, and the natives are delighted with the pointed stick, which saves their fingers considerably. I make the mealie hock with wire woven with the Kitselman woven-wire fencing machine. The size of mesh can be altered from mouse-proof to any desired size. The hock is raised above the ground on posts."

448. *Maize Pickers.*—In the American Corn-belt, where maize is the staple crop, it is grown for the ears principally. "The use of the corn binder and the shocker, while quite extensive, does not solve the corn-harvesting problem in the purely corn-raising regions, where a large share of the corn is still picked by hand from the stalks as they stand in the field." It is often difficult to get sufficient labour for this somewhat tedious work, and for over fifty years inventors have been busy, trying to perfect a machine to pick the ears from the stalks.

Several machines have been introduced since 1902 for this purpose.

"The corn picker as now constructed, resembles the corn binder in the construction of the main frame, drive wheels, and dividers. It passes along the row of corn, which is straddled by the dividers, and the stalks, after being righted by the points, chains and other devices, pass between a pair of inclined, corrugated rollers that snap or strip off the ears. The rollers are so placed that the ears fall naturally into a trough that extends along beside them. In order to provide snapping rollers to remove the ears and force them to fall

CHAP. XI. always to the same side, yet permit free entrance of the upright stalks at the receiving end, snapping rollers have been arranged in slightly skewed relation, by which the upright stalk may be gradually forced to one side as the picking rolls pass along, and the ears are broken off and directed to one side. The ears are carried back by a travelling conveyor and either delivered to a set of husking rolls or else, without being husked, carried by an elevator and delivered into a wagon which is driven alongside the machine.

FIG. 176.—Maize picker at work in America.

"Another form of modern practical corn picker has the guide chains with the usual prongs for straightening up the stalks. The chains form a stalk-passage extending rearwards through the machine. A rapidly moving chain provided with fingers is located at one side and between the guide chains in such a position that, as the machine passes over the row, the fingers engage the ears on the stalks and snap them off. By means of a deflector the ears are directed to a receptacle from which they are carried to the husking rollers and then to the wagon. The tops of the cornstalks are cut off, and by means of a conveyor this and other trash is carried to the rear and dropped on the ground.

" The corn picker is intended to remove the ears from the stalks, which are left in the field. Most of the machines are built on the assumption that the stalks are valueless, and therefore they are practically destroyed. It has not been possible to construct a picker that will not to some extent break down or tear down the stalks. This is somewhat objectionable because, where the corn is picked by hand, the dried corn leaves and stalks serve as roughage for cattle during the fall and winter. The machine has, however, this advantage, that the field can be picked more quickly and the cattle turned in earlier to make use of the roughage before the snow falls.

" Another objectionable feature of the corn picker as compared with the hand method of picking corn is that it shells considerable corn ; and, if the corn is lodged and tangled, more or less ears are missed by the machine. The corn picker with the husker attachment requires considerable motive power, at least four horses being required to pull it. For this reason some manufacturers have dispensed with the husking attachment and depend upon the snapping rollers for removing most of the husks. Machines of this kind will remove from 25 to 75 per cent of the husks, depending upon the stage of maturity of the corn, the brittleness of the stalks and the effects of freezing and damp weather. Where machines without the husker attachment are used, a stationary husker may be provided at the crib, in which the corn is husked and elevated into the corn-crib.

" There is a variance of opinion among farmers as to the advisability of husking the ears clean. In the South the common practice is to leave the husks on the ears, and it is claimed that this practice tends to prevent injury by insects. In the North it is the common practice to husk the ears clean before they are cribbed. The objections offered, in reply to inquiries, to using a corn picker which leaves the husks on the ears, are : that more crib room is required for the ears ; that they will serve to attract and harbour rats and mice ; that the ears will not dry out, but will be liable to mould ; that the husks interfere with the shelling ; that, while for feeding cattle and hogs the husks will be advantageous, as they will serve as a roughage, horses will toss the ears in trying to remove the husks, and thus lose ear and all. For selling purposes the corn needs to be husked clean in order to command the best market price."

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449. *Cost and Efficiency of Maize Pickers.*—The United States Department of Agriculture gives the following figures concerning cost and efficiency of American maize pickers:—

Number of acres harvested per day, about		7·73
Life of maize pickers, average in years		8·17
Acres of maize harvested, per picker (average over 8·17 years)		668·77
First cost of maize picker, average		$250·00
Cost per acre harvested, including price of machine, repairs, and interest on the investment, average per acre	58 cents, i.e.	2s. 5d.
Cost of driver and team:		
per day	$3·55 ,,	14s. 9½d.
per acre harvested	46 cents ,,	1s. 11d.
Cost per acre of two wagons with teams to remove ears from the machine and deliver them into the crib, at $3 per day for each	77 cents ,,	3s. 2½d.
Total cost of harvesting maize with a maize picker, per acre	$1·81 ,,	7s. 6½d.
Weight of maize picked per day, bushels		341
Number of men required to do the same work by hand		3·8
Cost of labour for same		$11·93
Cost of extra teams for same		$3·00
Total cost for picking the same number of acres by hand, as can be picked with a maize picker per day		$14·93
Cost per acre by hand		$1·93
Cost per acre by maize picker		$1·81

"While the saving effected with the corn picker is not large, the use of a machine *makes the farmer more independent of the labour market, as the work may be done without hiring extra men at a time when they are hard to secure.*

"But the advantage of hand over machine picking in the removal of the husks should not be overlooked." Moreover, "the corn picker is *still an experimental machine*, and not until it has been perfected should the farmer purchase it". At the same time it will be well to watch the development of the maize picker, as it may become of great importance to the South African farmer.

450. *Hand-husking in America.*—The method of hand-husking practised in America is described as follows:—

For convenience in husking a movable table is sometimes used, on which the stalks are laid while being husked. The ears are thrown in piles on the ground near the shocks, and afterwards hauled to the crib. The stover is sometimes hauled to the barn and stored, but often it is left standing in shocks in the field till needed for feeding during the winter.

It is important to choose suitable weather conditions for husking, since if the plants are too dry the stalks will break and blades will fall off and be lost. On the other hand extremely wet weather makes the ground too soft for hauling in the ears to the barn, and the grain gets wet and damaged. CHAP. XI.

Various forms of *husking pegs* and *hook huskers* are used for this purpose in America; they are made in various sizes and shapes to suit different hands by "The Boss Manufactur-

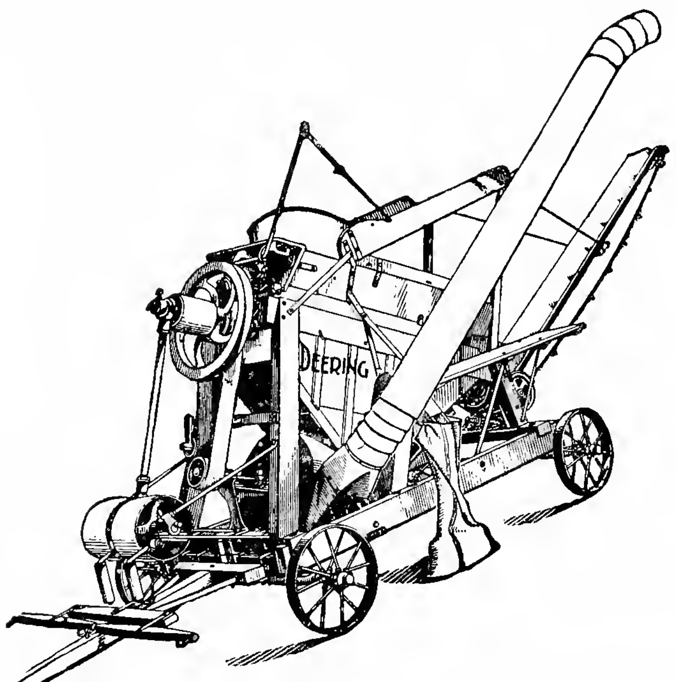

FIG. 177.—Deering combined husker and shredder. (Courtesy of Messrs. Malcomess & Co.)

ing Company," of Kewanee, Illinois, and probably by other firms also. Simple husking pins may be made of wood. Other aids to maize husking consist of gloves with projecting points or pegs; equipped with such a glove, the man husks the ears by tearing off the husks and snapping the stems.

451. *Combined Husker and Shredder.*—There is a particularly useful machine on the market for handling shocked maize, known as the *Deering combined husker and shredder.*

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This machine takes the stalks with the ears on them, removes the ears, husks them, and *shreds* the stalks and leaves for feeding.

There are many other makes, differing in design, but having much the same general construction. Where these machines are used it is a great advantage to have the stalks harvested by a maize binder, as they are then bound in straight bundles, thus saving time and avoiding the danger of choking the machine.

Special threshing machines have sometimes been used for

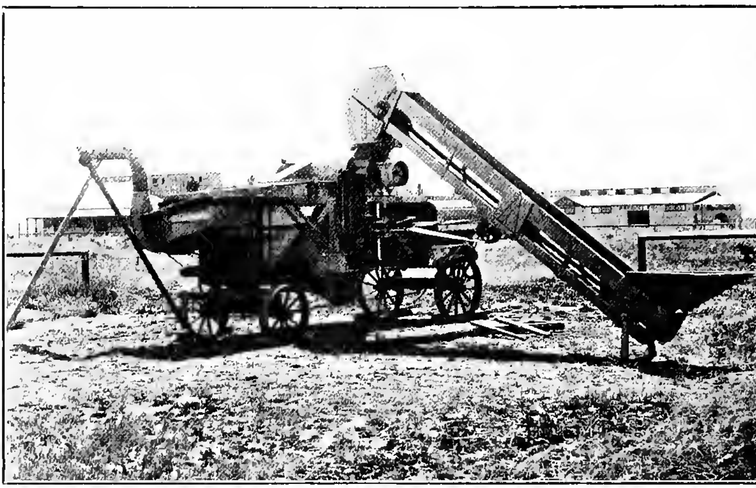

FIG. 178.—Marshall & Son's sheller. (Courtesy of Messrs. D. E. Hockly & Co., East London.)

threshing maize fodder, but they do not appear to be in general use; Hunt (1) suggests that the chief objection to the threshing machine was that it shelled the grain, which at that time of year usually contained too much moisture to be stored safely in that condition.

452. *Combined Husker and Sheller.*—Where large crops of say 500 acres and over are grown, hand-husking is a practicable impossibility owing to shortage of labour and the time involved. To meet this difficulty combined *huskers and shellers* have been designed, and a large number of them are now in use. In South Africa these are mostly of English make, and

among the firms in the market are: Marshalls of Gainsborough; Clayton & Shuttleworth, Ruston Proctor & Co., and Robey & Co., all of Lincoln; Ransomes Sims & Jefferies of Ipswich, and Garrett & Sons of Leiston. Some of these machines will shell, on an average, two muids per minute, or where they husk as well, one muid a minute. The price in South Africa is about £200 to £250 according to capacity. They are usually driven by portable engines of 6 to 7 nominal horse-power or 10 effective horse-power. In this case the sheller remains CHAP. XI.

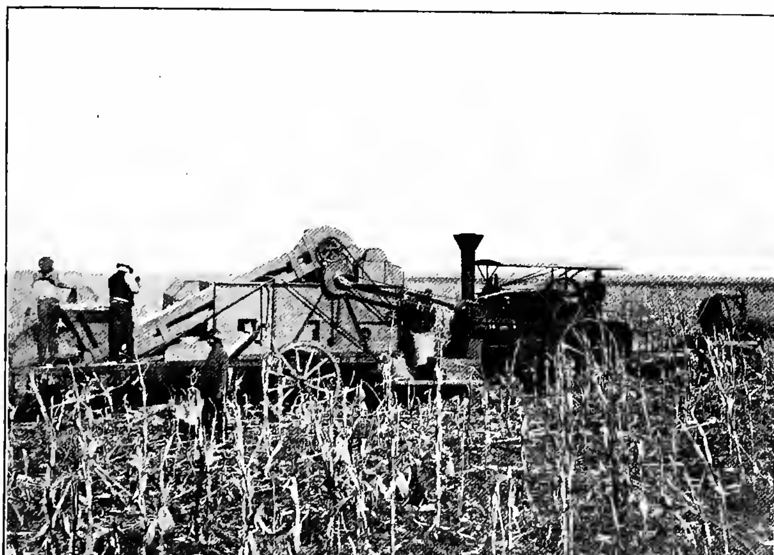

FIG. 179.—Steam traction sheller (Fowler engine and Ransomes sheller).

stationary and the ears are carted from the fields to the machine. At Vereeniging Mr. McLaren has attached a Fowler traction engine to a Ransomes sheller; this pushes the sheller before it at walking pace, through the field of standing maize; the machine is fed by fifty boys who walk ahead, each pulling the ears from two rows of maize, and carrying them in sacks or buckets to the hopper of the machine; a strip of 100 yards wide is thus cleared at each trip down the field. In this way the machine has been found by actual tally to average 60 muid bags of shelled maize per hour, in a ten-hour day.

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A smaller machine, the Marseilles-Adams, is also on the South African market; the listed price varying from £75 to £135 according to capacity.

Owing to the capital outlay involved in the purchase of a shelling outfit, and the short period in the year for which it is required, comparatively few private farmers in South Africa own one. But the number of itinerant machines is on the increase: these travel from farm to farm, husking and shelling

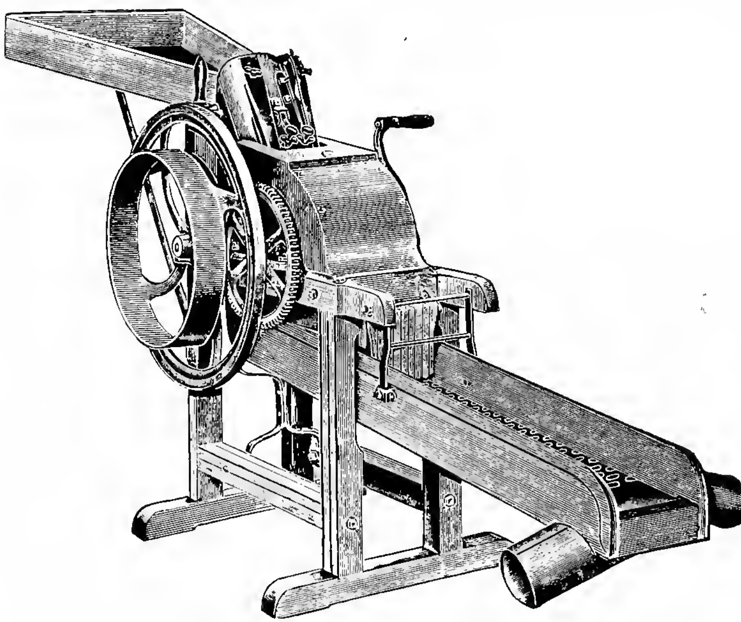

FIG. 180.—Convertible hand or power sheller, suitable for small crops.

for a percentage of the crop, or at a fixed price per muid, or at so much per day.

453. *Machines for Shelling Husked Maize.*—For shelling husked maize there are on the market many machines, worked either by hand or power, and varying in capacity and price to suit the needs of every farmer. Listed prices range from £1 10s. for the little *Clinton* hand sheller (weight 80 lbs.) to £50 for the *Champion*, requiring 6 to 8 brake horse-power, and having a capacity of 150 to 250 muids per day according

to the condition of the crop and the manner in which the sheller is operated and fed. CHAP. XI.

There are so many good shellers offered, that it is impossible to say which is the best, without giving each a thorough trial.

454. *Importance of Drying-out the Grain.*—Where the crop is grown for grain only, it is advisable to leave it in the field until it is thoroughly dry. The ear continues to accumulate nutriment for a considerable time after the stalk has been cut. The value of the grain in the European market depends largely on its dryness; for export it should not contain more than 12 per cent moisture. To secure this degree of dryness without injury to the grain, it should be allowed to dry out on the stalk. If the ears are "snapped" (i.e. broken from the stalk) before the grain is dry, the grain shrinks and is more or less damaged. Cutting and shocking the stalks, if done at the right stage of growth, does not interfere with the proper drying out and conditioning of the grain.

455. *Loss of Weight in Drying.*—A considerable loss of weight is found to take place in maize, left on the cob between harvest and the middle of November. The lost moisture is not replaced in spring by humidity of the atmosphere, even when good rains occur after the middle of October. Tests made at the Botanical Experiment Station, Pretoria, in 1908, showed that the loss of moisture averaged 21 per cent in seven months, but ran as high as 35 per cent. In the United States it averages about 15 per cent. South African maize is usually 5 per cent drier than the American, which added to their 15 per cent loss gives an average of about 20 per cent. Weighings were made on 1 April, at the beginning of the dry season, and again at the end, 17 November. The loss in drying on thirty ears of yellow dent, averaged 21·73 per cent of the original weight and varied from ·42 per cent to 31·2 per cent. Numerous tests have been made in the United States and have ranged from 3 per cent to an extreme of 30 per cent, according to degree of dryness at time of storing in the crib, in four and a half months.

The amount of loss depends largely on the condition of the ears at the time that they are first weighed, and varies

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considerably according to season and mode of storing. The results given in Table LXI have been obtained in the United States:—

TABLE LXI.

SHRINKAGE IN WEIGHT OF MAIZE STORED ON THE COB.

Stored for:	Total Shrinkage.	Average per Month.
3 months	3 per cent	1·0 per cent[1]
3½ ,,	11 ,,	3·3 ,,
5 ,,	15 ,,	3·0 ,,
5 ,,	11·5 ,,	2·3 ,,
Average shrinkage in five months, 2·4 per cent per month or 9·6 per cent in four months.		
8 months	15·5 per cent	1·94 per cent
9 ,,	7·75 ,,	·86 ,,
10 ,,	20·0 ,,	1·67 ,,
12 ,,	37·0 ,,	·31 ,,
Average shrinkage 1·19 per cent per month, or 11·9 per cent in ten months.		
The method of storage in these cases appears to have been in open cribs or in stacks, and the larger the crib or stack the less the shrinkage.		

In the case of shelled grain, a large number of experiments showed that the loss averaged 7·5 per cent in five months or 1·5 per cent monthly.

"Assuming a loss of 7½ per cent on shelled grain in five months, and a price of 10s. per muid of 200 lbs. at the start, the muid at the end of five months would weigh only 185 lbs. and the price at that time would have to be 10s. 9¾d. per muid to cover the loss through shrinkage. To this price would have to be added interest, which, at 8 per cent per annum, would amount to 2d. on 10s. for five months. There would also be storage charges, which, if the storing were done on the farm, might be taken as a halfpenny per muid. In addition to all this, there has to be taken into account the risk of damage by rats and weevils. This risk amounts to very little if the grain is stored in suitable bins, and the weevils are destroyed by use

[1] In this case the maize was in very dry condition when put into the crib.

of bisulphide of carbon, 1 to $1\frac{1}{2}$ lbs. bisulphide to 2,000 lbs. grain.

"Reckoning everything, it may be said that 10s. per muid at harvest time is equal to 11s. 1d. per muid in five months. In a general way it may be considered that there would have to be a rise of $7\frac{1}{2}$ per cent in three months, $9\frac{1}{2}$ per cent in four months, and 11 per cent in five months, in the selling price of mealies, in order that there should be no loss in the money value. Anything over and above these prices would be a gain. Thus there would be a decided gain if mealies, instead of being sold at 10s. per muid at harvest time, were sold at 12s. five months later" (*Pearson* in *N.A.J.*).

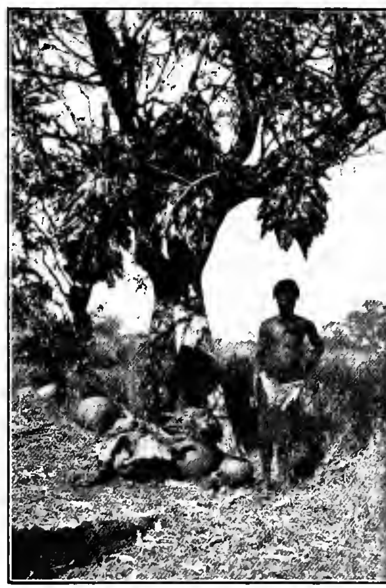

FIG. 181.—Native method of storing maize in the husk, in trees, Swaziland.

456. *Variation in Moisture-content is not Identical with Loss or Gain in Weight Due to Change in Moisture-content.*—Loss in weight due to the drying of maize always exceeds the percentage reduction in moisture, because only part of the moisture is lost in ordinary drying, and the second percentage of moisture is determined on the reduced total weight instead of on the original weight. The original percentage was determined on the dry material, plus a certain amount of moisture; after the loss of part of this moisture the percentage is again determined, but this time on a new basis, i.e. that of the net weight of dry grain, plus the *balance* of moisture. Therefore the variation in moisture-content is not identical with the loss or gain in weight.

For example, 100 lbs. of maize containing 25 per cent free water is dried out till it weighs only 85 lbs.; after losing 15 per cent moisture by drying out, the percentage of moisture

CHAP. XI. left will not be 10 per cent but 11·67 per cent. But 75 lbs. of dry matter, plus 15 lbs. of water lost, plus 11·67 per cent moisture remaining, equals 101·67, or 1·67 more than the original weight. The discrepancy is due to the fact that the 11·67 per cent of moisture remaining in the sample is not 11·67 per cent of the original 100 lbs., but of the 85 lbs. total weight left after partial drying.

457. *Storage in the Husk.*—In order to keep the grain until market conditions are favourable for its disposal, the methods of storing to preserve it from depredation by vermin,

FIG. 182.—Maize on the husk, stored in a pear-tree, by Coloured people, Swellendam District.

etc., vary according to the climate and the materials available for the construction of stores. In the Bush-veld of Swaziland the natives leave the ears in the husk, till required for use, and hang them in the branches of trees near the kraal or garden (Fig. 181).

The same method is practised by the Coloured people of the Cape Province (Fig. 182).

Among white people in South Africa it is not customary to leave the maize in the husk, owing to the danger of sweating and rotting if it is left in uncovered heaps in the field, and to the greater space required when stored.

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FIG. 183.—Maize hock, Waterberg District, Transvaal.

FIG. 184.—Maize hock, Bechuanaland.

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458. *Storage of Husked Maize.*—Nor is it advisable to leave the husked maize on the ground, on account of damage by termites. It is customary, therefore, to store it in some sort of crib, called a *hock*. This is variously constructed according to the materials available in different parts of the country.

Modern maize hocks of various sorts are shown in Figs. 183, 184, and 185.

459. *Storage of Shelled Grain.*—To reduce bulk and to be ready for a sudden rise in the market, it is becoming customary to shell early and sack the shelled grain. The sacks of

FIG. 185.—Method of storing maize, Government Experiment Farm, Potchefstroom.

shelled grain, containing 200 lbs. net each, are stored in sheds (Fig. 186), or, in the usually dry winters of the interior, may be stacked on large platforms, raised above the ground (Fig. 187), and covered with sailcloth.

The following description of the method of storing maize employed at the Trappist Monastery, Mariannhill, Natal, is taken from the *Natal Agricultural Journal* :—[1]

"The mealie store is an independent building erected on the face of the hill just above the mill proper. It contains five large cement-lined compartments, each capable of holding

[1] Vol. VIII, No. 10, p. 1014, Oct., 1905.

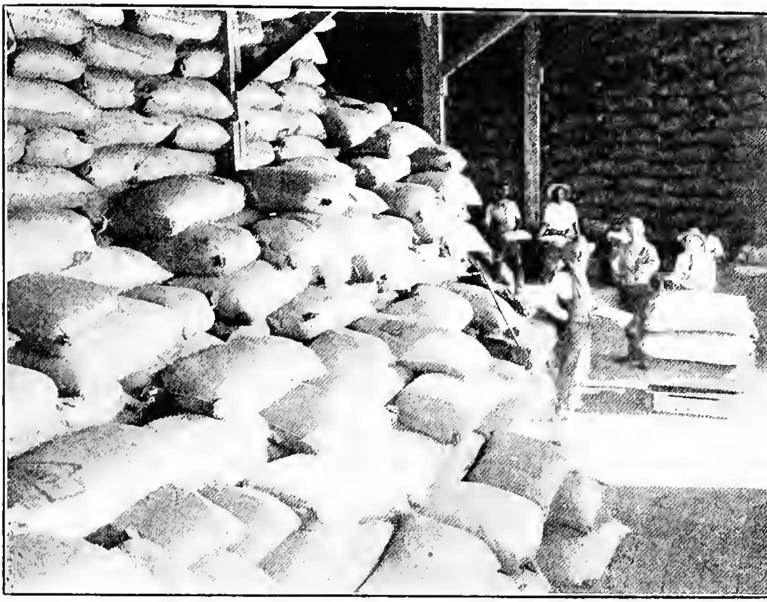

FIG. 186.—Re-weighing and shipping stored maize, Messrs. John Fowler & Co.'s Store, Vereeniging.

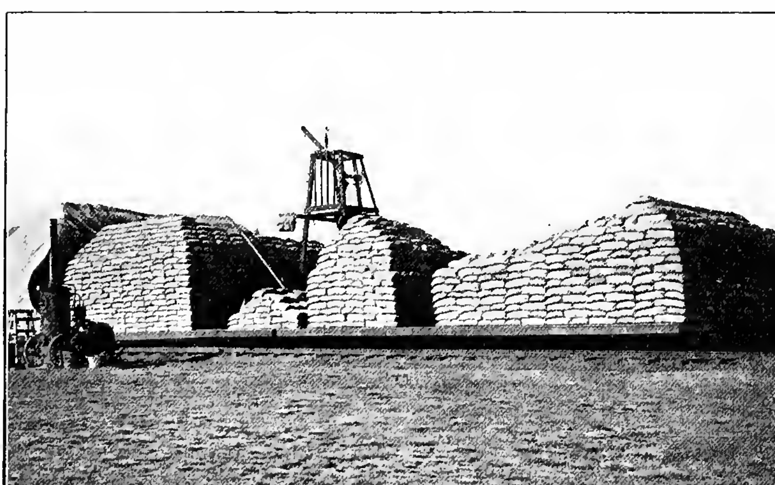

FIG. 187.—Stacks of shelled maize at Vereeniging, ready for market. (Courtesy of Messrs. John Fowler & Co., Leeds, Ltd.)

CHAP. XI. 500 muids of mealies. The building is 40 feet high, and the walls, for coolness and strength, are hollow and 3 feet in thickness. The floor at the top is of cement, small trap doors giving entrance to the five silos or bins. Here there is an ingenious appliance for cooling and airing the mealies as soon as the time for weevil life begins. Let us suppose that the contents of one bin have been consumed, and in consequence that one bin is empty. A trough in which a spiral worm continually revolves is built below the exits of the bins. Number two, we will assume, will be taken in hand. The door of the exit, about a foot square, is opened sufficiently to feed the trough; the revolving worm, like an archimedean screw, then brings along the mealies to the end of the building. Here they fall into a box in which an elevator—a band with buckets—carries them to the top of the building. Here they go into another trough and are forced along by a worm as far as the vacant bin, where an opening in the trough permits them to fall through. It will be seen that as soon as one bin has been emptied this automatic work can go on without cease—and to the discomfiture of the weevils. The cost of the appliances—two troughs with worms, and an elevator—being small, the system deserves consideration of those who handle large quantities of corn, where the climate, as at Mariannhill, is favourable for the weevil."

460. *Kaffir Method of Storage.*—After harvest the native hangs up the maize ears to dry in the open air (Figs. 188 and 189) for two or three months. In regions of winter rain this simple method would be impracticable owing to probable injury from damp. When sufficiently dry the grain is shelled off and stored in enormous jars of earthenware, wicker-work or grass; the latter is called in Sesutu a *sesco* (Fig. 190). These are sometimes buried in the ground. In Cape Province according to Wallace (1) they are simply buried in a pit shaped like a short-necked water-bottle, dug 8 to 10 feet deep underneath the cattle kraal, the narrow mouth being covered by a flat stone, and the joints drawn with fresh dung to hermetically seal it. A foot or so of well-trodden manure on the kraal floor is an effectual protection against rain, and there is little damage from soil moisture; the few grains on the outside which become mouldy, can be used for kaffir beer. The aroma inside the pit is said to be fresh and agreeable, not unlike that of malt or fresh sweet silage.

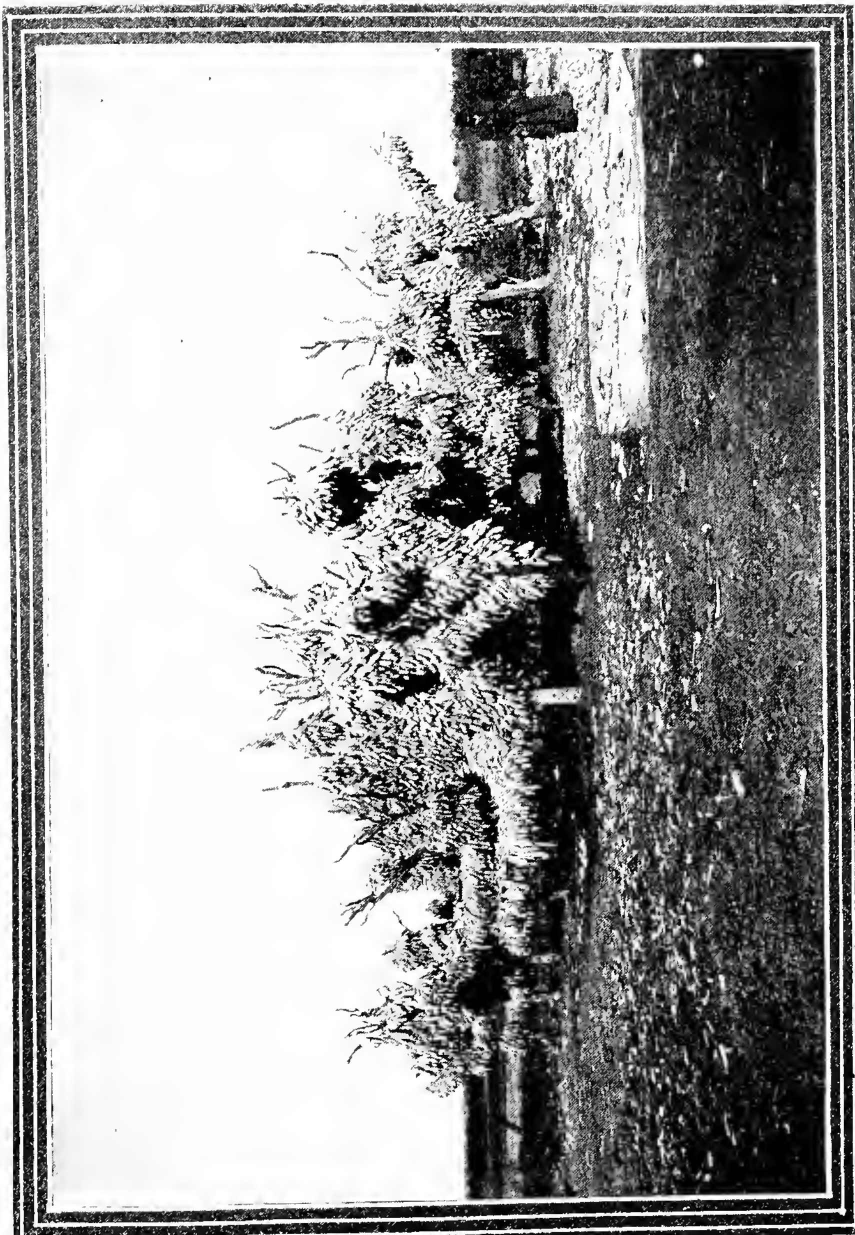

FIG. 188.—Method of drying maize, Marico District, Transvaal.

CHAP. XI. Burchell (1, Vol. II, p. 520) gives the following account of the method of grain storage practised by the Bechuanas, in 1811:—

"The corn is preserved in what may be termed large jars, of various dimensions, but most commonly between 4 and 5 feet high, and 3 wide. The shape of these corn-jars is nearly that of an egg-shell having its upper end cut off: sometimes their mouth is contracted in a manner which gives them a great resemblance to a European oil-jar. They are formed

FIG. 189.—Native method of storing maize, Zoutpansberg District.

with stakes and branches fixed into the ground and interwoven with twigs, this framework being afterwards plastered within and without, in the same manner as the walls of the building. Frequently the bottoms of these jars are raised about 6 inches or a foot above the ground: and the lower part of the stakes then being uncovered, gives them the appearance of standing on short legs. Their contents are usually protected by a covering of skin or straw."

461. *Need for Public Maize Stores or Silos in South Africa.*—The problem of storage pending favourable market

conditions is already felt to be a serious one. Winter is the best time for hauling the crop to the station, for the weather is dry, the roads are good, and the farmer has more time and more transport and labour available than at other seasons of the year. Moreover when the crop is once at the station it can be railed more promptly should a temporary

FIG. 190.—Basuto "sesco" of woven grass, for storing grain. (Courtesy of the Director, MacGregor Memorial Museum, Kimberley.)

rise in the market require immediate delivery. The large grower can provide his own store at the station, but for the small producer it may not be worth while to do so. The Bloemfontein Maize Conference of 1910, therefore, recommended that the Government be requested to erect covered storehouses at the chief inland grain exporting railway stations

CHAP. XI. for the convenience of farmers and merchants, and that a charge be made for storing and holding the grain, to cover cost of such services; regulations to be made to prevent grain from being held in such storehouses for speculative purposes.

Owing to danger of increase of moisture and of injury by weevil and grain, in the damper atmosphere of the coast, the Bloemfontein Conference recognized that such stores, warehouses or elevators should be erected at inland centres, at high altitudes (5,000 feet or over), preferably within about an engine run from the coast. It was stated that at low altitudes like Ladysmith (3,284 feet), maize could not be stored safely after the end of October on account of weevil.

At such centres, maize could be stored until sufficient quantities of one grade were accumulated to furnish a cargo of that grade, which could be run down to the wharf by special fast freight.

At some railway stations the Co-operative Societies have already erected warehouses for storing the grain of their members.

The South African Railway Administration leases land for the erection of stores for storage, but not for trading purposes.

In default of adequate storage, some farmers stack their grain under tarpaulins. This method is expensive and wasteful, for a certain amount of grain is damaged by leakage of water.

462. *Yield of Grain from a Given Measure of Ears.*—At the Government Experiment Farm, Potchefstroom, it has been found that a cubic yard of average husked ears will produce three muids (600 lbs.) of grain. In the United States it is found that 2 cubic feet of sound, dry maize on the cob will make a bushel (56 lbs.) of shelled grain.

To get at the quantity of shelled grain in a hock, crib, or barn of cobs, measure the length, breadth, and height of the crib. Multiply the length by the breadth, and the product by the height. Then divide the product by 2; this gives the number of bushels in the crib. For example, if the crib or barn is 20 feet long, 10 feet broad, and 8 feet high, and this is packed with husked maize: an area 20 by 10 by 8, equals 1,600 cubic feet; divide by 2, and we get 800, the number of bushels of shelled grain in the barn.

463. *Country Damage.*—In some seasons the maize crop is characterized by inferior quality in two directions: (1) by the abundance of poorly filled grains; (2) by the prevalence of discoloured or rotten grains. CHAP. XI.

Rotten grains occur largely at the tips of the ears, and are then due to weathering from exposure of the tip to the heavy rains of late summer. This exposure is caused by the shortness of the husks, which in many cases allow the tip of the ear to become exposed. This character is one that can and should be bred out by breeding from parent plants having ears well covered by the sheath.

In some cases the whole ear is made up of these rotten or discoloured grains; this is sometimes due to breakage of a weak stem, which allows the ear to fall to the ground, where it lies in the wet till harvest.

Where maize is grown on a large scale it is desirable that some means of removing damaged grains should be devised. Such damaged grains are lighter than sound ones; by careful weight of a large number the writer found a difference of 33 per cent to 40 per cent in their average weight as compared with an equal number of good grains, as shown in the following table (LXII); the weights were taken 30 October, 1909, at the end of the dry season.

Table LXII.

RELATIVE WEIGHT OF SOUND AND COUNTRY DAMAGED GRAIN.

	Hickory King.	*Iowa Silver-mine.*
1 Tea-box full of good grains weighs	41 ozs.	42 ozs.
1 ,, ,, bad ,, ,,	32·5 ,,	30 ,,
Difference in weight	8·5 ,,	12 ozs.
Percentage difference	20·73 per cent	28·56 per cent
1 Tea-box full of unselected grains weighed	40·50 ozs.	—
500 good ,, ,, ,, weigh	15 ,,	6·75 ozs.
500 bad ,, ,, ,, ,,	10 ,,	4·00 ,,
Difference in weight	5 ozs.	2·75 ozs.
Percentage difference	33·33 per cent	40·74 per cent

With such a marked difference in weight it should be possible to remove the bad grains by means of a winnower or

CHAP. XI. aspirator. The term "country damage" is applied to such grain, in the English corn trade, in contradistinction to damage in storage or transit.

Pests of Stored Grain.

Lay up for yourselves treasures . . . where neither moth nor rust doth corrupt.—Matthew vi. 20.

464. *Losses Accruing from Storage of Grain.*—If maize is stored for any length of time, it is subject to injury from the ravages of weevils and other insects, and of rats and mice. Loss of weight and depreciation in quality result. Rats and mice occur all over the country, but weevils are most troublesome at altitudes below 4,500 feet; the High-veld is therefore more suitable for the winter storing of maize prior to export, than localities at lower altitudes.

465. *Insects Injurious to Stored Grain.*—The principal insects which are injurious to stored grain in South Africa are the larvæ of (1) the angoumois grain-moth (*Gelechia cerealella*); (2) the granary weevil (*Calandra granaria*) and the rice weevil (*Calandra Oryzæ*).

As there is much confusion in the minds of merchants and others who handle and store grain, as to the way in which these insects live and propagate their kind, and as this ignorance of the actual facts makes it more difficult to combat the pest, a brief account of their life-history is here given. These insects either destroy, or greatly impair, the vitality of the grain. Trucks, stores and ships become infested with the adult insects, and whole consignments of sound grain may thus become infected in transit.

466. *Weevils.*—The popular idea with regard to weevils (*Calandra granaria* and *C. Oryzæ*) is conveyed in the expression often heard, that "Weevils come out of the grain but don't go into it". Like many untrained observers, those who make this statement utter a half-truth, the knowledge of which is perhaps more dangerous than total ignorance of the subject. It is true that the weevil does not enter the grain *in the same form* as the mature insect which the merchant finds emerging from it in his store, or crawling over his bags of grain. But it is equally true that the weevil could not come out of the grain unless it had first gone into it! How

are these two statements to be reconciled? The facts are briefly: a few weevils are found crawling over the maize ears in the field; they are carried into the yard or shed where the ears are stored for shelling, and thus find their way into the buildings. When conditions are favourable, the female weevil lays her eggs on the maize-grain, near the soft end. From the egg there hatches out a minute grub which bores into the soft end of the grain and begins to feed there, gradually working towards the upper part of the grain, and eating out a tunnel large enough to fit its enlarging body, leaving only a thin piece of the hull between itself and the outer air; it then pupates, and when combined conditions of moisture and temperature are favourable, the mature, blackish weevil pushes its way out of the hole. The two sexes then seek each other, mate, and the female lays her eggs; thus the life cycle is complete.

There may be several generations of weevils in a year.

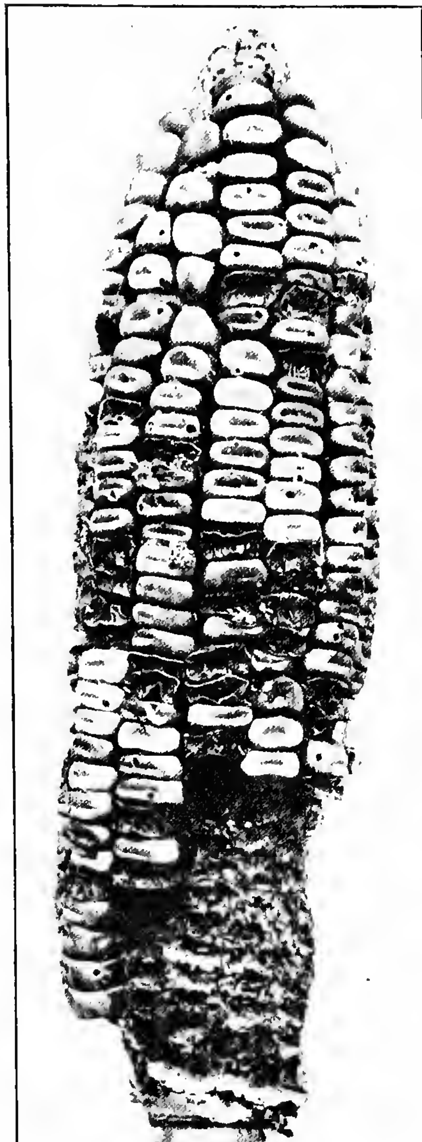

FIG. 191.—Effect of larvæ of the angoumois grain-moth on maize-grain in the ear.

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467. *The Angoumois Grain-moth* (*Gelechia cerealella*).—The eggs of the moth are laid on the grain and in due course the larva, in the form of a minute caterpillar or "worm," as in the case of the grub of the weevil, bores its way into the soft part of the grain, feeds and grows, pupates and finally emerges as a full-grown moth, ready to mate and lay a fresh lot of eggs. The holes in the grain formed by the larva of this insect are shown on Fig. 191.

468. *Remedies for Insect Pests.*—The storage of grain in weevil-proof tanks and silos greatly reduces the loss from this source, but it is not entirely effective because weevils and grain-moths (in the egg or larval stage, or even as adults) may be brought into the tanks with the grain, and thus start fresh infection. An application of carbon-bisulphide in the proportion of 1 lb. to 1 ton of grain or in empty tanks or stores 1 lb. for every 1,000 cubic feet, is said by entomologists to be the simplest and best remedy. This substance is highly explosive, and the greatest care must be exercised that no light be allowed in or near the place where the carbon-bisulphide is in use.

The late Mr. C. B. Simpson, Entomologist of the Transvaal Department of Agriculture, replied as follows to a correspondent, in the *Transvaal Agricultural Journal*:—

"You are indeed unfortunate on account of the fact that your mealies became infested in the field. The weevil usually hides in cracks and crevices, or in grain which is strewn about and attacks the new grain as soon as it is stored. A thorough cleaning of the building in which mealies are to be stored is, therefore, one of the best preventive measures. Many farmers in Natal and Cape Colony have found that large tanks, made of corrugated iron, are most admirable for storing mealies. These tanks, which hold from fourteen to fifteen bags of mealies, are filled almost to the top with the grain and a lighted candle is placed in the tank and is allowed to burn until the air is exhausted, after which the tank is securely closed. Some farmers go so far as to state that this burning candle kills all the weevils already in the grain and prevents others from entering; I do not, however, place any confidence in the candle as a destroyer of insects, but on account of the fact that the tank is tight, no insects can enter. Bags of mealies may be stored in tight iron buildings or large tanks. The ideal granary from the standpoint of insect ravages should be built at some distance from the other buildings and made as nearly vermin proof as possible, the doors should fit tightly, the windows covered with wire gauze, the floors, walls and ceilings should be smooth, so as not to afford any lurking place for insects, and it would be well to have them oiled, painted or white-washed ; a coat of coal tar has been strongly recommended for the latter purpose. CHAP. XI.

"You are, undoubtedly, already aware that kiln-dried mealies are but little attacked by weevils ; however, this method has many disadvantages.

"If the mealies have already been attacked by weevils, the following methods may be employed, which will depend largely upon the means at hand, as well as other conditions. The grain is put into some air-tight bin or barrel, such as may be at hand, and carbon bisulphide is applied. This chemical is a colourless liquid with a strong, disagreeable odour, vaporizes rapidly, is highly inflammable, explosive and poisonous. The vapour is about two and a half times heavier than air and, consequently, the liquid should be placed at the top of the bin. For large masses of grain, from 1 lb. to $1\frac{1}{2}$ lbs. is used to a ton of grain ; for smaller masses, 1 oz. is sufficient for 100 lbs. of infested matter. The bins are rendered as air-tight as possible, and the liquid poured in into an open dish, which is placed upon the grain. The infested grain is generally subjected to this treatment for 24 hours, but may be exposed much longer without harming it for milling purposes ; if not exposed for more than 36 hours, its germinating power will not be impaired nor is it rendered unfit for feeding purposes.

"The greatest care should always be taken with this chemical, as the vapour is explosive and a lighted pipe or cigarette may be sufficient to cause a disastrous explosion. I am quite sure that you will find carbon bisulphide the best method for the purpose, as it is largely used in other countries with universal success."

469. *Rats and Mice in Maize Stores.*—Rats and mice are as troublesome in South Africa as in other grain-producing countries. Numerous remedial measures have been recommended from time to time, in the *Agricultural Journals* of the several Colonies, but perhaps none of them is more efficacious than the old-fashioned cat or a good trap.

CHAPTER XII.

COMMERCE IN MAIZE GRAIN.

Merchandising . . . is the *vena porta* of wealth in a State.—BACON, *Essays*.

I thank my fortune for it, my ventures are not in one bottom trusted, nor to one place; nor is my whole estate upon the fortune of this one year: therefore my merchandise makes me not sad.—*Merchant of Venice*.

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470. *Time of Arrival of the South African Crop.*—Harvesting of the earliest-maturing South African maize begins about the end of May on the Transvaal High-veld, but the grain is still apt to be rather wet. The real harvesting season begins on the High-veld towards the end of June, and in the Midlands of Natal about the middle of July.

If earlier-maturing breeds were more extensively planted, there is no doubt that South Africa could begin to ship dry maize to arrive in Europe by the middle of June, especially if a better price could be secured to compensate for a possible lower yield per acre.

471. *Local Markets.*—South Africa is not only fortunate in being able to produce good maize and in having an oversea market for it, but also in having an increasingly large and profitable local market for what is rapidly becoming the most important crop of the country. A local market is often better for the small producer than that oversea. Maize is the staple foodstuff of the South African native, both in his kraal or on the mines. The consumption on the mines is large, but may not be increasing materially; there is, however, a rapidly increasing amount used for feeding stock such as ostriches, horses, mules, cattle and sheep; in this connection it is well to remember that the United States, which at one time exported some 50 per cent of her crop, now exports barely 1·5 per cent, although her total annual production has increased enormously in the same time. A repetition of history may be confidently

expected in the South African maize industry; the consumption of maize on the farms, and eventually also in local manufactures, will steadily increase. CHAP. XII.

472. *The Mines Trade.*—With regard to the quantities of maize, maize meal, and other maize products such as samp, which are consumed on the mines of South Africa, actual statistics seem to be lacking.

The method of feeding differs on different mines; some buy the rations for the "boys," while others prefer to let them buy their own, on the ground that they are less likely to waste it. The amount given in rations also differs, some mines allowing as much as 3 lbs. of mielie meal a day for each boy, and some giving less than 2 lbs., making up the difference with other foodstuffs.

According to the *Transvaal Leader* of 21 November, 1908, the local consumption of maize in "Johannesburg" was then calculated to be "at a low estimate" 70,000 muids per month, or 840,000 muids per annum; but it is not certain how much of the Witwatersrand was included in this calculation, and it would also include the maize used for feeding draught animals, which is no inconsiderable item. The writer is informed, however, by one of the large controllers of mines on the Rand, that 2 lbs. of maize meal a day, for each native, may be considered a good average figure as a basis of calculation. According to the 1911 census there were then employed in the mines of the Union 261,835 natives. Two pounds of meal a day is equivalent to 3·65 muids a year for each native, or a total of 955,697·75 muids of mielie meal per annum. Allowing 8 per cent for ordinary loss in milling, this represents 1,038,801 muids of maize consumed each year by the natives on the mines.

473. *Consumption on the Kimberley Mines.*—Tables LXIII and LXIV show the amount of maize consumed by the properties of the De Beers Consolidated Mines, in the year 1912. With an average monthly population of 14,306 natives and 1,173 draught animals, there is a total consumption of

15,396	bags of	white mielie meal.
934	,, ,,	samp.
13,025	,, ,,	yellow maize.

CHAP. XII. Allowing for 8 per cent loss in milling the maize into mielie meal and samp, this represents 16,076 muids of white maize actually used.

TABLE LXIII.

MAIZE CONSUMED BY THE DE BEERS CONSOLIDATED MINES, LTD., DURING THE TWELVE MONTHS ENDING 31 DECEMBER, 1912.

1912.	Kind of Maize.	Amount of Maize Bags.	Average Number of Cattle.
January	Yellow	1,181	1,204
February	,,	1,111	1,161
March	,,	1,006	1,160
April	,,	1,081	1,161
May	,,	1,117	1,169
June	,,	1,239	1,182
July	,,	1,034	1,159
August	,,	1,053	1,129
September	,,	981	1,155
October	,,	1,084	1,198
November	,,	1,074	1,204
December	,,	1,064	1,193
Total (200 lbs. per bag)		13,025	1,173 (Average number of cattle per month.)

TABLE LXIV.

MAIZE MEAL CONSUMED IN THE COMPOUNDS OF THE DE BEERS CONSOLIDATED MINES, LTD., DURING THE TWELVE MONTHS ENDING 31 DECEMBER, 1912.

1912.	Kind of Maize Meal.	Amount of Maize Meal.	Average Number of Boys.
January	White	1,391	15,195
February	,,	1,449	14,910
March	,,	1,271	14,749
April	,,	1,491	14,901
May	,,	1,338	14,610
June	,,	1,143	14,712
July	,,	1,400	14,673
August	,,	1,232	14,192
September	,,	1,190	13,694
October	,,	1,327	13,436
November	,,	957	13,275
December	,,	1,207	13,329
Total (180 lbs. per bag) (= 18,856·4 muids of 200 lbs.)		15,396 bags,	14,306 (average monthly population).

NOTE.—934 bags, each 196 lbs., of samp were also consumed in the Company's Compounds, by the natives, during the year 1912.

474. *Cape Stock Farmers.*—A considerable quantity of maize is imported into the Cape Province from the other Provinces, for feeding ostriches and other live-stock. During 1908, 174,827 muids were exported from Durban to Cape ports. Since Union, reduction of railage rates has permitted the direct consignment of maize by rail from the interior Provinces to consuming centres in the Cape Province. CHAP. XII.

475. *The Native Trade.*—The native trade provides a valuable local market for those farmers who live in proximity to Locations of sufficient importance. The South African native is characteristically lacking in thrift; no sooner is the crop harvested than he—or more often she—starts to barter it off for trinkets, salt, etc., without any thought of the future. The individual crop is small, and in this way soon exhausted; then the native begins to buy back from the local store-keeper or farmer at greatly enhanced prices. The native's methods of agriculture are not conducive to the conservation of soil-moisture; in seasons of only comparative drought his crop often fails, and he is compelled to purchase from the more successful white farmer, paying for his grain in labour or in kind. It is this improvidence which largely maintains the supply of native labour; if the native were himself a good farmer and thrifty, he would not be under the necessity of working for wages, and the white farmer would lose the benefit of his services.

476. *Local Prices.*—There is no doubt that the establishment of an export trade for South African maize has had a steadying effect on the local market. Although it is true that before it was established farmers were often able to realize 20s. per muid for their maize, it should not be forgotten that when there was a "bumper" crop prices fell to 4s. or even 3s. per muid, figures at which maize-growing did not pay; these low prices were due to the fact that production had exceeded local consumption; now that it is possible to export the surplus, the local market can no longer drop below paying prices.

The following figures, culled at random from the pages of the several South African *Agricultural Journals*, the Keeling Agency *Reports*, etc., etc., will give some idea of the range of prices prevailing in the several markets.

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TABLE LXV.

VARIATION IN MAIZE PRICES IN SOUTH AFRICAN MARKETS.

(Price per muid.)

Date.	Johannesburg.	Kimberley.	Maritz-burg.	Durban.	Bulawayo.	Salisbury.
1904. March (1) .	24/6	23/-	—	—	32/6	25/-
,, Oct. (6) .	10/9 to 11/9	—	7/6	—	—	—
1905. Sept. (3) .	8/- to 9/-	—	—	—	—	—
1906. Feb. (4) .	12/9 to 13/-	14/6 to 16/-	—	—	24/- to 25/-	22/6 to 25/-
,, Oct. (5) .	13/6 to 13/9	15/-	—	—	19/- to 22/-	17/- to 20/-
1908. July (7) .	—	8/9 to 9/6	—	10/-	—	—
,, March (11) .	8/- to 9/6	—	—	12/6 to 15/-	—	—
,, Feb. (8) .	8/- to 8/9	8/- to 10/-	9/-	9/6	—	—
,, Nov. (10) .	16/9 to 17/3	—	—	13/- to 14/-	—	—
1909. Nov. (9) .	7/10 to 9/3	—	—	—	—	—
1908. Oct. (12) .	9/9 to 11/10	—	—	—	—	—

(1) *Rhodesian Agricultural Journal*, Vol. I, No. 5, April, 1904, p. 143.
(3) ,, ,, ,, Vol. III, No. 1, October, 1905.
(4) ,, ,, ,, Vol. III, No. 3, February, 1906.
(5) ,, ,, ,, Vol. IV, No. 1, October, 1906.
(6) *Natal Agricultural Journal*, Vol. VII, No. 10, October, 1904, p. 1006.
(7) ,, ,, ,, Vol. X, No. 7, July, 1908, p. 914.
(8) ,, ,, ,, Vol. XI, No. 2, February, 1908, p. 229.
(9) *Circular* of the Keeling Agency, Ltd., dated 19 November, 1909.
(10) *Transvaal Leader*, 21 November, 1908.
(11) *Natal Agricultural Journal*, March, 1908.
(12) ,, ,, ,, October, 1908.

The prices paid by the native are usually good; in districts remote from rail-communication as much as 60s. per muid was paid in the years 1911 and 1912.

477. *Classes of Maize called for in the Local Trade.*—For the mills supplying the Rand Mines, the large, flat, white grain produced by *Hickory King* (8-row), 10-*row Hickory*, *Hickory Horsetooth*, *Mercer*, *Ladysmith*, and similar large-grained dent breeds, is in greatest demand when a choice is offered. This is partly due to "trade fancy," but millers state that there is less bran produced in milling these sorts than is the case with the small grain. Where there is no choice of white flats, any flat white dent is acceptable to the miller in preference to yellows or even to round whites. At one time, the writer is told, the natives employed on the mines would eat yellow mielie meal in preference to white, but now it is the exception for a Rand native to eat any but white meal. Various excuses are given—such as the undoubted difference in flavour between white and yellow meal; the supposed injurious effect of yellow

meal on the digestive system, etc. But in view of the large amount of yellow "corn-meal" consumed in the United States, one is scarcely prepared to accept these as valid reasons; it seems more probable that the real cause is the tendency of the native to imitate the white man, and that as the white man in South Africa eats only white mielie meal, the native thinks he ought to do so too. The reason may also be partly commercial; millers prefer to mill only one colour of maize, and may have been instrumental in gradually inducing the mine natives to use white meal, not only for that reason, but also because white maize is usually cheaper than yellow in the Johannesburg market. CHAP. XII.

Table LXVI.

COMPARATIVE LOCAL PRICES OF MAIZE CLASSES.

	Large White Flat.	Small Yellow.	White Round.	Yellow.	Mixed.
Johannesburg, Sept., 1904 .	10/9 to 11/3	—	—	11/- to 11/9	—
Johannesburg, Sept., 1905 .	8/6 to 9/-	—	—	8/- to 8/6	—
Johannesburg, Feb., 1906 . .	13/-	—	—	12/9	—
Kimberley, Feb., 1906 . .	14/6 to 15/6	—	—	15/3 to 16/-	—
Cape Town, Sept. (1906) .	11/9 to 12/-	13/3 to 13/6	—	12/- to 12/9	11/9 to 12/-
Kimberley, Sept. (1906) .	—	—	8/- to 9/6	8/6 to 10/-	7/- to 9/-
Bulawayo, Oct., 1906 . .	21/- to 22/-	—	—	19/- to 20/-	—
Kimberley, Dec. (1906) .	—	—	9/- to 10/-	9/- to 10/3	8/9 to 9/9
Cape Town, 14 Feb., 1908 .	13/- to 13/6	13/6 to 13/9	—	—	—
Cape Town, 14 Feb., 1908 .	13/9 to 14/-	—	—	13/6 to 13/9	13/-
Kimberley, 14 Feb., 1908 .	—	—	8/6 to 10/-	8/6 to 10/-	8/- to 9/3
Pretoria, 14 Feb., 1908 .	8/3 to 11/-	—	—	8/6 to 11/-	8/6 to 10/-
Cape Town, 11 July, 1908 .	12/6 to 12/9	14/9 to 15/-	—	14/6 to 15/-	—
Johannesburg, Oct., 1908 . .	9/9 to 11/5	—	—	11/6 to 11/10	—
Johannesburg, 19 Nov., 1909[1] .	8/3 to 8/5	—	7/10 to 8/-	9/- to 9/3	7/10 to 8/-

[1] Small white flat, 8/- to 8/3.

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For feeding draught animals, however, on the Witwatersrand, in Kimberley, and elsewhere, there is a demand for *yellow* maize, based on the idea that white is injurious to stock, especially to horses and mules. And in these markets yellows generally command 6d. to 1s. per muid more than whites.

That this demand is by no means small or to be despised is shown by the amount consumed by the De Beers Consolidated Mines, Ltd., alone (¶ 473). This class of trade will not buy white maize.

The municipality of Johannesburg and the firms of cartage contractors on the Rand are large buyers of yellows; in November, 1908, the municipality referred to was reported to have purchased 4,000 muids of yellows at 16s. 9d. (*Transvaal Leader*, 21 November, 1908).

478. *Comparative Local Prices of Maize Classes.*—The comparative figures in Table LXVI have been taken at random from the pages of the various South African *Agricultural Journals.*

TABLE LXVII.

NATAL PRODUCTION, IMPORT AND RE-EXPORT OF MAIZE AND MAIZE PRODUCTS, 1904-6.[1]

	1904. Lbs.	1905. Lbs.	1906. Lbs.
Maize produced in Natal	155,301,600	140,098,000	113,608,200
Imports:—			
By Sea	43,638,365	524,627	1,299,853
Overland	190,000	884,626	2,530,510
	43,828,365	1,409,253	3,830,363
Exports (not S.A.P.[2]):—			
By Sea	180,534	19,775	—
Cape Colony	8,736,101	133,592	—
Orange River Colony	4,881,551	80	48
Transvaal	16,270,817	1,042,696	20
Southern Rhodesia	—	6,985	—
Basutoland	152,120	—	—
	30,221,123	1,203,128	68
Exports (S.A.P.[2]):—			
By Sea	899,208	4,628,088	1,390,216
Cape Colony	17,071,092	79,638,771	39,404,961
Orange River Colony	599,679	314,023	450,477
Transvaal	30,143,272	44,668,807	31,874,661
Southern Rhodesia	1,000	13,200	508,600
	48,714,251	129,262,889	73,628,915

[1] From *N.A.J.*, Vol. X, No. 9, Sept., 1907.
[2] S.A.P. = South African Produce.

479. *Transvaal Maize Imports.*—A further idea of the local consumption is gained from the figures of Transvaal imports furnished by the South African Customs Statistical Bureau. From these we find that in addition to the large amount produced locally in this colony alone, she imported in the year 1907 (chiefly from Natal and the Orange River Colony) 389,649 muids of maize, valued at £177,006. The preceding table (LXVII) shows the export from Natal to the Transvaal in 1904, 1905, and 1906, both of Natal grown and imported maize. CHAP. XII.

TABLE LXVIII.

TRANSVAAL MAIZE IMPORTS, 1907 and 1908.

Month.	1907.				1908.			
	S.A.P.*		Not S.A.P.		S.A.P.		Not S.A.P.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Lbs.	£	Lbs.	£	Lbs.	£	Lbs.	£
January .	3,542,515	10,596	4,032	13	3,617,788	6,794	4,450	15
February .	5,593,583	15,460	—	—	3,778,022	6,816	—	—
March . .	4,960,123	13,449	—	—	1,890,250	3,637	—	—
April . .	2,693,074	6,880	—	—	2,840,710	5,833	796	3
May . .	4,070,155	10,222	136,195	292	3,163,707	7,679	—	—
June . .	4,298,887	10,541	100	—	3,722,656	7,575	—	—
July . .	9,192,755	22,338	2,300	26	3,250,891	6,674	—	—
August .	10,135,651	20,277	898	6	2,467,792	5,378	—	—
September	17,047,320	31,923	400	5	3,193,449	7,389	—	—
October .	10,594,039	20,277	—	—	2,393,604	6,037	224	2
November	563,768	1,135	4,800	18	1,323,129	3,829	20,000	75
December	2,186,259	4,340	2,640	10	2,530,996	8,111	44,352	170
Total .	74,878,129	167,438	151,365	370	34,172,994	73,752	70,852	265

* S.A.P. = South African Produce.

Summary.

	Lbs.	£	Lbs.	£
S.A.P. . . .	34,172,994	73,752	74,878,129	167,438
Not S.A.P. . .	70,852	265	151,365	370
	34,243,846	74,017	75,029,494	167,808
Muids . . .	171,219		375,147	

480. *Rapid Increase in Production.*—With the settlement of the Transvaal after the war, there soon came a great in-

CHAP. XII. crease in the area planted to maize; farmers realized that they had a good local market, worth competing for.

The increase in local production was so rapid that the imports into the Transvaal fell from 375,147 muids in 1907 to 171,219 in 1908, a reduction of about 55 per cent. From 1904 to 1908 the value of the imports of maize and maize products fell from £218,689 to £74,017, a reduction of about 66 per cent.

	Maize.	Maize Meal.	Total.
Fiscal Year—	£	£	£
1904-5[1] . . .	194,324	24,335	218,659
1905-6[1] . . .	141,300	23,329	164,629
Calendar Year—			
1907 . . .	—	—	167,808
1908 . . .	—	—	74,017

These figures are instructive in view of the fact that the consumption was increasing during this period, owing to the *increase in mine development and in number of boys employed.* No doubt this decline, which largely affected Natal, helped to induce that colony to look elsewhere and oversea for a new market.

There is no question that there will be an enormous increase in the production of South African maize within the near future. The falling off in exports during the season 1911-12 and the poor prospects for the season 1912-13 are merely temporary phases, due to a series of unprecedented droughts; to be able to do as well as South Africa has done under such adverse conditions, proves the soundness of the basis on which the industry has been established. But it is equally clear that however good her local markets may be, she must look to an export trade for the building up and maintenance of the industry. The time is coming when, instead of exporting grain for the manufacture oversea of articles which are required for consumption in South Africa, large factories will be established for the local manufacture of maize products. In time, also, every farmer will be feeding his stock on maize and turning it into beef, mutton, pork, wool, or ostrich feathers

[1] Figures furnished by the South African Customs Statistical Bureau.

for export. But even then there must be a surplus to send oversea. No farmer will be able to carry stock enough—in the maize belt at least—to consume all the maize he can produce, and every farmer will be well advised to plant a larger acreage than his anticipated local requirement, to provide against the partial failure of his crop. Although the United States no longer grows for export, her surplus is no mean figure, and she still furnishes huge cargoes of maize for the European markets—in fact she continues to be the largest supplier. However much local consumption increases, South Africa may always expect to have a good surplus. The recent ill-advised outcry against the export trade suggests an origin in the selfish motives of those who see that the steadying influence of the export reduces their chances of exploiting the local market.

481. *Importance of the Export Trade.*—It may be accepted as a fact that but for the export trade, the production of maize in South Africa could not have gone ahead as it has done; the local market alone, although good, was too easily flooded. The export of South African maize stimulates local trade, offers a profitable outlet for the surplus crop of the country, and prevents the accumulation of supplies and consequent glutting, with the inevitable result of low prices. While it is true that it is more profitable to export manufactured or second products than the raw materials or first products, there are conditions—especially in a new country—under which it is desirable to export the raw material. It has been said by a well-known South African financier that every sovereign brought into the country from oversea is worth two of those which merely change hands locally, because the former brings capital into the country, and in a new country capital is badly needed for the development of its agricultural resources.

482. *Oversea Markets.*—There is always a ready market for maize in Europe, as it is one of the best and most largely used foods for stock and poultry, and is also an important item in the distillation of whisky and gin, the brewing of beer, the manufacture of starch, glucose, etc., and the preparation of foodstuffs for human consumption.

Manufacturers in Europe are constantly finding new uses

CHAP. XII. for maize and the demand is steadily increasing. Owing to the increase in population in other producing countries of the world, the tendency is for them to export less and less; and the climatic conditions seem to preclude any very great increase in area available for maize production in those countries. With an increasing demand for maize and a tendency for the supply to diminish rather than to increase, there is a golden opportunity for South Africa to step into the market already made for her. This market is practically limitless and will take all that she can produce.

South African maize, when shipped in a thoroughly dry condition (to ensure which it is desirable not to export before 1 July), sells readily and commands good prices on the European markets. Owing to its relatively dry condition it is in good demand, but the great difficulty of the oversea merchant is to find enough of it to meet this demand. There is a danger that unless European consignees can depend upon steady and regular supplies, South African trade will not be permanently established.

It is therefore to the advantage of the South African farming community, as a whole, to increase the output and establish a permanent market. It has been demonstrated by actual experience that South Africa can produce maize at a cost that permits of profitable oversea export.

483. *European Consumption.*—The United Kingdom is the largest and best single oversea market for maize. It absorbs during the year something like 30,000,000 (thirty million) muids of maize, or nearly as much as the whole of continental Europe, which, at an average value of 10s. per muid or £5 per ton of 2,000 lbs., represents £15,000,000 (fifteen million pounds). Why should not the South African farmer earn a fair share of this amount and so enrich both himself and his country?

If South Africa can capture but a fifth of this trade it will mean about £2,500,000 after allowing for freight and other charges, and such a sum would obviously be a valuable help to the country. But she can do so only by putting on the market an article which is either better than, or cheaper than, that supplied by other competing countries, or at a time when they are unable to compete. Otherwise she must rely on increased demand and decreasing supplies to open these markets, at best an uncertain and unreliable policy. CHAP. XII.

The continent of Europe, especially Germany, Holland, Belgium and France, is a large and increasing consumer. In the eight months ended 30 August, 1907, Europe imported 18,000,000 quarters (432,000,000 muids) of maize, of which 8,000,000 went to the United Kingdom and 10,000,000 to the Continent. Of this amount the United States supplied the largest proportion. South Africa has also exported to the Canary Islands, Madeira, St. Helena, Australia, Mexico, Canada, India, Ceylon, Portuguese East Africa, Portuguese West Africa, Rhodesia, Katanga, Nyassaland, British East Africa, the Kerguelen Islands and Madagascar.

The shipments made by South Africa in 1908 are small in comparison with what they may or ought to be. It should be remembered that in 1906 over 27,260,000 muids of maize were imported into England. If only $\frac{1}{100}$ part of the whole of South Africa were planted with maize it would be 7,100,000 acres; estimating an average of four muids per English acre, the yield would be 28,400,000 muids, or a net weight of 5,680,000,000 lbs., a little over the amount consumed in England alone, without allowing for the enormous and increasing quantity used on the Continent.

484. *Possibility of Developing Trade with Canada.*—The Canadian Trades Commissioner in Cape Town reported some time ago that large quantities of white maize are imported into Canada every year for manufacturing purposes, from distances up to 1,500 miles by rail. Several shipments of South African Flat White maize were made, between 1907 and 1910, to the Ogilvie Flour Mill Co. of Montreal, and were pronounced the finest ever seen by them.

The Archer Manufacturing Company, St. John, N.B., reported that if the price could compete with that of the American article, a very large business could be done. Canadian steamers visit South African ports every month, and it is thought that the owners would be prepared to quote low freights for return cargoes.

485. *Egypt as a Possible Market.*—Although Egypt is a considerable producer of maize, there seems to be an opening for the South African article in that country. The following

CHAP. XII. letter from a correspondent at Helouan, near Cairo, was published in the *Transvaal Agricultural Journal*, Vol. VII, No. 26, page 309, January, 1909:—

Having made inquiries here as to the demands and price of maize, I think the opportunity offers of doing a certain amount of business if I can obtain shipments, properly bagged and of uniform quality and size. I am prepared to do business with the Government, that is, if they have a department which is superintending the shipment of maize, or with a reliable firm, but I must impress upon you that if a shipment is not of uniform quality, and according to samples, it will destroy all confidence with the bank that advances on grain, and also local buyers, and will prevent me establishing a trade. I know the Government is doing its utmost to encourage export, and I leave it to them to see that I am protected.

Methods of Dealing.—There are two ways:—

1. Selling on commission, that is, for firms, which does not appeal to me.
2. Buying direct. This would be better for both parties, as it might be necessary for me to split up the shipment and sell it in different districts.

Method of Shipment.—The sellers would ship via East Coast to Suez, avoiding canal dues. The shipping company might grant low rates for some time in order to start the trade.

Prices.—Sellers' prices include insurance and everything else, including landing charges by steamer at Suez.

Duty.—Payable by me at Suez.

Samples.—I would require 5 lb. samples of the different grades, with inclusive price, sent me every six weeks.

Method of Purchasing.—I should purchase by cable, and on receipt of your advices through which bank and on whom to draw. I use the expression on whom, as I may have to deal with some firms here who have agencies in the provinces, and the facilities for storing grain.

Prices.—State price per 100 lbs.

486. *India.*—Although India is herself a large producer the possibilities of that country as a market for South African maize should not be overlooked, especially in the periodically recurring seasons of drought.

487. *Australia.*—The direct service of steamers to Australia

and New Zealand affords the opportunity of developing a market there, especially to the stock-raising centres. The fact that South African cargoes for Australia do not cross the Equator should enable them to arrive in excellent condition. Some extensive shipments have recently been made. CHAP. XII.

488. *Prices in European Markets.*—Of some of the early consignments of South African maize, exported in 1907, it was reported: "The consignments of Natal mielies which have recently come to hand have met an active market, as much as 26s., and in some cases 26s. 6d. per quarter having been realized. A large quantity has reached Hamburg, Antwerp, and Rotterdam, during the last few days, to be used for distilling purposes, and good business is stated to have been done." [1]

489. *Prices on the English Market*, 1880-1908.—During the thirty years from 1880 to 1909 the average yearly price of "American" and Argentine maize on the English markets has fluctuated between 12s. 9d. per quarter (5s. 3¾d. per muid) in 1897, to 28s. per quarter (11s. 8d. per muid) in 1882. The mean of the yearly averages for the twenty-nine years from 1880 to 1908 was as follows:—

	London Market.		Liverpool Market.	
	Per Quarter.	Per Muid.	Per Quarter.	Per Muid.
	S. D.	S. D.	S. D.	S. D.
American Mixed Maize . .	21 3·7	8 10·56	20 5·3	8 6·21
La Plata Maize, 20 years .	19 8·3	8 2·47	19 3·4	8 0·41

The average yearly prices of American mixed and La Plata yellow maize, for London and Liverpool, prompt shipment, per quarter of 480 lbs., for the years 1880-1908, inclusive, will be found in Table LXIX.

From the following table we see that the average price of American and La Plata maize has been rising steadily from the year 1897, with but a slight drop in 1904.

490. *The High London Prices of* 1907-8.—The beginnings of the South African export trade are traceable to the conjunction of two fortuitous circumstances: (1) the temptingly high prices prevailing in Europe, and (2) increased production

[1] *N.A.J.*, Vol. X, No. 10, Oct., 1907.

of maize in the Transvaal and Orange Free State, which not only made it unnecessary to import from oversea, but seriously curtailed the demand for Natal maize on the mines, at the same time that her own production was increasing enormously.

TABLE LXIX.

AVERAGE YEARLY PRICES OF AMERICAN AND LA PLATA MAIZE IN LONDON.

London, per 480 lbs.			Liverpool, per 480 lbs.		
Year.	American.	La Plata.	Year.	American.	La Plata.
	s. d.	s. d.		s. d.	s. d.
1908	24 11	23 6	1908	24 9	24 0
1907	22 9	24 6	1907	22 6	24 0
1906	20 9	20 6	1906	20 6	20 2
1905	20 9	21 6	1905	20 6	21 3
1904	20 3	20 2	1904	20 1	19 11
1903	20 7	20 2	1903	20 4	19 9
1902	21 2	22 3	1902	20 11	21 7
1901	21 9	21 8	1901	20 1	20 7
1900	19 0	19 11	1900	18 1	19 6
1899	17 2	17 7	1899	15 10	17 0
1898	16 4	19 0	1898	15 5	18 9
1897	14 6	14 6	1897	12 9	13 11
1896	14 7	14 0	1896	13 5	14 5
1895	18 8	17 10	1895	17 9	17 6
1894	19 6	Failure	1894	19 2	Failure
1893	19 10	,,	1893	18 8	,,
1892	21 0	20 6	1892	20 3	20 0
1891	26 6	Failure	1891	26 5	Failure
1890	20 6	19 10	1890	19 7	18 6
1889	18 6	17 9	1889	18 0	17 5
1888	22 3	21 3	1888	21 5	20 7
1887	20 8	20 0	1887	19 6	19 6
1886	19 10	17 6	1886	20 0	17 4
1885	21 9	None shipped	1885	21 6	None shipped
1884	22 0	,,	1884	21 11	,,
1883	26 6	,,	1883	26 6	,,
1882	28 0	,,	1882	27 0	,,
1881	25 9	,,	1881	26 0	,,
1880	24 0	,,	1880	24 0	,,

In July, 1907, when it became necessary for Natal to find an outlet for her new season's crop, London prices were firm. 23s. 10½d. per 492 lbs. was paid for Galatz-Foxanian maize ex steamer. In September, 1907, South Russian realized 26s. 6d. per 492 lbs. and La Plata 26s. 6d. per quarter; in September, 1908, La Plata rose to 26s. 10½d. per quarter, and in December to 27s. 6d.

The high prices maintained during 1907 and 1908 were said to be due to the increased demand for maize for stock food and manufacture in the United Kingdom and on the Continent, coupled with very unfavourable reports of the crops in all three of the leading areas of production, the United States, Argentina, and South-Eastern Europe.

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491. *Early Export Prices for South African Maize.*—When in 1908 American Mixed averaged 24s. 11d. on the London market, and La Plata 23s. 6d., South African White Flat realized 26s. to 28s. per quarter, i.e. 10s. 10d. to 11s. 8d. per muid.

In September, 1908, sixty-eight bags of Transvaal white maize shipped per S.S. "Tintagel Castle," for the Government, were sold at 26s. 6d. per quarter ex ship. A consignment of 770 bags of white maize below grade sold at 27s. per quarter c.i.f. ; "this maize was of an irregular description, and it was solely owing to Plate maize coming forward damaged that so high a price was obtained".

In September, 1909, South African yellow round, in passage to London, sold at 27s. 7½d., a fall of nearly 1s. on the previous quotation. Prices were further reported as follows:—

2 *October*, 1909.

South African w.f., choice	25s. 9d. to 26s. 3d.
,, ,, w.f., f.a.q.	25s. 6d. to 26s.
,, ,, w.r., f.a.q.	24s. 6d. to 25s.
,, ,, y.r., f.a.q.	24s. 9d.

7 *October*, 1909.

South African w.f., choice	27s. 6d. for delivery Hamburg, October and November shipment.
,, ,, y.r.	24s. arrived.

12 *October*, 1909.

South African y.r., afloat	24s.

14 *October*, 1909.

South African w.f., afloat	25s.

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TABLE LXX.

PRICES OF SOUTH AFRICAN MAIZE IN EUROPE, 2 NOVEMBER, 1909.[1]

Translation of Cable No. 48, Received from the Agent-general, dated London, 2 November, 1909.

November or December shipment. Market is reported steady.

	Per 480 Lbs. Net. s.	d.	Per 200 Lbs. Net. s.	d.
London.				
Choice White	25	6	10	7½
F.A.Q. White	25	3	10	6¼
Choice Yellow	25	1½	10	5½
F.A.Q. Yellow	25	0	10	5
Amsterdam.				
Choice White	25	7	10	8
F.A.Q. White	25	4	10	6½
Choice Yellow	25	6	10	7½
F.A.Q. Yellow	25	0	10	5
Antwerp.				
Choice White	25	5	10	7
F.A.Q. White	25	2	10	5¾
Choice Yellow	25	0	10	5
F.A.Q. Yellow	24	10½	10	4½
Hamburg.				
Choice White	25	5	10	7
F.A.Q. White	25	2	10	5¾
Choice Yellow	25	0	10	5
F.A.Q. Yellow	24	10½	10	4½

The first column represents the cabled quotations per quarter of 480 lbs., and the second column for each port shows the equivalent price per 200 lbs. net.

By deducting 2s. 8d. per bag from the figures in the last column, we get the net price realized by the South African shipper.

[1] From *Transvaal Agricultural Journal.*

TABLE LXXI.

COMPARATIVE PRICES OF SOUTH AFRICAN MAIZE IN EUROPE DURING FEBRUARY, 1910.[1]

	Per Quarter of 480 lbs.			
	1 Feb.	9 Feb.	15 Feb.	23 Feb.
	s. d.	s. d.	s. d.	s. d.
London—				
Choice White	27 0	26 10	27 0	26 6
F.A.Q. White	26 9	26 9	26 9	26 3
Choice Yellow	26 10	26 10	26 10	26 3
F.A.Q. Yellow	26 9	26 10	26 9	26 0
Amsterdam—				
Choice White	27 4	27 6	27 6	26 7
F.A.Q. White	27 1	27 3	27 3	26 6
Choice Yellow	27 3	27 3	27 3	26 6
F.A.Q. Yellow	27 1	27 1	27 0	26 3
Antwerp—				
Choice White	27 3	27 3	27 3	26 4
F.A.Q. White	27 1	27 0	27 0	26 3
Choice Yellow	27 1	27 1	27 0	26 4
F.A.Q. Yellow	27 0	27 0	26 10	26 1
Hamburg—				
Choice White	27 3	26 10	26 10	26 3
F.A.Q. White	27 0	26 7	26 7	25 9
Choice Yellow	27 0	26 7	26 7	26 3
F.A.Q. Yellow	26 10	26 6	26 6	26 0

Fractions of a penny have been omitted.

On 30 November, 1910, South African Flat White sold at 23s. per quarter ex quay, while both Odessa and La Plata were 21s. per quarter ex ship.

On 1 December, 1910, it was reported that South African was "too dear" for the London market, at 21s. 6d. for choice and 20s. 9d. to 21s. 2d. for f.a.q., so attention was directed to American which was selling at 19s. 7½d. to 20s.

492. *Changing Prices per Quarter to Prices per Muid.*—In the London market maize is always sold by weight, the unit being the "quarter" of 480 lbs. To convert the market quotations from quarters to muids, we may remember that:—

24s.	per quarter	is equal to	10s.	per muid.
36s.	,,	,,	15s.	,,
6s.	,,	,,	2s. 6d.	,,
1s.	,,	,,	5d.	,,
3d.	,,	,,	1¼d.	,,

[1] From the *South African National Union Journal*, March, 1910; supplied by the Central Agency for Co-operative Societies.

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The following table is useful for ready reference :—

TABLE LXXII.

TO CHANGE PRICES PER QUARTER TO PRICES PER MUID.

Per Quarter.	Equivalent per Muid.	Per Quarter.	Equivalent per Muid.
s. d.	s. d.	s. d.	s. d.
0 1	0 0·4166	16 0	6 8
0 2	0 0·8333	17 0	7 1
0 3	0 1·2500 (i.e. $1\frac{1}{4}$d.)	18 0	7 6
0 4	0 1·6666	19 0	7 11
0 5	0 2·0833	20 0	8 4
0 6	0 2·5000 (i.e. $2\frac{1}{2}$d.)	21 0	8 9
0 7	0 2·9166	22 0	9 2
0 8	0 3·3333	23 0	9 7
0 9	0 3·7500 (i.e. $3\frac{3}{4}$d.)	24 0	10 0
0 10	0 4·1666	25 0	10 5
0 11	0 4·5833	26 0	10 10
1 0	0 5·0000 (i.e. 5d.)	27 0	11 3
2 0	0 10	28 0	11 8
3 0	1 3	29 0	12 1
4 0	1 8	30 0	12 6
5 0	2 1	31 0	12 11
6 0	2 6	32 0	13 4
7 0	2 11	33 0	13 9
8 0	3 4	34 0	14 2
9 0	3 9	35 0	14 7
10 0	4 2	36 0	15 0
11 0	4 7	37 0	15 5
12 0	5 0	38 0	15 10
13 0	5 5	39 0	16 3
14 0	5 10	40 0	16 8
15 0	6 3		

493. *Changing Prices per* 1,000 *Kilograms to Prices per Muid.*—Maize is usually quoted on the continental market at so many marks per 1,000 kilograms. The English sterling value of a mark is 11·75d.; a kilogram equals 2·20462 lbs. avoirdupois, therefore 1,000 kilograms equals 2,204·62 lbs. or 11 muids $4\frac{1}{2}$ lbs. For conversion table see Table LXXIII.

494. *Market Reports.*—The position of the local South African maize markets can be gleaned from the pages of the *Union Agricultural Journal*, issued monthly, free in South Africa, from the Government Printing Works, Pretoria.

Among the papers which report the oversea market are :—

George Broomhall's *Corn Trade News* (Liverpool).

The Corn Trade News (Mark Lane, London).

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Table LXXIII.

TO CHANGE PRICES PER 1,000 KILOGRAMS TO PRICES PER MUID.

Marks.	Per 1,000 Kilograms (2,204·6 Lbs.).			Per 200 Lbs. Net.		Marks.	Per 1,000 Kilograms (2,204·6 Lbs.).			Per 200 Lbs. Net.	
	£	s.	d.	s.	d.		£	s.	d.	s.	d.
1	0	0	11¾	0	1·06595	102	4	19	10½	9	0·72
2	0	1	11½	0	2·1319	103	5	0	10¼	9	1·79
3	0	2	11¼	0	3·1979	104	5	1	10	9	2·86
4	0	3	11	0	4·2638	105	5	2	9¾	9	3·92
5	0	4	10¾	0	5·329	106	5	3	9½	9	4·99
6	0	5	10½	0	6·3957	107	5	4	9¼	9	6·05
7	0	6	10¼	0	7·4617	108	5	5	9	9	7·12
8	0	7	10	0	8·5276	109	5	6	8¾	9	8·18
9	0	8	9¾	0	9·59355	110	5	7	8½	9	9·25
10	0	9	9½	0	10·6595	111	5	8	8¼	9	10·32
15	0	14	8¼	1	3·99	112	5	9	8	9	11·39
20	0	19	7	1	9·32	113	5	10	7¾	10	0·45
25	1	4	5¾	2	2·65	114	5	11	7½	10	1·51
40	1	19	2	3	6·64	115	5	12	7¼	10	2·68
50	2	8	11½	4	5·30	116	5	13	7	10	3·65
55	2	13	10¼	4	10·63	117	5	14	6¾	10	4·72
60	2	18	9	5	3·96	118	5	15	6½	10	5·78
65	3	3	7¾	5	9·28	119	5	16	6¼	10	6·85
70	3	8	6½	6	2·62	120	5	17	6	10	7·914
71	3	9	6¼	6	3·68	121	5	18	5¾	10	8·98
72	3	10	6	6	4·75	122	5	19	5½	10	10·04
73	3	11	5¾	6	5·81	123	6	0	5¼	10	11·11
74	3	12	5½	6	6·88	124	6	1	5	11	0·18
75	3	13	5¼	6	7·95	125	6	2	4¾	11	1·24
76	3	14	5	6	9·01	126	6	3	4½	11	2·31
77	3	15	4¾	6	10·08	127	6	4	4¼	11	3·37
78	3	16	4½	6	11·14	128	6	5	4	11	4·44
79	3	17	4¼	7	0·21	129	6	6	3¾	11	5·51
80	3	18	4	7	1·28	130	6	7	3½	11	6·57
81	3	19	3¾	7	2·34	131	6	8	3¼	11	7·64
82	4	0	3½	7	3·41	132	6	9	3	11	8·70
83	4	1	3¼	7	4·47	133	6	10	2¾	11	9·77
84	4	2	3	7	5·54	134	6	11	2½	11	10·84
85	4	3	2¾	7	6·60	135	6	12	2¼	11	11·90
86	4	4	2½	7	7·67	136	6	13	2	12	0·97
87	4	5	2¼	7	8·74	137	6	14	1¾	12	2·04
88	4	6	2	7	9·80	138	6	15	1½	12	3·10
89	4	7	1¾	7	10·87	139	6	16	1¼	12	4·17
90	4	8	1½	7	11·935	140	6	17	1	12	5·23
91	4	9	1¼	8	1·00	141	6	18	0¾	12	6·30
92	4	10	1	8	2·07	142	6	19	0½	12	7·36
93	4	11	0¾	8	3·13	143	7	0	0¼	12	8·43
94	4	12	0½	8	4·20	144	7	1	0	12	9·49
95	4	13	0¼	8	5·265	145	7	1	11¾	12	10·56
96	4	14	0	8	6·33	146	7	2	11½	12	11·63
97	4	14	11¾	8	7·40	147	7	3	11¼	13	0·69
98	4	15	11½	8	8·46	148	7	4	11	13	1·76
99	4	16	11¼	8	9·53	149	7	5	10¾	13	2·83
100	4	17	11	8	10·595	150	7	6	10½	13	3·89
101	4	18	10¾	8	11·66						

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Beerbohm's *Evening Corn Trade List* (London).
George Dornbusch's *Floating Cargoes Evening List.*
Cincinnatti Price Current.
Orange Judd Farmer.

495. *Prices Affected by the World's Supply and Demand.*—Prices are governed by the European demand for maize for stock food, and also by the surplus supply available from the larger producing countries. The world's supply is increasing, and it is only the recurrence of unfavourable seasons, in various parts of the producing area, that has kept prices so high. Nevertheless the world's demand for maize for stock feeding and manufacturing purposes is also increasing rapidly, and this will tend to keep prices up, though it cannot reasonably be expected that they will remain as good as they have been in recent years.

496. *Some Factors which Control Prices in the World's Maize Market.*—South Africa is in the rather fortunate position of being able to market her maize before the North American crop is in sight, and after the bulk of the Argentine crop has been moved. Nevertheless the crops of these two regions will, for some time to come, largely govern the prices obtainable for South African maize in the European markets. The size and condition of the South European crop also affects prices. In those quarters in which maize can be substituted for wheat, or wheat for maize, either as food or in the arts and manufactures, fluctuations in the size of the world's wheat crop also affect the maize market.

497. *The World's Supply of Maize.*—The importance of maize as a source of food for man and his domestic animals has led to its cultivation in practically all the tropical and subtropical parts of the world. It is also grown in those parts of the warm-temperate zone where the summer temperature and rainfall are relatively high and sunshine is plentiful.

Its wider distribution is limited, however, by its climatic requirements. In countries thus meeting its requirements, maize is the most extensively grown of any cereal crop, because it is at the same time one of the most productive and most easily produced crops. Some idea of its importance may be gained from the fact that the world's crop of maize amounted in 1906, which was a "bumper" crop year, to 3,928,947,000 bushels, i.e. 1,100,237,180 muids of 200 lbs.

South Africa's greatest competitors in the maize trade are the United States of America and Argentina. The former produces 2,927,416,000 bushels, or nearly 820,000,000 (eight hundred and twenty million) muids, which is 74·5 per cent of the total. At 8s. per muid this is worth £328,000,000, or many times the annual gold production of South Africa. Yet the United States exports (1909) under 11,000,000 muids, or about 1·4 per cent of her crop, and every year the percentage exported grows less. This is because home demands are increasing, while climatic conditions prevent a corresponding increase in the area of production.

Argentina produces less than 55,000,000 muids, and exports about 50 per cent of the crop. As her population increases, more will be consumed locally for stock food and manufacture. There has been a marked drop in the export from Argentina, as compared with that of any one of the three years 1904, 1905 and 1906.

Accompanying this fall in the exports from our competitors, we find the European demand steadily increasing; new uses are being found for maize every day, for stock food and in the arts and manufactures. This means that either the price of maize will rise, or new fields for its production must be found; but if the price increases it will tend to restrict the demand.

In addition to the United States and Argentina the principal sources of supply at the present time are: South-east Europe (Austria-Hungary and Roumania), Egypt, South Africa, Australia, and Mexico. No other large areas of the world seem to have climatic conditions ideally suited to maize production. Of these countries South Africa is the only one in which there seems any prospect of a large increase of acreage in maize. She has an ample average rainfall, coming at the right season of the year, and phenomenally dry winter weather for the natural production of the quality of grain most suitable for shipment.

South Africa, therefore, has a great opportunity for competing for the trade in a commodity the demand for which is steadily increasing, while the supply is tending to decrease,

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and for which increased production seems limited to her own territory.

498. *Early Attempts at an Export Maize Trade from South Africa.*—According to Mr. John Moon of Manderston, a consignment of Natal maize was shipped from Durban to London by Mr. T. P. O'Meara, M.L.A., somewhere about the years 1886-7, but the attempt to establish an export trade failed because the surplus available was not sufficient to establish and maintain a steady supply, and the export trade ceased practically when it began. Another attempt appears to have been made about 1890. Mr. Moon writes under date 16 November, 1910: "Some twenty years ago mealies were very low in price and we could only get about 4s. 6d. to 5s. per muid. A New Leeds farmer then decided to try the English market, and we as members each sent so many muids, making in all, as far as my memory goes, 1,000 bags; to our disappointment, after all expenses were paid, we were only left 4s. 9d. per muid. I think that ship freight was then 10s. 3d. per ton."

In the *Natal Agricultural Journal* for 23 February, 1906, we find the following:—

"*Mealies for England.*—In a letter from Mr. A. R. Rennie, of Messrs. Rennie & Sons, shippers, to Dr. Gubbins, M.L.A., published in the daily papers, some interesting facts are given with regard to shipments of mealies to London last year. The average price obtained was from 24s. 6d. to 24s. 9d. per quarter of 480 lbs. This works out at 10s. 2½d. per muid, and the sacks fetched 2⅞d. The price may therefore be calculated at 10s. 6d. per muid for mealies in London. Mr. Rennie says the mealies were not first-class. Reference to our exchanges shows the top price for mealies in London in the beginning of last month to have been 25s. per quarter. July, August and September are the months in London, according to Mr. Rennie, when the market is pretty bare. These facts are useful in showing that in the event of big crops there is no need for practically throwing away a large portion. Merchants should be able to buy at from 7s. to 8s. at the Point and be able to pay freight and shipping charges and come out with a little to the good. The price of mealies has been rising in England for some years. The reasons are various; one of them is the favour into which this cereal has risen with Scotch and Irish whisky makers."

499. *Natal Government Enterprise.*—Until the year 1907 the possibility of the South African maize crop as an article for oversea export was not thoroughly appreciated. As long as the local markets consumed more than was produced, there was little incentive to look abroad, and farmers were content to grow only enough for local requirements. In an unfavourable season this resulted in prices rising to 20s., 40s., and even 60s. per muid, while in a season favourable to the crop they were known to fall to 5s. and even 4s. 6d. per muid because there was no outlet for the surplus. Maize was therefore a very speculative crop. The writer well remembers, on his arrival in the Transvaal, being told by a well-known business man, who is also a farmer, that maize was not a white man's crop, but was only fit for Kaffirs to grow. CHAP. XII.

Four causes finally contributed to the establishment of the export trade in South African maize: (1) a "bumper" crop in 1907, which threatened to bring local prices below a paying basis (3s. and 2s. 6d. per muid were publicly suggested[1] as possible prices); (2) the financial depression following the close of the Boer War which put business men on the *qui vive* for new openings; (3) the high maize prices prevailing in Europe (¶ 490), which made it possible to export at a profit and thus stimulated production in South Africa; and (4) the wisdom and foresight of the several South African Governments in rendering practical assistance and encouragement to start an export trade, by offering reduced rates and other facilities. In addition to these, the exhibits at the South African Products Exhibition held in London, in February, 1907, undoubtedly led English merchants to make inquiry in South Africa.

The fact that the railways were under Government control enabled them to reduce railage rates to a nominal figure in order to meet the exigencies of the situation. Severe criticisms were levelled at the Governments for their action; they were accused of paternalism and interference with private enterprise; but whatever mistakes may have been made, the results have certainly justified the action taken, and credit should be given where it has been so well earned. Anyone who looks into the matter with an unbiased mind, and who knows anything of the vicissitudes, difficulties, discourage-

[1] *N.A.J.*, Vol. XI, No. 2, p. 137, Feb., 1908.

CHAP XII. ments and losses connected with the starting of new industries, will admit that the successful establishment of the export trade in maize is due in no small measure to the prompt assistance given to the infant industry by the several Governments.

To the Hon. Mr. W. A. Deane, Minister for Agriculture of the Colony of Natal, is said to be due the credit for definitely starting the export trade. Where so many officials were necessarily concerned it seems almost invidious to mention names, but there are some which stand out conspicuously, viz.: The Right Honourable General Louis Botha, Transvaal Minister for Agriculture; Sir T. R. Price, General Manager of the Central South African Railways; the General Manager of the Natal Government Railways; Mr. W. J. Palmer, Director of Agriculture, Orange Free State; Mr. F. B. Smith, Director of Agriculture, Transvaal; and Captain Rainnie, Port Captain, Durban. But in the words of Messrs. Wm. Cotts & Co., local exporters of grain, etc.: "Everybody concerned became enthused with the prospects this trade held out, and soon were hard at work to try and make it a success. The railway and harbour officials bent their full energies into their part of the business, and much credit is due to them for the unceasing efforts they put forward to carry things towards a successful issue" (*Cotts*, 1).

"Saturday, 3 August, 1907, is a historic date in the South African maize export. The Prime Minister and the Minister for Agriculture, of Natal, met at Maritzburg a number of persons interested in the production and handling of maize, to discuss the proposed organization of the export trade. A committee was appointed, consisting of Messrs. Hayne, H. A. Light, and A. G. May, representing the commercial community, and Messrs. J. G. Colenbrander, John Moon, and Walter Pepworth, representing the farmers, to decide the grades to be adopted."

Owing to lack of statistics as to supply and demand, Natal over-exported in the latter part of 1908, and it became necessary to import again. A case was reported in which a cargo of maize, which left Durban and was sold in Hamburg at 12s. 6d. per muid, was re-purchased, while still on the water, by the dealer who had originally sold it, for 17s. 6d. per muid.

500. *Reduction in Freight Rates.*—The Natal Government approached the Union-Castle Mail S.S. Co., Ltd., on the subject of reduced ocean freight rates. This resulted in their agreeing (as representing the "Conference Lines") to convey the traffic from Durban to London at a rate of 10s. per ton of 2,240 lbs., and they shortly afterwards extended the rate to include all South African ports as well as the continental ports of Antwerp and Hamburg. In July, 1909, the rate was raised to 11s. 6d. to cover the sorting at the port of discharge, as it had been found to the advantage of the trade to have this expense included in the freight rather than payable by the consignee. This low freight brought South African farmers and merchants into touch with the world's markets, and Canada, Mexico, Australia, London, Liverpool, Glasgow, Antwerp, and Hamburg have since become her customers. CHAP. XII.

The early experiences with maize export have been the same as those met with in most beginnings, and it was soon evident that methods would have to be greatly improved and abuses corrected. In April, 1907, Natal granted the traffic a rebate on the "South African Produce" railway rate.

In July, 1907, the Natal, Portuguese and Central South African Railway systems came to an arrangement whereby the coastward rate on maize for export would be considerably reduced. The rate per ton from Pretoria and Volksrust was fixed in both cases at 13s. 4d.; coupled with this, there was, also, a reduction in ocean freight, so that "it is now apparently possible to forward a bag of mealies from Pretoria via Delagoa Bay to London for something like 2s. 6d."[1]

In November or early December of the same year, according to a *Reuter* telegram to the daily press, quoted by the *Natal Agricultural Journal*,[2] negotiations were concluded between the Central South African Railways and the Cape Colony and Portuguese Railway Administrations, whereby the maximum rate for the conveyance of maize for export by any route, from any station in the Transvaal or Orange River Colony, was reduced to 10s. per 2,000 lbs., i.e. 1s. per muid.

[1] *N.A.J.*, Vol. X, No. 8, p. 833, Aug., 1907.

[2] Vol. X, No. 12, Dec., 1907, p. 1468: see also *Transvaal Agricultural Journal*, Vol. V, p. 339, Jan., 1908.

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This rate was to include delivery to vessels, and other services, and was to come into operation on 1 January, 1908. Negotiations were later completed with the Natal Government Railway Administration by which the same rates were made to apply over its lines. The special railway rate then worked out at ½d. per ton (of 2,000 lbs.) per mile, with a maximum of 10s. per ton, and was made to apply to all stations within 506 miles of the port.

At the same time arrangements were made by the Central South African Railway Administration for through booking and sales under Government auspices.

In Rhodesia a rate of ¼d. per ton per mile is in force; there is a flat rate of 1s. per bag to Beira, for export.

501. *Government Control of Export.*—The several Governments of the four Colonies which are now united in the Union of South Africa, agreed upon the policy of keeping the control of the export trade in their own hands, to avoid the experience of previous years and a repetition of the old charge of *mala fides* which had been laid to the account of the public of South Africa. Officials were appointed at the ports by the several Departments of Agriculture to inspect the grain and grade it according to an accepted standard, to deal generally with the traffic in such a way as to ensure the confidence of the oversea buyer, and to prevent those who had not the interest of South Africa at heart from gaining any temporary benefit at the expense of the country's good name. The code of regulations drawn up also provided that the grain must be properly dry before being railed for export, that it must be packed in new 2½ lb. bags, and must weigh 203 lbs. gross (*Hoy*, 1).

502. *Effect of Good Prices in Stimulating Trade.*—Fortunately for South Africa, local prices were at the time well in favour of the South African exporter. Some Natal farmers between Durban and Maritzburg obtained 10s. per muid f.o.r., their station, for large white *Hickory King*. During the season, local prices ranged between 7s. and 10s. on the Natal coast and in the Midlands, and between 5s. 6d. and 8s. 6d. in the northern districts of Natal, the Orange River Colony, and the Transvaal, according to distance, quality, and market. As much as 36s. per quarter (15s. per muid) was realized on the London market.

There is no question but that the inauguration of an export trade was very greatly stimulated by the exceptionally good market which prevailed in 1907 and 1908. The editor of the *London Corn Circular* stated that conditions during 1907 had been abnormal: "There have been no such prices for many years," he said, "and while it is fairly safe to say that the high rate will continue on the present crop, next year may see a drop of 5s. per quarter to the average. The American crop has been poor as to quantity and quality, and even last season's yield was indifferent." The *Corn Trade List*, in its issue of 1 November, 1907, remarked that: "There is very little or no improvement in the Roumanian crop prospects, and none in the outlook of the American crop, whilst the Argentine surplus shows evident signs of approaching exhaustion". CHAP. XII.

The *Times of Argentina*, of 30 September, 1907, expressed the opinion that there was then "very little maize left in the country, and since then nearly 1,000,000 quarters have been exported. We have for some time held the opinion that the high prices have drawn out this year's surplus at a far greater rate than usual, and it is not improbable that the exports will come to a somewhat abrupt conclusion much earlier than many expect. It has been reported this week, indeed, that some November-December contracts have been cancelled. The present week's shipments are cabled as 114,000 quarters, against 151,000 quarters last week, and 243,000 quarters in the corresponding week last year: and our correspondent adds that the inland movement is now small."

503. *Cause of Abnormal Prices.*—The cause of these prices was undoubtedly the unusual combination of "short" crops in the United States, Argentina, and Roumania, combined with an increased demand for stock-feeding and manufacture, both in England and on the Continent. Fortunately for South Africa, she had bumper crops, with a corresponding tendency to reduced local prices, which induced her to look abroad for an outlet for her surplus crop. It may thus be said that propitious circumstances forced her into the oversea market.

According to *Beerbohm's Evening Corn Trade List* (November, 1907), estimates of the yields in the big surplus-producing Maize States indicated a shortage in those States of

CHAP. XII. 284,000,000 bushels as compared with the previous year, and of 211,000,000 bushels as compared with the yield of 1905. But "it is always a difficult matter to suggest what surplus for export may exist in America; it largely depends upon the price obtainable".

504. *Natal Shipments*, 1907.—In September, 1907, the *Natal Agricultural Journal* (Vol. X, No. 9, p. 1022) reported that:—

"Mr. J. M. Westbrook, of the Dalton Farmers' Association, has been appointed by the Government as Inspector of Mealies at the Point. Not only are many farmers taking advantage of the Government grading, but the majority of the merchants also recognize the advantages to be derived therefrom and are having all the mealies passing through their hands for export, graded and weighed before shipment. This enables the mealies to be sold on sample before arrival. *Reuter's* agent cabled on 20 September that mealies were realizing 25s. 7½d. a quarter of 480 lbs. on the London market, a price equivalent to 10s. 8d. gross per muid of 200 lbs. If the Natal mealies realize the same figure, the net amount will be from 8s. 2d. to 8s. 9d. a muid according to the distance from the port. Merchants have this season—up to the date of these notes being written—sent away some 50,000 bags, and there are some 20,000 more at the Point ready for shipment. Farmers have sent away some 2,000 odd bags through the Government, and other consignments are coming forward by rail, so that it will be seen that a sufficient quantity is being shipped to prove the success or otherwise of the exportation."

In October, 1907, we find the following note in the *Natal Agricultural Journal*, Vol. X, No. 10, page 1185:—

"Most gratifying are the results of the effort that is being made to establish an export trade in grain with Great Britain.

"Once more we see the truth of the principle that adversity brings strength—in national as in individual life. Our commercial depression—one day we shall have cause to bless this much-maligned depression of ours!—has made us look to our own resources; and here we are with every prospect of some £200,000 or more coming into the country within the next two or three months as payment for the sale overseas of the

500,000 muids of mealies that we expect to export this season —and this season, moreover, we expect to do more than *experiment!* CHAP. XII.

"The future lies with our farmers. What we are capable of doing now is evident. Our mealies are pronounced excellent, and they are realizing good prices in Europe: a well-informed Durban correspondent tells us that 27s. 3d. per quarter has been paid in London for our grain this month, and in a cable to the Minister of Agriculture on 16 October, the Agent-General stated that he had been informed that it is 'extremely probable that the market will remain at 27s. to 28s. per quarter landed at wharf, until the end of November'. Freights are low enough; and the presence of a Government-appointed inspector at the port ensures adherence to standard. What more do we want? The next step is to extend the cultivation of our staple crop: there is plenty of land lying fallow on private farms all over the country, which can be cultivated and a bumper crop be ensured next season. We have nothing to fear as regards the market. In the old days, to extend the cultivation of a crop beyond a certain limit spelt loss: to a certain degree, the smaller the crop was, the greater was the gain. Now, however, with the limitless market that lies before us, we can safely put more and more land under mealies; and the extent of our income from this grain will only be bounded by our ability to produce.

"The following from the *Natal Mercury* comes as a refreshing breeze over the parched veld in these times of depression, and gives a good idea of what is being done: 'Mealies are being sent to the port from up-country faster, almost, than accommodation can be found for them, and at the present rate the shed space available at the Point will be presently exceeded. Bags of yellow and white grain lie stacked in tens of thousands in Sheds C, D, E, and F, five and six deep, and covering every foot of the floor area, except the space that is kept clear for narrow alleyways between the ramparts of grain bags. Rows of railway trucks, loaded with mealies, are constantly passing in and out of each shed, discharging fresh consignments of grain for the great oversea market which Natal has just freshly discovered, and the Government inspector, Mr. Westbrook, is being kept employed each day, from half-past seven in the morning to half-past five in the afternoon, in doing nothing else but testing the grain in the bags, grading it according to quality, and certifying it to be fit for exportation as first-class Natal produce.'"

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In November, 1907, *Beerbohm's Evening Corn Trade List* wrote regarding Natal maize in London:—

"A new source of supply has lately made itself felt, viz., Natal; some very fine samples of both white and yellow corn have lately been received in London, and there is, we believe, a fair quantity still to come; the value is about 27s. landed, whilst for shipment 25s. c.i.f., bags included, is quoted."

In December, 1907, the following London opinions were published in the *Natal Agricultural Journal*:—[1]

"Discussing the newly-awakened activity in the exportation of maize from Natal, *South Africa* says: 'While coming seasons may not offer the same inducement in respect of very high prices, there will always be a good market in London for the grain, and the South African Colonies must be prepared to secure their share in this market by exporting in much larger quantities, and by making up in the bulk the turnover for the proportionately smaller profits. The difference of the seasons will enable South Africa to supply the European market at a time of the year when fresh North American mealies have ceased to compete. . . . The South African article has made an excellent impression on the European market, and is subject to no disadvantages that do not apply to maize from other parts of the world. Indeed, in several respects, it is reported as superior to the North and South American article. For these reasons, South African growers and exporters should do their best to increase the quantity and the regularity of the supplies, while, of course, keeping up or even improving upon the present quality.'

"A representative of the same journal recently obtained the views of various people intimately connected with the London corn market respecting the importation of mealies from Natal, and the precise causes of the high prices that have been realized. While all admitted the hopeful character of the new movement, there was a general disposition to avoid prophecy as to the ultimate result.

"The editor of the *London Corn Circular*, a leading organ of the trade, stated that conditions during the past season have been abnormal. . . . The white African variety was described

[1] Vol. X, No. 12, p. 1468.

as a very bold, floury grain, and worth 6d. to 1s. per quarter more than the American maize. Although there is a prejudice against South African mealies on account of their being less known, the opinion was offered that if regular supplies were forwarded, they would obtain a firm hold on the British market in three or four years. A parallel case was instanced. Rangoon haricots on their first appearance met with nothing but hostility from the buyers, but by the perseverance of the shippers, they have now come to the front. Replying to a question as to the best means of making the brands known, it was stated that there was nothing like a good market for the purposes of publicity in such a case. The maize should be allowed to sell on its merits while there was a demand, and should not be held back for a price which the buyer refuses to pay. As a staple article it would be rapidly distributed, and with showy-looking stuff like the Natal mealies, inquiries would soon be made, thus leading to a regular trade. It was added that South African maize germ meal, which has been coming to hand in small quantities during the past three months, has created a very good impression, the latest price being about £6 7s. 6d. per ton. It is regarded by English stock keepers as an excellent food. CHAP. XII.

"A member of the firm of R. & W. Paul, Ltd., was somewhat more critical. He said that while the mealies came in their present condition people would buy them readily. When the maize arrived it looked very nice, but it showed traces of weevil, and the longer it stayed on their side the worse it became. On that account many firms would not take it, the Omnibus Companies objecting to it on that ground. 'There are very few American mealies coming in,' was the concluding remark, 'and there is every hope of creating a solid trade with South Africa if we can get anything like a regular supply. If the stuff comes in fits and starts no progress will be made. Putting the American and Natal mealies together there is very little to choose between the two. The African variety is always dry, and if the American should be in a bad condition its rival will have every opportunity of getting the best of the market.'

"Messrs. Berry, Barclay & Co., who have been handling a quantity of Natal maize, held similar opinons to those mentioned, emphasising the importance of keeping the weevil in check as much as possible. It was agreed that the British market can absorb practically any quantity provided the quality is maintained."

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505. *Transvaal and Orange Free State Shipments.*—As South African maize was from the start particularly well received on the London and continental markets, and favourably commented on in market reports, the demand soon exceeded the supply, and Durban merchants began to look to the Orange River Colony and the Transvaal for supplementary cargoes. From May, 1907, and onwards, they were able to obtain considerable quantities of the small round yellow and white Basutoland maize.

In July, 1907, the Johannesburg correspondent of the *Natal Witness* reported that there was a movement on foot to export from the Transvaal some 100,000 muids of maize during the current season.[1]

The Johannesburg correspondent of the *Natal Witness*, writing on 27 November, 1907, according to the *Natal Agricultural Journal*,[2] stated:—

"The Transvaal Government is so greatly impressed with the success of the Natal mealie exportation experiment that they intend to make a special effort to establish a big mealie growing industry in this colony. A million sterling is to be spent in settling white men on land which is suitable for mealies, on lines similar to the tin-mining scheme at Potgietersrust—that is, on a profit-sharing basis. The men will be given ground which, if they care to work hard, will eventually become their own. They will be supplied with provisions and tools, and Government steam ploughs will break up the land for them. Arrangements are being made with Delagoa Bay to provide shipping facilities enabling sailing vessels to take grain in bulk (thus saving the cost of bagging), and a uniform railway rate from all parts of the Transvaal will be charged. Hence, farmers living at a great distance from the port will be able to make the same profits on their grain as those nearer the line. The new land settlement scheme will, it is stated, be commenced next year, thus enabling settlers to sow their first crops next spring. It is believed that hundreds of men, who are unable to find work, will be glad of this opportunity of becoming successful farmers. Those who are prepared to work hard will be able, under ordinary circumstances, to make a good living, as mealies can be grown in almost every part of the Transvaal, and millions of acres of virgin soil are available."

[1] *N.A.J.*, Vol. X, No. 8, Aug., 1907, p. 833.
[2] Vol. X, No. 12, p. 1467.

At the close of the season of 1907 it was found that the Transvaal and Orange River Colony had been the largest contributors to the oversea trade (*Cotts*, 1). CHAP. XII.

506. *Some Difficulties Encountered.*—In the earliest stages of the industry the grain received at the coast was often in a condition quite unfit for export: "the bags used were mostly old, patched with calico, badly sewn, or even 'perished,' while the grain itself was unscreened, mixed, sometimes wet, and of varying weights". This seemed likely to nip the industry in the bud by giving the product a bad name, and it entailed much re-bagging, re-screening, re-weighing, and consequent loss in weight.

The difficulties experienced due to grain arriving in a condition unsuitable for shipment, soon showed the necessity for regulating the trade, if it was to be conducted under Government auspices. When the inland Colonies became contributors the several railway authorities and merchants concerned met in consultation, to recommend to their respective Governments uniform regulations. These were amended in conference from year to year as experience showed it to be necessary. Conferences were held under official auspices at:—

> Pretoria, 1908, 7 and 8 January (¶ 508).
> Durban, 1909, 6 to 10 September.
> Bloemfontein, 1910, 18 and 19 January (¶ 510).

At the last named conference, a committee to be called the "Annual Maize Committee" was organized to carry on the work, this committee to consist of "one representative from each Province to be nominated by the Associated Chambers of Commerce; one member of the Agricultural Department of each Province to be nominated by the respective Province; and one member representing each Province to be nominated by the South African Agricultural Union". The committee met in Durban on 11 May, 1910, and again in Bloemfontein on 11 July the same year, and has held subsequent meetings annually.

Owing to difficulties experienced by farmers in obtaining suitable bags of uniform weight and quality, the Railway Administrations undertook, as a temporary measure, to furnish bags on application; when, however, local firms stocked adequate

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507. *Inter-colonial Conferences.*—The following resolutions were passed by the several inter-colonial conferences, previously referred to, and are instructive as showing something of the problems which had to be faced in dealing with the new industry.

508. *Pretoria Conference, 7 and 8 January*, 1908.—

Present :—

Cape Colony : Mr. A. Robb, Assistant General Manager, C.G.R. ; Mr. W. Binns, Cape Government Railways ; Mr. P. J. Hannon, Agricultural Department ; Mr. H. Moss, Agricultural Department ; Mr. H. B. Briscoe, Port Goods Manager, East London.

Natal : Capt. J. Rainnie, Port Captain, Durban ; Mr. J. McConnachie, District Traffic Superintendent, N.G.R., Durban.

Orange River Colony : Mr. A. C. Lyell, M.L.A.

Portuguese Territory : Dr. Eduardo Saldanha, Portuguese Government ; Mr. Correa Mendes, C.F.L.M., Chief Clearing Officer ; Mr. V. L. L. deWaegenaere, Port Agent and C.F.L.M. Agent.

Transvaal : Rt. Hon. L. Botha, M.L.A., Minister for Agriculture ; Hon. H. C. Hull, M.L.A., Colonial Treasurer ; Mr. Smith, Director of Agriculture ; Mr. Jacobsz, Agricultural Department ; Mr. Enslin, Agricultural Department ; Mr. McDougall, Private Secretary to Colonial Treasurer ; Mr. Bok, Private Secretary to Minister for Agriculture ; Mr. T. R. Price, General Manager, Central South African Railways.

Union Castle Steamship Company : Mr. L. Clarence, Agent, Johannesburg.

SUMMARY OF DECISIONS.

1. Advisability or otherwise of encouraging the change of name from mealies to maize to correspond with the name this class of produce is now known by throughout Europe.

It was resolved that the policy to be pursued was to encourage as far as possible the use of the word "Maize" and in all invoices and consignment notes as well as bills of lading that this traffic be referred to as maize.

2. Size of bags.

The view of the Conference was that for the present it was undesirable to alter the size, namely 200 lbs. The Natal representatives reserved their assent meantime.

3. To consider :—

(*a*) Advisability or otherwise of bags being sold by Administration to senders on application ;

(*b*) If it be so decided, the procedure to be adopted for obtaining the bags for sale and the price at which bags are to be sold.

The following resolutions were arrived at, the Natal representatives reserving their assent pending the Conference to be held at Durban in a few days :—

(1) The Administration should not supply bags to traders.

(2) Tenders for the supply of bags required by the Administration should be called for in South Africa.

(3) The same conditions of railway carriage to apply to the conveyance of bags by the Administration as if they had been brought up for merchants or other traders.

(4) The Administration should add on its sale price an amount that would cover cost of handling, interest on capital and other charges. The amount of percentage to be added to be a matter for agreement between the respective Administrations.

(5) The bags only to be sold for cash on delivery.

4. The charge, if any, to be made for grading and stamping bags with Government mark.

5. To decide :—

(*a*) whether mealies exported not through the Administration, but forwarded to independent consignees, are to be stamped with the Government stamp, and, if so, the charge to be made;

(*b*) the course to be taken in the event of the foregoing being agreed to, and the procedure to be taken in the case of senders who decline to submit to Government examination and stamping.

It was unanimously agreed

(1) that all bags of mealies to receive the advantage of the low railway rate would require to be graded and stamped by the Government and that the charge for such services in the case of mealies other than those exported through the Government would be ½d. per bag;

(2) where consignor did not agree to this course the full ordinary grain rate would be charged for conveyance of such consignment;

(3) the grading of export maize from South Africa should only take place at the ports, the Natal delegates reserving their assent pending the decision arrived at at the forthcoming meeting at Durban.

6. To consider :—

(*a*) by whom the Bills of Lading shall be prepared and to whom forwarded, also whether

(*b*) such officer is to be authorized to prepare bills of lading in the case of consignments not forwarded through the Administration for disposal, and, if so, the charge therefor.

(*a*) It was agreed that in the case of maize entrusted to the Government for conveyance and for sale in Europe, the respective Coastal Administrations would arrange for the preparation of the bills of lading and other requisite documents, render the necessary services at the port of shipment, and would forward the documents as may be required.

(*b*) It was agreed where consignor desired the service rendered that for making out bills of lading and other documents and rendering the other usual services necessary for consignments not forwarded through the Administration, a charge of 3d. per ton be made, with a minimum of 10s. and a maximum of £2 10s. per consignment from one consignor to one consignee in one shipment, these charges to include provision of forms, preparation of bills of lading and clerical work in connection with payment of wharfage and other port charges, and the payment of stamps required by law to be affixed to the documents in compliance with Customs formalities and requirements, as well as any other usual and necessary services not included in the special export railway rate.

Messrs. Smith, Lyell and Price recorded their dissent from the stipulation that a separate charge would be made for the second instalment, in case of part shipments due to no fault of the sender of a consignment.

7. To decide whether the consignments are to be carried at owner's risk, or otherwise the course of procedure to be followed.

It was decided that the special railway rate quoted should be regarded as an owner's risk rate, but that the Administration would insure the maize against ordinary risk, in the case of consignments entrusted to it for conveyance and

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disposal, but against any special risk, such as heating, etc., consignors should be required to insure themselves if it was desired to be covered from such risks.

8. Allowance to be made on weight of consignments of mealies when dispatched, to cover processes of drying out and sifting in transit.

It was agreed that while the maize, as far as advantageously possible, would be sold on the weight as ascertained at the port of shipment, the Administration reserves the right of requiring an allowance of 2 per cent for sifting and drying out in the case of maize sent for disposal in Europe, in the event of its appearing that such loss in weight has occurred from such causes after actual weighing at destination.

9. To decide the charge to be made to cover :—

(*a*) Preparation of bills of lading and other documents and the services usual and necessary in case of shipments ;

(*b*) Customs charges and forms ;

(*c*) Stamps ;

(*d*) Any municipal charges levied ;

(*e*) Charges leviable at port of discharge and by agents entrusted in London and elsewhere with disposal of mealies.

It was agreed that it should be left to the discretion of the Administration to sell the maize on the most favourable terms, and that 2s. 6d. per bag was a reasonable inclusive charge to levy.

It was further recommended the maize be insured if possible on the full out-turn.

The Natal delegates undertook to represent the foregoing resolutions to the favourable consideration of their Administration.

10. To decide the time to be allowed for free storage at the port pending the shipment of the mealies, and the charge, if any, to be levied thereafter.

It was unanimously agreed that free storage be given at port of shipment where the maize was shipped by the first available steamer, but if maize was detained for subsequent shipment owing to absence of shipping instructions, a reasonable charge for extra handling and storage shall be made.

It was also agreed that the forwarding Administration would as far as possible regulate the traffic in accordance with shipping facilities. The Coast Administrations will advise the Inland Administration of the requirements in this respect.

It was further agreed that the charge be 1s. per ton to cover such extra handling and storage for one fortnight or part thereof. After such time the rent to be 3d. per ton per week or part of a week : the charge to be leviable from date of completion of the loading of a vessel by which such consignment or part thereof could have been shipped.

Note.—The foregoing extra charge if incurred at the request of sender, on a consignment entrusted to the Administration for conveyance and disposal, must be paid by such sender in addition to the suggested usual inclusive charge of 2s. 6d. per bag.

11. Desirability or otherwise of making advances to consignors on consignments of maize entrusted to Administration for transit and disposal and the amount of advances so recommended.

It was unanimously decided that this Conference suggest the advisability of the Government's consulting financial institutions as to senders (desiring it) receiving advances from them on consignments of maize which the grading officer had certified to having been received at the port for shipment and graded, in preference to the Administration considering the advisability or otherwise of undertaking such service.

12. To consider the steps to be taken to establish a uniform South African standard for mealies and grading.

It was agreed that a uniform system of grading be adopted for all South Africa, and that the same official brand shall be adopted for the whole of the grading, with the name of the port through which the grain was shipped, added. CHAP XII.

It was also agreed there shall be six grades for South African maize, namely: White, A1 and A2; Yellow, A1 and A2; and Mixed, A1 and A2; all falling below these standards to be distinctly marked "Below grade".

Instead of having the words in full, it would be sufficient if the following were adopted: W1, W2; Y1, Y2; and M1, M2, according as to whether the maize is white, yellow, or mixed.

It was agreed that stencils should be kept at stations, and consignors should be required to mark bags W., Y., or M., as the case may be, to indicate description of maize brought for conveyance. This was to be a condition of forwarding, and the lettering was to be in addition to the marks each bag must PLAINLY bear to identify the consignor thereof.

It was agreed that maize below grade be stencilled, in bold type, "Below grade," in a square with a diagonal bar across, beneath a crown, the interpretation being that the Government had handled the maize and declared it to be of inferior quality. All maize sent to the port for export where the reduced rate had been made applicable, should be shipped irrespective of quality, provided that the bags had been passed through the hands of the grader.

South African grade No. 1 would be considered as choice, and the grade No. 2 would be equivalent to what was considered in other places as F.A.Q.

Graders should select standard samples for exhibition at all railway stations for the information of farmers, and also the same standard should be forwarded to the various corn exchanges of Europe, distinctly labelled, as what is understood to be Standard No. 1 and Standard No. 2.

It was unanimously agreed to record that some consideration should be received from the Inland Administration for the services rendered in grading and marking at the Cape ports and, presumably, also at the Port of Durban, but the details of this shall be matter for discussion by correspondence and ultimate settlement between the Governments concerned.

Maize received in a weevily condition or showing the slightest sign of weevil should be refused and isolated and the sending station telegraphed to for instructions as to disposal, it being made a condition of acceptance of a consignment from senders at reduced rates that the Administration is given the right to dispose of weevily consignments of maize on account of whom it may concern, without first waiting for the instructions of senders should the circumstances indicate such a course to be expedient. In such a case, where the maize is disposed of locally, the low railway rate would not apply. It is also to be a strict instruction to the forwarding station staff that if any portion of a consignment of maize shows the slightest sign of being affected by weevil the whole consignment must not be accepted for export. Where weevils manifest themselves subsequent to grading, the consignor shall have the benefit of the lower rate with the exception of the rate for the portion of lines Ressano Garcia to Lourenço Marques, over which section the ordinary rate will apply.

13. To consider the measures to be taken to ensure the observance of the agreement as to common standard of grading by all Administrations.

Occasional samples are to be taken from the bags at each port and sent to some central depot to be examined, such depot to be hereafter named by the Agricultural Departments, and that the grading officers meet periodically to exchange views, compare notes, and inspect these samples.

14. Consideration of sea freight charges to be levied on grain when forwarded for disposal through Administration, and when forwarded for disposal through independent channels, and arrangements to be made in connection with any difference.

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It was agreed that it was unnecessary to pursue this question as it was the business of the Administrations to enter up any charges the steamship companies notified.

15. Discussion of preliminary arrangements necessary in connection with booking of export fruit at through rates.

It was agreed that as this was more of a local matter between the C.S.A.R. and Cape Administrations, Mr. Price would discuss the details with Mr. Robb, Mr. Hannon and Mr. Smith.

16. Channel of communication with London and distribution of information for European market.

It was unanimously agreed that this Conference having adopted standards for South African maize for export, and having also come to a definite agreement as to the charges and methods to be adopted for the export of such maize, regards it as a matter of material importance that similar action should be taken at the London end, whereby the maize of South Africa and the information in regard thereto shall be dealt with and be available through one channel, and by means of which channel information shall be furnished to the various European Corn Exchanges and the public generally.

The Conference, therefore, submits to the favourable consideration of their respective Governments the desirability of their taking such action as may be necessary to secure this desirable end.

17. Proposal that steps be taken to encourage the establishment of a market at Southampton for the disposal and distribution of maize from South Africa.

It was resolved that it be represented to the several Governments that it would be in the general South African interests if steps be taken to encourage the establishment of a market at Southampton for the disposal and distribution of maize from South Africa, and that the respective Governments be respectfully requested to take the subject into favourable consideration, and to take such action thereafter as may be deemed expedient to secure the end indicated.

18. Charging of exchange and cost of cables in connection with maize sold by the Administration.

It was agreed that if a charge for exchange $\frac{\text{and}}{\text{or}}$ cabling was to be made, it should be the same on maize exported via each port; whether exchange and cabling was to be charged for or not, the respective Governments were respectfully requested to ensure uniformity of practice being observed in this respect.

19. Whether, having come to an agreement, a joint notice should be issued to the public or an independent notice by each Administration.

It was agreed to recommend that whilst a joint notice might not be essential it was very desirable.

20. Confirmation of decisions by respective Governments.

It was agreed that it be understood that the resolutions arrived at by the Conference were subject to formal confirmation by the respective Governments.

21. Date from which recommendations were to be given effect to.

It was agreed that recommendations be given effect to as from 1 February, 1908, with the understanding that, where necessary, the spirit of the resolutions would be observed in the interval where it is necessary to do so.

22. Method of arriving at agreement with Natal.

It was unanimously agreed that in regard to the resolutions arrived at, as the Natal Delegates were not authorized to give decisions in certain matters, that this Conference decide that the channel of communication in regard to any representations that may be made by the Natal Administration in regard to the resolutions, with a view to modifying the same in some minor details, shall be the C.S.A.R. Administration, who will be authorized to communicate with the other Administrations for the purpose of arriving at a common agreement.

23. Consignments dispatched by co-operative societies to be regarded as from one consignor.

It was unanimously agreed to record an answer to an inquiry as to whether a co-operative society when exporting maize was to be regarded in the light of a firm entitled to forward as one consignor, that the position of the co-operative society was the same for the purpose of the resolutions arrived at by this Conference as a farmer or private individual.

24. Certificate of weighing at ports.

The following resolution was come to unanimously: "That in the opinion of this Conference, where certificates of weight are required, a weighing of 10 per cent of the consignment be regarded as adequate to enable the official grader to sign his certificate of weighing, and that to ensure uniformity of practice measures be taken as soon as possible to ascertain what the practice is in this respect in the case of exporters of maize from other parts of the world to Great Britain".

509. *Establishment of a Clearing House at Durban.*—Owing to the threatened congestion of the maize trade through failure to secure shipping, the Durban Chamber of Commerce approached the Natal Government with a suggestion that a clearing house be established under government control and at government expense. The Natal Government agreed, the several parties concerned came to an agreement, and the clearing house came into operation at the end of August, 1909. This in some considerable degree facilitated the export business, and on occasions was instrumental in inducing the Conference Lines to put on an extra steamer. It also placed the merchants in a position to charter outside steamers through the clearing house, and three of these were taken up at intervals. But as the quantity of freight available was small, and the low rate offered not very tempting, there was no competition, and few outside steamers could be induced to do business. Also the chartering of outside steamers was subject to the consent of the Conference Lines (*Rainnie*, 2).

510. *Bloemfontein Conference*, 18 *and* 19 *January*, 1910.—

Present :—

Railway Representatives : Sir Thomas Price, General Manager, C.S.A.R.; A. J. Robb, Assistant General Manager, C.G.R.; W. Binns, C.G.R.; J. McConnachie, District Traffic Superintendent, N.G.R.; John Rainnie, Durban Harbour Captain; W. J. K. Skillicorn, N.G.R., General Manager's Office; S. Seruya, C.F.L.M.; D. Watson, C.S.A.R.; G. S. Oettle, C.S.A.R.

Chambers of Commerce : A. Keeling, Johannesburg; A. Lewis, East London; M. W. Hayne, Durban; K. Spilhaus, Cape Town; Geo. Hobson, Basutoland; W. Ehrlich, Bloemfontein; C. F. Kayser, Port Elizabeth; H. Ruffel, O.R.C. Chamber of Commerce.

Shipping Interests : L. MacLean, Union Castle Line; Otto Siedle, Natal Direct Line, Durban; A. H. Rennie, Natal; W. Macfarlane, Union Castle Line, Durban.

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Departments of Agriculture: W. J. Palmer, Director of Agriculture, Bloemfontein; M. J. Joubert, Bloemfontein; B. Enslin, Pretoria; B. Stilling-Anderson, Co-operative Expert, Transvaal; J. Burtt-Davy, Government Botanist, Transvaal; R. W. Thornton, Cape Town.

Producers: H. A. Light, Natal; J. Moon, Natal; H. Stanley, Wepener; Wm. A. McLaren, Vereeniging; J. B. de la Harpe, Blackwoods, Fouriesburg; J. Pierce, Heilbron.

Official Graders: T. A. Westbrook, Durban; P. Rose-Innes, Cape Town; C. H. Keet, Lourenço Marques.

SUMMARY OF RESOLUTIONS AND DECISIONS.

1. Production and Harvesting of Maize for Export—Best Varieties to Grow—Grading on Farm, etc.

Resolution I—

"This Conference recommends to the favourable consideration of the South African Governments the advisability of issuing a joint notification, to be renewed periodically, to farmers throughout South Africa, giving:—

"1. (*a*) The descriptions of maize which experience has shown to be calculated to give the best yields in the several districts;

(*b*) the best methods to be employed in preparing the land for sowing and the best methods of harvesting;

(*c*) the descriptions of maize most in demand;

(*d*) the disadvantages of mixing maize, either as regards colour or quality, in the same bag;

(*e*) particulars as to the supply of pure seed and where procurable;

(*f*) any other information calculated to be of service to growers and buyers.

"2. That the different Departments of Agriculture issue small samples of pure seed to interested producers for experimental sowing, but that such distribution be limited to experiments only, so that commercial interests will not be interfered with."

2. Grading.

(*a*) Appointment of chief government grader, with assistants, at ports and inland centres.

Resolution II—

"This conference recommends that in order to secure uniformity of practice and standards, immediate measures be taken to place the grading of maize under one authority, and that for giving effect to this object a Chief Government Grader be appointed, with assistants, solely in Government employ, at the ports and inland centres."

It was also decided on 19 January that the following telegram be dispatched to the Prime Minister and Ministers of Agriculture of the Transvaal, Cape Colony and Natal; a similar communication to he addressed to the Prime Minister and Minister of Agriculture of the O.R.C.:—

"The Conference at which representatives of the farming and mercantile interests, and officers of the agricultural, port, and railway administrations of the Cape, Orange Free State, Natal, and Transvaal are present, as well as a delegate from Basutoland and a representative of the Province of Mozambique, has to-day passed the following resolution unanimously: 'This Conference recommends that in order to secure uniformity of practice and standards immediate measures be taken to place the grading of maize under one authority, and that for giving effect to this object a chief Government grader be appointed, with assistance, solely in Government employ, at the ports and inland centres'.

"It is of importance to our maize industry in its competition in English and other European markets that uniformity of standard practice and authority should be established without delay, and I was directed to express the hope that the Governments would be pleased to take measures in concert to establish such authority which would, *ipso facto*, be necessary under Union, at once instead of waiting until next June. The drawbacks the Colonies are subjected to under existing differing control and directions will be explained to you by your Government representatives."—(Signed) , *Chairman*.

(*b*) Fixing grading standards. What body is to fix grades?

Resolution III—

"This Conference recommends that a committee be appointed annually to meet at a time to be notified by the Union Minister of Agriculture, for the purpose of deciding the standard grades for each year, such committee to consist of one representative from each Province to be nominated by the Associated Chambers of Commerce, one member of the Agricultural Department of each Province to be nominated by the respective Governments, and one member representing each Province to be nominated by the South African Agricultural Union".

The Conference was further of opinion that the committee recommended in terms of the above resolution should be appointed in the first instance as early as possible, so as to enable the required regulations and certificates to be issued in good time for application at the outset of the approaching maize shipping season. The Conference also suggests that such committee be empowered to consult the representatives of the shipping, mercantile, agricultural, railway, and port interests, as it may deem necessary.

With a view to giving effect to the foregoing suggestion, the Chairman is authorized to communicate with the respective Governments on behalf of this Conference urging them to arrange—in anticipation of Union—the appointment of the committee.

3. Grading Standards.

(1) Should present standards be reduced?

(2) Should one standard be selected for each grade?

(3) What percentage of sound grain is required?

(4) Annual distribution of standard samples in South Africa, Great Britain, Europe, and other purchasing countries.

Resolution IV—

"This Conference recommends that the committee referred to in Resolution No. 3 also deals with—

(*a*) Reduction or otherwise of present standards.

(*b*) The advisability of one standard being selected for each grade.

(*c*) The percentage of sound grain necessary.

(*d*) The annual distribution of standard samples in South Africa, Great Britain, Europe, and other purchasing countries.

(*e*) That it be an instruction to the said committee that it should ascertain from the European markets the grades most acceptable and decide accordingly."

4. Grading at Ports.

Examination of every bag.

Resolution V—

"This Conference recommends that it be an instruction to the official grader that every bag must be examined at the port of shipment before granting a certificate".

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5. EXPORT TRAFFIC.

Standard official documents.

Resolution VI—

"This Conference recommends that a form of certificate, applicable to all ports in connection with the export of maize, shall be prepared by the Committee referred to in Resolution No. 3, in consultation with the chief grader. Any certificate to be issued must bear no alterations or erasures. The committee should further consider the advisability that all certificates be filled in with ink or typewritten."

6. BAGS.

(*a*) Purchase of.

(*b*) Use of old bags.

It was agreed—

"That the Chairman obtain information relative to the correct methods of sewing up bags, and that he have diagrams prepared for the information of producers".

Resolution VII—

"This Conference is of opinion that old or second-hand bags shall not be used for export purposes, and also urges that at least 2½ lbs. reputed shall be insisted upon for the present, but that actual 2½ lb. bags of "A" quality twill, or heavier bags if necessary, be used at the earliest possible date; such bags to be of a given measurement to carry 200 lbs. of maize".

7. BAGS OF MAIZE.

Limiting weight to 200 lbs.

Reduction of weight to 160 lbs.

Resolution VIII—

"This Conference recommends that the contents of bags of maize be limited to 200 lbs."

8. MARKS AND CERTIFICATES.

(*a*) Grade marks as leading marks.

(*b*) Reduction in number.

(*c*) Stencils to be used by different Provinces.

(*d*) Use of distinctive colour at each port for shipping marks.

(*e*) Full truck loads of one grade without marks.

(*f*) Grader's certificates and bills of lading.

(*g*) Weight certificates.

(*h*) Rejected grain certificates for maize rejected at ports.

Resolution IX—

Resolutions passed by sub-committee formed by this Conference and subsequently adopted by general conference:—

(*a*) That the various grades and sub-divisions thereof be indicated by running numbers from 1 to 15, such numbers to be stencilled in red and placed in a circle on the upper side of the mouth of the bag.

(*b*) That the leading mark and the port mark be one, and that the shipping companies be requested to submit to the committee appointed as per Resolution No. 3 the lettering they desire adopted for the different ports of discharge.

(*c*) That a uniform system of stencilling or stamping be adopted for marking purposes, such to be decided by the Chief Grading Officer.

(*d*) That the following colours be adopted by the several ports of shipment for indicating the port marks:—

Durban	Black.
East London	Blue.
Port Elizabeth	Red.
Cape Town	Green.
Delagoa Bay	Yellow.

(*e*) That it be optional for full truck loads of one grade, from one consignor to one consignee, to be sent without sender's marks.

(*f*) That all particulars stated on the grader's certificate, also appearing on the bill of lading, shall be identical on both documents, which must also bear the same date.

(*g*) That the railway and harbour authorities shall provide the proper facilities for correct weighing at the ports and shall issue weight certificates to the shippers when requested, and that it be an instruction to the port authorities not to issue such certificates unless the trucks have been retared.

(*h*) That it be a recommendation to the committee referred to in Resolution No. 3 to frame uniform certificates to be issued for grain passed or rejected by the Government graders at the several ports.

9. Shipment of Wet or Otherwise Unfit Maize.

(*a*) Can reduced rates apply to certain months of the year only?

(*b*) Reduction in rates on weevily maize.

(*c*) Rates on rejected maize.

Resolution X—

"(*a*) In the opinion of this Conference it is not advisable that reduced rates for maize apply to certain months of the year only.

"(*b*) That maize railed apparently in sound condition, which was found to be slightly weevily on arrival at the port, be allowed to be shipped at export rate, providing the shipping companies were willing to accept same."

10. Minimum Consignments.

To be accepted at reduced rates of export.

Resolution XI—

"This Conference recommends that the present arrangements as to the 100-bag minimum consignment should continue".

11. Railway, Ports, and Steamship Facilities and Rates.

(*a*) Radius of exportation for inland centres.

(*b*) Port charges and services.

(*c*) Similar practice to be adopted at all ports.

Resolution XII—

"(*a*) This Conference recommends that the export rate of 10s. per ton of maize shall apply to all South African centres represented at this Conference, where the export rate does not amount to less than 10s.

"(*b*) This Conference urges the necessity of similarity of practice being introduced at all South African ports, together with the services performed at each in regard to the export of maize oversea."

(*d*) Difference in weight of grain as ascertained by consignor and at port of shipment.

Withdrawn.

(*e*) Transmitting of maize and consequent mixing up of consignments.

No resolution arrived at. (Note: For decision re "Numerical checking of bags" *vide* Resolution 17.)

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(*f*) Advice of dispatch of maize.

Inter-railway departmental matter. Withdrawn.

(*g*) Forwarding of respective descriptions of qualities of maize in separate trucks.

Vide Resolution No. 9 (*e*).

(*h*) Shipping freights.

Resolution XIII—

"This Conference, having heard the views of the representatives of the steamship companies, desires to urge upon the several Governments and upon the Union Government the seriously prejudicial effect any increase of shipping freight will have on the production and export of grain; this Conference therefore resolves to urge upon the Governments to take such measures as may be necessary to ensure, if possible,

(*a*) maintenance of the present freight;
(*b*) sufficient ship tonnage to carry the maize traffic;
(*c*) opportunities to ship directly to other leading ports in the United Kingdom and the Continent, in addition to the present ports of landing; and
(*d*) a contract for at least three years to fix these conditions."

12. Collection of Agricultural Statistics by the Government.

Such statistics to include a forecast of harvests.

Resolution XIV—

"This Conference recommends that a properly constituted statistical bureau be at once inaugurated and an expert appointed. This bureau to provide statistics of acreage planted, report monthly on seasons and probable yield of crops, and show extent of South African consumption, estimates of final yield and of exportable surplus, the estimates to cover native crops and monthly statistics of quantity exported, etc."

13. Storage of Maize.

On farm, stations, inland storing stations, and at ports.

Resolution XV—

"This Conference is of opinion that maize for export should be stored up-country as long as possible, and that for this purpose the Government should be requested to erect covered storehouses but open at the sides, at the chief grain-exporting railway stations, for the convenience of farmers and merchants, and that a charge be made for storing and holding grain to cover the cost. Regulations to be made so that grain cannot be held in such stores for speculative purposes."

14. Grain Elevators.

Are such required?

Resolution XVI—

"This Conference having heard the views of the representatives of the steamship companies regarding the erection of elevators recommends that, before any decision be taken, exhaustive inquiries, preferably by the appointment of competent persons visiting Argentina, the United States, Canada, and Russia, be made by the Government".

15. Export Traffic.

Numerical checking of bags by railway authorities.

Resolution XVII—

"This Conference is of opinion that it is desirable that arrangements be made by the railway authorities to check (if requested by sender) the number of bags loaded, even if extra expense has to be incurred by the individual desiring such service. The department in such instances to accept responsibility for numerical shortages." CHAP. XII.

16. Milling Maize en route for England.

Rail charges on maize milled and subsequently exported.
It was agreed that the prevailing practice be continued.

17. Annual Committee for Grading Standards.

Powers and scope.
Resolution XVIII—

"That this Conference is of opinion that the committee recommended in Resolution No. 3 be appointed as early as possible, so as to enable the required regulations and certificates to be issued in good time for application at the outset of the approaching maize shipping season.

"The Conference also suggests that such committee be empowered to consult the representatives of the shipping, mercantile, agricultural, railway, and port interests, as it may deem necessary.

"With a view to giving effect to the foregoing suggestion the Chairman is authorized to communicate with the respective Governments on behalf of this Conference, urging them to arrange—in anticipation of Union—the appointment of a committee."

18. Identification Marks.

Grower's initials.
No decision arrived at in view of Resolution No. 9 (*e*).

19. Consignment Notes.

Receipts.
No decision arrived at.

20. Markets.

Supply of colonial.
Withdrawn; out of scope of conference.

511. *Annual Maize Committee.*—The committee appointed in terms of Resolution III of the Bloemfontein Conference, January, 1910, held its first meeting in the Town Hall, Durban, 11 May, 1910, Mr. W. J. Palmer, Director of Agriculture, Orange Free State, in the chair. There were present:—

Messrs. W. Batting (Cape), J. A. Westbrook (Natal), J. M. B. Stilling-Anderson (Transvaal), M. Joubert (O.R.C.), nominated by their respective Agricultural Departments.

Messrs. K. Spilhaus (Cape), M. W. Hayne (Natal), A. Keeling (Transvaal), H. Ruffel (O.R.C.), nominated by their respective Chambers of Commerce.

Messrs. J. Moon (Natal), W. A. McLaren (Transvaal), G. A. Kolbe (O.R.C.), nominated by the S.A. Agricultural Union.

Messrs. W. J. Palmer, Director of Agriculture, Bloemfontein, and Captain J. Rainnie, Port Captain, Durban.

Mr. J. Woodin (Cape), nominated by the S.A. Agricultural Union, was not present.

The following is a summary of the resolutions and decisions arrived at:—

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1. *Classes and Grades.*—That the classes and grades for the coming season be designated White Flat 1, 2, and 3; White Round 1 and 2; Yellow Flat 1 and 2; Yellow Round 1 and 2; Mixed Colours Round, Mixed Colours Flat, and Below Grade (all others).

2. *The Word "Class" Substituted for the Word "Standard".*—That the word "class" be used in future instead of the word "standard".

3. *Mixed Consignments.*—"This sub-committee recommends that the consignor be required to state on the consignment note full details, stating quantity of each class, and the consignor to be responsible for any extra charges incurred at the port through failure to do so. The railway consignment note should in every case reflect the class or classes of the grain."

4. *Grader's Certificates.*—"That the two specimen certificates submitted by the sub-committee, be adopted, and that it be an instruction to the graders to issue certificates for maize classed as below grade."

5. *Marking of Every Bag.*—"That this committee confirms the Resolution X (*e*) of the Bloemfontein Maize Conference."

6. *Numbers Substituted in Place of Letters.*—"That the grades in the order in which they appeared on the schedule of description be allotted each a number from 1 to 12, within a circle, and that these numbers be used instead of the letters and numbers appertaining to each grade as grader's marks, and that the grading certificate also state the same number and indicate to which of the grade letters and number it corresponds."

7. *Next Meeting.*—"That this committee meet again at a later date in the season for the purpose of deciding upon the question of samples."

8. *Weevily Maize.*—"That this committee recommends that if weevil is apparent on any bags in a truck, and, on examination, the grain in such bags is found to be weevil eaten, the whole truck be considered weevily."

9. *Official Certificates.*—"That the grader's certificate be written in ink or by means of a typewriter in terms of Resolution VI of the Bloemfontein Conference."

10. *Steamship Facilities and Rates.*—"That the Governments be asked to at once take up the question of shipping freights with the Shipping Companies in order that it might be settled at the earliest possible date."

512. *Government Facilities for Export.*—When the oversea export of maize was seriously taken in hand the several South African Governments agreed to offer the following special facilities to exporters:—

(*a*) Special reduced rail rates from sending station to all South African ports.

(*b*) Special reduced sea freight from South African ports to oversea markets.

(*c*) Service of grading officer at ports.

(*d*) Low insurance when handed to Government for disposal.

(*e*) Minimum of risk to consignments in handling or transit.

(*f*) Government shipment arranged at minimum of expense.

(*g*) Maize sold afloat.

(*h*) Storage facilities.

(*i*) Information regarding export arrangements, maize samples, etc., furnished by the High Commissioner for South Africa in London.

The conferences held from time to time resulted in concerted action amongst the several colonies.

The export business from its inception provided for three systems or schemes to meet the wishes of South African producers.

(1) Scheme C, where the special railway rate (now 10s. per ton) is granted for the export traffic.

(2) Scheme B, under which, at a combined rail, port, and agency charge, the railway and harbour authorities will act as shipping agents on behalf of the exporter.

(3) Scheme A, whereby not only are the foregoing facilities granted, but the Union Government's British representative will dispose of, on the London market, the consignment which has been handed to the Railway Administration, at a rate inclusive of rail, sea freight and all other charges incidental to the disposal of the grain. The results of the sale, which are cabled out, minus the fixed deduction, are paid over to the consignor.

Where full truck loads travel long distances, such traffic is more easily and economically handled than part lots for similar or short distances; hence the Government insisted that if advantage was to be taken of the low export rate, a minimum of 10 tons for all export traffic was to be maintained.

By endeavouring to ship unripened grain, for the purpose of completing oversea contracts secured at high prices, the ports were sometimes blocked with maize detained on the wharves to dry. The Government therefore provided that instead of receiving the benefit of the cheap export rate, exporters who are in the unfortunate position of having their grain rejected by the Government grader at the port have to pay ordinary rates, on which no rebate will be granted, even though the grain be subsequently declared fit for the oversea market. (Since the above was written this has been amended, as provided in the Regulations below.)

513. *Government Regulations and Railage Rates.*—(1) The following Regulations were in force on and from 1 October, 1913:—

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SECTION I.

SCHEME A.—*Maize, Oats, Kaffir Corn, Maize Products and Kaffir Corn Products handed to the Administration for Disposal through its Agents in London.*

2. All bags of maize and kaffir corn must weigh 203 lbs., oats 154 lbs., maize products and kaffir corn products 183 lbs. each, and this weight is to be charged for as one bag in each case.

3. (*a*) Ordinary consignment notes must be used, endorsed "Delivered to the S.A.R. Administration for export and sale in terms of conditions published in *Government Gazette* No. 145 Transvaal, / 49 O.R.C., / 9038 Cape, which I accept".

..................................Signature of Sender.

(*b*) Consignment notes must be made out in triplicate, and each copy signed in ink by sender. The special endorsement must also be signed by sender. The full christian name and surname of sender, and the name, number, and district of the farm must be shown on consignment notes.

(*c*) Consignment notes must be disposed of as follows:—

(1) Original copy returned to sender receipted.

(2) Duplicate which must give reference number and date of invoice, sent to Chief Accountant.

(3) Triplicate retained at station for reference.

(4) Charges will be as follows:—

(*a*) *From Stations on the Transvaal and Orange Free State Sections.*

2s. 11d. per bag in the case of maize and oats.

3s. 3d. ,, ,, kaffir corn, maize products, and kaffir corn products.

(*b*) *From Stations on the Cape Section.*

	Maize and Oats. s. d.	Kaffir Corn. s. d.
If consigned from stations 150 miles or under from the port	2 2 per bag	2 6 per bag
If consigned from stations 151-300 miles from the port	2 5 ,,	2 9 ,,
If consigned from stations over 300 miles from the port	2 8 ,,	3 0 ,,

(*c*) *From Stations on the Natal Section.*

The local rates at per bag (i.e. the local rate divided by 10) as quoted under Scheme C:—

Plus (*a*) 1s. 11d. per bag in the case of maize.
(*b*) 2s. 2d. ,, ,, oats.
or (*c*) 2s. 3d. ,, ,, kaffir corn.

(*d*) *From Stations on the Vryburg-Bulawayo Section of the Rhodesia Railways.*

	Maize. s. d.	Kaffir Corn. s. d.
If consigned from stations distant 100 miles or under from Vryburg . .	2 11 per bag	3 3 per bag
If consigned from stations distant 101-200 miles from Vryburg	3 2 ,,	3 6 ,,
If consigned from stations distant 201-300 miles from Vryburg	3 5 ,,	3 9 ,,
If consigned from stations distant 301-480 miles from Vryburg	3 8 ,,	4 0 ,,

If consigned from stations distant 481-588 miles from Vryburg, the charge per bag will be :—

Maize	. 2s. 8d. per bag	Plus railway carriage from forwarding station to Vryburg calculated at ¼d. per ton per mile.
Kaffir Corn	3s. od. ,, ,,	

5. All charges must be prepaid.

6. Invoices must be endorsed "Maize (Oats, Kaffir Corn, etc., as the case may be) for sale by the Administration in London ".

7. Custom Export Form (L) must be only made out when the traffic is forwarded via Lourenço Marques.

8. (*a*) Every assistance practicable must be rendered by the station staff, but senders must perform the loading themselves. Station masters should ascertain as far as possible beforehand when consignments are likely to come forward, so that truckage may be arranged, and double handling and storage at stations avoided as far as possible.

(*b*) Trucks must be carefully sheeted to prevent wet and subsequent danger of heating.

9. Particulars of consignments must be immediately telegraphed to the Headquarters Offices, Johannesburg, when forwarding instructions will be issued. This is necessary to arrange shipping accommodation, and to effect marine insurance on the consignments.

10. (*a*) On arrival of the consignment at port, delivery will be taken by the official to whom the grain is invoiced, who will grant quittance to the Railway Department and arrange, in the case of maize and kaffir corn, for it to be graded. The authorized officer at the port will take the necessary steps for shipment, preparation of the requisite bills of lading, etc., and other duties incidental to the shipment of the consignment.

(*b*) Bills of lading in triplicate must be made out in favour of the High Commissioner for South Africa, London.

11. Free storage is allowed at ports, if shipped by first available steamer, or such other vessel as may be convenient to the Department, but if detained at request of sender, the extra charges given in paragraph 39 will be levied in addition to the charge per bag mentioned in paragraph 4.

12. The official to whom the grain is consigned will advise forwarding station master (giving reference to invoice) particulars of the grain dispatched, name of vessel shipped by, and date of sailing.

13. On arrival of the vessel in London, the agent of the High Commissioner will take delivery, arrange for the grain to be either placed on the market or disposed of c.i.f., and cable by code word the amounts realized to the Chief Accountant, quoting reference to bill of lading.

14. The grain will, as far as is advantageously possible, be sold on the weight ascertained by request at port of shipment, the Administration reserving the right of requiring an allowance of 2 per cent for sifting and drying out thereafter, should such loss appear to have accrued from such causes after weighing at destination.

15. On receipt of cable advice the chief accountant will send a cheque to forwarding station, payable to sender, for the amount realized by each particular consignment, less the particular charges referred to in paragraph 4, and less 10 per cent pending receipt of final account sales documents. On receipt of these latter documents a full statement and final cheque will be forwarded. These cheques must be handed to the original sender by the station master personally, who will cash same for consignor, if desired, and provided sufficient cash is on hand for the purpose, on receipt at foot of cheques agreeing with signature on original consignment note, so as to ensure payment to proper individual.

16. The Administration is responsible for loss or other damage due to negligence or carelessness on the part of its servants or agents, and will provide therefor by insurance of consignments entrusted to the Administration for disposal, but is not responsible for any loss arising from inherent defects or natural causes such as weevils, heating, etc., providing ordinary care has been taken to prevent these arising.

17. Consignments showing the slightest sign of weevil, either wholly or in part, must not be accepted under *this scheme* of export.

18. Grain found at the port to be in a weevily condition before shipment, will not be exported under this scheme, but will be sold to best advantage on account of whom it may concern, at the port or such other place as may be convenient, without first waiting sender's instructions should circumstances indicate such a course to be expedient. The export rate for grain will not apply unless the weevils manifest themselves after grading, but in the latter case the C.F.L.M. proportion of the higher rate must be paid. The port official concerned will advise chief accountant and sending station of such action.

Scheme B.—*Maize, Oats, Kaffir Corn, Rye, Wheat, Maize Products and Kaffir Corn Products for Export Oversea for Disposal otherwise than through the Government Agent, but where it is desired that the Government shall Undertake the Duties of Shipping Agent at the Port of Shipment.*

This section does not apply in regard to grain forwarded for shipment via Point, and is only in force for consignments forwarded from Transvaal and Orange Free State stations.

19. Ordinary consignment notes must be used, embody all special shipping instructions, and be endorsed "S.A.R. Administration to undertake shipping

145 Transvaal,
agents' duties, in terms of *Government Gazette* No. 49 Orange River Colony,
9038 Cape,

the terms of which I accept," the special endorsement being signed by sender. These consignment notes will be filed by stations for reference in the usual way.

20. All grain will be charged at actual gross weight of bags.

21. The rates are as quoted in paragraphs 22, 29, and 30.

22. Further charges as follows must be entered up on the invoice :—

(1) Grading Fee, when leviable	½d. per bag
(2) Shipping Fees, including wharfage or dock dues .	3d. per ton
(3) Agency	3d. per ton,

with a minimum of 10s. per consignment and maximum of 20s. for agency work from one consignor to one consignee.

23. All railage and other charges incurred must be collected before shipment, unless ledger account has been sanctioned, and recharge arranged.

24. Sender's shipping instructions must be endorsed on original invoice and loading note.

25. Shipping will be arranged by the first available steamer, unless instructions are received to the contrary. If detained at port of shipment pending shipping instructions, the charges detailed in paragraph 39 will be levied to cover extra handling and storage.

26. On arrival of the consignment at port, delivery will be taken by the official to whom the grain is invoiced, who will grant quittance to the Railway Department, and arrange in the case of maize or kaffir corn for it to be graded. The authorized officer at the port will take the necessary steps after the grain is graded, for delivery to ship, preparation of the requisite bills of lading, etc., and other duties incidental to the shipment of consignments, including the posting of the bill of lading as directed in shipping instructions on consignment note, repeated on invoice and loading note.

27. (*a*) Senders must make their own arrangements for accommodation of the consignments on the vessel and for payment of freight.

(*b*) After shipment of maize, oats, kaffir corn, rye, wheat, maize products, and kaffir corn products *under this scheme*, the Administration takes no responsibility, and consignors must make their own arrangements for insurance.

28. Grain found at the port to be weevily may be exported provided it is not shipped in the same hold of any vessel carrying sound grain. It may, however, be sold to best advantage on account of whom it may concern without first waiting sender's instructions, should circumstances indicate such a course to be expedient. The export rate for grain will only apply in those cases where the weevily grain is exported oversea or is milled before export. The port official concerned will communicate to chief accountant and sending station the action taken.

Scheme C.—*South African Grain, its Products, and Compressed Fodder, Forage, Oat-hay, and Chaff for Export Oversea through Private Agents at the Respective Ports.*

29. (*a*) The following is the railway export rate for maize, oats, kaffir corn, rye, wheat, maize products, and kaffir corn products :—

To Cape Ports (Buffalo Harbour, Algoa Bay, Mossel Bay, and Table Bay Docks), and Point, Port Natal	From any station in Transvaal or Orange Free State	Per Ton. 10s.

Harbour or wharf dues are *not* included in the above rate.

Wharfage or dock dues on export grain and its products at Cape and Natal ports are levied and calculated at 5s. per cent *ad valorem*.

(*b*) The following consolidated railway and harbour rate (including wharfage or dock dues) is charged for the conveyance of South African grain, compressed fodder, forage, oat-hay, and chaff, for export beyond South Africa from stations in the Cape Province, via Table Bay, Algoa Bay, or Buffalo Harbour, and from stations in Natal to Point :—

Up to 40 miles	Rate 15 plus 1s. 4d. per ton
1 to 120 ,,	5s. 0d. ,,
121 to 240 ,,	½d. per ton per mile
Over 240 ,,	10s. 0d. per ton

(*c*) The following are the rates for export for the commodities referred to in paragraph (*b*) via any Cape port from stations on the Vryburg-Bulawayo section of the Rhodesian Railways :—

From Stations distant from Vryburg.	Rate per ton to any Cape Port.
1 to 100 miles	12s. 6d.
101 to 200 ,,	15s. 0d.
201 to 300 ,,	17s. 6d.
301 to 480 ,,	20s. 0d.
481 to 588 ,,	¼d. per ton per mile from forwarding station to Vryburg plus 10s. per ton from Vryburg to any Cape port.

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(*e*) The rate charged for the commodities mentioned in paragraph (*a*) is :—

To Lourenço Marques. From all stations in the Transvaal (except those west of Klerksdorp and south-east of Germiston on the Natal line) 10s. per ton.

Note.—Manufactured products of grain via Lourenço Marques will be subject to a wharfage charge of 1s. per ton at that port, whilst in the case of grain the Customs at Lourenço Marques will collect the sum of 8·7d. per ton for similar services.

Rates to Lourenço Marques from stations not given in above areas will be quoted on application.

30. The charge for grading is ½d. per bag.

31. All the special rates which have been quoted for oversea export trade are owner's risk.

32. Storage charges will be levied as laid down in paragraph 39.

33. All grain will be charged at actual gross weight of bags.

34. All grain and its products for export, however, must pass through the Government grader, otherwise full ordinary rates as given in the Tariff Book will apply. If found to be weevily, wet, unripe, or mouldy, the consignment will be detained pending sender's or consignee's instructions, and the export rate will be increased to the ordinary rates before parting therewith; if finally refused export by the grader, or if sold by the Administration, the higher rate will be deducted from proceeds of sale.

General.

35. Stencils for marking the class of maize, *vide* Clause 65, will be supplied to stations on requisition, as will also a rubber stamp with the endorsement to be made on consignment notes (see Clauses 3 and 19).

36. The grain export rate must be treated as a Station to Station rate, including handling at the port, in the same way as Rate 15, and cartage only raised when performed.

37. (*a*) Export grain and its products under Schemes B and C are charged at actual gross weight.

(*b*) Grain for export will be, if desired, weighed upon arrival at the coast and the necessary certificate furnished at a charge of 9d. per 4-wheeled and 1s. 3d. per 6- or 8-wheeled vehicle. (*Note.*—The truck must be re-tared within the twenty-four hours subsequent to off-loading having been performed.) A similar charge will be made if re-weighing, and the necessary certificates, are required immediately prior to shipment for export.

38. Grain and its products ex the Pankop line, for export, will be charged a special rate of 1s. 8d. per ton of 2,000 lbs. for railage over the branch line.

39. Shipment must be arranged by the first available steamer, unless instructions are received to the contrary. If detained at port of shipment pending further instructions, the following charges will be levied to cover extra handling and storage at Lourenço Marques and Point:—

(1) Grain awaiting shipment	21 consecutive days' free storage, and thereafter to be charged at the rate of 3d. per ton per diem.
(2) Grain which has been rejected as wet, weevily, mouldy, or on any other account, and is not shipped.	7 consecutive days' free storage, and thereafter charged at 3d. per ton per diem.

(3) Grain which has been rejected as wet, or on any other account, and is subsequently treated and rendered fit for shipment and is actually shipped	Same terms as No. 1.

(4) Any additional handling performed by the Administration to be charged at actual cost of labour and supervision plus 10 per cent.

Fractions of a ton to be reckoned as 1 ton.

Fractions of a day to be reckoned as 1 day.

(5) On all other cargo received from up-country by rail and *bona fide* for shipment, when storage accommodation is available.	7 days' free storage, and thereafter to be charged at the ordinary Harbour Tariff rates.

40. Particulars of sailings of vessels available for this traffic can be had on application to Headquarters Offices, Johannesburg.

41. The Administration does not now sell bags to the farming community.

42. (*a*) In all cases bags of not less weight than 2½ lbs., new and double sewn, *must* be used, and consignors dispatching grain for export *must* endorse the consignment note to the effect that the whole parcel of grain is *double sewn and packed in new 2½-lb. bags.* The staff handling this traffic must inspect the consignments frequently during loading into trucks, to ensure the bags being in accordance with these regulations.

(*b*) From and after 1 July, 1911, "A" quality twill bags, 8 porter, 8 shot, of not less weight than 2½ lbs., new and double sewn, have been insisted upon.

Note.—The weight of bags used for oats may be 2¼ lbs., but the bags must in all other respects conform to the terms of this regulation.

43. To prevent any misunderstanding with the public, the definition "double sewn" is that the mouth of the bag must be sewn with double thread first one way across and then in the reverse direction, the result being a line of xxxxxx composed of thread across the closed bag. *No "lugs" or "ears" should be made on the bags.* (This latter stipulation has since been made optional.)

No marks of any description to be placed by senders on the mouth of bag.

44. A register of private marks on bags will be prepared if senders will forward their proposed mark. Private marks should be of simple design, a square, circle, diamond, or other geometrical figure, with the initials or code word of owner and station code mark from which goods are forwarded.

45. Consignments are limited to a minimum of 10 tons of one kind of grain. Under Scheme A the Administration is prepared to accept smaller consignments and store them, free of charge, until such time as the 10-ton minimum can be made up either by original sender or by combining several small consignments to make up the 10-ton minimum. Station masters who think that small consignments are likely to remain on hand over a week under this arrangement must immediately telegraph to this office for instructions *re* forwarding. This arrangement is purely for senders' convenience and entirely at their risk, and its acceptance should be specially endorsed on the consignment note.

46. Every assistance practicable must be rendered by the station staff, but senders must perform the loading themselves. Station masters should ascertain as far as possible beforehand when consignments are likely to come forward, so that truckage may be arranged, and double handling and storage at stations avoided as far as possible.

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47. Only clean trucks, or those not likely to stain or taint the grain, must be used.

48. All grain for export must be loaded properly, the loading to be in rows and tiers, according to the particular class of truck utilized. This will facilitate checking the numerical quantity of bags by the staff.

49. (*a*) No export grain should be dispatched from stations and sidings unless the trucks be properly and securely sheeted to prevent wet and consequent danger of heating of the grain. All open trucks should be double sheeted, and roofed cattle trucks single sheeted. Windows of cattle trucks must be securely closed, to remain thus throughout the journey. Consignments loaded in open trucks should be "ridged" to prevent sagging of sheets, accumulation of water, its subsequent percolation, and damage to the consignment.

(*b*) Sending stations having an insufficient supply of tarpaulins should send special advice to the nearest depot station requesting trucks to be sheeted when en route to destination.

50. All the special rates which have been quoted for oversea export trade are owner's risk.

51. Although all the special export rates quoted herein are owner's risk, the Administration will accept responsibility for numerical shortage on grain export traffic loaded at stations where staff is available, at an extra charge of 1d. per bag. Consignors desirous of taking advantage hereof must endorse the consignment note, "Administration to accept responsibilty for numerical shortage". Stations must enter up these extra charges separately on the invoice, and give the "numerically checked" receipt.

52. The attention of station masters and others is specially directed to the fact that serious exception will be taken if bags of grain should arrive at the port dirty, soiled with coal dust, or droppings, etc., of animals, or stained with oils, such as paraffin, etc., owing to the unclean state of the truck prior to loading the grain. Particular care must be exercised as regards the cleanliness of the trucks when loading grain for transport.

Should any carelessness in this respect on the part of the staff be brought to light suitable notice will be taken.

53. (*a*) Stations must not certify as to the "quality" of the grain when giving sender's receipts for consignments.

(*b*) Seeing that the duplicate consignment note is commonly utilized by the mercantile community in its banking transactions, care must be taken when receipting to also date and stamp the duplicate consignment note with the station rubber stamp, as well as endorse whenever possible the truck number in which the consignment is loaded.

54. Samples of grain dispatched by the Agricultural Department to stations for the purpose of exhibiting grades will be conveyed "O.R.S.". Cartage, when performed, should be debited to the Agricultural Department.

55. No export maize or kaffir corn traffic must be accepted if the bags weigh more than 208 lbs. gross. Test weighing on the station scales should be made from time to time during the loading of the consignment.

56. (*a*) Maize for two different consignees or of two different classes should not be loaded in the same truck, but when this is unavoidable, each class and consignment must be loaded separately and truck labels endorsed showing position.

(*b*) Consignment notes should be endorsed that the grain is thoroughly ripe and dry, and should also state the class of grain and number of bags of each class, i.e. *Hickory King*, *Iowa Silver-mine*, white (round or flat), yellow (round or flat), red, mixed, or any other class, and should also furnish the year it was reaped, i.e. "Reaped, 1912" or "Reaped, 1913," as the case may be.

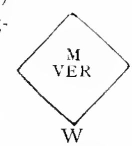
(*c*) All invoices for this traffic must show the number of bags of each class of grain, i.e. *Hickory King*, *Iowa Silver-mine*, white (round or flat), yellow (round or flat), red, mixed, or any other class and be endorsed with the remark "Reaped, 1912" or "Reaped, 1913," as the case may be. CHAP. XII.

57. The special rates which are in operation for export traffic are only applicable to South African products sent for export beyond South Africa (excluding Portuguese East Africa).

58. The name or private code of sender, with name of station dispatched from, as well as a letter indicating the class of grain, must be shown on the bags.

W will indicate White	Maize.	P will indicate Pink	Kaffir Corn.
Y ,, ,, Yellow		W ,, ,, White	
M ,, ,, Mixed		M ,, ,, Mixed	
		J ,, ,, Jiba	

Example.—A bag of white maize, say, from Morris, Vereeniging, would be marked . . . .



59. (*a*) To facilitate handling at ports and to provide space for the addition of the Government grading brand, the consignor must place his private marks in the *centre of the sack*.

(*b*) No senders' marks are to be placed at or near the mouth of bags, as this part is wholly required for the grade and port marks.

60. The following colours have been adopted at the several ports of shipment for indicating the port marks:—

Cape Town—Table Bay Docks	Green.
Delagoa Bay	Yellow.
Durban—Point	Black.
East London—Buffalo Harbour	Blue.
Port Elizabeth—Algoa Bay	Red.

61. To reduce the number of marks on the bags the following is a list of code letters which have been adopted by the Conference Lines for oversea ports, and consignors should, whenever possible, endeavour to make their code and shipping mark as one leading mark:—

Antwerp	A	Hamburg	H
Amsterdam	AM	Havre	HE
Belfast	BT	Hull	HL
Bremen	BN	Las Palmas	LP
Bristol	BL	Leith	LH
Cardiff	CF	Liverpool	LL
Cherbourg	CG	London	L
Christiania	CA	Madeira	M
Copenhagen	C	Middlesbrough	MB
Cork	CK	Portsmouth	PM
Dundee	DD	Rotterdam	R
Dunkirk	D	Southampton	S
Falmouth	F	Swansea	SA
Glasgow	G	Waterford	W

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62. (*a*) All maize and kaffir corn (including jiba) for export will be graded by the Government grading officer at port of shipment.

(*b*) Each bag will be Government marked according to grade, if to standard. Every bag will be examined before a certificate is granted in respect of any consignment.

(*c*) The classes will be as follows:—

Maize.	Kaffir Corn.
(*a*) White Flat.	(*a*) White.
(*b*) White Round.	(*b*) Pink.
(*c*) Yellow Flat.	(*c*) Mixed.
(*d*) Yellow Round.	(*d*) Jiba (or jhiba).
(*e*) Round Mixed.	
(*f*) Flat Mixed.	

(*d*) All grain not coming up to standard will be Government marked "No Grade" except in such cases as are referred to in paragraphs 62 (*g*) and 63.

(*e*) Weevily grain and wet grain which has been dried to the satisfaction of the grader will be permitted export under Government supervision, but will be granted a special form of certificate, which will be marked "weevily" or "wet maize dried to the satisfaction of the grader," as the case may be; provided also that no consignment of weevily maize be shipped in the same hold of a vessel carrying sound grain.

(*f*) The charge for grading is ½d. per bag.

(*g*) All grain rejected by the grader shall be removed from the wharf sheds not later than the fourth day after such rejection; provided that grain rejected on account of dampness may be dried by the consignee on premises to be provided by himself and at his own expense, and again offered for inspection within one month from date of rejection. Such grain will, if dried to the satisfaction of the grader, and tendered for export in the name of the original consignee who received the wet grain now dried, be allowed export under Government supervision, with a special certificate as provided for in clause (*e*).

63. (*a*) All grain rejected by the Government grader at the ports as unripe or mouldy is to be charged at full ordinary rates, and no reduction of railage will be afterwards granted, even if the grain be subsequently exported.

(*b*) Export of unripe or mouldy grain will not be allowed under Government supervision; and any exported must be charged ordinary railage rates.

64. Weevily grain stored in the sheds awaiting shipment will be charged the same storage charges as good grain. Additional haulage and handling charges will have to be paid. A cleansing fee of 6d. per short, and 1s. per 6- or 8-wheeled vehicle must be entered up, in addition to other charges.

65. (*a*) To further facilitate the simplification of marks appearing on the bags of maize shipped to oversea markets, it has been decided to indicate the various grades and sub-divisions thereof by running numbers from 1 to 12, such numbers being stencilled in red and placed in a circle on the upper side of the mouth of the bag:—

Flat White	No. 1	1
,, ,,	No. 2	2
,, ,,	No. 3	3
,, Yellow		4
Round White		5

Round Yellow	6
Flat Mixed	7
Round ,,	8
No Grade	9

(*b*) Bags containing kaffir corn will be similarly dealt with, and the marks are as follows :—

White	K1
Pink	K2
Mixed	K3
No Grade	K4
Jiba (or jhiba)	J

66. The consignee must in all cases be held responsible for the extra charges on any rejected grain or its products which have originally been charged at the export rate.

SECTION II.

Export of Grain Products Oversea.

1. Maize and kaffir corn consigned from inland stations (including stations on the Vryburg-Bulawayo section) to be milled in transit or at the ports, and exported beyond South Africa, will be carried at the rates referred to in paragraph 4 of Section I of this Notice, and subject to all the conditions given in the "General" section thereof, plus 10s. per short truck (20s. per bogie vehicle), plus ordinary charges for any services such as off-loading, cartage, etc., at the station where the grain is milled.

(*A*) *Where Milling is Performed at an Intermediate Station on the Direct Route, Prior to Export.*

2. Forwarding stations will invoice the traffic at the export rate plus 10s. per short truck (20s. per bogie vehicle), paid or to pay, as the case may be, direct to the port from which shipment will be effected.

3. (*a*) In addition to this it will be necessary for forwarding stations to render a memo. invoice to intermediate station at which the grain is to be milled, giving full particulars *and reference to entry to port.*

(*b*) When all charges are to be paid at the milling centre, sending station will invoice consignment "charges paid" direct to the port and obtain credit by recharge entry to the intermediate station.

4. When the manufactured product is forwarded to the port, the intermediate station will issue a memo. invoice to cover the consignment, giving full particulars *and reference to charges entry* from original forwarding station. (This reference will be obtainable from latter station's memo. invoice to the intermediate station.)

5. Should any charges be incurred at the intermediate station in respect to off-loading, cartage, or any other services, the charges should be raised at the intermediate station, clearance being effected by recharge on the destination station except when payment is made at the milling centre. Reference to charges entry from original forwarding station must be shown.

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(B) *Where Milling is Performed at a Station off the Direct Route, Prior to Export.*

6. Forwarding stations will invoice the traffic at the export rate plus 10s. per short truck (20s. per bogie vehicle), paid or to pay, as the case may be, direct to the port from which shipment will be effected.

7. When all charges are to be paid at the milling centre, sending station will invoice consignment to milling point, showing charges referred to in paragraph 6 as a "paid on" and add charges at Rate 15 for *total* mileage travelled off direct route to port, plus sidings charges where leviable, for *both* inward and outward services at milling station.

8. When charges are to be collected at port of shipment, entry to milling station must show the local charges as "Paid," and forwarding station will obtain credit by including recharge on entry to port.

9. No higher charge is, however, made than the local rate for haulage from the station of origin to the station at which the grain is milled, plus the export rate from the latter point in addition to the other charges referred to in paragraphs 6, 7, and 12.

10. In addition to this, it will be necessary for the forwarding station to render a memo. invoice to the intermediate station at which the grain is to be milled, giving full particulars and *reference to entry to port.*

11. When the manufactured product is forwarded to the port the intermediate station will issue a memo. invoice to cover the consignment, giving particulars and reference to charges entry from original forwarding station. (This reference will be obtainable from latter station's memo. invoice to the intermediate station.)

12. Should any charges be incurred at the intermediate station in respect of off-loading, cartage, or any other services, the charges should be raised at the intermediate station, clearance being effected by recharge on the destination station except when payment is made at the milling station.

(C) *Where Milling is Performed at a Station on an Alternative Route, Prior to Export.*

13. Forwarding stations will observe the instructions laid down in paragraphs 2 to 5.

14. When alternative routes are available traffic must, generally speaking, be forwarded via the shorter, but should the consignor elect to have the consignment milled in transit at a station on a longer route the difference in the through mileage between the longer and shorter routes must be charged for at local rates in addition to the charges referred to in paragraph 13.

General Instructions.

15. Grain ground into meal for cattle-feeding purposes loses no weight, therefore coarse meal must be reconsigned from the mill in quantities equal to the weight of the grain received, but in the case of maize ground into meal for human consumption, approximately 8 per cent of the maize is lost in milling, and, therefore, for such meal, shippers cannot be called upon to export more than 92 per cent of the weight of maize received, but of course railage charges must be collected on the quantity of maize invoiced by forwarding station.

16. When the manufactured product is reconsigned from the mill, which must take place within twenty-eight days of the inwards arrival of the grain, consignors should be called upon to furnish a certificate, in writing, in the following form:—

I hereby certify that the............bags of meal for.................................
..................(state whether for cattle feeding or human consumption) consigned to..on behalf of.................
...............................to be exported beyond South Africa, are the total product of the........................bags of maize received from.............................
on..

17. In the case of grain consigned to be milled at Cape Town, Port Elizabeth, East London and Durban, and subsequently exported, the Goods Superintendent at the ports will advise the harbour officials of such consignments, so that in the event of the manufactured product being carted to the docks, the necessary steps to protect the revenue and collect the charges due may be taken by that Department.

18. Forwarding station must see that the labels on trucks containing weevily grain are distinctly marked as "WEEVILY MAIZE" or WEEVILY KAFFIR CORN," and the grain described as such on the consignment note, and that such grain is not loaded with other traffic. The staff at stations where weevily grain is transhipped must also see that such grain is not transhipped into trucks containing other traffic.

Trucks which have been used for the conveyance of weevily grain must be properly cleaned before again being utilized.

514. *American Railage Rates.*—The South African farmer grumbles against the Government, as much as the farmers of other countries, and has not been slow to lay the blame for grievances—actual or imaginary—to Government ownership of railways. He has even suggested that the reduced rates and other facilities for the export of maize were inadequate. Some experience of private ownership of railways in new and thinly populated countries like South Africa, leads us to the conclusion that the South African farmer is far better off than the farmers of most other countries, and that he will be well advised to cling tenaciously to the ownership and control of his own railroads. The South African export freight rate for maize compares favourably with the American through rate of 26 cents (1s. 1d.) per 200 lbs. from Chicago to Boston. The following figures are given by Bowman and Crossley (1):—

"Maize is usually shipped from terminal to terminal export markets. The freight varies according to the route and method of exportation. In 1909 the rate for corn by river from St. Louis to New Orleans was 10 cents per 100 lbs. Corn shipped from Chicago to New York by lake and canal cost in 1906 ·0551 cent per bushel, exclusive of Buffalo charges and transferring from lake steamer to canal boat. By lake and rail, ·02572 cents per bushel covered the entire cost of transportation, shipped by rail entirely cost ·0952 cent per bushel during the same year. A freight rate of 13 cents per

CHAP. XII. 100 lbs. is charged from Chicago to Boston. Twelve cents to Montreal, Quebec and Portland, 12 cents to Philadelphia and 11½ cents to Baltimore, Norfolk (Virginia) and Newport News."

515. *Amounts and Sources of Supply of South African Maize Exported*, 1906-12.—The following is an approximate summary of South African maize exports for the seven years ended 31 December, 1912. It is instructive to note that in the dry years of 1911-2 the Transvaal exports exceeded those of the Orange Free State:—

Table LXXIV.

MUID BAGS OF MAIZE EXPORTED OVERSEA FROM THE UNDER-MENTIONED UNION PROVINCES AND BRITISH SOUTH AFRICA CUSTOMS UNION STATES DURING THE TWELVE MONTHS ENDED 31 DECEMBER.[1]

31 Dec.	Transvaal.	Orange Free State and Basutoland.	Natal.	Cape Province and British Bechuana-land.	Origin not Speci-fied.	Total.
1906	3,716	not stated	not stated	not stated	—	3,716 [2]
1907	43,764	,,	,,	,,	—	428,663
1908	114,825	141,203	289,535	,,	428	545,991
1909	202,943	1,035,602	312,522	120	—	1,551,187
1910	759,830	802,149	192,026	6,203	—	1,760,208
1911	652,254	314,731	41,566	7,892	—	1,016,443
1912	444,756	323,991	63,954	140	—	832,742 [3]
Totals	2,222,088	2,617,676	899,603	14,355	428	6,138,950

516. *Details of Exports*, 1911 *and* 1912.—Although the season of 1912 was a poor one from the point of view of production, South Africa, nevertheless, managed to export over 1,000,000 muids (3,897,210 bushels) of maize, valued at

[1] The 1909, 1910, and 1911 returns are obtained from the Annual Report, Union Department of Agriculture, year ended 31 December, 1911.

[2] Probably incomplete, and mainly to other South African ports.

[3] This is lower than the total export for that year (as given in Table LXXV) by 140,756; the higher figure probably includes overland exports.

£518,690. In addition to this, she also exported maize products to the value of £73,458, making a grand total of 1,197,483 muids, of the declared value of £592,148. CHAP. XII.

Of these products maize meal was the largest and most valuable export, amounting to £51,302. It is instructive also to note (Table LXXV) that the manufacture of other maize products is developing, and now includes samp, corn-flour, maizena, starch, and hominy-chop. This last item is of growing importance. In 1911 over 75 per cent of the export of hominy-chop, which reached a total value of £20,000, was exported to Germany for stock-feeding, which is suggestive of possibilities to the British feeder.

It is instructive to note that, as buyers of South African maize, Australia comes first with 242,000 muids, and Germany and Belgium next, each taking over 204,000 muids, while the United Kingdom comes only fourth with 194,000 muids.

The following figures showing the export of maize and maize-meal in 1911 and 1912 are obtained from the *Seventh Annual Statement of the Trade and Shipping of the Union of South Africa*, 1912 :—

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TABLE LXXV.

EXPORT OF MAIZE AND MAIZE MEAL, 1911-12.

Country of Destination.	1911.		1912.	
	Quantity.	Value.	Quantity.	Value.
Maize—	Muids.	£	Muids.	£
United Kingdom . .	494,008	195,628	193,941	88,042
Ceylon	1	1	—	—
Australia . . .				
N.S. Wales . . .	—	—	185,675·79	81,179
Queensland . . .	2,971	891	37,918·7	16,250
S. Australia . . .	—	—	7,040	2,992
Victoria . . .	659	264	11,684	5,282
Total Australia .			242,318·49	
New Zealand . . .	—	—	2·5	5
British East Africa . .	5	3	1	1
St. Helena . . .	107	69	152	97
Belgium	344,833	126,759	204,787	94,043
Belgian Congo . .	—	—	10,574	5,215
Kerguelen Isles . .	—	—	4	2
Madagascar . . .	3	3	·5	—
Germany	136,375	54,509	204,861	93,724
German S.W. Africa .	15,018	6,219	3,130·5	1,956
Madeira	13,970	6,155	1,770	885
Portuguese E. Africa .	6,665·6	3,506	76,121·75	40,827
Portuguese W. Africa .	5	6	1,348	796
Canary Islands . .	18,140	8,661	24,843	12,189
Ships' Stores . . .	11·5	6	27·5	15
	1,032,772	402,680	963,882	443,500
S. and N.W. Rhodesia .	—	—	111,690	60,308
	1,032,772	402,680	1,075,572	503,808
Maize Meal—	Lbs.	£	Lbs.	£
West Australia . .	200	1	200	1
St. Helena . . .	360	2	—	—
Belgian Congo . .	224	3	942	13
Madagascar . . .	—	—	137,250	375
German S.W. Africa .	1,288,013	3,047	120,080	325
Portuguese E. Africa .	1,325,617	3,658	10,693,805	35,850
Ships' Stores . . .	10	—	—	—
	2,614,424	6,711	10,952,277	36,564
S. and N.W. Rhodesia .	—	—	14,026	62
	2,614,424	6,711	10,966,303	36,626
Corn-flour and Maizena—				
Belgian Congo . .	1,552	26	884	15
Madagascar . . .	26	—	—	—
German S.W. Africa .	900	19	800	15
Portuguese E. Africa .	1,170	10	120	1
Portuguese W. Africa .	80	2	—	—
Ships' Stores . . .	226	6	565	17
	3,954	63	2,369	48

TABLE LXXV (*continued*).

Country of Destination.	1911.		1912.	
	Quantity.	Value.	Quantity.	Value.
Samp—	Lbs.	£	Lbs.	£
Mauritius	—	—	200	1
German S.W. Africa	134,389	359	206,261	617
Portuguese E. Africa	—	—	370	1
Ships' Stores	50	—	—	—
	134,439	359	206,831	619
S. and N.W. Rhodesia	—	—	964	5
	134,439	359	207,795	624
Hominy Chop—				
United Kingdom	1,593,207	3,425	1,640,179	4,495
Germany	6,927,846	16,342	6,424,750	15,687
	8,521,053	19,767	8,064,929	20,182
Starch—				
United Kingdom	—	—	304,375	1,302
Exported by Southern and N. Western Rhodesia.				
Maize—	Muids.	£	Muids.	£
S. Rhodesia	41,362·75	16,878	6,796	6,694
N.W. Rhodesia	9,572	5,620	8,982	8,188
	50,934·75	22,498	15,778	14,882
Maize Meal—	Lbs.	£	Lbs.	£
S. Rhodesia	1,938,576	5,620	1,672,143	5,591
N.W. Rhodesia	2,345	1,896	9,124	9,085
	1,940,921	7,516	1,681,267	14,676
Summary—				
Maize	—	22,498	—	14,882
Maize-meal	—	7,516	—	14,676
		30,014		29,558

SUMMARY, 1912.

		Muids.		Value.
Union of South Africa—				
Maize		1,075,572		£503,808
Maize Meal		54,831		36,626
Samp		1,039		624
Corn-flour and Maizena		12		48
Hominy Chop		40,324		20,182
Starch		1,521		1,302
Total Maize Products		1,173,299		£562,590
S. and N.W. Rhodesia—				
Maize	15,778		£14,882	
Maize Meal	8,406		14,676	
		24,184		29,558
Total Maize Export from British S. Africa in 1912		1,197,483		£592,148
		Quantity.		Value.
Maize		1,091,350		£518,690
Maize Meal		63,237		51,302
Other Maize Products		42,896		22,156
		1,197,483		£592,148

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EXPORTS OF SOUTH AFRICAN MAIZE FOR FIVE YEARS.[1]

	Quantity. Lbs.	Quantity. Muids.	Value. £
1908	92,688,535	463,442	207,291
1909	302,102,606	1,510,513	650,940
1910	356,303,905	1,781,519	693,413
1911	206,554,439	1,032,772	402,680
1912	192,775,746	963,878	443,492

TABLE LXXVI.

GRADED MAIZE EXPORTS EX EACH PORT, 1911.

1911.	Durban. Muids.	Cape Town. Muids.	Algoa Bay. Muids.	East London. Muids.	Totals. Muids.
January	27,844	45,427	21,952	—	95,223
February	47,675	16,401	35,506	2,406	101,988
March	7,262	7,476	12,584	230	27,552
April	1,961	2,792	—	—	4,753
May	1,818	—	—	—	1,818
June	460	322	—	—	782
July	2,857	7,904	—	—	10,761
August	67,629	40,237	16,000	6,225	130,091
September	139,612	83,858	42,870	33,884	300,224
October	105,588	75,561	34,563	7,376	222,888
November	40,450	17,891	26,575	2,885	87,801
December	17,715	—	12,447	2,400	32,562
Totals, 1911	460,671	297,869	202,497	55,406	1,016,443
,, 1910	1,238,269	285,816	115,700	120,423	1,760,208
,, 1909	1,001,081	346,978	47,919	155,209	1,551,187

	Transvaal.	O.F.S. and Basutoland.	Natal.	Cape and British Bechuanaland.	Totals.
Totals, 1911	652,254	314,731	41,566	7,892	1,016,443
,, 1910	759,830	802,149	192,026	6,203	1,760,208
,, 1909	202,943	1,035,602	312,522	120	1,551,187

[1] These figures do not quite agree with the totals, also from official sources, in Table LXXX, but a competent statistician would be required to go into them fully and explain the difference.

517. *Monthly Exports.*—The following table (LXXVII) shows in which months there is the largest movement in South African maize:— CHAP. XII.

TABLE LXXVII.

MONTHLY MAIZE EXPORTS FROM DURBAN, 1907-8.

Month.	1907.[1]		1908.			
			Maize.		Other Grain.	
	Quantity. Lbs.	Value. £	Quantity. Lbs.	Value. £	Quantity. Lbs.	Value. £
January .	610,337	2,039	9,698,234	19,326	182,594	1,222
February .	1,725,543	5,882	6,835,389	14,330	1,202,327	4,671
March . .	948,343	3,007	1,984,846	3,980	634,920	2,348
April . .	682,960	2,228	3,310,669	6,730	941,423	3,902
May . .	546,339	1,639	1,651,430	3,588	1,698,161	5,348
June . .	501,808	1,542	3,820,368	8,120	1,029,892	3,167
July . .	736,105	2,353	9,603,177	20,315	2,260,704	6,383
August . .	1,472,142	3,869	11,255,764	23,623	1,738,014	5,199
September .	1,578,911	3,965	7,352,950	17,590	1,739,305	5,665
October .	3,743,840	8,040	4,003,747	10,824	1,861,042	6,077
November .	3,712,225	8,528	1,767,666	5,105	1,070,530	3,785
December .	3,509,079	8,354	1,985,805	8,233	1,482,515	5,453
Total Lbs. .	19,767,632	51,446	63,270,045	141,764	15,851,427	53,220
,, Muids	98,838	—	316,350	—	79,257	—

518. *Destination of Maize Exported.*—The following table of official figures on the maize export of 1908 was prepared by the Natal Government Railways, and published by the *Press Agency*, in various South African papers, e.g. the *Sunday Times*, Johannesburg, 24 January, 1909. The total amount exported through Durban for the year was 545,991 muids, valued at £251,494, as compared with 428,663 muids in 1907, valued at £171,169. The increase amounted to 117,328 muids, valued at £80,325.

[1] N.B.—The figures for 1907 include all other sorts of grain and meal; in order to indicate the relative proportion which the latter occupy, their figures for 1908 are given alongside the maize figures for that year.

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TABLE LXXVIII.

RETURN OF MAIZE EXPORTED BY SEA FROM PORT NATAL DURING THE YEAR 1908.

Month.	United Kingdom.	Continent.	Canary Islands.	Australia.	Cape Colony.	Canada.	Delagoa Bay, etc.	Bombay.	Other Places.	Total.	Value.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	£
January	4,649,292	3,889,630	590,000	1,356,778	2,097,430	—	4,000	—	—	12,587,230	26,978
February	7,304,171	7,350,349	854,200	—	1,525,900	—	200 Inhambane	—	—	17,034,620	35,849
March	842,637	2,330,635	—	—	3,377,400	—	—	—	—	6,550,872	14,518
April	246,400	883,310	—	—	2,025,729	—	—	104,560	—	3,259,999	7,703
May	250,800	53,400	—	—	1,400,690	—	—	—	—	1,704,800	4,003
June	267,865	1,926,936	—	419,800	3,545,782	—	—	—	—	6,160,383	13,961
July	246,730	5,211,656	221,070	1,535,156	3,094,378	—	—	—	—	12,308,990	28,011
August	3,202,390	9,149,166	559,800	—	5,830,651	—	—	—	—	18,742,007	43,654
September	3,353,924	12,393,827	711,000	—	2,259,305	483,542	5,000 Beira	—	—	19,408,598	44,500
October	747,632	2,464,635	—	—	2,036,741	—	—	—	8,615	5,257,623	13,278
November	292,150	—	—	65,600	4,512,269	—	—	—	8,830	4,878,849	14,104
December	4,900	—	—	—	1,259,404	—	40,000 Rhodesia	—	—	1,304,304	5,035
Total, 1908	21,408,891	45,855,644	2,936,070	3,377,334	34,965,689	483,542	49,200	104,560	17,445	109,198,275 (545,991 muids).	251,494

TABLE LXXIX.

DESTINATION OF MAIZE EXPORTED, 1911.

Destination.	Durban. Muids.	Cape Town. Muids.	Algoa Bay. Muids.	East London. Muids.	Totals. Muids.
Antwerp	99,890	111,326	125,804	—	337,020
Hamburg	61,395	16,367	19,162	35,572	132,496
London	229,265	106,256	57,531	19,834	412,886
Liverpool	5,639	—	—	—	5,639
Southampton	—	1,351	—	—	1,351
Belfast	—	3,501	—	—	3,501
Glasgow	—	43,876	—	—	43,876
Canaries	30,487	—	—	—	30,487
German West Africa	—	15,192	—	—	15,192
Inter-colonial	33,995	—	—	—	33,995
Totals, 1911	460,671	297,869	202,497	55,406	1,016,443

519. *South African Ports of Export.*—Durban is the principal maize-exporting port of South Africa, for her geographical position with regard to the Maize-belt gives her an advantage, of which her enterprising merchants and energetic Harbour Board have made good use. The tonnage sent through this port in 1907, 1908, and 1909 is given by Downie (2) as follows:—

	Tons.	Bags.	Bushels.
1907	51,746	517,460	1,724,870
1908	54,579	545,790	1,819,971
1909	102,280	1,022,800	3,409,336

In 1909 the amount was approximately two-thirds of the total amount of maize exported from British South Africa, the remaining third was shipped through East London, Port Elizabeth, and Cape Town. Practically none was sent through Delagoa Bay.

Durban merchants claim the following advantages for their port:—

(1) It is the nearest port to almost all the best maize districts.

(2) The grain, therefore, has the shortest time on rail, with less risk of loss in weight and damage through heating, weevil, etc.

(3) Speedier realization and quicker returns.

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(4) Storage under covered sheds.

(5) No other port offers the same facilities for quick shipment. It is the starting-point for all the regular liners; a direct service to London is given by two steamship companies.

(6) The more expeditious the shipment, the less risk of grain getting out of condition before shipment.

(7) Durban is the largest market for the export trade.

(8) It is also the largest local market, possessing an increasing number of mills and factories, and grain which is not exported has a better chance for local disposal, at better prices.

Table LXXX, obtained from official documents, shows the relative quantities exported through the several ports in 1912. The figures in this table must be approximate only, as the total does not quite agree with the export total given in the *Annual Statement of the Trade and Shipping of the Union of South Africa*, for 1912.

TABLE LXXX.

AMOUNTS OF MAIZE EXPORTED THROUGH THE SEVERAL PORTS, 1912.

	Maize.		Maize Meal.		Total Value.
	Muids.	£	Lbs.	£	£
Cape Town	296,419	128,032	114,950	306	128,338
Port Elizabeth	30,537	13,642	—	—	13,642
East London	16,771	6,918	—	—	6,918
Durban	536,392	250,461	7,910	35	250,496
Other Union Ports	11,474	5,678	60	1	5,679
Delagoa Bay	72,283	38,761	10,828,251	36,206	74,967
Beira Feira and Overland	9,718	9,034	2,729,487	12,083	21,117
Total	973,597	452,526	13,680,658	48,631	501,157

Lourenço Marques, though the nearest port to the Central Transvaal, has taken very little maize for export. East London and Port Elizabeth have taken some of the crop, and have been found useful outlets when Durban was congested. Cape Town, being farthest removed from the producing centres,

TABLE LXXXI.

VARIETIES AND CLASSES OF MAIZE EXPORTED FROM SOUTH AFRICA, 1911 (IN MUIDS).

Origin and Port of Export.	Flat—White.			Flat—Yellow.		Round—White.		Round—Yellow.		Flat—Mixed.	Round—Mixed	Below Grade.	Total.
	1	2	3	4	5	6	7	8	9	10	11	12	
Transvaal	25,470	564,196	11,945	1,298	14,051	1,060	2,766	2,976	21,485	1,789	1,561	3,657	652,254
Orange Free State	8,624	160,121	7,721	88	6,959	—	3,068	1,382	108,793	1,493	11,210	5,272	314,731
Natal	18,070	15,409	174	—	5,294	—	—	—	2,462	13	135	9	41,566
Cape Province	—	7,330	—	—	—	—	—	—	299	16	247	—	7,892
Totals	52,164	747,056	19,840	1,386	26,304	1,060	5,834	4,358	133,039	3,311	13,153	8,938	1,016,443
Durban	28,864	300,068	7,291	176	15,993	—	329	1,172	92,139	537	8,153	5,949	460,671
Cape Town	21,979	218,047	11,704	817	7,239	1,060	2,744	2,910	26,359	1,010	1,568	2,432	297,869
Algoa Bay	1,321	176,990	—	—	2,230	—	2,367	276	14,340	1,656	3,317	—	202,497
East London	—	51,951	845	393	842	—	394	—	201	108	115	557	55,406
Totals	52,164	747,056	19,840	1,386	26,304	1,060	5,834	4,358	133,039	3,311	13,153	8,938	1,016,443

SUMMARY.

	Muids.	Per Cent.
Flat White	819,060	80·5
Flat Yellow	27,690	2·7
Round White	6,894	·7
Round Yellow	137,397	13·5
Flat Mixed	3,311	·3
Round Mixed	13,153	1·3
Below Grade	8,938	·9
Total	1,016,443	99·9

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has in previous years received little attention from exporters, but now that the export railage rate has been made uniform to all the ports, Cape Town is worth consideration, because of her dry summer climate, which should tend to check the development of weevil and grain moth, and to reduce the percentage of moisture absorbed by the grain, thus making her an especially good summer port of export. Beira is the port for Rhodesia.

520. *Varieties and Classes of Maize Exported.*—Of the 1,000,000 muids exported by South Africa in 1911, 80½ per cent consisted of the three grades of flat white (73·5 per cent was No. 2 grade and 5·1 per cent was No. 1), and 13½ per cent of round yellow. The balance was made up in the following order: flat yellow, 2·7 per cent; round mixed, 1·3 per cent; below grade, ·9 per cent; round white, ·7 per cent; and flat mixed, ·3 per cent. The details are given in Table LXXXI.

521. *Grading at the Ports.*—Graders are established at each of the exporting ports, and are under the direction and control of the Chief Inspector of Grain of the Union Department of Agriculture; all grain exported must pass through their hands. Brown-Duvel moisture testers are placed in their offices and have proved of inestimable value in determining the moisture-content of the grain offered for export. During the season 1911, 147,302 bags of maize were rejected at the ports as wet or mouldy. It is found that maize railed from the interior Provinces in a wet condition is usually more or less musty on arrival at Cape ports, whilst wet maize railed to Durban does not have time to become musty, owing to the shorter railway journey. Warnings against sending wet maize to the ports are issued in all the leading South African newspapers and journals. The Annual Maize Committee (1911) recommended that the Government should discourage the export of kiln-dried maize, and the Regulations were accordingly amended.

522. *Effect of Grading at the Ports.*—The grading regulations enforced at the South African ports during the season 1912-13 gave great satisfaction in the English market, and the writer was urged by merchants on the Baltic, Mark Lane, and Liverpool Exchanges to impress upon the Government the importance of not relaxing these regulations one jot.

It is satisfactory to note that no complaints from Europe were received by the Department of Agriculture during the CHAP. XII.

FIG. 192.—Grading maize for shipment, Durban.

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TABLE LXXXII.

MAIZE REJECTED BY GRADERS, 1911.

	Wet.	Mouldy.	Weevily.
	Muids.	Muids.	Muids.
Durban	67,340	4,319	7,617
Cape Town	46,115	10,764	124
Algoa Bay	6,136	8,404	—
East London	2,121	2,103	1,124
Totals, 1911	121,712	25,590	8,865

VARIOUS SHIPPED WEEVILY OR RE-DRIED.

From	Weevily.	Re-dried.	Kaffir corn.	Oats.	Chop.
	Muids.	Muids.	Muids.	Muids.	Muids.
Durban	—	13,665	—	—	39,758
Cape Town	—	18,789	—	13,121	300
Algoa Bay	—	—	—	—	—
East London	709	1,903	110	—	—
Totals, 1911	709	34,357	110	13,121	40,058

year 1911, in respect of any consignment of grain exported under Government supervision.

523. *Description of Grades.*—The Annual Maize Committee (¶ 506) of 1910 adopted a schedule of twelve grades for maize, but the 1911 Committee, sitting at Cape Town on 24 April, considered it desirable to abolish the No. 1 grades for Flat Yellow, Round White, and Round Yellow, thus reducing the grades to nine.[1] This was agreed to by the Government, the change published by Government Notice No. 196, of 10 February, 1912, reading as follows:—

With reference to Government Notice No. 964, of the 8 June, 1911, in regard to the grading of maize, kaffir corn, and jiba intended for export from South Africa, the Right Honourable the Minister of Agriculture has been pleased to approve of the deletion of clause *twelve* thereof, and to substitute therefor the following. This alteration to have force and effect on and after 1 May, 1912:—

[1] These could be still further reduced by combining F.W.3, R.W., F.M. and R.M. in one grade, to be called either "Mixed" or "Maize".

12. The following shall be the classes for grading :— CHAP. XII.

MAIZE GRADES.

Grade Mark to be Shown on Bags.	Class.	Description.
1	F.W. 1	To be sound, dry, plump, and well cleaned, with a maximum of together 1 per cent of yellow, discoloured or defective grain.
2	F.W. 2	To be sound, dry, and reasonably cleaned, and not containing more than 3 per cent of defective grain and 5 per cent of other coloured grain.
3	F.W. 3	To be sound, dry, and reasonably cleaned, and not containing more than 8 per cent of defective grain and 5 per cent of other coloured grain. Berries may be of irregular size and shape.
4	F.Y.	To be sound, dry, and reasonably cleaned, and not containing more than 4 per cent of defective grain and 5 per cent of other coloured grain. Berries may be of irregular size.
5	R.W.	To be sound, dry, and reasonably cleaned, and not containing more than 4 per cent of defective grain and 5 per cent of other coloured grain. Berries may be of irregular size.
6	R.Y.	To be sound, dry, and reasonably cleaned, and not containing more than 4 per cent of defective grain and 5 per cent of other coloured grain. Berries may be of irregular size.
7	F.M.	To be sound, dry, and reasonably cleaned, and not containing more than 10 per cent of defective grain.
8	R.M.	To be sound, dry, and reasonably cleaned, and not containing more than 10 per cent of defective grain.
9	No Grade	To include all maize which cannot be classed in a higher grade but in a dry condition and fit for shipment.

524. *Grader's Certificate.*—The following is the form of certificate recommended by the Maize Committee :—

UNION OF SOUTH AFRICA.

DEPARTMENT OF AGRICULTURE.

OFFICE OF THE GRADER OF GRAIN,

....

.... 19 ....

Grain Certificate No..........

I hereby certify that the grain described hereunder has been duly examined by me and found to be in sound condition and equal to the standard herein set forth, and is contained in bags in accordance with Government regulations.

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Shipment per s.s. ...

Consigned to port of ...

Consignor ...

Number of bags ...

Condition of bags ...

Shipping marks ...

Class and grade ...

Grade mark shown on bags ...

Remarks ...

This certificate is issued by the Government of the Union of South Africa without involving any responsibility whatever on the part of the said Government.

...

Government Grader.

...

Chief Inspector of Grain.

525. *Weevily Maize.*—The Maize Committee (1911) recommended, and the Government approved, that in the event of grain developing weevil after it has been graded, the consignee shall, upon receipt of notice thereof from the grader, remove the same forthwith; this stipulation has been embodied in the grading regulations.

526. *Removal of Rejected Maize at Ports.*—A regulation was promulgated by the Railway Administration, in 1911, to the effect that all grain rejected by the grader shall be removed from the wharf sheds not later than the fourth day after such rejection, but consignees were allowed to dry wet maize on premises provided by themselves, and to again tender same to the grader, for export.

527. *Re-bagging.*—The Annual Maize Committee (1911) resolved that if a consignment arrives at a port, and the grader cannot pass the bags, the consignee shall be permitted to re-bag; this was accepted by the Government, and the necessary instructions were issued to the graders.

528. *Marking Grades on Bags.*—In the season of 1910 there was some complaint about the ink used for marking grades on bags; a new ink was introduced in 1911, which seems to be satisfactory, no complaints having reached the Department during that year.

529. *Uniformity in Practice of Handling and Storing at Wharves.*—At the time when the export trade was inaugur-

ated, different methods of handling and storing grain were in vogue at the several ports, as they were not then administered by one central authority. Uniform methods and charges for handling and storing grain in the wharf sheds at the different ports have now been instituted.

530. *Bag Handling of Grain.*—The South African grain crop is entirely handled in bags, so also is the Australian wheat crop and that from the Pacific States of North America (California, Oregon and Washington), as well as part of the wheat and maize crops of Argentina.

The principal objections to bag handling are: (1) the cost of the bags; (2) the loss of time in handling the crop both at port of export and port of import; (3) greater storage space required. On the other hand, small parcels of bagged grain of different grades can be carried in any sort of railway truck and any type of vessel, whereas bulk handling limits the type of truck.

Much dissatisfaction exists with regard to the bag grain trade of Argentina, and shipment in bulk seems to be on the increase.

In the case of "Choice" (No. 1) flat white maize, the European trade appears to think that as it is a special quality, commanding a special price, it would be well to continue to ship it in bags; as it comprises only about 5 per cent of the export, this might be done without difficulty.

531. *Quality of Grain Bags.*—It has been found necessary to regulate the size, weight, and quality of bags used for export. The Annual Maize Committee (1911) confirmed the decision previously arrived at, that maize intended for export oversea shall be contained in new bags, of 2½ lbs. weight, "A" quality twill, 8 porter, 8 shot; bags when filled must weigh 203 lbs. gross, and the mouths must be double sewn, i.e. with double thread, first one way across and then in the reverse direction. "Ears" on the bags are objected to; it is better to sew right across the bag from side to side.

The grain bags at present in use are made of jute and are obtained from India. Their manufacture is said to be largely in the hands of small makers, and the trade is "cut so fine," that it leaves but a small margin of profit to be divided between manufacturer and dealer. Cases have been reported

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where some unscrupulous manufacturer or oversea dealer has put lighter-weight bags in the centre of the bale, to the annoyance and loss of the farmer. The bags now in general use measure 44 × 26 or 27 inches, and cost about 40s. per 100 f.o.r. Durban, or 7d. each wholesale, and 9d. each retailed in small lots, in the interior. If not badly damaged, they sell on delivery in Europe for about 3½d. apiece. Some farmers and merchants have advocated the use of 3 lb. bags as more serviceable and more generally useful than the 2½ lbs. weight, but it is considered that the latter, if made of good quality twill, should be sufficiently serviceable. Some even advocate the use of 2¼ lb. bags on account of their lower cost, and the fact that they are used in the Argentine maize trade; the price paid in Argentina is said to be about 4d. wholesale, as compared with 5½d. wholesale at the coast, in South Africa, for the heavier bag; buyers would allow 2d. for these bags in England; the difference of 1½d. per muid or 3½d. per quarter, although in favour of the South African shipper, would not, it is believed, compensate for the loss and inconvenience entailed by the use of the lighter bag. H.B.M. Consul at Rosario, Argentina, reports that owing to the poor quality and irregular sizes of the bags used in the Argentine trade, a large quantity of grain is lost in handling, and that shippers of Argentine maize are endeavouring to arrange for the use of stronger bags of uniform size, recognizing that the saving of grain now lost, and the greater facility in handling and storing bags of uniform size, would more than compensate for the slight increase in cost.

At Bahia Blanca the bags on arrival are ripped open by men armed with sharp knives, the grain is poured into the ship's hold and the empty bags are returned.

For retail in Europe, bags of close, heavy twill, carrying 240 lbs. (half a "quarter") are used. These are returned to the wholesale merchant, by the buyer, or retained at a charge of 1s. 6d. each. It has been suggested that South Africa might ship in this half-quarter sack; but it is too expensive, the trade does not ask for it, and the 240 lbs. bag is too heavy to handle on the farm and at the store. It has even been suggested that 120 lbs. bags (quarter of a "quarter") should be used; but this would mean a higher total cost for bagging, and it would be inconvenient, as the South African unit of weight is the muid of 200 lbs. The muid bag of 203 lbs. gross (200 lbs. net) seems to be the most satisfactory, all things considered. CHAP. XII.

532. *Bulk Handling.*—The value of bulk over bag shipment appears to depend on three factors, viz.: (1) Saving in cost of bag charges to the farmer, inasmuch as he can use the same bags over again; (2) reduced cost of shipment, resulting in lower rates, due to saving of time at each end of the voyage, in loading and unloading the cargo; cargo entirely bulked does not fetch quite as much as a cargo in bags, but this is because the value of the bags is always calculated very carefully by importers in offering a price; bulk shipment undoubtedly facilitates the loading and unloading of the vessels; (3) greater uniformity in cargo, slight variations being evened up in the bulk.

Odessa, and other Russian and Danubian maize, is almost invariably shipped in bulk; so is North American. Argentine maize is shipped in three ways: in bulk, in bags, and sometimes part bulked and part bagged, but most of it is exported in bulk.

Sir Thomas Price found that the greater part of the European trade was in favour of bulk shipment from South Africa. The reasons advanced were: the greater expedition in discharging; lesser cost of handling; better arrangements for and accuracy in weighing; and the dislike there is in many quarters to a bag of a special description (such as that used by South Africa) which differs in size, and in fastening at the mouth, from the bags which are common in the grain trade at the ports of Great Britain and on the Continent.

Bulk shipment means the minimum of cost in handling, the cheapest transport, and, what is perhaps of most consequence, it ensures that the grain will be placed on the purchasing market according to sample. The conclusion arrived at by Sir Thomas Price is that "it would be an advantage to South Africa to ship in bulk, but before any decision is taken or expense incurred in making facilities for so doing, it would be well to ascertain whether the shipping companies would be prepared to ship in bulk, or whether the apparatus to be provided at the ports should be suitable for dealing with bags as well as bulk until such time as the steamship companies can be induced to resort to bulk loading, as is becom-

CHAP. XII. ing so increasingly the practice in practically all other parts of the world—that is, if the shipping companies insist upon carrying the grain in bags" (*Price*, 2). The question is one which should be decided as early as possible, before vested interests and outlay on rolling stock, warehouses, and machinery make it too expensive to change. There is no question that whichever system is finally adopted, a good deal of saving in time and expense can be effected as compared with that incurred by present methods. Economical handling must be adopted if a large export trade is to be built up.

533. *Time Saved by Bulk Handling.*—Bulk grain can be loaded in at most two-thirds of the time required for bagged grain. At Bahia Blanca it has been found that the capacity of the electric conveyors is 150 tons per hour of bulk grain, but only 100 tons per hour of bagged grain; at some ports the movement is said to be more rapid. This fact is of great importance in regulating the cost of export. If a ship takes six days to load and six to unload a cargo of bagged grain, instead of four days required for each operation of handling bulk grain, the extra cost to the shipping company, which is ultimately borne by the farmer, would be large.

534. *Saving in Cost by Bulk Handling.*—A competent authority, of many years' standing in the handling of maize shipments, calculates the saving to South Africa by bulking the maize cargoes, at £1,225 for every steamer of 6,000 tons capacity.

"Bulk grain is worked very much quicker in some places than is the case at Bahia Blanca, and it can, I am sure, be safely stated that as a rule it is done in *one-third* of the time that it takes for bagged grain, and therefore that saving, alone, at ports of shipment and discharge, would justify bulk shipments.

"Take a 6,000-ton capacity steamer. She would cost in port to her owners about £40 per diem and would save at the loading and discharging ports an aggregate of eight days with a bulk grain cargo, compared with a bag cargo, and with the extra cargo displacing the bags, say 56 tons, besides the reduced stevedoring cost at both ends, i.e. from 9d. with bags to 6d. with bulk, the aggregate monetary saving to her would approximate £500.

"Then South Africa's direct gain would be a saving on

the shipping expense of possibly 4d. per ton, equalling £100. CHAP. XII.
Also, in a 6,000-ton bulk cargo 16,000 bags would be sufficient for securing purposes, giving a saving of 50,000 bags which would in the case of bag cargoes be at least 3d. per bag lost to South Africa each voyage, whereas with bulk cargoes the same bags could be used over and over again. This item of loss could be safely stated at £625, giving a total of £725 as South Africa's direct gain or a total gain of £1,225 to work on for a cargo of 6,000 tons; and on that basis 100,000 tons shipped in bulk would mean that we were in a better position by £20,000, equalling 4s. per ton, to meet competition, etc."

As a result of his investigations in Europe and America, in 1911, Sir Thomas Price (2) found some diversity of opinion as to the aggregate saving by shipping in bulk, but he was inclined to accept the opinion of Hamburg merchants that it might be put at 5s. per ton, with no less price, but the possibility of obtaining a higher price, for the grain; this 5s. per ton would obviously go into the pockets of the producer of the grain. There can be no doubt, he adds, as to the greater expedition in handling, and that there would be a saving of at least half the cost of the new bag which is now used; and, if the worst comes to the worst in the matter of the price paid for exporting the grain, i.e. if South Africa had to pay more than 11s. 6d. per ton (which it should not have to do), this saving in the price of the bags, which should amount to at least 2s. 11d. per ton, and probably 3s. 4d. per ton, would be valuable.

535. *Accumulation and Storage at Inland Centres.*—The present method of handling grain in South Africa is not entirely satisfactory. Maize is indiscriminately forwarded by the farmer or storekeeper direct to the coast, whenever he so inclines, irrespective of shipping facilities. There it is warehoused to await arrival of the steamer; as there are no elevators, the bags of grain are stored in flat sheds, causing serious congestion of wharf accommodation. It is highly desirable that transit grain silos or warehouses should be erected at large inland collecting centres, as is done in Australia and the United States; then, when a sale was effected, particulars of the steamer and date of arrival at the port could be communicated to the railway administration, which could, if necessary, run special fast maize trains from the elevators direct to the port and

CHAP. XII. alongside the vessel, where the grain could be rapidly discharged into the hold by electric belt-conveyors. Such a system could be adapted to the handling of grain either bagged or in bulk.

In Australia and the Pacific Coast States of North America, where the wheat crop is bagged, the bags of grain are stacked in flat sheds at the railway stations awaiting truckage. Where the crop has exceeded the accommodation provided, as is likely to happen in years of exceptionally good harvests or where new ground is constantly being broken by the plough, it often

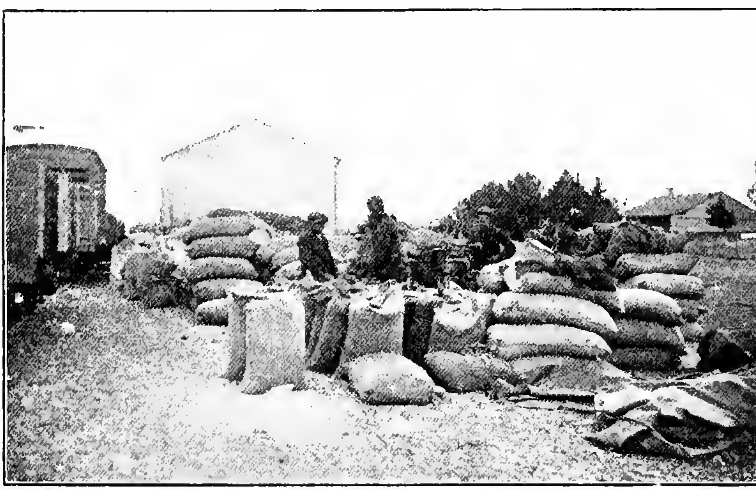

FIG. 193.—Re-bagging maize from small dealers, Vereeniging.

happens that the surplus sacks of grain must be stored outside the sheds, under tarpaulins.

536. *Transit Silos and Elevators.*—The growth of the *Elevator System* in the United States and Canada has been rapid; in 1901 the total capacity of the whole of the Chicago elevator warehouses was only 28,150,000 bushels (7,885,154 muids), while in 1910 it had increased to 58,945,000 bushels (16,371,150 muids) (*Downie*, 1). Now, the major portion of all grain handled in the United States and Canada is transported in bulk. At nearly all the important roadside stations in the Maize-belt, *transit warehouses and elevators* are placed, for storage purposes and to facilitate loading and off-loading;

at the more important of these stations there may be as many as a dozen such elevators. CHAP. XII.

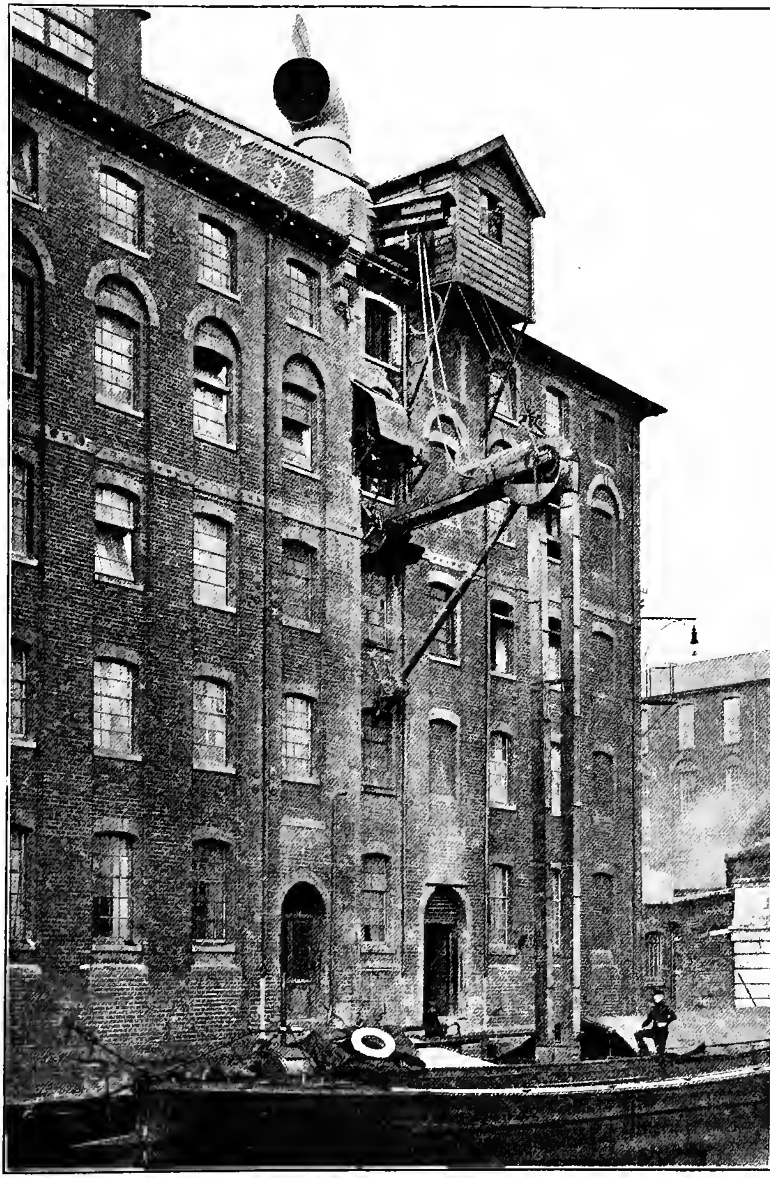

FIG. 194.—Granary and elevator.

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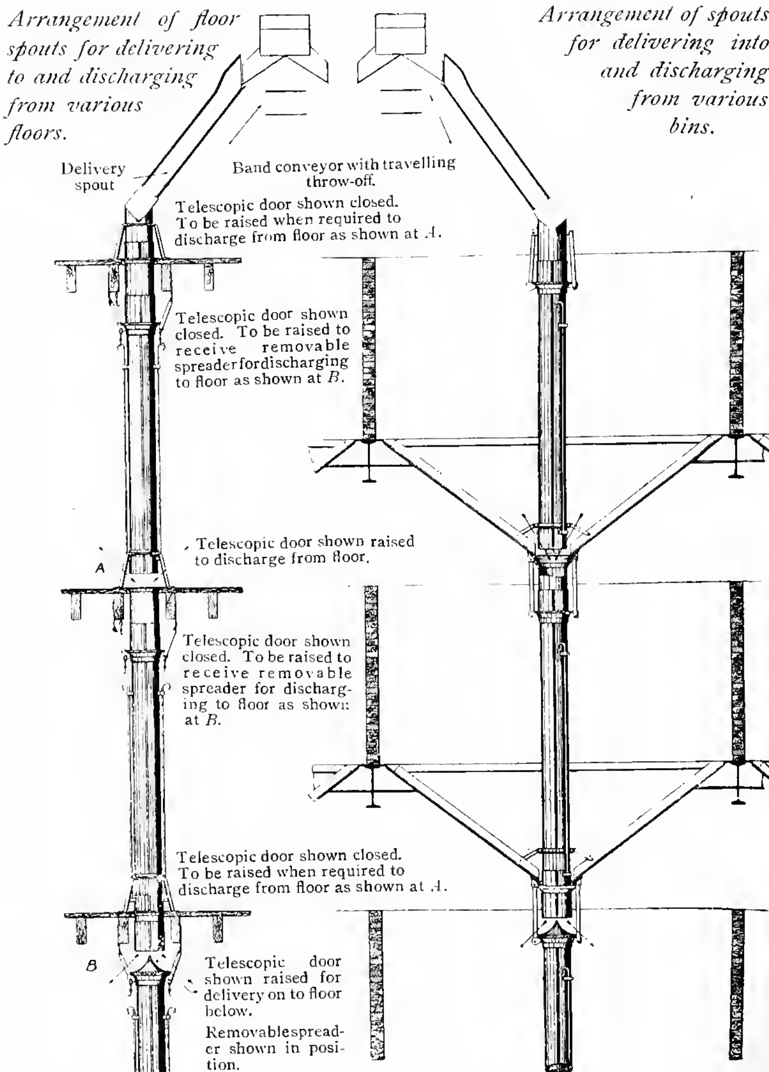

FIG. 195.—General arrangement of Spencer's improved system of granary floor spouts. (Courtesy of Messrs. Spencer & Co., Ltd., Melksham.)

The transit warehouses act as local collecting centres, from which the grain is dispatched in bulk to the large markets, where it is received into the larger *terminal silos*.

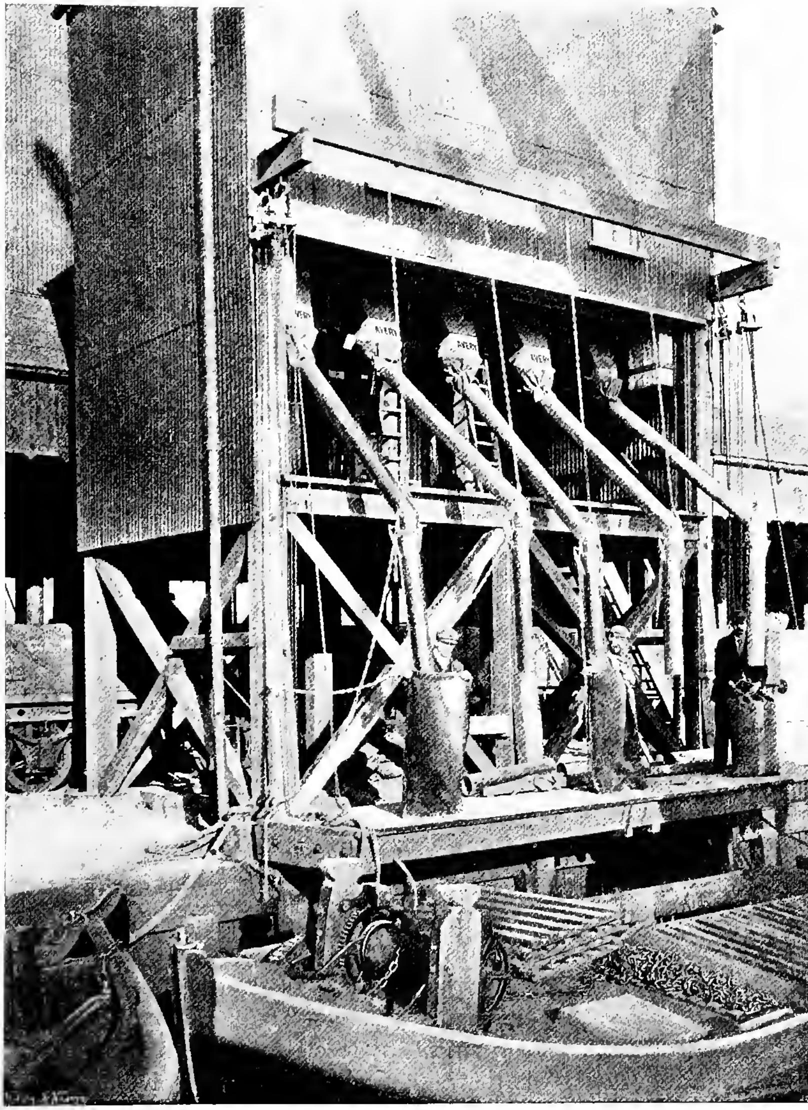

FIG. 196.—Automatic weighing and bagging off, from terminal silo, with Avery scales. (Courtesy of Messrs. W. T. Avery, Ltd., Birmingham.)

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537. *Payment to Farmers.*—In the United States it is customary to pay the farmer for his grain as soon as it has been delivered, weighed, classified and graded at the warehouse. The price paid is usually slightly below the ruling market rates. But the farmer is generally anxious to realize on his crop, as soon as it is threshed, so that he can pay his rent or other debts, or turn the money into stock for fattening. Immediate payment relieves him of much trouble and anxiety; as soon as he is paid, his control over the grain ceases (*Downie*).

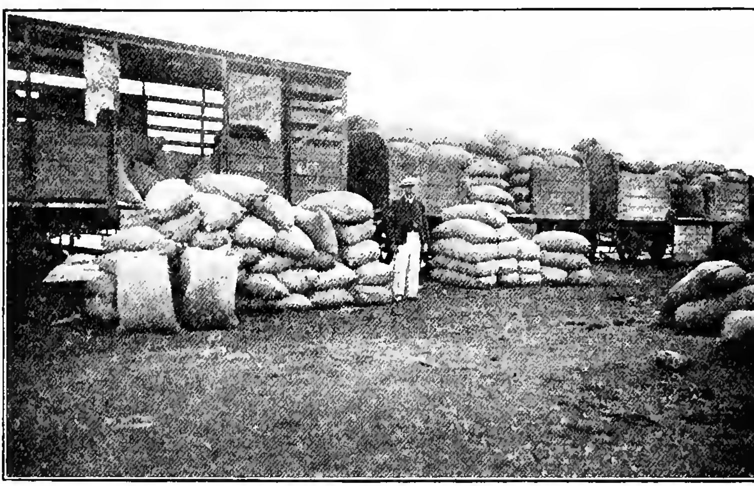

Fig. 197.—Loading trucks, Vereeniging.

538. *Trucking in Bags and in Bulk.*—The principal advantage of the bag system of handling grain is that it enables the railway administrations to turn to account their whole freight rolling-stock, to handle a rush of grain to the coast. For handling bagged grain any size or shape of truck can be used (Fig. 197), whereas a stock of special types of truck would be required to handle the bulk trade and thus involve a large additional capital outlay for rolling-stock. On the American railways covered box-trucks, specially designed for the purpose, are used for conveying grain in bulk. These vary in capacity from 20 to 50 tons (i.e. 200 to 500 bags). To fill a truck, the grain is drawn from the bottom of the elevator bin

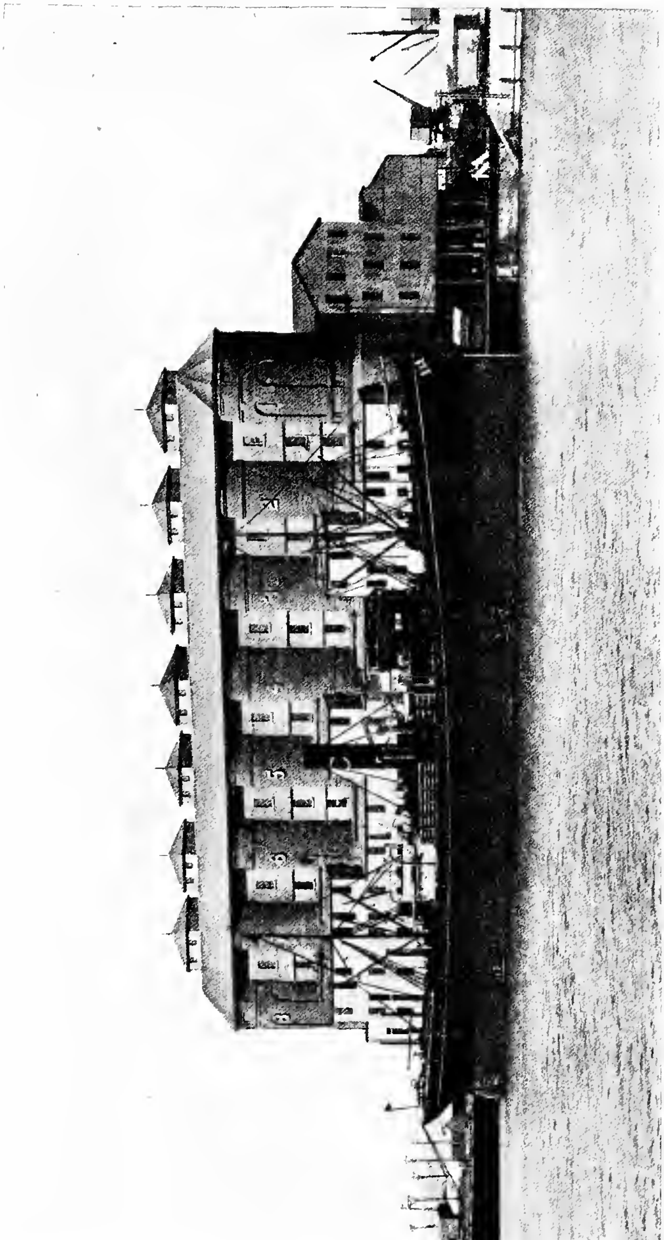

FIG. 198.—Grain silos at Puerto Galvan, Argentina. (Courtesy of Messrs. Henry Simon, Ltd.)

CHAP. XII. into the "boot," elevated to the top of the building, weighed in large hoppers, and then allowed to flow by gravity directly into the trucks.

539. *Storage at Ports of Export.*—In Argentina, at the port of Bahia Blanca, a large timber shed is provided for bagged grain, 200 metres long by 33 metres wide. At the back run two tracks for goods wagons, from which bagged grain is unloaded and carried to this warehouse or direct to the ship lying alongside the mole. For bulk grain, large terminal elevators are provided.

Some of the flat sheds on the Pacific Coast will store up to 560,000 bags, and most of them belong to, or are controlled by, the railway companies.

In the United States terminal elevators are used, but grain storage at the ports is said to be very limited and decreasing, while it is increasing at the inland terminals, such as Chicago and Minneapolis (*Bowman* and *Crossley*, 1).

540. *Electric Belt-conveyors for Bagged Grain.*—The present method in vogue in South Africa is to off-load the sacks to the wharf, whence they are swung into the hold of the vessel by means of stout cranes (Fig. 199). At some of the Australian and Argentine ports the grain is either shipped from the sheds or from the trucks direct, by means of a mechanical device known as the electric belt-conveyor. The sacks are placed on this belt, rapidly transferred to the ship, and automatically discharged into the hold of the vessel. Conveyors of this type were put into operation at Williamstown and Geelong, Victoria, in 1905, to supersede the primitive and expensive method of manual labour and slings, and to more economically and expeditiously cope with the increasing export of grain; they are said to have given every satisfaction. At Bahia Blanca, Argentina, there are sixteen fixed conveyors with rubber belting covered with steel sheetings; their capacity is 100 tons per hour loading grain in sacks. There are in addition fifteen electric movable conveying-belts, which may either operate independently or serve as complementary to the others; their capacity is 100 tons per hour and their length 10 metres. A travelling belt-conveyor is in use at the Kaffraria Steam Milling Company's warehouse at the Congella Wharf, Durban, South Africa.

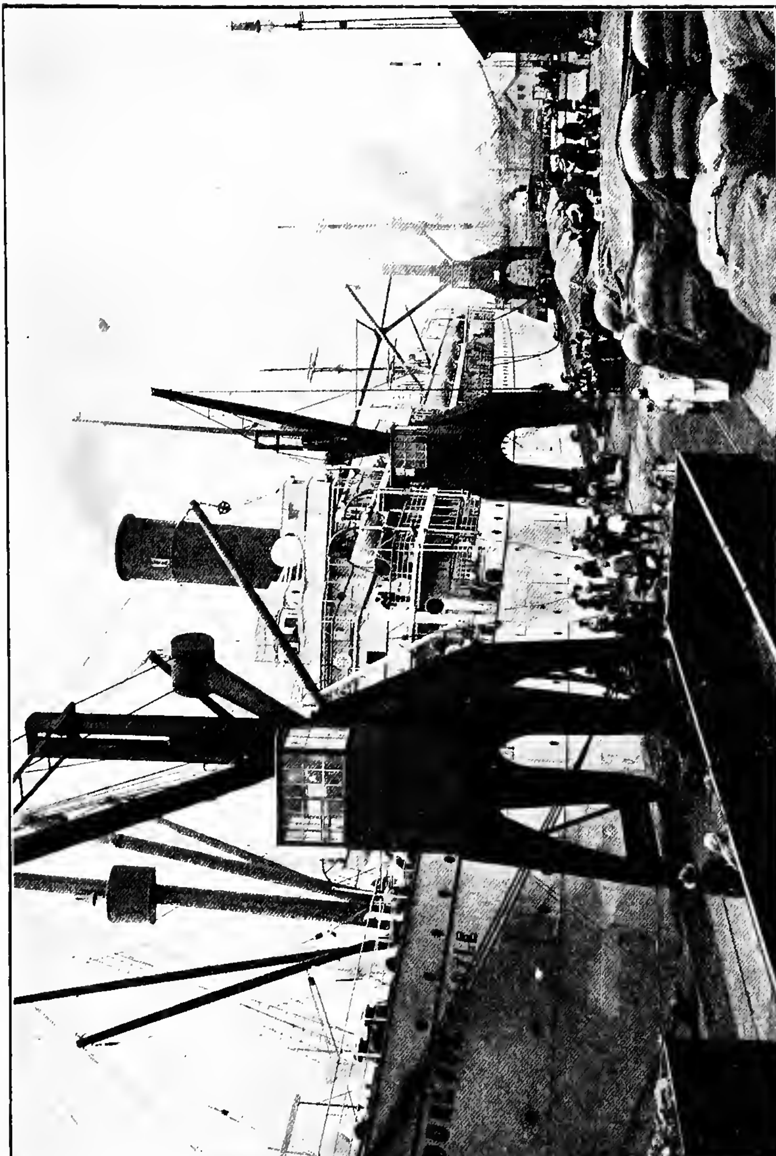

FIG. 199.—Loading s.s. *Dunluce Castle* with maize, by cranes, Durban wharves. (Courtesy of Union-Castle S.S. Co.)

CHAP. XII.

In England belt-conveyors are also used for moving bulk grain (Fig. 200).

541. *Wharf-shed Storage Charges.*—At Durban any grain stored over five days in Government Harbour sheds, in 1908, had to pay 3d. per ton per day, or any part of a day, for the first three days thereafter, and for the remaining period 1s. per ton per day, or part of a day. It was claimed by shippers that this regulation caused a good deal of unsatisfactory shipping. It tended to the quicker shipment of small parcels, but Mark Lane buyers were already complaining about the smallness of the parcels shipped from Durban, and the shippers complained that this regulation had forced them to ship small parcels to

FIG. 200.—Grain conveyor-belts.

avoid payment of this storage. Doubtless the Administration made the tariff so high to avoid congestion in the limited storage space available. The remedy seemed to lie with the shippers, who might arrange for larger parcels, by holding up-country, or storing in their own sheds.

Messrs. W. Cotts & Co. suggested that the time be extended to a week, charging a nominal rental of 3d. per ton per week the following week, making it 1s. per ton per week thereafter.

On 11 August, 1909, the following notice was issued by the General Manager of the Central South African Railways:—

"In view of the accumulation of maize at the Point, Durban, and the failure of consignees to effect prompt clearance, it is hereby notified that on and after date the Department holds itself free to call upon consignees to take delivery of any consignments within thirty-six hours of arrival, and that failing such delivery being effected, the maize will be off-loaded in the open when shed-accommodation is not available, and will remain at the entire risk of consignees, Government taking no responsibility in regard to them either as to their safety, or as to any damage which they may incur from wet, or from any other cause whatever. Owners are reminded that export maize is conveyed and handled solely at the risk of the owner, and the Department undertakes no liability in connection therewith either during transit, or at any other time. Previous notices as to free storage are modified accordingly."

With reference to the wharf storage charges at Durban, Messrs. W. Cotts & Co. pointed out in 1908 that:—

In London no storage is charged for the first three weeks; then the average rent is 3d. per ton per week; in Hamburg the charge is 10 pfennig (1d.) per ton per day after five days; in Antwerp about ¼d. per square metre per day, but with export goods these charges are rarely enforced if there is any just reason for delay.

It should be noted, however, that conditions at the above-named ports are not comparable with those in South Africa, where storage room is more limited, paying traffic is much less, and the ports are struggling to cover expenses.

542. *Construction and Capacity of Elevator Warehouses.*—One of the latest erected Canadian elevator warehouses, at Windmill Wharf, Montreal, is 238 feet long × 84 feet wide, and built entirely of non-combustible material. The structure, bins, bin-bottoms, etc., are of steel, roof of tile, and floors of concrete. It has ten elevator legs, equipped with cups 20 × 7 inches. Five of the legs are used for receiving grain and all ten can be used for discharging. The total elevating capacity is 100,000 bushels per hour. The grain is weighed in ten hopper-scales, each holding 2,000 bushels (about 560 muids). Two belt-conveyors in the cupola distribute the grain lengthwise through the building, through trolley spouts on the distributing floor. There is also an extensive belt-conveyor

CHAP. XII. system with nineteen marine loading spouts to deliver grain from the elevator to the ships. These belt-conveyors are 36-

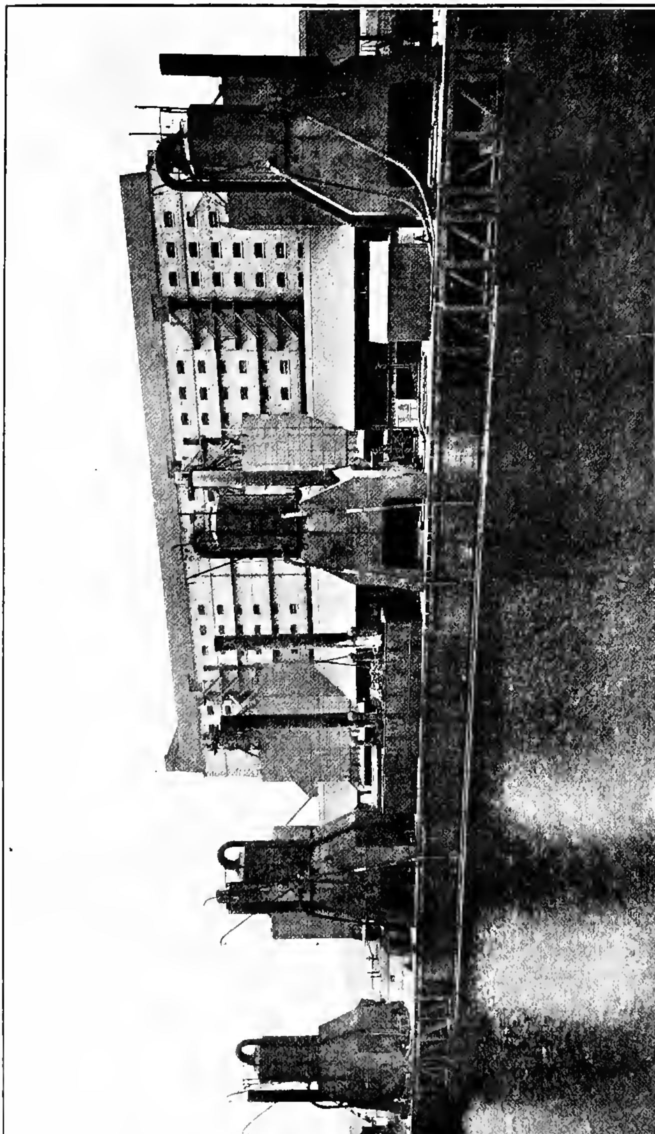

Fig. 201.—Central granary, Milwall Docks, London, showing stationary elevators. (Courtesy of Messrs. Goldstück, Hainzé & Co., London.)

inch concentrated belts with a shipping capacity of 15,000 bushels per hour each. On the Buenos Aires elevators the whole of the machinery is driven by electricity, each band and elevator being supplied from its own motor (*Downie*, 1). CHAP. XII.

The buildings are so constructed that the different grades of grain are received into separate chambers. They are equipped for expeditiously receiving and *conditioning* the grain when necessary, and for loading train-loads of trucks, or a large steamer, in a few hours.

543. *Cost of Erection.*—The cost of erecting, and equipping with all necessary mechanical appliances, a small country elevator warehouse of 10,000 bushels (2,800 muids) capacity, and measuring 20 × 30 feet × 50 feet high, is said to be about £700, in the United States. The Buenos Aires terminal elevator silo cost over £230,000 (*Downie*, 1).

It is estimated that a transit elevator silo at Durban, of 8,000 tons capacity, would cost not less than £116,000.

544. *Firms of Elevator Engineers.*—There are two large British firms engaged in the construction of elevator and grain handling and storage plants in different parts of the world—Messrs. Spencer & Co., of Melksham, Wilts, and Messrs. Henry Simon, Ltd., of Manchester.

545. *Elevator Systems.*—There are two principal methods of conveying bulk grain by elevators: the pneumatic or suction and the bucket and belt-conveyor method. Sir Thomas Price found that the Hamburg and Rotterdam authorities were in favour of the pneumatic method, as by it the grain could be worked out much more quickly than by the bucket elevator system. They admitted, however, that a certain amount of damage is caused by the grain becoming "floured" in passing so rapidly through the suction pipes and into the elevator. There was some disagreement as to the extent to which the grain suffered from the suction operations.

The testimony was uniform, however, that so far as South Africa is concerned, the bucket and belt-conveyor system would be found by far the best and cheapest to use, and speaking generally (still remembering South Africa's requirements), it was agreed that it was the cheapest to maintain, and was the most expeditious method of handling that had yet been generally adopted, and that it had been in operation sufficiently long to enable a definite and final opinion to be formed. The question therefore reduces itself to the adapta-

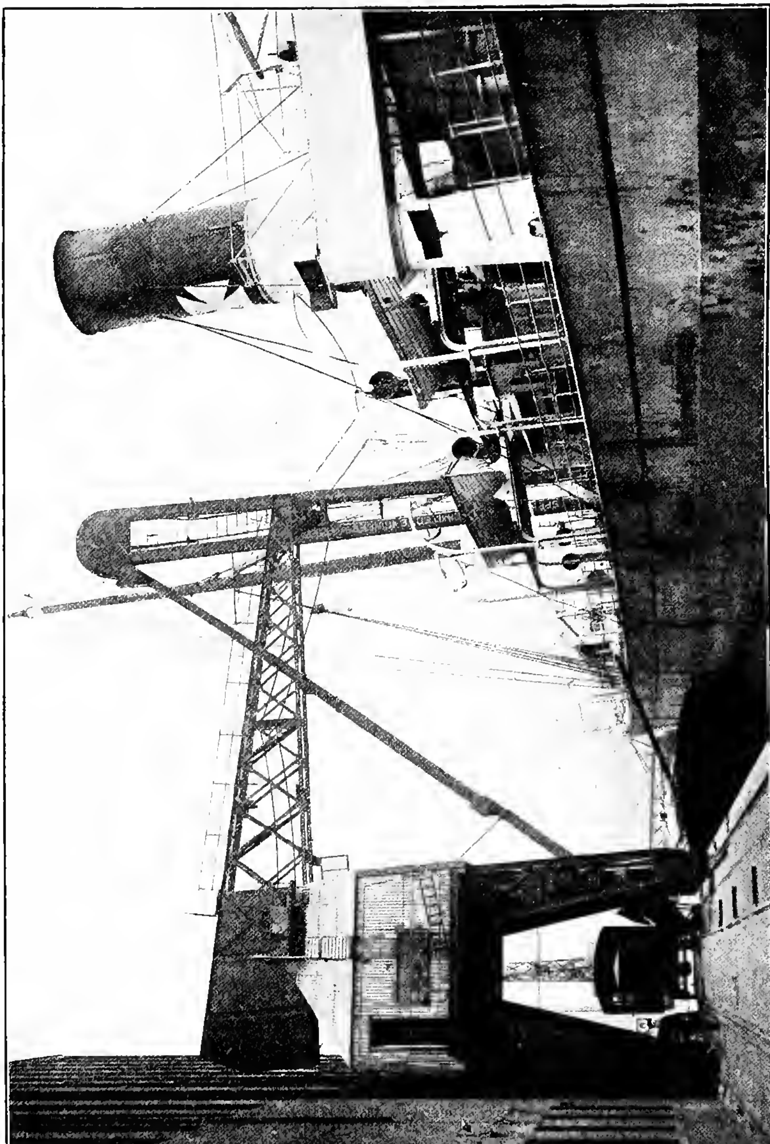

FIG. 202.—Steamer being discharged by travelling elevator, Victoria Docks, London. (Courtesy of Messrs. Spencer & Co., Ltd., Melksham.)

tion of this system, in the most suitable and economical form, to the handling and conveying of grain, to each individual case which presents itself. CHAP. XII.

Elevator warehouses for *bagged grain* are in use in Argentina. These possess some of the most modern installations for effecting the loading and off-loading of grain, for weighing separately, classifying, and drying.

546. *The Working of Elevators.*—The grain for a bulk elevator is run loose from the spout of the threshing machine into the farmer's cart, which is so constructed that when unhitched from the shafts it tips backwards and dumps the grain into the elevator spout.

At the Windmill Wharf elevator, Montreal, the system of working is as follows. Trucks conveying grain are shunted over large pits on the floor of the building; the truck doors are opened and the grain flows out into a hopper or pit leading to the boot of an elevator leg. The movement of the grain is assisted by a man with a large two-handled power shovel or scoop to which is attached a rope wound upon a rotating drum. From the boot the grain is constantly being elevated up the leg, weighed, classified, and transferred by gravity into the storage bins. From these bins it can be delivered in whole or part, as required, into trucks or direct into the hold of the ship.

At Mannheim the elevator spout can be extended sufficiently far out to discharge grain from a second vessel placed alongside the one next the wharf, while ordinary merchandise is being discharged from the latter by means of cranes. When the grain is emptied from the boats into an elevator, it is passed through a telescoping tube to automatic weighing machines, thence by means of conveyors to inside elevators. In the latter it is carried to the topmost story and discharged upon a conveyor by which it is carried to the various bins.

547. *Elevator Charges.*—The usual elevator warehouse charge in Chicago is $\frac{3}{4}$ cent per bushel (1·335d. per muid) for the first ten days or part thereof, and $\frac{1}{10}$ cent per bushel (·045 of a penny per muid) per day for each additional day thereafter, so long as it remains in good condition. This charge includes off-loading grain from trucks, storage, and re-loading into steamers or trucks. One elevator charges only

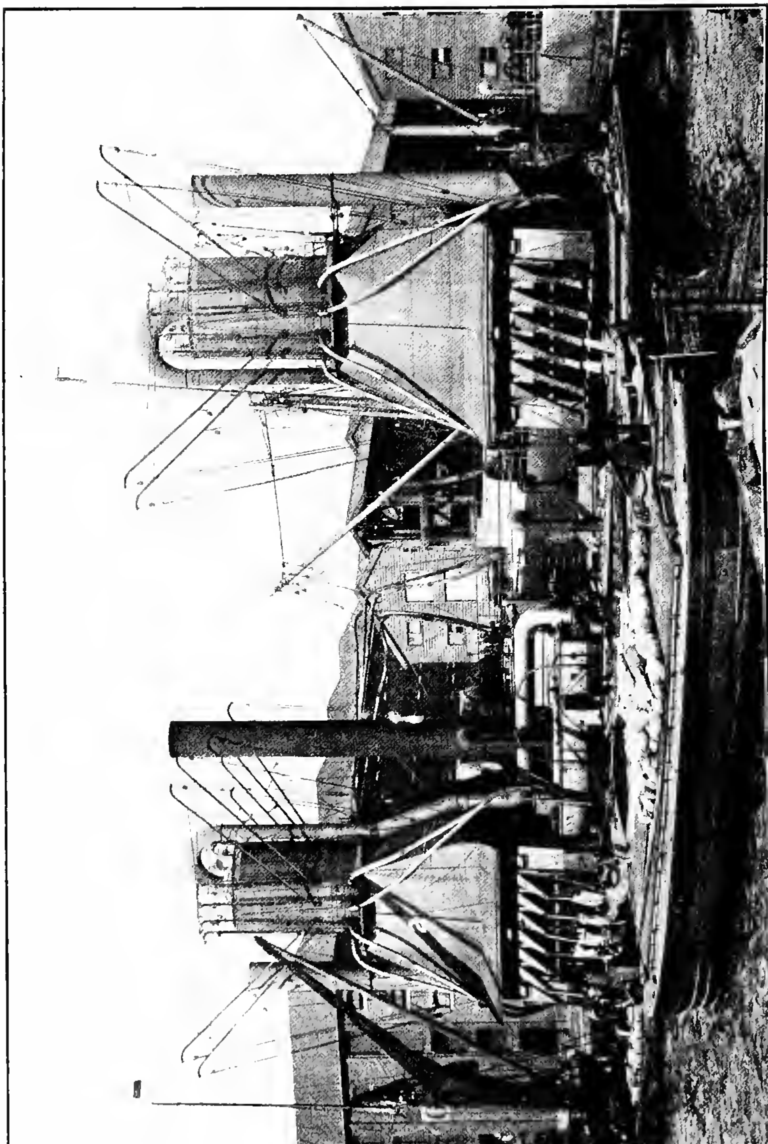

FIG. 203.—Steamer being discharged by floating elevator, Surrey Commercial Dock, London. (Courtesy of Messrs. Goldstuck, Hainzé & Co.)

$\frac{1}{2}$ cent per day for the first ten days or part thereof. For grain damp or liable to early damage (as indicated by its inspection when received) 2 cents per bushel (about $3\frac{1}{2}$d. per muid) for the first ten days or part thereof, and $\frac{1}{2}$ cent per bushel (about ·87 of a penny per muid) for each additional five days or part thereof. No grain will be received in store until it has been inspected and graded by authorized inspectors (*Bowman* and *Crossley*, 1). Operating expenses of terminal elevator warehouses in the States are usually covered by the sale of screenings, and the storage charges pay interest on capital expenditure as well as profit. The average running expense of each elevator in the State of Iowa is reported to be equivalent to $2\frac{1}{2}$ cents per bushel of grain handled.

548. *Elevator Certificates.*—At terminal points grain is inspected and graded by State officials before being deposited in the elevator warehouse. Immediately it has been stored according to grade (and if necessary cleaned or dried) a warehouse receipt is given to the owner. This receipt has to be presented at the State Statistical Bureau for registration and must be signed by the owner; it is then as negotiable on the money market as the grain itself. When it is desired to draw the grain, the owner presents his certificate at the Bureau for cancellation, and the grain is surrendered by the warehouse authorities. The length of time the grain remains in the bins depends upon circumstances, and it may so happen that the receipt will be sold and bought several times before the grain itself is moved. To deliver grain without scrupulously adhering to the Government regulations is treated as a criminal offence.

In Chicago there are two types of grain warehouse, the "regular" and "irregular," about an equal number of each sort. The "regular" houses are licensed by the Chicago Board of Trade; the grain handled by them is subject to inspection by the State Grain Inspection Department. They issue warehouse certificates which are *negotiable*, and which are treated as *collateral security* by banks, which issue loans on them at low rates of interest. "Irregular" warehouses are not operated under the rules of the Board of Trade, but are subject to inspection by the State Grain Inspection Department (*Bowman* and *Crossley*, 1).

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549. *Qualifications for Managership of Local Elevators.*—"The manager of an elevator warehouse should be a good judge of commercial grades. Experience and observation will teach him the grading of corn as indicated by its colour, moisture-content and amount of dirt present.

"An understanding of the meaning of local regulations is necessary for an intelligent interpretation of market reports. Familiarity with steps in the shipment of consignments will enable him to better appreciate the method of lining cars before loading. A knowledge of railway rates and the details of clear handling will often do away with shortage of shipping facilities at the time of a good market.

"Some education in regard to book-keeping and banking will stand the manager in hand in case his business grows. The present margin on shipments of grain demands close figuring to ensure profits.

"The manager should be the business man of the locality. His opinion upon the market should be respected by the shippers and farmers. His interest in the farming community should be substantial in the way of promoting corn and small grain exports besides introducing new seed and advocating improved varieties" (*Bowman* and *Crossley*, 1).

550. *Heating of Grain in the Elevator.*—The duties of an elevator superintendent or manager go much farther than the receipt, storage, and re-shipment of the grain. The superintendent should be able not only to keep grain in good condition during storage, but where possible also to send it out in even better condition than that in which it was received. He should therefore be able to judge, on receipt of a particular sample, just what kind of treatment it will require. He should be able to locate the particular part of a bulk lot of maize in which heating is taking place. Large accumulations of dust should be watched for closely. "In moving or changing grain from bins the weather should be favourable, both dry and cool. Warm, moist air when allowed to come in contact with moving grain may spoil it even if previously dry" (*Bowman* and *Crossley*, 1).

551. *Heating Caused by Moisture.*—Heating is due to an excess of moisture in the grain at the time of storing. Maize which is dried on the cob in the field, or in the crib, or local

elevator warehouse, shows little tendency to heating except at the time of year when germination usually takes place (which in the Corn-belt is about the middle of June) and in September; and in South Africa about October and November. When there is a tendency for the grain to sprout, special care should be taken to keep it dry. "Winter-shelled corn keeps as long as cold weather lasts, but when spring opens up it should be sent to the consumer at once as it is almost sure to heat" (*Bowman* and *Crossley*, 1). CHAP. XII.

552. *Loss of Weight and Damage Due to Heating.*—"Grain in a heated condition loses rapidly in weight. The *Shippers' Manual* for 1907, of the Chicago Board of Trade, reports a single car-load of hot corn shrinking 3,600 lbs. The Chicago Board of Trade has frequently weighed cars of hot corn on railway truck scales, day after day, the loss of weight being 150 lbs. per day per car-load." According to Prof. L. G. Michael, Chemist of the Iowa State Agricultural Experiment Station, "heating occurs when grain originally in a moist condition is put in bulk, thereby preventing it from drying out and consequently subjecting it to the action of fermentative bacteria or of plant growths resembling yeasts. All changes of this kind generate heat, which in time raises the temperature to such a degree that oxidation sets in. This may be so rapid as to cause spontaneous combustion. The heating is due almost entirely to fermentation which attacks the starch, changing it first to sugar which produces alcohol, and later acetic acid. If heating is continued for any length of time a decided *loss of starchy matter* results from the conversion of the starch to alcohol, with of course more or less injury to the unconverted starch. The matter of damage through heating is one of degree, from almost no harm, through slight rises in temperature, to almost complete ruin when fermentative changes are allowed to reach any advanced stage."

553. *Degree of Dryness Required for Export.*—If maize contains more than a certain percentage of moisture when shipped, it is apt to heat in the hold of the vessel, and to get musty and "out of condition". North American and Argentine maize often arrives in Europe in a damaged condition on this account. and some of the earlier shipments of South African maize also caused complaint.

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Experiments were conducted in 1909 by the writer, in collaboration with the Port Captain, Durban, to determine the degree of dryness requisite for safe shipment. These experi-

A

B

Fig. 204.—A, Drying wet maize, Durban wharves, 1909. B, Maize dried and re-graded ready for shipment, Durban, 1909.

ments were described in the *Transvaal Agricultural Journal*, and it is, therefore, unnecessary to repeat the details here. Our conclusions were as follows:—

Maize may contain from 12·5 to 13·5 per cent of moisture on arrival in London, and yet be perfectly sound and sweet. But as it may gain from 1·5 to 2 per cent moisture in transit, it should not contain more than 12 per cent moisture when it leaves South African ports. A sample containing 12·7 per cent on shipment was slightly damaged on arrival, but this ap- CHAP. XII.

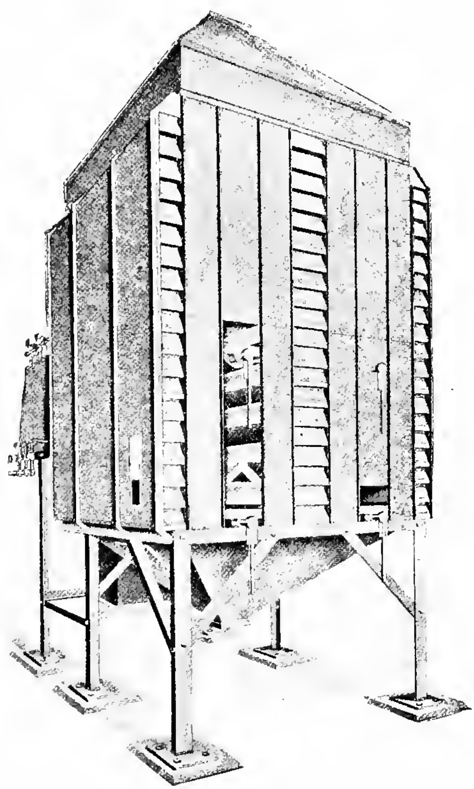

FIG. 205.—The Hess grain-drier for conditioning grain.

pears to have been due to contact with wetter bags, for it gained 1·7 per cent moisture in transit, bringing the moisture-content up to 14·2 per cent.

Maize containing 16 per cent moisture does not absorb much (·02 to ·36 per cent) in transit; but dry maize containing only 12·7 per cent moisture may absorb more. We

CHAP. XII. conclude that 12 per cent is about the maximum moisture-content which can be permitted for safe shipment.

554. *Conditioning Wet Maize.*—Different contrivances are in use for conditioning wet maize. The earlier consignments which were rejected by the graders at Durban were sun-dried on the wharves (Fig. 204).

The Hess grain-drier and cooler, for conditioning maize, is illustrated in Figs. 205 and 206. The following description

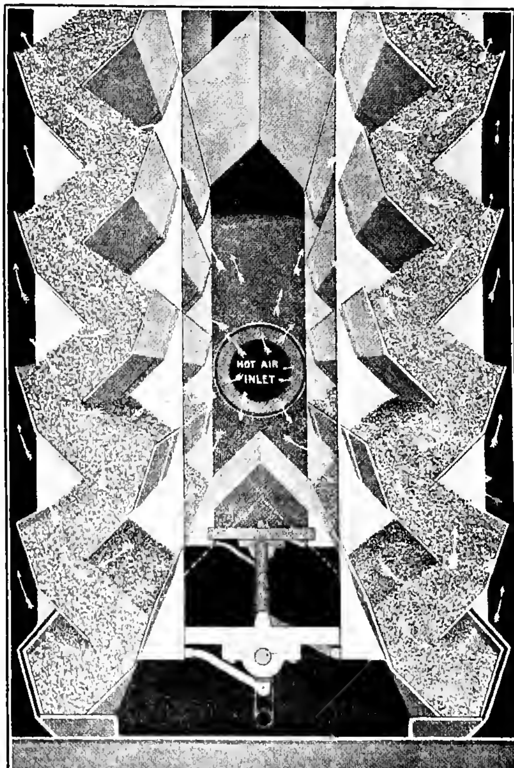

FIG. 206.—Vertical section through Hess grain-drier.

has been kindly furnished by the manufacturers, Messrs. Henry Simon, Ltd., Manchester:—

The general plan of this machine embodies: First, an arrangement for supporting the grain in layers. Second, means for warming or otherwise modifying the air to be forced through the material. Third, the use of a fan or fans to direct the air through the layers of grain. It consists of two series of racks, of which the upper series constitutes a drying or heating chamber, and the lower a cooling chamber; these chambers are separated by horizontal steel bulkheads, to prevent the mingling of the air, and the racks are fitted with steel slides to confine the grain to the proper chamber.

The heating chamber is subdivided into two sections, with the heat spaces on opposite sides of the grain racks. Above the heating chamber is placed a steel garner to contain a supply of grain for the heating chamber, and below the cooling chamber is placed a steel hopper, into which the cool grain is dropped from the cooling chamber.

The fan and steam coils are placed back of the racks, the fan drawing its air-supply from openings in the front wall of the housing, thence through the racks and grain of the cooling chamber. It is then forced up through the steam coils, and through the racks and grain in the heating chamber, and out of the drying-house through windows or through ventilators in the roof. The heat given off by the cooling grain is drawn through the fan and discharged into the drying grain, thus utilizing the heat which in other driers is wasted.

In operating this drier the damp grain is first spouted into the garner at the top of the machine, filling the racks of the heating chamber and the garner. The fan is then started, and the air, heated by the steam coils, is forced through the grain layers till the grain is dry, which ordinarily consumes thirty to forty minutes. The heated air is applied upon both sides of each grain column, treating every individual grain fully and equally. The operator then throws the levers at the bottom of the heating racks, having first closed the slides in the middle of the cooling chamber. This allows the grain in the bottom half of the heating chamber to drop down, filling the top half of the cooling chamber, and at the same time the damp grain in the garner fills the top half of the heating chamber. The motion of the grain in the racks thoroughly mixes the grain, so that every kernel is fully exposed to the drying and cooling currents.

After another period of drying, the slides in the middle of the cooling chamber are opened, and the grain in both chambers is allowed to drop, now filling all racks completely;

CHAP. XII. from this time on, the bottom half of the cooling chamber is emptied of its contents as they cool, the grain in the remaining racks progressing and mixing at each drop until it lands in the hopper below, uniformly dry and cool, and is then drawn off into storage.

FIG. 207.—Granary and barge elevator on the Thames; bagged grain has been poured from the steamer into the barge, for more convenient handling by the elevator. (Courtesy of Messrs. Spencer & Co., Ltd., Melksham.)

555. *Ocean Freight.*—The arrangement made by the South African Governments with the Conference Lines was that

maize should be shipped at the rate of 10s. per ton of 2,240 lbs., to Southampton, London, Hamburg, and Antwerp. Later this was raised, on account of extra cost due to sorting grades, etc., to 11s. 6d. plus 10 per cent primage.[1] This rate includes the charge for sorting at port of destination. To Canadian ports the freight is 12s. 6d. per ton, inclusive of primage, by steamers of the Elder-Dempster Line.

Where the shipment is made through Government, the charge, including shipping and harbour charges, preparation of shipping documents, Customs entries, and stamps, is 12s. 6d. per ton.

556. *Shipping.*—South African grain takes about twenty-eight days to land in Europe, which is the same time as taken by the voyage from Buenos Aires, so that, as far as time is concerned, bulk shipments could be made as successfully in the one case as in the other. The case of Australia and the Pacific Coast of North America is different, the voyage occupying about sixty days. The Pacific Coast shipping companies object to carrying bulk grain round Cape Horn, on the ground that there is danger of the cargo shifting; the vessels used in this trade (unlike those employed in the Atlantic grain trade) are not constructed for carrying grain in bulk. The question between shipment in bulk or in bags has been a matter of controversy on the Pacific Coast for many years (*Downie*, 1); a correspondent writes that there is often a good deal of complaint made in Europe against Californian cargoes, solely because they are shipped in bags.

Hamburg merchants have expressed the opinion that *full cargoes* of South African grain *shipped in bulk* should secure steamship freight at less than 11s. 6d. per ton. As against this, information was given by competent London authorities that the reason (more or less) why low freights were secured for grain from Argentina to Great Britain and the Continent was due to the fact that the "tramp" steamers obtained outward as well as homeward loads, and that if they failed to get any better paying cargo for the Argentine they could fill up with coal, whereas with South Africa, under the existing conditions, the "tramp" steamers would have to go

[1] In September, 1910, it was stated that the lowest charters obtainable outside the Conference Lines ranged from 14s. to 20s. per ton.

CHAP. XII. out empty, and naturally would require such a rate of freight as would pay them for the journey outward as well as for the return with a full cargo (*Price*, 2).

It is sometimes argued against bulk shipment that the vessels engaged in the South African trade are not equipped for this purpose, and that until the trade assumes far larger proportions than at present, the steamship companies would hardly be warranted in making the necessary changes. The writer is informed by a reliable shipping authority that although no "whaleback" steamers, such as are used in the American trade, are at present available for the South African trade, the vessels at present engaged could carry bulk grain by using a small proportion of bagged grain for trimming; thus with a 6,000-ton bulk cargo, 16,000 bags would be sufficient for securing purposes. Another correspondent, familiar with shipping conditions, writes: "The danger of shifting cargo is much more imaginary than real; in my opinion *no* danger exists if the reasonable and acknowledged precautions are taken".

557. *Tonnage.*—It is imperative that the best possible shipping facilities should be available to exporters, if the South African export trade is to be firmly established. Shipping arrangements should provide for tonnage being available to all United Kingdom and continental markets, as and when required, subject to reasonable notice being given by the Government Department in charge of the shipping arrangements. The need of direct freight to British ports in addition to London and Southampton is very apparent; Liverpool, Glasgow, Bristol, Hull, Leith, Belfast, and other great centres would take South African maize readily enough, but that there is no direct service, and the grain dealers at these ports are not accustomed to handling small parcels through other ports. A Liverpool merchant remarked to the writer, that "it borders on the ridiculous that there should be no direct freight from South Africa to Liverpool, the premier maize port in the United Kingdom". When there is enough through freight to warrant it, the shipping interests will lose no time in taking advantage of it, and as the South African maize export expands it will necessarily require freight for these ports. Such an arrangement would also enable South Africa to ship other produce, particularly

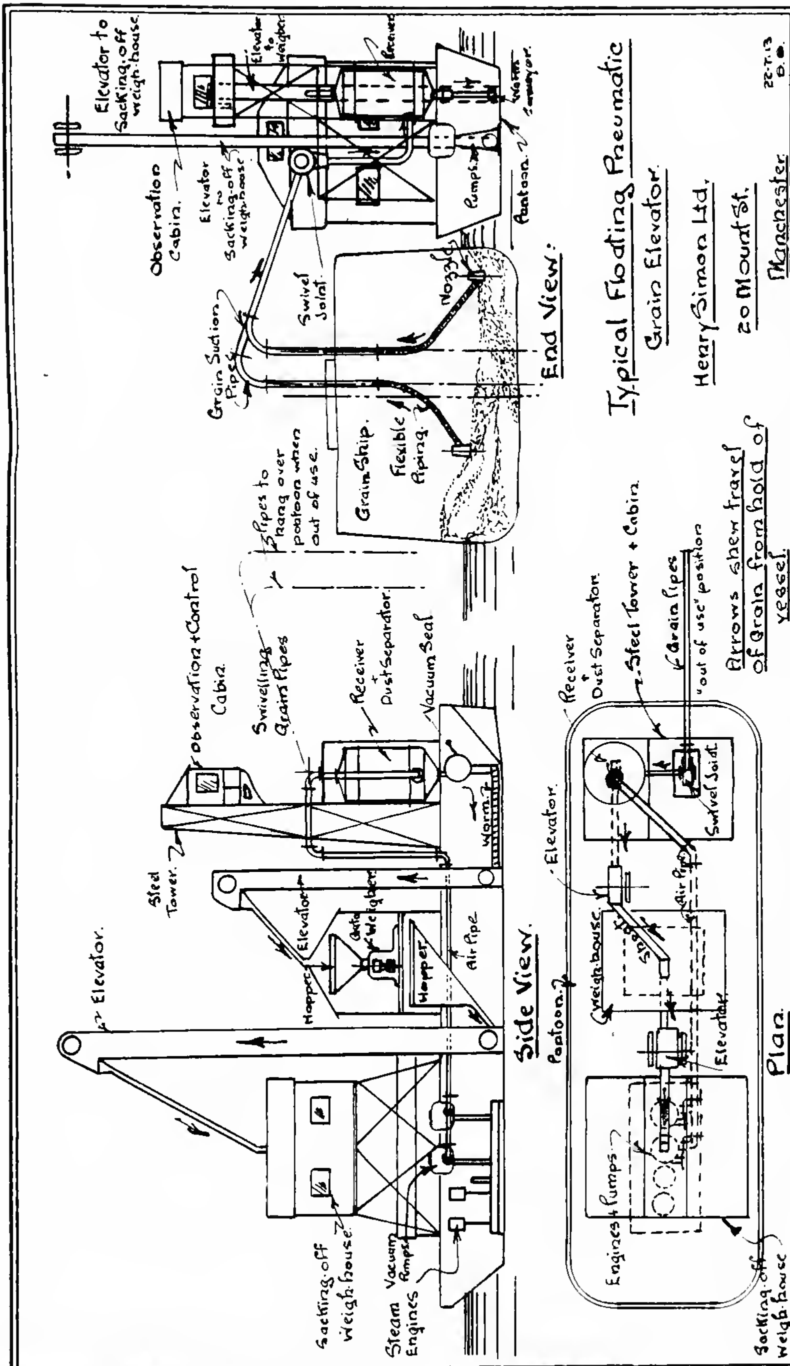

FIG. 208.—Diagram of floating pneumatic elevator. (Courtesy of Messrs. Henry Simon, Ltd., Manchester.)

CHAP. XII. wattle-bark and wool, direct to other large centres of consumption, and avoid the heavy railage rates now paid in effecting distribution to these markets through London, as at present, which severely reduces net returns.

During the last two years insufficient tonnage has been available in Durban from time to time, resulting in quantities of 8,000 to 10,000 tons of maize being held up in the wharf sheds for weeks at a time. When applications were made to the Conference Lines for additional tonnage, they generally replied that the rate was too low to attract outside shipping, and further that before they could agree to put on an extra steamer of their own they must be given a guarantee that a full cargo was available. This guarantee no individual shipper was in a position to furnish. It is quite evident, from the difficulties experienced during two seasons, in securing adequate shipping as required, that the solution of the problem lies in *producing more maize. When South Africa produces so much maize for export, that tramp steamers can always be sure of a cargo on arrival at her ports, she will be able to command the shipping situation.*

558. *Importing Ports of Europe.*—England is the largest consumer of imported maize, and Liverpool (Alexandra Docks) is the leading port of import, her supplies coming chiefly from the United States. Glasgow is also an importer from the States. South African maize is landed at London, Southampton, Antwerp, Hamburg and Rotterdam, and South European at London and Hull.

The principal European distributing points for maize are: Liverpool, Glasgow, Hull, Bristol, Manchester, Rotterdam, Hamburg, Antwerp, Bremen, Christiania, Copenhagen, Havre, Marseilles, Genoa and Naples.

559. *Bulk Handling at Ports of Import.*—The warehouses at Liverpool, London, Southampton, Antwerp, and Hamburg are so situated that grain can be sucked from the hold of the ship by elevators, floating (Fig. 208) or otherwise (Fig. 209), and discharged into the warehouse at the very minimum of expense. This can be done only where the grain is shipped in bulk. Where it is shipped in bags, it is often necessary to open and empty the bags into barges lying alongside the vessel, from which it is transferred by elevators to the silo (Fig. 207).

Fig. 208 shows a type of floating pneumatic elevator designed by Messrs. Henry Simon, Ltd., of Manchester, which has been largely adopted for the unloading and transport of grain from large ships at various ports, both at home and abroad. The plant is installed wholly on the pontoon; its operation is described as follows:—

"The intake pipes, two or more according to capacity, are lowered into the hold of the vessel, and the engines, which are

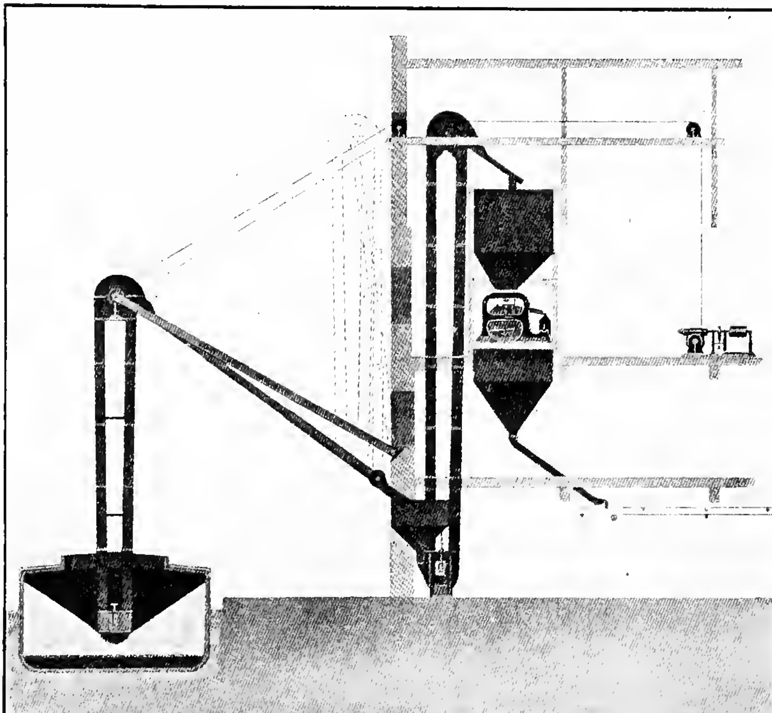

Fig. 209.—Diagram showing general arrangement of barge elevator and automatic weigher. (Courtesy of Messrs. Henry Simon, Ltd., Manchester.)

directly connected through a vacuum pump, are started up. The pumps create a vacuum in the pipes, causing the grain to be sucked through the nozzles at the end and to be carried to the receiver. This appliance extracts the dust, which is again mixed with the grain and delivered into the seal at the bottom. Loss of weight is thus eliminated. From the seal the grain passes along the worm to the small elevator which, CHAP. XII. in turn, delivers it to an automatic weighing machine, which weighs the grain in bulk. It is then fed into the large elevator, whence it passes to the sacking-off weigh-house, where it is again weighed and sacked off. The grain can then be delivered in sacks to barges alongside, or alternatively to the quay direct.

"The plant illustrated is capable of dealing with 180 tons of bulk grain per hour. All the tackle, etc., is carried on the pontoon and control can be easily effected from any point at will.

"A small engine and generator are provided, for supplying current to various small auxiliary motors for operating winches, etc., and also current for lighting purposes. The plant is self-contained, compact, and economical in working and is ideal for the purpose for which it was designed."

560. *British Silos and Elevators.*—At the larger British grain importing ports, such as London, Liverpool, Manchester, Southampton, Hull, Bristol and Barrow, several excellent appliances have been erected. At Manchester a silo of 1,500,000 bushels capacity has been erected for the Manchester Ship Canal Company.

561. *New Silo and Grain-handling Plant at Immingham Dock.*—Messrs. Henry Simon, Ltd., have recently completed the equipment of a grain silo at Immingham Dock, which has a holding capacity of 15,000 tons. The silo is situated at the east end of the dock, is constructed of reinforced concrete and stands over 100 feet high.

"It is approached by means of an overhead steel gantry 300 feet long and a front gantry runs parallel to the dock for a distance of some 550 feet, the approach gantry to the silo being at right angles to this. The grain is unloaded on the dock-front by means of a travelling ship elevator (Fig. 211) which runs on rails; these extend the whole length of the front gantry, making it possible to discharge at any point. The ship elevator forms a complete machine in itself, being fitted with bands, elevators, weigher and motors. The method of unloading ships, which can be in any position on the quay side, is briefly described as follows:—

"The intake elevator on the travelling ship elevator is lowered into the hold of the vessel, and the grain is then elevated, weighed and passed on to 27-inch wide band-con-

FIG. 210.—Grain warehouses, London Docks, fitted with Avery scales. (Courtesy of Messrs. W. T. Avery, Ltd., Birmingham.)

CHAP. XII. veyors in the front gantry, and these feed on to either of two bands, one 27 inches wide and the other 36 inches, in the approach gantry. The grain is conveyed by means of these band-

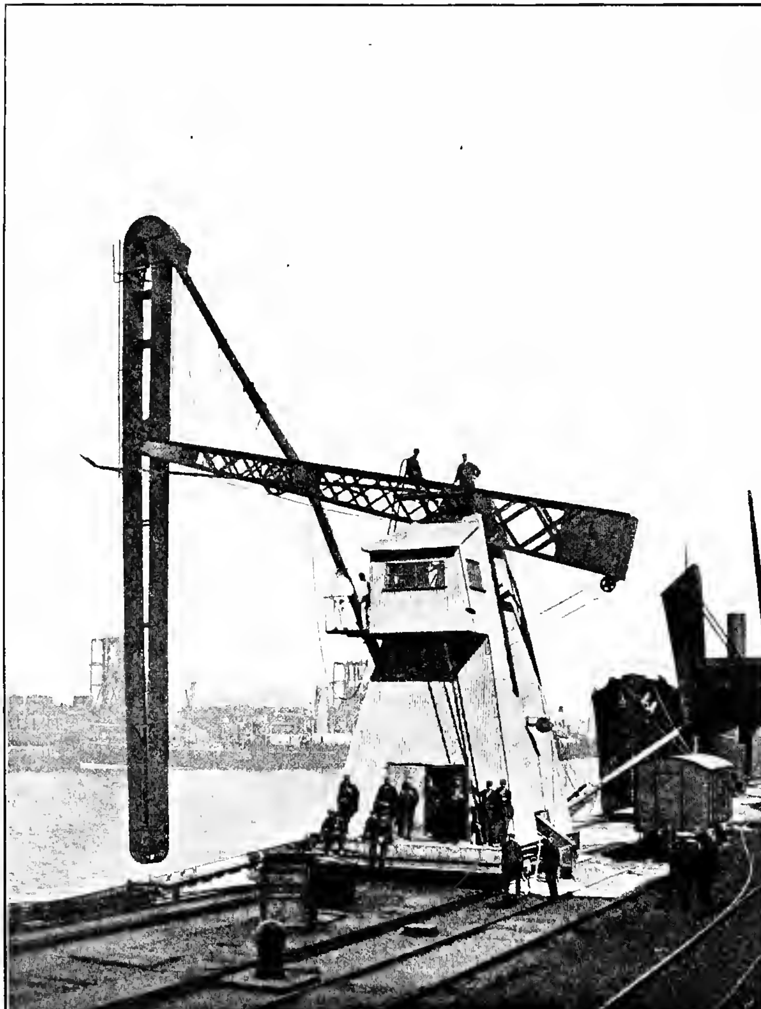

FIG. 211.—Travelling ship elevator. (Courtesy of Messrs. Henry Simon, Ltd.)

conveyors to the receiving house of the silo, where is situated a warehouse separator capable of dealing with 50 tons per hour, in connection with a patent cyclone dust-collector.

"The grain is lifted by two elevators, each having a capacity of 150 tons per hour, to the top of the silo, and from thence by means of band-conveyors running in two galleries it is distributed to any required bin or storage floor. There are eighty-two bins, and six floors where the grain can be stored in bulk. These six floors are each arranged with thirty-six floor spouts. These floor spouts are fitted with sliding sleeves at the top and bottom by means of which the grain can be fed to or taken from any floor. CHAP. XII.

"On the first floor of the building, arrangements have been made for sacking-off. On this floor are six Avery portable grain weighers with sacking-off appliances. The grain when sacked-off can be delivered by means of sack shoots, either to trucks or to sack bands which run along the approach gantry, at the end of which they can be delivered by means of an outside conveyor direct to barges. This conveyor can be lifted back into a tower in the centre of the front gantry and is then protected from the weather. Outgoing grain can also be handled in bulk with equal ease.

"On the ground floor of the silo are placed a number of conveyors which are fed from the bins and lead to either of the two elevators. These are used for the purpose of 'turning-over'. It is possible to 'turn-over' at the rate of 300 tons per hour; this large capacity is obtained by means of cross bands at the top of the silo, which allow the two elevators to feed simultaneously to one band, the two bands in the galleries having been specially made to deal with 300 tons per hour.

"Messrs. Henry Simon, Ltd., have also installed all the electric motors, the lighting, and a complete system of telephones. The power is transmitted to the travelling ship elevator through a series of plugs placed along the front gantry. By means of these same plugs the ship elevator tower is also connected to the silo by a loud-speaking telephone, an arrangement which is particularly useful."

562. *New Silo for the Manchester Ship Canal Company.*—The silo which Messrs. Henry Simon, Ltd., are building and equipping for the Manchester Ship Canal Company at the end of No. 9 dock, Salford, is to have a holding capacity of 40,000 tons, is to be five stories high and constructed in reinforced concrete.

"The building is to have a sacking shed running right

CHAP. XII. round, and two subways will run the whole length of the north and south sides of the dock and form the receiving connection from the quays to the elevator. There will be six band-conveyors in the subways, each capable of conveying 200 tons per hour. These will be fed direct from vessels lying alongside the quay, by means of floating elevators. The band-conveyors will in turn feed six receiving elevators in the silo, the elevators having a capacity of 150 tons per hour.

"The grain will be elevated to the top of the building, weighed, and then distributed, by means of a series of conveyors on the distributing floor, to the various bins. The upper portion of the outside row of bins, on the four sides of the building, will form the sacking and shipping bins. Spouts are to be arranged so that the grain can be weighed, loaded, in bulk or in sacks, to railway trucks on any side of the building, to carts on three sides, and directly into ships or barges on one side.

"In order to fill these shipping bins the bottoms of the storage bins are connected by conveyors and spouts to six shipping elevators of 150 tons capacity each, by which the grain is elevated, then weighed and distributed to any shipping bin.

"The grain will be cleaned, before sending out, by means of one large separator having a capacity of 4,000 bushels per hour. The wheat will also be subjected to an aspiration by two large fans. The building will be provided with goods-hoist and passenger lift. All the power required for the different operations will be supplied by electric motors. Each section of belt-conveyors, receiving and shipping elevators, will be driven by independent motors of 1,500 h.p."

563. *Continental Elevators.*—The ports of Antwerp, Hamburg, Rotterdam and Novorossijk, where grain is off-loaded in quantities, possess both suction and ordinary elevators and conveyors for transhipping direct in bulk and sacks from ocean-going vessels into trucks, river boats, etc. Grain arriving at these ports in sacks is frequently emptied in bulk into the river boats, etc.

At Mannheim, on the River Neckar, there is an adjustable ship elevator, capable of delivering from 79 to 89 tons per hour. Mechanical appliances for off-loading and storing grain are to be found at Ludwigshaven, Worms, Frankfort, Mayence, Cologne, Duisberg, Uerdiger, etc. (*Downie*, 1).

564. *Canadian Elevators.*—One of the largest elevators in the world, having a capacity of 7,250,000 bushels (2,000,000 muids), is situated at Port Arthur, on Lake Superior. Fort William, also on Lake Superior, has nine elevators, with a capacity of 14,000,000 bushels of grain. At Montreal there are several elevators on the most approved and modern plan, with a total capacity of over 1,000,000 bushels (*Downie*, 1).

565. *United States Terminal Elevator Warehouses.*—In the United States there are 422 terminal elevator warehouses, having an aggregate capacity of 73,000,000 muids, distributed among twenty-five large terminal markets or exporting ports.

TABLE LXXXIII.

NUMBER AND CAPACITY OF UNITED STATES ELEVATORS.

Exporting Points.	No. of Elevators.	Capacity.
Chicago	87	16,371,000 Muids.
Minneapolis	48	11,453,781 ,,
Duluth	23	8,453,781 ,,
Buffalo	28	6,766,000 ,,
Milwaukee	21	3,910,300 ,,
New York	18	3,706,000 ,,
St. Louis	39	3,383,753 ,,
Kansas City	38	3,162,465 ,,
Toledo	10	6,250,000 Bushels.
Omaha	15	6,040,000 ,,
New Orleans	9	5,180,000 ,,
Baltimore	5	5,100,000 ,,
Detroit	14	4,540,000 ,,
Montreal	10	4,150,000 ,,
Galveston	4	3,800,000 ,,
Philadelphia	4	3,100,000 ,,
Louisville	7	3,000,000 ,,
Newport News	2	2,560,000 ,,
Boston	4	2,200,000 ,,
Cincinatti	12	2,010,000 ,,
Indianapolis	9	1,955,000 ,,
Cleveland	6	1,916,000 ,,
Nashville	5	1,700,000 ,,
Seattle	2	1,550,000 ,,
Evansville	2	740,000 ,,
	422	

The above table does not include the vast number of smaller transit elevator warehouses to be found at the many small centres in the Grain-belts.

CHAP. XII.

566. *Argentine Elevator Silos.*—Buenos Aires has a series of elevator warehouses with a combined capacity of 91,600 tons. There are also six shipping silo towers, having a capa-

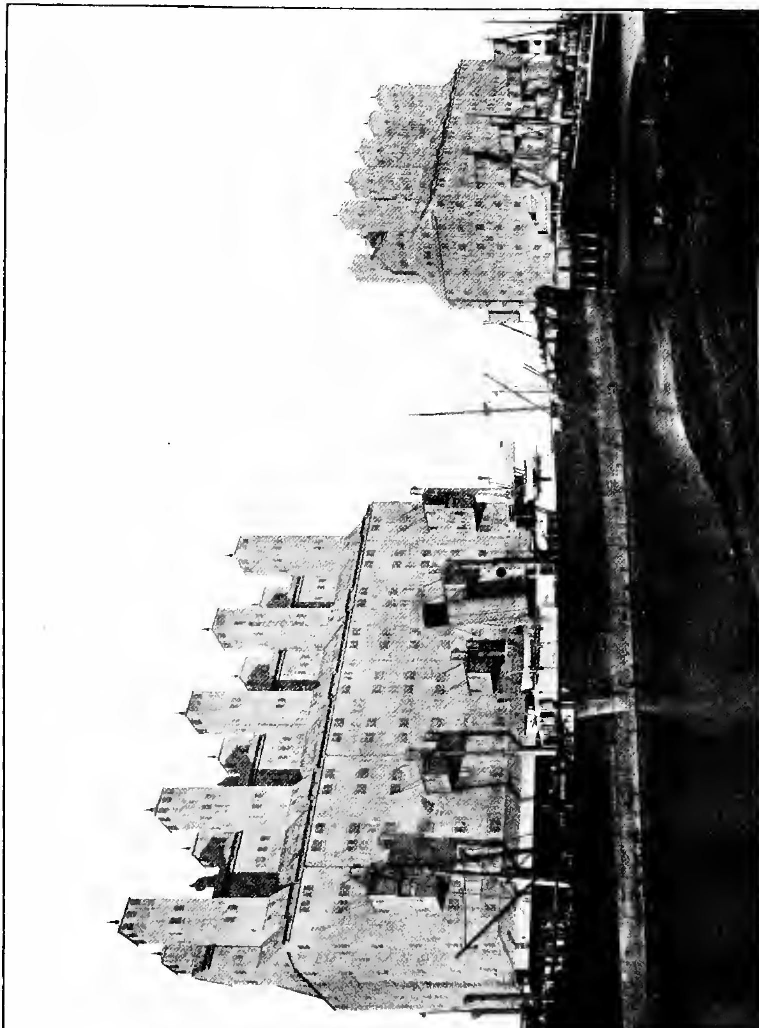

FIG. 212.—Terminal grain silos, Bahia Blanca, Argentina. (Courtesy of Messrs. Spencer & Co., Ltd., Melksham.)

city of 900 tons per hour, or 150 tons each silo per hour. Besides these, however, 450 tons per hour can be received and stored in bulk on the floor. The storage capacity of the three shipping blocks next to No. 2 dock amounts to 25,000 tons in bags. The main silo tower has a storage capacity of 19,500 tons, and grain is received into the silos at the rate of 780 tons per hour. The hourly quantity that can be received into the whole block of warehouses is 2,400 tons. The total bulk capacity of the silos is 29,100 tons. The whole of the machinery is driven by electricity, each band and elevator being supplied from its own motor (*Downie*, 1).

At Bahia Blanca there are two pontoon elevators, each of 75 tons capacity per hour, for loading grain from lighters into ships; these were constructed by Messrs. Spencer & Co., of Melksham, Wilts, England.

567. *Silos and Grain-handling Plant at Puerto Galvan, Argentina.*—Four silos and grain-handling plants have been erected at Puerto Galvan, for the Buenos Aires and Pacific Railway Co., by Messrs. Henry Simon, Ltd.

Grain elevator, No. 1, is built on the docks at Bahia Blanca, and is a typical example of silos constructed in reinforced brick. There is accommodation for storing grain either in bulk or in sacks, the grain arriving in bulk being put into one of the eight large circular bins, while that arriving in sacks is stored in the spacious warehouse at the back. The holding capacity of the bins is 1,000 tons each, or a total capacity of 8,000 tons, while the warehouse has accommodation for 12,000 tons of grain in sacks. The machinery for handling the grain consists of band-conveyors, elevators, weighers, etc., for receiving, weighing, and delivering the grain to ocean-going vessels at the rate of 2,000 tons per hour.

The facilities for discharging railway trucks are good; there are five separate sidings on which thirty-five wagons, each of 40 tons capacity, can be discharged simultaneously. The bands for receiving the grain run in subways below the railway lines, so that the grain is delivered on to the bands direct from the trucks, thus effecting a considerable saving in time and labour.

When the grain arrives at the silo, in bulk or in sacks, it can either be stored in the bins or warehouse, or, on the other hand, it can be weighed and delivered direct to vessels without entering the silos. Grain stored in the silos is delivered to vessels by gravity, while that stored in sacks is delivered by means of band-conveyors and shoots. The equipment includes

CHAP. XII. no fewer than twenty-six sack band-conveyors, nine bulk band-conveyors, fourteen elevators, and fifteen large automatic weighers. The various machines are driven by separate electro-motors. This plant was completed in 1909.

Grain elevator, No. 2, has no accommodation for *storing* grain, but is equipped with machinery for handling grain at the rate of 450 tons per hour, and the equipment includes appliances for receiving, weighing, and loading grain out to vessels at this rate. It is supplied with an efficient exhaust plant to minimize the troubles arising from a dusty atmosphere, and also complete electrical equipment for driving the machinery and lighting the granary. In this instance the building is of steel with floors of ferro-concrete. This plant was erected in conjunction with elevator No. 3, and was completed in 1912.

Grain elevator, No. 3, is arranged on similar lines to No. 2, with the difference that it has storage accommodation for 12,000 tons of grain in sacks on the floors of a large warehouse. The handling capacity of this plant is 600 tons per hour. This plant was erected in conjunction with elevator No. 2, and was completed in 1912.

568. *Private Ownership.*—The large majority of elevators in the United States are owned and operated either by companies uncontrolled by railways, but organized solely for the purpose of storing and handling grain, or by co-operative societies or private firms.

569. *Railway Ownership and Control of Elevators.*—What is probably the largest elevator warehouse in the world belongs to the Canadian Northern Railway Company, and is situated at Port Arthur. The Canadian Pacific and Grand Trunk Railway Companies have several elevators at Montreal on the most improved and modern plan. The Santa Fé Railway has a large elevator at Chicago. The number of terminal elevator warehouses, owned and operated by railway companies in the United States, is said to be small, but the number operated by companies which the railways control is substantially larger. The Argentine railways have erected elevators, with the permission of the Government, including one at Buenos Aires, built by the Buenos Aires and Rosario Railway Company (*Downie*, 1); the Buenos Aires and Pacific Railway Company has erected four elevators at Puerto Galvan,

and the Buenos Aires Great Southern Railway two at Bahia Blanca. CHAP. XII.

570. *Co-operative Elevator Warehouses.*—Of recent years, numerous co-operative farmers' elevator warehouses have been erected in the United States. The stock in these concerns is held by farmers of the district. In some cases they have not proved profitable, but others have given excellent returns (*Downie*, 1).

The following is taken from the articles of incorporation of the Farmers' Co-operative Society of Rockwell, Iowa: "The capital stock shall be, at the beginning of the business of this co-operation, not less than $1,000, paid in at such beginning, and may be increased from time to time to, and not exceeding, $25,000, and all increases of $1,000 shall be paid in from time to time on the issuance of shares of stock to purchasers becoming members. The said shares to be $10 each, and no member shall at any time own, or have any interest in, more than ten shares, and no shares shall be issued to anyone, except upon actual payment in cash, or for signed notes of the purchases, with security approved by the officers and director, and such note must be made payable during period in time not exceeding sixty days, and drawing interest of 6 per cent. No shareholder shall have more than one vote in conducting the affairs of this Society" (*Bowman* and *Crossley*, 1).

571. *The European Market.*—Although South Africa exports parcels of maize to many markets, Europe is her largest buyer, and is a more steady and reliable market than any other. Though the continental ports are beginning to absorb considerable quantities of maize, Great Britain is much the largest consumer, and the corn markets of Liverpool and London are by far the largest in Europe; parcels of South African maize sent to Antwerp and Hamburg are often sold through London.

The most important corn exchanges in which maize is bought and sold are: Mark Lane, and the Baltic (St. Mary Axe), London; Liverpool; Manchester; Hamburg; Antwerp, and Rotterdam.

When one first asks a corn merchant what types of maize are required on the English market, the invariable reply is that "any sort will sell". This is quite true, but it is never-

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theless only half the truth, and therefore is misleading from the points of view of the producer and exporter. Further inquiry from the same source elicits the information that while the merchant can sell any sort of maize, in any condition, sales will depend on two important factors, (1) the price, and (2) the quantity available. London is described as "the cheapest grain market in the world," and the ready sale of produce in that market depends on the price at which it can be delivered. It is, furthermore, much easier to sell whole cargoes than small

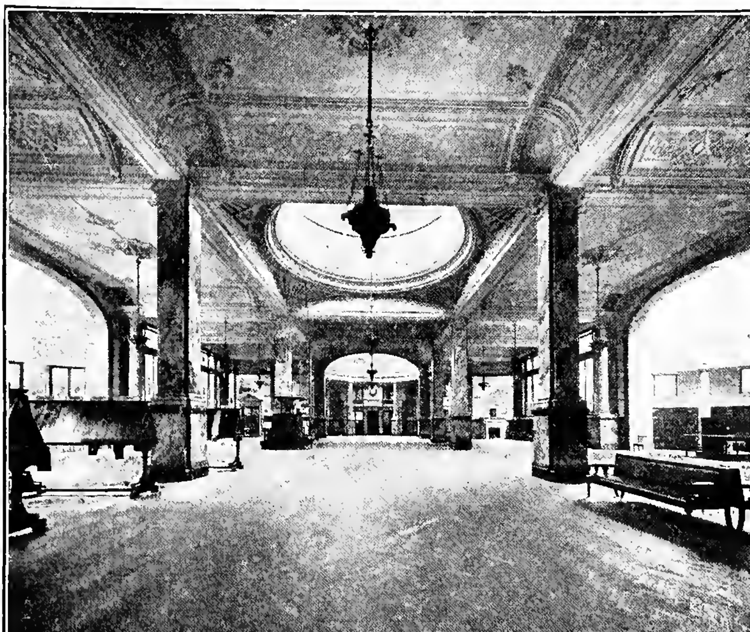

FIG. 213.—Interior of the Baltic Exchange, London. (Courtesy of the Secretary.)

"parcels" of say 400 quarters, i.e. 1,000 bags. The latter, if of good quality and condition, are bought up for special lines of trade, and as there are fewer buyers for these special industries than in the general market, small parcels are not placed so readily, though they often command a better price than low grade material.

For countries having a long and relatively expensive journey to the European market, it is desirable to export the article which will bring the best price and the largest profit after deducting cost of freight. So long as North America, Argentina, and S.E. Europe are able to supply cheap bulk maize, it would appear to be a sound policy for South Africa to cater for special lines of trade which are willing to pay a good price for a choice article in prime condition, rather than to attempt competition with the producers of "any sort" of maize such as will sell only at the cheapest rate. The English markets will even buy a cargo of damaged maize, provided it is *uniform* in quality and condition; but they will not pay much for it, which leaves but a small margin of profit for producer and local merchant; it is better, therefore, to keep such stuff at home for local manufacture, or for use as stock-food, and to export only the better qualities, which will command a good price, with a good margin of profit.

572. *Sale by Sample.*—In some American markets the inspection and grading have been developed to such a degree of perfection, and work so satisfactorily, that grain which is deliverable on contract is never shown by sample (*Scofield*). But in other markets, with less well-developed systems of grading, purchases for consumption or manufacture are made on the basis of sample, and this system prevails in many countries. Average samples of the various types are agreed on by either the Chamber of Commerce or the Produce Exchange, at the beginning of every season; these are sealed up and sent to all the corn exchanges in England and on the Continent, and on them all contracts for that particular season are based.

South African graders' certificates are accepted on the London market.

573. *Import Duty.*—Maize is admitted duty-free into England, Belgium, and Russia. Duty is payable in France, Germany, Spain, Sweden, and Egypt.

The following are the duties charged (*Bowman* and *Crossley*):—

France—3 francs (2s. 4·9d.) per quintal	(220·462 lbs.)
Germany—3 marks (1s. 5·8d.) per quintal	(,, ,,)
Spain—2·25 pesetas (10·8d.) per quintal	(,, ,,)
Sweden—3·70 kroners (2s. 0·7d.) per quintal	(,, ,,)

Under Article IV of the South African Customs Convention, the rebates of Customs duties granted on goods and

CHAP. XII. articles the growth, produce, or manufacture of the United Kingdom, were, from 1 October, 1908, extended to goods and articles the growth, produce, or manufacture of the Commonwealth of Australia. The Australian Commonwealth extended reciprocal privileges which included a rebate of 6d. per 100 lbs. on maize.

574. *Classes of Maize Required by the European Market.*—Each class and grade of maize has its particular place on the European market, and the price fluctuates to some extent with the demand for a particular grade. At one time "*Below Grade*" sells for as much as—or even more than—"*Choice*" i.e. (No. 1), not because it is better for the market, but because, at the time, the particular trade requiring Choice is fully supplied, while there is a shortage of Below Grade, which is sold to an entirely different class of trade. Weevilled maize, even, has a place on the market, but it should be distinctly labelled as such.

Mr. H. M. Colebrook, a large London dealer in grain, reported[1] as follows:—

(1) *Round Yellows.*—The classes of maize which command the best prices in Europe at this time are the small round yellows, of uniform size and colour, such as *Cinquantino*, *Odessa*, *Bessarabian*, and other Russian breeds. The small round yellows are used largely for feeding poultry and pheasants, and command a ready sale. Next to these in value come the larger round yellows from Argentina.

(2) *Flat Whites.*—South African flat whites, such as *Hickory King*, etc., come close to the above in value. "There is a demand springing up for the flat white maize in the manufacture of glucose and flaked maize used in brewing. If this demand continues, and should there be in addition demand in Europe for South African white maize for human food, the white varieties must appreciate and the relative values change correspondingly."

(3) *Flat Yellow.*—"The South African flat yellows are very close in value to the flat whites. There will always be a good demand for the South African large, flat yellow, and Cango types, at prices ranging from 9d. to 1s. a bag *under* those obtainable for small round yellow varieties, and (i.e. flat yellows) will be used for cattle food."

[1] 24 March, 1908.

(4) *Mixed.*—Lowest in value are the mixed varieties, and poorly grown maize of any description.

(5) *American.*—In "American" maize, those types most in demand on the English market are the flat yellow and white mixed known as "No. 2 American Mixed". Occasionally there are small shipments of large, flat white maize which command, with a very small market, a very high price, for seed purposes only. There is but little round maize of any sort from North America.

Mr. Clement, of Messrs. Harris Bros., of the Baltic Exchange, stated that White Flat Choice will command a special price so long as too much is not shipped, but that if a glut came in the market, it would have to be classed with the ordinary and sold at ordinary price.

Mr. Hislop, of Messrs. Berg, Sons & Co., of London, while not taking exception to the quality and feeding value of the "infinite variety" of maize grown in and exported from South Africa, stated that if the export were confined to *Flat yellow*, *Flat white*, and *Round yellow*, it would be better from a marketing point of view. Special care must be taken with respect to white maize, which is largely used for making a special corn-flour, which suffers if the grain is off colour. This trade requires that the grain be delivered in perfect condition, when it commands the highest price. Some Liverpool merchants, on the other hand, would welcome mixed flat maize.

575. *Differences in Market Value of Maize Grades.*—In the United States the difference between grades, under normal conditions, ranges from 3½d. to 5¼d. per muid. At other times, as in the case of a corner, the difference may be much greater.

European quotations show but little difference in value between the South African grades. On 6 January, 1910, the extreme variation was only from ½d. to 1½d. per muid. This slight difference may have been due to the fact that shipments being relatively small may have rendered them particularly uniform; or it is possible that at that time the system of grading not having been fully developed it was not as severe as might have been desirable.

576. *Number of South African Classes.*—Criticism has sometimes been levelled at South Africa for producing so

CHAP. XII. many types or classes of maize instead of concentrating on one, on the ground that (1) better prices are obtainable for large flat whites; (2) Rhodesia is said to be discarding yellows altogether, and concentrating on *Hickory King*, 10-row *Hickory*, and *Salisbury White* (a 12-row *Hickory*); and (3) because of the greater difficulty in handling and marketing so many grades.

It should be remembered, however, that by growing several types, South Africa will be able to enormously increase her producing area, and the amount available for export. The United States, which is the largest maize-producing and maize-exporting country in the world, produces *twenty-five* standard breeds, covering all four classes: flat white, flat yellow, round yellow, and round white. Moreover, (1) the English market calls for a large number of types; no one type is handled to the exclusion of others; (2) the best price is obtainable not for large flat whites but for small round yellows; (3) the demand for large flat whites is limited, and South Africa has been warned that it may be overdone; under such circumstances it is well not to have "all the eggs in one basket"; (4) the demand for "yellows" and "mixed" is unlimited.

With reference to the alleged difficulty in handling so many types, it is not likely that restriction to one type by white people will affect the supply of other types, inasmuch as native growers produce a considerable amount of that which is exported; it is bought from them by the small merchant in barter, and will always furnish a number of extra types, which will have to be handled.

The market wants larger shipments; it behoves us to make every possible district a producing centre, even if we have to add new types in order to do it.

577. *Standards of Weight and Measurement.*—In the English market maize is sold by the "*quarter*" of 8 bushels, i.e. 480 lbs., the standard bushel of maize weighing 60 lbs. *Galatz-Foxanian* quotations are for 492 lbs. On the continental markets it is sold by the 1,000 *kilograms*, equal to 2,204·62 lbs., or the *quintal* or *doppelzentner* of 100 kilograms or 220·462 lbs. avoirdupois, or $1\frac{1}{10}$ muids.

In South Africa maize is sold by weight only; the unit is the muid of 200 lbs. or 3·571 American bushels.

In the United States maize is sold by the bushel. The standard weight for a bushel of shelled maize is 56 lbs. in all the States except Arizona and California, in which it is 54 lbs. and 52 lbs. respectively. For maize *on the cob*, the standard weight is 70 lbs. in all the States which sell "ear maize," except Missouri, in which it is 72 lbs., and Ohio, in which it is 68 lbs. In Indiana and Kentucky the standard of weight is lowered to 68 lbs. during certain months of the year, i.e. 1 May to 1 November in Kentucky, and 1 December till the arrival of the new crop, in Indiana; this means that extra weight is allowed for moisture for the six months from 1 November to 1 May in Kentucky, but approximately for one month only (November) in Indiana. The following table shows the corresponding weight of American bushels in muids.

Table LXXXIV.

TABLE FOR REDUCTION OF BUSHELS TO MUIDS.

1 muid = 3·571 American standard bushels of 56 lbs.

Bushels.	Muids.	Bushels.	Muids.
·1 =	·028	27·0 =	7·56
·2 =	·056	28·0 =	7·84
·3 =	·084	29·0 =	8·12
·4 =	·112	30·0 =	8·40
·5 =	·140	31·0 =	8·68
·6 =	·168	32·0 =	8·96
·7 =	·196	33·0 =	9·24
·8 =	·224	34·0 =	9·52
·9 =	·252	35·0 =	9·80
1·0 =	·280	36·0 =	10·08
2·0 =	·560	37·0 =	10·36
3·0 =	·840	38·0 =	10·64
4·0 =	1·12	39·0 =	10·92
5·0 =	1·40	40·0 =	11·20
6·0 =	1·68	50·0 =	14·00
7·0 =	1·96	60·0 =	16·80
8·0 =	2·24	70·0 =	19·60
9·0 =	2·52	80·0 =	22·40
10·0 =	2·80	90·0 =	25·20
20·0 =	5·60	100·0 =	28·00
21·0 =	5·88	110·0 =	30·80
22·0 =	6·16	120·0 =	33·60
23·0 =	6·44	130·0 =	36·40
24·0 =	6·72	140·0 =	39·20
25·0 =	7·00	150·0 =	42·00
26·0 =	7·28		

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578. *Relative Weight and Bulk of South African Maize.*—The following figures are given by Sir Thomas Price (2) as the result of an investigation into the cubic space occupied by South African maize in bulk and in bags :—

YELLOW MAIZE.

	In Bulk.	In Sacks.[1]
1,289 lbs.	= 27 cubic feet.	29·895 cubic feet.
2,000 ,,	= 41·88 ,,	46·38 ,,
2,240 ,,	= 46·91 ,,	51·98 ,,

WHITE MAIZE.

	In Bulk.	In Sacks.[1]
1,232 lbs.	= 27 cubic feet.	—
2,000 ,,	= 43·82 ,,	49·822 cubic feet.
2,240 ,,	= 49·09 ,,	55·80 ,,

579. *International Trade in Maize.*—The following figures, statistics of the international trade in maize, including maize meal, for the years 1905-9, are furnished by the United States Department of Agriculture (*Year Book*, 1910), and represent, substantially, the international trade of the world. As there stated, "it should not be expected that the world export and import totals for any year will agree. Among sources of disagreement are these: (1) Different periods of time covered in the 'year' of the various countries; (2) imports received in year subsequent to year of export; (3) want of uniformity in classification of goods among countries; (4) different practices and varying degrees of failure in recording countries of origin and ultimate destination; (5) different practices of recording re-exported goods; (6) opposite methods of treating free ports; (7) clerical errors, which, it may be assumed, are not infrequent.

"The exports given are domestic exports, and the imports given are imports for consumption as far as it is feasible and consistent so to express the facts. While there are some inevitable omissions, on the other hand there are some duplications because of re-shipments that do not appear as such in official reports. For the United Kingdom, import figures refer to imports for consumption, when available, otherwise total imports, less exports of 'foreign and colonial merchandise'.

[1] These results are only approximate, as the number of sacks measured was small, and they therefore took up more space than they would have done if stowed tightly in the ship's hold.

Figures for the United States include Alaska, Porto Rico, and Hawaii." CHAP. XII.

TABLE LXXXV.

WORLD'S EXPORTS OF MAIZE (IN BUSHELS OF 56 LBS.).

Country.	Year Beginning.	1905.	1906.	1907.	1908.	1909.
Argentina	1 Jan.	87,487,629	106,047,790	50,262,705	67,390,728	89,499,359
Austria-Hungary	,,	62,218	22,361	120,144	381,821	48,218
Belgium[1]	,,	8,078,215	6,588,557	7,644,848	6,134,920	7,088,377
Bulgaria	,,	3,870,090	5,658,543	10,225,452	4,393,880	5,009,230
Netherlands[1]	,,	4,278,515	6,010,176	8,215,931	6,957,524	7,308,873
Roumania	,,	1,441,437	23,756,349	54,721,194	28,960,339	29,091,447[2]
Russia	,,	7,372,386	9,879,982	38,636,221	23,545,445	26,531,945[2]
Servia	,,	806,115	1,755,446	4,046,392	1,934,483	3,767,180
United States	,,	113,189,271	105,258,629	86,524,012	39,013,273	38,114,100
Uruguay	1 July	28,519	9,746	88,659	25,432	399,229
Other Countries	—	4,199,950	2,713,077	5,214,098	9,455,000	11,739,000[2]
Total	—	230,815,345	267,700,656	265,699,656	188,192,445	218,596,958

580. *United States Exports.*—It is sometimes queried how the United States can afford to export maize so cheaply. In the "Corn-surplus States," from which most of the export crop comes, farm-labour is not cheap (there is practically none, if any, coloured or "native" labour, such as is available in South Africa). The farm value, in 1909, was 7s. 3d. per muid, or about the same as in ordinary years in the Transvaal It should be borne in mind that—speaking generally—the American farmer does not grow for export; he grows to feed to stock, and sells only his *surplus* for manufacture or export. He usually has a surplus, because he must plant enough to provide for a possible bad year; if the crop is moderately good, he will still have some surplus for export, and if it is very good, he will have a large surplus.

The United States crop is so enormous that in 1905 she

[1] Belgium and the Netherlands are non-producing countries, therefore these amounts must be re-exports.

[2] Preliminary.

CHAP. XII. exported 31,700,000 muids (113,189,271 bushels); this represented under 3 per cent of the crop of that year.

581. *American Maize Grades.*—The rules recommended by the Chief Grain Inspectors' National Association of the United States of America classify maize-grain into three classes, viz. "yellow corn," "white corn," and "mixed corn". The following are the rules:—

No. 1. *Yellow Corn* shall be pure yellow corn, sound, plump, dry, sweet, and clean.

No. 2. *Yellow Corn* shall be 95 per cent yellow corn, dry, sweet, and reasonably clean, but not sufficiently sound or plump for No. 1 Yellow.

TABLE LXXXVI.

WORLD'S IMPORTS OF MAIZE (IN BUSHELS OF 56 LBS.).

Country.	Year Beginning.	1905.	1906.	1907.	1908.	1909.
Austria-Hungary .	1 Jan.	18,511,368	7,198,839	4,002,712	3,106,663	4,050,645
Belgium .	,,	24,169,780	20,125,507	23,505,832	19,158,096	22,099,848
British South Africa[1]	,,	3,448,954	315,835	51,298	145,275	155,389
Canada . .	,,	11,898,604	12,714,257	16,187,579	6,812,833	7,563,688
Cuba . .	,,	1,843,348	2,489,087	3,153,495	1,837,974	2,249,996
Denmark .	,,	10,859,257	18,855,752	2,383,282	10,445,555	9,151,750
Egypt . .	,,	1,279,749	1,438,435	196,539	845,205	748,865
France . .	,,	11,122,512	14,509,103	16,850,618	9,629,979	11,213,413
Germany .	,,	36,538,366	44,883,052	49,293,029	26,372,295	27,833,917
Italy . .	,,	5,902,875	8,666,763	2,815,120	2,987,496	8,459,986
Mexico . .	,,	1,115,007	1,882,218	1,554,145	179,157	1,167,733
Netherlands .	,,	16,234,785	25,305,233	29,192,195	25,261,400	22,914,269
Norway .	,,	544,596	718,276	1,937,926	809,841	965,347
Portugal . .	,,	2,724,050	370,611	677,726	2,015,388	2,367,800
Russia . .	,,	163,979	456,481	550,841	355,769	174,760[2]
Spain . .	,,	1,904,186	2,647,975	4,552,178	3,320,040	6,411,009
Sweden .	,,	491,035	564,946	330,588	488,077	272,284
Switzerland .	,,	2,498,380	2,887,291	2,867,764	2,480,164	3,143,216
United Kingdom .	,,	84,156,490	97,736,853	106,708,048	68,186,271	78,057,368
Other Countries .	,,	7,432,369	4,812,269	3,163,038	2,909,000	1,785,000[2]
Total .	—	242,839,690	268,578,783	269,873,953	187,346,478	210,786,283

[1] Only Cape Colony and Transvaal before 1906.
[2] Preliminary.

No. 3. *Yellow Corn* shall be 95 per cent yellow corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 Yellow.

No. 4. *Yellow Corn* shall be 95 per cent yellow corn, not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

No Grade Yellow Corn. (See general rule.)

No. 1. *Mixed Corn* shall be mixed corn, sound, plump, dry, sweet, and clean.

No. 2. *Mixed Corn* shall be mixed corn, dry, sweet, and reasonably clean, but not sufficiently sound and plump for No. 1 Mixed.

No. 3. *Mixed Corn* shall be mixed corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 Mixed.

No. 4. *Mixed Corn* shall be mixed corn, not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

No Grade Mixed Corn. (See general rule.)

No. 1. *White Corn* shall be pure white corn, sound, dry, plump, sweet, and clean.

No. 2. *White Corn* shall be 98 per cent white corn, dry, sweet, reasonably clean, but not sufficiently sound and plump for No. 1 White.

No. 3. *White Corn* shall be 98 per cent white corn, reasonably dry, reasonably clean, but not sufficiently sound and dry for No. 2 White.

No. 4. *White Corn* shall be 98 per cent white corn, not fit for a higher grade in consequence of being of poor quality, damp, musty, or dirty.

No Grade White Corn. (See general rule.)

No Grade—General Rule.—All grain of any kind and variety that is wet, hot, or in a heating condition, burned or smoky, contains weevil, or is for any reason unfit for warehousing, shall be classed and graded "No Grade".

"These rules have met with some criticism on the ground that the terms give great latitude for individual variations of opinion, 'reasonably dry' and 'reasonably clean,' for instance, being quite indefinite; and it has been suggested that the judgment of the inspectors should be guided and checked by actual

CHAP. XII. scientific determinations of the percentages of moisture, of coloured grains, of damaged grains, and of broken grains, and dirt; though of course this could not be done with every consignment, but only with a certain number of selected samples with a view to keeping the standard of grading uniform."

As Chicago is probably the largest maize market in America, it is well to see what classes and grades are recognized by the Illinois State Board of Railroad and Warehouse Commissioners. These are:—

Classes.	*Grades.*
"Yellow maize"	Nos. 1, 2, and 3.
"White maize"	Nos. 1, 2, and 3.
"Maize"	Nos. 1, 2, 3, and 4.

There are thus ten grades, as compared with South Africa's nine. It must be borne in mind, however, that these grades are mainly for the use of local buyers (distillers, manufacturers, and stock feeders) and not necessarily for the export trade. The Chicago grades differ from the South African in several important points, e.g. there are but three *classes* as against South Africa's five, which simplifies handling and shipping; *no distinction is made between flats and rounds*, i.e. Yellow Flats and Yellow Rounds are classed as "yellow maize". "Mixed" maize is called "maize," which is simpler and less derogatory. Mixed maize is given one additional grade, (4).

In the Chicago market "maize" is more extensively dealt in than yellow and white together; and much more yellow is handled than white. No. 3 is the grade usually dealt in in all classes. In the case of "maize" (i.e. mixed), No. 4 grade is much more common than No. 2.

Under the rules of the Board all maize that is less than $\frac{3}{4}$ (75 per cent) yellow or less than $\frac{7}{8}$ ($82\frac{1}{2}$ per cent) white is classed as "Maize". In other words, "yellow" maize may contain up to 25 per cent of white and white maize up to $12\frac{1}{2}$ per cent yellow, without being classed as mixed. But for No. 1 grade (i.e. Choice) it must be either *pure white* or *pure yellow*. In other parts of the United States it is considered that yellow maize should be at least 95 per cent yellow; white maize at least 98 per cent white, and that all maize not included in these limits should be classed as "mixed". CHAP. XII.

The maximum limits for each grade of maize are suggested in the following table:—

TABLE LXXXVII.

MOISTURE-CONTENT OF AMERICAN GRADES.

Grade No.	Maximum Percentage of Water Allowed in "Dry" Maize.		Maximum Percentage Damaged Grain Allowed.	Maximum Percentage Dirt and Broken Grains Allowed.	Remarks.
	Nov.-Mar.	Apl.-Oct.			
	Per Cent.	Per Cent.			
1	13	12	0	0	Shall be dry, plump, and well cleaned.
2	15	14	1	2	Shall be dry, reasonably clean, but not plump enough for No. 1.
3	17	16	3	3	Shall be reasonably dry and reasonably clean, but not sufficiently sound for No. 2.
4	19	18	6	5	Not fit for a higher grade in consequence of being of poor quality, damp, musty or dirty.

582. *Kiln-drying American Maize for Export.*—For several years past bitter complaint has been made as to the condition of North American maize arriving on the European markets. Although steps have been taken to remedy the trouble, by the erection of artificial drying apparatus at the ports of New Orleans (whence much of the wet maize comes), Baltimore, and Boston, criticisms of the condition of the North American article are still very severe on the Liverpool Exchange. Undoubtedly this state of affairs has helped to foster the South African trade, and has counteracted the bad impression given by the irregularity and small size of the parcels offered. The United States Department of Agriculture (10) reports as follows:—

"The trade in Argentine corn has grown, both because it is sold in London by tons, and because it stands shipment better than corn from this country on account of its hard, flinty character. Our softer dent corn is nevertheless preferred in all the European markets, and the maintenance and increase of our export trade are dependent only upon its being shipped so that it will arrive in uniformly good condition. As deterioration of corn during ocean transit is directly dependent upon the amount of moisture it contains, there is an easy and practicable remedy for the present condition, in artificial drying."

CHAPTER XIII.

THE MILLING, MILL-PRODUCTS, AND CHEMICAL COMPOSITION OF MAIZE GRAIN.

They . . . beat to death poor Pau-Puk-Keewis,
Pounded him as maize is pounded.

—*Hiawatha.*

The information on milling contained in this chapter has been most kindly furnished by Mr. W. H. Horsfall, the well-known South African miller of Aliwal North. Mr. Horsfall comes from an old Yorkshire family, engaged in milling for generations, and is thoroughly familiar with the business. He has made it a point not only to keep posted on all the latest improvements in milling methods and machinery, but has gone minutely into the chemistry and mechanics of the subject to find out how to get the most nutritious and best products. The illustrations of milling machinery are from blocks kindly supplied by Messrs. Samuelson of Banbury, and Messrs. W. S. Barron & Son of Gloucester.

583. *Native Methods of Grinding.*—The method of crushing and grinding maize grain between two stones, the one hollowed and stationary on the ground, and the other rounded and held in the hand, was in vogue among the primitive American Indians, and is still employed by the natives of Basutoland and those of other Native Territories and Reservations of South Africa (see Fig. 231). But when once the South African native gets into the town he is as particular about his mielie meal as any white man, even to its colour and the fineness of the grinding; he has a strong partiality for white meal in preference to yellow. CHAP. XIII.

584. *Modern Milling Methods.*—Millers have adopted improved methods, during the last few years, for the milling of maize. In the old types of mill, maize is ground just as it is received from the farm, whereas in the most modern milling plants it is now subjected to a cleaning process which removes all the dirt or refuse left on or among the grain after it is shelled.

All maize mills do not turn out the same products; these

CHAP. XIII. differ according to the particular machinery used, and there is no uniformity of composition in the products turned out under the same name. In South Africa there are mills producing, from one lot of grain, the following products :—

Samp.
Mielie meal, No. 1 quality.
Mielie meal, No. 2 quality.
Germ meal.
Hominy-chop.

By such a process there is practically no waste; *first*, the grain is cleaned; *second*, it is steamed to soften the hull, which is then removed, chopped up, and mixed with screenings from other steps in the process, to form hominy-chop, which is sold for stock food; *third*, the grain is cracked and the "germ" removed ("degerminated"); the latter is then ground into "germ meal," which is also sold for stock food; this contains much of the protein and oil; *fourth*, the larger portions of starchy grains, free from "germ," are sifted out to form samp; this contains less protein and practically no fat; *fifth*, the finer portions are ground into mielie meal, from which the No. 1 grade is sifted; *sixth*, the siftings of No. 1 meal are again ground and form No. 2 meal.

585. *Condition for Milling.*—Maize for milling should be in dry condition; to produce the best results the moisture-content should not be more than 10 to 12 per cent; if this is much exceeded, the capacity of the milling plant is considerably reduced, and an uneven grade of meal is produced which will not keep in good condition for any length of time. South African maize is pre-eminent for its dry condition, as the maize crop is dried by the sun, Nature's own method and the best. If due care is taken that the maize is dry before shelling, it is unnecessary to resort to artificial means of "conditioning" the crop, either for home consumption or for export, as is done in so many other parts of the world.

586. *Mill-products of Maize.*—The various mill-products which can be obtained from maize include :—

Ordinary maize meal.
High-grade maize meal for table use.
Crushed maize.
Maize-and-cob meal.

Samp, hominy, and grits.
Flaked maize or corn-flakes.
Starch.
" Corn-flour."
Flourine.

The by-products include :—

Maize bran.
Hominy-chop or hominy-feed.
Maize germ.
Germ meal.
Gluten-feed.
Gluten meal.

587. *Hominy Mill Products.*—Hopkins (3) gives the following interesting account of the products obtained in American hominy mills :—

" The whole corn is somewhat softened by steaming and is then run through a hulling machine, which not only removes the hull, but loosens the germ and breaks off the horny gluten and more or less white starch. The dust or pulverized material coming from the hulling machine consists largely of white starch and horny gluten. The hulls and germs are each separated but not in very pure condition, leaving what is termed *hominy*, which consists chiefly of the horny, starchy part of the kernel, with more or less adhering white starch.

" The product which is known as *grits* is made from the hominy and consists of the horny, starchy part separated in very pure form. In making the grits the coarse hominy is run through a grinding machine and reduced to a coarse powder which may be termed coarse grits, much of the adhering white starch being rubbed off from the horny starch in this process. The coarse grits are then run through one or two more grinding machines, until the horny starch is reduced to a rather fine powder, which may be termed fine grits. This material consists of the horny starch in very pure condition. After each grinding the fine dust, consisting largely of the white starch, is separated from the grits and goes into the product known as corn-flour.

" In addition to the corn-flour thus regularly separated, and handled in considerable quantities, there is constantly produced a small amount of what is termed ' break ' flour. This is an exceedingly fine dust, also produced in the process of breaking the corn particles in the grinding machines which

CHAP. XIII.

reduce the hominy to grits The break flour is carried from the machine by an air current through conduits and finally collected. This is another very pure form of the white starch.

"Thus, in the regular milling process, there are two physical parts of the corn kernel separated in very pure form, namely, horny starch (fine grits) and white starch (break flour or corn-flour), and two other distinct parts which are separated somewhat less perfectly, the hulls and the germs."

The following table shows the composition of the several parts of the maize-grain, as separated by the hominy mill and by hand respectively :—

Table LXXXVIII.

COMPOSITION OF PARTS OF THE GRAIN AS SEPARATED BY THE MILL AND BY HAND.

Names of Parts.	Methods of Separation.	Protein.	Oil.	Ash.	Carbo-hydrates.
		Per Cent	Per Cent	Per Cent	Per Cent
Hulls . .	By mill	6·85	2·94	1·11	89·10
,, . .	By hand	4·97	·92	·82	93·29
Horny starch (fine grits)	By mill	8·46	·44	·26	90·84
	By hand	8·12	·16	·18	91·54
White starch (corn-flour) .	By mill	5·91	1·63	·49	91·97
White starch (break flour) .	,,	5·88	2·04	·68	91·40
White starch (from tip) .	By hand	6·10	·29	·29	93·31
Germs . .	By mill	15·84	21·26	7·41	55·49
,, . .	By hand	19·91	36·54	10·48	33·07
Whole corn .	Mill sample	9·31	4·20	1·43	85·06
,, ,, .	Ear No. 1	9·28	4·20	1·41	85·11

Hopkins (3) points out that

"In general the composition of these mill separations agrees with the composition of the same parts separated by hand, although in nearly all cases the mill products show more or less contamination or mixture with other parts of the kernel. Thus the mill hulls are noticeably high in protein and oil owing to the presence of some particles of horny gluten and germ ; while the mill germs are too low in protein and oil because of the presence of some hulls and tip caps. Furthermore, some oil is lost from the germ and absorbed from other parts in the milling process. The fine grits are almost pure horny starch, except that they contain about twice as much oil as the hand-separated product. This is doubtless due to the fact that some germs are broken or crushed in the hulling machine, and the liberated oil is absorbed to some extent by the hominy, chiefly, of course, by the white starch, as indicated by the high oil-content of the break flour and the other regularly separated corn-flour, although it is evident that a small portion of this liberated oil remains adhering to the fine grits. The white starch contains 5·88 to 5·91 per cent of protein, while the horny starch (fine grits) contains 8·46 per cent, or almost one-half more.

"It will be observed that the two samples of whole corn (Table LXXXVIII) are almost identical in composition. While the corn is fairly representative of much of the white corn grown during the season of 1902, attention is called to the apparent fact that this is not the most suitable corn for the manufacture of hominy and grits. It seems evident that corn containing a higher percentage of the horny starchy part would be more valuable for the hominy mill. The manager of the American Hominy Company's mills at Decatur has assured the writer that he prefers corn which shall run high in grits (horny starch), but he does not desire that the oil-content should be increased; indeed, it would be much better for milling purposes to have the percentage of oil in corn reduced, because of the difficulty of preventing the oil from being absorbed by the other products and injuring their quality, the tendency being for the oil to become rancid when exposed to the air. The hominy mills offer some encouragement to farmers to grow corn especially suited for their use."

588. *The Best Sorts of Maize for Milling.*—The best sorts of South African maize for milling are found among the flat dent breeds, and include:—

White Breeds:—

Hickory King;
10-*row Hickory*;
Iowa Silver-mine;[1]
Horsetooth types (including *Natal White Horsetooth*, *Mercer*, *Ladysmith*, *Hickory Horsetooth*, and *Salisbury White*).

For the manufacture of samp, hominy, cerealine, etc., white

[1] Since the above was written, Dr. Juritz has issued a report on some comparative analyses of *Iowa Silver-mine* and *Hickory King* mielie meal which

CHAP. XIII. maize of a long-grained type, such as *Iowa Silver-mine*, *Ladysmith*, or *Mercer*, yielding a high percentage of horny endosperm, is required. Soft, starchy, immature, or mixed maize is said to be useless for this purpose.

The "flour corns," "flour maize" or "bread-mielies" make the softest floury meal of any variety of maize, but as their protein-content is low, their nutritive value is poor; moreover they do not keep well, being more quickly attacked by weevil and grain moth than the harder types.

Yellow breeds:—

Chester County;
German Yellow (the true dent type);
Eureka.

Yellow Horsetooth, *Golden Beauty*, and *Reid Yellow Dent* are also suitable for milling and the manufacture of flakes.

The different breeds of hard round flint maize, such as the *White* and *Yellow Cangos*, are not considered suitable for milling as they produce a very sharp, gritty meal, and it requires more power to reduce them than is the case with any of the other sorts named.

589. *Construction of a Modern Mill and Modern Machinery.*—The modern mill is designed and planned by the milling engineer before a brick has been laid. In the arrangement of the machines, elevators, shafting, and belt drives, it is essential, in order to produce the best results with the smallest consumption of power, that the engineer should have the "first say" as to the internal construction of the building. He will see to it that there is sufficient floor space to get comfortably round every machine for inspection and sampling of products, etc., with some space to spare for additional machines when necessary; sufficient height between floors for spouting by gravitation, and plenty of light; and the best driving arrangements for each machine. Another desideratum is the lowest possible fire risk and insurance rate, which means that there should not be a *machine* in the *store*, nor a *bag of produce* in the *mill*, except the sacking-off products; the two buildings

show, among other things, that *Iowa Silver-mine* is an ideal mielie for samp-making, even preferable to *Hickory King* (assuming that it does not make too much meal in the process of degermination), because of its lower percentage of fat; one object in samp-making is to get the product as free from oil as possible.

should either be a few feet apart or, if adjoining, a fire-proof party-wall should divide them. CHAP. XIII.

The selection of the most suitable and economical form of motive power depends greatly on the location of the mill and an abundant supply of good water. If it is near the coal-fields a steam-plant is generally preferred, but this must be of the very latest type of construction; it should include a compound condensing engine worked with superheated steam of 120 to 150 lbs. boiler-pressure, and with feed-water heating apparatus, if it is to be as economical as a suction gas engine and plant of the latest type, such as "The National Gas Engine".[1]

In some of the large centres, such as Capetown, Johannesburg, and Durban, electric motors have been adopted, but they are only practicable where the current can be obtained at a price under one penny per unit.

The selection of the best milling machinery is probably the most difficult task confronting the purchaser of a new plant, as there are five or six first-class English milling engineers represented in South Africa[2] who turn out machines which are not surpassed in design, results, economy of power, and durability. Apart from any favourite make or design of machine, the point which appeals most to the practical miller is the best "flow sheet" which the engineer can supply, as this is really where the results and the profits come in. It invariably follows that the best machines and the best "flow sheet" go together, for the engineer who recognizes the importance of keeping his machines strictly up-to-date, and perhaps a little ahead of his competitors' machines, is wide-awake enough to engage the services of the most competent milling expert (who prepares the diagrams for the mill) whom money can employ.

[1] For which Messrs. Stewarts & Lloyds are the agents in South Africa; they also supply an apparatus for producing steam from the waste heat of the exhaust gases, which is necessary for the steaming-worm, gelatinizers, and dryers of the mill. Mr. Horsfall speaks highly, from his own practical experience, of the economy in fuel and general running of this make of engine. The "Lister" petrol engine, for which the Agricultural Supply Association, Ltd., Johannesburg, is the South African agent, is also highly spoken of by those who have used it.

[2] In addition to Messrs. Samuelson and Messrs. Barron, Messrs. Henry Simon, Ltd., of Manchester, and Messrs. E. R. & F. Turner, Ltd., of Ipswich, supply milling machinery to South Africa.

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Apart from the commercial side of the business, the ideal combination to produce the "fattest" balance sheet is the best machinery, the best "flow sheet," and a thoroughly practical miller to work them; unfortunately the last named is a *rara avis*, comparatively speaking, in South Africa.

590. *Cleaning and Preparation.*—The machine used first, for the cleaning of maize, is the zigzag separator. This consists of a number of sieves built in a frame in zigzag shape (Fig. 214) (whence the name) and covered with perforated

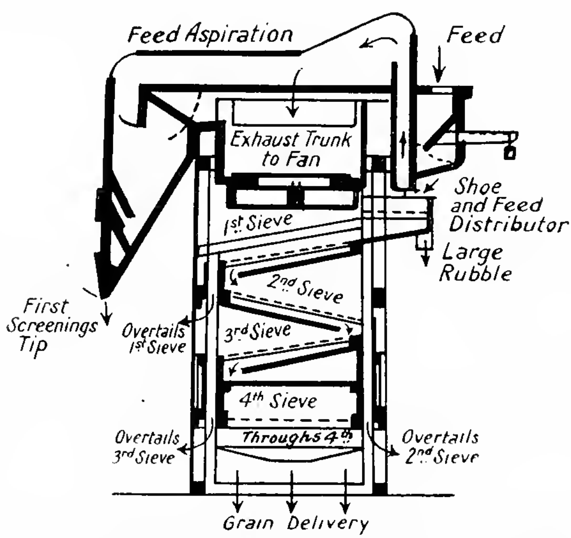

FIG. 214.—Zigzag separator. (Courtesy of Messrs. Samuelson.)

steel similar to those used in a wheat-cleaning machine, except that the perforations are larger to suit the different types of maize milled. It is operated by an eccentric shaft; a large fan is fixed on the frame, and the grain is subjected to a strong air current on entering and leaving the machine. After passing over a magnetic separator, which extracts any nails, pieces of wire, or metal, the grain is fed into a special "scourer" which polishes it and takes out any weevils if old maize is being treated.

If it is desired to turn out a high grade mielie meal for table use, the grain is subjected to further treatment by passing it through a "steaming-worm," into which is conducted "live" steam to toughen the bran-skin just before the grain passes to the grinders. The process is diagrammatically shown in Fig. 215. CHAP. XIII.

591. *Grinding.*—The grain is now in a fit state for grinding. This operation is performed either by stones or rollers, or by a combination of both.

For grinding maize and other cereals or mill-products, which require to be ground into a fine meal, a millstone has been put on the market in recent years, constructed of emery, or carborundum of a hard grain which, when dressed, has a fine, sharp, cutting face.

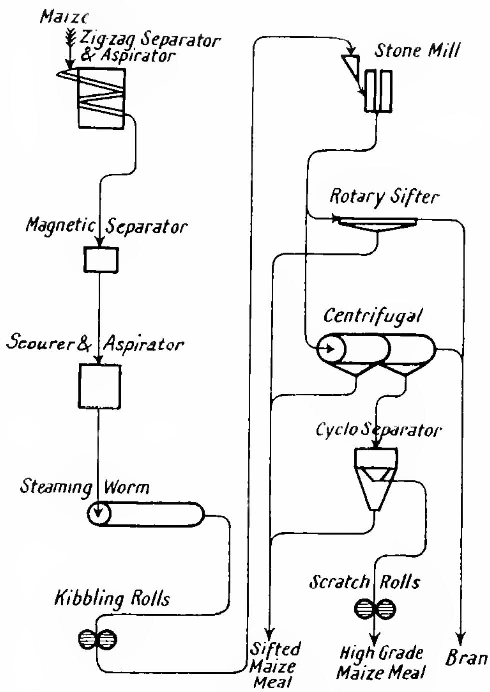

FIG. 215.—Diagram of maize-meal plant.

592. *The Millstone Process.*—The popular form of machine consists of two stones placed vertically, one stationary and the other or "runner stone" fixed to a disk-plate on a horizontal shaft turning at the rate of 400 to 500 revolutions per minute, according to the size of the stones. These stones are enclosed in a suitable cast-iron case, with feed-hopper and inlet, and two outlets to suit the position of the discharge spout. The shaft has automatic self-oiling bearings with ball-bearing thrust collar, and adjustable safety springs to prevent breakage, allowing the stone to give, in case any hard substance gets in. Better work is done if the maize is passed through "kibblers" or a pair of "kibbling rolls," with the feed-regulating roll specially fluted for treating maize, before it is passed

CHAP. XIII. on to the stones, and by this means also the life of the stones is lengthened.

The original type of this machine is believed to have been introduced by Messrs. W. S. Barron & Son of Gloucester, England; it was named the "Dreadnought," and has deservedly met with great success. It has lately been much improved by being fitted with "kibblers," which dispenses with the use of a kibbling roll, relieves the main stones of the rough work, and—the makers claim—entirely does away with

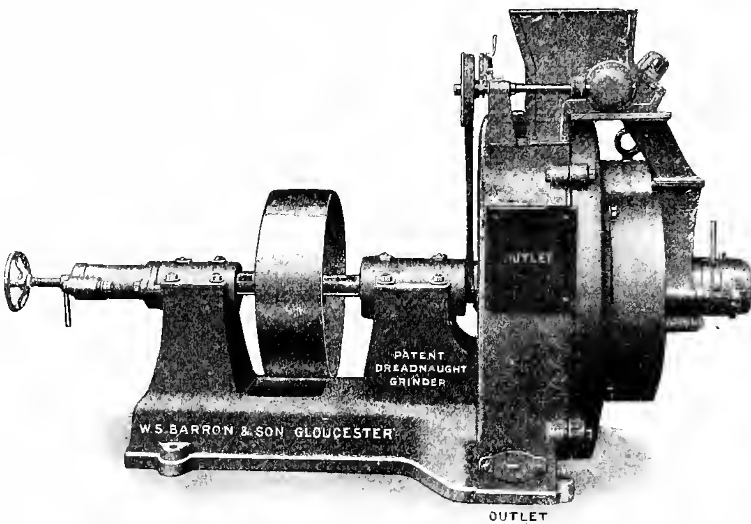

FIG. 216.—"Dreadnought" grinder. (Courtesy of Messrs. W. S. Barron & Son, Gloucester.)

stone dressing. The "Dreadnought" cuts up the maize, bran included, into a fine, even-grained meal, and the whole design and arrangement of the machine are admirable. (Figs. 216 and 217.)

If "sifted mielie meal" is required, the product is then passed on to a "rotary sieve scalper" which separates the meal from the bran.

For making the highest grade mielie meal for a nourishing and wholesome breakfast porridge, suited to the most fastidious palate, the type of maize is carefully selected, and the process is elaborated. A "centrifugal dressing machine" (Fig. 218), clothed with a steel slatted wire cover of suitable mesh, is sub- CHAP. XIII.

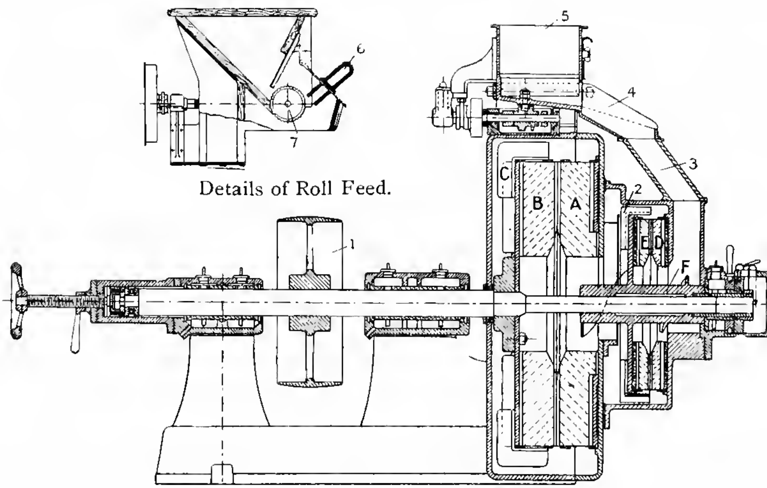

FIG. 217.—Diagram of "Dreadnought" grinder. (Courtesy of Messrs. W. S. Barron & Son, Gloucester.)

A, Fixed stone. B, Runner stone. C, Scrapers. D, Fixed kibbler. E, Runner kibbler. F, Kibbler runner plate. 1, Scrapers. 2, Feed spout. 3, Feed hopper. 4, Shaker shoe. 5, Feed roll. 6, Magnets. 7, Pulley.

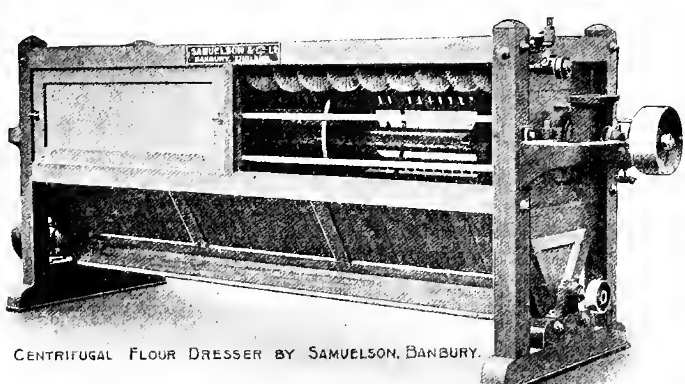

FIG. 218.—Centrifugal dressing machine. (Courtesy of Messrs. Samuelson, Banbury.)

stituted for the rotary sieve scalper; the head-end is clothed fine for dressing-out the fine meal, and the tail-sheet has a

CHAP. XIII. coarser cover for separating the granular meal from the bran, which passes out of the machine at the tail-end. The product of the tail-sheet is then purified on a "cyclo-separator" which subjects the material to a strong air current and eliminates the fine bran and other impurities. After it has been reduced on a pair of finely fluted rollers it passes to the posser (Fig. 219) for sacking off as a fine, pure meal.

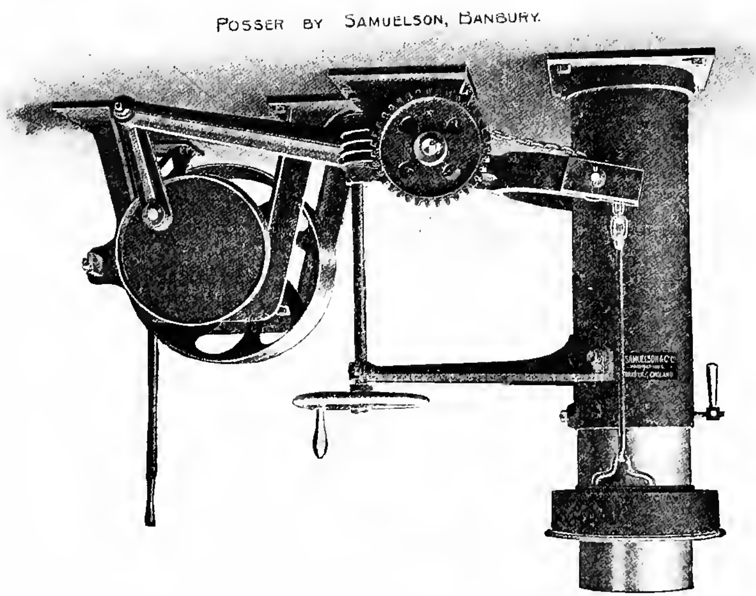

FIG. 219.—Posser. (Courtesy of Messrs. Samuelson, Banbury.)

593. *The Roller Mill Process.*—The roller process of maize grinding is generally carried out on a three-pair, high roller-mill (Fig. 220), consisting of three pairs of fluted rolls, superposed in an iron frame, with suitable feed roll and feed hopper fixed on the top of the frame. The grain is fed on to the first pair of rolls (which are coarsely fluted), through the feed hopper and feed roll, and are then passed on to a sieve, operated by a cam or reciprocating motion, which takes out the fine meal before the remainder passes on to the second "break" or pair of rolls, when the same process is repeated; it finally passes from the third pair of rolls, which are finely fluted, as finished

meal and bran. For "sifted meal" it is treated on the rotary sieve scalper previously referred to. CHAP. XIII.

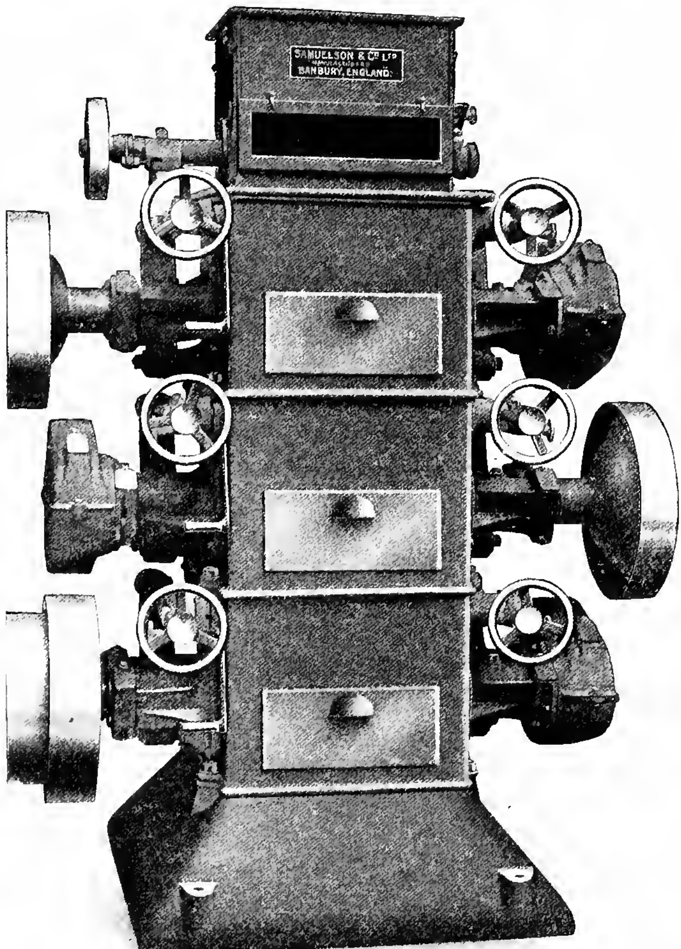

FIG. 220.—Three-pair high roller mill for grinding maize. (Courtesy of Messrs. Samuelson, Banbury.)

The advantage of this system lies in the fact that it requires less power to work it than is necessary for the millstone process, and that it makes a meal comparatively free

CHAP. XIII. from bran chips. But while the percentage of bran given off is larger, the meal produced is more granular and, it is said, has not as high a nutritive value as that obtained by the stone mill process; moreover, the wear and tear of the corrugations on the rollers is very heavy and they require constant refluting, otherwise the power must be considerably increased.

594. *Loss in Milling.*—The normal loss in milling should not exceed 1½ to 2 per cent if the maize is good, sound, and dry; this loss is due to cleaning and evaporation during the milling process. From 3 to 12½ per cent of bran is extracted when making "sifted mielie-meal," according to the system employed (i.e. the emery-stone or the roller process), the degree of fineness in dressing, and the kind of maize which is milled. In South Africa, a bag of mielie meal usually weighs 183 lbs. gross.

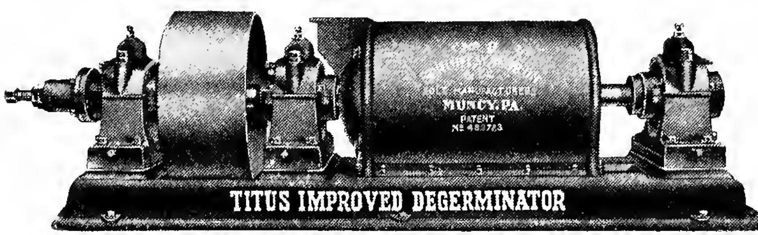

FIG. 221.—Improved degerminator.

595. *Samp.*—Another mill product largely used is known as samp, the manufacture of which has increased rapidly in South Africa during the last few years. Owing to the exceptional suitability of the South African types of maize (such as *Iowa Silver-mine*, *Ladysmith*, and *Hickory King*) for the manufacture of samp, and the adoption of the American system of manufacture and types of machinery, South African millers have practically ousted the American product from the local market.

For samp making, the grain is cleaned by the same process employed before milling, as described above (¶ 590). But a different manufacturing plant is required. This consists of a degerminator (Fig. 221) which removes the bran-skin and "germ" (i.e. the embyro), and breaks the grain into coarse particles. After passing through a steam dryer, the broken grain is treated on the "hominy separator" (Fig. 222), a double-dressing machine clothed with perforated steel or wire of suitable mesh, which takes out the "hominy-chop". This by-product consists of the "scourings" made by the degerminator in the breaking-process, combined with the bran and the "germ"; it contains a fairly high percentage of protein, is rich in oil, and therefore makes a highly nutritious cattle food, for which purpose a considerable quantity is exported from South Africa to Europe. The hominy separator also grades the samp and grits into suitable sizes; they are then subjected to a strong "aspirating" current. The grits are either reduced to CHAP. XIII.

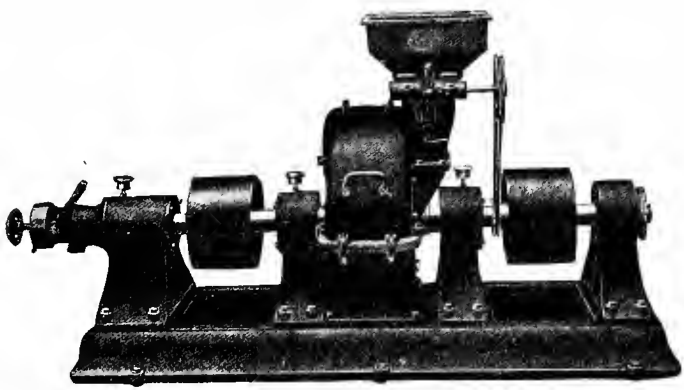

FIG. 222.—Hominy separator.

meal, on fluted rolls, or, if required for table use, are first purified. The process is diagrammatically illustrated in Fig. 223.

596. *Flaked Maize.*—Flaked maize is prepared as a breakfast food, and is also used by the brewing trade. The process of preparation is a continuation of that employed for samp. After the samp has been reduced to pure grits, these are "gelatinized," and then "flaked" by heavy rolls of special construction. The flakes are conveyed to a drier and subsequently sifted by a sifter to remove dust and flakes too large in size. A diagram illustrating a flaked maize plant is shown in Fig. 224.

Chemical Composition.

597. *Importance of a Knowledge of the Chemical Composition.*—A knowledge of the chemical composition and nutritive

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value of maize is important to us in order that we may intelligently "balance" the ration, by the addition of proper amounts of foodstuffs containing suitable proportions of other substances, and feed it so judiciously and economically that we shall secure the best results at the least cost.

It is also important that we should know the composition of the various mill products in order to take the fullest advantage of them, and utilize what otherwise might be waste.

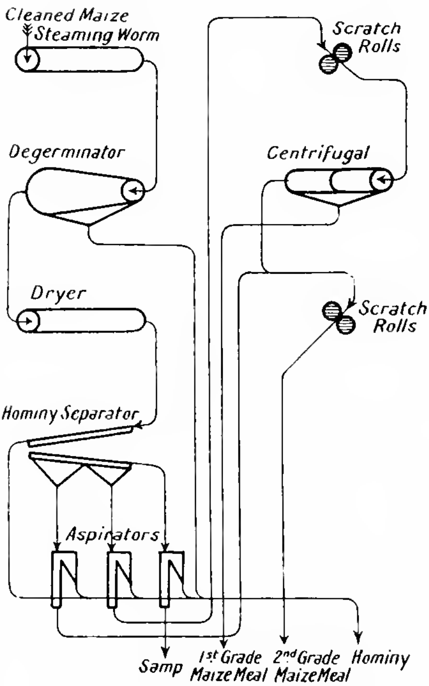

FIG. 223.—Diagram of samp plant.

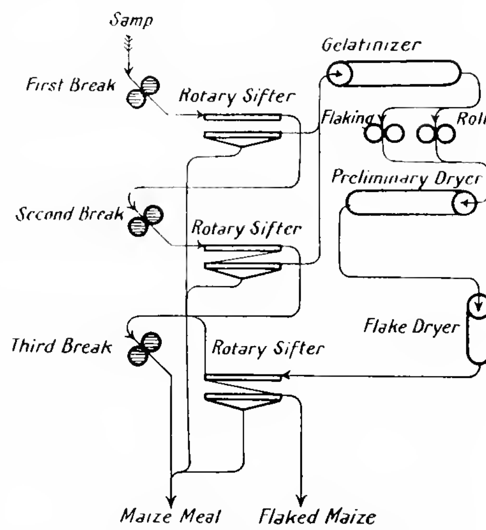

FIG. 224.—Diagram of flaked-maize plant.

Foodstuffs vary in nutritive value according to their chemical composition and digestibility. Some are better suited for developing the necessary muscle and bone of growing animals, others for producing fat or milk. Some, though rich in certain ingredients, are so poorly "balanced," that if fed alone they result in malnutrition and the consequent arrested development of growing animals. No one foodstuff can meet all the requirements of the successful feeder. The art of preparing food for either human beings or domestic animals, lies in producing rations so well balanced that the most complete development and the greatest amount of vital energy are secured at the lowest cost; or, in the case of animals for special uses, providing such rations as will bring about the particular results desired. In other words, the feeder must know, either by practical experience, or by scientific knowledge—and better by a combination of both—what particular combinations of foodstuffs will produce the desired results. A comprehension of foods and feeding is of value no less to the manager of the Mine Compound, feeding his thousands of natives with a view to producing the maximum of efficiency, than to the producer of beef, mutton, wool, and horse-flesh.

To acquire knowledge of all these points by practical experience alone, unaided by scientific study, is at best a very expensive and slow process, if indeed it is possible. The practical stock feeder, without any scientific knowledge, may be very successful with his stock up to a certain point, and as long as economic conditions and the state of his crops and of his veld remain the same; but when any of these change he finds himself in difficulty, and does not usually readjust himself without loss of time and money; often he fails financially through his inability to effect an adjustment.

But with a fair knowledge of the composition and nutritive value of the different available foodstuffs he is in a position to calculate what combination of materials producible on his farm, or readily and cheaply obtainable, can be most effectively and economically used at any time, under varying conditions of season, market, and other factors which affect prices and relative values.

On the other hand, scientific knowledge is not likely to help a man much unless he can combine it with sound business management and practical understanding of the feeding of animals.

598. *The Important Chemical Constituents of Foodstuffs.*—The important chemical constituents of foodstuffs in general are as follows:—

Protein (i.e. nitrogen × 6·25)—muscle-forming material.

Nitrogen-free extract (or carbohydrates minus the crude fibre)—fat forming material.

Ether extract, or fats, waxes, oils, and resins—heat producers.

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Ash or mineral substances, which have an influence on the formation of the bones.
Crude fibre—indigestible matter.
Water.

A large amount of work has been done in the United States—the home of the maize crop—in investigating the composition, digestibility and feeding-value of different parts of the maize plant, both by means of chemical analyses and by feeding tests and experiments to show its digestibility. To no other country can we turn for such complete information on the subject as to this one, where hundreds of such tests and analyses have been made.

599. *Chemical Composition of the Whole Grain.*—Careful studies have been made by the New Jersey and other State Agricultural Experiment Stations of the United States. These analyses show that the average composition of maize grain is as follows:—

TABLE LXXXIX.

AVERAGE COMPOSITION OF MAIZE GRAIN.

	Moist.[1]	Dry.[2]	Dry.[3]
	Per Cent	Per Cent	Per Cent.
Protein	10·3	12·6	12·85
Nitrogen-free Extract (Starches, Sugars, etc.)	70·4	79·4	80·12[4]
Ether Extract (Fats)	5·0	4·3	5·36
Crude Fibre	2·2	2·0	—
Ash	1·5	1·7	1·67
	89·4	100·0	100·0
Water	10·6	0·0	0·0
	100·0	100·0	100·0

600. *Protein.*—By the protein of feeding-stuffs we mean those ingredients which contain nitrogen, e.g., maize gluten and the white of eggs. The average nitrogen-content of protein is about 16 per cent. It is the protein of the foodstuffs which builds up various tissues of the animal body such as the muscles, tendons, internal organs, skin, etc., as well as the organic part of the bones.

[1] Myrick (1). [2] Henry (1). [3] Hopkins (3).
[4] Including crude fibre.

Protein occurs to some extent in all parts of the maize grain, but not in equal proportion. Voorhees (1) finds that the portion richest in protein is the horny layer, and this is confirmed by Hopkins (4). The latter (3) gives the distribution of the protein, in a medium protein maize, as follows:—

TABLE XC.

DISTRIBUTION OF PROTEIN IN PARTS OF THE MAIZE GRAIN.

			Totals.
In Tip Cap	1·14		
In Hull	2·07		
Total in Pericarp			3·21
In Horny Gluten	16·67		
In Horny Starch	42·36		
Total in Horny Endosperm		59·03	
In Crown Starch	11·88		
In Tip Starch	5·75		
Total in Starchy Endosperm		17·63	
Total in Endosperm			76·66
In Embryo, or "Germ"			20·14
Total			100·01

"As an average, about 22 per cent of the total protein is contained in the horny gluten, nearly 40 per cent in the horny starch, and nearly 20 per cent in the germ, thus these three parts contain about 80 per cent of the total protein in the kernel" (*Hopkins*, 3).

High protein maize is characterized by the large proportion of the *horny* part, and a correspondingly smaller proportion of the white *starchy* part.

601. *Protein obtainable from* 100 *lbs. of Maize Grain.*—Hopkins (3) gives the following tables showing the weight and distribution of the protein that may be obtained from 100 lbs. of maize grain:—

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TABLE XCI.

PROTEIN IN 100 LBS. OF MAIZE.

	Low Protein Corn.			High Protein Corn.			Difference.
	Per Cent of Corn.	Per Cent of Protein.	Lbs. of Protein.	Per Cent of Corn.	Per Cent of Protein.	Lbs. of Protein.	Lbs. of Protein.
In Embryo or "Germ"	9·33	18·01	1·68	11·44	21·25	2·43	·75
In Endosperm . .	90·67	5·69	5·16	88·56	13·80	12·22	7·06

"We thus find," he says, "as a result of corn breeding, that in the seventh generation we have a maximum difference of only ·75 lb. of protein in the germs from 100 lbs. of low protein and high protein corn, while in the endosperms from these two kinds of corn we have a difference of 7·06 lbs. of protein in 100 lbs. of corn. In other words, in changing the protein-content of corn, the effect produced in the endosperms amounts to almost ten times the effect produced in the germs."

TABLE XCII.

DISTRIBUTION OF PROTEIN IN 100 LBS. OF MAIZE.

	In Low Protein Corn.	In Medium Protein Corn.	In High Protein Corn.
In Tip Caps	·09	·13	·08
In Hulls	·27	·23	·23
In Horny Endosperm . .	5·25	6·69	8·20
In White Starch . . .	2·37	2·00	1·80
In Embryo or "Germ" .	1·91	2·28	2·33
Total . . .	9·89	11·33	12·64

602. *The Proteids of Maize Grain.*—Chittenden and Osborne (2) find that the maize grain contains several distinct proteids, well characterized in reactions and composition. Of these, there are three globulins, one or more albumins, and an alcohol-soluble proteid known as *zein*. The quantities of the different proteids in the maize grain are estimated (*Hopkins*, 4), as follows :—

		Per Cent.
(1)	Proteose, soluble in pure water	0·06
(2)	Very soluble globulin	0·04
(3)	Maysin, soluble in extremely dilute salt-solution	0·25
(4)	Edestin, soluble in more concentrated salt-solutions	0·10
(5)	Zein, soluble in alcohol	5·00
(6)	Proteid matter[1] soluble in dilute alkalies	3·15
(7)	Proteid matter insoluble in any of these solvents	1·03

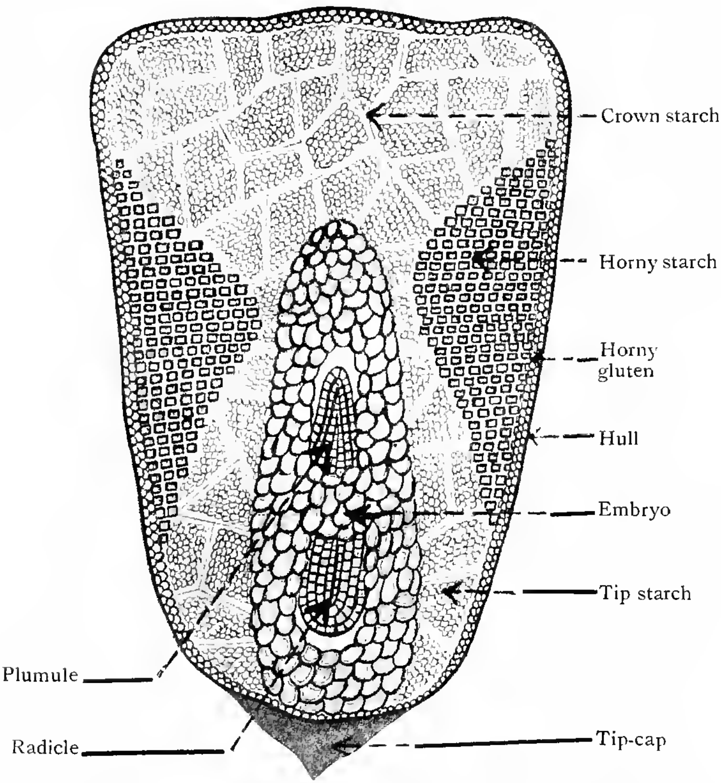

FIG. 225.—Physical composition of low-protein maize grain. (After Hopkins; from Bulletin of Illinois State Agricultural Experiment Station.)

The mean percentage of nitrogen in maize proteids is calculated by Hopkins as 16·02.

603. *Zein.*—The proteid *zein* is soluble in warm dilute alcohol, but insoluble in water. It is characterized by a high

[1] The protein is estimated by multiplying the amount of the nitrogen-content in the residue from 100 parts of maize, by the factor 6·25 (*Hopkins*, 4).

content of carbon, by its resistance to the action of dilute alkalies (i.e. non-convertibility into alkali-albuminate), and by the ease with which it is converted into an insoluble modification on being warmed with water, or with very weak alcohol. Soluble zein and the insoluble modification have the same chemical composition. Both respond to the ordinary proteid reactions (*Chittenden* and *Osborne*, 2).

604. *Ether Extract or "Fat"*.—This consists of fat, wax, resins, and similar substances. In grains and seeds it is nearly all fat or oil, and has a corresponding feeding value. In the case of maize, over 80 per cent of the fat or oil is contained in the embryo, and the rest nearly equally divided between the pericarp and the endosperm.

The following is the distribution of the ether-extract or fat in the grain of a medium protein-content maize, as determined by Hopkins (3):—

TABLE XCIII.

DISTRIBUTION OF FAT IN MAIZE.

			Totals.
In Tip Cap	·69		
In Hull	1·08		
Total in Pericarp			1·77
In Horny Gluten	12·21		
In Horny Starch	2·32		
Total in Horny Endosperm		14·53	
In Crown Starch	·59		
In Tip Starch	·68		
Total in Starchy Endosperm		1·27	
Total in Endosperm			15·80
In Embryo or "Germ"			82·43
Total			100·00

"The germ [embryo] contains from 80 to 84 per cent of the oil while all other parts combined contain only 15 to 20 per cent of the total oil in the kernel. Based upon this fact is the method for selecting high oil or low oil seed-corn by mechanical examination, the ears whose kernels show a large proportion of germ being high-oil corn, and those with small germs, low-oil corn. About 12 per cent of the total oil is contained in the horny gluten, leaving only about 5 per cent of the oil distributed among the remaining five physical parts, and more or less of this small amount is undoubtedly absorbed from the contiguous germ or horny gluten."

To breed maize for high oil-content, select for seed those ears having grain with large embryo.

605. *Carbohydrates.*—The carbohydrates include the starch, sugar, pentosans, gums, organic acid, crude fibre, and bodies other than the protein, ether-extract (fats) and ash. In analyses made to determine feeding-value, the amount of "*crude fibre*," which includes the cellulose and is largely indigestible, is given separately and the remainder of the carbohydrates stated under the heading "*Nitrogen-free extract*".

The function of the carbohydrates as foodstuffs is to produce fat. Hopkins finds the carbohydrates to be distributed as follows in the grain of a medium protein percentage ear :—

TABLE XCIV.

DISTRIBUTION OF CARBOHYDRATES IN MAIZE.

			Totals.
In Tip Cap	1·56		
In Hull	6·80		
Total in Pericarp	——		8·36
In Horny Gluten	7·15		
In Horny Starch	51·12		
Total in Horny Endosperm	——	58·27	
In Crown Starch	18·96		
In Tip Starch	9·45		
Total in Starchy Endosperm	——	28·41	
Total in Endosperm			86·68
In Embryo or "Germ"			4·97
Total			100·01

606. *Ash.*—The percentage of ash in maize grain is comparatively low, i.e. 1·5 per cent in moist grain and 1·7 per cent in dry. The following is the average of 15 analyses as given by Wolff (*Aschen Analysen*, 1880):—

K_2O	Na_2O	MgO	CaO	Fe_2O_3	P_2O_5	SO_3	SiO_2	Cl
29·8	1·1	15·5	2·2	0·8	45·6	0·8	2·1	0·9

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"It seems evident that as a rule the ash of corn [maize grain] contains at least 95 per cent of the phosphates of potassium and magnesium, about twice as much potash as magnesia being present" (*Hopkins*, 3).

An extended investigation of the ash of maize grain, with reference to its content of fertilizing elements, was made by Scovell and Peter at the Kentucky Station (*Rep.* 1891). They found an average of 51·91 per cent phosphoric oxide (P_2O_5) and 29·15 per cent of potassium oxide (K_2O).

The low percentage (2·2) of lime has an important bearing on the feeding value of maize for growing pigs; whether used alone or with skim milk only, the addition of some substance containing more bone-making material is necessary. It is found that maize-fed pigs readily eat ashes to which they are allowed access.

The following is the distribution of the ash in the grain of a medium protein-content maize, as determined by Hopkins (3):—

TABLE XCV.

DISTRIBUTION OF ASH IN MAIZE.

			Totals.
In Tip Cap	1·06		
In Hull	3·06		
Total in Pericarp			4·12
In Horny Gluten	9·56		
In Horny Starch	7·38		
Total in Horny Endosperm		16·94	
In Crown Starch	2·67		
In Tip Starch	1·72		
Total in Starchy Endosperm		4·39	
Total in Endosperm			21·33
In Embryo or "Germ"			74·55
Total			100·00

607. *Water.*—Water is essential to the animal metabolism. But it is usually obtainable with so little difficulty from other sources than the foodstuffs that the relative value of foodstuffs is, as a rule, calculated on the basis of water-free material.

The percentage of water contained in the various foodstuffs varies greatly; dry maize-grain contains 10 to 12 per cent; dry oat-hay or "forage" about 15 per cent; pasture-grass up to 75 per cent; cabbages, pumpkins, and "prickly-pear," or spineless cactus "leaves," about 90 per cent. CHAP. XIII.

608. *Physical Composition of the Grain.*—The maize grain is not a homogeneous mass, and from the milling and feeding

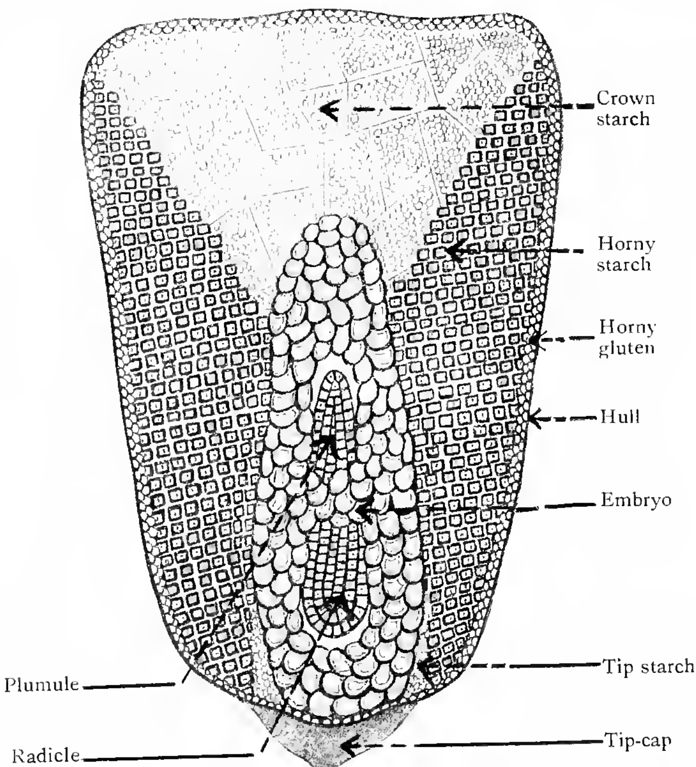

FIG. 226.—Physical composition of high-protein maize grain. (After Hopkins; from Bulletin of Illinois State Agricultural Experiment Station.)

points of view it is important to know the chemical composition of the several parts into which it is separable. A grain of maize consists of six readily observable and distinctly different physical parts, known as:—

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A. The Pericarp.
 (i) The Tip Cap.
 (ii) The Hull.
B. The Embryo ("Germ").
C. The Endosperm.
 (iv) The Horny Gluten.
 (v) The Horny Starch.
  a. Crown Starch.
  b. Tip Starch.
 (vi) The White Starch.

609. *Mechanical Separation of the Different Parts for Analysis.*—Comparatively pure samples of these six principal parts may be made by the use of a small, sharp knife. Waste will be obtained in the process, consisting of horny gluten, horny starch, and white starch.

To make the separation, the grains should be first soaked for 15 or 20 minutes in hot water. The tip cap is then easily and completely separated by simply cutting under one edge and then pulling it off.

The hull is separated without difficulty by peeling it off in strips, using the knife to start the peeling at the tip end where the hull has been broken by removing the tip cap. By taking care, the complete hull can be peeled out of the *dent* in the grain of dent maize.

The horny gluten is then more easily distinguished. It will be plainly seen that it covers the whole grain, except, possibly, the exposed part of the embryo. The horny gluten is removed by carefully shaving it off with the knife; if the pieces have been allowed to dry for some time, the adhering particles of starch can be more easily separated; in scraping them off, more or less horny gluten will also be scraped off, so that while it is possible thus to obtain a pure, clean sample of the horny gluten, some waste material is also obtained, which consists of the three endosperm substances—horny gluten, horny starch, and white starch.

With care the embryo can be removed completely; if any particles of starch adhere to it, they can be easily and completely scraped off. The remaining part of the grain consists only of the horny starch and the white starch; this is allowed to dry, and is then broken in two, lengthwise.

The crown starch may be dug out with the knife, care being taken not to remove any of the horny starch.

The tip starch is removed in the same way.

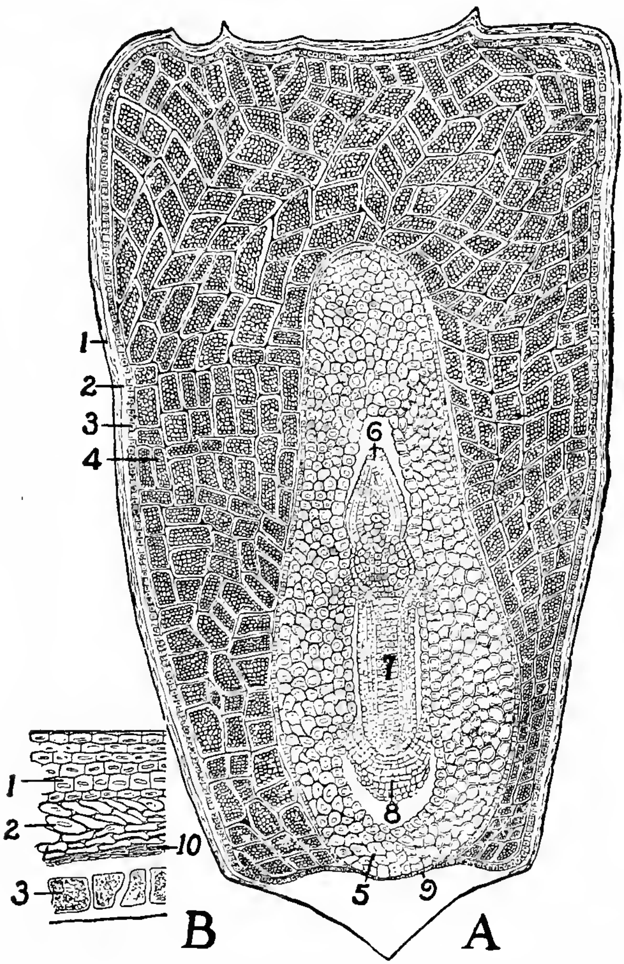

FIG. 227.—Enlarged longitudinal section of maize grain. The internal structure is diagrammatic, the cells as here shown being about 100 times larger than their true proportion to the rest of the illustration. A, 1, hull; 2, testa; 3, aleurone layer; 4, endosperm cells; 5, scutellum; 6, plumule, or bud of the embryo; 7, primary root; 8, root-sheath; 9, a row of cells similar in appearance to the aleurone layer but smaller. B, section more highly magnified, showing, 1, epicarp; 2, testa; 3, aleurone layer; 10, perisperm. (From Hunt, *The Cereals in America*, Orange Judd Co.)

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The horny starch from each half will then, usually, remain in one piece; this is then carefully scraped to remove all adhering particles of white starch or horny gluten, the scrapings being carefully saved and added to the waste material.

By this method of separation eight different products are obtained, one of these being the waste material made up of particles from the different parts of the endosperm.

The above notes are taken from Hopkins (3), and the present writer has followed him in employing the term "starch" in a technical or commercial sense, and not as the name of a definite chemical compound.

610. *Relative Proportions of the Parts of the Grain.*—The relative proportions of the parts of the grain, as obtained by averaging three analyses compiled from Hopkins's tables, are:—

TABLE XCVI.

RELATIVE PROPORTIONS OF THE PARTS OF MAIZE GRAIN.

			Totals.
Tip Cap	1·43		
Hull	5·83		
Total Pericarp			7·26
Horny Gluten	11·15		
Horny Starch	43·04		
Total Horny Endosperm		54·19	
Crown Starch	17·38		
Tip Starch	10·16		
Total Starchy Endosperm		27·54	
Total Endosperm			81·73
Embryo or "Germ"			11·02
Total			100·01

611. *Chemical Composition of the Physical Parts of the Grain.*—The New Jersey Station has obtained the following results of analyses of the three primary parts of the maize-grain:—

TABLE XCVII.

CHEMICAL COMPOSITION OF HULL, EMBRYO AND ENDOSPERM.

	Hull.	Embryo.	Endosperm.
Protein	6·6	21·7	12·2
Ash	1·3	11·1	0·7
Fat	1·6	29·6	1·5
Carbohydrates—			
Nitrogen-free Extract	74·11	34·7	85·0
Crude Fibre	16·4	2·9	0·6
	100·0	100·0	100·0

The chemical composition of the grain and its several parts varies in different breeds and different strains. The following is the percentage composition of an ear of medium protein-content as ascertained by Hopkins (3):—

TABLE XCVIII.

CHEMICAL COMPOSITION OF THE PHYSICAL PARTS OF THE GRAIN.

	Per Cent of Whole Grain.	Protein.	Oil.	Ash.	Carbohydrates.	Total.
Tip Cap	1·46	8·83	2·30	1·11	87·76	100·0
Hull	5·93	3·96	0·89	0·79	94·36	100·0
Horny Gluten	5·12	22·50	6·99	1·72	69·09	100·0
Horny Starch	32·80	10·20	0·24	0·24	89·32	100·0
Crown Starch	11·85	7·92	0·17	0·24	91·67	100·0
Tip Starch	5·91	7·68	0·39	0·31	91·62	100·0
Germ	11·53	19·80	34·84	9·90	35·46	100·0
Mixed Waste	25·40	11·10	1·23	0·57	87·10	100·0
Whole Kernel	—	10·95	4·33	1·55	83·17	100·0

The percentage distribution of the total content of protein, oil, ash, and carbohydrates through the different parts of the grain is shown in the following table (*Hopkins*, 3):—

TABLE XCIX.

PERCENTAGE DISTRIBUTION OF THE CHEMICAL COMPONENTS OF THE GRAIN.

	Protein.	Oil.	Ash.	Carbohydrates.
Tip Cap	1·14	0·69	1·06	1·56
Hull	2·07	1·08	3·06	6·80
Horny Gluten	16·67	12·21	9·56	7·15
Horny Starch	42·36	2·32	7·38	51·12
Crown Starch	11·88	0·59	2·67	18·96
Tip Starch	5·75	0·68	1·72	9·45
Germs	20·14	82·43	74·55	4·97
Total	100·01	100·00	100·00	100·01

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612. *The Tip Cap.*—The tip cap is a small cap which covers the tip end of the grain and protects the end of the embryo. It is composed of material somewhat resembling that of the cob, and comprises from 1¼ to 1½ per cent of the whole grain. It consists mainly of carbohydrates (87 per cent). When the grain is very dry and hard, the tip cap sometimes remains attached to the cob in shelling; failure of the seed to germinate has been attributed to the consequent exposure of the radicle of the embryo.

The chemical composition of the tip cap is as follows:—

TABLE C.

PERCENTAGE COMPOSITION OF THE TIP CAP.

	Percentage Composition	
	Of Tip Cap.	Of Whole Grain.
Protein	8·83	1·14
Oil	2·30	·69
Ash	1·11	1·06
Carbohydrates	87·76	1·56
	100·00	

613. *The Hull.*—The hull, husk, or skin, is the thin outer covering of the grain, corresponding to the pericarp of a fruit. It comprises from 5½ to 6 per cent of the whole grain.

TABLE CI.

PERCENTAGE COMPOSITION OF THE HULL.

	Percentage Composition	
	Of Hull.	Of Whole Grain.
Protein	3·96	2·07
Oil	·89	1·08
Ash	·79	3·06
Carbohydrates	94·36	6·80
	100·00	

It consists mainly of carbohydrates (94 per cent) and contains nearly all of the crude fibre of the grain; it contains a lower percentage of protein than any other part of the grain. In the process of manufacture the hull is usually removed as a by-product known as maize bran. CHAP. XIII.

614. *The Embryo or "Germ".*—The embryo lies at the tip end of the grain, on the upper side facing toward the tip of

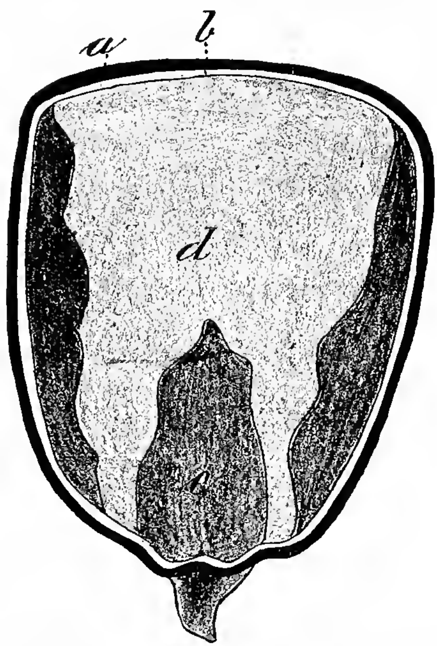

FIG. 228.—Hull, endosperm, and embryo. (*a*) The husk or skin, which covers the whole grain; it consists of two distinct layers, the outer and inner, which when removed constitute the bran and contain practically all the crude fibre of the whole grain. (*b*) A layer of gluten cells, which lies immediately underneath the husk; it is yellow in colour, and cannot be readily separated from the remainder of the grain. This part is richer than any other in gluten. (*c*) The embryo, which is readily distinguished by its position and form; it also contains gluten, though it is particularly rich in oil and mineral constituents. (*d*) The endosperm portion, which is composed chiefly of starch; the dark colour indicates the yellow, flinty part, in which the starch-holding cells are more closely compacted. (From Myrick, *The Book of Corn*, Orange Judd Co.)

the ear, and practically in the middle, usually extending from one-half to two-thirds of its length (Figs. 227 and 228). The embryo contains all the vital parts of the young plant, as described elsewhere (¶ 63). It varies greatly in size, comprising

CHAP. XIII. from $9\frac{1}{2}$ to 12 per cent of the whole grain; is particularly rich in oil (82 per cent) and ash, and carries one-fifth of the protein of the whole grain. In the process of manufacture of hominy and starch-products the embryo is usually separated and treated as a by-product under the name of "germ".

TABLE CII.

PERCENTAGE COMPOSITION OF THE EMBRYO.

	Percentage Composition	
	Of Embryo.	Of Whole Grain.
Protein	19·80	20·14
Oil	34·84	82·43
Ash	9·90	74·55
Carbohydrates	35·46	4·97
Total	100·00	

615. *The Endosperm.*—The endosperm of the grain is not, as we have seen, homogeneous, but consists of two very distinct portions, the "horny" and the "white starchy" parts; the horny portion is further subdivided into two parts, the "horny gluten" and the "horny starch". The horny part is readily distinguishable by its translucence when the grain is held up to the light, and the relative proportion of translucent horny endosperm and of white starchy endosperm forms some guide to the relative feeding-value of the grain.

616. *The Horny Gluten.*—The "horny gluten" or *aleurone layer* lies immediately beneath, and is usually much thicker than, the hull. It constitutes a second covering of the seed and surrounds the starch; in some breeds of maize it is readily distinguishable because it carries the colouring matter of the grain. The amount of horny gluten varies greatly in the grain (Hopkins notes variations between 5·12 per cent and 14 per cent), and may be increased by breeding. It does not consist of *pure gluten*, but is richer in percentage of protein-content than any other single part, though it contains only $16\frac{1}{2}$ per cent of the total protein-content of the grain.

TABLE CIII.

PERCENTAGE COMPOSITION OF THE HORNY GLUTEN.

	Percentage Composition	
	Of Horny Gluten.	Of Whole Grain.
Protein	22·50	16·67
Oil	6·99	12·21
Ash	1·72	9·56
Carbohydrates	69·09	7·15
	100·30	

617. *The Horny Starch.*—The "horny starch" is found on the back and sides of the grain, lying next below the horny gluten. It does not consist of pure starch, but contains considerable amounts of other substances, especially protein. In an examination of the grain with the unaided eye the horny glutenous part and the horny starchy part are not readily distinguished from each other, the line between them being somewhat indefinite and indistinct. Together they constitute the horny part of the grain.

TABLE CIV.

PERCENTAGE COMPOSITION OF THE HORNY STARCH.

	Percentage Composition	
	Of Horny Starch.	Of Whole Grain.
Protein	10·20	42·36
Oil	·24	2·32
Ash	·24	7·38
Carbohydrates	89·32	51·12
	100·00	

The horny starch is only half as rich in protein as the horny gluten, but as there is so much more of it (it comprises up to 45 per cent of the whole grain), it contains 42 per cent of the total protein-content, and 51 per cent of the total carbohydrates.

The percentage of horny starch varies in individual plants, and may be greatly increased by breeding.

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618. *The White Starchy Parts.*—The white starchy part occupies the crown end of the kernel above the embryo, and it also nearly surrounds the germ towards the tip end of the grain. For convenience this substance is called "*white starch*" (¶ 609), though it does not consist of pure starch. In some grains the horny starch extends nearly or quite to the embryo, near the middle of the grain, and thus separates the "white starch," more or less completely into two parts, called respectively "*crown starch*" and "*tip starch*".

TABLE CV.

PERCENTAGE COMPOSITION OF WHITE STARCH.

	Percentage Composition			
	Of White Starch.		Of Whole Grain.	
	Crown Starch.	Tip Starch.	Crown Starch.	Tip Starch.
Protein	7·92	7·68	11·88	5·75
Oil	·17	·39	·59	·68
Ash	·24	·31	2·67	1·72
Carbohydrates	91·67	91·62	18·96	9·45
	100·00	100·00		

619. *Chemical Composition of Different Varieties and Breeds of South African Maize.*—Ingle (5) has given the following analyses of ten breeds representing three botanical varieties of maize, grown at the Government Experiment Farm, Potchefstroom, Transvaal. It will be noticed that in all cases the flint are distinctly richer in protein, ash, and fat, and poorer in carbohydrates than the dent breeds, while the flour corn is lowest in protein, ash, and fat, though richest in starch.

It would appear from these analyses that flint maize is better for feeding purposes than the dent breeds, and that Transvaal maize is drier (doubtless due to climatic conditions) than the average North American product, which contains (average of 154 analyses) 10·95 per cent of moisture.

TABLE CVI.

CHEMICAL COMPOSITION OF DIFFERENT VARIETIES AND BREEDS.

Description.	Moisture.	Ash.	Crude Fibre.	Nitrogen-free Extract.	Ether Extract.	Protein (N × 6·25).
Flint Maize—						
White Cango	7·81	2·26	1·70	72·83	5·09	10·31
Vilmorin's Early Yellow	6·92	1·42	1·68	73·98	5·25	10·75
Indian Pearl	7·47	1·88	2·23	71·40	5·40	11·62
Mean of Three	7·40	1·85	1·87	72·74	5·25	10·89
Dent Maize—						
Golden King	7·64	1·29	2·28	75·18	4·61	9·00 [1]
Hickory King	6·76	1·24	1·68	76·64	4·24	9·44
Yellow Hogan	6·73	1·25	1·91	76·11	4·87	9·13
King of the Earliest	7·27	1·24	2·19	75·49	4·25	9·56
Red Hogan	6·60	1·28	1·75	76·33	4·73	9·31
Early Leaming	6·76	1·27	1·83	75·45	4·63	10·06
Mean of Six	6·97	1·27	1·94	75·87	4·53	9·42
Soft or Bread Maize—						
Brazilian Flour corn	7·72	1·14	1·51	76·26	4·37	9·00
Mean of Ten	7·16	1·42	1·86	74·96	4·74	9·81

At the suggestion of the writer, Mr. R. D. Watt (3) later carried out a further series of analyses of Transvaal-grown maize in order to prove or disprove the idea then prevalent in some quarters that a *broad-grained* type of maize like *Hickory King* is of higher feeding value than the narrow, wedge-shaped type. "As the feeding value of maize depends almost entirely on the percentage of protein it contains, this ingredient, only, was determined." The protein-content, as shown in Table CVII (following), entirely upsets this idea, for *all* the broad dent varieties, except *Woods Northern White Dent*, are very near the bottom of the list; *Hickory King* itself comes very low. The average protein-content of the four breeds of the broad type is 9·44 per cent, whereas the average of the thirteen wedge-shaped breeds is 9·77 per cent. It is evident from the table that the *colour* of the maize grain is no guide as to its protein-content, though the difference in flavour of the yellow maize may affect its feeding-value.

[1] Two other samples of *Golden King* analysed at the Pretoria laboratories gave only 8·98 and 8·88 per cent of protein respectively. It is evident that this is not a good breed of maize for feeding purposes.

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TABLE CVII.

PROTEIN-CONTENT OF EIGHTEEN SAMPLES OF TRANSVAAL MAIZE.

Variety.		Colour of Grain.	Shape of Grain.	Protein.
				Per Cent
Improved Early Horsetooth .	Dent	White	Narrow	10·47
Thoroughbred White Flint .	Flint	,,	Broad	10·43
Woods Northern White Dent .	Dent	,,	,,	10·43
White-cap Dent	,,	Yellow and White	Narrow	10·25
Early Star Leaming . . .	,,	Yellow	,,	10·07
Extra Early Huron Dent (I) .	,,	,,	,,	10·06
Extra Early Huron Dent (II) .	,,	,,	,,	9·93
Yellow Hogan	,,	,,	,,	9·91
Iowa Silver-mine . . .	,,	White	,,	9·90
Champion White Pearl . .	,,	,,	,,	9·86
Hawkesbury Champion . .	,,	Yellow	,,	9·69
Hickory Horsetooth . .	,,	White	,,	9·64
Austin Colossal . . .	,,	Yellow	,,	9·61
Hickory King (good sample) .	,,	White	Broad	9·34
Chester County . . .	,,	Yellow	Narrow	9·30
Hickory King (crossed) . .	,,	White	Broad	9·01
Golden King	,,	Yellow	,,	8·98
Wisconsin White Dent . .	,,	White	Narrow	8·58

From this table it is also perfectly clear that high-protein maize can be grown in the Transvaal, five of the dent breeds averaging as high as, and two of them *exceeding*, the analyses of American-grown dents. Another interesting and valuable point brought out is that dent maize may contain a higher protein-content than flint maize. The question of the production in South Africa of maize of high feeding value, therefore, resolves itself entirely into one of breeding.[1]

620. *Chemical Composition of Different Varieties of North American Maize.*—The following figures are given by Jenkins and Winton (1) as the average results of 208 analyses of samples representing the five important botanical varieties of maize grown commercially in the United States :—

[1] Since the above was written Dr. Juritz reports as the result of recent analyses, that "*Iowa Silver-mine* gave distinctly better protein percentages than *Hickory King*".

TABLE CVIII.

	Water.	Ash.	Protein.	Crude Fibre.	Nitrogen-free Extract.	Fat.
Dent maize; average of 86 analyses .	10·6	1·5	10·3	2·2	70·4	5·0
Flint ,, ,, ,, 68 ,, .	11·3	1·4	10·5	1·7	70·1	5·0
Sweet ,, ,, ,, 28 ,, .	8·8	1·9	11·6	2·8	66·8	8·1
Pop ,, ,, ,, 4 ,, .	10·7	1·5	11·2	1·8	69·6	5·2
Flour ,, ,, ,, 5 ,, .	9·3	1·6	11·4	2·0	70·2	5·5
Average of 208 analyses of all varieties .	10·9	1·5	10·5	2·1	69·6	5·4

621. *Composition of Maize Grain Grown in Different Localities.*—The cultivation of maize under the different telluric and climatologic conditions of different parts of the country does not appear to materially affect its composition. As the result of over 200 analyses of maize grain, from different parts of the United States, Richardson (1) found it to be "very constant in its composition, within narrow limits".

A very interesting and valuable series of twenty-seven analyses has recently been completed by Mr. H. J. Vipond, Chemist of the Department of Agriculture, Union of South Africa, to determine the percentages of—

Protein
Ash
Lime
Magnesia
Sulphuric Acid
Phosphoric Acid

in samples of various breeds of maize grown in parts of the country with different soils and widely different climatic conditions. The result is given in Table CIX following. The suggestion had been made in the public press that South African grown maize appeared to be less nutritious than that grown in the United States, and that the climate or soil might cause a difference in the chemical composition. The results of these twenty-seven analyses clearly prove that *South African maize is usually quite as rich and sometimes richer in nutrients than that grown in the United States* and subjected to the same analysis.

Protein: the extreme range of variation in protein-content was 4·72 per cent or from 8·23 per cent to 12·95 per cent.

Table CIX.

COMPOSITION OF GRAIN GROWN IN DIFFERENT LOCALITIES.

Record No.	Name of Breed.	Origin.	Received by Bot. Div.	Chemistry Division No.	Moisture Per Cent.	Protein Per Cent.	Ash Per Cent.	Lime Per Cent.	Magnesia Per Cent.	Sulphuric Acid Per Cent.	Phosphoric Acid Per Cent.
501/11	Hickory King	W. B. Bosse, Richmond, Natal	6/9/11	2328	8·57	9·71	1·26	Trace	Not determined	·06	·60
498/11	,, ,,	J. Moon, Manderston, Natal	1/9/11	2329	8·15	9·98	1·29	,,	,,	·05	·62
571/11	,, ,,	M. Geerdts, Schapenrust, Transvaal	27/9/11	2330	8·25	10·15	1·09	,,	·19	·04	·51
553/11	Iowa Silver-mine	Experiment Farm, Potchefstroom, Transvaal	5/10/11	2331	8·24	9·63	1·17	,,	·21	·02	·50
502/11	Natal White Horsetooth	W. B. Bosse, Richmond, Natal	6/9/11	2332	9·08	9·36	1·20	,,	·20	·04	·58
504/11	Golden Beauty	,, ,, ,,	6/9/11	2333	9·04	9·98	1·22	,,	·20	·04	·63
503/11	Yellow Horsetooth	,, ,, ,,	6/9/11	2334	8·70	10·06	1·23	,,	·22	·02	·57
580/10	German Yellow	J. W. Flett, Craigside, Natal	12/9/10	2335	8·63	9·36	1·23	,,	·19	·03	·62
624/10	Sheep's Tooth	Bright & Pallister, Buffelspoort, Transvaal	29/9/10	2336	8·41	10·06	1·29	,,	·21	Trace	·62
382/11	Chester County	C. F. Stallard, Nancefield, Johannesburg	8/6/11	2337	8·08	8·58	·94	,,	·20	·01	·42
543/11	Eureka	M. Geerdts, Schapenrust, Transvaal	27/9/11	2338	8·28	9·19	1·08	,,	·20	·06	·47
457/11	Wills Gehu	Oscar Wills & Co., U.S.A.	2/8/11	2339	8·27	11·11	1·40	,,	·27	·04	·69
497/11	,, ,,	Pullen, Schuurweberg, Pretoria	1/9/11	2340	8·06	11·55	1·14	,,	·23	·03	·52
496/11	Wills Dakota	,, ,, ,,	1/9/11	2341	7·61	11·29	1·04	,,	·19	·05	·45
402/11	Reids Yellow Dent	Vogler & Son, U.S.A.	21/6/11	·342	8·82	9·36	1·33	,,	·22	·01	·64
508/11	Boone County	Archibald & Co., Umzinto, Natal	11/9/11	2343	8·01	9·84	1·12	,,	·20	·02	·48
552/11	Yellow Hogan	W. A. McLaren, Vereeniging, Heidelberg Dist.	3/10/11	2344	8·19	9·71	1·24	,,	·23	·03	·62
573/11	Chester County	S. J. Hyde, Leeuwdoorns, Wolmaransstad	30/8/11	2345	8·12	9·58	·94	,,	·19	·02	·39
468/11	"Argentine"	Skinner's Court, Pretoria	12/8/11	2346	7·98	8·23	1·42	,,	·25	·01	·69
767/11	Cinquantino	Vilmorin-Andrieux & Co., France	·8/12/10	2347	8·05	12·95	1·48	,,	·29	·04	·79
483/11	White Botman	Fleming, Leeuwdoorns, Wolmaransstad	21/8/11	2348	7·94	12·69	1·10	,,	·23	·01	·44
574/11	Virginia Horsetooth	P. C. Bezuidenhout, Kameeldrift, Pretoria	21/8/11	2349	7·96	10·84	1·51	,,	·22	·02	·67
—	Mielie Meal	W. H. Horsfall, Aliwal North, C.P.	—	2350	8·70	8·71	1·07	,,	·20	·02	·49
—	White Cango	Cullinan, "England," Vryburg Dist.	—	2377	7·67	11·64	1·22	,,	·23	·03	·56
—	Yellow Cango	,, ,, ,, ,,	—	2378	7·55	10·76	1·04	,,	·21	·01	·44
—	German Yellow	,, ,, ,, ,,	—	2379	7·56	10·93	1·37	,,	·23	·04	·51
—	Eureka	,, ,, ,, ,,	—	2380	7·19	10·15	1·09	,,	·25	·02	·63
	Average of 23 South African grown samples				8·14	10·14	1·18		·195	·028	·545
	Average of the two American samples				8·54	10·23	1·36		·24	·025	·665
	Cinquantino, European grown				8·05	12·95	1·48		·29	·04	·79

The average protein-content of all samples was 10·20 per cent, and twenty-two samples ranged from 8½ to 11½ per cent with the mode at 9½ to 10½ per cent, as follows:— CHAP. XIII.

8 – 8½	per cent	=	1 sample
8½ – 9½	,,	=	6 samples
9½ – 10½	,,	=	11 ,,
10½ – 11½	,,	=	5 ,,
11½ – 12½	,,	=	2 ,,
12½ – 13	,,	=	2 ,,
			27

It is also clear that variation in protein percentage *depends on the breed* rather than on the locality, the range of variation in protein-content of maize of different breeds grown on the same farm extending to 1·5 per cent; between two different breeds both grown at Leeuwdoorns there was a difference of 2·11 per cent protein. The difference between samples of the same breed grown in the one case at Richmond, Natal, and in the other case on the Transvaal High-veld, is only ·44 per cent.

As compared with the United States, a sample of *Wills Gehu* grown in the Pretoria District shows an *increase* of ·44 per cent protein over the original sample imported from the breeder in the United States (but the imported grain was more than a year old).

622. *Relative Feeding-value of Maize, Wheat, and Other Cereals.*—According to the Bureau of Chemistry of the United States Department of Agriculture (*U.S.D.A.*, 9), *the same amount of digestible matter* in wheat and in maize is purchased for the same amount of money when both are selling at the same price per bushel. The maize would yield 2½ lbs. more carbohydrates than the wheat, and the wheat 2½ lbs. more protein than the maize.

As compared with wheat, maize is rich in starch and fat and low in protein-content As compared with rice it is richer in protein and fat, but contains much less starch. The following table (CX) taken mainly from Church (1), shows the relative chemical composition of the principal cereals of the world:—

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TABLE CX.

CHEMICAL COMPOSITION OF THE DIFFERENT CEREALS OF THE WORLD.

	Water.	Protein.	Starch.	Fat.	Fibre.	Ash.	Authority.
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	
Maize (India) . .	12·5	9·5	70·7	3·6	2·0	1·7	Church
,, (U.S.A.) . .	10·9	10·5	69·6	5·4	2·1	1·5	Jenkins
,, (Transvaal) .	7·2	10·1	74·3	4·9	1·9	1·6	Ingle
Rice (India) . .	12·8	7·3	78·3	·6	·4	·6	Church
Kaffir corn (India) .	12·5	9·3	72·3	2·0	2·2	1·7	,,
Buckwheat . .	13·4	15·2	63·6	3·4	2·1	2·3	,,
Barley (India) . .	12·5	11·5	70·0	1·3	2·6	2·1	,,
Wheat (India) . .	12·5	13·5	68·4	1·2	2·7	1·7	,,
Oats (India) . .	12·7	10·1	56·0	2·3	16·6	2·3	,,
Kaffir Manna-koren (*Pennisetum spicatum*) (India) . .	11·3	10·4	71·5	3·3	1·5	2·0	,,
M'Pawha or Ragi (*Eleusine Coracana*) (India) . . .	13·2	7·3	73·2	1·5	2·5	2·3	,,
Common millet (India)	12·0	12·6	69·4	3·6	1·0	1·4	,,

623. *Composition of Maize By-products.*—The following report on analyses of maize products used for stock-food is furnished by Hunt:—

TABLE CXI.

COMPOSITION OF SOME MAIZE BY-PRODUCTS.

	Water.	Protein (N × 6·25)	Ash.	Fats.	Nitrogen-free Extract.	Crude Fibre.
Gluten Meal . .	9·2	36·9	1·1	3·9	46·7	2·2
Maize Bran . . .	9·1	9·9	1·3	5·6	62·0	12·1
Gluten Feed . .	8·5	25·7	1·2	4·4	53·5	6·7
Germ Meal . . .	9·1	23·0	2·6	10·7	45·6	9·0
Hominy Feed . .	9·3	11·2	2·7	8·6	63 7	4·5
Cerealine Feed . .	10·2	11·2	2·6	8·1	63·3	4·6
Distillers' Grains (mostly Maize) . . .	8·8	35·0	2·4	11·3	30·4	12·1
New Corn Product .	8·5	6·5	5·4	2·9	49·3	27·3

Some of the products of the maize mill or factory are superior in nutritive value to the best products of the wheat mill, as is shown by the following table:—

TABLE CXII.

COMPARISON OF MAIZE AND WHEAT PRODUCTS.

	Total Digestible Nutrients in 100 Lbs.			
	Protein.	Carbo-hydrates.	Fat.	Total.
Maize Products—				
1. Glucose Meal	30·3	35·3	14·5	80·1
2. Gluten Meal	25·8	43·3	11·0	80·1
3. Sugar Meal	18·7	51·7	8·7	79·1
4. Grano gluten	26·7	38·8	12·4	77·9
5. Germ Meal	9·0	61·2	6·2	76·4
6. Hominy Chop	7·5	55·2	6·8	69·5
Wheat Products—				
7. Dark Feeding Flour	13·5	61·3	2·0	76·8
8. High Grade Flour	8·9	62·4	0·9	72·2
9. Low Grade Flour	8·2	62·7	0·9	71·8
10. Wheat Bran	12·2	39·2	2·7	54·1

624. *Composition of Maize Bran compared with Wheat Bran.*—The composition is shown in the following table :—

Maize *bran*, though proportionately rich in carbohydrates, is relatively poor in protein, and contains more indigestible matter (crude fibre) than wheat bran, so that it is not a suitable food by itself. If used to mix with meal or other carbonaceous foods, a larger proportion would have to be used to yield sufficient protein, than in the case of wheat bran.

TABLE CXIII.

COMPOSITION OF MAIZE BRAN AND WHEAT BRAN.

	Maize Bran.		Wheat Bran.
	Dry.[1]	Moist.[2]	Moist.[2]
	Per Cent	Per Cent	
Protein (N × 6·25)	6·6	9·9	15·4
Nitrogen-free Extract (Starch, Sugar, etc.)	74·1	62·0	53·9
Ether Extract (Fats)	1·6	5·6	4·0
Crude Fibre	16·4	12·1	9·0
Ash	1·3	1·3	5·8
Water	0·0	9·1	11·9
	100·0	100·0	100·0

The analysis of wheat bran is given for comparison.

[1] New Jersey Station. [2] Hunt.

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625. *Digestibility of Maize Products.*—The comparative feeding-value of certain maize foods, based on their digestibility, has been worked out by Henry (1), as follows :—

TABLE CXIV.

DIGESTIBLE NUTRIENTS IN MAIZE PRODUCTS.

	Dry Matter in 100 Lbs.	Digestible Nutrients in 100 Lbs.			
		Protein.	Carbo-hydrates.	Ether Extract (Fat).	Total.
Dent Maize Grain	89·4	7·8	66·7	4·3	78·8
Flint ,,	88·7	8·0	66·2	4·3	78·5
Sugar ,,	91·2	8·8	63·7	7·0	79·5
Maize Cobs	89·3	0·4	52·5	0·3	53·2
Maize-and-cob Meal	84·9	4·4	60·0	2·9	67·3
Maize Bran	90·9	7·4	59·8	4·6	71·8
Germ Meal	89·6	9·0	61·2	6·2	76·4
Hominy Chops	88·9	7·5	55·2	6·8	69·5
Starch Refuse	91·8	11·4	58·4	6·5	76·3
Gluten Meal	91·8	25·8	43·3	11·0	80·1
Gluten Feed	92·2	20·4	48·4	8·8	77·6
Grano-gluten	94·3	26·7	38·8	12·4	77·9
Glucose Meal	91·9	30·3	35·3	14·5	80·1
Sugar Meal	93·2	18·7	51·7	8·7	79·1

626. *Actual Amounts of Protein, etc., obtainable from each Part of the Grain.*—From the tables given in the preceding pages we have seen (a) the amount of each of the four ingredients, protein, ash, fat, and carbohydrates, found in the grain of different varieties, breeds, and strains of maize ; (b) the proportion of each of the physical parts of the grain ; and (c) the percentage of each of the four chemical compounds found in each of the physical parts of the grain.

But these tables do not show us at a glance the actual amount of each substance obtainable from any one physical part of the grain ; for instance, we find from one table that the grain contains 4·67 per cent of oil or fat, and from another that the embryo carries about 82 per cent of the total amount of fat contained in the grain, but they do not show what 82 per cent of 4·67 per cent actually amounts to. It is not sufficient for the manufacturer to know that the grain contains 4·67 per cent oil, because we know that some of this oil is distributed among all of the physical parts of the grain, from which it would not be practicable to recover it; only that—or a portion of that—which is contained in the germ, is available to the manufacturer. Multiplying 4·67 per cent by 82 per cent we obtain 3·8 per cent, which is the amount of oil contained in the embryo. CHAP. XIII.

For convenience of reference the writer has worked out the several percentages from Hopkins's (3) tables of analyses of low protein, medium protein, and high protein ears. These are given in Table CXV, following:—

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TABLE CXV.

ACTUAL WEIGHT OF PROTEIN, CARBOHYDRATES, FATS, AND ASH IN 100 LBS. OF GRAIN, AND ITS DISTRIBUTION IN EACH OF THE SEVERAL PARTS OF THE GRAIN.

	Low Protein.	Medium Protein.	High Protein.	Average.
		Protein.		
	Lbs.	Lbs.	Lbs.	Lbs.
Tip Cap	·09	·13	·08	·10
Hull	·27	·23	·23	·24
Horny Gluten	2·23	1·89	3·27	2·46
Horny Starch	3·02	4·80	4·93	4·25
Crown Starch	1·53	1·35	1·20	1·36
Tip Starch	·84	·65	·60	·70
Embryo	1·91	2·28	2·33	2·17
				11·28
		Ash.		
Tip Cap	·01	·02	·03	·02
Hull	·04	·05	·07	·05
Horny Gluten	·11	·15	·23	·16
Horny Starch	·07	·11	·09	·09
Crown Starch	·07	·04	·05	·05
Tip Starch	·04	·03	·05	·04
Embryo	1·01	1·14	1·19	1·11
				1·52
		Fat.		
Tip Cap	·01	·03	·03	·02
Hull	·05	·05	·05	·05
Horny Gluten	·46	·59	·61	·55
Horny Starch	·06	·11	·10	·09
Crown Starch	·04	·03	·07	·05
Tip Starch	·04	·03	·11	·06
Embryo	3·50	4·02	4·02	3·85
				4·67
		Carbohydrates.		
Tip Cap	1·09	1·28	1·48	1·28
Hull	5·10	5·60	5·74	5·48
Horny Gluten	8·81	5·88	9·20	7·96
Horny Starch	34·01	42·05	39·76	38·61
Crown Starch	19·62	15·59	12·56	15·92
Tip Starch	12·79	7·77	7·51	9·36
Embryo	3·17	4·09	4·38	3·88
				82·49

Summary.

	Lbs.
Protein	11·28
Ash	1·52
Fat	4·67
Carbohydrates	82·49
	99·96

CHAPTER XIV.

MAIZE GRAIN AS FOOD.[1]

Gave the first feast of Mondamin,
And made known unto the people
This new gift of the Great Spirit.

—*Hiawatha.*

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627. *The Uses of Maize Grain.*—After considering the vast production of maize and the enormous commercial interests involved in handling the crop, the question naturally arises, what is all this grain used for? The principal uses of maize grain are: (1) for human food, ground into meal and other products; for this purpose white maize is usually preferred in Europe and South Africa, and yellow in North and South America; (2) as a source of alcoholic beverages; (3) for stock food, either whole or crushed, or ground; yellow maize is preferred for this purpose; (4) in the arts and manufactures, for which cheap, damaged grain, either yellow or white, is largely used.

In the course of preparation for human food and for manufacture, certain by-products are obtained which are also used, in addition to the whole or crushed grain, for stock food.

For Human Food.

628. *Maize the Staple Foodstuff of the American Aborigines.*—The earliest European explorers of America found the Indian tribes cultivating maize as their principal cereal. Longfellow's poem *Hiawatha* gives an insight into the importance of the place held by maize in the life of the American Indians, and the legends which they wove around it.

[1] In this chapter has also been included a discussion of the uses of the juice of the maize stalk for the preparation of sugar and syrup.

The ancient Aztecs of Mexico used maize as a staple food, and Prescott tells us that they were addicted to "confections and pastry, for which their maize flour and sugar supplied ample materials". Maize, he adds, was "the great staple of the country" in the sixteenth century, "as, indeed, of the American Continent. . . . The Aztecs were as curious in its preparation, and as well-instructed in its manifold uses, as the most expert New England housewife." Hernandez (1) "celebrates the manifold ways in which the maiz was prepared". Torquemada obtained possession of the royal account-book from the palace of Tezcuco, from which he found that among the items of yearly expenditure of the palace was one for 4,900,300 fanegas of maize, the *fanega* being equal to about 100 lbs. weight (*Prescott*, 1).

Describing the natives of the lands adjacent to the Bay of Campeachy, Dampier (1) wrote in 1676:—

"This country is very fruitful, yielding plentiful crops of maiz, which is their chiefest subsistence. After it is boiled, they bruise it in such a rubbing stone as Chocolate is ground on. Some of it they make into small thin cakes, called Tartilloes. The rest is put into a Jar till it grows sowr; and when they are thirsty, mix a handful of it in a Callabash of Water which gives it a sharp pleasant Taste, then straining it through a large Callabash prick'd full of small Holes to keep out the Husks, they drink it off. If they treat a friend with this drink, they mix a little honey with it; for their ability reaches no higher: And this is as acceptable to them as a glass of wine to us. If they travel for two or three days from home, they carry some of this ground Maiz in a Plantain leaf, and Callabash at their girdles to make their drink, and take no further care for victuals till they come home again. This is called posole: and by the English poorsoul. It is so much esteemed by the Indians, that they are never without some of it in their homes.

"Another way of preparing their drink is to parch the maiz, and then grind it to powder on the rubbing-stone, putting a little Anatta to it; which grows in their plantations, and is used by them for no other purpose. They mix it all with water, and presently drink it off without straining. In long journeys they prefer this drink before Posole."

The Incas of Peru, at the time of the Spanish conquest

(1524-33), are said to have been "well acquainted with the different modes of preparing this useful vegetable," though it seems they did not use it for bread, except at festivals (*Prescott*, 2). CHAP. XIV.

629. *Maize Adopted as the Staple Food of the African Races.*—The size of the grain and the heavy yield and easy cultivation of the maize crop were probably responsible for the early and rapid spread of this cereal over Africa, ousting the much-grown native grains of the continent such as *Sorghum vulgare*, *Eleusine Coracana*, *Pennisetum spicatum*, and *Eragrostis abyssinica*.

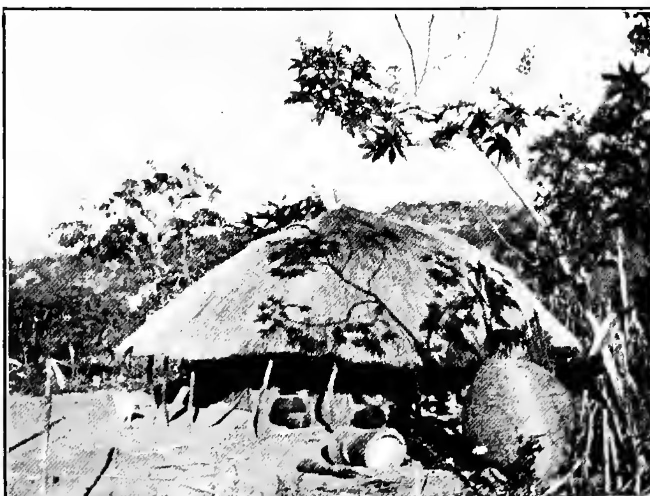

FIG. 229.—Shangaan kraal, Zoutpansberg District, Transvaal, with basket for storing maize grain, and wooden mortar and pestle for stamping mielies.

Maize is now so largely used as a staple article of food by the Bantu races, that it is somewhat difficult for the younger generation to realize that it has not always been so. But history and the accounts of travellers tell us, and it is confirmed by white men and natives still living, that within the memory of man, maize was not known as a cultivated crop to the natives of certain parts of South Africa (¶ 13). South of the Equator it was introduced by the Portuguese voyagers of the sixteenth century (¶ 13) under the name of *milho*, i.e. grain (¶ 18).

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The usual method employed by the South African native for preparing maize for food is to grind it into meal with stones (Fig. 231); it is then made into porridge with boiling water, and partially cooked until of a coarse bread-like nature, when it is eaten alone, out of the hand, or mixed with milk and eaten with the long spoons which they carve out of some soft wood such as that of the maeroola-tree, *Sclerocarya caffra* (Fig. 230).

A favourite dish among some South African tribes is prepared by soaking mielie meal in water for some hours, until

FIG. 230.—Zulus eating maize-meal pap.

fermentation has commenced, when the mixture is well stirred and then strained through a sleeve or bag made of one or another of the various native fibres found in different parts of the country. This preparation is known to the natives of some parts of South Africa as *marewu*.

630. *Use of Maize in Tropical Africa in* 1795.—Mungo Park (1) writing of the natives of the Gambia, in 1795, speaks of several articles of food prepared by them from maize. The most common was a sort of "pudding" called *kouskous*, described as follows:—

"It is made by first moistening the flour with water, and then stirring and shaking it about in a large calabash or gourd, till it adheres together in small granules, resembling sago. It is then put into an earthen pot, whose bottom is perforated with a number of small holes; and this pot being placed upon another, the two vessels are luted together, either with a paste of meal and water, or with cow's dung, and placed upon the fire. In the lower vessel is commonly some animal food and water, the steam or vapour of which ascends through the perforations in the bottom of the upper vessel, and softens and prepares the *kouskous*, which is very much esteemed throughout all the countries that I visited. I am informed that the same manner of preparing flour is very generally used on the Barbary coast, and that the dish so prepared is there called by the same name. It is therefore probable that the negroes borrowed the practice from the Moors."

For gratifying a taste for variety, another sort of pudding called *nealing* was sometimes prepared from the maize meal.

In preparing their maize for food, he says, that these natives use a large wooden mortar called a *paloon*, in which they bruise the grain until it parts with the outer covering or husk, which is then separated from the clean corn by exposing it to the wind, nearly in the same manner as wheat is cleared from the chaff in England. The corn thus freed from the husk is returned to the mortar, and beaten into meal, which is dressed variously in different native countries.

He also states (*ibid.*) that the anthers of the maize tassel, stewed in milk and water, were eaten in times of great scarcity of food, by the Mandingoes.

631. *An Important Article of Diet of the American People.*—We are told that "the first generations of English-Americans subsisted mainly on maize" (*Century Magazine*, 1). Bacon (1) describes the method of preparation in the early days of its introduction into Europe as follows: "Indian maiz . . . must be thoroughly boyled, and made into a maiz-creame, like a barley-creame," doubtless having imported the recipe from the American continent.

Maize continues to be an important article of diet of the American people; in one form or another it is met with in all parts of the country and among all classes of people.

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632. *Probable Increase in Demand among the White Races.*—Increasing knowledge of the value of maize as an article of human food is increasing the demand in Europe. A set of recipes for the use of maize in domestic cookery, published by the Transvaal Department of Agriculture and now in its fifth edition, has done much to stimulate its use in South Africa. The increase in population among the wheat-consuming peoples of the world, and the threatened shortage in the world's wheat supply, should also tend to increase the consumption of maize.

633. *Advantages of Maize as an Article of Food.*—Maize is an important food-stuff, whether for man or for his domestic animals. It is more highly nutritious, digestible, and wholesome than is usually recognized. In total amount of digestible nutrients it is only excelled by wheat, and then only to the extent of about 2 per cent (2·2), as is shown in the following table:—

Table CXVI.

TOTAL DIGESTIBLE NUTRIENTS IN 100 LBS. OF SEVERAL CEREALS.

	Protein.	Carbo-hydrates.	Fat.	Total.
1. Wheat	10·2	69·2	1·7	81·1 lb.
2. Maize	7·9	66·7	4·3	78·9 lb.
3. Rye	9·9	67·6	1·1	78·6 lb.
4. Rice	4·8	72·2	0·3	77·3 lb.
5. Barley	8·7	65·6	1·6	75·9 lb.
6. Kaffir Corn	7·8	57·1	2·7	67·6 lb.
7. Oats	9·2	47·3	4·2	60·7 lb.
8. Buck-wheat	7·7	49·2	1·8	58·7 lb.

Director W. A. Henry (1) observes that, considering the nutrition it carries, and the market price, maize is by far the cheapest food offered to mankind over a large part of the civilized world. That it has not been more generally used can be explained only in part. In the first place, maize meal alone cannot be made into a light, porous loaf, as can flour from the wheat grain, owing to differences in the character of its gluten. Again, when reduced to meal by grinding, the oil of the grain, and especially that in the embryo, soon becomes rancid, and the meal loses its palatability; this trouble is remedied in part by processes of manufacture in which the "germ" is removed. The impression as to the keeping qualities of maize which this latter statement appears to convey is, perhaps, rather misleading; the writer has known maize meal to have been kept for more than a year, through the hottest summer known in Pretoria (1911-12), without having turned in the least rancid at the end of the period. In 1903, however, maize meal imported from Baltimore, U.S.A., to South Africa, and which had, therefore, crossed the Equator, was so rancid as to be unfit for food.

Though maize flour contains a comparatively small proportion of protein, this defect will probably be remedied in course of time; the Illinois State Agricultural Experiment Station has already, after but a short period of work, succeeded in increasing the protein-content by about 2 per cent.

The following comparison of the food value of "Johnny Cake," i.e. maize meal bread, and of wheat bread, is drawn from analyses by Atwater and Wood, and Dr. Robert Hutchinson:—

TABLE CXVII.

COMPARISON OF THE FOOD-VALUE OF WHEAT BREAD AND MAIZE BREAD.

	Wheat Bread. Per Cent.	"Johnny Cake." Per Cent.
Water	40·0	38·0
Protein	6·5	8·5
Fat	1·0	2·7
Carbohydrates (Starch, Sugar, and Dextrine)	51·2	47·3
Cellulose	·3	—
Ash	1·0	3·5
	100·0	100·0

The "Johnny Cake" is drier by 2 per cent, and contains 2 per cent more protein,[1] 1¾ per cent more fat, and less starch than wheat bread.

Bowman and Crossley (1) state that maize is "very well digested in the human body. Experiments show that 90 per cent of its dry matter is absorbed, as compared with 82 per

[1] The higher percentage of protein is probably due to the addition of milk, egg, and wheat flour.

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cent in the case of wheat. Of the protein of maize, but 19·2 per cent escapes absorption; in wheat about 20 per cent is lost. Maize is an economical food." Table CXIV (in the previous chapter) shows that several foodstuffs prepared from maize are extremely rich in protein, the surplus carbohydrates having been removed for the preparation of starch, etc.

634. *Injurious Effect of Unsound Grain.*—Unsound maize, particularly if it is mouldy, is likely to be as injurious to man and domestic animals as other unsound grain, and should be avoided. It is stated that some years ago, when tens of thousands of bags of maize were imported into South Africa from oversea, there was practically a plague of "scurvy" among the natives, causing loss of life and enormous loss to the mines, through sickness. This was attributed to the fact that the imported maize was "kiln-dried," and, therefore, lacking in certain nutritive properties (*Transvaal Leader*, 21 Nov., 1908).

The possible connection between these cases and pellagra does not appear to have been suggested.

635. *Pellagra.*—In parts of Italy, Roumania, Spain, Egypt, and the United States, a serious disease of human beings, known as *pellagra*, occurs, which produces eruptions, gastro-intestinal trouble, and often insanity and death. Persons affected with pellagra are known as *pellagrins*. This disease has been attributed to the consumption of mouldy or otherwise damaged maize,[1] and Hackel observes, referring no doubt to pellagra, though he does not name it, that the *exclusive* use of maize as human food "gives rise to a skin-disease". It has been stated that:—

"In Italy, pellagra is one of the chief plagues of the country, and it is dreaded not so much on account of its deadliness, but because of the indescribable wretchedness and suffering to which it gives rise during its slow, cruel course of many years. . . . An examination of the mortality tables shows very clearly that pellagra is not decreasing, but increasing. . . . It has been pointed out again and again by numerous observers that the areas of pellagra endemicity and those of maize culture by no means overlap. . . . When once established in a region,

[1] It has been variously called "Maïdismus" and "Psychoneurosis maïdica"; see also chap. x., under *Diplodia*.

pellagra is very permanent, but its prevalence varies considerably from year to year, not always in direct ratio to the amount of rainfall, or the hygrometric state of the air, as has been erroneously asserted, but in connection with other œcological conditions not yet determined" (*Sambon*, 1).

Hunter (1) informs us that for 200 years pellagra has been a subject of serious inquiry, but that up to the present its cause is purely a matter of conjecture. "The solution of this problem," he adds, "has at various times been proclaimed, but subsequent investigations have failed to furnish corroborative material." Generally speaking, medical men are divided into two schools of thought over the etiology of pellagra: (1) those who hold the zei-toxic theory, based on the work of Balardini in 1844, and who have therefore been called "*zeists*"; and (2) the "*anti-zeists*," including those who hold that pellagra is a protozoal disease, or due to some other cause than the consumption of maize.

The Illinois (U.S.A.) State Pellagra Commission, appointed in 1909, issued a report in November, 1911, which was published in 1912. This report covers 250 pages, and furnishes an interesting summary dealing with the clinical manifestations, pathology, and theories as to etiology of the disease. From this summary the following information as to the possible connection between maize and pellagra has been extracted; the italics are supplied by the present writer:—

"1. *Pellagra in Relation to Maize.*— . . . All work directed to this question has uniformly yielded negative results. . . . The evidence collected in this report all tends to discredit any such assumption. . . . It seems to us that the burden of proof must rest with the zeists. The following facts may be especially emphasized as tending to *discredit any causal relations between maize and pellagra:* (1) *Sound Maize;* (*a*) excessive corn-feeding was not accompanied by more pellagra than was observed in individuals kept upon a strictly corn-free diet, other conditions being, as far as possible, identical as regards the age, sex, mental and bodily condition, habits, and occupation of the patients and the size, location, and general arrangement of the buildings, although cases developed under both conditions; (*b*) maize products constituted only a moderate proportion of

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the general diet of those affected; (*c*) cutaneous tests in pellagrins, with extracts of corn, gave rise to no anaphylactic symptoms. (2) *Damaged Maize;* (*a*) the corn used in the State Institutions (where the cases investigated occurred) has been of high grade; (*b*) all experimental work has necessarily been performed upon animals. In none have there been any pellagra-like manifestations, and in fact with few exceptions the toxicity has been low; (*c*) cutaneous anaphylaxis tests with extracts from damaged corn were negative.

"If one adds to these direct observations the keen critical analysis by Sambon of the foundations upon which the maize hypothesis rests, one cannot but feel that the arguments in its favour are *extremely slender*.

"2. *Antizeist Theories.*— . . . All investigations carried out by us with the object of demonstrating the presence of a blood parasite have so far failed. Nevertheless, it is quite possible that a parasite may live and propagate in the blood but require special methods for its demonstration, not yet discovered. . . . The relation of Simulia to pellagra, hypothecated by Sambon, finds but little support from the researches we have been able to make. . . .

"This discussion would not be complete without consideration of the problems of prevention. The evidence seems conclusive that *poor nutrition* is an important factor in predisposing to the disease, although we fully admit and can confirm the occurrence of pellagra in persons well nourished and apparently robust. The investigation of the dietaries of the State Institutions reveals no defect in quality or quantity, but only a low animal protein content. The Italian peasantry have suffered more from pellagra than any other people, and their diet consists almost exclusively of maize in the form of polenta. They eat practically no meat, fish, milk, or eggs. In fact it may be said that meat becomes a luxury in all conditions of poverty. Maize has a large protein value, but this apparently cannot satisfactorily take the place of animal protein altogether. It may be, then, that conditions in which the animal protein constituent of the diet is low, constitute a predisposing factor to infection with pellagra. . . . We do not consider that pellagra is due to lack of food or even to deficiency in any particular constituent of the food. Our impression is rather that pellagra is due to infection of the body with some micro-organism. It does seem possible, however, that a diet deficient in animal protein may so alter the body that the infecting organism has a better chance to grow."

The Commission closes its Report with the following conclusions and recommendations :—

(1) According to the weight of evidence pellagra is a disease due to infection with a living micro-organism of unknown nature.

(2) A possible location for this infection is the intestinal tract.

(3) Deficient animal protein in the diet may constitute a predisposing factor in the contraction of the disease.

(4) The number of cases of known pellagra renders this disease a decided menace to the public health of this State.

(5) Careful search for, and investigation of, suspected cases outside the State hospitals for the insane, is extremely desirable in view of experience elsewhere.

We therefore beg respectfully to recommend :—

(1) That a new Commission be appointed and funds provided for a continuance of this investigation with adequate assistance.

(2) That as a prophylactic measure the animal protein content of the State Hospital dietaries be increased.

(3) That the State Board of Health be advised to require notification of all cases of pellagra.

Pellagra produces a skin eruption, most common on the backs of the hands and lower parts of the forearms, often extending as a cuff around the wrist just above the palm ; the elbows and areas on the inner sides of the arms and forearms ; the forehead and cheeks ; the neck, and finally the dorsa of the feet ; at times the eruption is widespread over the whole body. Gastro-intestinal troubles are very frequent. There is a great tendency to the development of mental disorder of delirious type. The mortality may be very high ; pellagra was given as the immediate cause of death in 49·61 per cent of the 258 cases at the Peoria, Illinois, State Hospital.

One of the latest (14 March, 1913) reports published in the United States concludes : " The great prevalence of pellagra in certain districts and the important relation that exists between pellagra and the public health would seem to be ample justification for undertaking on a large scale the herculean task

CHAP. XIV. of unravelling the etiology of this puzzling disease, in order that measures based on fact might be instituted for its prevention" (*Grim*, 1).

For the information of readers who may wish to pursue the subject farther, the writer has extracted the most promising titles from the *Index Medicus* from October, 1912, to April, 1913, inclusive; these and other references will be found in the bibliography under the names of the following authors:—

Andenino, Cesa-Bianchi, Forbes, Frosini, Grim, Hirschfelder, Hunter, Jennings, Krauss, Lavinder, Lombroso, Merck, Nicolas, Nicholls, Pieraccini, Procopin, Rondoni, Roy, Sambon, Sandwith, Sheppard, Singer, Tuczek, Wood, and Wussow.

Lavinder (1), writing in 1908, states: "Most of the literature is in Italian, French, or German. There is but little in English. The writings of Roussel [1845] and Lombroso are important. The monographs of Tuczek and Procopin are more recent and give a good account of the disease; I am especially indebted to these two authors. Sandwith's article, in English, is brief, but gives a good account of the disease in Egypt. Most of the dictionaries, encyclopedias, and reference handbooks give good brief articles. In Allbut's *System of Medicine*, edition of 1905, will be found a fairly satisfactory account. In most of the larger textbooks on the skin will also be found some description of the disease."

The editors of the *Index Medicus*, who adopt the policy of classifying it as far as possible upon the latest accepted views in medicine, have since the beginning of the present year (1913) removed pellagra from the catalogue of "Diseases due to Specific Infection," where it appeared in 1912, to the class "Intoxications," which includes also beri-beri.

636. *Variety of Maize Preparations Available.*—An objection sometimes raised against the use of maize for food is the supposed lack of variety which its extended use would entail. This idea is erroneous, as we shall endeavour to show.

Cracked maize, called "samp," "hominy" or "stamped mielies," is boiled (often with salt meat) as a vegetable, and may be used as a substitute for potatoes or rice. Coarsely ground under the name of "fine hominy," "grits," or "hominy grits," and in South Africa "semola," it is boiled and eaten with milk and sugar as a porridge, or made into puddings, scones, fritters, etc. Maize meal, known in South Africa as mielie meal and in America as corn meal, is cooked and eaten in the form of porridge, called variously "corn meal mush" (United States), "stirabout" (Ireland), and "mielie meal porridge" or "pap" (South Africa); in Italy cheese or other protein foods are added, when it is called "polenta"; maize meal is also made into puddings, cakes, fritters, etc., and (in the United States) into corn pone, hoe cakes, or, with the addition of wheaten flour in the right proportions, into griddle cakes, muffins, and a light friable wholesome bread, known as corn-bread or "Johnny Cake," and in Mexico into tortillas and enchilladas.

Mixed with wheaten flour, or wheat and rye flour, it makes the famous "New England" or "Boston" brown bread. Ground to a very fine flour and sifted, it is known as cornflour or corn-starch, and used in the preparation of blancmanges or puddings. The grains of pop-corn are "popped" or roasted until they burst open, mixed with a boiled sugar-syrup and eaten as sweetmeats. The young ears of sweet or sugar maize are boiled or roasted and highly esteemed as a fresh or "green" vegetable, they are also pickled in vinegar or tartaric acid, or preserved in brine.

A pamphlet containing 134 selected recipes in which maize in some form is the main ingredient, was prepared in 1909 by Mrs. Burtt-Davy with the assistance of Miss J. C. van Duyn, and published as *Farmers' Bulletin* No. 1 of the Transvaal Department of Agriculture. These recipes include dishes under the following heads:—

	Recipes.
Porridge	4
Pancakes	8
Muffins, Gems, etc.	20
Bread	10
Soups	7
Maize with Meat	5
Meat Substitutes	14
Maize as a Vegetable	12
Custards, Puddings, etc.	35
Cakes	11
Sweets	2
Preserved Maize for Winter Use	6
	134

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These are but a few of the many hundreds of recipes in use in the United States and other parts of the world, and were selected to illustrate the possibilities of maize as a food, not as a complete or comprehensive list.

637. *Maize Meal, Corn Meal, or Mielie Meal.*—The method of treatment practised by aboriginal peoples, both in Africa and America, was to rub the grain into a meal on a hard and slightly hollowed stone, using a smaller, rounded stone with which to do the rubbing (Fig. 231). The product was coarse, consisting of endosperm, hull, and embryo ("germ") more or less mixed with particles of stone. Frequent use of this rough meal by white people, in the early days of South African settlement, was said to produce intestinal troubles, due partly, perhaps, to the coarseness of the particles and the bits of stone worn off in the process, and partly to the lack of cleanliness in preparation. Maize meal is now ground by machinery, between ridged steel plates or rollers (see chapter XIII.) which produce a meal of much finer quality than that obtained by the older processes. Two classes are produced: (1) whole meal, in which the embryo is ground up with the endosperm; (2) the new process meal in which the embryo, as well as the hull, are removed by special machinery.

Owing to the amount of oil it contains, the old-fashioned whole meal does not keep as well in hot weather as the new process maize meal, for the embryo holds 82 per cent of the total oil-content of the grain. But the higher oil content, on the other hand, adds greatly to the food value in cold weather.

Ordinary maize meal is classified into white and yellow, and graded into coarse, medium, and fine.

Maize meal is sometimes used as an adulterant of wheaten bread. "Flour so adulterated yields fewer loaves than an equal quantity of pure wheat flour, and the bread produced is more moist than wheat bread, and has a tendency to be sodden. An addition of 10 per cent of maize flour is calculated to mean a reduction of five loaves on the sack" (*Bowman* and *Crossley*, 1). Good loaves, though dark in colour, can be made by adding good wheat flour to fine maize flour.

Maize meal forms an important item of export from the United States, amounting in 1907 to 766,880 barrels, valued

A

B

FIG. 231.—Native women grinding maize. A, Transvaal Basutos; B, Xosas.

CHAP. XIV. at £475,000. The principal countries importing from the United States in 1904 were (*U.S. Government*, 1):—

	Per Cent.
British Africa	32·79
West Indies (excluding Porto Rico)	27·30
United Kingdom	21·32
Canada (including Labrador and Newfoundland)	9·675
Other Countries	8·915
	100·00

638. *Cornflour, Oswego, Maizena*, etc., consist mainly of starch, much of the proteid and mineral matter having been removed by treatment with dilute alkaline solutions. These forms of maize starch, as has been said, are used largely in the preparation of puddings, blancmanges, etc.

639. *Maize Starch.*—The finer qualities of maize starch are said to be largely used as a substitute for arrowroot.

Maize starch is also commercially mixed with wheat flour, and the mixture sold at a considerably lower figure than "all-wheat" flour. The pure food laws of many of the North American States now prevent the sale of this compound under the name of wheat flour, and require that the fact of its being a mixture must be clearly designated.

640. *Samp, Hominy, and Cerealine.*—These are preparations from which the hull, embryo ("germ") and soft "crown starch" have been removed, sometimes by treatment with lye, leaving only the hard "horny endosperm"[1] (¶ 615). Practically all of the oil and some of the protein have been removed; the percentage of carbohydrates is therefore high, but there is still a considerable proportion of protein left.

641. *Stamped Mielies.*—Stamped mielies, so well known in South Africa, differ from hominy in that the embryo is not removed, and they are not treated with lye; the oil-content is therefore greater.

Stamped mielies are prepared by the native women (Fig. 232) of the country districts or smaller towns, with long hard-wood pestles, and a narrow, deep wooden mortar hollowed out of the trunk of some soft-wooded tree, especially the wilge-

[1] Called "horny" from the translucent appearance of this part of the grain. It does not imply that it is insoluble or indigestible.

boom (*Salix babylonica*), the wilde wilge-boom (*Salix capensis*) or the maeroola (*Sclerocarya caffra*). To prevent the dry, hard grain from scattering during the process of stamping, the succulent leaves of a wilde vyg-bosje (*Mesembrianthemum* sp.) are sometimes added, to be removed again in the subsequent washing.

642. *Whole or Crushed Maize as a "Cereal Food".*—"Sweet corn" or Sugar maize, parched and ground, and

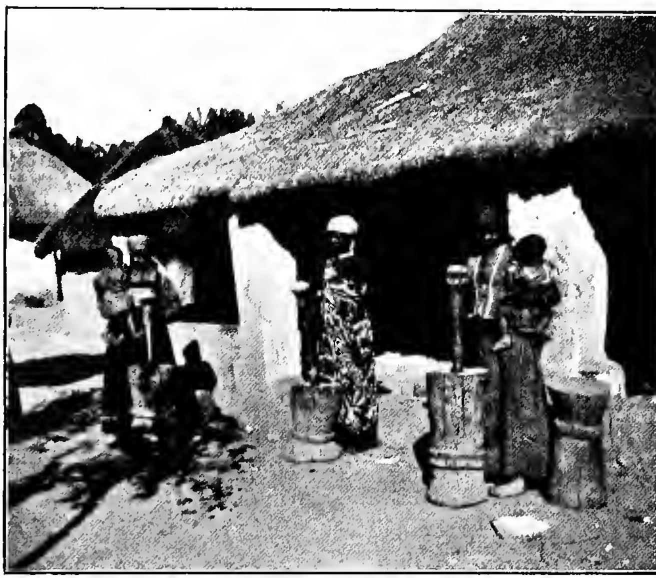

FIG. 232.—Modjajie women stamping mielies.

served with cream or milk, makes a delicate and nutritious substitute for the boiled breakfast porridge.

Freshly popped "corn," served with cream, is a much used breakfast food in the United States, though pop-corn is most commonly eaten hot from the popper with a little salted butter or merely a sprinkling of salt.

643. *Corn-flakes*, *Silver-flakes*, *Corn-crisp*, *Fanko*, etc., are prepared from grain from which the germ and hull have been removed, and which has been treated with sugar and salt. The prepared grain is cooked by steam, dried, rolled, and toasted in a special oven. It is said that No. 3 or No. 4

CHAP. XIV. grade maize may be used for this purpose. The use of these and similar preparations is extending steadily in the United States, Europe, and South Africa. Their protein content is relatively low. One of the largest firms of manufacturers in the United States uses 210,000 muids of choice maize per annum in the manufacture of these and other products (*Bowman* and *Crossley*, 1).

644. *Tortillas and Enchilladas.*—The "tortilla" or Mexican corn-cake is said to be the main food of 90 per cent of the native population of Mexico. The total annual consumption of tortillas is valued at $76,560,000 gold (*Bowman* and *Crossley*, 1). In Mexico the tortilla is made from shelled maize which has been allowed to soak over-night in rather strong lye water, made from wood ashes, in an earthenware jar; this process swells the grain and softens the hull. The whole grain is then pounded or water-ground into a paste in a *metate* or hollowed stone, with a more or less cylindrical pestle. The paste is afterwards rolled or patted into thin cakes (sometimes 2 feet in diameter) which are baked or fried. In California the paste or meal is mixed with salt, water, and a little fat, into a batter stiff enough to be moulded with the hands into round, flat cakes which are baked in the ashes or on a hot stone. The *enchillada* is a tortilla cooked in a pan and then fried in olive oil and stuffed with a mixture of red pepper, onions, raisins, and garlic, and dressed with hard-boiled eggs and grated cheese.

645. *Maize as a "Green" Vegetable.*—The young grains of the maize ear, before they harden, form a favourite article of food in maize-growing countries. The ears are either boiled or roasted, and if not overcooked[1] the grains are creamy and palatable. In order to make this vegetable available the year round, and for use in countries where the crop is not grown, a large industry in the "canning" of green maize has been established in the United States. Canning factories exist which every season put up thousands of tins of "green corn" cut from the cob, ready to be warmed and eaten when the fresh article is out of season; "canned corn" is a staple vegetable in the United States during the winter months.

[1] At a low altitude 8 minutes in rapidly boiling water usually suffices—long cooking only tends to harden the grains and make them indigestible.

South African housewives "bottle" it for domestic use, and there seems to be no reason why the bottling or canning of green mielies should not become an industry in South Africa. CHAP. XIV.

Sugar-maize is usually considered the best type to eat as "green corn" or "green mielies," as it is softer and has a sweeter flavour than either the flint or dent varieties.

The green or canned corn is often cooked with Lima, string, or French beans; this mixture, known as "succotash," is a favourite dish in the United States.

646. *To Keep Maize on the Cob.*—The following recipe for keeping maize on the cob appeared in the *Transvaal Agricultural Journal*, having been taken over from the *Rhodesian Agricultural Journal*:—

Take a basket of corn after all the husks and silks have been picked off, and place in a tight box with a stone jar of water.

Now in an earthen dish place some sulphur, and with a paper or live coal light it, and close the box that the fumes of the sulphur may not escape. In eight or ten hours open the box, turn the charred sulphur over and light again, and close the box for twenty-four hours. Then take the corn and put into the crock of processed water; add more sulphur to the dish, light, close the box, and repeat again in twelve hours.

When wanted for use soak in soda water for twelve hours, changing the water at least twice—it is very hard to get the acid taste from the cob—and then boil as green corn; or cut the corn from the cob, put on in a kettle of water with a large teaspoon of soda, and boil five minutes; then change the water three times, only letting the water come to the boil. When you add the last water also add one tablespoon of white sugar, and cook ten minutes. Season with cream or butter and salt and pepper.

647. *Dried Maize for Winter Use.*—Maize dried in the following manner retains more of its sweetness, is much easier to prepare, and takes less space in the pantry than if canned or bottled: Husk the maize, put into a kettle of boiling water, and cook for three to five minutes, to "set" the milk in the grain. Then cut from the cob and, with the back of the knife, scrape the cob to get all the milk, and spread in shallow pans. Dry in slow oven or in the sun. When perfectly dry put into paper

CHAP. XIV. bags. Before using, soak the maize over-night in milk, or water, or equal parts of both; cook in the same liquid; a little sugar, salt and butter may be added.

648. *Maize as a Sweetmeat.*—*Candied pop-corn* is a form of sweetmeat in the United States; it has also found its way into Europe and South Africa. As its name implies it is prepared from the variety of maize known as pop maize (*Zea mays* var. *præcox*) or pop-corn. This type has a very hard surface, and is so constructed that under the application of a strong heat the contained moisture expands, causing the grain to burst and the starch on the inside to evert. In this manner the hard grain is transformed into a light, edible mass. This is stirred into thickened sugar syrup until the grains adhere to each other, then rolled lightly into the favourite "pop-corn balls".

649. *Glucose.*—Glucose is the largest single product prepared from maize starch (chap. XVII., ¶ 757) by conversion into grape sugar. It is made in various degrees of density, from syrup to solid grape sugar, each of which is designed for a specific purpose. Pure glucose syrup has but little flavour and but half the sweetness of cane syrup; its principal use appears to be as a "filler" or adulterant of cane syrup. Maize syrup is, therefore, mixed with 10 per cent, more or less, of the latter, and sold as a substitute for golden syrup and molasses, under such names as "Karo Corn Syrup," "Korn King Syrup," etc. It is used as a basis for many of the manufactured jellies, which are then flavoured with fruit juices. It is also used in the preparation of sweetmeats, preserved fruits, non-intoxicating beverages and beer, and in the tanning of leather (*Bowman* and *Crossley*, 1). In 1906 the United States exported 94,827 tons (short) of grape sugar, valued at £716,466.

Glucose is extensively manufactured in the United States[1] and in Germany. A glucose factory has recently been established in Manchester, England, and another in Melbourne, Australia, is reported as having a capacity of about 150,000 bushels of maize per annum. South Africa would appear to be as favourably situated as Australia for a glucose factory.

[1] The principal glucose manufacturers in the United States include: The Corn-products Manufacturing Company of New York and Chicago; the Glucose Sugar Refining Company of Chicago; the New York Glucose Company of New York; Thos. Sealy, New York; the Perfection Jar Glucose Company, Philadelphia; and W. F. Stark, Milwaukee.

650. *Maize Stalks as a Source of Sugar and Syrup.*—Prescott (1), quoting Zuazo, states CHAP. XIV.

That the gigantic stalks of maize produced in the equinoctial regions of Mexico "afford a saccharine matter not found to the same extent in northern latitudes, and supplied the Aztecs with sugar (see ¶ 653) little inferior to that of the [sugar] cane itself, which [latter] was not introduced among them till after the Conquest" (1521-2).

Quite recently the question of the commercial production of sugar from the maize stalk has been brought into prominence in the United States by Mr. W. A. Kerr and Prof. Stewart. These gentlemen state that if the ears are removed from the growing maize stalk at a certain time before the plant ceases growth it will continue to grow from four to six weeks beyond its normal period, and that during that time the plant increases in size and weight, and that the saccharine content increases to more than double the normal amount.

The following table of analyses, showing the progressive stages of sugar accumulation in the juice from the beginning to the close of the period of saccharine development, was published in *American Industries* (February, 1910, pages 16 and 51), and is stated to be typical of the average result obtained by Messrs. Kerr and Stewart:—

TABLE CXVIII.

SUGAR IN MAIZE JUICE AT DIFFERENT STAGES OF PLANT GROWTH.

	Before Sterilization.[1]			After Sterilization.			
	Tassel Developing.	Grain.		One Week.	Two Weeks.	Four Weeks.	Six Weeks.
		In Silk.	In Milk.				
Sp. Gr. . .	1·0126	1·034	1·048	1·050	1·058	1·069	1·0759
Sucrose, Per Cent	0·000	2·90	6·70	9·70	11·09	13·79	14·66
Reducing Sugar .	1·87	3·00	2·50	1·90	1·47	1·11	1·79
Combined Sugar	1·87	5·90	9·20	11·60	12·56	14·90	16·45
S.N.S. . .	1·13	2·80	1·80	1·80	1·44	1·90	1·92
Total Solids .	3·00	8·70	11·00	13·40	13·90	16·80	18·37
Co. of Purity .	—	33·3	60·9	72·3	79·7	82·4	79·8

[1] The context indicates that by "sterilization" is meant the removal of the ears before the growth of the plant has ceased.

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The article above referred to continues :—

"The results obtained from the corn under the conditions which existed this year were entirely satisfactory. The defecated juice worked perfectly and I believe there will be less loss in defecating the corn juice than that from the cane. The whole operation during the boiling to massecuite was beyond my expectations and entirely satisfactory. The sugar obtained from the runs has all the good qualities of cane sugar, shows a very good colour, and by washing it with a little water showed a polarization of 98·5 degrees. . . .

"A ton (2,000 lb.) of corn [maize] cane utilized under this patented process, contains an average of 570 lbs. perfectly dry solid matter, and of this 270 lbs. were in solution in the juice. Of this dissolved matter an average of 240 lbs. per ton is sucrose, 20 lbs. uncrystallizable sugar and 10 lbs. organic matter not sugar. The average yield of dry crystallized sugar is: 1st sugar 96° centrifugal, 160 lbs. ; 2nd sugar 89° centrifugal, 30 lbs.

"About 6 gallons of molasses, containing about 70 lbs. of uncrystallizable sugar, remain as a by-product, which is converted into ethyl spirits producing 5·18 gallons of 95 per cent alcohol. . . .

"In one ton of green ear and husk product there is about 580 lbs. of dry substance, of which 21 per cent, or 420 lbs., is fermentable matter, 85 lbs. of dry pulp and about 30 lbs. of corn gluten. The fermentable matter will yield half its weight (210 lbs.) or 31·1 gallons of 95 per cent alcohol."

Writing in the *Agricultural Journal* of the Union of South Africa in May, 1911, Dr. A. I. Perold gives extracts from an article on this subject which appeared in the *Resumen di Agricultura*, of October, 1910, which was taken over from the *Boletin de la Sociedad Agricola Mexicana*. Dr. Perold summarizes his article as follows :—

"1. Maize will, under proper treatment, give as high a percentage of sugar as cane sugar does on an average.

"2. It will give as much crystallizable sugar as the sugar cane.

"3. Permit area, the total production of maize stalks is equal to that of the sugar cane in the fertile soil of Louisiana.

"4. The sugar obtained is proper 'cane sugar' (saccharose).

"5. It gives by-products that are easily sold and realize as much as, and even more than, the sugar. CHAP. XIV.

"6. The cost of manufacturing this sugar is much less than in the case of either sugar beet or sugar cane.

"7. This sugar can be produced in unlimited quantities, it being possible to supply the whole demand of the United States within a few years.

"8. Although the operations of manufacture are distinct, the machinery does not essentially differ from that used for cane sugar.

"9. The whole of the residue (after extraction of sap from stalks) can, at a low cost, be converted into a pulp for paper or into cellulose, which can be used for the manufacture of smokeless powder, celluloid, collodion, etc., at a lower cost than when produced from cotton.

"10. The green ears are easily sold as maizena, gelatine, or even as ensilage or cattle food.

"11. The combination of the manufacture of the sugar with that of the various by-products will keep the staff and the machinery of the factory busy during the whole year, instead of being at a standstill for a greater part of the year.

"12. The cultivation of maize for this purpose will give higher profits than if the crop were disposed of in any other way, and will therefore be to the advantage of all maize-growing countries."

Owing to the wide publicity given to the claims of Messrs. Kerr and Stewart by the press of many parts of the world, it seems desirable to refer to the subject, if only to bring this method of treatment to the attention of those in a position to give it a thorough test. To quote the editor of the *Union Agricultural Journal* :—

"The production of sugar, starch, and other by-products from maize is by no means new, but whether the very sanguine estimates outlined by our contributors will be realized on an industrial basis has yet, we understand, to be proven. However, the subject is of such importance to this country that further inquiries are being set on foot. . . . It has always to be remembered, however, that to set such an industry firmly on its feet in a country like South Africa, with its peculiar labour conditions, would call for the greatest care and forethought, as well as much capital and organizing ability. The sugar-cane industry of Natal is the nearest approach to any-

CHAP. XIV. thing of this kind which we have as an example, and the history of that effort is sufficiently full of warnings to give thoughtful men pause before embarking on similar adventures. The sugar industry is now well established, but its path has not been entirely beset with roses."

651. *Corn Oil.*—The larger American corn factories express the oil from the maize embryo after the grain has been "de-germinated" for the manufacture of starch, etc. About 90 per cent of the oil may be extracted in this way. When properly refined it is clear and tasteless, and is used in the United States as a salad oil. A large quantity of corn oil is exported from the States to countries which manufacture olive oil, for which it is supposedly used as a substitute or "filler"; the exports for a single year have amounted to 4,383,926 gallons, valued at £277,590, or 1s. 3d. per gallon.

652. *Maize Vinegar.*—According to Blyth (1) the great majority of the commercial vinegars in the United Kingdom are derived from the acetous fermentation of a wort made from mixtures of malt and barley.

In 1910, Dr. Juritz (1) observed that, "with an increasing cultivation within, and a growing export from the Union of South Africa, of cereal grain, and notably of maize—the use of which for the manufacture of malt vinegar is expressly allowed in the Cape Colony Statute—it is by no means unlikely that, ere very long, the manufacture of malt vinegar may also become a local industry of considerable standing".

The principal differences between malt vinegar and other commercial vinegars, such as rice vinegar, sugar vinegar, and spirit vinegar, are defined by Blyth as follows:—

The extract in malt vinegar is very much higher than in sugar vinegar, and nearly ten times as much as in spirit vinegar.

The acid-extract ratio is considerably lower in malt vinegar than in spirit vinegar.

The ash of malt vinegar is about ten times the amount of the ash percentage in spirit vinegar, and is nearly double the amount found in sugar vinegar. At least one-half of this ash should, in the case of a genuine malt vinegar, consist of potassium phosphate, with an additional quantity of calcium phosphate.

Proteins and phosphoric oxide are both considerably higher in malt vinegar than in either spirit or sugar vinegar. Sulphuric acid, on the other hand, is, as a rule, high in sugar vinegar, but never so in genuine malt vinegar.

Juritz (1) finds that vinegars prepared from rice and *maize grits*, i.e. the maize grain from which the embryo and hull have been removed, do not contain as much as 30 per cent of phosphoric oxide in their original solids, that is to say, less than half the quantity found in *genuine malt vinegar* solids; in such cases the phosphoric oxide sometimes falls even as low as 15 per cent in the vinegar solids. He concludes an interesting discussion of the analytical problems which would be involved in limiting the definition of malt vinegar to the product obtained from *whole* grain, as follows:—

"One thing is clear from even a casual consideration of all the questions concerned. If the manufacture of maize vinegar is ever to become a large local industry, two alternatives are open: either (*a*) the use of maize grits must be studiously avoided in the general interest, lest the market be flooded with the products of fermentation of damaged rice—products which would be indistinguishable from vinegar produced from maize grits, but would possess a sufficiently evident distinction from whole-maize vinegar, or (*b*) definite standards will have to be laid down by legislation, discriminating more clearly than at present between vinegar prepared from whole grain containing a certain proportion of phosphates and nitrogen, and vinegar made from more exclusively starchy materials like rice or maize grits" (*Juritz*, 1).

Maize for the Manufacture of Beverages.

Maize whisky could be bought then for 15 cents a gallon.—LELAND, "Mem.," I. 13, 1893.

653. *Maize Juice.*—The Indians of Virginia appear to have made use of the saccharine juice of the maize *stalk* in the preparation of a beverage, for Bruce (1) informs us that "except the juice sucked from the crushed fibre of the maize stalk, they had no knowledge of any spirits".

The Aztecs also seem to have made use of the juice of the stem, for Prescott (1) states that Zuazo extols the "honey" of maize as equal to that of the bees. He says that the Peruvians, CHAP. XIV. also, extracted a sort of honey from the maize stalk, and adds that:—

"The saccharine matter contained in the maize stalk is much greater in tropical countries than in more northern latitudes, so that the natives in the former may be seen sometimes sucking it like the sugar cane".

In South America alcoholic drinks, called *chica* and *pulque de mahiz*, are said to be prepared from the saccharine juice of the maize stem.

654. *Fermentation Products of the Grain.*—The large quantity of starch present in maize-grain renders it particularly suitable for the preparation of alcoholic liquors.

After cleaning and crushing the grain, the hull and embryo are removed. The remainder is then ground and cooked to dissolve the starch. The starch is fermented with 10 per cent of barley-malt and yeast, and 40 gallons of water per bushel of grain. The enzymes of the malt change the starch into sugar, and the yeast plants (*Saccharomyces*), feeding upon the latter, deposit alcohol as a waste-product. The alcohol is evaporated off from the remaining water, etc., and is then condensed over cold coils. The residue left in the fermenting tanks is washed to remove any alcohol left, and pressed to take out as much as possible of the liquid. The latter is known as "*distillery slop*," while the more solid portion is called "*distiller's grains*"; both are used for stock food (¶ 676 and 677).

The preparation of alcoholic drinks from maize was practised by the aborigines of America in prehistoric times; for although, according to Bruce (1), the Indians of Virginia had no knowledge of the use of spirits at the time of the advent of the "pale-face," Prescott (2) tells us that the Incas of Peru made an intoxicating liquor from fermented maize-grain, to which, like the Aztecs of Mexico, they were immoderately addicted. "One kind of the fermented liquors, *sora*, made from the corn [maize] was of such strength that the use of it was forbidden by the Incas, at least to the common people. Their injunctions do not seem to have been obeyed so implicitly in this instance as usual." In some parts of South America, we are informed, a kind of beer called *chica* or maize beer is made from the grain (*Moloney*, 1).

The African native has long been accustomed to brew "beers" from his native grains, and it is not surprising, therefore, that he soon learned the art of preparing an alcoholic beverage from maize, either alone or as an addition to some other starchy foodstuff. Torday (1) informs us that the national beverage of the Basonge of the Kasai Basin in the Belgian Congo is a kind of beer made from manioc and maize. CHAP. XIV.

Damaged maize is commonly used in the preparation of kaffir beer, a fermented beverage which is both a food and an intoxicating drink (Fig. 233). Because it is of greater value

FIG. 233.—Zulu women carrying kaffir beer for a "beer-drink".

in the form of "pap" than the other cereals grown by the natives, it is probable that less maize is used for this purpose than mabele or kaffir corn (*Sorghum vulgare*), um-velli-velli (*Pennisetum spicatum*), or um-pawha (*Eleusine Coracana*). Wallace (1) referring to the native method of storing maize in pits in Cape Colony, observes that a few mielies round the edges of the pit, which become mouldy, "are utilized for making kaffir beer, a beverage having the consistency of thin porridge, of which the natives are fond".

The Rev. A. T. Bryant (1) states that, in the native kraals of South Africa, kaffir beer is properly made of mabele alone, but at times or in localities where that grain is scarce, maize may be partly, or even entirely, substituted. Dr. Klein (1) adds that on the Witwatersrand a certain amount of mielie-meal is used to mix with ground kaffir corn malt, in the preparation of kaffir beer for use in the compounds.

655. *Beer.*—The *whole* maize-grain is not used for the production of malt, on account of the large amount of oil contained in the embryo. When the embryo has been removed by the process known as *de-germination*, the remaining starch of the endosperm, prepared in the form of "flaked maize," can be used as a raw material for the brewing of beer, when malt, prepared from some other cereal, usually barley, is added. The advantages claimed for the mixture are that, as the malt contains a much higher percentage of dextrine than is required to change its own starch into sugar, there is a surplus of dextrine which can be used to convert the maize starch into sugar. Maize flakes are practically soluble, and it is stated that beer brewed from this mixture "clears" much more rapidly than if brewed from malt alone, and is practically fit for table use within ten days after brewing.

656. *Whisky and Gin.*—Large quantities of maize are consumed in distilleries, for the manufacture of whisky and gin. The writer is informed that approximately 30,000,000 gallons of British whisky and gin are prepared from maize, with the addition of a certain amount of malt to convert the maize starch into sugar. The "Bourbon Whisky" of the United States is said to be largely manufactured from maize; 20,000,000 bushels (over 5,500,000 muids) of maize are consumed annually in the United States distilleries. Sixty-eight per cent of the grain used in the manufacture of distilled spirits in the United States in 1900 consisted of maize, the total value of the maize so used that year being £1,542,170. In Roumania, also, there are distilleries for the manufacture of maize spirits.

657. *Coffee Substitute.*—Before coffee was plentiful and cheap in South Africa, and where it is still scarce and expensive, roasted maize-grain has been used by the Boer as a coffee substitute. This use is probably quite old, for Burchell (1) tells us that in 1811 the missionaries in Griqualand West used it for this purpose: "When their store of coffee became low,

the ripe grains [of maize], roasted and ground, were mixed with it, but the beverage made from this mixture, though not unpleasant to the taste, had a heating quality which would not agree with every stomach ".

Maize Grain for Stock Food.

658. *Maize Grain for Stock Food.*—The importance of the maize crop as stock food, to supplement the wild pasturage of countries like South Africa, can scarcely be over-estimated; maize is the most profitable crop that can be grown for the purpose. The export price of the grain is not the measure of the crop value; to constantly export the raw products of the soil is not a sound policy either from an agricultural view or from the point of view of State economics; for, unless the plant-food removed from the soil in this way is replaced (see chap. VIII.), it results in depletion of the land; therefore it is an unsound policy.

The better way is to turn the raw material into a second product; this may be done in factories, which should be established in the country of production if economic conditions permit; but generally speaking the farmer finds it better to produce the secondary products himself, in the form of beef, mutton, pork, wool, hides, feathers, etc.

Maize grain is one of the most valuable and best relished foodstuffs for farm animals. Their fondness for it is remarkable; a possible explanation of this, suggested by Henry (1), may lie in the relatively high oil-content of the grain, which on mastication breaks into flinty, nutty, sweetish particles, and is therefore more palatable than, for instance, the wheat grain, which on crushing and mingling with saliva turns to a sticky dough.

Being rich in starch and oil, the function of maize is to produce fat and heat; for fattening purposes, Henry says, *no other grain equals maize.*

In the largest maize-producing country in the world, the United States, the farmer usually finds it more profitable to make his maize crop walk to market on four legs than to sell the grain to the manufacturer or dealer, for export, unless the prices offered by these men are unusually good. As a rule he

CHAP. XIV. sells only the surplus of his crop; a farmer who has foresight naturally plants more than he expects to use, to avoid the risk of a shortage of food-stuffs for his stock in the event of a bad season. In ordinarily favourable seasons he harvests more than he actually needs for feeding, and is able to sell the balance. Of the enormous United States crop of 747,000,000 muids only $1\frac{1}{2}$ per cent (about 10,000,000 muids) is exported.

Hunt (1) says that in America, the home of maize, the *chief* use of this crop is as food for domestic animals.

> "In connection with grass it is *the* meat-producing material of the United States. The wonderful development of our pork industry is directly related to our maize crop. . . . The ears of maize are the natural food of the civilized hog." "The total amount of digestible nutrients in the grain and stover are about in the proportion of two to one, but the proportionate food value of the grain is greater on account of its greater net available energy."

The use of maize grain as an addition to veld grazing, veld hay, or other roughage is increasing in South Africa, though its value is not yet fully appreciated. Some farmers perhaps go to the other extreme, and think that because maize is a good food it may be fed without stint; but this is not the case. The grain by itself is too concentrated for a ration, and it contains too high a percentage of carbohydrates (fat formers) to be used alone. Moreover, a mixed ration is more suitable and more economical in any case.

But, as Henry (1) has well said, "Let us not despise maize because, when wrongly and excessively used . . . it failed to develop the normal framework of bone and muscle. Each feed has its function in the nutrition of animals, and only by its abuse can unfavourable results follow. This grain has enabled the United States to take first rank among nations in the quantity of pork produced, and upon its judicious use rests future success."

659. *Grain and Pasturage.*—Where the natural summer pasturage is scarce, and the lack of food, together with flies and heat, are reducing gains in the "condition" already made by slaughter bullocks, Henry recommends that feeding with maize grain should be adopted. The feeder begins by supplying about a peck (14 lbs.) of maize per head, increasing the amount

by midsummer to fully ⅓ bushel (18⅔ lbs.) daily, for grown bullocks. The grain is dealt out once a day in a feed box in the camp. Pigs are allowed to follow to save the waste.

"Instead of giving maize only, it is better, when possible, to substitute 2 or 3 lbs. of oil-meal or bran for the same weight of grain. The feed should always be supplied at the same hour. Where maize is fed not over half the usual area of pasture land is required. Pasture-fed steers eat about as much grain as if confined to the feed-lot."

J. D. Gillett, the great Illinois steer feeder of the last generation, is quoted by Henry as having said that he could not afford to fatten steers *in winter*. His cattle were fattened in the summer and autumn, subsisting in winter in the maize stalk fields, and on the dry grasses of the pastures. In summer they luxuriated in rich old blue-grass pastures where the feed boxes always stood loaded with grain. "The great success of this feeder is sufficient evidence of the wisdom of his practice, with the conditions and markets then prevailing, i.e. good prices for well-fattened cattle."

But Wallace (2), in summarizing the experience of numerous cattle feeders in the Western States, writes: "The general opinion seems to be that good steers fed grain or grass will gain from 75 to 100 lb. per month, and that steers on good pasture will, during the two or three most favourable grazing months, gain almost as much on grass alone. . . . From all the facts I have been able to obtain, I am inclined to the opinion that in general there is not much money in feeding grain to steers that are on full pasture of the best kind." Henry (1) also concludes that, "where pastures carry a sufficient growth of [nutritious] grass for full feed, even during midsummer, it is usually best to allow the cattle to subsist entirely on natural herbage, for this is of low cost, and animals relying upon their own exertions gather their food vigorously and willingly, wasting no time in standing idly waiting for it".

"One mistake that is sometimes made, is turning on pasture steers that have been heavily grained during the winter. This is usually a losing operation, and the more radical the change from the dry lot to the pasture, the greater will be the loss" (*Pacific Rural Press*, 9 June, 1906).

Transvaal sheep farmers have found it useful to feed about ¼ lb. of maize grain per sheep per day during the winter months, to those animals which are kept on the High-veld pastures (¶ 687).

The Illinois Station found it profitable to feed maize to pigs running on pasture (¶ 688).

660. *Feeding Maize on the Cob.*—Where labour is scarce and high-priced, and maize is cheap, it is found economical to feed the grain on the ear without husking it. The simplest way is to use maize direct from the shock, throwing the long stalks, with the ears attached, into the mangers. The cows first pick out the ears, and after eating these finish off the leaves and then the stalks.

"By supplying maize on the stalk for the evening feed so as to allow the cows a long period for working them over, all will be consumed before morning except some of the coarser portions of the stalks, thus reducing the labour of removing the waste. Dairymen generally prefer, however, to run their shock maize through the feed-cutter or shredder, which leaves the material in a form relished by the cow and easily handled; the broken ears of maize are then easily masticated, the cobs also being consumed" (*Henry*, 1).

But in feeding in this way care should be taken to obtain a fairly close estimate of the proportion of grain to roughage. By selecting an average shock, husking out the ears, and ascertaining how much shelled grain it carries, the amount which should be fed can be determined.

Although the maize cob (i.e. after the grain is shelled) consists largely of crude fibre, and therefore has a low feeding value, it can be used to advantage for stock-feed under certain conditions. If the grain has not fully *ripened*, the cob is less hard and woody, and contains more nutriment, and such cobs are readily eaten by cattle, provided no deleterious fermentation or fungous growth has developed. As a result of experience and observation, many cattle feeders find it advantageous to use this otherwise waste product by feeding the whole ear, i.e. cob and grain together (*Henry*, 1).

"The practice, common in the Corn-belt, of supplying unhusked or unground maize to steers has developed the feeling among eastern feeders that the method is wasteful, and could be immensely improved by grinding the grain." Henry combats this idea: "No one," he says, "can study the western situation without becoming impressed with the belief that the better class of these [western] feeders are, after all, about right in this practice. Maize," he adds, "is never so acceptable to a steer as when in the husk. There is a freshness and palatability about an ear of corn wrapped in Nature's covering which every steer recognizes and shows by the eagerness with which he consumes it." CHAP. XIV.

"*Snapped corn*," i.e. the ear severed from the stalks but still wrapped in the husks, is successfully used for steer feeding.

"In general, directions for feeding cheap maize may be summed up by the single statement: Let the feeder supply this grain to his cattle in the most inexpensive manner possible so long as they consume full rations without difficulty in mastication."

The Texas Station (*Bull.* 2) made a saving of 3 per cent by feeding both cob and husk with the grain. The husked ears were coarsely ground.

661. *Frequency of Feeding Grain.*—"It is reasonable that all young animals should be fed at least three times a day, while those approaching maturity and not being heavily fed are amply provided for in two feeds.

"Maturing cattle prosper, and perhaps do their best, when supplied grain but once a day. The once-fed steer goes to the trough with paunch well emptied and appetite at the best; filling himself to the utmost, he has ample time for rumination and subsequent digestion" (*Henry*, 1).

662. *Preparation of Grain for Feeding.*—In the dry interior districts maize on the cob stored in the hock becomes very hard and dry, the moisture-content falling from 20 per cent to 10 or even 9 per cent. In this condition it may hurt the mouths of animals in the process of mastication. With some breeds of maize the large size of the ear makes it difficult to get it into the mouth. In such cases some form of treatment before feeding may be found necessary. The methods usually practised are (1) to break the ears in the feed-box into three or four pieces with a hatchet—this is somewhat crude, but simple; (2) to run the ears, with or without the husks, through a crusher, which reduces them to a reasonable degree of fineness, breaking the cobs into many pieces and cracking some of the grains; (3) to soak the grain, which enables the animal to

CHAP. XIV. crush it more easily, and often to consume a larger quantity; (4) to grind into "corn-and-cob meal," or to shell and grind into maize meal.

663. *Dry* v. *Soaked Maize.*—By soaking, the grain is made more easily masticable, though apparently less digestible.

A trial was made in Germany of the comparative feeding value of dry and soaked maize. Twenty sheep, nearly two years old, were fed 1·4 lbs. of whole maize grain per head per day, ten receiving the grain dry and ten receiving it soaked with as much water as it would absorb. This was continued for fourteen weeks. At the end of the trial the lot which had received dry grain had increased 12·1 lbs. per head more than those which had the soaked grain. The investigators concluded that the poor results obtained from the soaked grain were due to decreased secretion of saliva (*Mueller in Braunschw. Landw. Zeit.*, 1885, p. 209; *Jahresb. Agr. Chemie*, 1885, p. 576).

Wolf (*Landw. Jahrb.* 16, 1887, Sup. III, p. 21, quoted by *Henry*) found that in the case of healthy horses with good teeth the utilization of beans and maize remained about the same, whether fed whole and in dry condition, or after having been soaked in water for twenty-four hours, with due precaution in the latter case against loss of nutrients.

Experiments at the Kansas Station (*Bull.* 4) showed that steers fed with soaked maize did not consume quite as much as the other lot, yet made a better gain; there was a saving of 15 per cent by soaking shelled grain. Where, however, pigs followed the steers, and got more than one-half of their feed from the droppings, the droppings from the steers which had dry maize gave the best results, and the saving by soaking was only 5 per cent.

664. *Maize-and-cob Meal.*—The unshelled ears of maize are in many cases ground up with the cob. The resulting product is known as "corn-and-cob meal" or "maize-and-cob meal". There is very little nutriment in the cob itself, which consists largely of cellulose. On the other hand, pure maize meal is too concentrated, lying heavily in the stomach, and while in this state is not so easily penetrated by the digestive fluids, whereas the particles of cob mixed with the meal keep it looser and in a condition to be more easily digested.

The following extracts from Bulletins show what practical feeders think of this mixture:— CHAP. XIV.

"Practical experience is strongly in favour of using the cob with the grain when feeding meal to farm animals." "Corn-and-cob meal has been found very satisfactory by feeders, the animals not getting 'off feed' so easily as when pure meal is fed." "Stockmen quite generally report favourably on its use." "It will be found satisfactory for dairy feeding, and is recommended whenever it is possible to secure it at not too great expense for grinding." "For horses it is preferable to pure maize meal . . . on account of its higher percentage of cellulose, which renders it more like oats."

For dairy cows the Ohio Station tested its value when fed with hay, as compared with ear maize, with satisfactory results in favour of the corn-and-cob meal.

For fattening bullocks, the Kansas College of Agriculture (1) found that it gave a better daily gain than maize meal, and that a pound of corn-and-cob meal is equal to a pound of pure maize meal in feeding steers.

In trials at the New Hampshire (1) and Kansas (2) Colleges of Agriculture corn-and-cob meal proved superior to the same weight of maize meal for pigs; at the Missouri College (*Bull.* 1), however, it required very much less maize meal than corn-and-cob meal to produce 100 lbs. gain in weight.

Experiments conducted by the Paris Omnibus Company showed that it proved more acceptable than pure maize meal (*Pott, Fuhling's Landw. Zeitung*, 1893, p. 483).

It sometimes happens that the cob is not sufficiently ground owing to the additional power required to make it fine; if it is left too coarse, the animals usually pick out only the meal, and reject the pieces of cob. If the cob is ground as fine as meal (not merely crushed, but *ground* into a perfect meal), it is probable that 100 lbs. of corn-and-cob meal will give the same result as 100 lbs. of pure maize meal, the percentage of cob to meal on an ear being between 1 : 3 and 1 : 4, in South Africa. The relative value will therefore depend on the cost of grinding, assuming that there will be a one-fifth gain in feeding value; if the cost is not more than 50 per cent greater than that of shelling and grinding the grain into maize meal, it is estimated that it will pay to grind the un-

CHAP. XIV. shelled ears. It is recommended by the School of Agriculture, Middelburg, Cape Province, that, after husking, the ears should be allowed to dry in the hock for at least two months, until *thoroughly* dry, before grinding.

Maize-and-cob meal can be ground on the farm by machines specially constructed for the purpose;[1] they are driven by horse- or ox-power, or by oil, gas, or steam engines. Where cheap power is obtainable, it is obviously desirable to grind up the nubbins for stock-food, instead of shelling them off with the bulk of the crop.

665. *Maize-cob Charcoal.*—Where maize cobs are burned for fuel, the ashes should be saved for the pigs (¶ 688).

Maize cobs are plentiful in many parts of the country. Henry (1) states that where pig-feeding is largely practised, they can serve no better purpose, as far as needed, than in producing charcoal for use in the feeding pens. The following directions for reducing maize cobs to charcoal are given by Theodore Louis (1), "a breeder of high repute in the north-west":—

"Dig a hole in the ground 5 feet deep, 1 foot in diameter at the bottom, and 5 feet at the top, for the charcoal pit. Take the maize cobs, which should have been saved in a dry place, and starting a fire in the bottom of this pit, keep adding cobs so that the flame is gradually drawn to the top of the pit, which will thus be filled with the cobs. Then take a sheet-iron cover similar to a pot-lid in form, and over 5 feet in diameter, so as to amply cover the hole, and close up the burning mass, sealing the edges of this lid in turn with earth. At the end of twelve hours you may uncover and take out a fine sample of corn-cob charcoal."

Charcoal so produced may be fed directly or, better still, compounded, as directed by Mr. Louis, in the following manner:—

"Take 6 bushels of this cob charcoal, or 3 bushels of common charcoal, 8 lbs. of salt, 2 quarts of air-slaked lime, 1 bushel of wood ashes. Break the charcoal well down with a shovel or other implement, and thoroughly mix. Then take 1¼ lbs. of copperas and dissolve in hot water, and with an ordinary watering-pot sprinkle over the whole mass and then

[1] These machines are now stocked in South Africa by Messrs. Malcomess & Co. and other leading agricultural implement dealers.

again mix thoroughly. Put this mixture into the self-feeding boxes, and place them where hogs of all ages can eat of their contents at pleasure." CHAP. XIV.

666. *Maize Meal.*—Maize meal is a somewhat heavy, rich food, which is apt to induce indigestion and other troubles if fed alone. "It should always be lightened or extended by the use of bran, shorts, oil meal, or some other feed of light character . . . in which case the dangers incident to its use are usually overcome." The dry meal is unpalatable, and should be soaked with water before feeding (*Henry*, 1).

Whether meal or whole grain should be fed appears to hinge on cost of grinding. Henry (1) concludes:—

"Whether corn should be fed whole or as meal, depends upon circumstances. If the kernels are so hard as to cause sore mouths, thereby preventing easy mastication, the grain should be ground. If no trouble arises from this source, the utility of grinding hinges on the relative cost of grain and grinding. We have seen that some grain is saved by reduction to meal, and the feeder can easily estimate whether he should incur the extra expense of grinding. Where grinding is not possible, hard corn may be prepared for feeding by soaking the grains."

For Dairy Cows.—The Maine Station (*Rep.* 1895) tested maize meal for dairy cows, as compared with wheat meal. Making allowance for normal decrease in milk-flow with the lengthening of the lactation period, the results were practically equal.

For Bullocks.—Trials at the Experiment Stations of the United States show that maize meal gives larger gains with steers than the same weight of unground grain. It is probable also that meal permits of a higher "finish" with steers than unground maize. But practical experience and studies by the Stations show that pigs following steers fed on maize meal got very little from the droppings; not because such droppings are without nutriment, but rather because the meal in the droppings is in a form which cannot be utilized by the pig. Henry, therefore, concludes that where maize is cheap, and there is a demand for pork, the western custom of feeding maize whole to steers, with lively shotes following, is the most economical, all things considered, if rationally practised.

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The Kansas Station (*Bull.* 34 and 60) tested the value of maize meal as compared with ear maize for feeding steers. The steers fed ear maize gained somewhat more than those fed maize meal, but they required 6 per cent more grain.

Georgeson observes that "this is not a very favourable showing for maize meal, and I confess the result is contrary to my expectations. A considerable percentage of the whole maize passes through the animal undigested, and it would seem that the digestive juices could act to better advantage on the pure maize meal than on the partially masticated grains of maize, and extract more nourishment from it, but apparently this is not the case."

Referring to the same experiment Henry (1) notes that :—

"In the second trial there was a saving of 35 per cent of the maize by grinding, which may be regarded as the extreme saving possible in such feeding. This result is the largest saving of grain by grinding yet reported by any of the Stations so far as the writer is able to learn" (*Henry*, 1).

667. *Maize Meal for Pigs.*—Henry (1) made a careful test with seventy pigs to determine the relative value of whole maize and maize meal ; the maize used was a yellow dent containing about 12 per cent moisture. In three out of four trials the meal was more economical than whole grain : a saving of 8 per cent in weight fed was effected by grinding. Tests conducted at the Kentucky, Ohio, and Missouri Stations, with only two, three, and four pigs in each lot (twenty-six in all) showed a saving of only 2 per cent. But the experiments of several Stations show that maize meal is of practically equal value with wheat meal for feeding pigs. Henry's own experiments show that a mixture of wheat meal and maize meal is superior to wheat meal alone for feeding pigs, resulting in a saving of 3 per cent in weight of material fed. He points out that while larger returns can be secured from maize meal than from whole grain, it has several disadvantages in practical use, though towards the close of the fattening period it is especially useful in giving more finish.

668. *Maize Meal for Lambs.*—Experiments at the Wisconsin Station (2) show that maize meal can be used satisfactorily for fattening lambs ; it proved a more economical food alone than in combination with oats or peas, before weaning, and of

equal value to these combinations after weaning. Henry (1) concludes that it is probable that maize meal will force the largest and most economical gain with lambs both before and after weaning, the protein required being obtained from the mother's milk and pasture grass respectively. Craig (*Wisconsin, U.S.A., Rep.*, 1897) found that maize meal was more economical than oats, wheat, bran, or cracked peas, for feeding slaughter lambs before weaning; it took 86 lbs. whole oats, 77 lbs. wheat bran, 73 lbs. cracked peas, and only 63 lbs. of maize meal to produce 100 lbs. gain in weight, and the weekly returns were as good.

The Wisconsin Station (1) also made a comparative test of feeding lambs with and without grain before weaning, with the result that those which received grain continuously from birth until ten months old sheared a heavier fleece, containing more "yolk" or grease, and matured much earlier, than those without grain, and were fit for market at any time, so that advantage could be taken of any favourable fluctuation in market prices.

669. *Mill and Factory By-products for Feeding.* — Up-to-date milling and maize manufacturing companies now make a good deal out of the sale of by-products obtained in the manufacture of maize meal, starch, and glucose (see chap. XIII.).

Some of these by-products are rich in fats and protein, and are too concentrated to be fed alone, but may be diluted or extended with some light material like wheat bran or maize bran (*Henry*, 1).

The products of the factory are sometimes disposed of in a wet condition, and are then called "wet starch," "wet glucose feed," etc.

Feeding tests conducted at American Experiment Stations have proved that some of these by-products, especially "gluten meal" and "maize feed," have a high nutritive value.

670. *Maize Bran.*—This consists of the hulls of the maize grain, and its feeding value is relatively low (¶ 623 and 624), but it is useful for extending concentrates such as maize meal.

671. *Gluten Feed.* — This substance is obtained in the course of the manufacture of starch from maize, and consists of all the by-products obtained in the process, which are combined into one feed under this name. It is really the maize

CHAP. XIV. grain deprived of most of its starch. This feed is rich in fats and protein (¶ 623), and is considered well suited for dairy cows and for fattening stock. The separate by-products of the starch factories, which together constitute "gluten feed," are known separately as "sugar feed," "wet starch feed," "wet glucose feed," and "dried starch".

The Vermont (U.S.A.) Station (*Bull.* 48), tested the value of "maize feed" as compared with maize meal and bran, equal parts by weight, for feeding dairy cows; the roughage consisted of two parts of hay and one of silage. There was a gain of 10 per cent milk and 11·8 per cent fat with the use of gluten meal (*Henry*, 1). The composition of "maize feed" is not stated, but presumably it is practically the same as "gluten feed".

672. *Gluten Meal.*—This differs from gluten feed in that it does not, as usually manufactured in the United States, contain either the hull or bran of the grain, or the embryo. It is a highly concentrated foodstuff, rich in protein (about 30 per cent) (¶ 623).

The Vermont (U.S.A.) Station (*Bull.* 48) tested the value of gluten meal, as compared with maize meal and bran, for dairy cows. These were fed daily with 8 lbs. maize meal and bran, equal parts by weight, during the first and third periods. In the second period gluten meal was substituted for half the maize and bran mixture. Because of the heavy character of the gluten meal it was deemed advisable that not over one-half of the concentrates in the ration should consist of this material. The roughage was of equal parts, by weight, silage, and hay. There was a gain of 10·4 per cent of milk and 13·2 per cent of fat by substituting gluten meal for half the maize meal and bran (*Henry*, 1).

The Maine (U.S.A.) Station (*Rep.* 1896) tested the value of gluten meal as compared with cotton-seed meal for dairy cows. Six cows, averaging 900 lbs. each, were fed for two months on rations containing cotton-seed meal and gluten meal. The results showed that gluten meal is fully equal to cotton-seed meal when fed in sufficient quantity to make the amount of digestive nutrients equal in each ration. It is not equal to cotton-seed meal, pound for pound, as a source of protein, as it contains on an average about one-quarter less of that nutrient. It makes a very good quality of butter, but slightly softer than that made from cotton-seed meal, when fed at the rate of 3 lbs. per day. The rations in this test consisted of:—

(1) Gluten meal, 3 lbs.; maize meal, 2 lbs.; bran, 2 lbs.; timothy hay, 15 lbs.; silage, 20 lbs.

(2) Cotton-seed meal, 2 lbs.; maize meal, 2½ lbs.; bran, 3 lbs.; timothy hay, 15 lbs.; silage, 20 lbs.

The Cornell (U.S.A.) Station (*Bull.* 89) found that for feeding pigs a combination of gluten meal and maize meal was about 7 per cent superior to wheat meal, when both were fed in connection with skim milk.

The Ohio (U.S.A.) Station (*Bull.* 60) found that gluten meal was of approximately equal feeding value, pound for pound, with oil meal, for fattening steers, and that the one which can be bought for the least money is the one to use.

The Virginia (U.S.A.) Station (*Bull.* 156), comparing the feeding value of gluten meal and cotton-seed meal, concluded that they have nearly the same value for milk production; the results of the investigation are shown in the following table:—

Table CXIX.

RELATIVE FEEDING VALUE OF GLUTEN MEAL AND COTTON-SEED MEAL.

	Feed.	
	Gluten Meal.	Cotton-seed Meal.
Cost per ton	$28·40	$27·00
Per cent of protein	36·25	37·81
Coefficient of digestion	89·00	88·00
Per cent digestible protein	32·26	33·27
Protein on unit basis (equivalent)	103·00	100·00
Cost per 100 lbs. of digestible protein	4·40	4·05

673. *Maize "Germ"*.—The embryo of the maize-grain is rich in oil and protein (¶ 614). The oil is usually extracted for commercial purposes, and the residue, in the form of cake or meal, used for stock-food; these by-products are highly concentrated foodstuffs and "should never be fed in large quantity, but mixed with other grain feeds".

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674. *Corn-oil Cake.*—In the form of large thin slabs "corn-oil cake" and "Kositos oil-cake" are prepared from the residue of the maize embryo after extracting most of the oil; this residue still contains a good deal of oil and is rich in protein. The United States exported to European markets 2,444 tons in 1900, and over 7,000 tons in 1906, valued at £34,900. This went to the following countries, arranged in the order of the quantities purchased: France (most), then Germany, Holland, Scandinavia, the United Kingdom, Belgium, and British Columbia.

675. *Germ Meal or Corn-oil Meal.*—This is prepared either from corn-oil cake or from the unpressed embryo. Of this article the United States has exported as much as 24,210 tons per annum, valued at £124,300, most of which was purchased by the United Kingdom and Germany for feeding stock. In the United States its commercial value is lower than that of linseed-oil meal.

A mixture of unpressed germ meal with one-third its weight of whole oats is said to be a popular horse feed among American draymen and breeders (*Bowman* and *Crossley*, 1).

676. *Distillers' Grains.*—Distillers' grains are a by-product obtained in the manufacture of alcohol, spirits, and whisky. The annual output of distillers' dried grains from the United States is said to exceed 40,000 tons, which is largely exported to Germany for cattle feeding. According to the Vermont Station (*Rep.* 1903):—

"There are, quite generally, three grades made, one from the distillation of alcohol and spirits, a second from the distillation of Bourbon whisky, and a third from that of rye whisky. The first-named is the higher in feeding value, and is most apt to be of even quality, maize being the main, and sometimes the only, grain used. The other grades vary in their composition in proportion to the relative proportion of maize, rye, and malt used in the mashes; the more the maize, and the less the smaller grains, the better the grade of the product."

The high protein content (35 per cent) should render this foodstuff most valuable. It is also rich in fats (11·3 per cent) and correspondingly low in carbohydrates (30·4 per cent).

677. *Distillery Slop.*—After the alcohol has been taken off, in the distilling of spirits, the residue is pressed to remove as much of the remaining liquid matter as possible; this is used by cattle feeders under the name of distillery slop.

678. *Brewers' Grains.*—Brewers' grains are a by-product obtained in the brewing of beer; they usually consist of a mixture of several grains, varying according to the locality where they are made; commonly maize, barley, and rye. Brewers' grains form an acceptable food for milch cows, where large percentages of protein are required (*Hunt*, 1).

679. "*New Corn Product.*"—Under this name a substance has been sold for stock-food in the United States which is composed of the husks, leaf-blades, and stalks (freed from the pith) of the maize plant, ground into a coarse meal. Though it contains a high percentage of indigestible matter ("crude fibre"), the Maryland (U.S.A.) Station (*Bull.* 51) found it more digestible than timothy hay, in place of which it was successfully used for feeding horses. The protein content is only 6·5 per cent, which is less than that of maize bran; the ash is high (5·4 per cent); carbohydrates moderately high (49·3 per cent).

A somewhat similar product is made by mixing maize leaves with the rough outer part of the stalk and other refuse from the *cellulose factories* (see chap. XVII.), and grinding the whole finely for stock-food. A by-product of the *paper factories* (*ibid.*) is also sold for stock-food; experiments show that the feeding value of this material is higher than that of the original stalk containing the pith.

Another stock- and poultry-food sold in the United States is said to be prepared from the dry leaves, husks, and outside of the maize stalk, mixed with ox blood, molasses, meals, and chopped meat.

680. *Cerealine-feed.*—This is a by-product obtained in the manufacture of "cerealine" breakfast foods. The crude fibre is low; the protein, ash, and fat are moderate, and the carbohydrates high; it is almost identical with "hominy-feed".

681. "*Hominy-chop*" *and* "*Hominy-feed*".—These consist of the hull, germ, and starchy refuse from the samp or hominy factory, and differ from crushed maize in that a large portion of the starchy endosperm has been removed, leaving a higher

CHAP. XIV. proportion of protein and oil. The Geneva (N.Y., U.S.A.) Station (*Bull.* 166) reported the protein content to be about 10·6 per cent, and the starch and sugar 46 per cent, while if screenings and bits of cob are included the fibre content may equal 7 per cent. It is almost identical with "cerealine-feed".

682. *Maize for Dairy Cows.*—Henry (1) says that the pre-eminence of the great dairy region of the Western United States is "due in no small measure" to the use of maize products for feeding dairy cows. "No article is more palatable to the cow than maize in almost any form, and her fondness for it has often led to its abuse"; it should not form more than one-half or three-fifths of the concentrates fed to the dairy cow. It is better to feed the grain mixed with roughage.

"The relation of concentrates to roughage should always be borne in mind. The rule should be to feed nearly as much roughage as the cow will consume without overtaxing her; then supply sufficient concentrates to bring the digestible matter up to the required standard. About $\frac{4}{10}$ths of the digestible nutrient should be given in the form of concentrates and $\frac{6}{10}$ths in the roughage. It will not do to feed all grain in expectation of better returns. A satisfactory ration must possess a certain bulk or volume in order to properly distend the abdomen. Without this the process of digestion cannot proceed normally. This should never be forgotten, even when forcing cows in dairy contests."

The dairy cow when yielding a liberal supply of milk "should be regarded as an animal at hard labour. . . . The work-horse must have more grain and less roughage as his labour increases, and the same is true with the cow. A portion of the provender must therefore take the form of grain or concentrates. Moreover, if she is yielding a large amount of milk, i.e. working hard, it is best to aid her by reducing the grain to fineness by grinding. The 'dry' cow is doing little work and can subsist on less feed, and this may be coarser in character."

"Gluten meal, cream gluten, grain gluten, corn germ, and other by-products of maize are all excellent articles for feeding the cow, and their use is strongly recommended. Eastern dairymen have learned to appreciate these articles and use them extensively, while western dairymen, often living at no great distance from the factories where they are produced, know little or nothing concerning them" (*Henry*, 1). The value of maize meal for cows is mentioned in ¶ 666, and the comparative value of gluten meal and cotton-seed meal in ¶ 672. CHAP. XIV.

683. *Maize Rations for Dairy Cows.*—The Wisconsin Station obtained a number of reports from particularly successful dairymen, in all parts of the United States, of the rations used by them. From these the writer has selected the following as containing maize or maize products:—

Connecticut.—Maize silage, 35 lbs.; maize-and-cob meal, 3 lbs.; hay, 10 lbs.; bran, 3 lbs.; cotton-seed meal, 2 lbs.; Chicago gluten meal, 2 lbs.

Illinois.—Maize grain, 8 lbs.; oats, 1½ lbs.; clover hay, 10 lbs.; timothy hay, 10 lbs.

Indiana.—Maize silage, 30 lbs.; maize fodder, 3 lbs.; clover hay, 5 lbs.; oat straw, 1 lb.; wheat straw, 1 lb.; bran, 5 lbs.; oil meal,[1] 2 lbs.; cotton-seed meal, 2 lbs.

Iowa.—Maize silage, 50 lbs.; maize fodder, 5 lbs.; maize ears, 5 lbs.; oat straw, 1 lb.; barley straw, 1 lb.; hay, 5 lbs.; ground oats and barley, 2½ lbs.

Kentucky.—Maize silage, 32½ lbs.; maize fodder, 3 lbs.; maize meal, 5 lbs.; clover hay, 6 lbs.; ship-stuff, 4 lbs.; oil meal, 2 lbs.

Massachusetts.—Maize silage, 40 lbs.; gluten meal, 2 lbs.; clover hay, 5 lbs.; English hay, 5 lbs.; bran, 2 lbs.; cotton-seed meal, 1 lb.; oil meal, 1 lb.

Michigan.—Maize silage, 27½ lbs.; clover hay, 3½ lbs.; timothy hay, 3½ lbs.; bran, 3·6 lbs.; oats, ½ lb.; oil meal, ½ lb.; rye, 1 lb.

Minnesota.—Maize stover, 8 lbs.; maize meal, 3 lbs.; clover and timothy hay, 7 lbs.; oat forage (dry), 5 lbs.; oats, 3 lbs.; ruta-bagas, 3 lbs.; bran, 2 lbs.; oil meal, 2 lbs.

Nebraska.—Maize stover, 5·7 lbs.; maize meal, 2·9 lbs.; prairie hay, 20 lbs.; bran, 2·9 lbs.; oil meal, 1·4 lbs.

New Hampshire.—Maize stover, 10 lbs.; maize-and-cob meal, 2 lbs.; clover and witch-grass hay, 10 lbs.; barley forage, 5 lbs.; shorts, 2 lbs.; cotton-seed meal, 2 lbs.

[1] Oil meal: the residue after expressing the oil from linseed.

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New Jersey.—Maize silage, 24 lbs.; maize meal, 8 lbs.; bran, 2 lbs.; oats, 4 lbs.; oil meal, 2 lbs.

New York.—Maize silage, 25 lbs.; maize meal, 4 lbs.; mixed hay, 7 lbs.; bran, 5 lbs.; oil meal, ½ lb.; cotton-seed meal, ½ lb.

North Carolina.—Maize silage, 30 lbs.; maize fodder, 8 lbs.; maize meal, 3 lbs.; bran, 3 lbs.; cotton-seed meal, 1 lb.

Ohio.—Maize stover, 20 lbs.; maize meal, 8 lbs.; maize-and-cob meal, 3 lbs.; clover hay, 10 lbs.; bran, 1 lb.; roots, 8 lbs.

Pennsylvania.—Maize silage, 45 lbs.; mixed hay, 7 lbs.; bran, 6 lbs.; cotton-seed meal, 2 lbs.

Texas.—Maize silage, 30 lbs.; maize meal, 1·3 lbs.; sorghum hay, 13½ lbs.; cotton-seed meal, 2·6 lbs.; cotton seed, 2·2 lbs.; wheat bran, 1·3 lbs.

Vermont.—Maize silage, 35 lbs.; maize meal, 3·2 lbs.; mixed hay, 10 lbs.; bran, 2 lbs.; oil meal, 1 lb.; cotton-seed meal, 8 lbs.

West Virginia.—Maize silage, 48 lbs.; maize-and-cob meal, 2½ lbs.; ground wheat, 2½ lbs.; barley meal, 2½ lbs.; oats, 2½ lbs.

Wisconsin.—Maize silage, 40 lbs.; clover hay, 8 lbs.; bran, 6 lbs.; pea meal, 2 lbs.

Canada (Eastern).—Maize silage, 15 lbs.; turnips, 45 lbs.; wheat chaff, 7 lbs.; oats, 2½ lbs.; pea meal, 2½ lbs.

Summarizing the above we find that

Maize Silage is used for feeding dairy cows in the States of Connecticut, Indiana, Iowa, Kentucky, Massachusetts, Michigan, New Jersey, New York, North Carolina, Pennsylvania, Texas, Vermont, West Virginia and Wisconsin, and in Eastern Canada. The amount used ranges from 15 lbs. in Eastern Canada to 50 lbs. in Iowa, the average being about 34 lbs.

Maize Stover.—Minnesota, Nebraska, New Hampshire, and Ohio. Amount used: from 5·7 lbs. in Nebraska to 20 lbs. in Ohio.

Maize Fodder.—Indiana, Ohio, Kentucky, and North Carolina. Amount used: from 3 lbs. in Indiana and Kentucky to 8 lbs. in North Carolina.

Maize Grain.—Illinois; amount used: 8 lbs.

Maize Ears.—Iowa; amount used: 5 lbs.

Maize Meal.—Kentucky, Minnesota, Nebraska, New Jersey, New York, North Carolina, Ohio, Texas, and Vermont. Amount used ranges from 1·3 lbs. in Texas to 8 lbs. in New Jersey and Ohio.

Maize-and-cob Meal. — Connecticut, New Hampshire, Ohio, and West Virginia. Amount fed: 2 to 3 lbs.

Gluten Meal.[1]—Connecticut and Massachusetts. Amount fed: 2 lbs.

684. *Maize for Fattening Cattle.*—Prof. Henry (1), who is the foremost American authority on stock feeding, says: "Indian corn must continue the great grain-food for steer fattening in the United States. While we cannot vie with England in luxuriance of pasture, the advantage given our farmers by the corn-plant more than offsets this, and places us at the front in beef production. No concentrate is so relished by cattle as corn, the kernels of which carry considerable oil, rendering them toothsome and palatable to a degree not equalled by other grain. Not only does corn carry oil, but it is loaded with starch, likewise a fat-former, thus affording the nutriment needed for filling the tissues of the steer's body with fat, rendering the muscles tender and juicy. The success of steer-feeding in America must depend largely upon the supply of Indian corn available for this purpose."

In feeding whole maize grain to cattle some of it passes through the alimentary tract undigested. The Wisconsin Station (*Rep.* 1892) found that over 18 per cent of the maize fed as dry grain (but only 3 per cent of the grain from the silage) passed through cows in unbroken form. The Kansas Station (*Bull.* 47) found 11 per cent of soaked maize and nearly 16 per cent of the whole and broken dry maize passed through steers. It takes twenty-one to twenty-four hours for the grains to pass through them. The dry grain voided by steers does not become fully saturated, although it has passed through the whole length of the alimentary canal. This grain need not be wasted, as already pointed out, if vigorous young pigs are given the opportunity of searching it out among the droppings.

Some idea of the extent to which maize is used for fattening cattle in the Western States may be gathered from the statements of the Standard Cattle Company, Ames, Nebraska,

[1] Gluten meal: prepared from maize.

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of which an extended account is given by Coburn (2). Taking one year, 1896-7, as an example, we find that 5,454 head of cattle were marketed; these were fed for 215 days, the average gain per beast being 238 lbs., or 1·1 lbs. per day. To secure this gain the average amount of food consumed per head was:—

	Lbs.
Maize Grain	3,900
Maize Stover	2,150
	6,050
Hay	1,483
	Bushels.
Bran	2·3
Oats	·2
Barley	·7
Oil Cake	·7

Henry (1) has worked out the following rations, compounded in accordance with the Wolff-Lehmann feeding standard for steers weighing 1,000 lbs.: "These rations are constructed on purely theoretical grounds, but will be found satisfactory where the feeding-stuffs called for are reasonable in price".

Table CXX.

THEORETICAL RATIONS FOR STEERS OF 1,000 LBS.

	Amount Fed.	Dry Matter.	Digestible Nutrients.		
			Protein.	Carbo-hydrates.	Ether Extract (Fat).
	Lbs.	Lbs.			
Ration 1—					
Maize Fodder	8	4·62	·20	2·77	·03
Clover Hay	2	1·69	·13	·72	·03
Dent Maize	14	12·52	1·09	9·34	·60
Oil Meal, O.P.	4	3·63	1·17	1·31	·28
Total	28	22·46	2·59	14·14	·94
Ration 2—					
Maize Silage	30	6·27	·27	3·39	·21
Oat Straw	5	4·54	·06	1·93	·04
Roller Bran	10	8·81	1·22	3·92	·27
Corn-and-cob Meal	4	3·40	·18	2·40	·12
Cotton-seed Meal	2	1·84	·74	·38	·24
Total	51	24·86	2·47	12·02	·88

The following rations, which include maize in some form or another, have been selected from those used by the various Experiment Stations in the United States and Canada :— CHAP. XIV.

Stover and Maize Grain (*Kansas Station*, *Bull.* 39).

	Lbs.
Maize Stover	5
Ear Maize	26·7
Total	31·7
Average weight of Steers fed	1,211
Daily Gain	1·7

Maize Meal "Balanced" (*Kansas Station*, *Bull.* 34).

	Lbs.
Maize Meal	10
Shorts	5
Bran	2
Oil Meal	4
Tame Hay	6·5
Total	27·5
Average weight of Steers fed	1,083
Daily Gain	2·4

Maize Silage (*Texas Station*, *Bull.* 27).

	Lbs.
Maize Silage	20
Cotton-seed Meal	5
Cotton-seed Hulls	7·2
Total	32·2
Average weight of Steers fed	638
Daily Gain	1·76

Maize Silage (*Oregon Station*, *Bull.* 37).

	Lbs.
Maize Silage	18
Clover Hay	8
Chopped Wheat	10·3
Total	36·3
Average weight of Steers fed	847
Daily Gain	·2

Maize Grain and Roots (*Ontario Agricultural College*, *Rep.* 1883).

	Lbs.
Maize Grain	9·25
Roots	34
Hay	9·5
Bran	3·5
Total	56·25
Average weight of Steers fed	1,106
Daily Gain	2·31

Maize Grain and Meal, plus Oil Meal (*Iowa Station*, *Bull.* 20).

	Lbs.
Snapped Maize	22·5
Maize Meal	3·7
Oil Meal	4·2
Hay	5·7
Average weight of Steers fed	1,340
Daily Gain	2·8

Maize Grain and Cotton Seed (*Texas Station*, *Bull.* 27).

	Lbs.
Maize Grain	5·3
Cotton Seed	5·2
Hay	5·3
Total	15·8
Average weight of Steers fed	576
Daily Gain	1·9

685. *Maize for Work-oxen.*—A little crushed maize grain fed with a ration of hay and silage (¶ 718 and 726) during the winter months keeps oxen in good condition, and enables them to continue at work throughout the South African winter, when natural herbage is scarce.

686. *Maize for Horses.*—Next to oats, maize is the grain

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most commonly fed to horses in America; it is used most largely in the southern portion of the Corn-belt and southward in the cotton States. While conceding that maize is not the equal of oats as a grain for the horse, Henry (1) concludes that, because of its low cost and high feeding value, it will be extensively used wherever large numbers of horses must be economically maintained.

Maize may be fed whole to horses, but generally it is made fine by grinding, and mixed with various other concentrates. Maize-and-cob meal is preferable to pure maize meal (¶ 664); the latter should be diluted or extended with something of a light character, such as bran, which is light and cool in effect and furnishes protein and mineral matter (*Henry*, 1).

"Maize contains a high proportion of digestible carbohydrates, and tends to make the animals fat and liable to sweat; while it improves their appearance, it somewhat detracts from their physical energy" (*Lehmann*, quoted by *Wolff*, 1).

The conclusions reached as a result of the maize feeding experiment of the Paris Omnibus Company, employing nearly 10,000 horses, were that:—

"A mixture of 6·6 lbs. of maize and 12·1 lbs. of oats will prove the most satisfactory for work-horses, the ratio varying in each case according to the temperament of the animal. Compared with the time when only oats were fed, they are more calm at the present and lack the former abundance of vivacity; but, on the other hand, work as well and as rapidly as before."

The company saved about 38s. 7d. per horse during the year by the partial substitution of maize for oats (*Henry*, 1. See also *Journ. de l'Agric.*, 1877, p. 127; *Biederm. Centralbl.*, 1877, p. 255.)

Further experiments in maize-feeding were conducted by Muntz in 1881 with 362 horses belonging to the Paris Omnibus Company. With a daily ration of:—

	Lbs.
Maize	6·7
Oats	9·5
Beans	2·1
Bran	1·1
Hay	10·4
Straw	11·0
	40·8

the average weight of the horses remained the same during the experiment, and the amount of work done did not change, showing that the ration met the requirements of the animals. CHAP. XIV.

In a second test the following ration was used :—

	Lbs.
Maize	9·7
Oats	6·8
Beans	3·3
Bran	0·9
Hay	6·6
Straw	13·2
	40·5

On this ration, not only did the animals continue to work as before, but also gained in weight.

In these experiments it was found that maize is best if crushed before feeding to horses, and if crushed with the cobs left in. "Corn-and-cob meal is considered a better feed than pure corn meal on account of its higher content of cellulose, which renders it more like oats. Thirty per cent of an oat ration may be replaced by maize-and-cob meal." Similar reports as to the availability of maize for horse-feeding are published in regard to the Berlin Street Car Company (*Nordd. Landw.*, 1881, p. 141; *Biederm. Centralbl.*, 1881, p. 768), the Berlin mail-horse stables (*Landw. Blatt. f. Oldenburg*, 1880, p. 180), and the New York Omnibus Company (*Thur. Ldw. Zeit.*, 1880, p. 16); see also the exhaustive report on the subject by Bruckmüller on experiments conducted with army horses under the auspices of the Austrian Government, in *Oest. Viertelj. f. Wiss. Vet. Kunde*, 49 (1878), p. 1; *Biederm. Centralbl.*, 1878, p. 420.

The Utah Station (*Bull.* 30) found that horses fed maize and timothy hay did as well as those fed oats, clover, and timothy hay; also (*Bull.* 36) that maize sustained the weight of horses better than oats.

On the other hand, it is stated (*Fühling's Landw. Zeitung*, 39, 1890, p. 63) that the stockholders of the London Omnibus Company objected to the intensive feeding of maize to the horses of the company "because the mortality had increased with the extensive feeding of maize, and the horses seemed to

CHAP. XIV. wear out much sooner". The horses fattened by the maize feeding, but the muscular system was not kept strong, and the nervous force of the animals decreased, as a result of which the veterinarian was oftener consulted than before the extensive use of maize began. Similar experiences were reported in the case of the street-car horses of Berlin (*Jahrb. Agrl. Ch.*, 1890, p. 641, quoted by *Henry*, 1).

In Germany, Dr. Kloepfer draws the following conclusions (*Biederm. Centralbl.*, 1895, p. 275) from investigations conducted by himself and others concerning the value of Indian corn as a food for horses: "Maize is well adapted to replace oats, since the chemical composition of both cereals, especially as regards protein and fat, are nearly the same. The whole of the grain feed may be made up of maize in winter time, and three-fourths of it in summer time. Five pounds of maize are equivalent to 6 lbs. of oats. The heaviest feed should be given at night. The change from oats to maize feed should occur very gradually, the transition period lasting from two to four weeks according to the extent to which the oats are to be fed in connection with the maize. *New maize should not be fed to horses.* The American dent varieties are the best adapted to horse feeding" (*Henry*, 1).

Settegast (*Thierzucht*, II. 110) concludes that, while among all cereals oats are the best adapted for horses, and can hardly be replaced for colt-raising, maize may be considered as approximating oats in value for work-horses. "Experiments have shown that a ration of 18·7 lbs. maize and 11 lbs. of straw is profitable for omnibus horses. Maize is best suited to animals at plain steady work. Its supply should be limited with colts and growing horses because of its lack of ash and protein" (*Henry*, 1).

687. *Maize for Sheep.*—During the last twenty-five years a new industry has sprung up in the Western United States—that of fattening "plains" sheep in the Corn-belt. In the winter of 1889-90, 625,000 head of plains sheep were fattened in the State of Nebraska alone, the great maize crop of that year forming the basis of operations (*U.S.D.A.*, 8). The system is described briefly as follows:—

During the summer, plains sheep purchased in New Mexico, Colorado, or other western ranges, are gradually moved east-ward, grazing as they go. . . . By the time the maize is ripe the sheep have reached some point where it is for sale in vast quantities and at a low price. A corral or enclosure is made of pickets, and into this the sheep are driven, to remain until fattened. . . . Often 20,000 to 30,000, divided into a few bunches, are fed at a single point. Wild hay [i.e. veld hay] is unloaded against the picket fence through which the sheep feed; the only labour in handling the hay after unloading is for an attendant to keep it moved up close to the fence. In addition, from 1½ to 2 bushels of maize [84 to 112 lbs.], fed in troughs, are required per day for every 100 head of sheep. To this is usually added a few pounds of oil meal (linseed or cotton-seed). The feeding continues about 100 days, the sheep gaining on an average 15 lbs. per head during that time. The profit comes mainly from increasing the original value of the sheep. The industry is an irregular and uncertain one. . . . The profit depends upon the price of maize, which varies greatly from year to year and cannot be foretold much in advance of the time for feeding. Large numbers of Montana sheep are fed in much the same manner, in Minnesota, on the screenings from mills and elevators, this feed proving excellent for the purpose. Because of bits of straw and chaff in the screenings, fattening sheep do not surfeit so easily on them as on maize grain, and they may even be fed on the screenings without giving any hay in addition.

A large proportion of the slaughter sheep of the United States are fattened on maize grain. The Michigan, Wisconsin, and Minnesota Stations have studied the ration of maize grain and hay required for fattening lambs; they found that lambs averaging 81 lbs. each, during feeding trials averaging thirteen weeks in length, made gains of $\frac{3}{10}$ lb. per head daily, requiring about 500 lbs. of maize grain and 400 lbs. of hay for 100 lbs. increase in live weight (*Henry*, 1). The average daily ration of the 45 lambs tested was 1·42 lbs. of maize and 1·03 lbs. of hay per lamb. The highest average daily gain was obtained with the highest average daily ration of maize (1·53 lbs.); this ration was also the most economical, for it required the smallest weight of both maize and hay to produce 100 lbs. live weight.

Except in rare cases (such as valuable breeding sheep with poor teeth), whole grain only should be used for sheep, for of all farm animals the sheep is best able to do its own grinding. There is a common saying among stock feeders that "a sheep which cannot grind its own grain is not worth feeding" (see also ¶ 668).

Henry (1) concludes that it is not desirable to feed maize grain alone to *ewe* lambs which are later to be used for breeding purposes. But he finds that maize is the best single grain for slaughter lambs, causing them to put on fat rapidly and not forcing growth as is the case with some other concentrates. "Grain never gives such large returns as when fed to thrifty young animals, and the grazing lamb is no exception."

Several sheep farmers on the Transvaal High-veld are finding it profitable to give about ¼ lb. of maize grain per day to their sheep in winter, especially the stud rams and ewes. The grain is fed either crushed or whole. Some farmers feed it in troughs in a shed near the kraal, before the sheep are turned out into the veld in the morning. To prevent the animals stealing from one another, other farmers find it preferable to scatter the grain broadcast among the grass of the veld so thinly that the animals have to hunt for it. If the grain is fed always at the same spot, the sheep keep too closely to that part of the camp, and do not forage enough for their food, so it is usual to scatter it one day on one part of the camp and the next day on another part. For breeding ewes maize should form a small part, at most, of the winter ration; with good summer pasture they need no grain.

For fattening older sheep, as much as 1·4 lbs. of whole maize grain per head, per day, over a period of fourteen weeks, has been found satisfactory in Europe. Soaked maize proved far less profitable than dry (¶ 663).

The use of maize meal for lambs is discussed in ¶ 668.

688. *Maize for Pigs.*—If barley is the natural food of the domesticated English pig, maize is certainly the natural food of the American hog, and will also be that of the South African. In America, Henry (1) says that, although the special function of maize in pig feeding is for fattening purposes, maize, as the cheapest grain, must continue to be the common feeding stuff for all sorts of pigs.

"Having a proper knowledge of its composition and limitations," he adds, "the feeder is in a position to wisely use this great cereal. For breeding-stock, maize should constitute not over half the ration at any time, the amount being smallest with young animals. As the body increases in size and nears maturity, the demand for protein and ash becomes less, and the proportion of maize to other grain can be gradually increased until, during the fattening stage, the ration may, if desired, consist almost wholly of this grain."

There can be no doubt that many valuable sows have been utterly ruined for breeding purposes by *over*-feeding on maize and meal alone. . . . On this account sows should not be allowed to run with fattening hogs kept on maize, but in pasture, and allowed plenty of sop made of equal parts of shorts, maize meal, and wheat bran (*Coburn*, 3).

Henry (1) summarizes the investigations of the several American Experiment Stations with regard to pig feeding, and finds that pigs weighing less than 50 lbs. each, averaging 38 lbs., consume on the average 2·23 lbs. of grain or grain equivalent daily. As the animal increased in weight there was a gradual increase in the amount of food consumed, until the 450 lbs. pig was eating 10 lbs. of grain daily, or more than four times as much as the 50 lbs. pig.

He finds that when pigs have maize as their exclusive ration, they acquire a strong craving for wood ashes, considerable quantities of which are consumed if opportunity offers. He experimented to determine whether the ashes were of any benefit to the pigs or not. "As the trials progressed, it became evident that none of the pigs were properly nurtured, though the difference in favour of those getting bonemeal or ashes was very marked. The pigs which were allowed neither ashes nor bonemeal were most plainly dwarfed. It was evident that the maize meal, salt, and water did not supply all the elements essential to building a normal framework of bone and muscle. These dwarfs became so fat that the jowls and bellies of some of them nearly touched the ground.

"The pigs getting ashes or bonemeal grew very well for some time, but toward the close of the trial they made only fair gains, showing that the nutrients supplied were still too limited in character to allow normal development. . . . Feeding bonemeal or hardwood ashes to pigs otherwise confined to

CHAP. XIV. a maize-meal diet effected a saving of 23 per cent in the maize required for 100 lbs. of grain ; . . . the strength of the thigh bones was about double that of pigs not allowed bonemeal or ashes. . . . The bones . . . of the pigs getting ashes or bonemeal contained about 50 per cent more ash than the others ; . . . and still retained their form after burning, and did not crumble when carefully handled," while the others crumbled at once on handling. The strengthening effect of the ashes is attributed to the lime present. For further information on the effect of an excess of maize in the ration on the character of the bones, the reader may refer to *Bulletin* 201 of the Ohio Station, page 164.

Henry (1) notes a growing demand in the market for leaner pork. He advises that the demand can be met by "using more protein-rich feeds, with less maize, during the growth of the pig, and especially by shortening the fattening period. Feeding the by-products of milling, oats, barley, or the waste products of the dairy, with maize, the fattening period not being unduly prolonged, produces pork which will easily meet the requirements of the most discriminating market."

"Whether maize should be fed whole or as meal (¶ 667) depends upon circumstances. . . . Where grinding is not possible, hard maize may be prepared for feeding by soaking the grains. Ear maize and shelled maize can be satisfactorily fed to fattening pigs upon a feeding floor of matched lumber swept clean each day. Maize meal should always be soaked with water before feeding, the dry meal being unpalatable. Remembering that feeds in combination are better than the same feeds given singly, the prudent stockman will provide some complementary feed for pigs getting corn, even though the proportion of the secondary feed be small."

For pigs running on blue-grass pasture the Illinois Station (*Bull.* 16) found that the best returns were secured when giving a half feed of maize grain during the first eight weeks, then following for the next four weeks with a full feed of maize, the pigs still running on pasture. Where a full feed of grain was given for the whole period a much larger amount of maize was consumed for an equal gain in weight. "There was a saving of 30 per cent when a half feed of maize was given on pasture, and of 20 per cent when a full feed was given, as compared with feeding hogs in the lot without pasture" (*Henry*, 1).

Henry (1) found the saving of feed effected by allowing pigs to follow steers feeding on maize or maize meal amounted to 52 per cent in the case of maize, and 3 per cent in the case of maize meal, over the amount required to feed pigs in the pen. The amount of maize required to produce 100 lbs. gain was found by the Illinois Station to vary from 333 to 808 lbs. with an average of 534 lbs. The average daily gain was about 1·1 lbs. Eleven pounds increase, live weight, is considered in the United States to be a satisfactory return from a bushel (56 lbs.) of maize.

For feeding trials with gluten meal and maize meal for pigs, see ¶ 672.

689. *Maize for Ostriches and Poultry.*—Maize grain has become an important item in the dietary of the domesticated ostrich. In the districts in which ostrich growing is carried on most extensively, comparatively little maize is produced, and considerable quantities are imported from those parts of the country better suited to its production. One pound of grain per day, per bird, is recommended by many ostrich growers, and this amount is fed the year through.

In England there is an extensive trade in maize for feeding pheasants and poultry. For this purpose the small-grained sorts, such as Odessa, Galatz, Bessarabia, and Cinquantino, are preferred. This class of maize commands from 5d. to 7½d. (rarely up to 1s. 8d.) per muid more in the London market than the larger-grained classes. Unfortunately these types are in South Africa poor yielders, and the extra price obtainable is not sufficient to compensate for the smaller crop.

In warm climates maize seems to be too fat-forming a food for poultry except in the winter months, and Mr. Bourlay, the poultry expert of the Department of Agriculture of the Union of South Africa, recommends that even then it should not be used more than three times a week. A handful per bird, given at night, is the usual ration.

A Transvaal farmer once remarked to the writer: "I don't sell my mielies, but give them to my wife. I tell her that a bag of mielies will feed ten fowls; she can at any time sell those ten fowls for the table at 1s. 6d. apiece, which is 15s. in

CHAP. XIV. all. How else can I get 15s. for a bag of mielies?" He might have added that he also got the "droppings" from the ten fowls, a most excellent fertilizer for the garden.

690. *Manurial Value of Foodstuffs.*—A factor of importance in determining the relative values of foods is their effect in enriching the excreta of the animals which consume them, and thus adding to their manurial value. This aspect of the question is fully recognized in most European countries and in the United States. Ingle (2) gives the following example:—

Average samples of linseed cake contain 4·75 per cent of combined nitrogen, 2 per cent of phosphoric acid, and 1·4 per cent of potash. Although a certain proportion of these constituents is retained in the animal, being used in forming new tissue, the larger proportion eventually passes into the excreta and is available for manurial purposes. The proportion of the whole retained in the body, varies greatly with the age and condition of the animal, being greatest in young animals and least in adult working animals. In English farm tenancy, compensation is paid by the incoming to the outgoing tenant for every ton of food consumed, on the basis of the assumption that half the nitrogen, three-quarters of the phosphoric acid, and all the potash passes into the excrement; and that (1) all the constituents from the food consumed on the farm the previous year, (2) half those consumed two years ago, (3) one-quarter of those consumed three years ago, and (4) one-eighth of those consumed four years ago, are still available in the soil.

Messrs. Voelcker and Hall (1) prepared a table showing the valuation per ton as manure of the leading foodstuffs, which was reprinted by Mr. Ingle (2) in the *Transvaal Agricultural Journal* for 1906. They show that the oil-cakes, pulse, and leguminose hays, as naturally to be expected, have the highest manurial value. The cereals take the following sequence in compensation value for each ton of food consumed during the previous year; probably the money values would not be the same in South Africa, but their *relative* value would be approximately the same:—

	S.	D.
Malt Culms	35	11
Wheat Bran	28	11
Oats	15	5

	S.	D.
Malt	15	2
Wheat	14	10
Rice Meal	14	3
Barley	13	9
Maize Grain	13	0
Oat Straw	7	7
Barley Straw	6	9
Wheat Straw	6	5

Henry (1) gives the following as the fertilizing constituents in 1,000 lbs. of certain maize products:—

TABLE CXXI.

FERTILIZING CONSTITUENTS OF 1,000 LBS. OF CERTAIN MAIZE PRODUCTS.

	Nitrogen.	Phosphoric Acid.	Potash.
	Lbs.	Lbs.	Lbs.
Maize Grain (Average of all American Analyses)	18·2	7·0	4·0
Dent Maize Grain	16·5	—	—
Flint Maize Grain	16·8	—	—
Sweet Maize Grain	18·6	—	—
Maize Cob	5·0	0·6	6·0
Maize-and-cob Meal	14·1	5·7	4·7
Maize Bran	16·3	12·1	6·8
Gluten Meal	50·3	3·3	0·5
Germ Meal	26·5	8·0	5·0
Starch Refuse	22·4	7·0	5·2
Grano-gluten	49·8	5·1	1·5
Hominy-chop	16·3	9·8	4·9
Glucose Meal	57·7	—	—
Sugar Meal	36·3	4·1	0·3
Gluten Feed	38·4	4·1	0·3

CHAPTER XV.

THE PRESERVATION AND USE OF MAIZE STOVER, HAY AND SILAGE, FOR STOCK FOOD.

Fields of corn brandishing their myriad swords under the impulse of the breeze.—LEROY SCOTT (1).

CHAP. XV. 691. *Loss of Stock from Lack of Winter Food.*—The winter of 1912 will long be remembered for the heavy loss of stock incurred by farmers in each Province of South Africa.

In countries where the climate is such that the pasturage does not grow all through the year, or does not remain green, the stockman must take the precaution either (*a*) to keep only so many head of stock as can be carried on his winter or dry-season veld, or (*b*) to preserve as much food during the growing season, as is needed to keep his stock through the period when the pasturage is scarce. The first method necessitates locking up too much capital in keeping extra pasturage for winter; the second means the growing of surplus food in the summer, and is the more economical.

The mild South African winter makes stock-farming comparatively easy, and in consequence the stock-farmer is apt to become somewhat easy-going. If frozen ground compelled him to house his cattle in winter and to hand-feed them, as is necessary in some countries, he would have to be more provident; but because in most winters his animals manage to keep alive without artificial feeding, the average farmer does not trouble to provide winter feed. The South African farm is often too large, and in consequence the farmer does not get the full value from it; many farmers possess two or more stock-farms, one on the High-veld plateau and the other in the Bush-veld or "winter's-veld" as it is sometimes called, the latter being used, as its name implies, for the pasturing of stock during the winter months; this conduces to slovenly farming and tends to the propagation of scab and other evils among the animals. CHAP. XV.

The usual arguments against providing winter food are (1) that it involves too much personal labour, or (2) that it costs too much for hired labour, or (3) that trekking to the winter-veld is easier and cheaper. The answer is, that without necessarily working harder himself, the farmer can increase his profits by more intensive agriculture, and thus afford to employ more white labour; that trekking results in too much loss of stock and risk of infection, and indirectly involves the locking up of too much capital in a second farm, with consequent loss of interest; therefore it is not cheaper. By keeping the same amount of stock on a smaller farm, the farmer could either (*a*) let a portion of his present large holdings and use the rent for the hire of labour or purchase of labour-saving machinery, or (*b*) sell one farm, or a portion, and use the proceeds for the permanent improvement of the remainder. Farmers who have given up the annual trek to the winter-veld have found that their profits are greatly increased, as they lose less stock from the depredations of vermin and Kaffirs, and do not incur the risk of annual reinfection of their farms with scab and ticks.

At best, trekking is a poor makeshift; it cannot be depended upon as an infallible means of saving the stock in winter, for in some seasons, such as the winter of 1912, even the Bushveld grass is insufficient to save the stock.

692. *The Remedy.*—When we speak of such losses as occurred during the winter of 1912, as unnecessary, we do so not merely from a theoretical point of view, nor merely because the farmers of other countries have proved them unnecessary, but because we already have the proof of it before us in South Africa. We can point to farmers whose stock did not suffer during the winter of 1912; their oxen were ploughing through the winter, and were still fat at the end of the season, their cows were giving milk, and their sheep and lambs were healthy and in good condition. And these men did not have irrigated lands on which to grow lucerne and root-crops. Many South African farmers now have hundreds of acres of winter pasture-grass—New Zealand tall-fescue (*Festuca arundinacea*), *Phalaris bulbosa*, *Paspalum dilatatum*, and sheep's burnet (*Sanguisorba minor*)—which prove particularly valuable in the months of

CHAP. XV. September and October when there is usually the greatest scarcity of food.

But it is the despised mielie that will do most to save the situation. Maize is not only the staple crop of South Africa, but it is essentially the dry-farmers' crop. It was proved in the dry season of 1911-12 that a paying crop could be produced with less than 12 inches of rain, and the writer saw crops which were actually grown in the Orange Free State with a rainfall of only 8 inches between 1 October and 30 April.

Even in the driest years, and when the rains come late, maize can be grown for fodder or silage over a large part of South Africa, because it can be planted, for these purposes, so much later than when grown for grain.

There are farmers who grew winter food, and who yet were on the verge of suffering and loss, because their supplies were practically exhausted before the new grass came on. But these men, while they did well to keep their stock in condition so long, might have done better by providing two stacks of hay and two pits of silage for every one which they did make. Even if not required, it would not have been wasted, for in the climate of South Africa hay or silage will keep till a second year, if necessary, without any difficulty. It is the regular practice of European farmers to have one stack of old hay untouched when the new one is built, and it has been the plan at the Botanical Experiment Station, Pretoria, to start winter feeding with a two-year-old silage pit, reserving the current season's pit for the succeeding year, or for an emergency. One of the truest remarks made at the 1912 Dry Farming Congress, at Bloemfontein, was that, instead of expecting a drought once in five years, the farmer should prepare for one every year; if this advice is followed, he will be safe. Another good point was made at the same Congress, when Mr. J. J. van Niekerk urged farmers not to carry more stock than they could provide winter food for.

693. *The Feeding-value of an Acre of Maize.*—If we should hear to-day, for the first time, of a grass which would yield up to 18 tons of dry food from an acre of ground, and of which the supply of seed was limited and the cost exorbitant, there would be a scramble for it such as there was for *Northern Star*

potato a few years ago. People would willingly pay 10s. a pound for the seed, and every one would soon be growing it! Maize is a fodder grass that offers just such returns at 2½d. the pound for seed, yet most farmers do not think it worth the trouble to find out what can really be done with it; when its possibilities are hinted at they answer: "Oh! we know all about the mielie!" Why should there be this indifference to the value of the most wonderful fodder crop on earth, the world's "wonder-grass"? The reason is threefold: (1) Because the maize plant grows so easily that the average farmer allows it to grow without care or attention, therefore comparatively few people ever see, or have any conception of, a really good maize crop; their only idea is of a crop such as a Kaffir might grow. If the maize plant could not be grown without as much care and attention as is given to the mangel or onion, we should think more of it! (2) Because maize is an old and well-known crop it does not appeal to us as an attractively advertised *novelty* would; (3) because to produce a *heavy* crop of maize, the land must be well prepared and fertilized, and the crop carefully cultivated, which undoubtedly requires work; and it is human nature to be on the lookout for the easy thing in life. We read of some novelty (such as "*Helianti*") which purports to give large returns without labour, and eagerly buy it, only to learn that the advertisement has failed to note the universal truth about farm crops, that *no good crop of any kind can be produced except "by the sweat of the brow"*.

But it has been well and truly said (*Plumb*, 1) that there is no crop which will produce the same amount of equally nutritious fodder from an acre of land, and at so small a cost, as maize, and it will pay us to give it closer attention. Myrick (1) points out that the maize *plant*, quite apart from the ear, whether green or dry, is a palatable and healthful food for horses and ruminants, and that the dry matter is *more digestible* than that of timothy or clover hay. When properly prepared, the *food value* of the dry matter is rather less, but with the grain added, rather more than that of timothy hay. Investigations carried out at the Maryland (U.S.A.) Station by H. J. Patterson (1) show that a crop of maize will produce over a ton and a half (3,172 lbs.) *of total digestible matter* from an acre of ground.

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694. *Yield of Dry Fodder.*—The yield per acre of *dry* maize fodder varies from $11\frac{3}{4}$ tons (colonial) on very rich land and in a favourable season, down to $2\frac{1}{2}$ tons on poor land in a bad season. The following figures are on record:—

TABLE CXXII.

YIELD PER ACRE OF DRY MAIZE FODDER.

	Lbs.	Colonial Tons.
Victoria, Australia	36,000 to 14,000	18 to 7
Natal	23,607 to 10,117	11·8 to 5
Illinois Station	10,000	5
Various Experiment Stations (cited by *Henry*, 1)	9,000 to 5,000	4·5 to 2·5
New Jersey	8,200	4·1
Ontario, Canada	8,135	4
Ohio Station	6,000	3
Maine Station	5,580	2·79
Pennsylvania Station	5,520	2·79
Cornell Station	4,536	2·26
Wisconsin Station	4,490	2·24

695. *Yield of Green Maize Forage and Silage.*—From 10 to 55 tons per acre of green forage or silage can be obtained from the maize crop under favourable conditions. Henry of Wisconsin (1) quotes 15 to 25 tons as the yield obtained at a number of stations in the United States, presumably in the Corn-belt. Bowman and Crossley (1) give 12 to 15 tons as the usual yield in the United States. Sawer (1) mentions 24 to $35\frac{1}{2}$ tons for parts of Natal.

The following figures are also on record:—

TABLE CXXIII.

YIELD PER ACRE OF GREEN MAIZE FORAGE.

	Tons.
Victoria, Australia	$21\frac{1}{2}$ to $55\frac{3}{4}$[1]
Ontario Station	$20\frac{1}{2}$
Maine Station	$19\frac{3}{4}$
New Jersey Station	$11\frac{1}{4}$
Pennsylvania Station	$9\frac{1}{4}$
Cornell Station	$7\frac{1}{4}$ to 11

[1] Calculating a loss of two-thirds moisture in drying, this would give roughly 7 to 18 tons of dry fodder (see *Victorian Journal of Agriculture*, Vol. VIII, Pt. 6, June, 1910).

The five stations last named are *not* in the area known as the Corn-belt. CHAP. XV.

Hunt (1) concludes that 12 tons per acre of suitably ripened maize is a good yield, and that 8 to 10 tons is a safer estimate when calculating how much land should be planted to provide silage for a given number of animals. Messrs. Hutchinson and Shaw, Standerton District, Transvaal, calculate their average yield at about 9 tons per acre.

696. *Food Value of Weeds.*—There is always a certain amount of food to be obtained off the maize lands, from the late crop of weeds. Some of these, especially black-jacks (*Bidens pilosa*) and the sweet-grasses (*Chloris virgata* and *Panicum lævifolium*), are undoubtedly nutritious, but it would not be sound or profitable farming to allow the maize crop to become weedy for the sake of the food to be obtained from the weeds.

697. *Forms in which Maize can be Preserved for Stock Food.*—Maize is used for stock food in the following forms:—

(1) Maize stover.
(2) Maize fodder.
(3) Green maize forage.
(4) Maize silage.
(5) Maize grain and grain-products.

The value of maize grain for stock food is discussed in the previous chapter; in this chapter we shall deal with the other parts of the crop.

698. *Relative Composition of Maize Stover, Fodder, Silage, and Grain.*—The relative composition of maize grain, silage, fodder, and stover is shown in the following table (No. CXXIV), compiled by Henry (1), from the results of 194 American analyses, i.e. 99 of silage, 35 of fodder, and 60 of stover. A comparison is also made with the average of 208 analyses of maize grain.

Hunt (1) calls our attention to the fact that the average composition of the water-free substance of the sixty samples of maize stover is almost identical with the average composition of sixty-eight samples of timothy hay, except for a somewhat higher percentage of fat in the latter and a corresponding higher percentage of nitrogen-free extract in the maize stover.

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Table CXXIV.

RELATIVE COMPOSITION OF MAIZE SILAGE, FODDER, STOVER, AND GRAIN.

	Protein (N×6·25).	Nitrogen-free Extract.	Fat.	Ash.	Crude Fibre.	Water.
Fresh Silage	1·7	11·1	0·8	1·4	6·0	79·1
Field-cured Fodder	4·5	34·7	1·6	2·7	14·3	42·2
Stover	3·8	31·9	1·1	3·4	19·7	40·1
Dry Grain	10·5	69·6	5·4	1·5	2·1	10·9
Water-free—						
Silage	8·0	53·0	3·8	6·6	28·7	—
Fodder	7·8	60·1	2·8	4·7	24·7	—
Stover	6·4	53·2	1·7	5·7	33·0	—

But the relative value cannot be determined alone by the relative amounts of nutrient substances contained. These substances are not always of equal digestibility, and it is therefore desirable that we know the relative digestibility of the food eaten. Then again there are the questions of relative palatability and of waste of material in preparation and feeding, all of which affect the relative value from the point of view of the feeder.

699. *Relative Digestibility of Maize Fodder, Stover, and Silage.*—Henry (1) has worked out the following table to show the comparative feeding-value of maize fodder, stover and silage, based on their digestibility:—

Table CXXV.

RELATIVE DIGESTIBILITY OF MAIZE FODDER, STOVER, AND SILAGE.

	Digestible Nutrients in 100 lbs.				
	Dry Matter in 100 lbs.	Protein.	Carbo-hydrates.	Ether Extracts (Fats).	Total.
Maize forage, green	20·7	1·0	11·6	0·4	13·0
Maize fodder, field-cured	57·8	2·5	34·6	1·2	38·3
Maize stover, field-cured	59·5	1·7	32·4	0·7	34·8
Maize silage	20·9	0·9	11·3	0·7	12·9

700. *Amount of Digestible Matter in Different Parts of the Maize Plant.*—Patterson (1) shows that in a crop of maize the fodder produced contains a larger amount of total digestible matter than the grain. The figures for total digestible matter in the crop of an acre, as given by him, are:—

	Lbs.
In ears	1,530
In fodder . . .	1,642
	3,172

701. *Loss of Weight and of Feeding-value and other Changes due to Curing.*—In the preservation of maize for winter use the amount of feeding-matter obtained from the stack or silo will be less than the amount put down. This loss is not only in moisture-content, but also in actual dry matter; there is also a slight loss in feeding-value.

Moisture-content.—Approximately two-thirds of its moisture-content is lost in curing maize fodder in the field.

Dry matter.—Maize fodder loses from 19 to 21 per cent of dry matter in the process of field-curing. This loss is nearly 5 per cent less if the fodder is cut in the green-mielie stage than if allowed to become nearly ripe, which appears to be due to the larger amount of soluble carbohydrates present in the latter stage of development.

Loss in Feeding-value.—There is also a slight loss of food-value in the process of preservation. This occurs principally in the "nitrogen-free extract," i.e. the carbohydrates other than the fibre. This loss is found to be less in the case of silage than of fodder, and greatest in the case of stover.

702. *Losses in the Silo.*—These vary in amount, depending on the construction of the silo (chapter XVI.) and the care and method employed in filling and covering it. But even with the best of silos, filled in the best possible manner, a certain amount of loss cannot be prevented. This is partly due to fermentative bacterial agency, but partly also, as shown by Babcock and Russell (1, pp. 177-84), to the respirating activity of the protoplasm, which still lives and continues to give off carbonic acid gas (CO_2) for some time after the maize plant has been cut for the silo. This latter item of loss has been shown to amount to about 1 per cent of the total weight of the

CHAP. XV. silage, and the total unavoidable loss to from 2 to 4 per cent (*Wisconsin Bull.* 83, p. 64). Hunt (1) considers it probable that, if the silo is properly constructed and filled, and feeding begins as soon as it is filled, the total loss need not exceed 10 to 12 per cent. What the extent of the loss is in general farm practice does not appear to be known, but the American Experiment Stations have frequently reported up to 20 per cent, which means that, if we wish to provide 160 tons of silage for the latter part of winter and early spring, we must grow and put into the silo 200 tons; if the loss is only 15 per cent we shall have 170 tons of silage from our 200 tons of maize.

FIG. 234.—Cattle feeding on standing maize stover, Transvaal.

703. *Maize Stover.*—Maize "stover" is the residue of the maize crop after the ears have been removed, and its feeding value is therefore lower than that of maize fodder. After the ears are harvested, the stalks are sometimes left standing in the field, and cattle are turned in to pick up the ears lost in harvesting, and to eat what they can of the stover and the grass and other weeds found in the rows (Fig. 234). But useful as the stover is, this simple method of treatment is not the most, but the least economical.

"It is to be deprecated because of the wastefulness of the process. The stover dries so much after maturity that a great deal of nutriment in the stalk is lost before the maize is eaten. Because of this over-curing, the palatability of the maize is greatly lessened; hence much of it will not be consumed. A large proportion of it becomes broken down and fouled, which causes still further waste. The cattle are often required to graze upon it when the weather is unfavourable, hence there is a loss in thus exposing the animals. Of course it is better to pasture the maize than not to use it at all, but the stover would furnish much more food if it were harvested and fed to the animals as needed. The prodigality of some of the western farmers of this country [United States] furnishes a striking illustration of this wasteful method of handling, or rather not handling, maize stover. Each acre of the food, *if properly utilized*, is worth as much as an acre of average timothy hay" (*Shaw*, 1).

The most nutritious part of the stover is the *leaf;* but the leaf left in the field becomes so brittle in a dry atmosphere that it is easily broken into minute fragments by the animals which wander over the field in search of stray ears of grain; these pieces are carried away by the wind or, falling on the ground, are trampled under foot; a few days after the stock are turned into the standing stover very little is left but bare stalks which are the least nutritious and least digestible part.

The less wasteful way is to harvest the maize stalks before the ears are quite dry, and to stook them in the field; by this method there is not so much loss of dry matter and of feeding-value. Even when stover which has been harvested is fed to stock, there is a considerable waste, not only in loss of leaf, but the Wisconsin Station found that 34 per cent of the *whole* stover was not eaten.

Stooked maize may be passed through a "combined husker and shredder" (Fig. 235), which removes the husks, shells the ears and "shreds" the stover into short lengths which are more readily eaten by the animals and are thus less wasteful than whole stover.

In some countries maize stover is fed with the addition of a little molasses to render it more palatable.

704. *Stover for Dairy-cows.*—Cows are fond of the finer parts of the maize stalk, and if the stover is run through a

CHAP. XV. feed-cutter and not too liberally supplied, only a small part of the stalk will be wasted. Henry (1) points out, however, that in some parts of the United States, especially in the South, the maize stalks are coarse and inert and not much relished by cows; it is said to be so, also, in the warmer parts of South Africa. But he adds that the same maize stalks are relished when preserved in the form of silage.

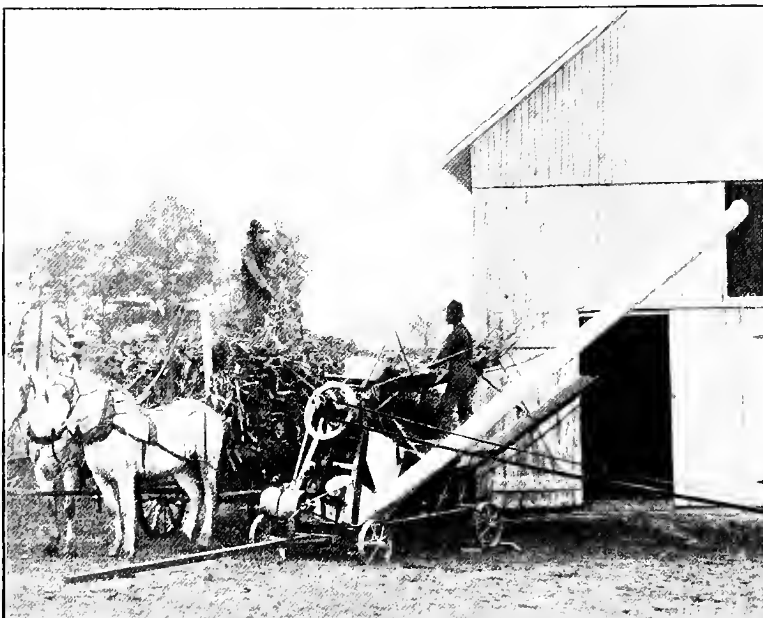

FIG. 235.—Shredding stover in the United States.

The Wisconsin Station (*Rep.* 1884) tested uncut maize stover for dairy cows, as compared with mixed hay and clover; the results were practically equal; but it was found that three tons of maize stover, as fed in this experiment, were worth only one ton of mixed clover-and-timothy hay. It required 193 lbs. of maize stover, plus 60 lbs. of maize meal and bran, to produce 100 lbs. of milk; and 3,880 lbs. stover, plus 1,233 lbs. maize meal and bran, to produce 100 lbs. of butter.

705. *Stover for Sheep.*—The Michigan Station made a comparative test of feeding lambs with maize stover, maize

grain, and roots, as compared with clover-hay, bean-straw, maize grain, and roots. The results were highly satisfactory and in favour of the stover, grain, and roots, as the more economical of the two feeding mixtures. CHAP. XV.

"The principal objection to feeding maize stalks [stover] to lambs is that, when fed in the bundle from racks, the lambs waste a large percentage of the fodder. The only satisfactory method of feeding them is in racks after the stalks have been cut in a cutting-box or silage machine. The stalks fed in this experiment were cut with an ordinary silage cutter and fed

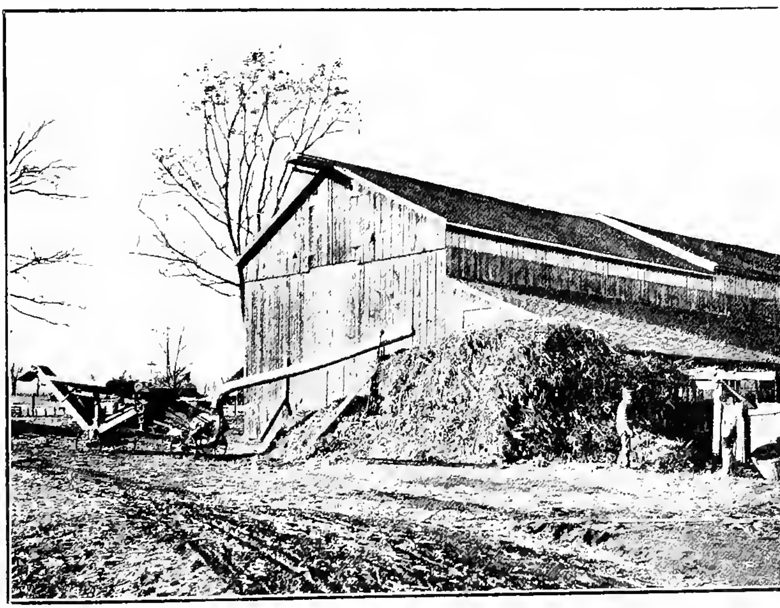

FIG. 236.—Shredded stover on an American farm.

from racks. The average daily ration of this fodder was 1·18 lbs. for each of the ten lambs. Each lamb in the lot receiving maize stalks as the fodder ration, gained an average of 2·15 lbs. per week, or 30·2 lbs. for the whole period. Such flattering results should make every sheep-feeder value his maize stalks highly, and induce him to take every possible precaution to properly preserve them" (*Mumford*, in *Michigan Station Bull.* 136).

706. *Maize Fodder or "Shocked-corn"*.—The simple method of preserving maize for winter use in the form of

CHAP. XV. "fodder" or "shocked corn," is largely practised in the North Atlantic and Southern States, and in parts of the North Central States, and has been successfully adopted by a few South African farmers for several years. By maize "fodder" we mean the whole plant as taken direct from the "shock" without husking, thus supplying in one both concentrated food and roughage, and with a minimum of labour.

"The fodder, with its wealth of ears, is thrown into long feed racks standing in an open lot or under a shed, the steers doing the husking and grinding" (*Henry*, 1).

This method is largely employed in the fattening of beef for the large American markets.

Maize fodder has a higher feeding value than maize stover, but slightly lower than maize silage; it is less palatable than the latter, and there is a larger amount of waste in feeding.

707. *Maize Fodder for Dairy Cows.*—The Pennsylvania Station (*Rep.* 1892) tested the feeding value of maize fodder for dairy cows, as compared with timothy hay. More milk was obtained from the timothy but more butter from the maize fodder. The cows fed on the timothy gained in weight, while those on maize fodder lost. The cows ate about 3 per cent more of the hay than of the maize fodder. "The trials show these two feeds to be substantially equal, pound for pound." From this the high value of maize fodder is apparent; for while 4,000 lbs. of timothy hay per acre is considered a good return, the maize fodder used in the trial yielded at the rate of 8,885 lbs. per acre. The trial suggests the possibility that timothy hay conduces to the storage of fat in the body of the cow, while maize fodder turns the fat into milk (*Henry*, 1).

708. *Maize Fodder for Bullocks.*—Stewart (1, p. 311) reports a trial conducted by himself with ten steers averaging 1,175 lbs. weight each, which were fed 4 measured acres of shock-maize, estimated to yield 40 bushels (11·2 muids) of grain per acre. The unhusked shock-maize was passed through a feed cutter, and 40 lbs. of the mixture, with 2 lbs. of linseed meal, was fed daily. The 4 acres kept the 10 steers, or an average of 2·5 steers per acre, for 70 days, each steer gaining 200 lbs., on the average, in that time. Making allowance

for the oil-meal, this author concludes that the crop gave a return of 400 lbs. of beef per acre; at 5 cents (2½d.) per lb. the increase was worth $20 (£4 3s. 4d.) per acre of maize so fed. This is about *double* the return obtained by Morrow from an acre of Illinois *pasturage* grazed by yearling steers.

709. *Composition of Dry Maize Fodder.*—The combined result of a very large number of analyses shows that in field-cured dry fodder the leaf-blades are the richest in protein (6 per cent), the stalks containing only 1·9 per cent and the husks 2·5 per cent. Maize fodder, cut before the grain is dead ripe, is much more nutritious than the stover, the fodder containing more protein, nitrogen-free extract and fat, and less ash and fibre. The following table is extracted from Jenkins and Winton's (1) tables:—

TABLE CXXVI.

COMPOSITION OF THE DIFFERENT PARTS OF THE DRY MAIZE FODDER.

Dry Fodder, Field-cured.	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Number of Analyses.
Fodder . .	42·0	2·7	4·5	14·3	34·7	1·6	35
Stover . .	40·1	3·4	3·8	19·7	31·9	1·1	60
Leaves . .	30·0	5·5	6·0	21·4	35·7	1·4	17
Husks . .	50·9	1·8	2·5	15·8	28·3	0·7	16
Stalks . .	68·4	1·2	1·9	11·0	17·0	0·5	15

710. *Relative Value of Fodder from Different Varieties.*—Comparison of Jenkins and Winton's (1) tables also shows that there is but little difference in feeding value of the fodder of any one variety and that of another:—

TABLE CXXVII.

RELATIVE VALUE OF FODDER FROM DIFFERENT VARIETIES.

	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Number of Analyses.
Flint breeds .	79·8	1·1	2·0	4·3	12·1	0·7	40
Dent breeds .	79·0	1·2	1·7	5·6	12·0	0·5	63
Sugar breeds .	79·1	1·3	1·9	4·4	12·8	0·5	21

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711. *Moisture-content of Maize Fodder and Stover.*—The amount of water in field-cured maize fodder has been found to vary from 23 to 60 per cent, and in field-cured stover from 15 to 57 per cent in different localities and seasons (*Hunt*, 1.)

The moisture-content may also vary up or down, according to the weather. The Connecticut Station (*Rep.* 1878) records a case in which the moisture-content of field-cured maize fodder doubled between 11 November and 8 February; it weighed 5 tons when put in storage, and 8 tons three months later; "this is probably unusual, but it shows the possibility of variation of weight due to atmospheric conditions".

To determine the amount of digestible nutrients in any given sample, therefore, a fresh analysis should be made for any particular part of the country or any given season; the average of all analyses can be of no practical use for this purpose. The relative amount of protein, fat, and carbohydrates will probably not vary very greatly from the mean.

712. *Green Maize Forage.*—Maize is sometimes grown for green fodder for dairy cows, horses, etc. But there is usually such an abundance of summer feed on South African farms that it is not required at that time of year except perhaps for dairies in or near towns. Being sensitive to frost maize cannot be grown as a winter crop, except in quite frostless localities where lucerne might in many cases be produced with equal or greater advantage.

Sir J. Percy Fitzpatrick observes:—

"I saw in many places in Germany that the small farmers plant maize for cow and pig feeding. The grain of course cannot mature there, but they get a good weight of green food. Most plots are only about 10 yards by 50 yards. The maize is planted in rows, the plants being about 6 inches apart and the rows about 12 inches apart. The result (on presumably highly manured ground) is a dense mass of stems, with leafy tops, 10 feet high. It struck me that this would be a good addition to feed for cows in milk. Such small plots could be sown close to the cow sheds and the reaping and transporting costs would be trifling."

713. *Relative Value of Green Maize Forage from different*

Varieties.—Henry (1) gives the following as the average composition of green maize forage in the United States:— CHAP. XV.

	Digestive Nutrients in 100 lbs.	Nutritive Ratio.
Dent breeds	13·5 lbs.	1 : 14·5
Flint ,, ...	13·0 ,,	1 : 11·39
Sweet ,, ...	14·2 ,,	1 : 11·25

There is, therefore, a marked difference in favour of flint and sweet maize as regards nutritive ratio, and of sweet maize as regards digestive nutrients. But there is another aspect of the case from the farmer's point of view. The yield per acre is usually so much larger in the case of the dent breeds that it may be more profitable to grow them and to make up the deficiency in protein—which must be supplied in any case—with a rather larger proportion of protein-rich foodstuffs. Still another aspect is that, as the quality of the stalks and leaves declines rapidly after maturity, their feeding value will be found to depend more on the length and manner of storing than on the variety of maize grown. The application of manures also affects the quality.

714. *Maize Silage.*—Of the three forms in which maize fodder is preserved (i.e. silage, fodder, or stover), the silage is the most palatable and gives the least waste in feeding. The protein content of the silage is slightly higher than that of the fodder; the fat is 1 per cent higher and the ash 2 per cent higher; on the other hand, the nitrogen-free extract (*carbohydrates*) is 7 per cent lower, and the indigestible matter ("crude fibre") 4 per cent higher in the silage than in the fodder. To compensate for the latter the palatability of the silage is greater than in the case of the fodder, and there is far less waste in feeding it, because the silage—if properly prepared and properly fed—is eaten up clean, while the rough ends of the fodder are usually wasted. The succulence of the silage is of value in the dry period of early spring, and a rather higher rate of feeding can be maintained with it than with dry fodder, which helps to increase the yield of butter-fat.

"Experiments show the digestibility of silage and maize fodder to be about equal, when all other conditions except method of preserving, remain the same. A large number of feeding experiments, mostly with milch cows, show, in general, CHAP. XV. about equal food value for amount of dry matter consumed, but that ordinarily there is less waste in the consumption of silage, thus adding to the total returns per acre" (*Henry*, 1).

The following definition of silage is given by Russell (1):—

"When the green parts of living plants are cut up and packed in a loosely covered vessel allowing entrance of air, mould soon makes its appearance and decomposition begins; the mass becomes alkaline and is ultimately converted into black humic bodies quite unfit for cattle food. But if air is excluded the change is fundamentally different; no mould develops, the temperature rises, the mass takes on a greenish-brown colour and characteristic odour, it becomes acid and for a long period is suitable for cattle food. The former is a putrefactive change, the latter gives rise to silage. The general chemical changes known to take place during ensilage are the conversion of sugar and similar bodies into carbon dioxide and water, the production of volatile acetic and butyric acids and of non-volatile lactic acid and the conversion of protein into non-protein material."

The modern meaning of the word *silage* is green, succulent food-stuff which has been preserved in a silo. A *silo* is a pit or erection in which such food-stuff is preserved. The process of preserving the material is known as *ensiling*. The process of ensiling food-stuffs is a very ancient one (¶ 743) but was originally applied mainly to grain; it was practised by the South African native to preserve his kaffir corn, probably long before the advent of the white man.

The relative weight of crop which can be obtained from an acre of cultivated land is one of the main considerations in deciding between the relative merits of the various silage crops.

It is false economy to make silage of any crop which can be preserved in the ordinary process of haymaking, and in the climate of South Africa, with its dry atmosphere and abundance of sunshine, the making of silage from grass, and such crops as teff or manna, is not recommended. There is a minimum loss in the feeding value of such crops when made into hay, but they do not make such good silage. With bulky, succulent crops like maize, kaffir corn, sorghum, and teosinte, which do not dry readily, ensiling is often the best method of preservation, especially at the time of year when they are usually ready to be preserved, and when—except in the Western Province—South African farmers are apt to have many days, and sometimes several weeks, of continuous rain.

"If the stockman desires a cheap, succulent feed for his cattle in winter, he will find it in maize silage. The same quantity of nutriment that a root-crop yields can be produced more economically in maize forage stored in the shape of silage" (*Henry*, 1).

715. *Maize for Silage may be Planted Late.*—Another advantage of ensiling maize is that for this purpose it may be planted after the last safe date for planting the grain crop, and harvested before the grain crop is ready. Much of the silage maize of the Transvaal is planted in January, and it is ensiled during the months of March or April. On the High-veld of the Transvaal and Orange Free State, the planting period starts earlier, i.e. from the first week of November to the first week of December, according to the breed of maize grown. Harvesting should be completed before the frosts begin, for although frosted maize can be ensiled profitably if cut immediately after it is frosted, it is difficult to get it all cut quickly enough. The preparation of silage can be continued during the rain, as the green fodder may be ensiled safely even when wet.

716. *Uses of Silage.*—Maize silage is especially useful for feeding to cattle (¶ 717 and 718) and sheep, and is also suitable for horses and mules. It is particularly valuable for breeding-stock, especially dairy cows and ewes with lamb, because it stimulates the milk flow. For fattening slaughter-stock it is an invaluable addition to the veld grass or dry hay during the winter months. In limited quantity it is also used for working oxen and other animals, to help in maintaining their condition. It is generally advisable not to feed silage alone but as part of a mixed ration.

717. *Silage for Dairy Cows.*—Silage, principally from the maize plant, is now a factor of first importance on thousands of American dairy farms. That it is well liked by the cow; that she thrives on it and yields milk liberally; that properly fed, it does not impair her health; all these points have been settled in favour of the silo and its product (*Henry*, 1). See also ¶ 683 and 724.

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The New Jersey Station (*Bull.* 122) tested silage for milk production in comparison with maize fodder. A portion of the fodder was left uneaten, but the silage was eaten without waste. While both lots of cows gained in weight during the trial, those which had the silage ration produced 12·8 per cent more milk and 10·4 per cent more fat than those fed on dry maize fodder.

718. *Silage for Bullocks.*—Maize silage is used satisfactorily for steers during the early stages of fattening. "At first as much as 40 or 50 lbs. of silage may be given daily to each steer. When the full grain-feeding period arrives let the allowance be cut down to 25 or 30 lbs. per day; a limited use of this feed will keep the system cool and the appetite vigorous" (*Henry*, 1).

At Vereeniging, Mr. McLaren's working oxen receive from 20 to 30 lbs. per day of maize silage and 6 to 8 lbs. of crushed maize grain, which keeps them in good working condition during the dry spring months (September, October, and November) when veld grass is scarce; the actual amount varies with the amount of hard work being done.

719. *Maize Silage* v. *Timothy Hay.*—The Maine Station (*Rep.* 1889) tested maize silage for dairy cows, as compared with "good hay" (mostly timothy) for milk production. There was an increase of 7 per cent milk when changing from hay to silage and hay, and a decrease of 8 per cent when changing back from silage to hay.

"In this experiment the addition of silage to the ration resulted in a somewhat increased production of milk solids, which was not caused by an increase in the digestible food material eaten, but which must have been due either to the superior value of the nutrients of the silage over those of the hay, or to the general physiological effect of feeding a greater variety of foods. In other words, 8·8 lbs. of silage proved to be somewhat superior to 1·98 lbs. of hay (mostly timothy), the quantity of digestible material being the same in the two cases. . . . Assuming the digestible matter of hay and silage to be of equal value, pound for pound; when hay is worth $10 [£2] a ton, silage of the kind used in this experiment would be worth $2·25 [9s.] per ton. But this silage contained more water than the average. . . . Had it been of average quality, then the ton value reckoned on the above basis would be $2·62

[11s.]. But in this case we should give the silage the credit of the increased milk production, which seems to have been at the rate of 85 lbs. of milk to each ton of silage" (*Jordan*, 1).

720. *Maize Silage* v. *Roots*.—The Michigan Station (*Bull.* 84, p. 107) concludes that "until further trial, we may consider roots and maize silage practically equal in feeding value for fattening lambs". "Maize silage is only slightly inferior in feeding value to roots such as mangels and swedes, and to all intents and purposes can replace them in the feeding ration" (*Holm*, 7).

721. *Comparative Farm Value of Maize Grown for Silage and for Grain*.—Comparing the value to the farmer of maize grown for silage or for grain to put on the market, in the latter case the stover being consumed on the farm, Holm (7) obtains the following figures:—

	Per Acre.
Yield of say 8 muids of maize per acre at 10s.	£4 0 0
Value of stover per acre say	0 10 0
	£4 10 0

Estimating 4 tons of silage to be equivalent in value to say 1 ton of oat-hay, and calculating oat-hay at £5 per ton, the silage would be worth 25s. per ton. The value of an acre of maize yielding only 10 tons of silage would therefore be worth £12 10s., as against £4 10s. for the grain and stover, leaving a difference of £8 in favour of the silage; if we deduct from this £2 per acre for extra cost of labour in making the silage, we still have *a balance of £6 per acre in favour of silage*. But that is perhaps the least important aspect of the case, as *the value of plenty of good succulent fodder for live stock during the winter season can hardly be estimated* (*Holm*, 7).

722. *Cost of Silage Production*.—The cost of producing maize silage in the Transvaal is estimated by Holm (7) at 10s. to 12s. per ton, the figures working out as follows:—

	Per Acre.
Ploughing, cultivation, seed, and seeding	£1 15 0
Cutting and hauling to silo	1 15 0
Chaffing and pitting	1 10 0
Total cost per acre	£5 0 0

At 10 to 15 tons per acre the cost per ton works out, therefore, at 10s. to 6s. 8d. according to yield per acre. The interest and depreciation on capital expenditure for excavation of pit and cost of machinery would, he calculates, bring the cost up to 12s. or 10s. per ton. But it is, of course, impossible to form an exact estimate, as the cost varies under different circumstances. If the loss in weight in the silo equals 15 per cent, this amount should be added to the cost. It is calculated that maize silage should prove "a very cheap feeding stuff at the above figures" (*Holm, 7*).

Some farmers who do not include in their costs the labour regularly employed on the farm for other purposes, nor make any charge for their working oxen, put the cost as low as 5s. per ton.

723. *Amount of Silage Required for Feeding.*— Twenty acres (English), or an area of 96,800 square yards, say 346 × 280 yards, should produce 200 tons of maize suitable for ensiling. With a loss of 15 per cent in the silo this will give 170 tons of silage at the time it is most required. For capacity of silos and acreage required to fill them, see chapter XVI., ¶ 746.

If they have roughage such as veld grazing or veld hay in addition, 170 tons of silage will feed and keep in condition 680 sheep, or 170 oxen, or 113 dairy cows, for 100 days; or 500 sheep and 24 oxen and 4 dairy cows, for 109 days. These figures are based on the allowance of 5 lbs. of silage for a sheep, 20 lbs. for an ox at work, and 30 lbs. for a dairy cow, in addition to roughage.

On the dry lands of the North-western Orange Free State and parts of Bechuanaland, it is possible that not more than 5 tons of maize silage per acre will be produced; but even then the crop is well worth preserving for winter feed.

724. *The Feeding of Silage.*—Much waste of good silage often takes place through ignorance of the fact that it spoils quickly if exposed to the air; the advent of fresh oxygen facilitates decomposition. To prevent such waste, a certain amount of the exposed surface should be removed regularly each day after the pit has once been opened. With a rectangular pit, a better check can be kept on the amount of surface exposed than with a circular pit. In opening the pit it is customary to first remove the soil for a width of 6 feet at one end, and to feed the material from this space until the bottom

is reached; this makes room for subsequent work. After this a portion not less than 2 inches thick is removed from the exposed surface every day, and no more is uncovered than can be treated in this way. Chopped silage may be filled into bags and is then easily carted to the place where it is required. CHAP. XV.

Care should be taken when the feeding of silage is begun, for if fed indiscriminately at first it may cause scour. The quantity should be small for a few days, and should be increased gradually. Chopped silage can be conveniently mixed with the maize grain and bran when these are also used. If silage is fed in the open, it is well to put out each day only so much as will be consumed during that day, as it is likely to deteriorate if exposed to the atmosphere for any length of time (*Holm*, 7).

The character of silage is such that, though cows seemingly thrive on it, even when fed alone, some dry roughage should be supplied with it (*Henry*, 1). This should preferably be a nitrogenous food such as lucerne, cowpea, velvet-bean, or peanut hay; even teff hay, though not as rich in protein as these, may be used with advantage.

Good maize silage should contain a liberal supply of ears, and the amount to be fed will depend directly on the proportion of ears to forage. From 30 to 50 lbs. is the usual daily allowance for a cow (*Henry*, 1).

725. *Silage Feeding Table.*—The following table (CXXVIII) given by King (1), shows the inside diameters of silos 24 feet and 30 feet deep, which will permit the surface to be lowered in feeding at the mean rate of 1·2 to 2 inches per day, assuming 40 lbs. of silage to be fed to each cow.

726. *Importance of a "Balanced" Ration.*—Ingle (2 and 3) has pointed out the danger of feeding draught animals upon an exclusive diet of cereals, because such a diet does not adequately supply the needs of animals with respect to bone-forming materials, especially lime and phosphoric acid. The value of foodstuffs is usually based on the proportions present of the three following classes of constituents:—

(1) Proteids or albuminoids (i.e. nitrogenous substances);
(2) Carbohydrates (e.g. starch and sugar); and
(3) Ether extract or fatty substances,

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Table CXXVIII.

SILAGE FEEDING TABLE.

No. of Cows.	Feed for 240 Days.						Feed for 180 Days.					
	Silo 24 ft. Deep. Rate 1·2 in. Daily.			Silo 30 ft. Deep. Rate 1·5 in. Daily.			Silo 24 ft. Deep. Rate 1·6 in. Daily.			Silo 30 ft. Deep. Rate 2 in. Daily.		
	Tons.	Inside Diameter.		Tons.	Inside Diameter.		Tons.	Inside Diameter.		Tons.	Inside Diameter.	
		ft.	in.		ft.	in.		ft.	in.		ft.	in.
10	48	11	11	48	10	2	36	10	4	36	8	9
15	72	14	7	72	12	5	34	12	8	54	10	9
20	96	16	10	96	14	4	72	14	7	72	12	5
25	120	18	10	120	16	0	90	16	4	90	13	10
30	144	20	8	144	17	6	108	17	10	108	15	2
35	168	22	4	168	18	11	126	19	4	126	16	4
40	192	23	10	192	20	3	144	20	8	144	17	6
45	216	25	7	216	21	5	162	21	11	162	18	7
50	240	26	8	240	22	7	180	23	1	180	19	7
60	288	29	2	288	24	9	216	25	3	216	21	5
70	336	31	6	336	26	9	252	27	4	252	23	2
80	384	33	8	384	28	7	288	29	2	288	24	9
90	432	35	9	432	30	4	324	30	11	324	26	3
100	480	37	8	480	31	11	360	32	8	360	27	8

To secure satisfactory results in stock-feeding, it is necessary to supply these three classes of materials in *well-balanced* rations, i.e. in proportions suitable to the special requirements of the particular class of animal we are feeding. The proportion of nitrogenous to non-nitrogenous materials is known as the "*nutritive ratio*". This ratio is approximately fixed (within limits) for different classes of animals under different conditions, and it is found that to secure the most satisfactory results these limits cannot be exceeded.

Ingle gives the following nutritive ratios as those which have been found, by experiment, to be most suitable in the rations required for various purposes; in this table the first column represents the proteids and the second the carbohydrates and fats :—

Table CXXIX.

NUTRITIVE RATIOS FOR DIFFERENT ANIMALS.

For very young animals	1 : 4·0
,, oxen at rest	1 : 11·0
,, oxen moderately worked	1 : 7·5
,, oxen heavily worked	1 : 6·0

For horses moderately worked	1 :	7·0
,, horses heavily worked	1 :	5·5
,, cows giving little milk	1 :	6·0
,, cows giving much milk	1 :	5·0
,, sheep for wool production	1 :	8·0
,, fattening sheep, cattle, and pigs	1 :	5·5
,, laying hens or ducks	1 :	4·0

Ingle (2 and 3) notes that working horses or mules fed upon an exclusive diet of maize grain and oat-hay are receiving either too little nitrogenous matter for their requirements, or, if they secure the requisite amount by eating more food, are taking more fats and carbohydrates than they require. This is, therefore, a wasteful method of feeding, and is likely also to injure the health of the animals. Ingle recommends, not the reduction of the amount of maize grain, but the substitution for a portion of the oat-hay of some foodstuff with a "*narrower*" albuminoid ratio, i.e. of some product richer in nitrogenous material, such as teff grass, lucerne, velvet-bean hay, peanut hay, maize forage, maize stover, soybeans, peas, beans, or the various oilcakes. In other words, we should not—as we are too apt to do—run to the extreme of condemning maize grain because it is too "*broad*" a ration to be used alone, but should "*narrow it down*" by the addition of suitable "balancing" material.

727. *Nutritive Ratios of some Food-stuffs.*—Ingle has also given the following list of nutritive ratios:—

TABLE CXXX.

NUTRITIVE RATIOS OF DIFFERENT FOODSTUFFS.

Maize ("bread" or "flour-maize"; Transvaal grown)	1 :	9·6
Maize (dent; Transvaal grown)	1 :	9·2
Maize (flint; Transvaal grown)	1 :	8·0
Kaffir corn	1 :	8·2
Oat grain	1 :	6·0
Wheat grain	1 :	6·4
Barley grain	1 :	6·0
Buckwheat	1 :	6·1
Millet (grain)	1 :	5·7
Linseed	1 :	5·1
Peas	1 :	2·7
Soybeans	1 :	2·0
Horsebeans	1 :	2·0
Cowpeas	1 :	2·8
Linseed cake	1 :	2·0
Coconut cake	1 :	3·2

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Peanut cake	1 : 0·9
Bran	1 : 3·6
Lucerne hay	1 : 2·3
Teff grass (*Eragrostis abyssinica*) hay (Transvaal grown)	1 : 7·7
Boer manna (*Setaria italica*) hay (Transvaal grown)	1 : 10·1
Natal blue-grass hay [1]	1 : 10·2
Rhodes grass (*Chloris gayana*) (Transvaal grown)	1 : 3·5
English meadow-hay	1 : 4·9

[1] Several grasses pass under the name of Natal Blue-grass, e.g. *Themeda Forskalii*, and species of Andropogon.

728. *Mixtures to Increase the Feeding Value of Maize Silage.*—To give more "balance" to the ration of maize silage some nitrogenous material should be added. Where concentrated foodstuffs such as linseed meal, peanut meal, hominy-chop, or soybean cake are cheap, they can be added to the daily ration. But many farmers will probably find it more economical to grow a leguminose crop which can be cut up and mixed with the maize in the silo. There are several such crops which can be grown in the summer season and used in this way. These include:—

Velvet-beans (*Mucuna utilis*). A Bush-veld and Low-country crop, rather slow of growth, but giving a remarkably heavy yield. The seed should not be planted until the ground is warm. It is usually planted in rows 4 feet apart, with two or three seeds dropped every 2 feet in the row. Sometimes the velvet-bean is planted with the maize for silage, but this may interfere somewhat with the cleaning of the latter crop.

Cowpeas or kaffir-beans (*Vigna Catjang*) form a valuable crop for silage or for hay. In cold soils the seed is apt to rot if planted before the ground is warm. The principal drawback to the cowpea as a farm crop is the difficulty of threshing the seed, as the pods do not open easily. In the Southern States, where it is largely grown for stock-food, farmers usually shell out only enough to plant their own crop; the seed is particularly subject to weevil; for these reasons it is both scarce and costly, but there is generally a limited supply on the local markets. A good plan is to sow cowpeas broadcast among the maize at the time of the last (say the fourth) cultivation. This adds to the feeding value of the stover or fodder and helps to check the seeding of weeds.

Velvet-beans and cowpeas are usually cut for silage when the beans are well filled in the pod. But as the velvet-bean is a slow-growing crop, it is often rather late in coming to maturity, and it is sometimes necessary to cut it in the flowering stage.

The hyacinth-bean (*Dolichos Lablab*) is another admirable fodder crop.

Peanuts or monkey nuts (*Arachis hypogæa*). When grown for the "nuts" the peanut straw can be used in the silo, but the crop is too light to be grown especially for silage.

Soybeans (*Glycine hispida*) are being grown in the Transvaal and Natal for rotation crops, and can be used for silage. In some localities they are considered less satisfactory as regards yield than either velvet-beans or cowpeas.

Sugar-beans (*Phaseolus vulgaris*) can be grown for silage; the running sorts are preferable as they give a greater yield of fodder.

Lucerne (*Medicago sativa*) can be cut green and used to add nitrogenous matter to the maize silage; if the weather is not suitable for making lucerne hay, this is a convenient way of utilizing the crop. Lucerne is considered to be in the best condition for ensiling when it is beginning to flower.

729. *Kinds of Silage.*—Silage may be either "sour" ("green") or "sweet" ("brown"). The difference depends on the degree and kind of fermentation, and this, again, is regulated by the temperature of the mass. If the temperature is allowed to rise above 130° F., sweet silage results; if it reaches 150° F. it becomes "brown"; if it gets to 160° F. and over, it becomes what is known as "burnt" silage, which is undesirable. If the temperature does not exceed 120° F. the silage will be green or sour. Sour silage is found to keep better than sweet, after the silo or stack has once been opened for use. When the stock have been fed on sour silage for a few days and have become accustomed to it, they are said to prefer it to "sweet". But "sour" silage is apt to leave an unpleasant odour about the premises. "The best silage is probably that which is intermediate between the sour and sweet stages" (*Holm*, 7).

730. *Composition of Maize Silage.*—Russell (1) has studied the chemical changes taking place during the ensiling of maize, and finds that the main groups of compounds found in maize

CHAP. XV. silage are: fatty acids, hydroxy-acids, amino acids, basic diamino acids, purin, and other bases besides the ordinary constituents of the plant cell, the celluloses, protein, etc. The non-nitrogenous acids are not found in maize at the time of cutting, and the nitrogenous acids, though they are found, occur to a smaller extent than in silage.

The characteristic silage changes are the disappearance of sugar, of some less resistant celluloses, and of part of the protein, and the formation of the bodies enumerated above.

Three agents appear to be involved in making silage: the living maize cell, the enzymes, and micro-organisms. It is considered that the two former bring about the primary and essential changes, the latter only secondary and non-essential changes.

The formation of acetic and butyric acids appears to be a respiration effect, and comes about when the living cell is deprived of oxygen. Sugar disappears during the process.

The decomposition of the protein and nucleo-protein is effected by enzymes present at the time of cutting the maize, which can go on acting in the silo even after the cell is dead. Characteristic products of protein-hydrolysis were identified in the silage.

These are regarded as the primary and essential changes. Bacteria are, however, always present, and attack the less resistant celluloses, the products of protein-hydrolysis, and no doubt other substances as well, but not the resistant fibre. Typical products of bacterial activity were found—formic acid, higher fatty acids, humus, and amines.

The growth of mould is inhibited except at the surface layer where fresh air has access. Here the changes are fundamentally different; there is no development of acetic or butyric acids, the mass is alkaline; non-protein material already existing in the maize is converted into protein, and there is also a loss of nitrogen.

731. *Changes in the Protein due to Ensiling.*—The New Jersey (U.S.A.) Station (*Bull.* 122) found that ensiling resulted in the conversion of about two-thirds of the more complex albuminoids into the simpler amides. "Silage often contains nearly half its nitrogen in amide form, while dry fodder-corn has not more than from 12 to 15 per cent of its nitrogen in

the form of amides" (*Henry*, 1). The albuminoids are usually insoluble in water, or may be rendered so by heat, while the amides are soluble in water. This would suggest that the amides might be more readily digestible than the albuminoids, and in partial corroboration of this view we find that maize silage will produce 12·8 per cent more milk and 10·4 per cent more butter-fat than maize fodder.

Henry (1) says that "it is now fairly well established that a large majority of the amides found in plants are nutrients proper, that is, when fed they enter the system and are oxidized in the same way as other food nutrients". "Asparagin, an amide present in most young plants, has repeatedly been shown to cause a gain of protein in the body when fed with a fodder poor in protein." . . . "In some of their functions at least, amides may replace albuminoids." . . . "Equally good results have been obtained where amides have been substituted for part of the albuminoids in the ration for growing animals and milch cows, as were obtained when albuminoids only were fed."

732. *Moisture-content of Maize Silage.*—The moisture-content of maize silage varies considerably, but not as much as that of maize fodder, e.g. the variation is recorded as ranging from 62·4 per cent to 87·7 per cent. A ton of silage containing 62·4 per cent water would, of course, contain more than three times as much dry matter as that which contained 87·7 per cent water. Much of the silage in the United States contains 70 per cent or less of water. The Wisconsin Station (*Rep.* 1895) reports a case in which the water in the silage increased 2·3 per cent after it was put into the silo; Hunt (1) concludes that "the loss of dry matter in silage is greater than the loss of water".

733. *Composition of Maize Silage Compared with that of Green Maize Forage.*—Analyses of green maize and of maize silage by Feruglio and Mayer are reported in Table CXXXI.

734. *Popular Objections to Silage.*—Objection is sometimes raised to feeding dairy cows on silage for the reason that silage is supposed to give an unpleasant smell and flavour to the milk. When such is the case, it is because sufficient and suitable care has not been taken with the feeding. Neither the flavour nor the odour of the silage pass through the body of the cow to the milk, but they may be acquired from bits of

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TABLE CXXXI.

COMPOSITION OF MAIZE SILAGE COMPARED WITH THAT OF GREEN MAIZE FORAGE.

On a Dry Matter Basis.	Green Forage, Per Cent.	Silage, Per Cent.
Crude Protein	8·419	8·562
Ether Extract[1]	2·173	5·000
Invert Sugar	14·296	4·701
Sucrose	2·511	0·273
Amids	1·960	1·100
Pentosans	20·686	19·130
Cellulose	28·248	27·758
Ash	7·050	6·400
Undetermined (obtained by difference)	12·880	20·171
Acidity	1·777	6·905
	100·000	100·000
Water Content	79·295	78·770
The Pure Protein	4·000	2·560

silage left scattered about during the milking. On this account silage should not be fed before but immediately *after* milking, so that any odour which may have been disseminated through the cowshed may have gone before the next milking time, thus preventing the absorption by the milk of any undesirable flavour.

735. *The Best Breeds of Maize for Silage.*—In farm practice it is often the custom to plant for silage the same breed of maize that is grown for grain, the extra weight of green stuff being obtained by closer planting. The usual experience is that it involves too much labour and expense to keep a special sort of maize for silage; as the silage crop is planted too late to ripen seed, it is necessary either to buy seed of silage maize, or to grow a special seed plot; if the latter plan is adopted, it involves the danger of cross-pollination with the main grain crop, especially through the scattering of the seed and the consequent growth of volunteer plants.

But if a special sort is desired, it should be (*a*) one that is early in maturing, so that it can be sown late and yet be ready for harvest before the first frost falls; (*b*) one suited to the soil and climate; (*c*) one that will give a large amount of foliage and succulent stems. The choice is therefore limited to those

[1] "Fats."

breeds which suit the particular district. *Yellow Horsetooth* and *Natal White Horsetooth* are favourites in some parts of South Africa, as they are vigorous growers and heavy yielders under favourable conditions, but they are inclined to be rather late in maturing, and in cold localities, therefore, must be planted early. CHAP. XV.

The *Argentine* maize, a yellow flint breed recently introduced into the Transvaal, is a promising silage maize. Some of the ordinary breeds, such as *Hickory King*, have developed strains with a habit of *stooling* (i.e. branching from the base),

FIG. 237.—Filling silage-pit, Vereeniging. (Courtesy of Messrs. John Fowler & Co. (Leeds), Ltd.)

which are better suited for silage than the unbranched strains; but here again, the difficulty of maintaining the supply of seed has to be faced.

736. *Planting Distance for Silage or Fodder Maize.*—The distance for planting maize for silage is discussed in chapter IX. (Tillage, Planting, and Cultivation).

737. *Best Condition of the Crop for Harvesting.*—The stage of growth and best condition of the crop for harvesting, and the chemical composition at various stages of growth, are discussed in chapter XI. (Harvesting and Storage of Maize).

738. *Methods of Ensiling.*—The modern silo is sometimes

CHAP. XV. an elaborate and expensive structure, which may cost hundreds of pounds (Figs. 241-3); but good silage can be made in a very simple manner and at small cost. Three methods of preparation are in vogue: stacking, burying in a pit, and preserving in an air-tight chamber. The principle is the same in all cases, i.e. development of a limited degree of fermentation followed by the exclusion of air to prevent desiccation and to arrest decomposition. These ends are attained by building up a mass of moist vegetation, which then begins to sweat; if this sweating were allowed to continue indefinitely "spontaneous combustion" would ensue, and the mass would be spoiled. The most suitable temperature is from 130° to 140° F. To allow the whole mass to reach this temperature it must not be too deep at any one time; to prevent increase of temperature above this point, fresh material is added, the added weight tending to compress the lower mass, force out the air, exclude a fresh supply of oxygen, and thus check fermentation. In practice it is not necessary to use a thermometer to determine the actual temperature; if the surface heat becomes so great that one can only with difficulty bear to keep the hand in it, more fodder should be added or the pit, if filled, should be sealed up; but if it does not get warm, it should be kept open a few days, and a little water may be poured on it to assist in starting fermentation.

739. *The Addition of Salt.*—Silage is greatly improved by the addition of salt; Prof. Wrightson recommends the use of 1½ lbs. to every ton of the green material. Salt has a stimulating influence on the appetite of the animal, facilitates the passage of the albuminoids from the digestive canal into the blood, and in general increases the energy of the vital processes. The feeding of salt is therefore especially useful with horses, young animals, and milch cows fed to their full capacity. Another effect of salt is to increase the excretion of urine (*Henry*, 1).

740. *The Modern Silo.*—"The more compact the silage, the better it keeps. The greater its diameter and the more nearly circular the silo, the less the resistance of the sides to packing. The deeper the silo, the more compact the silage and the less the surface exposure in proportion to the whole mass. . . . The surface area of the silo should be such that

the silage will be fed rapidly enough to prevent decay. It should never be more than ten square feet per cow; five is better, while seven and a half gives good results. The riper the silage, the *less weight* the silo will hold. The higher the silo and the greater the diameter, the *more weight* the silo will hold. The weight and keeping quality will depend also upon the manner of filling. . . . The more slowly the silo is filled, the more it will hold. A silo 16 feet in diameter and 30 feet high will hold, when continuously filled with suitably ripened maize, 33½ to 40 lbs. of silage per cubic foot, or about 100 tons of silage. A cubic foot of such silage is a standard daily ration for a cow in milk. The capacity of the silo required may be calculated in cubic feet by multiplying the number of animals to be fed by the days of feeding desired" (*Hunt*, 1).

The construction of modern silos is discussed in the following chapter (XVI.). Some silos in South Africa have been constructed of double walls of corrugated iron, well braced and hooped together, and are reported as having been quite successful.

But at best the silo is an expensive item, and where other and more imperative outlay is required on the farm, its construction may well be left till a future time. In the climate of South Africa, at least the greater part of which enjoys a dry winter, excellent silage can be made either in a pit or in a stack.

741. *The Stack Silo.*—The stack silo is built up in the form of a haystack (Fig. 238) of maize stalks not cut into lengths. Several Transvaal farmers have made stack silage for years, and find it an economical and easy method of preserving winter feed. The principle to be followed in making stack silage is to pack the maize stalks as closely and evenly as possible, a small quantity at a time; four or five ox-wagon loads per day are sufficient for a moderate stack. This is built up to the required height (usually 10 or 12 feet), and when a suitable temperature has been obtained the stack is weighted down to prevent further increase of temperature. Some farmers use a thick layer of veld hay, which gives the necessary weight and can afterwards be used as bedding. In the Bush-veld, where wood is plentiful, poles can be utilized; in other places, bricks, stones, and even corrugated iron and soil

CHAP. XV. are used with success. Some Bush-veld farmers build the silo on timbers laid on the ground, with cross-pieces under the ends; a similar arrangement of poles is laid on top of the stack; the upper and lower cross-pieces are connected by chains or strong steel rope, and tightened by leverage; this operation is carried out every few days, until the mass ceases to settle.

In making stack silage there is a good deal of waste on the outside of the stack; this may be reduced by paring off

FIG. 238.—Making stack-silage, Standerton District, Transvaal. (Farm of Messrs. Hutchinson & Shaw, Zandbaken, Val Station.)

the sides and ends every three or four days while the stack is being built (Fig. 239), the parings being thrown into the centre. Some farmers put a layer of wet dung 9 to 12 inches thick, to seal up the top of the stack and prevent injury and waste.

742. *The Pit Silo.*—At the Botanical Experiment Station, Pretoria, at the Government Experiment Farm, Potchefstroom, at Messrs. John Fowler and Company's Demonstration Farms, Vereeniging (Fig. 237), at Major Doyle's farm, Woburn, on the Springbok Flats, and on several other farms the pit method of preparing silage has been in use for several years; in the

climate of the Transvaal it proves both economical and effective. At Potchefstroom it has been customary to make about 150 tons of pit-silage per annum, and at Vereeniging about 600 tons. These pits (Fig. 240) are not lined in any way and have no floor other than the solid ground. They are covered with earth, and there is no roof over them, so that the cost of pre-

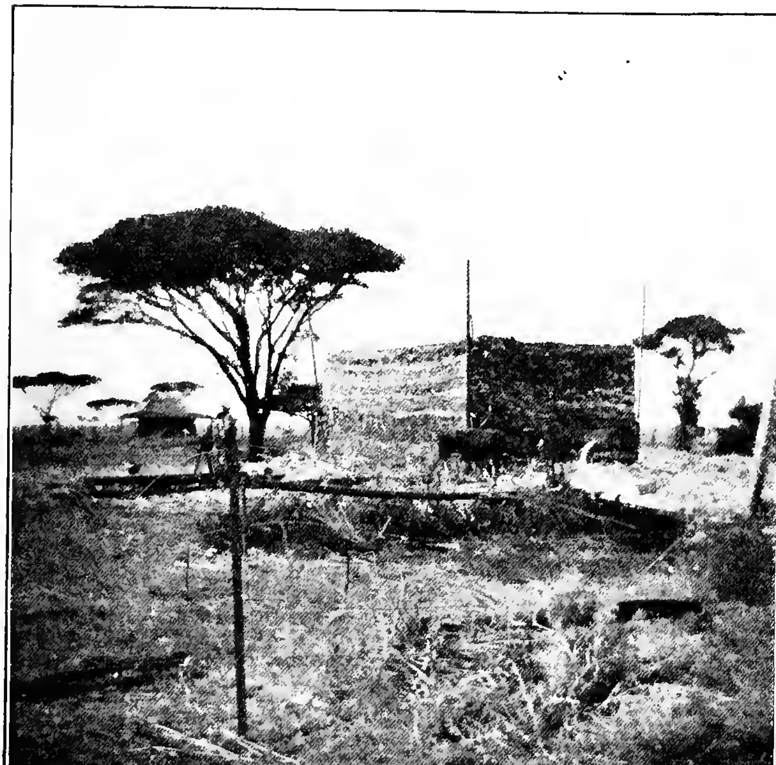

FIG. 239.—Stack-silo, Springbok Flats, Transvaal. (Note that the rough sides have been pared smooth.)

paration of the silo is very small. As the silage is stored during the dry season, there is usually no danger of seepage, provided a suitable site for the pit is selected; in some localities a catch-water ditch around the upper side of the pit is found desirable. If the pit has to be made in loose soil, a lining of corrugated iron or other suitable substance may be

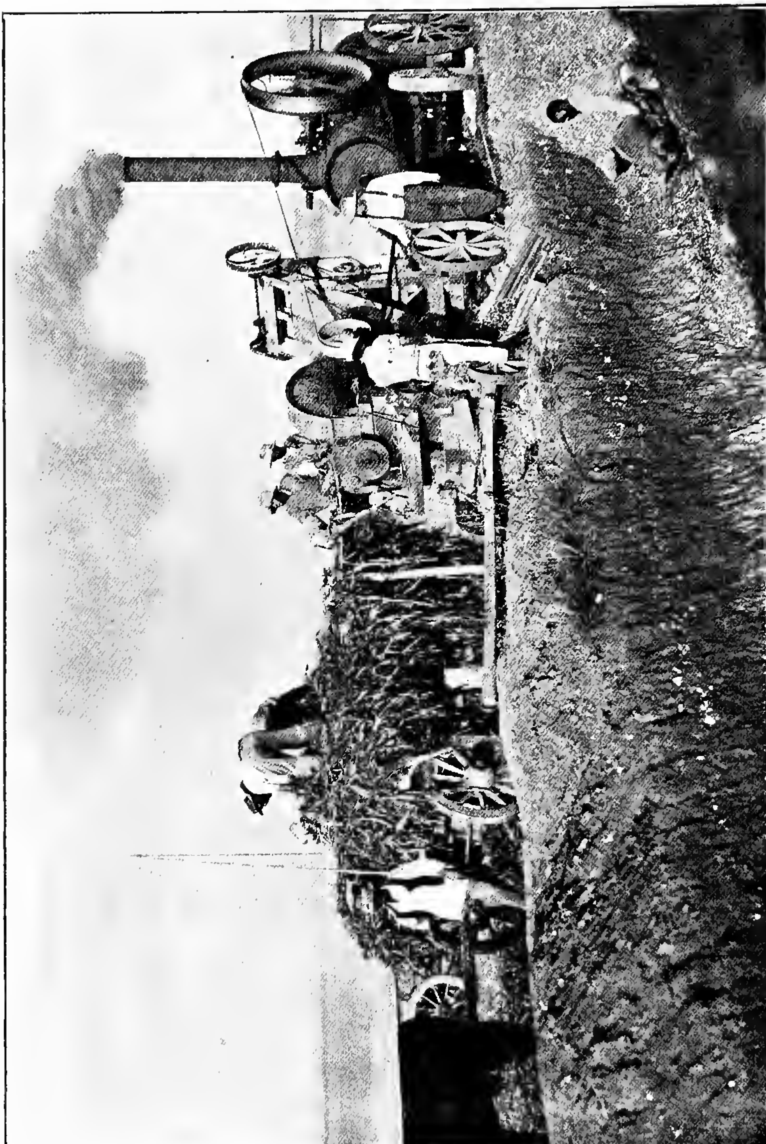

FIG. 240.—Cutting silage and filling pit, Burttholm, Vereeniging.

used. If there is danger of springs breaking into the pit, some provision for drainage may be found necessary. Rectangular pits are preferable to circular ones, because in the former, when opened for use, the silage can be removed in sections without uncovering the whole surface, thus preventing loss from exposure to the atmosphere. Several small pits are preferable to one very large one, because it may be desired to reserve one or more of them for another year, and there need be no damage to the silage through its having been kept over if protected from the weather and from seepage of moisture; but once opened to the air, the contents do not keep.

A pit 25 feet long, 15 feet wide, and 8 feet deep, containing 3,000 cubic feet, would hold about 55 tons of silage. If the maize has been well cut and packed, a cubic foot should weigh from 35 to 40 lbs. Some farmers put the maize stalks into the pit whole, as they would on to the stack, but the usual method is to cut them into lengths of ½ to 1½ inches with a chaff-cutter (Fig. 240), which results in closer packing and a better quality of silage; in this form it is more easily removed from the pit, and there is little or no waste in feeding, such as there is when the material is left long. The time consumed in cutting is well spent. The pit may be filled as rapidly as the maize can be cut, or the filling may extend over a fairly long period, without affecting the quality of the silage; the usual method is to put 2 or 3 feet of silage into each pit each day, allowing it to heat and settle for a day or two (not more than three), when another 2 or 3 feet may be added. To prevent loss of time, two or three pits, in close proximity, may be kept going by moving the chaff-cutter from one to the other. For small pits the cutting may be done by hand-power, but horse-gear or steam-power are used for the larger. Much of the success of the work depends on the management of the pit; the fodder should be kept spread evenly over the surface as the cutting proceeds, and exceptional care should be taken to keep the outsides well trodden; if the mass at the edges of the pit remains loosely packed, it will become mouldy and unfit for food. When the mass is a few feet deep a mule or horse is kept walking about in the pit to tread it down. If the maize is rather too mature and dry, a little water should be thrown over the mass occasionally. The pit is filled to about a foot

CHAP. XV. above the ground level and allowed to settle for a day or two; it is then covered with a layer of soil about a foot deep and evenly spread to give the necessary pressure and to exclude air. The silage can be kept indefinitely in the pit, or feeding can commence (if the latter is kept sealed) in about two months.

742A. *The American Cornstalk Disease.*—In the central maize districts of the United States many farmers continue to follow the old practice of picking by hand the ears from the standing stalks, turning the cattle into the stalk fields to gather the stray ears left by the huskers, and to eat what they like of the maize leaves and stalks, and the weeds found among them.

"Not infrequently, within a day or two after turning the cattle into the fields, they suddenly sicken and die. Thousands of cattle are lost each fall in this way, and the subject has attracted much attention and elicited several theories as to the cause."[1] Moore concludes that "the disease is probably due to some poisonous principle in the dried cornstalk or its leaves".[2] This disease is commonly known as "cornstalk disease".

Moore (*ibid.*) points out that animals which are fed with *shocked maize*, or cut *maize stover*, do not get cornstalk disease.

Brimhall[3] considered that the so-called "cornstalk disease" is in a large percentage of cases to be included under hemorrhagic septicæmia, which he traces to *Bacillus booisepticus.*

Price reported the presence of an enzyme in cornstalks from a field where cattle had died of cornstalk disease; "this peroxydase had the properties of catalase; it lost its power of splitting up glucosides when subjected to a temperature of 78° C. The proteolytic enzyme was broken up at 68° C. The cornstalk enzyme appeared to have the same resisting power toward heat as that obtained from bitter almonds." Negative results were obtained from attempts to find either prussic acid or a glucoside which might break up into prussic acid. Although not conclusive, Price believes that his in-

[1] *U.S.D.A., Bur. An. Ind. Bull.* 10. See also *Kansas Station Bull.* 58.

[2] Henry, *Feeds and Feeding*, p. 175.

[3] See *Exp. Sta. Rec.*, XIV, 201 (1902-3); XVI, 603-4 (1904-5); and *Report of the Vet. Dep. of the Minn. State Bd. of Health*, 1903, St. Paul, 1903.

vestigations indicate the presence of an enzyme in maize stalks, which may give rise to the formation of prussic acid by the splitting up of glucosides, and that this would account for a certain percentage, at least, of the cases of cornstalk disease; see *U.S.D.A., Bur. Anim. Ind. Rep.*, 1904, pp. 66-75 (reprinted as Circular 84) and *E.S.R.* XVII, p. 702, 1905-6. CHAP. XV.

Craig notes that a disease referred to by this name appeared quite extensively in Indiana during 1902 and 1906. After summarizing the theories held by different observers, he concludes that there are probably several diseases referred to under the same name. While the symptoms resemble those of toxic poisoning, which it had been suggested might be due to potassium nitrate in the maize stalks, it is by no means certain that potassium nitrate in the maize is the cause of the trouble. He suggests that prussic acid may at times be developed in the corn. See *Indiana Sta. Circ.* 3, p. 10, 1906, and *E.S.R.* XVIII, 676-7, 1906-7.

Though subjected to a thorough test, Alway and Trumbull reported failure to find even a trace of prussic acid in cornstalks or suckers from a field in which several cattle had just died. Feeding tests to calves gave negative results. Similar tests with Sorghum confirmed Brunnich's findings of prussic acid (*E.S.R.* XV, p. 355), so that the negative results with maize do not appear to be due to fault in the method adopted.

Further information on the cornstalk disease may be found in the publications cited in the Bibliography under the names of Price, T. H.; Craig, R. A.; Alway, F. J., and Peters, A. T.; Billings, F. S.; Peters, A. T., and Avery, S.; Peters, A. T.; and Mayo, N. S.

CHAPTER XVI.

THE CONSTRUCTION OF MODERN SILOS.

Probably the most important change that has been made in the handling of the maize plant in the last quarter of a century is the practice of putting the unripened plant, cut into small pieces by a feed-cutter, into a receptacle with air-tight sides and bottom, called a silo.—Prof. T. F. HUNT.

The information contained in the following chapter was prepared by Mr. A. Morrison Hay, of the Public Works Department, Union of South Africa, and appeared originally in *Farmers' Bulletin* 59 of the Transvaal Department of Agriculture; it was subsequently revised and published in the *Agricultural Journal* of the Union of South Africa (*Hay*, 1). Mr. Hay has kindly given permission to reproduce it here, with certain alterations and additions which he has himself suggested. The present writer has omitted Mr. Hay's paragraph describing silage, as the information has already been given in chapter XV.

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743. *Historical.*—Silos, or chambers for the storage and preservation of food, have been in use in one form or other in various countries from very early times. At the time of Pliny, in France, Spain and other parts of Europe, grain was preserved in trenches, dug in the ground; he mentions in certain of his writings that "the best plan of preserving grain is to lay it up in trenches dug in a dry soil, called siri, as they do in Cappadocia, Thracia, Spain, and in Africa". This method of preserving grain was not confined to the East, as at the time of the discovery of America by Columbus the natives were in the habit of storing grain in pits, and certain tribes continue the practice to the present time. The ancient Egyptians, as we learn from Scripture, stored sufficient grain in the seven years of plenty to serve themselves and other nations during the seven years of famine that followed. The Egyptian silos were evidently of a more improved and permanent nature than the rude trenches above referred to, as Wilkinson in his work, "The Ancient Egyptians," states that "some of the rooms in which they housed the grain appear to have had vaulted roofs. These were filled through an aperture near the top, to which

the men ascended by steps, and the grain, when wanted, was taken out from a door at the base." CHAP. XVI.

It is important to note that the early silos were used principally for the preservation of corn and other dried cereals, for indefinite periods, and there are instances of corn having been preserved in good condition for the long period of 200 years. On the other hand, the silos of the present day are used more particularly for the storage of green fodder, to provide food for cattle during the winter months, or for a year at most. Food thus preserved may, however, be kept indefinitely, provided that air is not allowed to enter the silo. For this reason it is important that the sides and floor should be perfectly air-tight, and it is also essential that the sides be smooth and vertical, so that the silage may settle uniformly and compactly, leaving no vacant spaces for the accumulation of air.

The word "silo," taken from the Greek "siros"—a pit for holding grain — is the name now applied to any air-tight chamber formed for the preservation either of dried grain or green food. It may be simply a trench or pit dug in the ground in any dry position, into which the silage is filled and weighted down with planks, earth, or other material. More commonly it is a structure of wood, metal, brick, stone, or other building material, or a combination of these, built entirely above ground or extending down only a few feet, and standing either by itself or forming a part of the other farm buildings. The origin of structural silos on the modern plan is of very recent date, but the progress of siloing has been so rapid and successful—in America, at any rate—that in the short period of thirty years, over a hundred thousand silos were built in the United States alone, and the number is steadily increasing.

744. *Form.*—In form the silo may be built either square, rectangular, octagonal, or circular on plan. If forming part of a scheme of buildings its shape would probably be decided by the position it occupied and the space available, but if standing alone, either form could be adopted at will. The round silo (Fig. 241) is more favourable to the even and compact settling of the silage owing to the absence of corners and, consequently, more favourable to its perfect preservation. On the other hand, it does not fit in with other buildings so readily and with-

CHAP. XVI. out loss of space, as a square or rectangular silo, and for this reason the latter are likely to be more frequently built. The same remarks would also apply to octagonal silos. If standing alone, however, no objection can be raised either to the round or the octagonal form of silo, and as the proper preservation of the silage is the main object to be attained, one or other of these

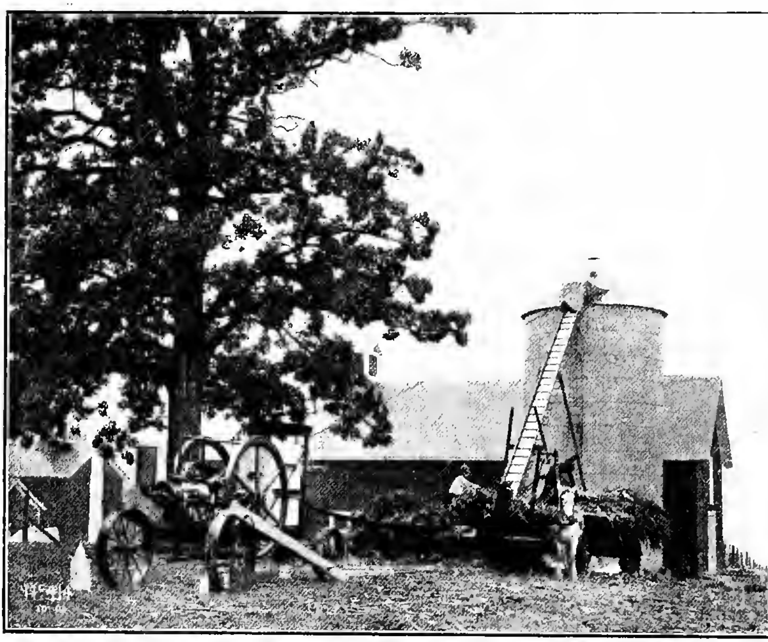

FIG. 241.—Filling round silo in the United States.

forms should be adopted in preference to the others. The main objection to square or rectangular silos is the presence of corners, which prevent the silage from settling uniformly and compactly, thus causing waste of space and creating undesirable accumulations of air. This defect may be remedied to a considerable extent by having the corners well rounded. Of the two, the square silo is perhaps the better form, and probably somewhat cheaper than a rectangular one of equal capacity, as the wall space is rather less.

745. *Size.*—Where a large quantity of silage is required it is advisable to have it stored in two or more moderately-sized

silos in preference to one very large one. With very large silos too much surface of silage is exposed while feeding; and, if the height is increased to modify the surface dimensions beyond a reasonable limit, excessive labour is involved in the working. With rectangular silos the difficulty can be obviated by having one or more partitions dividing the silo into two or more square, or nearly square, compartments. The height above ground should not exceed 20 to 25 feet, and the depth under ground should not be more than 5 or 6 feet, the limit from which a man can conveniently lift the forage.

Whatever form is adopted for the silo, it should always be

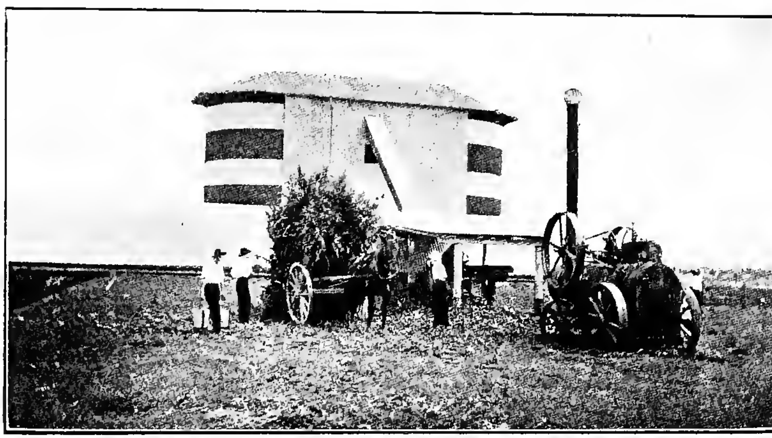

FIG. 242.—Filling twin tub-silos, Australia.

built with a greater capacity than would be necessary if it could be filled at once to the top with good silage, as considerable allowance has to be made for waste from settling and from spoiled silage. Even if material is added a second or third time there will still be a certain amount of waste space to be allowed for. One-fifth is considered a low estimate for loss of space and waste silage.

746. *Capacity.*—As a basis on which to ascertain the size of silo necessary to hold food for a certain number of cattle for a certain period of time, 40 lbs. may be taken as the average amount of silage required to feed one animal per day, and 40 lbs. may also be taken as the average weight of a cubic foot of silage. Therefore, if the number of animals is

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multiplied by the number of days during which they have to be fed, the result will equal the number of cubic feet of silage space required. Supposing thirty animals have to be fed for six months, or 184 days, the total amount of space required would be 30 × 184 = 5,520 cubic feet.

To find the number of cubic feet in a square or rectangular silo multiply the length in feet by the width, and then by the height, and the result will give the total number of cubic feet. Thus, if a square silo measures 14 feet each way on plan and 25 feet in height, the cubical contents would be 14 feet × 14 feet × 25 feet = 4,900 feet.

In the case of a round silo, multiply the square of the diameter in feet by the height, and then by ·7854. For example, if a round silo measures 14 feet in diameter and 25 feet in height, the cubical contents would be 14 feet × 14 feet × 25 feet × ·7854 = 3,848 feet approximately.

The following table (No. CXXXII) shows the capacity of silos of different dimensions and the acreage of maize required to fill them, on the basis of a crop of 15 tons (Colonial) to the acre:—

Table CXXXII.

CAPACITY OF SILOS.

Dimensions.	Capacity in Tons.	Acres of Crop necessary (15 Tons per Acre).
10′ × 20′	28	3
12′ × 20′	30	3
12′ × 24′	49	$3\frac{2}{5}$
12′ × 28′	60	4
14′ × 22′	61	$4\frac{1}{2}$
14′ × 24′	67	$4\frac{2}{3}$
14′ × 28′	83	$5\frac{2}{3}$
14′ × 30′	93	6
16′ × 24′	87	$6\frac{2}{5}$
16′ × 26′	97	7
16′ × 30′	119	8
18′ × 30′	151	$10\frac{1}{6}$
18′ × 36′	189	$12\frac{1}{3}$

747. *Position.*—As regards position, the silo should be placed as near as possible to the centre of feeding, to minimize the labour of carrying food to the various mangers. In round or octagonal farm buildings, such as are common in America,

the silo usually takes the same shape as the main building, and is placed in the centre, where it occupies a convenient position from which to feed the various animals stalled around the building. A circular silo may be situated at a corner of the main building, where it not only proves a useful adjunct but also forms a very pleasing feature. A convenient arrangement is to have the doors of the silo opening into a passage-way, or into the feed store or mixing room, which usually occupies a central position. A saving in the cost of erection

FIG. 243.—Filling square stone-silo, Irene, Transvaal.

can often be effected by utilizing one or more of the walls of the main building in the construction of the silo.

748. *Materials.*—The material to be used in the construction of a silo would probably be decided by local conditions. That most readily obtained in the locality in which the silo is to be built would naturally be chosen, provided it fulfils the conditions required for a good silo. Metal has been tried in some countries, but has not been found satisfactory, on account of the initial cost and the readiness with which it yields to the corroding action of the silage juices. In America wood has

CHAP. XVI. hitherto been very largely used in the construction of silos, on account of the abundance of timber in that country and the comparative ease and cheapness of erection, and wood is considered one of the best materials for the preservation of silage. It is not likely, however, to be much used in South Africa, on account of its scarcity and want of durability.

For durability, either reinforced concrete, stone, or brick, or a combination of these materials, is to be recommended. Reinforced concrete is probably the best material, especially for circular silos, but requires more skilled labour in the construction, and is consequently more costly. Stone or brick structures require less skill in building, and as either one or other of these materials can usually be readily obtained throughout South Africa, they are likely to enter more largely into the construction of silos.

Whatever material is used—whether concrete, stone, brick or wood—the foundation should always be of some material that is not subject to early decay, more particularly if it extends for some depth below the surface of the ground. In a dry soil a good quality of brick or stone built with lime mortar is sufficient, but if there is a tendency to dampness, either cement concrete or stone, built with cement mortar and plastered on the outside with any damp-proof composition, forms the best foundation. It is important that the foundation should go down to a solid bottom, and it should extend a few inches above the highest point of the ground, and be covered on top with a damp-proof course to prevent moisture from rising to the structure above.

749. *Reinforced Concrete.*—The methods of building with either brick or stone are too well known to everybody to require any explanation, but concrete construction being less familiar, a short description of the materials used and methods adopted in the erection of reinforced concrete silos may be useful. The walls, only, need to be described, as the foundations, floor, roof, doors and other parts can be practically the same as for brick or stone silos. The concrete should be composed of one part best Portland cement, two parts clean sharp sand and four parts stone broken to such a size as will pass through a ring of ¾ inch diameter, all thoroughly mixed together to the proper consistency with clean water. The reinforcement should con-

sist of round iron rods arranged both vertically and horizontally and embedded in the concrete near the outer surface of the wall. The vertical rods should be $\frac{7}{8}$ inch in diameter, spaced from 12 inches to 15 inches apart and extending from foundation to top of wall. The horizontal rods should be $\frac{1}{2}$ inch in diameter, spaced from 9 inches to 12 inches apart. They should be in as long lengths as possible, hooked together at ends so that each row forms a continuous band round the silo. The horizontal and vertical rods should be securely wired together at all points of intersection to form a rigid network of iron. There are of course other methods of reinforcement, but the above with a 6-inch thickness of concrete is simple and sufficient for any silo up to say 18 feet in diameter and 30 feet in height. To erect the walls it is necessary to have moulds or forms curved to the same radius as the silo, one convex on face placed inside the wall, and one concave on face placed outside the wall, the two 6 inches apart from each other with the reinforcing rods between. A sufficient number of these forms must be provided to go completely round the silo, and when they are placed in position and firmly fixed, the concrete is gently dropped into the space between them in layers of not more than 6 inches deep and carefully and thoroughly rammed. These forms can be made of a rough framework of wood with a lining of galvanized sheet-iron on the curved face to give a smooth finish to the surface of the concrete. Each of the forms may be of approximately the same size as the sheet-iron lining to avoid waste, viz. 6 feet long by 3 feet wide. When the concrete has sufficiently set the forms should be carefully removed and refixed at a higher level and again filled with concrete and this process repeated until the top of the wall is reached. It is an advantage to have two sets of forms, so that the second and succeeding rows can be placed in position before the next lower is removed. The door openings should be formed as the work proceeds, the reinforcement should be modified and strengthened around the openings and a splayed recess should be left all round on the inside into which the door will fit without any framework of wood. The roof can also be of concrete, either flat or cone shaped, and if so constructed the concrete should be approximately the same thickness as for walls and with similar reinforcement.

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750. *Floor.*—If the silo is built on a soil that is dry all the year round no other floor is necessary. Broken stones might be laid over the floor to a depth of 6 to 8 inches, and then covered with a layer of clean, dry earth or ant-heap, and rolled or rammed till a compact and even surface is formed. Such a floor could only be used where the ground is sufficiently dry and where there is no danger of destructive insects or vermin entering through the floor. In other cases a floor of cement concrete should be laid, 4 to 6 inches thick, on a bed of broken stones, as above described, and tile-pipe drains might also be put in to carry off the water to some lower level.

751. *Walls.*—The thickness of the walls depends greatly on the material used in the construction, and on the size of the silo. The larger and deeper the silo the greater is the pressure on the walls, and with an increase of pressure there must be a corresponding increase in the thickness of the walls. For a silo of the capacity referred to in the preceding pages, built with stone, the walls should be at least 22 inches thick at the base, but may be diminished to 16 inches at the top, where the pressure is considerably less. If built with brick, the thickness might be 22 inches, or 2½ bricks, at the bottom, diminishing to 14 inches, or 1½ bricks, at the top. Stout hoop-iron bands or iron rods are frequently built into the walls to strengthen them, particularly near the doors, where the proximity of so many openings tends to weaken the masonry. If built of reinforced concrete a thickness of 6 inches for the full height is sufficient.

752. *Plaster.*—To facilitate the settling of the silage the walls of brick or stone silos should be plastered inside to a perfectly smooth surface, with a thick coating of cement plaster, which must be of the very best quality and well put on, as the acids in the silage are apt to soften it and cause it to crumble away. Concrete silos require only to have all rough parts scraped off, and the surface, both outside and inside, rubbed over where necessary with a canvas pad and neat cement to fill up any air bubbles or other small holes. Where an inferior class of bricks is used in the construction of the walls the outside face should be plastered with cement plaster, but if the bricks are of good quality they may be left exposed and the joints filled up and struck as the building proceeds, or after-

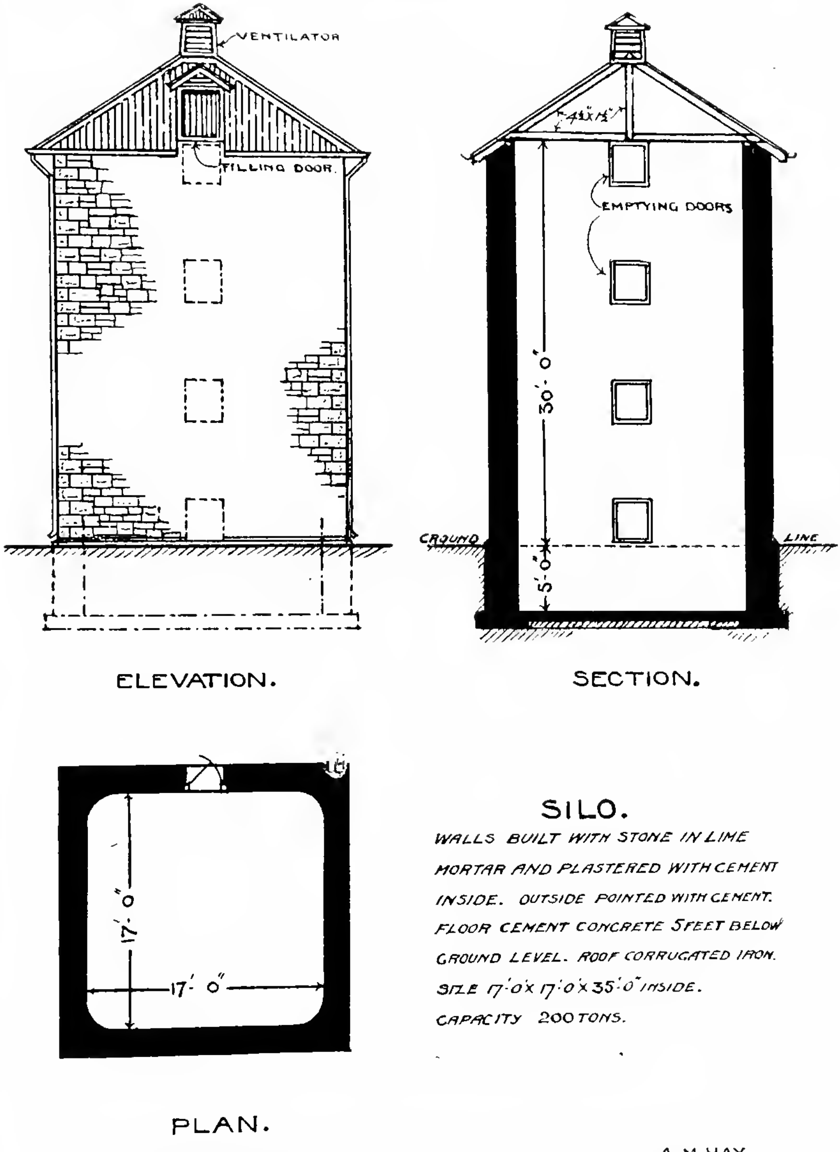

FIG. 244.—Plan of silo. (Courtesy of Mr. A. Morrison Hay.)

CHAP. XVI. wards raked out and pointed with cement mortar. Stone walls require only to have the joints of the outside face raked out and pointed with cement mortar.

753. *Roof.*—Any of the materials in general use may be used for a roof covering, and any form of roof may be adopted, provided adequate provision is made for filling the silo and also for ventilating it during the process of fermentation. The "lean-to" roof does not fulfil these conditions, and is seldom used. The ordinary pitch roof with a gable at either end, or the pyramidal or conical roofs shown on the accompanying diagram, are undoubtedly the best forms, as they allow for the filling door being placed either in the gable or on the slope of the roof, and also admit of proper ventilation being arranged for. With a roof of corrugated iron, which is the covering most commonly used in South Africa, the slope of the roof need not be very steep, and the timbers forming the trusses need not exceed 4½ inches × 1½ inches, or 6 inches × 1½ inches at most, according to width of silo. A ventilator should be placed at the apex of the roof, and openings should be formed at the eaves to create a draught and assist in carrying off the foul air and gases rising from the silage.

754. *Doors.*—The doors required for a silo consist of a filling door placed in the gable or in the roof, above the highest point to which the silage is filled, and three or four emptying doors placed one above the other at convenient intervals apart and usually at one side of the building. The filling door should be large enough to freely admit the carrier, say 2 feet 6 inches wide and 3 feet to 4 feet high, according to available space, and should be placed at the side most convenient for filling. The cut fodder is conveyed straight from the cutting machine through the filling door to the centre of the silo by means of a carrier or an elevating tube, up which it is forced by air pressure.

The doors through which the silage is emptied should be about 24 inches wide and 30 inches high, one at the top and one at or near the level of the ground, and the others placed at intervals of about 4 feet apart vertically. They should be of well-seasoned timber, strongly made to resist the excessive pressure and heat, close fitted to exclude all air, and placed flush with the inside face of the wall. The doors may be hinged to the frame, or they may simply be put in place while the silo is being filled, and suspended with chains to the wall when not in use; the former method being perhaps the more satisfactory. To make the doors more perfectly air-tight, thick felting is sometimes tacked to the frame, and stout paper is often pasted over the doors for the same purpose.

755. *Chute.*—In most cases it will be found of great advantage to have a vertical chute attached to the silo, down which the silage can fall when emptied from any of the doors. It is made in the form of a long box, extending from near the ground to the top of the silo, and covering the doors. It requires only three sides, the wall of the silo forming the fourth, and should measure about 2 feet 6 inches by 2 feet inside. A ladder running up the full height is fixed inside the chute, giving access to the doors when the silo is being filled or emptied. The lower end may be left open or may be fitted with a sloping bottom to slide the silage into a cart, barrow, or other receptacle used for conveying it to the cattle. A small door can be formed in the front or side to give access to the ladder.

The accompanying diagram (Fig. 244) shows a square silo measuring 17 feet each way on plan and 25 feet in height (above ground) and having a capacity of 4,900 cubic feet, equal approximately to 98 tons of silage. It is on the lines described in the preceding paragraphs, built of stone in lime mortar, covered with a roof of corrugated iron, and having a floor of cement concrete 5 feet below the ground level. Four emptying doors are shown on one side and a filling door in the roof. There is a triangular ventilating panel over the filling door and a large ventilator at the apex for escape of foul air, and for the admission of fresh air there is an opening of about 4 inches high between the walls and the roof all round. The inside corners are shown well rounded to facilitate the settling of the silage. Though shown standing alone, it need not necessarily do so, but could be attached to other buildings where found most convenient.

Such a building, if erected by contract at current prices in South Africa, would cost approximately £230, but a farmer could build it much more cheaply by employing local tradesmen and providing all necessary transport and native labour.

CHAPTER XVII.

OTHER USES OF THE MAIZE CROP.

Take of Indian maiz half a pound.—BACON, *Medical Remedies and Workes*, III. 828 (1626).

CHAP. XVII. 756. *Importance of Maize Products for Manufacturing Purposes.*—The importance of maize as raw material for manufacture is but little realized outside of the United States. A single firm of Chicago manufacturers uses every year over 10,000,000 (ten million) muids (20,000,000 centals) of low-grade maize (No. 3 and No. 4 grade, mostly the latter) for manufacturing purposes. Much of this grain would be almost valueless upon the market for any other purpose (*Bowman* and *Crossley*, 1). Starch, glucose, dextrine, corn oil, glycerine, sugar, alcohol, cellulose, rubber filler, paper, mats, hats, charcoal, tobacco-pipes, fire-lighters, gunpowder, and medicines are among the many materials and articles now prepared from maize.

The grain furnishes the larger part of the raw material utilized in these manufactures; but the stem, pith, leaf, husk, cob, chaff, and silks are also used.

Much attention has of late been given in South Africa to the question of establishing more local industries, and to the cultivation of special crops to maintain factories for the local production of the goods used in South Africa. But in such discussions and inquiries attention seems to have been directed largely to the introduction of new crops such as sugar-beets, ramie, rubber, soy-beans, linseed, etc., the profitable cultivation of which on a large scale is problematical, or at least not yet established; the further utilization of crops such as maize, already well-established in the country, is a sounder and more economical policy.

In every young country there are peculiar difficulties to be overcome before new industries can be established; these may include climatic conditions, relative scarcity of water, high cost of living, scarcity and cost of skilled labour, cost of land for factory sites, etc. With so much to handicap manufacturing enterprises, their success must depend on the availability of raw materials at low cost. It is evident, therefore, that—other things being equal—the supply of crops well-established and largely grown in the country is more likely to be uniform in quantity and price than in the case of crops specially grown to support a special industry.

The conclusion seems reasonable that if maize can be exported profitably from South Africa for manufacture in Europe, the saving on cost of export should materially offset the extra cost incurred by manufacture in South Africa. Certain local industries have already been established, and are running successfully, even though a large part of the raw material used by them is *imported* from over-sea. Maize is the staple crop of South Africa, and the amount annually produced is increasing rapidly; it is therefore worth the careful attention of business men looking for good business openings. It promotes economical production for the factory to be as near as possible to the source of supply of the raw material.

A crop which can be utilized for the manufacture of *many* distinct products and by-products is likely to be more economically and profitably handled than one which is limited in its application and from which there is a large residual waste. The object of this chapter is to describe the large and varied number of products which not only can be, but *are*, manufactured from the maize plant, *no part of which need be wasted.*

757. *Starch.*—The manufacture of maize starch has become an extensive and important industry in North America. The total output of the grain-starch factories of the United States, in the census year 1900, had a value of over $8,000,000, or approximately £1,700,000. Of this amount $6,900,000, or 86·25 per cent, was the value of the starch itself, and $1,100,000, or 13·75 per cent, the value of the by-products of starch manufacture. In 1906 the starch *export* of the United States amounted to 33,287 tons, of 2,000 lbs., valued at £306,120. Starch is used in the preparation of baking powder, and by cotton and paper manufacturers for stiffening; maize starch is

CHAP. XVII. said to have largely replaced potato-starch in the preparation of commercial laundry starch (*Bowman* and *Crossley*, 1).

The *Amylum*, or *Starch* of *materia medica*, is officially described in the United States pharmacopœia as "the fecula of the seed of *Zea Mays* Linné (Nat. Ord. Gramineæ)," and in the British pharmacopœia as "the starch procured from the grains of common wheat, *Triticum sativum* Linn., maize, *Zea Mays* Linn., and rice, *Oryza sativa* Linn."

"The granules of maize starch are very small, with a diameter not exceeding—according to Payen—one-sixth of that of the potato, and little more than one-half of that of the wheat granules. They have a very distinct hilum, but no evident concentric striæ. . . . Starch is nutritive and demulcent, but in its ordinary form is seldom administered internally. Powdered and dusted on the skin it is sometimes used to absorb irritating secretions and prevent excoriation. Dissolved in hot water and allowed to cool, it is often employed in enemata, either as a vehicle or as a demulcent application in irritated states of the rectum. It may be used as an antidote to iodine" (*Wood*, *Remington*, and *Sadtler*, 1).

Starch is prepared from maize grain by soaking the latter until soft, in a warm solution of sulphurous acid, when it is ground into meal in running water: the hulls float on the surface and are removed by sieving through silk; the germs sink to the bottom, and the water, carrying the gluten and starch in suspension, passes on through long "settling-troughs," in which the heavier starch settles to the bottom while the gluten floats on. The various by-products thus separated are dried and sold separately or variously combined. The starch obtained from the settling-troughs is known as "green starch". The "green starch" is treated in different ways for various manufactured products. The starch by-products together constitute "gluten feed"; separately they are known as "sugar feed," "dried starch," "wet starch feed," "wet glucose feed," etc. (¶ 671, chap. XIV.). In the process of manufacture the addition of one part of water changes starch into cane sugar; cane sugar, by the addition of one part of water, becomes glucose. By heating to 280° Fahr., in the presence of dilute nitric acid, green starch is converted into dextrine, or by treatment with dilute hydrochloric acid (or sulphuric acid with a limited amount of nitric acid) glucose is formed. The sulphuric acid is afterwards neutralized with chalk or marble dust, and the hydrochloric acid with soda (*Bowman* and *Crossley*, 1).

758. *Dextrine.*—Dextrine is a gummy substance into which starch is convertible by diastase or by certain acids. It is prepared from the "green starch" as it first comes from the settling-troughs. Dextrine in various forms has a wide use in sizing cloth and as a mordant or medium for conveying colours in cloth and calico printing. It is used extensively in the manufacture of paste and mucilage; American postage stamps are "gummed" with dextrine. It is also prepared in granular form and used as a substitute for gum-arabic.

759. *Corn Oil.*—Corn oil is expressed from the embryo or "germ" of the maize grain. It is used as a lubricant and illuminant; for the mixing of paints and, to some extent also, as a filler for certain animal oils. It has also been advertised as a cheap substitute for cod-liver oil in cases of tuberculosis, as a palatable and easily assimilated fat. The most important part of the process of manufacture appears to be the degermination of the grain. There are two systems of degermination, the wet and the dry. The extraction of the embryo is said to be much more perfect in the wet than in the dry process, but the latter is said to be considerably less expensive, and is the one usually adopted. Messrs. Rose, Downs, and Thompson, of Hull, England, who are manufacturers of degerminating plants, state that they have known cases where the "germ," extracted by the wet process, has contained 52 per cent of oil, whereas it usually contains about 20 per cent by the dry process, showing that in the latter case a considerable quantity of the endosperm or hull is removed with the embryo. The embryo, after extraction, may be treated in an ordinary Anglo-American mill or in a chemical extracting plant.

760. *Rubber Filler.*—By vulcanizing maize oil, what appears to be a satisfactory rubber "filler" is now manufactured. The material is coarse in texture and is said to lack some of the characteristics of real rubber, but it can be mixed with certain proportions of the latter in the manufacture of articles where durability, rather than great elasticity, is required. It is some-

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times called a rubber substitute, but the term is misleading in this case, as the corn oil product can only be used satisfactorily in combination with real rubber. It is then employed in the manufacture of "solid rubber" tyres, buffers, sole-rubber, etc.; it is reported to be very popular on account of its usefulness as an insulator and filler, and because of its low cost.

761. *Glycerine.*—Glycerine is a sweet, colourless, inodorous, viscid liquid, formed from fatty substances and consisting of carbon, hydrogen, and oxygen. Glycerine is obtained from different oils and fats, including maize oil, in the processes of manufacture.

762. *De-natured Alcohol.*—Enormous quantities of commercial alcohol are prepared from maize grain. In a single year the United States used 16,555,804 bushels of maize grain valued at $5,968,198 in the manufacture of distilled liquors, including alcohol, Cologne spirit, and whisky, etc.

After the removal of the hull and embryo, 10 per cent of barley malt and yeast are added, and the grain is allowed to ferment. The enzymes in the malt change the starch of the grain into sugar, and the sugar into alcohol. A bushel of maize will produce about 2·7 gallons of 95 per cent alcohol, and a muid will produce from 8 to 9·5 gallons. At an average price of 6s. per muid for maize grain, its cost for manufacturing a gallon of 95 per cent industrial alcohol would be about 7½d., according to American prices. This figure may be doubled to cover cost of manufacture, storage, etc., and another 5d. added for profits of manufacturer and dealer. At these figures industrial alcohol, if untaxed, could be sold for about 1s. 8d. per gallon (*U.S.D.A.*, 1).

De-natured alcohol has a large and increasingly important place not only as a solvent but also as a source of heat, light, and power. Cheap alcohol is used in Germany on a large scale in place of paraffin, petrol, gasoline, etc., for industrial purposes. Germany, like South Africa, is not a producer of mineral oils, and although she can obtain her oil at much lower cost than the South African farmer can, she finds it cheaper to use alcohol; apart from motor carriages, Germany is reported to have in use over 5,000 small alcohol-propelled engines for agricultural and similar purposes. As an illuminant it is stated that alcohol, when burned in a suitable lamp, gives about twice as much light, with a consumption of only half the quantity of liquid, as compared with paraffin. The various forms in which alcohol is applied to industrial purposes in Germany include: motor-cars, motor-boats, motors for threshing, grinding, wood-cutting, ploughing, pumping, churning, and other agricultural purposes; for house, shop, and street lamps; heating-stoves, cooking-stoves, heating laundry irons, etc. In the United States the use of small engines and motors on the farm, to replace expensive manual labour, is rapidly increasing. In England, too, there has been a noticeable increase within the last few years in the application of these engines to agriculture.

The principal drawback to the more extended use of this fuel for mechanical purposes has been the fact that alcohol is an important source of Government revenue in most civilized countries, and Governments have been reluctant to run the risk of losing any of this revenue. The excise duties were for a long time so high as to practically prohibit the use of alcohol for domestic purposes. The difficulty which faced the Government was to provide that, if the prohibitive duty were removed in the case of alcohol used for industrial purposes, the latter should not be used as a beverage without paying full duty. Germany and the United States overcame the difficulty by enacting legislation which provided that alcohol which had been *de-natured*, i.e. mixed with a certain proportion of denaturing materials sufficient to prevent its use as a beverage, should not be taxed. The passage of the United States Act

"was alcohol's new day, and is destined to have a wide influence upon the agricultural pursuits of the country. In the matter of small engines and motors alone, one estimate places the farm use of these at three hundred thousand, with an annual increase of one hundred thousand. This means an economical displacing of horse and muscular work almost beyond comprehension. If now the farmer can make from surplus or cheaply grown crops the very alcohol which is to furnish the cheaper fuel for his motors, he is placed in a still more independent and commanding position in the industrial race. . . . The wisdom of the German system, established by the law of 1887, has long ceased to be a question of debate.

CHAP. XVII. For every Reichsmark of revenue sacrificed by exempting de-natured spirits from taxation, the empire and its people have profited tenfold by the stimulus which has thereby been given to agriculture and the industrial arts" (*Wright, Spon,* and *Chamberlain,* 1).

By *de-natured alcohol* is meant alcohol which has been rendered unpalatable by the addition of some poison or other dangerous or unpleasant substance which renders it unfit to drink. This is done with the object of rendering the spirit so objectionable that if allowed by Government to be manufactured and sold duty free, for industrial purposes, it shall not be used as a beverage and thus defraud the Government of legitimate revenue. To be effective such treatment must not render the alcohol unfit for use in the arts and manufactures, and at the same time it must be of such a nature that the objectionable matter cannot be readily removed by distilling.

The substances used for this purpose include wood alcohol, benzol, benzine, ether, camphor, petro-naphtha, caustic soda, castor oil, oil of nicotine, ammonium iodide, sulphuric acid, pyridine, cadmium iodide, etc., which render the alcohol dangerous, or at least undrinkable, while not impairing its value for industrial purposes.

The following account of the manufacture of de-natured alcohol in Peoria, Illinois, U.S.A., is taken from *Harper's Weekly*, and appeared in the *Natal Agricultural Journal* (*Anon.*, 6):—

"Maize explains Peoria ; in a way . . . it is thedistilleries, seventeen all told, that have made Peoria famous. It is the centre of spirit manufacture, for it is, or has been until the last few years, the very heart and geographical middle of the Corn-belt, and the other grains are not so far distant as to involve an excessive haul. This is the economy of manufacture, to be near the raw materials.

"One of the biggest and most thoroughly equipped of the great distilling establishments of Peoria was the Atlas—a sky-scraping collection of brick buildings in the outskirts of the town, with a row of mighty steel stacks towering up into the sky.

"When the knowledge of what Germany and the other

European countries were doing with de-natured alcohol began to be disseminated in this country, when its big utility for purposes of heating, lighting, motive power, and commercial manufacture were made known, the Atlas Distillery stopped making whisky. The last gallon of the national stimulant was shipped out from its doors some three years ago, and to-day, instead of contributing its thousands upon thousands of barrels of strong drink, its mills are grinding grain, its cookers and vats and stills are seething with the processes that go to the making of de-natured alcohol.

"The Atlas has ceased to be a drink-maker, and is helping to turn wheels and heat houses by the new cheap agent and assisting the cunning works of commerce and the arts.

"Last year the establishment used something over 3,000,000 bushels of maize, rye, and barley. The long trains, grain-laden, drawn in by the railroads from various sections of the farming country, are taken over its sidings and up to the unloading sheds at the side of one of the tall buildings.

"From the car doors it is shot down through a grating at the side of the track under the long shed. Underneath this is a hopper from which the flying carriers, whisking up and down on their swiftly moving belting, take it up into the big storage receptacles high in the roof.

"Thence it is delivered as needed to the groaning mills, and all the air is resonant through the long days with the sound of the grinding. When ground it is transferred to the 'cookers' in an adjoining room, vast metal receptacles that themselves look like big boilers. Here in the shape of 'mash' the grain lies for an hour, and then is forced by vacuum pressure into a vat, where a revolving beam keeps it constantly agitated and through which with only brief delay it is pumped into the fermenting-tubs.

"These are gigantic wooden affairs, with their tops away up in the shadows under the roof. Here the grains lie for seventy-two hours. Underneath the iron-grated floor of the gloomy house where these tubs are crowded together there is a huge cistern into which the mash drops from the tubs. From this cistern, after a short period of retention, it is pumped into a beer-still. At this stage of progress the mass is known to the distilleryman as 'beer'.

"While it lay in the fermenting-tubs the yeast was introduced, so that now, when it reaches the beer-still, it is in a lively state of fermentation and vapours are thrown off which

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are the first material results of the changes it has undergone. Inside of the still when these vapours rise to the top they are condensed into 'high wines,' which are drawn off, while the mash, with its remaining moisture after all the high wines have been collected, is carried away to the feed-house.

"Now that Nature's mysterious work of chemical extraction has been perfected, modern ingenuity takes the grains in hand to see what can be made of them. Here is where science achieves her finest triumphs and becomes the true servant, for it is in the saving of every atom of waste, the conversion to profit of things already used and which former ages considered of no worth, that latter-day manufacture makes its surest margin of gain. Millions have thus been added to the wealth of the world in the past decade.

"When the mash, now known as 'slop,' heavily saturated with moisture, is first taken to the feed-house it is subjected to heavy pressure and all possible liquid squeezed out of it. The residuum of the grain is then dried by being run through heated chambers and over spiral evaporators and packed as feed for cattle.

"There still remains, however, the liquid, and this upon examination is found to be high in nutritive elements. After sundry experiments a mechanical method was obtained of converting this into solid form, and now it comes out from the final stage of reduction in the shape of a thin, breadstuffy brown sheet which when it first leaves the compressing-rollers has the appearance of crepe paper. Added to the dried-out grains before mentioned, about 4 lbs. to the bushel, there results a nutritious cattle feed, which wet down with corn stalks and other fodder is one of the most effective of milk-producers, showing as high as 33 per cent of proteids, 14 per cent of fats, 40 per cent of carbohydrates, and from 12 to 14 per cent of fibre. This utilization of the fluid residuum adds about 1 cent a lb. to the value of the food. Thus the last elements of worth in the grain are saved, and preserved in this way go back through the medium of manure to the land to make more corn.

"Meantime the work of making de-natured alcohol goes on without interruption. The high wines which were solidified from the vapours thrown off from the mash in the beer-vat are again vaporized by means of steam coils and redistilled in a similar fashion, after which they come out in the shape of alcohol.

"It is at this stage that the real making of de-natured alcohol by these several chemical and manufacturing processes begins. The pure grain alcohol is carried over in long pipes from the distillery to the de-naturing bonded warehouse in another part of the great plant and stored in an immense tank.

"All along one side of the place are huge, white-painted wooden tanks, and at the head of the line a weighing-tank with scales attached, into which the pure alcohol is drawn for measurement, and where wood-alcohol and benzine are added before the de-naturing process begins. Pipes lead to each of the de-naturing tanks, one tank being reserved for each of the formulas at present prescribed by the Government.

"Uncle Sam keeps scrupulous watch of the manufacture to see that no pure alcohol escapes to any quarter without paying its due portion of tax, and that all is used in the de-naturing processes which render it, nominally at least, undrinkable.

"What is known as the 'complete' de-nature is made up of 10 gallons of wood-alcohol to 100 gallons of grain-alcohol and the further addition of ½ gallon of benzine. This is the mixture as it is weighed in the weighing-tank and cast off thence into the other tanks where special formulas are prepared. Off at one side of the warehouse is a room in which are stored all the materials used in the different commercial de-natures. . . .

"When these de-natures are finished the barrels are rolled up and filled from the tanks, and the gaugers keep record of it all. To distinguish the de-natured alcohol in shipment from the ordinary alcoholic products, green-painted barrels are used to contain it, and for the shipments to the great chemical manufacturing houses of the East steel drums are employed."

It is largely the damaged or inferior quality grain which is used for the preparation of de-natured alcohol, and distillers state that the better qualities of South African maize will be too expensive for this purpose. But there will always be a certain amount of damaged, inferior, and native-grown grain which would be available in South Africa, and there is a large distilling plant a few miles from Pretoria, now lying idle, which could be made available for the purpose.

Alcohol could also be obtained from the stalks of the maize plant if they were cut at the right stage of growth, and especially if the sugar-content of the stalk were to be increased. It has been suggested (*Pacific Rural Press*, 8 Sept., 1906) that alcohol will yet be produced at a much lower cost than has ever been known, by the utilization of waste maize stalks, husks, cobs, etc., but this problem appears to be still a subject of experiment.

763. *Gas for Illuminating and Heating.*—In an article in *The Garden Magazine* for November, 1907, the following statements were made:—

"The Middle West has found a new use for the straw and corn cobs which heretofore it was necessary to burn in order to get them out of the way. On June 15th, 1907, at Beatrice, Neb., a plant was put into operation which manufactures illuminating gas from straw, corn-cobs, and things of that sort. The gas is sold to the residents for one dollar per 1,000 ft., which is seven dollars less per 1,000 ft. than the price charged for coal gas by a Company in the same city. Ton for ton more gas was produced from the vegetable matter than could be produced from the best Pennsylvania coal, 16,000 cu. ft. being taken from a ton of cobs and straw, which is 60 per cent more than the coal could have produced.

"Another advantage of the vegetable gas is that it produces 660 British Thermal units of heat against 600 units for the coal gas. From now on there is no reason why towns of the Middle West should not be provided with gas plants, for there is abundance of fuel which may be had for the hauling, which costs a very small amount per ton. It costs six dollars a ton in Beatrice, Neb., for coal from which to manufacture gas. Gas plants already in operation can be converted to use straw and such things."

The following information on the subject was obtained from an attorney of long standing in Beatrice, Nebraska, the city referred to, and was courteously forwarded by Dean C. E. Bessey, of the Department of Botany, University of Nebraska:—

"It is true that when the new Gas Company first started here they used straw, cornstalks, cobs, etc. They advertised this fact very much in advance, claiming that a better and much cheaper gas was to be the result. Soon after they were started they were forced to mix oil with their straw. I just phoned to the Company, and they tell me that now they use coke and steam." CHAP. XVII.

764. *Maize Charcoal.*—A fine quality of charcoal is manufactured in the United States, from maize cobs, by the following process: A hole, 5 feet deep, 1 foot in diameter at the bottom and 5 feet at the top, is dug in the ground for a charcoal pit. A fire is started at the bottom of the pit with a few dry maize cobs; these are added to until the flame is gradually drawn to the top of the pit, which is then full of cobs. A sheet-iron cover, shaped like the lid of a kaffir pot, sufficiently large to cover the 5-feet hole and close up the burning mass, is placed over the aperture and sealed down at the edges with earth or cow-dung to keep out the air. It requires twelve hours to complete the burning. This method may perhaps require slight alteration to adapt it to local conditions.

765. *Paper Material.*—The increasing scarcity and cost of wood are leading manufacturers to inquire for other materials for the manufacture of paper. The cost of paper is a particularly important question in South Africa, where it is claimed that some 43 per cent of the cost of the paper on which newspapers are printed goes to pay for transport from Europe, or, in other words, that for every £100 spent in London for the paper, another £75 is spent to transport it to the Transvaal. If the paper were manufactured in South Africa, that extra 43 per cent would either be saved to the publishers and go towards a reduction in the cost of the threepenny dailies, or it would, at least, be expended in South Africa (*Burtt-Davy*, 5).

Much has been said and written from time to time in favour of growing a special fibre crop in South Africa for the local manufacture of paper. But before attempting the production of special crops for the purpose, it is worth while to consider whether it would not be cheaper to make use of material already being grown in the country.

In 1906 the writer went carefully into the question of the utilization of maize stalks and husks as paper material and, after correspondence with the Imperial Institute and the United

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States Department of Agriculture, it was found that the material was quite satisfactory for the purpose; in fact paper made from maize husks is described as remarkably tough and lacking the undesirable brittleness of common straw papers. The leaves, stalks, and sheaths ("husks") of the maize plant have been extensively used in Southern Europe and the United States for the manufacture of paper. According to Simmonds, maize paper appears to be the least exceptionable of all papers not made from rags. It is remarkably tough and devoid of the silicious matter usually characteristic of straw papers, and is considered particularly suitable for bank-note paper and for envelopes. The coarser husks are used for the manufacture of wrapping paper.

The practical aspect of the problem depends on whether suitable paper can be manufactured locally at the price of the imported article, viz. about £16 10s. per ton. This, again, depends largely on the cost of erection and maintenance of plant, and cost of the necessary chemicals, most of which must be imported. The problem is chiefly an economic and commercial one, and the Imperial Institute advised that "a careful survey, by a practical expert, of the local conditions and the cost of manufacture would be necessary before a decision could be arrived at".

The following information on the subject is contained in a now rare publication by Mr. J. R. Dodge (1), and is given for the benefit of readers interested in this subject:—

The husks or spathes enclosing the ears of maize have been used in various ways in many countries:—

(1) As a fibre for yarns, for crash;
(2) For plaiting, like many of the reeds;
(3) For filling mattresses and for upholstery; and lastly,
(4) For making paper.

There is a record of two maize-paper establishments existing in Italy in the eighteenth century.

"*Economic Considerations.*—The commercial industry belongs chiefly to Germany, Austria, and Hungary, though a patent for maize-paper process was issued by the United States in the beginning of the present century, to John Harkins, of New Jersey, in 1802; another was issued in 1838 to

Homer Holland of Massachusetts, and in 1860 a patent was issued for making paper pulp of corn cobs. Among the first serious experiments in manufacturing paper from maize were those made just prior to 1860 by Moritz Diamant, a Bohemian, who suggested to Baron Bruck, Austrian Minister of Finance, a process for making paper from maize. The imperial paper mill at Schlogemuhl, near Gloggnitz, undertook the manufacture under Diamant's direction; the product was not quite satisfactory either in quality or in cost of manufacture. His first application for Government aid was in 1856. After the unsuccessful experiment, followed by effectual efforts to induce private individuals to continue the work, he made a second request of the minister of finance, fortified with recommendations from judicious, practical men, and the experiments were continued, but were not yet fully successful. To reduce the cost a 'half-stuff factory' was erected in a maize district, designed to cut off the heavy expense of transportation of the crude material. The product was so inferior that Diamant became disheartened, absented himself, and was released from his position, leaving the question unsolved. The cost of this experiment was about $13,000, which had been advanced by the imperial paper mill. The direction of the Schlogemuhl paper mill, not disposed to discontinue the effort to make a good and cheap paper, continued the experiments, aiming first to reduce the cost of production and, secondly, to investigate the cost of using only the finest husks enclosing the ear, rather than the leaves of the stalk entire. The result was, if not a material for paper cheap as rags, the discovery of a new fibre capable of being spun and woven, and furnishing in its waste a cheap paper. Specimens resulting from these Austrian experiments were sent to the United States Department of Agriculture. Among them were yarns to be used as a substitute for flax in crash, and oilcloth made from it, with a variety of papers, including 'Royal Chancery,' letter paper, flower paper, cigarette paper, silk paper, and drawing paper, ranging in price from $1·60 to $4·80 per ream.

"The progress made in perfecting the manufacture of paper has of late been very satisfactory. Evidence of this is abundantly afforded in the specimens recently received at the U.S.A. Department of Agriculture from Dr. Chevalier Auer de Welsbach, director of the imperial printing establishment at Vienna and superintendent of the imperial paper mills at Schlogemuhl, who had been unremitting in his efforts, which

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have been crowned with a large measure of success. Among these papers are found parchment and document papers of great strength and durability; tracing paper of superior tenacity and transparency, an effect of the natural gluten of the husks, rendering unnecessary the present expensive process of its manufacture and supplying draughtsmen with the cheapest material known; letter paper in various styles and in several colours, with a smooth and polished but soft surface, which takes the ink kindly; 'chancery papers' of great variety in size, very heavy and durable; beautiful silk paper of several colours, of wonderful delicacy in structure and finish; paper for the manufacture of artificial flowers, in lilac, rose, blue, green, and brown, gossamer-like yet strong, weighing but 6 lb. to the ream; and cigarette paper, but little heavier, weighing but 7 lb. to the ream. Of most varieties, both hand and machine papers are produced. A peculiarity of this paper, due to the large proportion of gluten it contains, is worthy of mention: placed with common paper in water and left to soak until the latter will fall to pieces by its own weight, the maize paper on trial seems nearly or quite as tenacious as ever. The process of manufacture is claimed to be simple; the humblest labourer can readily understand it with little instruction and practise it with success. The cost of the husks (and it seems that leaves are to some extent included) is from 32 to 56 cents per 125 English lbs. (per centner), or $9 per ton at the higher price, which represents more the labour of gathering than the value of the material. This is, of course, in the locality of their production. The cost of extracting the fibre from 100,000 centners (6,250 tons) is estimated: For coal and other materials, $15,705; labour, $6,400; interest and loss, $4,296; raw material, including local freight, $80,000: total, $106,401. To this add for labourers and repairs to swell the total to $109,496. The product is 10 per cent of spinning fibre, 19 per cent of paper stuff, and 11 per cent of feed stuff, or 40 per cent in all, leaving a loss of 60 per cent. The spinning stuff is worth $64,000; paper material, $72,200; feed stuff, $15,400: total, $151,600. Deducting the expenses of manufacturing, a profit of $42,104 is shown."

In the year 1908-9 the Natal Government, through its Commercial Agent, received the following memorandum on the subject from the United States Department of Agriculture at Washington (*N.A.J.*, Vol. XII, No. 2, February, 1909):—

"That good paper can be made from corn [maize] stalks was proven long ago. The Government's present experiments which are being carried out by the Forest Service and the Bureau of Plant Industry in co-operation, are merely to obtain authentic data on this subject, and to determine if possible just what is necessary to make the manufacture of paper pulp from corn stalks a commercial success. The corn stalks thus far experimented with have been those grown locally during the season of 1907, but there is no reason to suppose that the material grown in the Corn-belt would not yield fully as good a product.

"The stalks are received in the laboratory in bundles, which are opened out and shaken to remove loose dirt. They are then cut into short pieces and washed to remove as much field dirt as possible, and are then ready to put into the digester for cooking. Before the regular cooking process is commenced the stalks in the digester are extracted several times with water and live steam under 10 to 25 pounds pressure. This removes much soluble material, containing most of the nutritious matter originally present in the stalks, and after partial evaporation of the extract it could probably be used as cattle food. After the extraction with water is completed, the caustic soda is added to the material in the digester and the regular cooking process is proceeded with. The 'cooks' made have varied from several hours at 95 pounds steam pressure down to one and a half hours at 110 pounds, and the caustic soda used has been from 10 to 25 per cent of the bone-dry stalks removed. It is found that the best results are obtained by using about 15 to 10 per cent of caustic soda and cooking about two hours after a pressure of 110 pounds is reached.

"After the 'cook' is completed the fibre is blown out of the digester into a vat with a false bottom which allows the waste liquors to drain away. The material is washed in this vat with hot water until the waste liquors, which are very dark brown, are removed, and it then goes to a specially constructed screen which separates the pith cells from the long fibre. This process is necessary as the pith cells tend to make the paper harder than is desired for many grades. The fibre, after separation of the pith, is found to be long and strong and could be used for nearly any grade of white paper as it is found to bleach easily with 7 to 12 per cent of bleach. It could also be employed in the unbleached state for wrapping paper, and with the addition of ground wood for the production

CHAP. XVII. of cheap printing paper. The pith-pulp in its dry state is very hard, and in some ways resembles horn; it has limited water and grease proof qualities, which might make it of value in certain grades of wrappings. Its remarkable bending qualities when slightly moist would probably make it serviceable in the production of box board.

"From the results of these tests already completed it is safe to conclude that one ton (2,000 lbs.) of bone-dry stalks will yield about as follows: Food extract, 300 lbs.; long fibre, 300 lbs.; pith, 600 lbs.; waste, 800 lbs."

Writing in June, 1910, the Agricultural Technologist of the United States Department of Agriculture reported:—

"This office has in charge projects for the utilization of corn stalks for paper, and incidentally we are at work on making a food extract of commercial value. But it is quite safe to say that at the present time no process can be recommended as having stood the test of practical manufacture. With the increasing price of wood and other sources of paper it is quite possible that corn *stalks* may be utilized as raw material for paper."

766. *Cellulose.*—The inside of the maize stalk is a pithy mass mainly composed of cellular tissue, free from sap and other impurities. It therefore furnishes a nearly pure "natural" cellulose, easily and cheaply produced from an almost inexhaustible supply. In the United States, according to Dodge (1), this pith is extracted by machinery, and is used in the manufacture of celluloid, paper-pulp, a floor-covering resembling linoleum, viscose nitrates, insulation for refrigerator trucks, steam-pipe and boiler coverings, and dry cells for electric storage batteries.

Treated with nitric and sulphuric acids cellulose produces guncotton. Guncotton and nitro-glycerine form smokeless powder. Pyroxylin varnish is a by-product obtained in the manufacture of cellulose. It is stated that "this source of cellulose will make possible the practical production of many articles that have heretofore been only made as the result of laboratory experiments" (*Watts*, quoted by *Dodge*, 1).

An interesting use of the cellulose obtained from maize stalks was recorded by Cramp (1) as follows:—

"The corn-pith cellulose is employed as a packing material in the coffer-dams in connection with the armour plating of United States war vessels. The corn pith is suitably cleaned and pressed into blocks, when it is ready to use. A cellulose belt of three feet may be said to be as efficient as six inches of best steel. Experiments have shown that there is no danger of the substance being washed out through shot holes by the action of the sea, and it is considered better in many ways than other substances, such as coco-nut fibre, which have also been used. Coir fibre employed as packing has been ignited, while corn pith has proved incombustible. A special advantage results from its great absorption of water, whereby a shot hole is soon filled up through the filling of the corn-pith packing."

In some parts of the United States the prepared *pith* from the maize stalk is said to be used in the manufacture of horse collars and mattresses; while in Florida it is said to be made into many forms of "pottery," "delicately tinted in greens and greys, which make exquisite decorative novelties for the drawing-room" (*Dodge*, 1). It is also said to be used in the manufacture of box board at a much lower cost than that prepared from rags or wood-pulp.

767. *Other Uses for Maize Husks.*—In addition to its use as a paper material (¶ 765), the thin papery *husk* surrounding the maize ear is used in the United States as filling for mattresses and pillows and for packing horse collars. In South Africa and in the Northern United States maize husks are twisted and plaited into artistic door-mats, which are very durable; good examples have been turned out by the native schools in Natal, and in the Zoutpansberg District, Northern Transvaal, under the direction of the Transvaal Department of Education; also by prisoners undergoing sentence at the Central Prison, Pretoria, where the industry has been wisely fostered by Mr. J. de Villiers Roos, Secretary of the Law Department. Maize husks are also used in the Southern United States, in Jamaica, and South Africa, in the manufacture of light summer hats, both for women and men; in Florida, U.S.A., the husks, split into strips, are made into "chip hats," and when properly trimmed are said to be both stylish and pretty, and are sold in the Florida bazaars. The Moqui

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Indians of the Western United States plait their food-trays out of maize husks, according to Dr. Fewkes (*Dodge*, 1). Useful and durable baskets and mats are woven out of maize husks and string. The husks are placed between damp cloths for

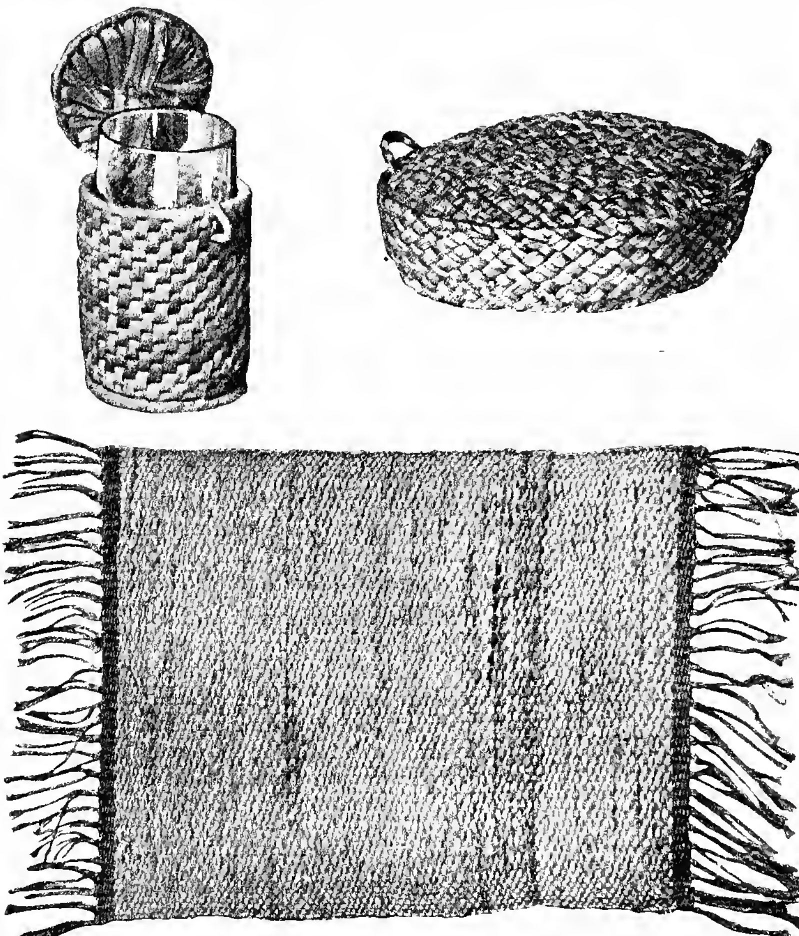

FIG. 245.—Mats, etc., made of maize husks. (Courtesy of *Ladies' Home Journal*.)

several hours to make them flexible, thus preventing breaks and tears in working. Throughout the construction small headless nails or $\frac{3}{4}$- to $\frac{1}{2}$-inch brads are used. A woven mat like that shown in Fig. 245 can be made on an ordinary loom;

it measures 28 by 22 inches; the warp consists of common twine and is woven with ripe maize husk. CHAP. XVII.

768. *Other Uses for Maize Cobs.*—In addition to their use for the manufacture of charcoal and corn-and-cob meal already alluded to (¶ 665 and 764), maize cobs are used in St. Louis, Mo., U.S.A., for the manufacture of "Missouri corn-cob" tobacco-pipe bowls; these are prepared from a particularly large type of maize, and are chiefly used locally, but there is a limited export to the British Islands and the Colonies. Cobs are also used in America and France as fire-lighters; at one time maize-cob fire-lighters were retailed in Paris for twelve to twenty francs per 1,000. On the treeless parts of the South African High-veld, where wood and coal are scarce and expensive, maize cobs are in some cases the only fuel used; they make an excellent "baking fire"; in the United States a ton (2,000 lbs.) of maize cobs is estimated to be worth one-third of a ton of dry, hard wood. In some parts of South Africa maize cobs are used for firing the tobacco seed-beds, and are considered the best fuel for the purpose.

In 1906-8 experiments were conducted at the Dynamite Factory of the British South African Explosives Company, Limited, Modderfontein, Transvaal, in the use of maize cobs, ground down to an impalpable powder, as a substitute for the imported "wood-meal" or wood-pulp in the manufacture of explosives. Writing in September, 1908, the General Manager, Mr. Cullen, stated that the trials had not been very successful, so that the idea of working up the maize cobs had been abandoned.

In parts of Iowa, where maize is shelled on a large scale, the cobs are carted back to the land as a fertilizer for the addition of humus, potash, and phosphoric acid. Maize-cob ash contains about 50 per cent potash.

769. *Maize Chaff.*—Maize chaff, obtained in the cleaning of shelled maize in the mills, and in the preparation of corn cob pipes, is used in upholstery and mattress-making.

770. *Zea or Maize Silk.*—The "styles and stigmas of *Zea Mays* Linné (Nat. Ord. Gramineæ)" are official in the United States pharmacopœia under the name "zea," "Maidis stigmata" or "corn silk". The portion which is used in medicine is that which is commonly known as the "silk" of the "ear," being

CHAP. XVII. the elongated styles and stigmas collected from the "nearly-ripe maize fruit". It is officially described as "thread-like; about 15 cm. long and 0·5 mm. broad, yellowish or greenish, soft, silky, finely hairy, and delicately veined longitudinally; inodorous, taste sweetish" (*U.S. Pharmacopœia: Wood, Remington*, and *Sadtler*, 1).

Wood, Remington, and Sadtler (1) describe the composition, medical properties, and uses as follows:—

"Rademaker and Fischer (1) determined the presence of 2·25 per cent of *maizenic acid* in dried corn silk. It was first described, however, by Dr. Vautier. It is freely soluble in water, alcohol, and ether, but insoluble in benzin. Rademaker and Fischer found, in addition to the acid, fixed oil, resin, chlorophyll, sugar, gum, extractive albuminoids, phlobaphene, salt, cellulose, and water.

"Zea has been highly recommended by various surgeons as a mild stimulant diuretic, useful in *acute* and *chronic* cystitis, and in the bladder irritation of *uric acid* and *phosphatic gravel.* It has also been employed in *gonorrhœa*, and has been affirmed by M. Landreux to be a useful diuretic, and even cardiac stimulant in the *dropsy of heart disease.* It has been commonly used in the form of infusion, two ounces to the pint of boiling water, taken almost *ad libitum;* but the fluid extract dose, one to two fluidrachms every two or three hours, is an excellent preparation. A solid aqueous extract would probably represent all the activity of the drug, and may be given in doses of five to ten grains three to six times a day. Maizenic acid has been used in doses of one-eighth of a grain (0·008 gm.)."

771. *Maidis Ustilago.*—Maize smut is said to be used sometimes, under the name *Maidis Ustilago,* in Materia Medica, in the place of Ergot.

772. *Use of Maize Straw for Thatching.*—Tucker (1, p. 299) speaks of maize straw as used for thatching roofs in parts of south-east Europe.

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ABBREVIATIONS USED IN CITING REFERENCES.

A.J.U.	= Agricultural Journal of the Union of South Africa; commenced 1911.
Ann. Rep.	= Annual Report.
Assn.	= Association.
Bull.	= Bulletin.
Bur. Pl. Ind.	= Bureau of Plant Industry, U.S.D.A.
C.A.J.	= Agricultural Journal of the Cape of Good Hope.
Exp. Sta. Rec.	= Experiment Station Record, published by the United States Department of Agriculture.
N.A.J.	= Natal Agricultural Journal.
R.A.J.	= Rhodesian Agricultural Journal.
T.A.J.	= Transvaal Agricultural Journal.
T.D.A.	= Transvaal Department of Agriculture.
U.S.A.	= United States of America.
U.S.D.A.	= United States Department of Agriculture.

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