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FIELD CROP PRODUCTION

LIVINGSTON

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Small Plots of Cereals at the Dominion of Canada Experimental Farms, Ottawa

FIELD CROP PRODUCTION

A TEXT-BOOK FOR ELEMENTARY COURSES IN SCHOOLS AND BRIEF COURSES IN COLLEGES

BY

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PREFACE

THIS book is intended to supply in convenient form general information regarding the subject of field crops, for use in agricultural schools and in elementary courses in colleges. It is in no sense a complete or exhaustive treatise on the subject, such as would be desired for regular college courses in field crops.

In the author's judgment, the most effective method of presenting the subject of field crops to students in elementary courses is by the combination textbook and lecture plan, the textbook to furnish basic information, and the lecture to include such specific information as the instructor cares to give. In very elementary courses, the textbook would probably furnish the principal source of instruction. In presenting the subject of field crops to students of short or two-year courses in agricultural colleges, it is necessary, on account of the vast amount of experimental data which is accumulating and constantly changing, to devote a large part of the time allowed to the course to information of this sort, which leaves but little time for presenting the more elementary phases of the subject. A more complete and satisfactory course can, in the author's opinion, be given if the student by the aid of a general textbook can acquire these elementary facts outside of class hours. The elementary courses may be made very complete, if desired, by the use of such a textbook, and the devoting of the major part of the lecture periods to the consideration of experimental results in general, to the making of local applications and the applying of the principles of plant physiology and plant-breeding to field crops.

Many students in field crop courses, both in agricultural schools and colleges, have come from town or city homes, and have had little or no farm experience. While it is not possible to acquire farm experience from a textbook, it is possible to gain from such a source much of the general information which is lacking.

In the writing of this book there has been included but little statistical matter and but little experimental data, which can be presented in a more up-to-date form by means of lectures. As the book was originally written, it contained some discussion of all of the North American field crops, but in order to keep it within a reasonable size, it has been necessary to omit some of them, the most important of which are sugar cane and tobacco.

The author has observed, first as a student and later as an instructor, that the interest which the student feels in any subject depends largely upon whether or not the subject matter is presented in an attractive manner. For that reason he has included in this book somewhat in detail some facts which are of interest but not generally considered of vital importance.

It is hoped that this book will prove useful as a general textbook of field crops in elementary courses, and as a supplementary textbook in other courses, for students with little or no elementary knowledge of the subject.

I am indebted to C. G. Williams and F. A. Welton of the Ohio Experiment Station, to Professor E. G. Montgomery and Dr. H. H. Love, of Cornell University, to C. R. Ball and Dr. C. E. Leighty, of the U. S. Department of Agriculture, and to Professor H. D. Hughes, of Iowa State

College, who have read the manuscript in whole or in part and who have offered many helpful suggestions. I am grateful to those who have written chapters which have been included in the text, and which appear under their names, and to those who have furnished illustrations, to whom credit is given in the list of illustrations. I wish also to express my appreciation to my wife, Inez Van Sickle Livingston, for her constant assistance in preparing the manuscript for the press.

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FIELD CROP PRODUCTION

CHAPTER I

INTRODUCTORY VIEW

All the plants that grow on the earth are called, collectively, the plant kingdom. The plant kingdom is made up of innumerable forms of vegetation, ranging in size from the tiny one-celled plant, so small that it cannot be seen with the unaided eye, to the giant trees of the forest. Between these two extremes are to be found myriads of intermediate forms, the algæ that grow in ponds and streams, the mosses and lichens that grow on the trees and rocks, the ferns of the woods, the grasses and grains of the fields, the wonderful shrubs and plants with which we beautify our yards and gardens, and numerous other similar and related forms. Plants differ not only in their size, structure and habitat, but also in the kinds of food that they are able to use and in their usefulness to man. Some forms of vegetation are able to secure their food from the inanimate world in the form of chemical elements or compounds in the soil and in the atmosphere, and by certain life processes are able to convert them into forms useful in building up their own structures. Other forms are not able to do this, but must derive a part of their food from compounds that have already been incorporated in the bodies of other plants or animals. To the former class belong most of our cultivated plants, while in the latter class are to be found many of the plants that injure and produce disease in the cultivated forms. To this group belong the rusts and smuts that attack the grains, the blights and wilts that lay low the vegetables, and many other injurious, as well as some useful forms.

In their usefulness to man, plants vary greatly. They are of service to him principally in furnishing food, clothing, and shelter. They are also a factor in many industries, the products of which supply in some form or other the needs of man. Every industry, in fact, no matter how far removed from the growing of plants it may seem to be, is either directly or indirectly dependent upon it. The fundamental basis of any industry is to be found in the food supply of the people who engage in it, and of the people who consume the commodities produced. Men derive their supply of food principally from two sources, plants and animals. The animals, however, are either directly or indirectly dependent upon plants, so that, in the last analysis, the food supply of the nations of the world and consequently the existence of all the industries of the world are dependent upon the production of plants. Not all plants, however, are useful to man, many of the most troublesome diseases that attack the crops being plant growths.

1. Classification of plants. — Because the plant kingdom is made up of these multitudes of widely differing forms, it has been necessary for botanists, for purposes of study, to classify them into various groups. This branch of the study is called systematic botany, and has occupied the attention of botanists for many years. The classification has to do with the arranging of plants into groups, based upon their similarity of parts, — their evident relationship. While it is not necessary for the general student of field crops to go exhaustively into the subject of systematic botany, a knowledge of its principles is necessary to a satisfactory understanding of field crops and of the terms employed in any discussion of them.

2. Species. — The grouping can best be understood perhaps if we start with the individual.[1] If a seed of Kentucky blue-grass is planted, it will with favorable conditions for growth develop into a plant, which in time will produce seeds for its own perpetuation. If these seeds in turn are planted, they will give rise to other plants, which in time will produce seeds, and so on. Within a few years a large number of plants will result, the progeny of a single blue-grass seed. A careful examination of these plants will show that, while they are very much alike, slight variations occur in size, form and color of their various parts. While these variations may occur, the plants on the whole resemble each other very closely, having descended from a common ancestor. These plants and all others, wherever they may be found, resembling them so closely that they might well have come from the individual plant of which we spoke, are placed in a group called a species. A species, therefore, is made up of individuals so near alike that they may be regarded as having come from a common ancestor.

3. Variety. — As has been noted, slight variations occur among the individual members of a species. Sometimes variation in form, size or structure of a plant or its parts is such as to make it more useful to man than the other members of the species. Frequently man selects plants possessing some superior quality and develops from them, by using their seeds for perpetuation, a group of plants

[1] Method of presenting classification of plants adapted from Percival's Agricultural Botany.

that varies slightly in some one or more characteristics from the other individuals in the species. Such a group of plants is called a variety. A variety, therefore, is a group of individuals within a species that possesses some variation from the species as a whole. As yet no varieties have been developed from Kentucky blue-grass, but examples of varieties in abundance may be had from the grain crops, such as corn and wheat. Thus we find many varieties of corn, such as Reid Yellow Dent, Boone County White, Calico, and many others. These varieties have some character or characters that distinguish them from corn in general. The color of the grain, the size of the ear and plants, the length of season required for growth, and similar variations are distinguishing variety characteristics.[1] Varieties, however, are not so different from the other individuals of the species as to form a separate and distinct species by themselves. Thus Reid Yellow Dent and Boone County White, and all other varieties of corn, are members of the corn species *Zea Mays*.

4. Genus. — If one examines closely all kinds of grasses, it will be found that certain kinds bear a close resemblance to Kentucky blue-grass, in the general appearance, manner of growth, structure of parts, the arrangement of flowers, and the like.[1] Thus such species as Canada blue-grass, Rough-stalk meadow-grass, and

[1] In presenting the scheme of classification of plants, the author has used such general terms as "manner of growth," and "general appearance" in referring to varietal and generic characteristics, viewing the subject from the agronomist's point of view, as the discussion for elementary students of the plants with which he deals does not necessitate going into the intricate distinctions employed by the botanist. The term "variety" is used in the agronomic sense, not as a sub-species as the botanists use it.

Wood's meadow-grass so closely resemble Kentucky blue-grass as to establish with it a close relationship. Species which are thus closely related are placed in a group called a genus. A genus, therefore, is a group of closely related species.

5. Naming of plants. — For convenience in describing and identifying the various species that comprise a genus, and to distinguish the various genera, it has been necessary to name plants in such a way as to indicate the species and genus to which they belong. The botanical or scientific name of a plant is composed of two Latin words, the first of which is the name of the genus and the second that of the species. Thus Kentucky blue-grass is known as *Poa pratensis*, Canada blue-grass as *Poa compressa*, Rough-stalked meadow-grass as *Poa trivialis*, and Wood's meadow-grass as *Poa nemoralis*. Varieties of farm crops are not given Latin names, but frequently are named for the man who is responsible for their development, as Reid Yellow Dent corn, or sometimes for the section of the country in which they were developed, as Boone County White, or by some other distinguishing name, such as Pride of the North, Rust-proof, Medium Green, and the like.

6. The family. — On observing the pasture and meadow grasses, one will almost immediately note their similarity and general appearance, manner of growth, shape of leaves, character of stems, and other characters. It may be seen, however, that this resemblance is not close enough to group them all in the same genus, but that the various genera are similar and may be classed together in a larger group, which is called the family. Thus the meadow and pasture grasses together with other grasses may all be included in a large group or family, called the Gramineæ or grass family. The family group may include genera of considerable variation in size or other characters; thus oats, wheat, barley, and even corn, each of which belongs to a different genus, are all members of the grass family. But the variation between oats and the meadow grasses like timothy is not so great as would appear without examination of the plants themselves. Examination will reveal the similarity in the character of growth, shape, and structure of the leaves, stem, and flowers. The nearness of their relationship will become more evident if one of them is compared with a species of another family, such as one of the clovers. Immediately a great dissimilarity between these will be noticed in the leaves, stem, roots, and flowers.

7. Orders, classes, and divisions. — As genera and families have been formed, so are the closely related families grouped into orders. Orders with similar characters are grouped into classes, and similar classes form divisions. The division represents the largest group of the plant kingdom.

8. Divisions. — The plant kingdom has been divided into four great divisions, namely, Thallophytes, Bryophytes, Pteridophytes, and Spermatophytes. The Thallophytes and Bryophytes comprise the lower forms of plants; the algæ, fungi, and bacteria belonging in the former group, and the liverworts and mosses in the latter. The plants of these two divisions have neither true stems nor leaves, nor do they produce flowers and seeds. The Pteridophytes include the ferns and related plants. The plants of this division have stems and leaves, but do not produce true flowers or seeds. These three great divisions of the plant kingdom, Thallophytes, Bryophytes, and Pteridophytes, are often grouped together into the "flowerless plants." The one remaining group, namely, the Spermatophytes, includes all of the seed-producing plants. To this group belong almost all of the cultivated plants, and it is by far the most important division in its relation to mankind. The Thallophytes, however, are of considerable importance to man in that within its membership are to be found the bacteria, both useful and harmful, and also the numerous plant diseases. The farmer, therefore, is economically interested chiefly in only two of the great divisions of the vegetable kingdom, the Thallophytes and the Spermatophytes.

The two classes of Spermatophytes are the Gymnosperms and the Angiosperms. The Gymnosperms include those plants the seeds of which are naked or not inclosed, and are formed on the outside of a modified leaf. A large number of the Gymnosperms are coniferous or cone-bearing trees, such as the pine, cedars, yews, and similar plants. The Angiosperms include those plants whose seeds are inclosed in pod- or sac-like structures. To this group belong almost all of the cultivated plants. The Angiosperms may be divided into two sub-classes, namely, the Dicotyledons and the Monocotyledons. The dicotyledonous plants may be distinguished by the presence of two cotyledons or seed leaves, while the monocotyledons have but one. Both dicotyledonous and monocotyledonous plants are to be found in our cultivated forms. The Leguminosæ, to which belong the clovers, peas, and beans, is an example of the former, while the Gramineæ, or grass family, to which belong the grasses and grains, is an example of the latter.

9. Length of life. — Based upon their length of life, plants may be divided into annuals, biennials, and perennials. An annual is one that lives only during one growing season. A biennial is one that requires two growing seasons to complete the life cycle, no seeds being produced during the first season, but only leaves, stems, and roots. The seed is produced the second season. Perennials are plants that live for more than two years. Some perennials, such as alsike clover, live but a short time, three or four years or so, while other perennials, such as alfalfa and blue-grass, live for many years. Some annuals utilize parts of two growing seasons, instead of making all their growth in one season. An example is winter wheat, which makes a partial growth during the fall and completes its growth the next year. Such plants are called winter annuals.

10. Cultivated plants. — The flowering plants, including both monocotyledons and dicotyledons, of which there are a great number, and which are found in all parts of the world where plants exist, may be divided into the cultivated and uncultivated plants. However, some plants that are cultivated in one part of the world may grow wild in other lands. Of the great number of flowering plants, species of over 200 families are cultivated by man. These include those cultivated for their flowers, fruit, stem and leaves, roots, tubers, grain and fiber. The cultivated plants may be grouped into two general classes, horticultural plants and field plants. Horticultural plants are the fruits and vegetables. Field plants are those plants grown in fields for their stems, leaves, roots, tubers, fiber, or seeds.

11. Field crops. — Field crops may be defined as those plants grown in cultivated fields under a somewhat extensive system of culture. Horticultural crops, on the other hand, are those plants grown in comparatively small areas under systems of intensive culture. This is not a hard and fast distinction, however, since such crops as the sugar beets, while considered as field crops, are grown under rather intensive systems of culture. Tobacco, also, is a field crop that requires intensive culture, while on the other hand, vegetables and fruits are frequently grown in comparatively large areas. The student of field crops is interested in the study of all plants grown as field crops, and in their culture, harvesting, storing, market, and uses. Closely related to the study of field crops are the problems of soil fertility. Frequently these two subjects are grouped under the same term, agronomy, which means culture of the fields. The agronomist, therefore, may be a student or an investigator of problems relating to both soil fertility and farm crops, or he may confine his attention more especially to one or the other of these two branches.

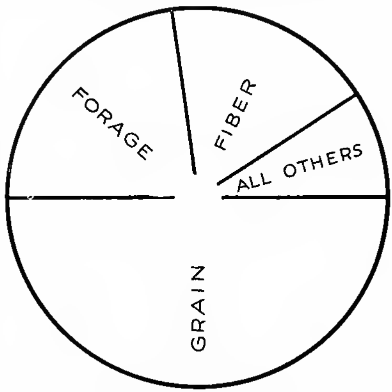

FIG. 1. — Comparative value of crops in the United States.

12. Classification of field crops. — For convenience in study and in describing general methods of culture, the various field crops may be grouped into several classes. The classification of the subject which will be followed in this book divides them into grain, forage, fiber, root. and, related crops, and miscellaneous crops. In this classification the grouping of the crops is based in part upon the most important parts of the plants, and in part upon the uses made of them. This method of classification, as indeed any method that might be employed, is more or less general and several irregularities occur in it. Thus the grain crops are usually grown for their grain, but frequently the straw is used for forage, and sometimes the entire plant is so used. Sometimes, too, a crop may be grown for one purpose in one place, and for another use in another locality. Thus flax, which has been grouped with the fiber crops, is grown in some places entirely for its seeds, in which case it should, perhaps, be grouped with the grain crops. The millets are likewise, in some countries, grown primarily for their seed, but in this country they are generally used for forage. In a general way, however, the grouping here followed will indicate the most common usage of the crops, but mention will usually be made of any other uses to which they may be put. The relative importance of the various crops is shown in the diagram.

13. The grain crops. — Grain crops are crops that are grown primarily for their seed or grain. This term is more inclusive than the term "cereals," which is defined as any grass grown for its edible grain. The term grain crops is used to include all crops grown for their grains, regardless of their botanical relationship. The cereals, however, are by far the most important grain crops, and if it were not for the cereals, this group would have a small membership and a rank of little consequence, instead of being, as it now is, the most valuable and useful group of field crops.

14. The forage crops. — Forage crops are those crops grown primarily for forage, which may be defined as roughage or bulky feed for domestic animals. The forage crops have great bulk and low feeding value per unit of weight as compared with the grain crops. Forage crops may be cut and dried before feeding, as is the case with hay or stover, or they may be fed green, either by allowing the animals to graze upon them, or by cutting and feeding them directly from the field. The straw of the grain crops is frequently used for forage. Forage crops, however, usually mean the crops in which the entire above-ground part of the plant is used. Almost all of the important forage crops are included in the membership of two botanical families, namely, the Gramineæ and Leguminosæ, or as the two groups are commonly called, the "grasses" and "legumes." The forage crops rank next to the grains in value and acreage, and if native pasture is included, the acreage is greater than that of the grain crops.

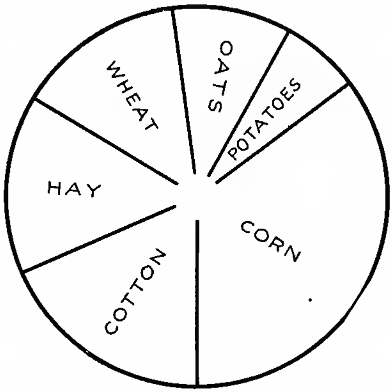

FIG. 2. — Six leading crops of the United States.

15. The fiber crops. — Fiber crops are those crops grown for their fiber, which is used in the making of textiles, ropes, twine, and the like. Cotton is by far the most important of this group of plants, and its great acreage and value give to the fiber crops the third rank in this respect.

16. The root and related crops. — Root crops are those crops grown for their enlarged tap roots. Several other crops with thickened leaves and stems which resemble the true root crops in their composition and feeding values, and also in the general methods of their culture, are usually included in this class. A more detailed explanation will be found in the introductory paragraph of the chapter on root crops.

17. Miscellaneous crops. — Under this head are grouped all farm crops not included in any of the preceding classes. As might be expected, these crops vary greatly in their botanical relationship, culture, and uses. The two principal crops of this group are the potato, which is grown for the tubers, and tobacco, which is grown for its leaves and is used as a stimulant. The latter is not included in this book.

18. Definition of terms. — Several terms are employed in field-crop literature, both in text-books and in the agricultural press, that should be defined. Some of them refer to a special use made of a crop, which may be a member of any of the general groups previously discussed, but usually belongs to the grain or forage crops.

A *soiling crop* is one that is cut green and fed green directly from the field. Thus corn, if it is cut and thrown over the fence to animals, or fed to them in the feed lot, becomes a soiling crop.

A *green manure crop* is one that is grown to plow under or to disk into the soil to improve the physical condition of the latter, and to increase its fertility.

A *cover crop* is one that is seeded so as to make a growth to cover or protect the soil in the field or orchard during the winter.

A *catch crop* is a crop sown between two regular crops. Thus, if rye is seeded in the corn at the time of the last cultivation, and the field is seeded to oats or some other crop in the spring, the rye crop may be defined as a catch crop. It may at the same time serve as a cover crop, or as a green manure crop, or for pasture, or for all three purposes.

A *silage crop* is one grown for the silo. Maize is the leading crop grown for this use.

CHAPTER II

CROP ROTATION

By J. F. Barker

New York Agricultural Experiment Station

When any one crop is grown continuously on the same field for a number of years, the average yield is almost sure to be less than if that crop had been grown in a suitable rotation with other crops. Thus if corn, oats, wheat, and hay are grown on a farm, the land devoted to these crops may be divided into five fields of equal size and the four crops changed each year in regular order from one field to another, except that hay would always be grown on a field two years in succession. In this way better average yields would result than if each field were devoted to one crop continuously. This principle is recognized in greater or less extent by nearly all practical farmers; but the following epitomized results of carefully conducted field experiments bearing upon the subject furnish the concrete evidence necessary to a definite understanding of this principle. Such results are of more significance than any amount of theory or generalized experience. It should be said, in explanation, that comparisons of rotative and continuous cropping are here made between adjoining or near-by fields rather than adjoining plots. The figures therefore are probably not so closely comparable as in fertilizer tests. But considering that at each station the crops in rotation and continuous cropping are grown on the same type of soil having practically the same previous treatment, and taking into account the length of time the experiments have been in progress, the comparisons are unquestionably reliable to a close degree.

19. Rotation experiments at Rothamsted. — In the Rothamsted experiments, wheat grown in a four-year rotation gave during sixty years nearly double the average yield per acre of wheat grown continuously. In the case of barley the difference is also very great, but the yields of barley in rotation have fallen off more rapidly than wheat, owing to the latter crop coming directly after the clover and so getting the greater benefit of the clover sod.

ROTHAMSTED EXPERIMENT STATION, ROTHAMSTED, ENGLAND

(60 Years of Field Experiments)

	WHEAT BU. PER ACRE			BARLEY BU. PER ACRE		
	First 20 yr.	Second 20 yr.	Third 20 yr.	First 20 yr.	Second 20 yr.	Third 20 yr.
Rotation: turnips, barley, clover, wheat	30	21	24	38	22	14
Rotation: turnips, barley, fallow, wheat	35	23	23	37	23	16
Continuous culture . .	16	14	12	20	13	10

The yields in continuous culture have fallen off most rapidly during the first few years of the experiment, for at the outset the land devoted to continuous culture was producing fully as well as that used for the rotation experiment. During the last fifty years the falling off under continuous culture has been comparatively little and has now reached a low level at which it may be sustained almost indefinitely. This is what usually takes place under any poor system of farming; yields fall off rapidly at first and soon reach a low level below which they are not easily reduced. Comparisons here have been made only between the unfertilized plots in the two systems of cropping. By means of commercial fertilizers the yields of wheat and barley, even in continuous cropping, have been maintained at a high level. But the necessary quantity of fertilizer has been so great that the increased yields resulting from their use have not paid the cost. Also, when the fertilizers are used, the crops are now so dependent upon them that if they are discontinued, even for a single year, the yields drop very low.

20. Rotation experiments in Iowa and Illinois. — A most striking example of the rapid decline in production under continuous cropping is shown in the experiments with corn growing at both the Illinois and Iowa experiment stations. In both cases the fields are located on typical dark brown silt loam prairie soil which at the outset yields without fertilization 70 to 80 bushels of corn per acre. The Illinois experiments show that after 10 or 12 years of continuous corn culture the yields of corn on this soil are reduced to about 35 bushels per acre. Under a rotation of corn and oats, which is a poor rotation, but better than a single crop, the yield is 62 bushels. Under a four-year rotation of corn, corn, oats, and clover the yield is 66 bushels. The corresponding figures for a similar experiment on a smaller scale show still further reduced yields, but the reduction in the last 16 years has been going on much slower than at first.

UNIVERSITY OF ILLINOIS EXPERIMENT FIELD AT URBANA, ILL.
TYPICAL CORN BELT PRAIRIE SOIL

(Three years' averages: bushels per acre)

CROP YEARS	CROP SYSTEM	EXPERIMENTS IN PROGRESS 13 YR.	EXPERIMENTS IN PROGRESS 29 YR.
1905–6–7	Corn every year	35 bu.	27 bu.
1903–5–7	Corn and oats rotation	62 bu.	46 bu.
1901–4–7	Corn, oats, clover rotation	66 bu.	58 bu.

IOWA AGRICULTURAL EXPERIMENT STATION, AMES, IOWA.
TYPICAL CORN BELT PRAIRIE SOIL

(Figures give bushels per acre)

Rotation of corn, corn, oats, clover, compared with continuous corn

	1904	1905	1906	1907	1908	1909	1910	1911	1912
Corn in rotation	75	87	69	57	70	54	60	44	60
Continuous culture	74	73	53	47	53	31	46	32	47

The results from nine years of experiments at the Iowa station are even more striking than those from Illinois. They show that, while each system started out with a yield of approximately 75 bushels of corn per acre, continuous cropping never after the first year produced as much by ten bushels per acre as in a four-year rotation of corn, corn, oats, and clover. Such results as these, obtained on typical corn belt prairie soil of proverbial fertility, furnish overwhelming evidence against the one crop system.

21. Rotation experiments in Ohio. — Results from the Ohio Station furnish much additional evidence on the subject under discussion; they also throw light on certain phases of the question with which the others do not deal. In the experiments at each of the other three stations the soil at the outset was in a good state of productiveness, yielding without fertilization, 30 to 35 bushels of wheat or 70 to 80 bushels of corn. At the Ohio Station, however, at the beginning of the experiments the soil was in a badly run down condition. It had been subjected for a half century or more to an exhaustive system of farming. Also, this land in its virgin state was not so productive as the prairie soils of Iowa and Illinois and was less durable than the Rothamsted lands. Crop yields, therefore, being already reduced to rather low figures, there has not been the opportunity for further rapid reductions under continuous cropping. However, on unfertilized land the average acre yields for the last five of the 18 years show that continuous cropping has reduced the yields as compared with the rotation in use as follows: Corn from 26 down to 8 bushels per acre, oats from 29 to 15 bushels, and wheat from 14 to 6 bushels.

It is worth while to make a comparison of the two systems under fertilizer treatment. There being no plots in either of the two systems which have identical fertilizer treatment, certain ones have been selected having the same kind of treatment but in different amounts, and the larger applications being on the continuous culture plats. This makes the comparison all the more striking since the more heavily fertilized crops under continuous culture give lower yields. Nitrogen, phosphorus, and potassium to the amounts indicated in the table are applied in the form of nitrate of soda, dried blood, acid phosphate, and muriate of potash. In the rotation system the amount indicated is applied only once in five years and is divided

OHIO EXPERIMENT FIELDS, WOOSTER

Experiments in progress 18 years, 1894–1911. Rotation of corn, oats, wheat, hay, hay, compared with continuous culture

	Corn		Oats		Wheat	
	First 5 yr.	Last 5 yr.	First 5 yr.	Last 5 yr.	First 5 yr.	Last 5 yr.
Treatment for each five-year period	Rotation					
Unfertilized	31	26	30	29	8	14
38 lb. N., 30 lb. P., 108 lb. K.	36	45	38	48	14	28
8 tons manure	40	47	32	39	12	26
Treatment for each year	Continuous Culture					
Unfertilized	26	8	28	15	10	6
24 lb. N., 10 lb. P., 40 lb. K.	45	35	42	24	20	22
2½ tons manure	37	18	31	23	13	17

between the corn and wheat. In the single crop system the application shown is applied every year. The comparative yields for the last five years are as follows, the larger being always for the rotation system: corn, 45 and 35 bushels per acre, oats, 48 and 24 bushels, and wheat, 28 and 22 bushels. Comparing the rotation plots receiving 8 tons of manure in five years with continuous culture plots receiving $12\frac{1}{2}$ tons in the same length of time, we have the following yields, the larger always in favor of the rotation system: corn, 47 and 18 bushels, oats, 39 and 23, and wheat, 26 and 17. Certainly here is abundant data to show that even with liberal fertilizing crops cannot be grown to good advantage under a one crop system.

22. Why rotation gives better yields. — In studying natural phenomena it is good practice first to make observations and gather data and then try to discover the principles which underlie the working of these phenomena. Having obtained definite data to the effect that a rotation system of cropping affords better yield than continuous culture, we next ask the question, why?

(1) Cultivated crops rapidly deplete the organic matter and nitrogen of the soil. Cultivation favors rapid oxidation and destruction of organic matter with the consequent rapid liberation of nitrogen. Then, too, a cultivated crop leaves very little in the way of roots and stubble to be added to the stock of organic matter in the soil. Erosion, both by wind and water, is much more rapid when a few inches of the surface is kept loose by cultivation. As the organic matter and nitrogen is found mainly in the surface soil, it is rapidly lost when erosion is accelerated. Aside from this loss, erosion is, of course, wasteful of the best part of the soil.

(2) Single cropping favors insects and weeds. Any crop grown on the same ground year after year encourages the presence of such insects and in some cases such weeds as prey especially on that crop. This is one of the worst troubles in continuous corn growing; the corn root worm develops badly under those conditions. In the continuous culture of wheat at the Rothamsted station the ground at

one time became so foul with weeds that it was necessary to devote a year to fallowing before another crop could be grown.

(3) Legume crops help out on the nitrogen supply. A rotation of crops gives an opportunity to include some legume, especially clover or alfalfa, which will leave the soil richer in nitrogen than before the crop was grown. If one-fourth or more of the rotation is devoted to one of these crops and if a part of the crop, as well as the roots and stubble, are turned under, and perhaps also an occasional catch crop of some other legume is plowed under, it is possible to supply in this way sufficient nitrogen for all the other crops in the rotation, and thus the supply of this element be maintained indefinitely. It must be remembered, however, that legumes as well as any other plants can feed upon the nitrogen already in the soil and in fact always take a part of their supply in this way, so that if the crop is entirely removed and only the roots and stubble plowed under, the soil is seldom being enriched in nitrogen and may, in fact, be somewhat reduced. Clover, for example, is known to take, under average soil conditions, about one-third of its nitrogen from the atmosphere. Now the roots and stubble of clover seldom amount to more than one-third of the crop, and, as nitrogen is constantly being lost from the soil by leaching, it may often happen that a clover crop in the rotation does not increase the nitrogen supply at all, though, of course, it does not deplete this supply to the extent of a non-legume crop.

(4) Heavy sods supply organic matter. Crops such as grasses, and clovers, which keep the surface soil well filled with a mass of fibrous roots, increase materially the organic matter content of the soil. When this sod is plowed under, the soil is much benefited in respect to

organic matter; also, the decaying roots render the soil looser and more friable.

(5) A rotation alternates deep and shallow rooted crops. Crops that send their roots down deeply help to prevent a compact condition of the subsoil and so maintain better drainage and a better moisture reservoir. Also, by feeding on deeper layers of soil the total supply of plant food is more economically utilized. It is, therefore, advantageous to both the shallow and deeply rooted crops that they should occasionally alternate with one another.

(6) Influence of toxic substances. It is probably true that many or all crops excrete or leave in the soil certain organic compounds which are more or less injurious to succeeding crops of the same kind, but are less harmful or perhaps not at all so to other crops. In certain instances, however, a crop is thought to exert a more toxic effect on another growing with it than on itself. The Duke of Bedford and Spencer U. Pickering, working at the Woburn Experimental Fruit Farm near Bedford, England, report experiments which seem to prove that grass has a very toxic effect on fruit trees. They demonstrate that this effect is entirely separate from that of robbing the trees of available plant food and moisture. The United States Bureau of Soils has investigated the subject of toxic compounds in the soil to an elaborate extent. It has shown clearly that when the water extract from a poor soil is shaken with some insoluble absorbing material such as finely powdered charcoal and then filtered, the filtrate will grow better plants (in aqueous solution) than the original extract. Other experiments show that the extract from certain poor soils will not grow plants so well for the first few weeks as distilled water. Wheat

seedlings do not grow so well the second time in the same solution, although the nutrient constituents may be maintained at the same concentration. Certain organic compounds which have been isolated from the soil and their formulæ determined are demonstrated to produce a toxic effect when added to a nutrient solution in which young plants are growing. Those who have investigated this subject most thoroughly believe that the accumulation of toxic compounds in the soil is an important factor in the rapid decline of crops growing continuously on the same land.

Aside from the question of crop yields there are other reasons along the lines of economy and convenience which make it preferable to rotate a series of crops on different divisions of the farm rather than devote separate fields to the growth of each crop continuously. Yet it is seldom important to follow year after year a rigid rotation. In fact, if a four or six year rotation is adopted, one is likely, for some good reason or another, to make some little change in his plans before more than one cycle of the rotation has passed. With the frequent change in value of crops and knowledge of important new crops come changes in the rotation system. It is important always to have a well-planned rotation under way, but one should not hesitate to make changes that are in the line of progress, to substitute a different crop for one that has started off poorly, or occasionally increase the acreage of a money crop at the expense of a less profitable one, even though by such changes he may never actually complete a perfect cycle of the rotation planned.

23. Planning a rotation. — Any farm of good size may have two, three, or more different rotations in progress, having a series of fields set apart for each rotation.

In planning these rotations the first thing to consider is the crops one desires to raise. This will be based upon the crops most profitable for the locality, and best adapted to the soil in question, and the preferences of the land owner. These crops are then arranged into one or more suitable rotations in such a way as best to meet the problems of maximum yield, economy of labor, and, in short, greatest net profit; considering not merely the present but a period of at least several years. It may very often happen that to plan a satisfactory rotation one will find it advisable to include for the sake of the rotation a crop which in itself is not especially desirable or profitable. Thus some farmers say they would not grow wheat except that it makes a convenient crop with which to seed down to meadow or pasture. In arranging crops in a rotation some of the following principles may well be kept in mind:

A rotation should usually contain at least one legume crop, a sod producing crop, and a cultivated crop. Other crops may be worked in with these as desirable.

A long rotation with a great variety of crops may be the best from a fertility standpoint but is seldom practicable to carry out. Usually a rotation of three to six years is most suitable.

Deep-rooted crops should be alternated with shallow rooted crops when the latter are to be grown.

Potatoes do especially well following a clover or alfalfa sod or buckwheat stubble. Barnyard manure is best applied to some crop a year previous to potatoes rather than the same season.

Corn is a rank feeder and can utilize quantities of coarse manure better than most other crops. It does especially well on recently turned sod ground.

For a poor soil low in organic matter, a four or five year rotation containing two or three years of a sod producing legume crop is desirable. A dark colored, fertile soil may well grow more cultivated and small grain crops.

Buckwheat or flax are poor crops to precede a small grain crop. There is apparently some injurious effect produced by these two crops which is entirely separate from any question of plant food or physical condition of the soil.

Wheat does well following a cultivated crop and especially well if this is a legume such as beans or peas. Oat stubble is a good site for wheat if the ground is prepared immediately after the oats are off.

Alfalfa should be sown without a nurse crop. Most grasses and clover, if sown in the spring, do best with a nurse crop. Wheat, barley, or oats make a good nurse crop.

It is a good plan to arrange a place or two in the rotation for short time catch crops to be plowed under as green manure or source of nitrogen supply.

24. Rotation does not maintain fertility. — Although much may be said in favor of crop rotation, we need to guard against the erroneous impression that a systematic rotation of crops is in itself sufficient to maintain the fertility of the soil and insure good crop yields indefinitely. This theory has gained acceptance by some and has occasionally found expression in magazines and farm papers. The advocates of this theory provide only that the rotation include crops adapted to the soil in question, that some legume be grown, and that good cultivation and drainage be provided. The data given in the early part of this chapter is convincing evidence against any such teaching.

In the four-year rotation at Rothamsted wheat yields were not sustained, although that crop immediately followed the clover. Barley, occupying a less favorable place in the rotation, declined during 40 years from 38 to 14 bushels. The decline in yield of turnips and clover was even more striking.

In the Illinois experiments the rich virgin soil of the corn belt has under a favorable rotation declined in productiveness during 29 years from more than 70 bushels of corn per acre to an average of 58. Even during 13 years the yields have not been sustained. On the rich prairie soils of Iowa corn yields have noticeably declined during a period of nine years under a similar rotation. At the Ohio station, beginning with a poor, run down soil, a favorable five-year rotation has, during a period of 18 years, somewhat improved the yield of wheat and maintained the production of oats, although the corn crop has declined. However, there is no evidence here that anything like satisfactory crop yields can be maintained by rotation.

From the Pennsylvania experiment station 25 years of crop yields are reported, the rotation being corn, oats, wheat, and hay (clover and timothy). Comparing the average of the first twelve years with the average of the second twelve, we find that where no fertilizer has been added the yield of corn has declined from 42 bushels per acre for the first period to 28 bushels for the second. Oats in this time has dropped from 37 to 25 bushels. Wheat has given the low yield of about 13 bushels for both periods. Hay has dropped from 1½ tons to 1 ton per acre.

All the above are results from carefully conducted experiments and are fair examples of what a good rotation together with good cultivation and tile drainage can do towards keeping up soil fertility and maintaining satisfactory crop yields. A rotation of crops reduces the plant food supply in the soil (excepting nitrogen) even more rapidly than the one crop system, and to maintain good crop yields under rotation requires the addition of mineral fertilizers or the application of liberal amounts of farm manure. On the average farm the problem will be best solved by using a certain amount of each. But to go into this phase of the subject more in detail properly belongs to a text-book on soil fertility.

25. Suggested rotations. — The following are examples of rotations commonly recommended or in frequent use:

Corn, oats, clover.
Corn, wheat, clover.
Corn, oats, wheat, clover.
Corn, corn, oats, clover.
Corn, corn, oats, clover, wheat, clover.
Corn, oats, wheat, hay, hay (mixed clover and timothy).
Potatoes, wheat, clover.
Potatoes, wheat, alfalfa, alfalfa.
Cowpeas (or soy beans), wheat, hay, hay (mixed).
Alfalfa 4 years, corn 2 years, oats or wheat 1 or 2 years.
Corn, corn, oats, hay (clover and timothy), pasture.
Oats (or barley), beans, wheat, hay.
Corn, barley, wheat, clover and timothy 1 or 2 years.
Rye, hay, potatoes, oats or barley.
Wheat, hay, potatoes, beans.
Tobacco, rye or wheat, clover.

In almost any of the above rotations one or two catch crops may be grown and plowed under without adding a year to the rotation. Thus where corn is followed by a spring crop such as oats, the farmer may sow cowpeas, soy beans, clover, or vetch in the corn at last cultivation and plow it under the following spring. Where oats, wheat, or barley is followed by a cultivated crop to be put in late the next spring, an even better opportunity is offered for a catch crop.

CHAPTER III

CORN OR MAIZE

HISTORIANS tell us that when Columbus landed in Hayti in 1492 he found the natives growing a plant which they called Mahiz. So unusual was this plant that ears of it were among the numerous presents taken back to Spain and presented to the queen as trophies of the new world. Columbus called the plant maize after the Indian name, or Indian corn, to distinguish it from the corn plants of the Old World. Writings of the early explorers of America tell us that maize or Indian corn was one of the staples of primitive agriculture at the time of their explorations. One of the first Spanish explorers to visit Mexico wrote extensively about the culture of corn by the native Indian tribes, who were growing it around their temporary dwellings, making use of it in various ways. The account includes a description of several kinds of cakes and breads, and also tells of both fermented and unfermented drinks made from it. All students of American history are familiar with the important part played by this cereal in the lives of the early English colonists. That corn was grown a long time before the discovery of America by Columbus is evident from the discovery of the ears in the burial mounds of the prehistoric tribes of Ohio, of the cliff dwellers of southwestern United States, and in the mounds left by the early tribes that inhabited the west coast of Peru in South America. Almost all authorities believe that corn is a native of the Western Hemisphere, probably having its origin in what is now Mexico. Corn was not known in the Old World until after the discovery of America. It seems to have been first introduced into the countries bordering the Mediterranean, possibly by a ship sailing in from America and stopping at the various ports of the countries along the coast. From these ports it spread into adjoining countries, and carried with it the name of the country from which it was introduced. Thus it was known by such names as Spanish wheat, Italian wheat, Egyptian wheat, Turkish corn, Barbary wheat, and other similar titles. The names thus received have sometimes led to confusion as to its origin. When first introduced into these and adjoining countries, it spread rapidly; but its usefulness does not seem to have been appreciated, excepting in Spain and Portugal; elsewhere it was grown as a curiosity until the last century.

26. Botanical characters. — Corn, *Zea Mays*, is a large rank growing plant, belonging to the genus *Zea* of the grass family. It has no close relatives either among cultivated or wild grasses, and it is therefore quite different from the other familiar cereals as to the structure and arrangements of its parts, and in many other respects. On account of its sensitiveness to frost, corn cannot be planted so that it will make part of its growth in the fall, live over the winter like wheat or rye, and complete its growth and produce seed the following spring and summer. It is therefore called a spring annual.

27. The roots. — The roots of the corn plant may be divided into three separate groups, namely, the temporary, the permanent feeding roots, and the brace roots. When the kernel is placed in the ground, with conditions favorable for growth, a root shoot called the hypocotyl rapidly pushes downward into the soil. Soon two or three branches grow out from the base of the hypocotyl. These are somewhat smaller, and usually grow out laterally from the seed. These roots with their branches form the temporary root system. They make their growth largely from the food that is stored up in the kernel, and their function is chiefly that of supplying water to the young plant. While the temporary roots are being formed, the plumule is pushing up through the soil and finally unfolds its leaves above the ground. About the time the leaves are unfolding, another group of roots begins to grow from the lowest node of the plumule, usually about one inch below the ground, although if the soil is cloddy and dried out some distance below the surface, the node forms deeper in the soil. This, the permanent root system, is formed near the surface of the ground, regardless of the depth of planting. Thus we see that deep planting will not insure deep root system as many are inclined to believe. The roots of the permanent system grow out laterally for some distance before turning downward. This system is not made up of a great number of single roots, but rather is it a complex group, since each root gives off many branches from which in turn spring other branches, and so on until finally the last branches are tiny rootlets. Most of the branches are in the first 15 to 20 inches of the soil, and only a few are sent down deep into the ground. The roots grow very rapidly at first, more rapidly than does the plumule. Hunt reports a plant only one-half inch high, with root and branches measuring 8 inches in length, and one 3 inches high with root measuring 13 inches in length. So rapidly do they grow that under favorable conditions the roots of plants 35 or 40 days old will meet between the rows, and when the corn is in tassel, they will reach into almost every inch of the upper soil. The depth to which the roots will penetrate depends largely upon the position of the water table and upon the texture of the soil. In loose, fertile soil they have been known to penetrate 5 or more feet, and even in clay soils they will extend as far as 4 feet into the ground. When the permanent root system is well started, the temporary system withers and dies, since its period of usefulness is ended.

The brace roots spring from the first, second, third, and sometimes from the fourth node above the ground. They are so called because their chief function is to form braces or props, to prevent the plant from being blown over. When wind or rain bends the plants over, brace roots are rapidly produced from the side of the node nearest the ground, to prevent succeeding storms from laying them low. Usually when the plant stands upright, the brace roots do not grow very long, if at all, although they sometimes do when the plant is favored with good growing weather, or by very fertile soil. The portion of the brace root above the ground is considerably enlarged and is dark green in color. Those which enter the ground are reduced in size there, and perform the same function as the underground roots.

28. The stem or culm. — The stem of the corn plant, unlike that of wheat and oats, is filled with pith. It differs also from the culm of the other cereals, in the shape of the internodes, which, with the exception of those near the top, are slightly flattened or grooved on the side next to the leaf sheath. Where an ear is developing, the internode beside it is greatly flattened, or even becomes curved to make further room for the growing ear. Corn stalks vary greatly in height. Even in the same field we may find the plants growing in fertile bottom soil several feet taller than those growing on the less fertile soils of the upland or hillside. The growth is likewise influenced by the amount of sunshine, rainfall, and length of the growing season. Some varieties of corn naturally grow taller than others, even when they are grown side by side. Early maturing varieties are usually smaller than those maturing later. The average height of most varieties is from 8 to 15 feet, although some small types, such as pop corn and sweet corn, grow from 4 to 10 feet high, while some other types sometimes reach a height of 20 to 25 feet.

29. The leaves. — Since corn is a large, rank-growing plant, it needs a great expanse of leaf surface to afford room for the combining of the necessary amount of the elements of plant food required for its growth. Therefore the leaves of the corn plant are much broader and longer than those of the smaller growing cereals. The width of the leaf varies greatly in different types and varieties, and with individual plants of the same variety. Continuous selection of seed for a few years from plants having wide leaves has resulted in the production of a wide leafed strain, which is well adapted for forage or for use in the silo. The number of leaves on a growing plant varies from 10 to 20. A leaf grows from each node of the stalk, but the lower leaves seldom grow to maturity, since many are broken off during cultivation, or they wither and die. Usually not more than 12 or 14 are growing at one time. One can scarcely realize what a large surface is exposed by the leaves of a single corn plant. At the Missouri Experiment Station, the exposed surface of twelve growing leaves of a single plant was found to be 24 square feet, from which it may be seen that the total leaf surface exposed by a field of corn would be several times the area on which the plants stand. At maturity about 20 per cent of the weight of the plant is leaf, although earlier in the period of growth the percentage of leaf is greater. The decrease during the ripening period is due in part to loss of lower leaves and in part to the transfer of food to the developing ear.

30. The flowers. — Cultivated corn bears its flowers on two separate parts of the plant, this feature distinguishing it from the other cereals. The male or staminate flowers are borne in spikelets arranged on a branched tassel on the top of the stalk. The tassel, which is usually from 5 to 12 inches long, is made up of a central branch, and of from eight to ten lateral branches, growing out near the base of the central branch. The spikelets each contain two flowers, which, when mature, dangle the anthers on long filaments over the edge of the glumes, permitting the pollen to be spread by the breeze. Have you not often wondered why there is always an even number of rows on an ear of corn? It is because the female or pistillate flowers are borne in spikelets which are arranged in pairs on the cob. Each of the spikelets has two flowers, but one flower in each does not develop. Thus in reality there is but one fertile flower in each spikelet, and since the latter are arranged in pairs, two rows of kernels develop together. The style or silk extends from the ovulary to beyond the end of the husk, bearing a stigma covered with a sticky substance to catch the pollen. The silks from the lower ovules are the first to appear beyond the husk, and therefore are the first to be fertilized, so that the first kernels to appear on the ear are at the base of the cob. After fertilization has taken place, the style withers and dies. In some varieties of corn there may be seen a scar on the kernel, showing the former attachment of the silk. The number of pollen grains produced by the flowers of a single tassel has been estimated at about 18 millions, or about 9000 pollen grains to each ovule. So

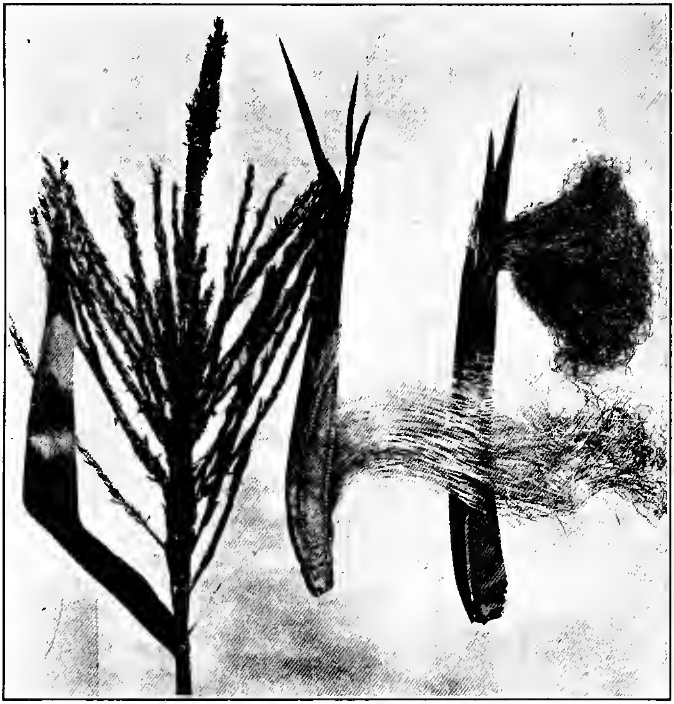

Fig. 3. — Staminate and pistillate flowers of the corn plant.

we find that nature has made a liberal provision of pollen in order to insure that one grain of the thousand produced will effect the fertilization of the ovary. Extremely hot winds may so injure the pollen grains as to make them incapable of fertilization, and likewise are heavy rains unfavorable, since the water washes the pollen to the ground. The corn plant is cross-pollinated or wind-pollinated. Self-pollination has been rendered difficult by the position of the male and female flowers, the anthers being so placed that a light breeze is necessary to spill the pollen, which will insure its being carried away to other corn plants. Another provision made by nature to prevent self-pollination is that the silk almost always matures after the pollen of that plant is shed. A single corn plant out of reach of pollen from other corn plants usually has either a few scattered grains on the ear, or no grains are produced at all.

31. The ear. — The ear is carried on a short shank or branch growing from a node between the leaf sheath and the culm. The shank is made up of several short internodes, from each of which grows a husk, and these, overlapping, form the covering of the ear. When the shank is short, the ear stands upright; but if it is long, the ear tips over and at maturity points downward. In fertile soil or in favorable growing seasons, ear shoots may start from several nodes, but usually only one or two develop. The top one develops first, and if it is removed the one below it grows to maturity. Some varieties, especially those grown in the southern part of the United States, often produce two or more ears per stalk. Most of the varieties grown in the Northern States produce but one ear, but in thinly planted fields or in favorable seasons, two ears per stalk are quite commonly found. There is great variation in the size of the ears and in the number of rows of grain. The ears vary in length, from one inch in certain varieties of pop corn, to as much as 16 inches in some of the larger varieties of dent corn. The number of rows of grain varies from eight in the flint to as many as 24 or more in the dent corn.

32. The kernel. — After fertilization has taken place, the kernel begins to develop. At first it appears much like a water blister, but after a few weeks it has greatly increased in size and contains a milky fluid. This is called the "milk" stage, and at this time it has a sweet taste, due to the presence of sugar which is later changed to starch. From the milk stage it gradually changes, with the ripening of the plant, to the "dough" stage, and finally at maturity it becomes firm and dry. An examination of the mature corn kernel will show that it is made up of several distinct parts. If the kernel is soaked in warm water for half an hour, it can be separated into the tip cap, the hull, the aleurone layer and endosperm, and the germ. The tip-cap and the hull are the outside coverings of the kernel. The tip-cap is located at the tip of the kernel and serves to attach it to the cob and also to protect the tip end of the germ. The hull is made up of three distinct thin layers, which are separated only with difficulty. They are composed largely of woody fiber and of gum, which keeps the kernel from drying out. The hull and the tip-cap taken together make up about 7 per cent of the kernel. The aleurone layer, lying directly beneath the hull, is made up of a single layer of thick cells, and comprises 8 to 14 per cent of the corn kernel. Immediately under the aleurone layer lies the endosperm, which makes up about 70 per cent of the grain. It is composed largely of starch cells, which are of two kinds, namely, the hard or horny starch, and the soft or white. In some types of corn both kinds are present, while in other types we find only one of the two kinds. Lying at the front of the kernel, that is, facing the tip of the ear, is the germ. Starting at the tip, it extends sometimes two-thirds of the distance to the crown, and makes up from 7 to 15 per cent of the kernel. It is divided into two parts, the scutellum and the growing portion. The latter is divided into the plumule and the radicle.

The color of the grain, in the case of white or yellow corn, is determined by the color of the endosperm and the aleurone layer. In the blue, purple or black, it is due to the color of the aleurone layer only, while in red corn the color pigment is found in the hull, and the endosperm may be either white or yellow.

33. Ancestors of the corn plant. — Some of our cultivated grains can be traced back to a time when their ancestors were growing wild in uncultivated lands. With the corn plant this has not been possible, since no wild types nor any very close relatives have been found. One of its nearest relatives is a plant called teosinte, a forage plant that grows luxuriantly in the favored sections of Mexico and Central America. This plant produces many branches, sometimes as many as forty or fifty coming from a single seed. At the end of the branches are tassels on which the grains are produced.

Those of us who have worked in the corn field, in cutting or husking, have seen individual corn plants which show great variation from corn plants in general. It is not uncommon to find a corn plant with grains in the tassel. Less frequently, perhaps, do we find branching corn plants, each branch carrying an ear. If we have been close observers, we have often seen appendages attached to the tip of the husk, closely resembling the blade of a leaf. Why do we find these variations? Might it not be that these plants show a reversion, or a striking back to the original wild type? This is thought to be true by some botanists and agronomists. Corn has been successfully crossed with teosinte and the progeny resembles both parents. From the study of these interesting variations Professor Montgomery has explained the origin of the corn plant in the following way:

The ancestors of the corn plant were probably plants having many branches like teosinte, and were the result of a cross of teosinte on some similar plant, or the progeny of a sport of teosinte crossed with the common form. In either case the original corn plant had branches coming from the axils of the leaves. At the end of these branches were tassels similar to those found on field corn. They differed from the corn tassel in that both male and female flowers were produced, and after fertilization grains developed. Thus the occasional plant that we find in a field of corn having grains in the tassel is a reversion to the original form. At first both male and female flowers were produced in the tassel of each branch. But the highest tassel, the one on the main stalk, was not well located to receive pollen, since the pollen would naturally be carried downward, while those on the lower branches were in a favorable position to receive pollen but not in a

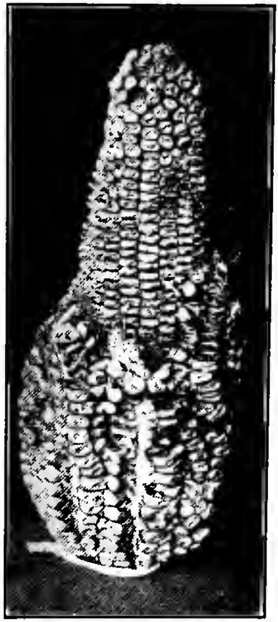

FIG. 4. — An ear of dent corn, with small ears clustered at the base, showing reappearance of lateral branches.

FIG. 5. — A branching corn plant grown in Ohio, perhaps a reversion to an ancestral form.

position to pollinate those higher up. Thus the female flowers on the upper tassel were incompletely fertilized, if fertilized at all, and due to the loss of function gradually disappeared, so that after a time only male flowers were produced. On the tassels of the lower branches, the male or pollen producing flowers gradually lost their usefulness, and after a time only female flowers were produced on these branches.

After the disappearance of the male flowers from the lower branches, the central spike of each tassel developed into what is now the cob, and at the same time the lateral branches gradually disappeared. Some proof of this assumption is to be found in the frequent occurrence of an ear developed in the usual way, but with five or six small ears clustered at the base. The small ears are probably due to the reappearance of the lateral branches of the original tassel. After the development of the central spike of the tassel into the ear, the load carried at the end of the branch was greatly increased in weight. In order to overcome the inconvenience of carrying a heavy load at the end of a long branch, nature gradually shortened the internodes of the branches, thus reducing them in length, until now the ear is carried on a short branch near the main stalk. As the branches were shortened, the nodes were brought close together, thus causing the leaf sheaths to overlap or telescope. The leaf sheaths thus telescoped form the husks that cover the ear. During the time that the branches were becoming shorter, the leaf blades were gradually disappearing, and now in most cases only the sheath remains. Very frequently, however, we find husks with quite long blades on them. This is a reversion to the original form when the shank was a long branch, and leaves were produced on it as they now are on the main stalk.

The corn plant formerly produced several branches each carrying a small ear, but through the centuries that it has been cultivated by man, he has selected large ears for seed which were probably produced on plants having few branches, and has in this way developed plants that produce one or two large ears rather than several small ones. However, it is not infrequent that we find corn plants with two, three, and in rare cases four or five ears. If we could catch hold of these ears and pull the shank out, extendimg the internodes so that they would be the same length as those of the main stalk, we would have a branched corn plant, similar in this respect to the original form.

TYPES OF CORN

Zea Mays has been divided into six distinct types or classes. The character and arrangement of the endosperm is the principal basis for this division. In the different types we find variations in the shape of the kernel and the manner of growth of the plant.

34. Dent corn. — Dent corns have the hard or horny endosperm arranged along the sides of the kernel and the white or soft endosperm surrounding the germ on three sides and extending to the crown. Thus the horny endosperm forms rigid sides to the kernel, while the center, being composed of soft endosperm containing a large amount of water, shrinks more rapidly than the sides and causes a dent in the crown at maturity. Because of this dent in the crown, the class is called dent corn. The degree of the dent is largely due to the proportion of soft to hard endosperm. Dent corn is characterized by its deep and usually wedged shaped grains, large diameter of the ear and large number of rows of kernels. There is of course great variation in the height of the plant, the size and shape of the ear, and the like, due to variety differences or to environment. Usually only one ear is produced on each stalk, but when planted thinly or on very fertile land, two and sometimes three ears are produced. Dent corn does not sucker freely except when thinly planted. The number of rows of kernels per ear varies from 10 to 24, but almost all of the dent varieties have from 16 to 20 rows. The ears vary from 6 to 14 inches in length, and from 5.5 to 7.5 inches in circumference. The most common measurements are from 6.5 to 7 inches in circumference and from 8 to 9 inches in length. Ears vary

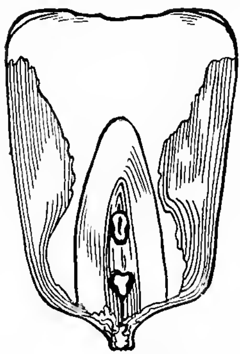

Fig. 6. — Cross section of a kernel of dent corn.

in weight from $\frac{1}{2}$ pound to $1\frac{1}{8}$ pounds. A good dent ear weighs from 12 to 15 ounces. Dent corn to fully mature requires a growing season of from 90 to 100 days for the early varieties, to 130 to 150 days for the late varieties. There are over 300 varieties of dent corn, and in this large number of varieties great variation is found in the adaptability to soil and climate, length of growing season and in the general character of the plant and ear. White and yellow are the principal colors found in this type, but there are also varieties of blue, purple and mottled dent corn. Dent corn is of greater agricultural importance by far than all other types combined, for it is the corn of the great corn growing sections of the world. In the United States dent corn is the type that is grown in the great corn producing states of the Central West. The bulk of the corn produced in the United States for use in this country and that grown for export belongs to this class.

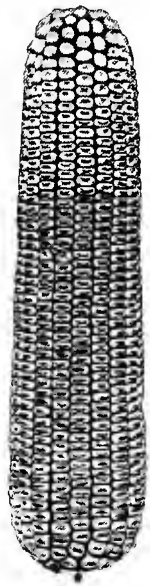

FIG. 7. — An ear of dent corn.

35. Flint corn. — The name flint is given to the varieties of corn belonging to this class because of the hard flinty appearance of the kernels as viewed on the ear. If a kernel of flint corn is split open, it will be found to contain both hard and soft endosperm, but arranged differently from that found in dent corn. In flint corn the hard or horny endosperm extends up the sides of the kernel and also over the crown, thus surrounding the soft endosperm and the germ. Because the hard endosperm shrinks uniformly, no dent is formed in most cases, although when the hard endosperm is in a thin layer over the crown, as is found in some varieties, a slight dent is formed. Flint corn is characterized by a somewhat smaller plant than the dent, with a tendency to produce two ears. The ears are smaller in circumference but of about the same length as those of the dent type. The number of rows on the ear varies from 8 to 16, with 8 the most common. The name "eight-rowed" corn is sometimes applied to certain varieties of this type. The grains are hard, with a smooth, flinty appearance, and more oval in shape than the dent. White and golden yellow are the most common colors. A good ear of this type will weigh 7 or 8 ounces. Flint corn does not require as long a growing season as the dent varieties. It is grown principally in the New England States, New York, Pennsylvania and Canada, and other regions with short growing seasons.

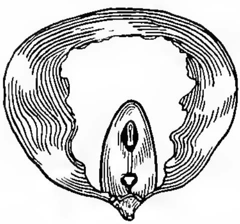

Fig. 8. — Cross section of a kernel of flint corn.

Large yields have been reported from flint varieties, and in comparative trials it has sometimes outyielded the dent, although where the dent variety can be grown, successive crops of it will yield the best average. Flint corn is highly prized by millers for making corn meal, it being more desirable for this purpose than dent varieties.

36. Pop corn. — This type of corn gets its name from the well-known characteristic of popping, or bursting into a large white fluffy mass when heated. If we examine the inside of an unpopped kernel, we will find that almost all of the endosperm is of the hard or horny sort. Sometimes we may find a thin layer of the soft starch around the germ, but if it is present in too large amounts the corn does not pop well. The popping of the kernel is due to the pressure exerted in the starch cells by the changing of the moisture in them to steam, when heat is applied. The pressure of the steam inclosed in the cells is so great as to cause an explosion of such force as to turn the kernel inside out, and completely change its texture into a light, fluffy mass, from fifteen to twenty times the size of the unpopped grain. Those of you who have had experience in the popping of corn know that, unless the corn is properly dried out, your efforts will not meet with success. And, too, if the corn is too dry a good pop cannot be made. For this reason it is best to keep the corn on the cob and shell it just before popping, since if kept in this manner it does not dry out so completely. The plant of the pop corn does not grow as large as the dent or flint types. It varies from 3.5 to 10 feet. Several ears are frequently produced on a stalk, and freak plants or sports are more common than in other types. The varieties of pop corn may be divided into two general classes, namely, the rice and the pearl. The rice corn is characterized by the crown of the kernel coming to a sharp point, giving a rough or prickly appearance to the ear. At the apex of the pointed crown may be seen a scar showing the former attachment of the silk. In the pearl corn the kernels are rounded or flattened at the crown and are smooth, having the appearance in

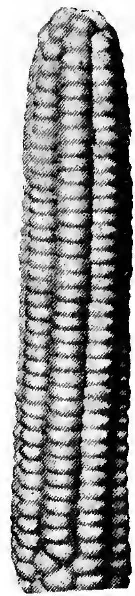

FIG. 9. — An ear of flint corn.

this respect of an ear of flint corn. In the rice corn the ears are inclined to be tapering with the kernels in irregular rows, while in the pearl corn the ears are more often cylindrical and the kernels are in straight rows. There are early, medium and late varieties of both the rice and pearl corn. One variety, called Tom Thumb, because of its diminutive proportion, is frequently grown as a curiosity. A perfectly formed ear measuring 2 inches in length would indeed, when compared with a good ear of dent corn, meet the demands of the curious. Pop corn can be grown anywhere that dent or flint corn can be grown. Farmers usually supply their own needs by growing a small patch with the garden truck. The production to supply the numerous pop corn wagons and confectionery stores has been largely confined to one county each in Iowa and Nebraska. In these sections soil and climate are particularly well suited to its growth, and here it has become an important crop, grown and harvested by farmers who have become specialists in its production. So great is the industry in these sections that hundreds of car loads are sent out from shipping points each season. One bushel of ears when husked weighs about 38 pounds. When cured for one season, at which time it is put on the market, 35 pounds is the standard weight per bushel of ears. Fifty or sixty bushels of ears per acre is considered a very good yield.

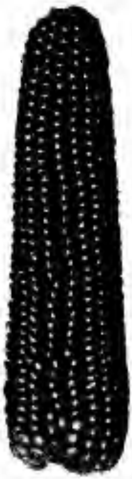

Fig. 10. — Rice pop corn.

37. Soft corn. — One has only to examine a longitudinal section of a kernel of this type to learn why it has been called soft corn. Such an examination will reveal the fact that no hard endosperm is present, but that the entire endosperm is made up of soft starch. So soft are the kernels of this type of corn that even when they mature they can sometimes be dented with the thumb nail. Soft corn is usually a large, rank-growing plant requiring a long growing season to come to its maturity. For this reason it is not grown to any extent in the United States. One variety, sometimes called Squaw corn, which has a comparatively short growing season, is grown in the Dakotas and other Northwestern States. Another variety, Brazilian flour corn, is sometimes grown for the silo. Soft corn is more commonly grown in Mexico, Central America, and portions of South America, which have long growing seasons, although compared with dent or flint corn it is not of much commercial importance. The Indians are said to have grown it extensively on account of the ease of grinding it into meal. Soft corn is believed to be one of the oldest types of corn, since it has been found in the mounds of prehistoric tribes in southwestern United States and on the west coast of South America. The ears of soft corn are similar in appearance to those of the flint type. The kernels are usually large, sometimes measuring as much as three-fourths of an inch in breadth.

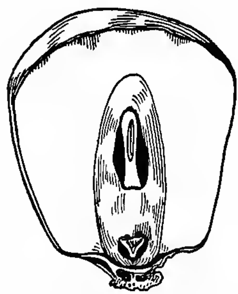

FIG. 11. — Cross section of a kernel of soft corn.

38. Sweet corn. — In this type of corn little starch has been developed in the kernels, and almost all of the carbohydrate is in the form of sugar, giving them a distinctly sweet taste. The grains are usually broad wedge shaped, having a wrinkled or shriveled appearance, and the endosperm is horny and translucent. The plants grow from two to ten feet in height, with a marked tendency to sucker, and to produce two to three ears on a stalk.

FIG. 12. — An ear of soft corn.

Sweet corn is grown largely for cooking and canning purposes, and for this use is harvested before it reaches maturity. The time required for it to reach the stage when it is best suited for this purpose is from 50 to 100 days, depending upon the variety. In the New England States, parts of New York, Pennsylvania and Ohio, sweet corn is grown in a large way and hauled direct from the field to the canning factories. Growers in these regions where this practice is followed enter into contracts with the owners of the factories to deliver their crops at a given rate per ton. The price of course varies with supply and demand, and also with the variety grown, some varieties commanding a premium of as much as two dollars per ton over the less desirable varieties. The price is from 6 to 10 dollars per ton. The yield obtained varies from two to four tons per acre, or even

FIG. 13. — An ear of sweet corn.

more when good cultural methods are practiced, and when growing conditions are favorable. Thus the gross income from an acre may amount to as much as 40 dollars, which, considering the small amount of labor required, gives a good return to the grower, when compared with the earnings from other farm crops.

39. Pod corn. — This type of corn gets its name from the fact that each kernel is inclosed in a little husk or pod. The pod corn plant is inclined to be leafy and suckers abundantly, often having heavy tassels producing kernels. The kernels may resemble those of almost any of the other types of corn, due probably to the fact that it has been subjected to frequent crossings with other types. It has been suggested that pod corn is probably the primitive type from which the other types have been developed, but recent investigation does not uphold this contention. Those who uphold this theory explain that the husks which inclose the kernels were the means by which nature protected the latter from birds and animals, and that they also assisted in their dissemination, since a kernel inclosed in a pod will float on water. Since corn has become a cultivated plant the pods have lost their usefulness and

Fig. 14. — An ear of pod corn.

have gradually disappeared, until now in the other types of corn we find them only in a rudimentary form. If we examine closely an ear of dent or flint corn, we find rudimentary husks at the tip of the kernel, and when the kernel is removed, the husks do not remain attached to it as in pod corn, but stay on the cob. The fact that pod corn frequently produces corn on the tassel leads us to believe that it is closely related to the primitive type, in which all the kernels were produced in a tassel-like structure. Pod corn is of no economic importance, being grown only as a curiosity, for which purpose it is sometimes sold by seedsmen under the name of Egyptian corn, Rocky Mountain corn, or primitive corn.

USES OF THE CORN PLANT

The various uses of the corn plant may be classified into three groups, viz., human food, animal food, and miscellaneous.

40. Use as food. — Corn finds its chief uses as human food in the form of green ear corn served as roasting ears or cut from the cob, and as corn meal, served as corn meal mush or corn bread or cakes, and as pop corn eaten from the hand. Varieties of sweet corn are most commonly used for roasting ears or for canning. Sometimes flint and dent corn are used for this purpose, but they find their greater usefulness as human food in the making of corn meal. Flint corn is superior to any other type for this purpose. The pop corns are used almost entirely as human food.

The use of corn as a stock food is too well known to require much comment. The grain itself, either ground or whole, is the most common form used for this purpose. Other forms are ensilage, fodder, and stover, and it is also used as a soiling crop. The grain, when considered from the standpoint of its chemical composition, is relatively high in fat and starch but low in protein. It is therefore an excellent food for fattening animals, but is not desirable as the main portion of the ration for young growing animals or for milch cows. Corn stover, if cut at the proper time and well preserved, compares favorably with timothy hay in feeding value. Ensilage, in which both the grain and roughage are fed together, besides being high in digestible matter, is also very palatable, thus making an excellent feed for most farm animals. Many of the by-products from manufacture are important live stock feeds.

41. Manufactured products. — Lye hominy is a well-known product of corn, the manufacture of which is often conducted on a small scale by the housewife. In the making of lye hominy, the whole kernels are treated with a solution of alkali or lye to loosen the hull. After the treatment, the hulls are easily removed. The hulled kernels are then thoroughly washed to remove all of the lye. Hominy mills perform the same operations on a much larger scale. A rather flinty type of white corn is most desirable for hominy.

Cerealine is a similar preparation made from the hard, horny portions of the kernel. Corn with a large proportion of horny endosperm is desired by the manufacturer of cerealine. Many concerns place upon the market breakfast foods made from corn, which may be grouped under the term of corn flakes. White corn is most often used in their manufacture. The kernels are first cracked and the germ removed. The second step in the process is that of steam cooking the cracked kernels, adding sugar and salt to flavor them. After the cooking they are dried and run between heavy rollers which roll each particle of corn kernel into a flake. The flakes are then toasted and boxed for the market.

In the making of corn starch, several other products, which were formerly grouped under the term of by-products, are produced. Recently, however, these products have become of such importance that the term " by-products " can no longer be accurately applied. Sometimes the entire profit from a starch factory is derived from the utilization of what was formerly waste.

In the manufacture of starch, the shelled corn is first steeped in water for a time, and then the kernels are cracked by running them through coarse crushers. The ground mass is then transferred to separators and a small amount of water is added, making a milky liquid. Upon stirring, the germs arise to the surface and are removed. The germs thus liberated are thoroughly washed to remove all the starch and are then placed in a hydraulic press which presses out the oil. That part which remains in the press is either sold as corn oil cake or is ground and sold as germ meal. The oil which has been removed by pressure is used in this country in the manufacture of soap, soap powders, and paints, and a large amount is exported in the crude form for similar uses abroad. A substitute for rubber has been made from germ oil and is used after vulcanizing as a supplement of, or as a substitute for, rubber in the making of automobile tires, rubber shoes, and other rubber goods.

That part which is left in the tanks is the glutinous material, bran and starch. This, when run over bolting cloth, allows the starch and glutinous matter to pass through and retains the bran, thus separating it. The bran is washed to remove all the starch and is then dried and ground and sold as cattle feed. The starchy liquid containing the starch and glutinous matter is run over slightly inclined tables, and because of specific gravity the starch is deposited on the tables, while the glutinous material is carried over the end of the tables into receiving tanks. The latter is concentrated by filter presses and dried. When ground it is sold on the market as gluten meal. Sometimes the ground bran is mixed with the glutinous matter and with the liquid used in steeping at the beginning of the process. The mixture is dried to 10 per cent of moisture and then ground, bagged, and sold on the market as gluten feed. The water used in steeping the uncracked kernels removes some of the starch and mineral elements, which, when added to the grain and gluten meal, make a more desirable feed for animals. Gluten meal, therefore, differs from gluten feed in that the feed has besides the gluten a certain per cent of bran and mineral elements. These two feeds, together with oil cake, have a very important place in the trade of concentrated stock feeds. The starch remaining on the incline table is termed green starch, and when removed from the tables is diluted with water until it forms a milky liquid. From this liquid by careful refining corn starch is removed. After filtering, it is dried in kilns and ground fine, run through revolving silk screens, and is then boxed or barreled and put upon the market for home consumption or for the trade. By varying time and temperature in refining, various grades and kinds of starch are made. From the starch, corn sirup, corn sugar, mill, laundry, and edible starch are made. Green starch when subjected to a high heat under pressure in the presence of hydrochloric or certain other acids forms glucose. Sugar made from corn in this manner is used in the making of sirup, in the brewing of ales and porters, in fermenting beers, and in the making of caramel.

42. Miscellaneous uses. — The grain of corn is used in the making of alcohol, but because of the price of corn and the comparative cheapness of other material that can be used as a source of alcohol, it is not likely that it will be used extensively for this purpose. Corn stalks and the pith from the stalks have been used successfully in the making of paper. Whether or not the making of paper from them will be placed on a practical basis will depend largely upon the invention of suitable machinery. If corn stalks can be utilized in this way, the great loss in the large fields of the Middle West will be greatly reduced. The pith of the corn stalks is also used in the manufacture of gunpowder, while in the packing of battleships it is especially valuable, since when wet it will swell and thus close an opening that may be made by a projectile. The husks of corn are used in upholstering and in the making of mattresses and door mats. Cob down is also used in upholstering and in the packing of pillows. The utilization of the corn plant is extending into many trades, and doubtless it will in the future be found useful in many ways unknown at present.

PRODUCTION AND DISTRIBUTION

43. The world's production. — Since the discovery of America, corn has been introduced into the leading agricultural countries of the world. A study of the table of the world's production of corn for the five years, 1908 to 1912, shows that the bulk, or about 76 per cent of the world's corn crop, is produced in North America. The United States is by far the greatest corn producing country of the world, producing in the five years above mentioned over 70 per cent of the world's crop. Europe is second, producing 544 million bushels or about 19 per cent as much as the United States. Austria-Hungary, Roumania, Italy, and Russia are the leading corn producing countries of Europe, while France, Portugal, Spain, and Bulgaria produce only a few millions of bushels each. In Africa, Egypt and South Africa are responsible for over 80 per cent of her total crop. In South America, Argentina is by far the leading corn growing country, while small amounts are produced in Chili and Uruguay. A remarkable increase in production has been made in Roumania and South Africa within the past few years. Roumania cannot hope for a much further increase in her production, since almost all of the land adapted to corn growing is now being utilized. The English government, by the establishment of experiment stations to study the best methods of culture, has been largely responsible for the development of South Africa into an important corn growing country. This country will doubtless still further increase her production, since considerable land is yet available for the growing of this crop. Of all the corn growing countries, Argentina in South America alone gives promise of becoming a strong competitor of the United States.

World's Corn Crop

(Five years' average, 1908–1912)

North America	
United States	2692 million bushels
Mexico	140 million bushels
Canada	19 million bushels
Total	2851 million bushels
South America	
Argentina	162 million bushels
Uruguay	5 million bushels
Chili	1 million bushels
Total	168 million bushels
Europe	
Austria-Hungary	250 million bushels
Roumania	93 million bushels
Italy	78 million bushels
Russia	67 million bushels
All others	66 million bushels
Total	544 million bushels
Africa	87 million bushels
Australia	10 million bushels
Grand total	3660 million bushels

Leading Corn Producing States of United States

(Five years' average, 1908–1912)

Illinois	380 millions
Iowa	355.6 millions
Missouri	221.3 millions
Indiana	189.5 millions
Nebraska	177.7 millions
Ohio	156.5 millions
Kansas	156.1 millions
Total	1636.7 millions

Agriculturally, Argentina is yet a new country, and the vast areas of undeveloped land, which seem to be adapted to the growing of this crop, will doubtless within a few years be put under the plow. In the United States most of the land adapted to the growing of corn is now being tilled, and if our production is to be increased, it must come through a greater yield per acre. The development of high yielding strains, and the practicing of better methods of culture are the means open to us for greatly increasing our production.

Corn does not play a very large part in the world's commerce. Only four countries export any considerable amount. These in order of their exportation for 1907 to 1911 are: Argentina, 60 millions of bushels, United States, 53 millions of bushels, Roumania, 31 millions of bushels, and Russia, 30 millions of bushels. Argentina, while her total production is small as compared with the United States, exports considerably more than this country. The corn crop of the United States is largely utilized here in the feeding of live stock, and while only a little of it is exported as corn, much more finds its way to foreign markets in the form of pork and beef. Statistics giving the population of the United States and the production of corn by decades since 1850, show that our production has been keeping pace with our increase in population, the per capita production averaging slightly less than 30 bushels. While the United States as a whole is the leading corn growing country of the world, this position is due to the corn crop of a few states which comprise what is known as the corn belt. The eight states shown in the table and parts of other states lying adjacent to them form the great corn growing section of the United States and are known as the corn belt states. These seven states produce almost two-thirds of the crop of the United States and almost 50 per cent of the world's corn crop. While corn is reported as being grown in every state in the Union, these eight are the only ones that produce a surplus crop. The value of the corn crop in the United States in 1910 was estimated at 1500 millions of dollars, and in 1911 at 1700 millions of dollars. The value of the cotton crop is about 60 per cent that of corn, of wheat about 40 per cent, and of hay about 50 per cent that of the corn crop.

ADAPTATION

44. Climate and soil. — Both climate and soil are important factors in the distribution of the corn crop. The fact that so large a per cent of the corn crop is grown in the seven states of the corn belt is evidence that in these states are found the most suitable conditions for its growth. Of the two factors, climate is the more important. Corn requires a long, hot growing season with a great amount of sunshine and rainfall. If the temperature of the growing months, May, June, July, and August, is hot and is accompanied by an abundance of sunshine and plenty of rainfall, corn will grow luxuriantly, soil and other factors being favorable. The corn plant requires a large amount of water to make its growth. It has been estimated that about three hundred tons of water must pass through the plants for each ton of dry matter formed. Thus the rainfall of the growing months is closely associated with production. It has been found that in the corn belt, the rainfall for July is more closely associated with the yield than that of any other month.

Corn grows best on loose, fertile, well-drained soil. Clay soils are not well adapted to the growing of corn, unless well supplied with organic matter. When lacking in organic matter, clay soils become hard, the soil particles packing closely together, and moisture is neither retained well nor absorbed in large amounts. The reason corn is grown so commonly and produces so abundantly in the corn belt states is that there the soils are made up largely of alluvial or drift deposits, and these states are also favored with abundance of sunshine and rainfall.

CHAPTER IV

CORN OR MAIZE (*Continued*)

There remain to be discussed, in the treatment of maize, the practical questions of cultivation, the harvesting and storing and marketing, the improvement of the types and varieties, and the insects and diseases.

METHODS OF CULTURE

Numerous experiments, as well as the experience of many growers, have demonstrated that higher yields can be secured when corn is grown in a rotation than when grown in the same field year after year. Continuous cropping of corn has been practiced in many parts of the corn belt for a few years, but after a time decreased yields have resulted. A ten year average at the Ohio Experiment Station for corn grown under continuous culture gave a yield of 9.64 bushels per acre, while that grown in five-year rotation gave 38.85 bushels per acre. The place taken by corn in most well-managed rotations is after grass and clover. Corn can use sod better than does wheat or oats, while wheat and oats do well after corn. A rotation based on this fact will usually consist of corn, wheat and clover, or corn, oats, wheat, clover and timothy. In either case the grass is plowed under and the land put into corn. The organic matter added by this practice produces a beneficial effect, by increasing the water-holding capacity and preventing the soil from becoming hard and compact. Barnyard manure is sometimes applied to the grass land in the spring, thus benefiting both the hay and the corn, or it is applied to the meadow after the hay is cut, and turned under for corn. Soils that have been under cultivation for a long time, or that are naturally deficient in some of the elements of plant food, may be greatly benefited by the addition of commercial fertilizers

Fig. 15. — Unfertilized and fertilized corn plots grown in continuous culture for 18 years.

to supplement the barnyard manure. No certain fertilizer can be recommended as the best corn fertilizer. Some fields require one element of plant food or a mixture of fertilizing constituents, while others may require quite a different treatment. In other words, the soil should be fertilized and not the corn. When commercial fertilizers are applied to corn land, they should be broadcast or drilled in with a fertilizer drill. The practice of sowing the fertilizer into the hill with the corn is not to be recommended, since the corn roots will find plant food so close at hand that they will not branch out or grow down deep in the soil, and when dry weather comes later in the season, the roots will not be able to reach the water in the deeper subsoil. A small root system will thus result from sowing the fertilizer in the hill, and the corn will be more easily blown over. Sometimes a small amount, 60 to 100 pounds of fertilizer per acre, if placed in the rows, will start the plants off more rapidly, thus enabling them to get ahead of weeds and insects.

45. Plowing and preparing the seed bed. — It might be well before discussing the methods of preparing the land for corn, to consider some of the essentials of a good seed bed. Why should the land be plowed? Will not the plants grow as well in soil that has not been broken up by the plow? When we know the principles underlying the purpose of plowing, we are more nearly able to analyze the conditions and thereby determine the most desirable practice to follow. There are several reasons why plowing makes the soil more favorable for plant growth. In land that has not been plowed for some time the soil particles are packed closely together and the surface soil becomes firm and compact. When this condition exists, the soil does not readily absorb water from falling rain, and much is lost by surface runoff. And, too, since the soil particles are close together, moisture that is already in the soil will reach the surface by capillarity and be lost by evaporation. Thus plowed land will not only absorb more water but will also prevent that which is already in the soil from being lost by evaporation. Plowing increases the available water for the plant in another way. Since the plant only uses capillary water, or that which forms a film around the soil particles, plowing by breaking up the soil into finer particles permits the presence of a larger amount of film moisture. The breaking up of the soil into fine particles also permits the air to enter the soil more freely and thus supply the root cells with oxygen, which they require just as do those plant cells above ground. Plants obtain their food by means of root hairs which are so delicate that they cannot penetrate the soil particles, but grow around them. Thus a soil composed of many fine

Fig. 16. — Plowing with a tractor.

particles provides greater feeding area for the plant than one made up of large particles. Another purpose of plowing is to incorporate with the soil the organic matter that it has accumulated on the surface or that is applied in the form of manure or by growing a green manure crop. The organic matter when mixed with the soil not only supplies it with plant food, but improves its physical condition, permitting better aëration and increasing its water-holding capacity. The depth at which to plow depends largely upon the preceding practices and upon the nature of the soil. Deep plowing is to be preferred since it increases the feeding area for the plant roots. However, if the practice of shallow plowing, four or five inches, has been followed for some time, it is not well to turn up too much of the subsoil at one time. By plowing an inch deeper each year until a depth of 8 or 9 inches is reached, the small amount of subsoil turned up each year will gradually be mixed with the surface soil and organic matter, and thus running together or puddling will not result.

46. Time of plowing. — The plowing for corn may be done in the fall, winter, or spring. In order to determine which is the most desirable time to plow a field, it is necessary to consider both the advantages to be gained, and the disadvantages that may result from the practice. These will be taken up in the following paragraphs.

47. Conservation of moisture. — The loose ground turned up by fall plowing will absorb more water from the rain and snow during the winter and spring than unplowed land. Much of the water runs off from the surface if the ground is not broken up. Not only will loose soil absorb more water than hard unplowed ground, but less will be lost by evaporation. Plowing breaks up the surface soil and separates the soil particles so that the film moisture cannot get hold of them and reach the surface to be lost by evaporation. Fall plowing, while conserving moisture, at the same time is conserving heat, for it enables the heat of the sun in the spring to be used in warming up the seed bed instead of being used in evaporation.

48. Saving of time. — At the time fall or winter plowing is being done, the extremely busy season is over; thus the plowing can be more thoroughly done, since it need not be rushed by other work. At the same time it lessens the work of the farmer in the spring when he is busiest.

49. Weathering. — Increasing the depth of plowing can be done more satisfactorily in the fall than in the spring. The subsoil that is turned up in the fall will be incorporated with the surface soil by freezing and thawing, which are excellent agencies in pulverizing the soil.

FIG. 17. — A field of corn almost completely destroyed by grubworms.

50. Killing of insects. — Many of the troublesome insects injurious to field crops can be effectively combated by fall plowing. Many insects spend the winter a few inches below the surface of the ground, some in the egg stage, some in the worm or grub stage. Fall or winter plowing will break many of the eggs or egg sacs, bring the caterpillar and pupa to the surface, where many will be killed by freezing and others eaten by birds, or skunks and other animals. The cut-worm and the grubworm pass the winter in the ground in the partly grown stage. Fall plowing has been recommended as one of the best methods of combating them. The practice of fall plowing interferes with the winter resting stage of many other insects, chief among which are the corn-bill-bug, corn-root louse, grasshopper, wire-worm, and the corn root webworm.

51. Puddling. — Tenacious soils, or soil with little or no organic matter, if fall plowed, will sometimes become hard and compact by spring. If plenty of humus is furnished the soil by the application of barnyard manure or by the turning under of green manure crops, little puddling will result from fall plowing.

52. Washing. — When the ground is steep to the extent that losses of the soil are likely to occur by surface washing, fall plowing is not generally recommended; but if the ground is slightly rolling, plowing at right angles to the slope will reduce the amount of washing. The slight ridges produced by the plow will have a tendency to prevent washing, and much of the water will be absorbed by the loose soil.

53. Loss of plant food. — Since no crop is growing on the land in late fall or early spring, certain elements of plant food that have become soluble may be washed from the soil. The loss in this way is not great, however, and rarely is the loss of plant food from this cause sufficient to prevent fall or winter plowing if other conditions are favorable for the practice.

54. Spring plowing. — If fall plowing cannot be practiced, then it is best to plow as early in the spring as possible. Unless plowed early in the spring, the soil, which has been packed down by the rain and by freezing and thawing, will permit the water from below to reach the surface and be lost by evaporation. Land plowed late in the spring is usually dried out to such an extent that a fine seed bed cannot be secured. When barnyard manure or a green manure crop is plowed under, it should usually be done early, since if turned under late in the spring, it will not have time to decay and may prevent the water from coming up, and the corn roots from growing downward.

55. Preparing the ground after plowing. — Fall plowed land is usually allowed to remain until spring without further preparation. The mistake is often made of delaying the preparation of fall plowed land until just before

Fig. 18. — Organic matter should not be plowed under in large amounts late in the spring, as it may prevent the capillary rise of moisture.

seeding. When this practice is followed, complaint is often made that corn suffers more from lack of water than that on spring plowed land. This is due to a failure to establish early in the spring the earth mulch which has been settled down by the freezing and thawing of winter. The mulch should be reëstablished as soon as the ground is dry enough in the spring, by cultivation with a harrow, and not be left to lose moisture until planting time. On spring plowed land the most successful plan of conserving moisture is that of following the plow each day with the harrow. If this is not done, moisture will evaporate from the furrow slice, which will then become hard, making the further preparation of the soil a difficult task. A roller can sometimes be used to advantage in packing loose soil or in crushing clods. For crushing clods, a small roller is better than a large one, since a large roller will be more

FIG. 19. — A good type of roller for crushing clods.

likely to push them down in the ground, while a small one will crush them in the attempt to climb over them. A roller made up of many small rods, or any form that will give an uneven surface, is more efficient in crushing clods than a smooth one. The roller should always be followed with the harrow, since the former crushes the particles of soil together and thus reëstablishes capillarity, permitting the escape of moisture.

56. Testing the seed. — When a farmer refers to a ' stand " of corn, he has in mind the relation of the number of stalks of corn actually growing in a given area, say an acre, to the number he had intended to have when planting the seed. For example, if the farmer has planted 12,000 kernels per acre, he would like to have 12,000 plants grow to maturity. However, if only 9,000 plants result from the 12,000 kernels planted, he says that there is three-fourths or 75 per cent of a stand. While the farmer that plants 12,000 kernels would like to have them produce 12,000 plants, he is very seldom, if ever, successful in getting that number. It is doubtful if the farmers of the corn belt states, on the average, have over 75 per cent of a stand. That is to say, if he plants 100 acres of corn and only gets 75 per cent of a stand, then there are 25 acres of the hundred that are not growing any corn. The grower has plowed, prepared, and planted the 25 acres, but does not receive full value for his labor. While 75 per cent of the stand spread over 100 acres will doubtless give a greater yield of corn than the same number of stalks on 75 acres, it will not in all probability give as great a yield as a 100 per cent stand on 100 acres.

There are many reasons why the farmer does not secure a perfect stand of corn, chief among which are : cut-worms, wire-worms, crows, poorly plowed and carelessly prepared seed bed, and poor seed corn. Probably the most common cause is that of poor seed. If one ear in which the kernels are dead is planted, it will mean a loss of 800 stalks which should produce 800 ears of corn. It is important, therefore, that only that corn be planted that will produce a strong, vigorous sprout. Careless handling of seed corn in the fall and winter is usually responsible for lack of vitality. While ears having weak or dead kernels can sometimes be discarded by their general appearance, it is not always possible to detect them by this means. The only accurate way is to plant them and see if they will grow. This can be done by taking several kernels from each ear, and planting them in a small box filled with sawdust, sand, or soil. A box 24 × 24 inches and 4 inches deep is a convenient size. Put 2 inches of soil or sand in the box and

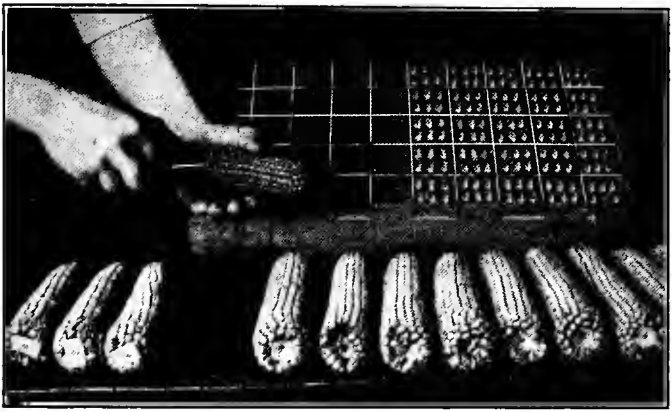

FIG. 20. — Making a germination test.

press it down firmly with a brick or the hand. Then drive tacks or small nails 2 inches apart along the sides and ends of the box and stretch cords over the top each way so as to form 2-inch squares. These squares can be numbered by figures along one side and letters along one end. The ears are numbered by attaching a small piece of paper to the butt by a pin. To remove the kernels, use a pocket-knife, inserting the blade at the edges of the kernels between the rows, and pry them out. Begin near the butt of the ear, remove one kernel, then turn the ear a little and remove another kernel a little higher up, going around the ear in a spiral so that six kernels are removed by the time the ear is turned around and the last kernel is taken out near the tip of the ear. Place the six kernels in square No. 1 of the germinating box. Handle ear No. 2 in the same way, placing the kernels from this ear in square No. 2 of the germinator. After six kernels have been removed from each ear and placed in the small square of the germinator corresponding to the number of the ear, fill up the box with dirt or sand. Then with a sprinkling can wet the soil until it is reasonably moist. Care should be exercised in selecting a place to set the tester, as a more accurate test can be secured if it is placed under conditions as near like those found in the field as possible. If the tester is placed behind the stove or in the furnace room, many kernels will grow that would not grow if planted in the field. Since the object of the test is to discard those that would not grow in the field, it is desirable to have the tests made under conditions similar to those found in the field. The results of the tests should be read when the plants are about 2 inches high. The samples that do not produce six strong, vigorous plants should be noted, and the ears from which they were taken should be discarded. In this way, only those ears will be used for seed that have a strong vitality. A tester the size of the one given above will test at one time 144 ears or enough to plant 10 or 11 acres. There are many kinds of commercial testers on the market, many of which are very reliable, while some do not meet the claims that are advanced for them. A home-made tester will do the work just as well as any of the commercial forms, and has the advantage of being much cheaper. This test may be made in late winter or early spring and will require from 2 to 4 weeks for completion, depending on conditions for growth.

57. Grading seed corn. — Many growers think it is necessary to plant corn from the butts and tips to insure well-filled butts and tips in the progeny. Reports of eight experiment stations of tests running from 1 to 9 years in which the seed from the butts, tips, and middles of the ear was compared, showed that there has been practically no difference in yield. In order to get a uniform drop from the planter, it is a good plan to shell off the butts and tips from the seed ear. To still further increase the efficiency of the planter, it is well to select ears that are uniform in the size and shape of the kernel. A seed corn grader made up of three sieves with openings of different sizes may be used to remove the large and small kernels. Iowa Station reports that a planter using seed graded in this way gave 95 per cent of a perfect drop.

58. Time of planting. — Corn may be planted in the spring as soon as the danger from frost is over, and the soil is warm enough for the seed to germinate. Planting at this time would be regarded as early, while if it is delayed three or four weeks from this time it would then be considered late planting. The date at which the soil is at the proper temperature and the danger of frost is over will vary in a given locality with the season, and in different sections with the latitude. Early planting usually gives the best yield of mature corn. Corn planted late quite frequently has from 25 per cent to 35 per cent of moisture at harvest time, and in this condition is likely to spoil in the crib. Early planting is often impossible because of the lack of proper drainage which prevents early preparation of the soil. In many cases the increase in yield of mature corn will in a few years pay for the draining.

59. Depth of planting. — Corn may be planted from 1 to 5 inches deep; 1 to 2 inches deep may be considered shallow, while from 3 to 5 inches may be regarded as deep planting. The results of numerous experiments comparing deep and shallow planting, have generally been in favor of shallow planting. The depth of planting, however, will depend largely on the physical condition of the soil. If the soil is finely pulverized and the moisture has been retained by frequent cultivation, shallow planting is best. If the surface soil is lumpy and is dried out, it may be best to plant rather deeply, in order to cover the corn and place it where there is enough moisture to start germination. In many sections of the Western States corn is planted with a lister. The lister is an implement which plants the corn in the bottom of the furrow, the furrow being made by two disks or shovels running at either side of the drill hoe. Where this practice is followed the land is not plowed, and cultivation consists in plowing dirt into the furrow as the plants increase in height. The advantage over the ordinary method is that of the time and labor saved from plowing, and the securing of better moisture conditions, especially in rather dry areas. Listing can be practiced successfully only on loose, fertile soils.

60. Rate of planting. — The rate of planting refers to the number of stalks per given area. The proper rate of planting corn will depend largely upon the fertility of the soil, and the purpose for which it is grown. Because of the several factors that will influence the best rate of planting corn, the experiment stations have not been able to make definite recommendations as to the number of stalks per hill or the number of hills per acre. Several stations have conducted experiments along this line, and from the results obtained have made general recommendations to assist the grower in determining the proper rate of planting. Corn may be planted in hills, that is, several kernels in a group, or drilled, in which case kernels are placed along in a row, one kernel at a place. At the Nebraska Station, with hills 44 inches each way, the yield of grain was about the same for 3, 4, or 5 grains per hill. When the corn was planted thinly, large numbers of suckers or tillers were produced, many of which produced ears. When planted thickly, the percentage of barren stalks was greater. In Illinois, tests were made at the main station and also on various soil types in different parts of the state. The results indicate that in the fertile soils of Northern Illinois, higher yields are obtained with hills 36 inches each way and 3 stalks per hill, while in some of the less fertile soils, the best yield was obtained with 2 stalks per hill. At the Ohio Station, with the rate of planting varying from 1 to 5 grains per hill, and hills 42 inches each way, there was a variation of only a few bushels in the yield of 3, 4, and 5 stalks per hill. Four stalks per hill produced the largest yield. Two stalks per hill produced about 81 per cent and 3 stalks about 95 per cent as much as 4 grains.

Fig. 21. — Planting corn with a check rower.

In the results of the Ohio and Nebraska experiments there was a noticeable difference in the size of the ear, and the per cent of barren stalks from the thick and thin planting. This is due in a great measure to the ability of the corn plant to adapt itself to existing conditions. If planted too thinly, the plants in order to produce as much as possible under existing conditions, produce large ears, more plants bear two ears, and there are fewer barren stalks. If planted too thickly, the ears are smaller, the percentage of two-eared plants is lower, and the percentage of barren stalks is greater. Many growers prefer a high percentage of large ears rather than a larger number of small ears and a few more bushels per acre, although if the corn is to be used for feeding live stock, there is no objection to the small ears. Many growers of show or seed corn plant thinly in order to produce a large number of big ears. For good soil conditions of the corn belt a rate of 3 grains per hill and hills 36 by 42 inches should produce a high yield of grain. In less fertile soils, 2 grains per hill may be a better rate at which to plant.

The Ohio Station, in comparing hilling with drilling of corn, found that one grain every 12 inches or 2 grains every 24 inches gave better results than 3 grains per hill 36 inches apart, or 4 grains per hill 48 inches apart. One objection to drilling corn is that of not being able to cultivate it both ways, thus requiring in weedy fields considerable hand work with a hoe. In the rolling sections of the country drilling is the general practice, since if the rows are run at right angles to the slope, the soil does not wash so badly as when the stalks are grouped in a hill quite a distance apart. While drilling may give three or four bushels more per acre than the same number of grains planted in hills, it is often a question whether the increase in yield will compensate for the extra labor necessary in keeping the field free from weeds. When corn is grown for stover, the thicker rate of planting will give the highest yield of roughage. When planting for the silo, the corn should be drilled, if possible, at the rate of one grain every 10 or 12 inches. While this may not give as great a tonnage as thicker planting, the percentage of grain is higher, thus giving equal if not a little more feeding value.

61. Cultivation. — The principal reasons for cultivating the corn during the early stages of growth are to kill the weeds and conserve moisture. As has been pointed out, growing corn requires a large amount of water, and the amount of rainfall during the growing season is closely correlated with the yield. While it is not possible to control the amount of rainfall during the growing season, it is possible to save a large part of that which falls early in the season for the use of the plants when their needs for water are greatest. To do this it is necessary to keep the surface soil broken up into fine particles, to form a mulch which will prevent the water that is in the lower soil from reaching the surface and being lost by evaporation. Weeds are undesirable in a corn field because they not only use up the water that should be left for the use of the corn, but they also use up plant food. Therefore one operation may serve to kill the weeds, and also to reëstablish the earth mulch to prevent evaporation of water. When the plants are small, this can best be done by a weeder or a spike tooth harrow, providing the ground is not cloddy at the time of cultivation, and if large annual weeds have not got a start. Cultivation is therefore rendered less difficult by thoroughly preparing the ground before planting. If a weeder or harrow is run over the field on a hot, sunshiny day, before the plants are up, it will establish the earth mulch and kill the weeds that are just starting. The weeder or harrow should be run over the field frequently until the plants are seven or eight inches high. These implements should not be used early in the morning or on cloudy days, since at this time the plant cells are filled with water and the plants are easily broken off. After the corn is too big to cultivate with the weeder, the mulch should be maintained by a cultivator equipped with small shovels, which should be run about 2 inches deep. Shallow cultivation will conserve the moisture and kill the small weeds quite as well as deep cultivation. However, if large annual weeds are started, it may be necessary to run the shovel somewhat deeper in order to uproot them. Deep cultivation cuts off many of the corn roots and turns up a lot of moist soil which will dry out by exposure to the wind, thus causing a greater amount of moisture to be lost than by shallow cultivation. After the corn is too large for the cultivator, and the roots have grown in the upper soil, the mulch can be maintained by dragging a mower wheel or a plank drag between the rows. This will not only keep the dust mulch and kill the weeds, but will also provide a good seed bed for the seeding of catch-crops in the corn, or for the seeding of wheat later in the season. The frequency of cultivation will depend largely on the nature of the soil, the number of weeds present, and the amount of rainfall. In a very dry season it will be profitable to continue the cultivation until late in the summer, while in seasons of plentiful rainfall, such cultivation may not be necessary.

HARVESTING AND STORING

62. Harvesting. — The method of harvesting depends largely upon the use that is to be made of the crop. If only the grain is desired, the most common practice of harvesting is that of husking the ears by hand from the standing stalk. Usually the ears are thrown directly into a wagon which accompanies one or two huskers. In a field of good corn one man, depending of course upon the individual, can husk and haul to the crib from 50 to 90 bushels per day. A machine has been placed on the market that will husk the corn from the standing stalk, and by means of a conveyor deliver the ears into a wagon driven along beside the husker. A husker of this sort requires six or eight horses to pull it. The machine has not been regarded as a satisfactory one, and can only be used in very large fields where few turns are necessary. The machine is not in common use even among the growers who harvest a large acreage.

Sometimes the grower uses not only the ears, but also the leaves and stalks. Corn fodder is the corn plant cut off near the ground and consists of the stalk, ear, and leaves. If, after cutting, the ears are husked out, the leaves and stalks are called corn stover. Corn may be cut either by hand or by means of corn cutting machinery. The number of hills put into one shock varies from 100 to 144 or more. The cutting may be done by means of a sled with a knife on either side, and drawn by a horse walking between the two rows that are being cut. Two men stand on the sled and catch the corn as it is cut off by the knife. When they have secured an armful, the horse is stopped while the fodder is set up into a shock behind the sled. When the corn is down badly, this method of cutting cannot be employed. Another type of cutter, which is equipped with a large platform, permits the shock to be set up on the platform, and when completed is transferred by means of a lever to the ground behind the cutter. The corn binder now in general use cuts and binds the fodder into bundles which are dropped off on the ground, and later set up into shocks. The time of cutting in order to secure the best yield of both grain and stover is when the husks are dry and from one-third to one-half of the leaves are still green. If cut before this time, the feeding value is not so great, due to immaturity;

FIG. 22. — Harvesting corn with a corn binder.

and if cut much later, many of the leaves will drop off during the cutting. When the ears only are desired, they should be left on the stalk until fully mature. If removed before maturity, all of the starch will not be transferred from the leaves to the ear, and thus they will not have as great a feeding value as when fully mature.

Many corn growers do not husk out the ears after cutting but feed the fodder to cattle, supplying them with both roughage and grain. In almost all cases the ears are husked out and fed separately from the stover. The husking may be done by hand or by means of a husker, which not only removes the ears, but also shreds or cuts the stover up into small pieces. Stover after passing through the husker and shredder is called shredded stover. It is usually stored in the barn, or sometimes in stacks out of doors. Shredded stover is much more convenient to handle in indoor feeding than stover not shredded. In some sections of the country only the leaves are used as forage. Where this practice is followed, the leaves are stripped from the plant and hauled away, leaving the stalk and ear in the field. Sometimes the top of the stalk, that part above the ear, is cut off and shocked, leaving the lower part of the stalk and the ear standing. When the corn is used for ensilage, it should be cut just a little before it would be in proper condition to put into the shock. If allowed to become too dry, it will not pack in the silo, and it will be necessary to add water at the time of filling in order to make it pack more closely and to exclude the air. When corn is to be put into the silo, it is well to start cutting while it is a little green, for if cutting is begun just at the proper stage, part of the corn will have become too dry before the work is finished.

Fig. 23. — Filling the silo.

Another method of harvesting the corn crop is that of turning hogs that are being prepared for the market into the field. This method is followed only in a comparatively small way, and usually only a part of the crop on a given farm can be " hogged down " to advantage. The yield of corn, of course, will determine the number of hogs per acre that can be profitably turned into a given area. Ten acres of good corn will carry 75 good sized hogs to advantage. It is advisable to divide the field by means of a temporary fence, thus confining the hogs to a small area, which method will insure less waste than would result if they were given the run of the entire field. When the

Fig. 24. — A field of corn in shock.

corn has been well cleaned up, the feeding area can be extended by moving the temporary fence. When the field has been completely run over by the hogs that are being prepared for market, old hogs such as brood sows may be turned in to clean up the corn that has been left here and there over the field. When the farmer is prepared to harvest a part of the crop in this manner, it is to be recommended, since much labor is saved in the husking. Wet seasons are not favorable for " hogging down " corn, since the loss by waste is much greater than during the dry season. The tramping by the hogs in wet soil may cause it to break up cloddy the next spring.

63. Loss in store. — The moisture content of ear corn at the time of harvest varies from 15 per cent to as much as 35 per cent, or more. The moisture content depends largely upon the maturity. Corn that is well matured usually has from 16 to 20 per cent of moisture at the time of harvest, while immature corn may have as much as 30 or 35 per cent. Corn with high moisture content loses considerable weight in store, due to the evaporation of the water. Many experiments have been conducted to determine the amount of shrinkage of ear corn in store. The weight of the corn when put into the crib compared with the weight when taken out will show the loss due to the drying out while in store. The moisture content of corn when well dried out is from 10 to 14 per cent. Thus corn with 30 per cent of moisture at the time of harvest will show a loss in weight of from 15 per cent to 18 per cent when completely dried out. The loss of well-matured corn while in storage is not nearly so great as the loss in immature corn. Perhaps the loss of well-matured corn will not exceed 8 or 10 per cent for the first year. Experiments conducted by the Illinois Station show that the greatest shrinkage occurs during the months of April and May. After May, corn in store loses very little in weight. If kept in store for two years or more, there is very little loss in weight after the spring following the time when it was stored in the fall. In this connection it is interesting to compare the advantage of marketing in the fall at the time of husking, with those of marketing in the following spring or summer, or at a still later date. To decide whether or not to market in the fall, the maturity of the corn at the time of harvest, the price in the fall, and the probable price in the spring or summer must be considered. Of course it is to be remembered that grain dealers do not pay corn prices for water. When corn with a high per cent of moisture is sold in the fall, the usual practice is not to buy it at a per bushel rate, but at a given price per 70 pounds or 72 pounds, as the case may be, depending upon the moisture content. Farmers who purchase corn for feeding should consider the moisture content just as do the grain dealers. Good ventilation in storage is essential, especially if the corn is not well dried out when husked. Storing corn in tight bins or cribs, unless it is well dried out, will be likely to cause molding and rotting.

IMPROVEMENT OF CORN

64. Method of improvement. — Increasing the yield of corn may be accomplished either by improving the fertility and physical conditions of the soil, or by improving the plant, or by both. Improving the soil has been briefly discussed under cultural methods, and only improvement of the plant remains to be considered. The first consideration in the improvement of corn is the selection of the variety. Varieties of corn vary greatly in their adaptability to soils and climate, and in yield. There are a large number of varieties of dent and flint corn, some of which differ greatly in the character of the plant, and in the size, shape, and color of the ear and kernel. Many others, however, are so similar in all respects that it is impossible to distinguish between them. This is due in great measure to the common practice of giving to the corn the name of the man from whom the seed was secured, and henceforth that particular strain is known as "Jones'" Yellow Dent, "Wilson's" White, or "Knox County" Corn, as the case may be. Sometimes, too, after a few years of selection for a special type, the grower renames one of the older varieties. This has naturally led to considerable confusion, and emphasizes the importance of a uniform nomenclature. Many of the older varieties and some of the newer ones have been developed into a fixed variety type by careful and consistent selection. Thus Leaming, Reid's Yellow Dent, and Pride of the North are distinct varieties, while many other so-called varieties are only selections from the older varieties.

65. Variety test. — The selection of a variety for any given locality involves the choice of a variety adapted to the soil and climate. Not only must it be adapted to soil and climate, but it must also be a high yielder of a good quality of corn. It is not safe to select a variety from a distance or even from a neighboring county, unless one is sure that it will be adapted to the conditions found on the farm on which it is to be grown. Corn plants are sensitive to a change of soil and climate. A variety that is well adapted to one section of the country or to one farm may not be suited to another farm. Many have experienced sad results from buying seed from a well-recommended variety in another state or even within the same state. The custom of purchasing seed from growers of prize-winning corn regardless of adaptability of that variety to the conditions under which it is to be grown, has often resulted in serious loss to the purchaser. The only safe way to get seed corn from a distance is to purchase a small amount and try it out for a few years in a small plot. If it produces a good yield of mature corn, a larger amount of seed corn can then be secured for seeding a larger acreage. Maturity is an important consideration. Immature corn, as pointed out in the paragraph on storage, is not to be desired in any event. Seemingly high yields at husking time may result in a much lower yield of inferior quality when properly dried out. Each farmer can with little time and expense conduct on his farm a variety test that will answer the question as to which variety is the most profitable for him to grow. A small plot may be laid off in the corner of the regular field and planted with several different varieties along with his own. A comparison of the yield of mature corn at harvest will decide the question. In a small plot two rows may be planted from one variety, the next two rows from another, and so on. It is necessary, however, to have some standard by which to measure the new varieties. This is best done by planting each fourth plot with home grown seed. This will serve as a check or standard with which to compare the new varieties. If it is not desirable to lay off the small area, the test can be made by planting a round with the planter through the field with one variety, and the next round with the seed of another, and so on. Each fourth round should be planted with home grown seed in order to note variations in soil, and to have a standard for comparison. Marked variations will usually be seen in a variety test in the general character of the plants, the date at which the tassels and silks appear, the time of maturity, and in yield. Professor C. G. Williams suggests the following method of determining the yield: "In determining the yield per acre, each variety is compared with the check plots between which it grew, the number of bushels by which it exceeds or falls short of the check is determined, and this excess or shortage added to or subtracted from the average yield of all of the check plots." The variety that gives the highest yield of mature corn of good quality should be selected for perpetuation. Seed corn should not be selected from the variety test plots, for since corn is a cross-pollinating plant, the varieties growing side by side have intercrossed and the progeny of such seed would be a mixture. The variety test only points out the variety best adapted to the field in question, and the seed for planting the next year's crop should be secured from the same grower that furnished the seed for the test plot.

66. Seed selection. — The most common method of selecting seed corn is that of laying aside the best appearing ears that are found during harvest or that are found here and there as the corn is fed from the crib during the winter or spring. Sometimes seed selection is delayed until spring, when the seed ears are picked from the crib. The best corn growers, however, practice field selection. Field selection is going into the field and selecting the ears from the standing stalks. There are several reasons why field selected seed is to be preferred to seed selected from the crib in the spring, or even to seed selected from the wagon at harvest time. It is not always the large, well-proportioned ear that one would naturally pick when selecting from the crib that produces the largest yield. In many cases these superior looking ears have been produced under extremely favorable conditions. Probably they have grown in a hill of only one stalk instead of three, perhaps on some unusually fertile spot, or over a tile drain, or under some abnormal conditions that were favorable to their growth. The merits of these ears will not, in all probability, be reproduced in the progeny unless planted under the favorable conditions that produced them. In field selection only ears that are found growing under normal conditions of stand, fertility, and the like are selected. The excellence which these ears will possess is hereditary, and will, therefore, in all likelihood be transmitted to the progeny. The height of the plant, and the height at which the ear is carried on the stalk, should also be considered. Tall plants are not usually desirable when corn is grown for the grain, since tall corn is difficult to handle in cutting, and if harvested from the standing stalk, the ear is in an awkward position to husk. Selection of seed from plants carrying the ear at a medium height will after a few years produce a strain of corn in which most of the ears will be at a convenient height to husk. Likewise selection for medium height of stalk will develop plants of convenient height to harvest. If the corn is a little late for the average season, by selecting seed from the early maturing plants that will be found growing here and there over the field, one can in a few years have the general crop ripen a week or ten days earlier. Another thing that should be considered in field selection of seed is the vigor of the plant. Some plants are easily blown over, while others are able

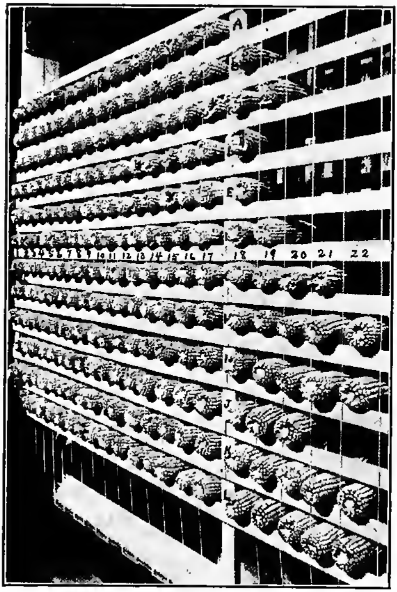

FIG. 25. — Rack for storing seed corn.

to carry their load and remain in an upright position until harvest time. One of the greatest advantages to be gained by fall selection of seed is the opportunity afforded it to thoroughly dry out before freezing weather comes. Seed corn if not well dried out before a hard freeze may have the vitality greatly impaired, and in some cases the germ may be killed. Seed corn should be stored in a well-ventilated room. The ears should be piled or hung up in such a manner as to permit a free circulation of air among them. During damp weather a little artificial heat will assist in drying them out.

67. Some results of field selection. — At the Nebraska Station, seed selected from a plot growing five plants per hill was compared with seed grown at the rate of three plants per hill and one plant per hill. The seed selected from these plots was planted the next season at the uniform rate of three plants per hill. Three years' average gave the results shown in the table below:

Seed from	Yield Next Year when Planted at Rate of 3 Stalks per Hill
1 stalk per hill	61.8 bushels
3 stalks per hill	62.2 bushels
5 stalks per hill	64.4 bushels

At the Ohio Station, seed selected in the field from plants growing under normal conditions of stand and fertility was compared with the seed selected from the wagon at harvest time. In selecting from the wagon the appearance of the ear was the only guide, since the conditions under which it had grown could not be determined. When planted the next year at a uniform rate of three kernels per hill the field selected seed produced 3.72 bushels of corn more per acre than that produced by the wagon selected seed. There are those who object to field selection of seed, contending that ears removed from the stalk before cutting time are not fully mature. This objection may be overcome by marking ears desired for seed, before the corn is put into the shock, and separating them at husking time from the rest of the corn. It is well to select from the field a larger number of ears than will be necessary to plant the next year's crop. This will permit the sorting over of the seed, and the discarding of undesirable ears or those with faulty germination.

68. Ear-to-row test. — Ears of corn vary greatly in size, shape, weight, and other ear characters. They also vary in productiveness. It would be a great convenience to the corn grower if he could by the appearance of an ear estimate with some degree of accuracy its ability to yield. This, however, has not been found possible with the present knowledge of the relation of ear characters to yield. The ear-to-row test is the only method of picking out the high yielding ears. "This test consists in comparing the relative productiveness of a number of ears of corn when planted side by side, an ear or a part of an ear to a row. Ears for such tests may well be selected while ripening in the field, in order that the condition of growth may be noted, and only such ears chosen as give some reason for believing that their excellence may be due to something other than favorable environment." An ear-to-row test may be carried out in the corner of the regular corn field. The soil should be uniform in fertility, and if underdrained, the rows should run at right angles to the drain in order that all the rows will be affected alike. The rows for convenience may be made 50 hills long. Plant row No. 1 with corn from ear No. 1, row No. 2 from ear No. 2, until a row 50 hills long is planted from each ear that is to be tested. A selection of 50 ears makes a convenient number for an ear-to-row test. Every tenth row should be used as a check row. Ten ears may be selected for this purpose. These same ten ears should be used in planting all of the check rows, each ear planting the same number of hills in each row. Check ear No. 1

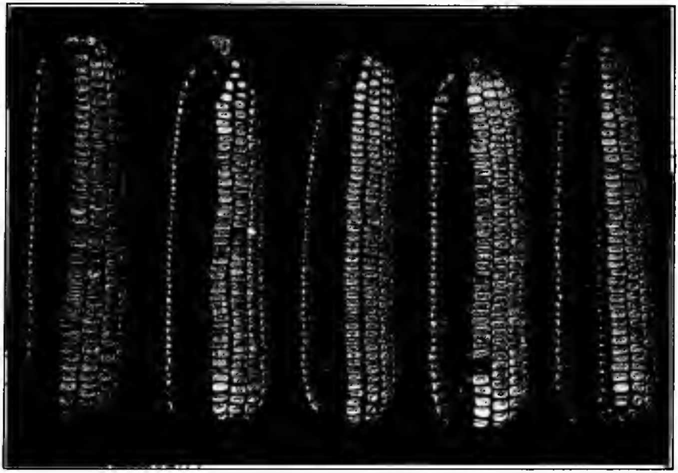

FIG. 26. — Remnants of an ear-to-row test.

should be used in planting the first five hills in each check row. Check ear No. 2 should be used for the second five, check ear No. 3 for the third five, and so on until the fifty hills in each are planted, five hills from each of the ten ears. It is well to plant four or five kernels per hill in order to insure a perfect stand. When the plants are five or six inches high, each hill should be thinned down to three plants. More reliable results are secured when the test is made in duplicate, the second series of rows being some distance from the first. At harvest time each row is husked separately, and the yield is determined in the same way as in the variety test. Seed corn is not selected from the rows giving the highest yield, because cross-pollination has taken place, and probably the low as well

FIG. 27. — A corn-breeding plot. Rows 1, 3, and 4 have been detasseled.

as the high yielding ears are represented in the ears of each row. The ear-to-row test is only a method of picking out the highest yielding ears, and not for the production of seed corn. When the rows are planted, only a portion of the ear is used, the remainder being preserved for crossing the next year.

69. The breeding plot. — The remnants of the four or five highest yielding ears are planted the next season in the breeding plot. This plot should be some distance from other corn fields, to prevent mixing. The plot necessarily must be small. Rows twenty-five hills in length and as many rows as the remnants will plant is the usual size. The remnant of the highest yielding ear is used as the sire, the three or four other remnants as the dam or female of the cross. The sire ear should be used to plant every third row. In order to make it reach as far as possible, these rows should be planted thinly, usually two kernels per hill. The remnants of the other ears are used to plant the rows between the sire rows.

FIG. 28.—A multiplying plot, out of the reach of pollen from other corn.

When the tassels begin to appear, the plot should be visited each day and tassels removed from the middle rows. This will insure the pollen from the highest yielding ear fertilizing the plants produced from the remnant of the three next highest yielding ears. If the rows planted by each ear are recorded, the pedigree of the corn can be determined for each ear. At harvest time the rows from each are harvested separately.

70. The multiplying plot. — The multiplying plot is planted next year from the ears grown in the detasseled rows. This plot, too, should be a distance from other corn fields. The multiplying plot, as the name indicates, is simply a plot to increase the supply of seed in order to plant an entire field the next year. Some of the best ears from the breeding plot and also from the multiplying plot should be taken back to the ear-to-row test each year. This method gives an opportunity for comparison of the improved strain with the general crop.

71. Corn judging. — Within the past few years corn shows have become quite common throughout the corn growing sections of the country. They have done and are doing a great service in creating a wider interest in the study of corn growing, and in showing the possibilities of improving the quality of the crop. The general plan of conducting the contest has much to do with the benefits to be derived from the show. Too frequently, perhaps, the show evolves into a contest to determine which exhibitor has best solved the problem of the proper rate of planting to grow large ears, and of his ability to select a good show sample. Quite frequently it is said at a show by a defeated contestant, that, although he did not win the prize, he has the consolation of knowing that he produces more corn of a better quality per acre than does the exhibitor who carries off the prize. This, as has been pointed out in the paragraph on the rate of planting, is quite frequently due to the fact that many exhibitors have learned that corn when planted thinly produces a higher percentage of large, fine looking ears, than when planted at the normal rate, or at a rate that would produce a higher yield per acre. Many seedsmen plant thinly in order to grow a greater number of large, well-proportioned seed ears per acre. This practice, of course, as shown in the discussion of field selection, is not to be recommended, since the excellence of such ears is due to environment and not to heredity. The greatest service perhaps that has been and can be rendered by the corn show to the growers of the community is to be found in the lessons of the importance of maturity, the vitality of the seed corn, and the possibilities of improvement in the uniformity of the product.

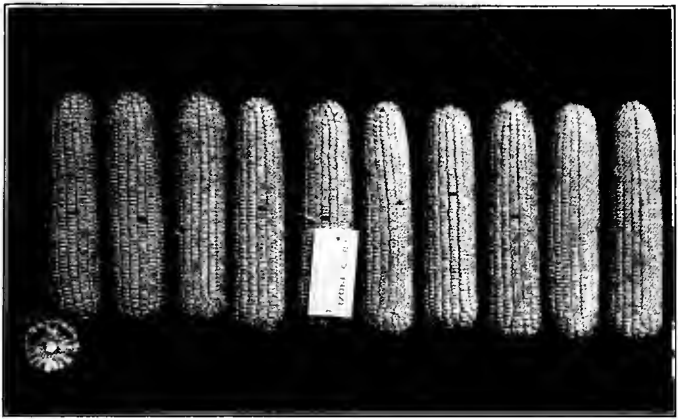

Fig. 29. — A good sample of show corn.

INSECT AND FUNGOUS DISEASES

72. Insects. — The farmer has many difficulties to overcome in growing a profitable crop of corn, and among them insect troubles often have no small place. Some kinds of insects are always present in the corn field, but the damage done by them is comparatively small, while others may appear in such numbers in certain years as to cause serious trouble and sometimes greatly reduce the yield. Of the many insects that attack the corn plant only a few can be discussed in this book.

73. The wire-worm. — Almost every one has seen the beetles which when placed on their backs will jump up into the air with a clicking sound and light right side up. They are known as the "click beetle," and are the adult form of the wire-worm. The eggs are laid usually in grass land. The larvæ which hatch from them require from three to five years to complete their growth. The second year after grass land has been planted in corn, the larvæ feed upon the newly planted kernels and upon the roots of the young plants. Serious damage sometimes results. Quite frequently it becomes necessary to replant the field. The larvæ become full grown in midsummer and after pupation, which lasts three or four weeks, the adult beetles appear. The adults fly to the grass lands and deposit eggs for a new brood. No satisfactory method has been recommended to prevent their ravages. They may be held in check quite effectively by fall plowing, which kills many of the larvæ, and also many of the adults. The practice of a short rotation, which allows the field to remain in grass but one year, will largely prevent their increase to such numbers as would seriously injure the corn crop.

74. The grub-worm. — The large May beetles or June bugs which are numerous during early summer are the parent form of the white grub-worm. Like the click beetle, the June bug lays its eggs in the meadow and pasture lands, usually in June or July. The young grubs live upon the grass roots, and require about two years to become full grown. When sod lands are plowed and put into corn, the grubs, being deprived of the grass roots, attack the roots of the corn. If the field has been in grass for some time previous to plowing, the grubs may be numerous, and since there are so few corn plants in comparison to the grasses per acre, many grubs may be found at work on the roots of one corn plant. As many as 25 grubs have been found on one hill, in fields that were badly infested with them. When the grubs are numerous, they do serious damage, sometimes destroying the entire crop. The most effective means of controlling them is, as in the case of the wire-worm, the use of a short rotation and practicing summer or fall plowing. Sometimes if hogs are turned into the field they will follow the plow and destroy many of the grubs.

75. The cut-worm. — The cut-worm is a common foe of many farm and garden crops. It gets its name from its well-known habit of eating only as much as is necessary to cut off the plant, thus leaving a path of destruction as it proceeds from plant to plant. The adult form is a moth, which lays its eggs principally in sod lands. The eggs are laid in midsummer and the larva becomes partially grown before winter. After passing the winter in the ground, it wakes up in the spring and lays low the plants that come in its way. There is no practical means of controlling its attacks upon the corn. A mixture of wheat bran, Paris green, and molasses may be used effectively in controlling it on small areas, but this is hardly practicable in the corn field.

76. The corn-root louse. — The corn-root lice are very interesting insects. They are interesting because the ants which so carefully guard and care for them are often given credit for the damage done. If a nest of the small brown ants is broken open in the fall or winter, usually there will be found the eggs of the corn-root louse carefully stored away. When spring comes, the ants carry the lice eggs to the roots of the smart weeds, where they hatch and the larvæ feed upon the roots. If corn is planted near by, the ants will carry the lice to the roots of the young corn plants on which they will feed, and if they are plentiful, will cause the corn to have a stunted appearance and the leaves will turn red and yellow. When such areas are seen in the corn field, usually the ants are credited with the injury, since they are seen busily engaged about the base of the corn plant. The facts are, however, that the ants are only indirectly responsible for the injury. They care for and protect the lice because the latter excrete from a pair of small tubes on the back part of the abdomen a sweet, honey-like fluid upon which the ants feed with great relish. So long have they looked after the welfare of the lice that the latter are now dependent upon them, and if the ants are destroyed, the lice soon perish. The destruction of the ants, therefore, is the means of controlling the lice. This may be done by digging up the nest in winter or by killing them by pouring a quantity of carbon bisulphide into the nest and covering it over with a blanket to retain the fumes.

77. The corn root-worm. — Growers often wonder why their corn blows over in some fields and not in others. If the corn that blows over is in a field that has been in corn for two years or more in succession, the corn root-worm may be the cause of the trouble. This insect has been a serious pest in many sections of the country, particularly in those sections where rotation of crops is not regularly practiced. The eggs of the corn root-worm are laid in the ground near the base of the stalk sometime in the fall. They hatch in June and the root-worm feeds on the roots of the growing corn plant, first on the small roots, then burrowing into the larger ones. The root system is seriously injured if the worms are plentiful, and a rain with some wind will cause the corn to blow over. The worms are about one-half inch in length with a red or brown head. In late summer they enter the pupa stage and soon come out as adult beetles. The adult beetles are about one-fourth of an inch long. The adult of the Northern corn root-worm is a plain grass-green in color, while that of the Southern corn root-worm is yellowish green with twelve black spots on the back. The larvæ of the two species are very similar. The adults feed on the corn silks in the fall, and the farmer often thinks they are seriously affecting the corn, but they have done all the damage they can do, except to lay their eggs which will hatch the following spring. The Southern corn root-worm is not common in the Northern States. The Northern corn root-worm is more common and often it does considerable damage. The latter is easily controlled because the larvæ feed on no other roots except those of the corn, so a simple rotation will starve them out. In the case of the Southern corn root-worm the rotation of crops will not control the insect to so great an extent, because the larvæ of this species feed on the roots of other plants.

78. Fungous diseases. — Wherever corn is grown, corn smut is found. This fungus attacks the ear, tassel, leaves, or the stalk of the plant, developing at maturity into a large mass filled with small, powdery black spores. The fungus may attack the plant any time after it is a couple of feet in height until it nears maturity. The spores may remain in the field from the previous year, or they may be carried there in manure or by the wind. During the summer they are blown about by the wind, and fall upon the growing plant. If they light upon the tender part of the plant, and if moisture is present, they start to grow. Therefore the tassel, silk, brace roots, and the base of the leaves afford the most favorable locations for growth. The damage done each year has been estimated at one or two per cent of the crop, while in a year of extremely favorable conditions for it, the loss may be much greater. The treatment of the seed before planting to kill the spores does not greatly assist in controlling the disease, since the spores are carried from field to field by the wind. The only effective means of controlling it is by going into the field several times during the season and cutting off and destroying the diseased portion of the stalk. Corn stover affected with smut is thought by many farmers to cause illness to animals to which it is fed. In experiments to determine whether or not the corn smut is the cause of illness among animals, it was fed in comparatively large amounts to groups of animals, and the results carefully noted. In no case did the animals show any effects from the feeding of the smut.

79. Ear-rots. — It is the very general opinion of farmers that the ear-rots of corn are caused by adverse weather conditions. Careful studies of these diseases will show that they are caused by a fungous growth, and while the weather conditions may be favorable or unfavorable for the growth of fungus, it is not the direct cause of the trouble. There are several kinds of ear-rots, but their appearance on the ear is so similar as to be generally regarded as one form. The most common is the *Diplodia*, or dry rot, which attacks the husks, kernels, and the cob of the corn, causing the husks to stick to the ear. The ear becomes dark in color, often nearly black, except for the white mold-like growth which is abundant between the rows of kernels. It is a common practice at husking time to throw the ears of corn affected with this disease on the ground. This practice is the means of spreading the disease and giving the best opportunity for its being carried over the winter. The spores from the ears thrown on the ground spread to the corn stalks, where they make a slight growth. The next year the spores are spread by the wind to the growing corn, where, if weather conditions are favorable, they develop into the disease. The Illinois Experiment Station has found that stalks, after having been plowed under for two years, still retain the spores that will germinate under favorable conditions. This station, therefore, recommends that diseased ears be destroyed. It is also a good plan to burn the stalks on a field that is badly affected. It was found, further, that corn grown in a rotation was not so badly affected as that grown under a continuous cropping system.

Beside the dry rot, there are several species of fusarium that attack the ear in much the same way. The casual observer would not be able to distinguish them from the dry rot.

80. Rust and bacterial diseases. — Corn is affected by several kinds of leaf rusts and bacterial diseases, but the damage done is usually small.

81. Protection of seed corn from crows and rodents. — Crows and rodents sometimes do considerable damage to corn by digging up the newly planted kernels or by pulling up the young plants to get the kernel. Trouble from these sources can be largely overcome by treating the seed corn before planting with coal or pine tar. The tar, slightly warm, should be applied to the shelled seed at the rate of about one tablespoonful to each nine or ten quarts of corn. Stir the mixture until each kernel is covered with a thin coat of tar, then add a handful of air slaked lime or wood ashes, and stir again. The ashes or lime prevent the kernels from sticking together. After drying, the seed is ready to plant.

CHAPTER V

WHEAT

Wheat culture has occupied the attention of man ever since he progressed far enough to record his history. At the beginning of records some 3000 years B.C., wheat culture occupied an important place in the affairs of man.

82. History. — In very ancient Egyptian monuments, older than the Hebrew Scriptures, kernels of this cereal have been found. Records of ancient China show that wheat was cultivated there 2700 years B.C., while the lake dwellers of Western Switzerland cultivated wheat as early as the Stone Age. The existence of different names for wheat in most ancient languages gives reasons for believing that it was cultivated long before the dawn of recorded history. The development of wheat, therefore, has been coincident with that of civilization. Its importance to the civilized nations to-day is perhaps no greater than it was centuries ago, with its more primitive culture, to a more primitive people. The origin of the wheat plant is largely a matter of speculation. The ancient Chinese considered it a gift direct from Heaven. The Egyptians attributed its origin to the mythical god of the Nile, while the Greeks believed it to have been presented to their nation by Ceres, the goddess of Agriculture. Botanists are not agreed as to the primitive plants from which it has developed. Wheat plants growing wild have been found, but it has never been clearly shown that they were not planted by roaming tribes in their journeys across the country. Recently, however, a wild wheat has been found growing in the eastern Mediterranean countries which is thought by some to be an ancestral or closely related form, from which, or from a common ancestor of which, our present day wheat has developed. The wheat plant is so old that it is a most difficult task to determine its ancient family record. It is believed by De Candolle to have had its origin in the Valley of the Tigris and the Euphrates, and from there to have spread at first into China and Egypt, and later to have been carried, with the spread of civilization, into all temperate parts of the world. So far as is known, it was not grown in America until after the discovery of this continent by Columbus.

83. Botanical characters. — Wheat is an annual belonging to the tribe Hordæ of the grass family. The prominent characters that distinguish the species of this tribe are the one to many flowered spikelets which are sessile, and arranged alternately upon the rachis, forming a spike. Rye, barley, and rice are closely related to wheat. Wheat belongs to the genus *Triticum*, of which it is the only prominent species, and is characterized by one spikelet at each joint of the rachis, the outer glumes of which terminate in a beak. The flowering glume may have either short or long awns, or may be awnless. Wheat may be either a fall or a spring annual, some varieties being adapted to fall and others to spring seeding. When the seeding is done in the fall, it is called winter wheat; when seeded in the spring, it is called spring wheat.

84. The roots. — The roots of the wheat plant, like those of the corn, may be divided into temporary and permanent systems. When a kernel of wheat starts to grow, it sends out a whorl of three roots, which form the temporary root system. After the plumule unfolds above the ground, the permanent roots start out from a node below the surface. For a short time both the permanent and the temporary roots serve the needs of the young plant, but as the permanent system develops the temporary system withers and dies. The permanent roots increase rapidly in length and develop into a complex fibrous root system, which serves the plant throughout the remainder of its life. The permanent roots branch freely, as many as eight to ten branches being given off from one inch of the main roots. Most of the root system of the wheat plant is in the upper 15 to 20 inches of the soil. Below this depth it does not branch freely, but sends long runners down deep into the subsoil. The depth to which the roots will penetrate depends largely upon the physical condition of the subsoil, and upon the location of the water table during the growing season. In loose soils, with the water table several feet below the surface, wheat roots may go down 6 or 7 feet or more. The roots of the permanent system do not vary greatly in diameter, being about the same size their entire length.

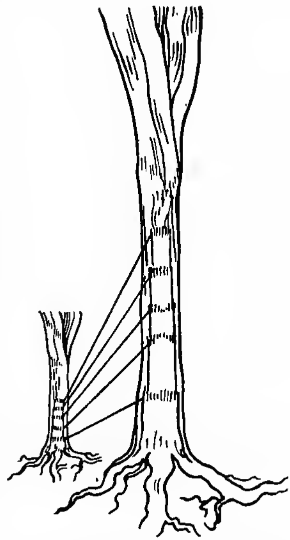

FIG. 30. — Diagram showing how the plant increases in height by lengthening of the internodes.

85. The stem or culm. — During the early life of the plant the internodes are short, giving at this time the appearance of a leafy, low-growing plant. A little later, however, the internodes elongate quite rapidly, pushing the nodes farther apart and lengthening the stem. Before this stage begins, buds appear at the lower nodes and develop by lengthening their internodes into full-sized stems along with the lengthening of the main stem. This is called tillering or stooling. Thus one seed normally produces several stems, sometimes as many as a dozen or more. The number of tillers produced depends upon several factors. Some varieties naturally produce more tillers than others. Thin seeding promotes the growth of a larger number of tillers than a thicker rate of seeding. Winter wheat usually tillers more than spring wheat. Poor or infertile soils retard the production of tillers. Thus it is seen that many more heads or spikes are produced on a given area than there were kernels planted, the number depending upon the several factors above mentioned. The length of the stem, when fully grown, varies with the variety and soil. Some varieties grow only 2.5 to 3 feet in height, while others under the same conditions may reach a height of 4 or 5 feet. Aside from the variation in the length of the stem, there is also found variation in the number of tillers, thickness of the stem wall, and in the number of nodes. In describing or identifying varieties of wheat, the color of the stem, particularly that of the upper internode, is of considerable

FIG. 31. — Diagram showing stooling or tillering in wheat.

service. The stem of the wheat plant in most varieties is hollow, excepting at the node, where it is solid. In some few varieties the stem is partly or entirely filled with pith. The number of pounds of straw required to produce a bushel of grain varies greatly with the variety and with the soil. At the Ohio Station, with 45 varieties, during a period of 13 years, the weight of straw varied from 92 to 132 pounds per bushel of grain, the average being about 105 pounds of straw per bushel of grain. When manure or fertilizer was applied at this station, there was a greater proportionate increase in the weight of the straw than in the grain.

FIG. 32. — Variation in number of culms per plant.

86. The leaves. — As in the corn plant, the leaves are arranged alternately, one leaf growing from each node of the stem. While the plant during its early stage of growth has a leafy appearance, after the internodes have become full length, the leaves appear to be few in number. This is due to the fact that they are then arranged on a lengthened stem. The leaves of wheat are short and narrow as compared with those of the corn plant. They vary in different varieties in length, width, smoothness, and prominence of veins. The leaf sheaths of wheat and rye are hairy, while in barley and oats they are smooth. The lower leaves wither and die as the plant approaches maturity, and at the beginning of ripening only the upper leaf and the topmost internode are green.

87. The spikelets. — A spikelet is composed of two outer glumes, inclosing from two to five flowers, each with a flowering glume and palea. In the wheat plant only one spikelet grows from each joint of the rachis. The rachis may be defined as that part of the stem which passes up through the head. The joints of the rachis are close together, thus forming a compact head or spike. The number of spikelets per head varies with different varieties, the thickness of planting, the condition of the soil, and with the weather. The number varies from 10 to as many as 50 or more. In fertile soils more spikelets are produced per head than in poor soils. A thin rate of seeding also favors the production of a larger number of spikelets. Some varieties naturally have a larger number of spikelets per head than do other varieties. At the base of the head there are usually one or more sterile spikelets, — that is, spikelets in which the flowers do not become fertilized and produce kernels. This varies with the growing season and with the rate of planting. Unfavorable growing seasons and a thick rate of seeding are favorable for a large number of sterile spikelets. The spike or head may vary in length and in shape. The

Fig. 33. — Variation in size of head and number of spikelets.

shape may be tapering to the tip, tapering both ways from the middle, tapering from the top to the bottom, or it may be uniform throughout the length of the spike. The outer glume in the wheat spikelet is oval in shape and terminates in a beak which varies in sharpness and length.

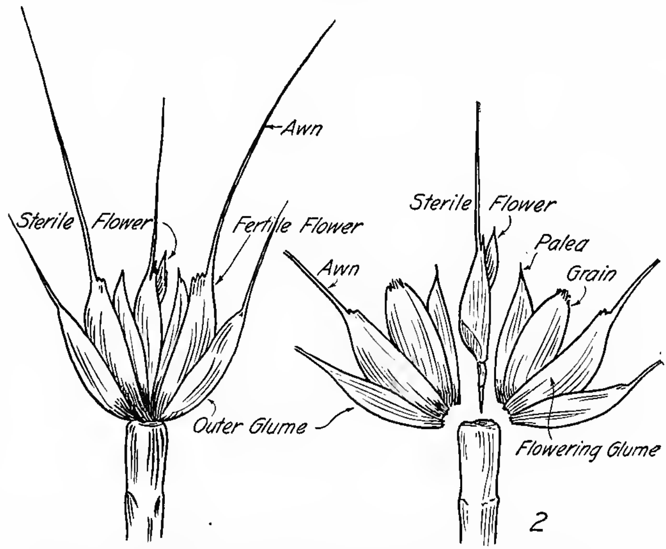

FIG. 34. — A spikelet of wheat. No. 1 shows parts in position as they appear on the head. No. 2 shows parts dissected.

The outer glumes also vary in color and they may be velvety or hairy, or smooth, depending upon variety.

88. The flowers. — Each flower is inclosed in a flowering glume and palea. The flowering glume is larger than the palea and is on the outer side of the kernel, that is, next to the outer glume. The tip of the flowering glume in some varieties is extended into an awn or beard, while in others no awn appears. The latter are called beardless, awnless, or bald varieties. The palea is a thin, membraneous glume, the edges of which are folded inside of the flowering glume. The flower proper is inclosed within and consists of the ovulary, stigma, and stamens. The stamens are three in number, the filament of which is short before fertilization, bearing at the top an elongated anther. The stigma is composed of two branches, each provided with tiny, feathery branches to catch the pollen. Wheat is a close or self-pollinated plant. When the time comes for fertilization, the filaments of the stamens rapidly elongate, and in so doing, upset the anthers, which spill the pollen on the stigmas. While the spikelet may have from 2 to 5 flowers, usually only 2 or 3 develop. Those which do not develop are called sterile flowers. When seeded thickly or on poor soil, or if not favored with good growing weather, fewer flowers develop. Usually 2 or 3 flowers of each spikelet develop, however, and under favorable conditions as many as 5 may mature grains. The number of kernels per spike, therefore, varies greatly in the same field, or even in different spikes of the same plant. In the threshing of wheat, the kernel is liberated from the outer and flowering glumes and from the palea, all of which taken together are called the chaff.

89. The kernel. — After fertilization the ovulary develops into an oblong grain, with a deep groove or furrow on the side next to the palea. Great variation in size, shape, color, and hardness is found in the kernels of different varieties. Slight, or in some cases marked, variations are found among the kernels of a single spike. Upon examination of the kernel, a lot of short hairs will be found at the tip. This is called the brush. If a cross-section be made, it will be seen that the kernel is made up of several distinct parts. The outside covering of the kernel is made up of three layers, which are separated only with difficulty; taken together they are called the bran. In the milling of wheat, for the making of flour, the bran is removed and used as stock feed, and does not enter into the making of flour. The bran makes up about 5 per cent of the entire kernel. Surrounding the kernel, immediately under the bran, is a single layer of large cells called the aleurone layer, comprising 3 to 4 per cent of the kernel. In the milling of wheat this aleurone layer is not included in the flour. Under the aleurone layer lies the endosperm, which is made up of thin walled starch cells. The endosperm makes by far the largest part of the kernel, from 82 to 85 per cent, most of which enters into the making of flour. At the base of the kernel at the side opposite the crease will be found the small embryo or germ. The germ of the wheat kernel is small in proportion to the size of the kernel, when compared with that of corn.

TYPES OF WHEAT

90. Classification. — The cultivated species of the genus *Triticum* may be grouped into eight distinct classes or types. According to almost all botanists, only three of the types are considered as distinct species, the others being sub-species. The following outline, arranged by Hunt, shows the relationship of the eight types of wheat:

- Triticum
  - monococcum — (1) einkorn
  - stativium
    - spelta — (2) spelt
    - dicoccum — (3) emmer
    - tenax
      - vulgare — (4) common wheat
      - compactum — (5) club wheat
      - turgidum — (6) poulard wheat
      - durum — (7) durum wheat
  - polonicum— Polish wheat

91. Einkorn. — Einkorn is the German for one grain, and this type of wheat is so named because, in most the common varieties, it has but one grain per spikelet. Einkorn is a short-strawed, narrow-leafed plant, with a compact, heavily bearded spike. It seldom grows to a height of more than three feet, the straw is stiff and carries the head erect even when ripe, thus giving it a different appearance when growing in the field from that of our common wheat. Einkorn is thought to be one of the more primitive types, and more closely related to the original forms than other types. It is grown in a limited way in the poor, stony soils of southern Europe. It has never been grown in the United States except in an experimental way.

FIG. 35. — Einkorn.

92. Spelt. — When seen growing in the field, spelt looks very much like our common wheat; but if we examine the spikelets, they will be found to be quite different from those of common wheat. The spikelets usually contain two kernels, which are tightly held within the glumes. When spelt is threshed, unlike common wheat, the kernels are not separated from the glumes, but are retained in them. Threshing does not even remove the spikelets from the rachis, but a portion of it is broken off and retained by each spikelet. Spelt, therefore, cannot well be used for making flour, but can be fed to live stock without further threshing. It is not grown in the United

States or in Canada, but it is grown in southern Europe, where it is used as feed for live stock. There are both spring and winter varieties, some of which are bearded, but almost all of which are beardless. It is doubtful if spelt will be extensively grown in any part of the United States.

Fig. 36. — Spelt.

93. Emmer. — Emmer is often confused with, and sometimes goes under the name of, spelt. The two types are, however, quite different. The stem or culm of emmer is quite frequently filled with pith, the leaves are broader, and it is more heavily bearded than spelt. The spikelets of spelt are farther apart on the rachis than those of emmer, those of the latter being quite close together, giving a compact appearance to the spike. Like spelt, the kernels of emmer are retained in the glumes after threshing. Emmer is not used for the making of flour, but is useful as a stock feed. It is grown to some extent in the northern states of the Great Plains of the United States, where it usually goes by the name of spelt. It is more drought-resistant than many of the other grain plants and therefore may develop into a useful plant in the semi-arid regions of this country. In Europe

Fig. 37. — A head of emmer.

it is grown to some extent in Russia, Germany, Italy, Spain, and in a very limited way in other countries.

94. Common wheat. — As the name indicates, this is the type most commonly grown in the wheat-growing countries of the world. The botanical characters of this type have been discussed in the preceding paragraph. The cultural methods and uses will be discussed in the following pages of the chapter.

Fig. 38. — Club wheat.

95. Club wheat. — This type of wheat gets its name from the short, compact heads, which are either square or larger at the top and taper toward the base. In this type of wheat the spikelets are very close together on the rachis, so close that sometimes they almost stand at right angles to it. Three or four grains usually develop in each spikelet. They may be either white or red, the color depending upon the variety. Club wheat has a short, stiff straw, which is less liable to lodge than the varieties of common wheat. It is also less likely to shatter, because the glumes hold the kernels more tightly, and even when the crop is fully ripe, little shattering occurs during harvesting. This type of wheat, therefore, is well adapted to the Pacific Coast region, where, on account of the absence of rainfall, it may be, and often is, left standing in the field for several weeks after ripening before it is harvested. Club wheats are heavy yielders as compared with the common wheats. While the heads are short, the spikelets are close together, and more kernels are usually produced in the spikelets than in the spikelets of common wheats. Their general methods of culture are similar to those of the common wheats.

96. Poulard wheat. — Poulard wheats are distinguished by their tall, stiff straws, sometimes filled with pith, broad, hairy, or velvety leaves, broad heads with short bristly beards, and large, hard kernels. Poulard wheats are not grown, except in an experimental way, in the United States. They are grown in Turkey, Russia, France, Egypt, and other countries bordering the Mediterranean Sea. The flour made from them is used to some extent in the manufacture of macaroni, and in the making of bread, by mixing it with flour from common wheat.

97. Durum wheat. — This type is very similar to the poulard wheats, some varieties, in fact, being hard to distinguish from them. It differs from the poulard wheat in having smooth leaves, long, heavy beards, and rather pointed, hard, semi-transparent kernels. The beards of durum wheat, together with the shape of the head, give to it, when seen at a little distance, the appearance of bearded barley. The kernels are the hardest of any of the wheats. Durum wheats are nearly all spring varieties, adapted to hot, dry climates, and grow well in soils that are slightly alkaline. They are, therefore, well adapted to the semi-arid sections of the Western States, and will grow in soils that contain too much alkali to grow the common varieties. It has been said that the introduction of the durum wheats into the United States has greatly increased our annual production of wheat by extending the wheat-growing area into the dry alkali regions, where the common varieties would not produce a profitable yield. They have been grown in the United States only within the past 30 years. Durum wheat is used largely in the making of macaroni, and is often called macaroni wheat. As yet it is not used to a great extent in the making of bread flour. Some mills, however, have milled it and placed the flour upon the market, and in the opinion of many, bread made from it is to be preferred to that made from common wheat. Durum wheat is also grown in Central and South America, Russia, and the Mediterranean countries of Europe.

FIG. 39. — Polish wheat.

98. Polish wheat. — Polish wheat has a tall, smooth, pithy straw, a large chaffy-appearing head, due to the loosely arranged spikelets, and large, long kernels. On account of the shape of the kernels, this type of wheat is sometimes called giant or Jerusalem rye. Polish wheat is well adapted to arid districts, but it is not grown in the United States except in a small way. It is grown in Russia and the countries of the Mediterranean region. It is not well adapted for bread-making, unless mixed with common wheat, and is used almost exclusively in the making of macaroni, spaghetti, and other similar products.

99. Bread wheats. — Of the eight types of wheat, only four, — namely, common, club, durum, and emmer,— are at present of economic importance in the United States. Of the eight types, only two find their greatest usefulness in the making of bread or pastries. These are the common and club wheats, which supply not only the United States, but the whole world, wherever wheat bread is used. Durum, poulard, and Polish are used only in a limited way in the making of bread, their greatest usefulness being found in the manufacture of macaroni, spaghetti, and other similar products. Emmer, spelt, and einkorn are used in the feeding of live stock. Bread wheats and those used in the making of macaroni may be classed in several different ways. They may be divided into two groups based upon the time of sowing, viz. spring or winter wheats; based on the structure of the kernel, viz. hard and soft; according to their uses, viz. bread and macaroni; according to the color of the grain, viz. red and white. Most often the classification used is a combination. Thus spring wheat may be either white or red, hard or soft, used either for bread or macaroni.

THE USES OF WHEAT

100. General uses. — The wheat crop is perhaps more closely related to the welfare of mankind than is any other crop. Almost all of the grain from the world's wheat crop is used in the manufacture of flour for human consumption, although a small amount of it is used in the feeding of animals, the grain for this purpose being principally that of poor quality and unsuitable to use in the making of flour. In the milling of wheat flour, several by-products result which are important live stock feeds, and the straw also is used for the feeding and bedding of animals. In its chemical composition and palatability, the wheat grain ranks high as a feed for live stock, but the high price per bushel which it commands for flour-making purposes prevents, excepting in years of heavy yield, its use as feed for domestic animals. The milling of wheat, the grades and kinds of flour, and the uses of the by-products of milling will be briefly taken up in the following paragraphs.

101. The evolution of the flour mill. — The story of the processes through which wheat passes, from the time it reaches the mill until it appears on our tables as bread or other baked foods, is a long one. It might be interesting to trace very briefly the evolution of the flour mill, from the time when the first miller, in prehistoric times, took the wheat grain from the stalk and used his teeth as bur stones. The simplest milling device of which we know is the hand-stone, consisting of a hollow stone into which the grain was placed, and a crusher with which to pound it. Four thousand years later came the invention of the saddle-stone, a marked improvement over the hand-stone. In using this device the grain was placed on the concave surface of the lower stone, and rubbed by the upper stone, which worked backward and forward, and not by rolling or pounding. The saddle-stone was in very general use, as is proved by the prehistoric remains of almost every European race. A contemporary of the saddle-stone was the mortar, used by the Greeks and other nations.

The first complete grinding machine came with the invention of the quern, shortly before the beginning of the Christian era. Here the grain was ground with a circular motion, and the two stones, instead of being loose, were fastened together. At first the grinding surfaces were flat, but later they were grooved. A handle, fitted into a hole drilled in the upper stone, was the means by which the miller caused the upper stone to revolve upon the lower. The quern is still commonly used in parts of Europe, Asia, China, and Japan.

Women were the millers of the races for many centuries.

Later it became the custom to compel the slaves and criminals to grind the flour and bake the bread. Still later cattle furnished the motive power, and following the cattle-mill came the water-mill, first used by the Greeks about 50 years B.C. Not until several hundred years later was the windmill invented, and from the time when it first came into use, great improvements were made in it over the original type, and its use was rapidly extended. In 1784 we have the invention of the steam-mill in London. In the year 1870 there was introduced in Minnesota a machine which was to revolutionize the milling industry in this country. The purifier, which was a machine for separating middlings and flour, enabled the miller of the Northwest to make acceptable flour from spring wheat, which had hitherto been despised on account of its dark color. During all this time the grinding surfaces of the milling machines had been mill-stones, but in 1878 there was introduced into this country the roller-mill, which marked the greatest of all advances in the milling business.

102. Modern milling. — In modern milling there are three fundamental processes, viz. cleaning, tempering, and grinding. Each of these three main processes is composed of several minor processes. The object of cleaning is to remove all dust or dirt and foreign seeds. Special machinery is used to rid the wheat of foreign seeds, after which the grain is either dry-cleaned by being run through scourers, or else it is washed and dried. The next process is tempering the grain by the application of heat and moisture, in the form of steam or water, or both. This toughens the bran so that it will not crumble into fine particles, but will break off in large pieces. Then comes the milling proper, which is quite a complicated process and cannot be explained here in detail. The grains are run, first between corrugated iron rollers, where they are cut and broken, but not crushed. This is called the first break, after which the wheat is sifted several times to separate a part of the interior from the rest of the kernel. The scalpings, as the bran and adhering portions of the interior part of the grain are called, are then run through another set of rollers, with finer corrugations, and again sifted. This process is repeated until no more of the interior may be separated. The interior of the grain thus removed is called middlings. The middlings are run through the middlings purifier. This removes the germ and small particles of bran, after which the middlings are ground between smooth rollers, sifted, and reground until they are of the required fineness, which an expert is able to determine by the feel and color of the flour.

103. Grades and kinds of flour. — Many different grades of flour result from the modern processes of milling, based upon the purity of the product, that is, freedom from germ and bran particles. The finest flour is the patent grade, which may be further graded into first and second patent, while the lowest grade is known as red dog. In all of the large mills, and in many of the smaller ones, great care is taken to maintain uniform quality in the flour. For this purpose an expert is employed to make actual baking tests of grain as it comes to the elevator, grinding the samples of wheat in a small mill made for that purpose. He compares each bake with that made from a standard flour put out by the mill.

There is some little difference in the composition of the hard or spring wheat flour of the Northwest and the soft or winter wheat flour, the spring wheat flour being stronger, that is, containing a higher percentage of gluten, the presence of which enables the yeast-leavened loaf to retain its shape. The red winter wheat flour is softer, containing more starch and less gluten, and thus is better flour for quick breads, cake, pastry, etc., although the best grades of red winter wheat flour will make very acceptable yeast bread of excellent flavor, texture, and shape. Many millers now follow the practice of blending spring and winter wheats in making flour, and thus get a very satisfactory flour for general purposes. The very soft wheats of the Pacific Coast, containing a high percentage of starch, and being very weak in gluten, are used almost entirely in the

FIG. 40. — Loaves of bread illustrating the baking qualities of flour made from different varieties of wheat.

making of pastry flour. Durum wheat flour has in the past been used chiefly in the making of macaroni and similar products, being especially well adapted to this use on account of the very high percentage of gluten which it contains. It is quite likely, however, that it will soon come into common use as bread flour. Bread made from durum flour is a rich creamy color, and has an excellent flavor.

It should be noted that there are great variations in wheat of the same kind, especially the red winter wheats, as to yield, and also as to bread-making qualities. The baking of bread with flour made from certain varieties of wheat will result in a loaf of good color and shape, fine texture, even grain, and excellent flavor, while that made from another variety of this same sort of wheat may give a loaf gray in color, coarse-textured, poor in flavor, and of poor shape. These differences are due mainly to the quality and quantity of the gluten present. A great opportunity exists for the farmer to improve the bread-making qualities of his wheat, as well as its yield.

Graham flour is wheat meal made by grinding the whole wheat kernel. As a matter of fact, however, there is very little true Graham flour on the market, the so-called Graham flour being usually a mixture of a poor grade of white flour and bran.

True whole wheat flour is similar to Graham flour, but contains only the inner layer of bran, and since the cellulose is in very finely divided particles, it is not nearly so irritating to sensitive digestive organs as is the bran in Graham flour.

104. By-products of milling. — Usually about 70 to 80 per cent of the wheat kernel, depending upon the variety of wheat, the milling process to which it is subjected, and the physical character of the grain, enters into the making of flour, the remainder forming the by-products. The principal by-products of the milling of wheat are bran, shorts, and middlings. Sometimes the lowest grade flour, called red dog, is considered a by-product and is used for feeding live stock. The bran is the outside covering of the kernel, together with the aleurone layer, and a small amount of adherent portions of the endosperm not removed in the milling process. In the milling of wheat some of the bran is reduced to rather fine particles, and this, when separated from the coarser bran, is known as shorts. The middlings contain a greater proportion of endosperm and usually more of the germ than do the bran and shorts. The germ or embryo, containing a high percentage of fat and being comparatively high in protein, does not enter into the making of flour, since it injures the keeping quality of the latter, but is removed during milling and may be added to any one of the above feeds. The by-products are excellent feed for live stock and command for this purpose a high price upon the market. Their relative composition may be seen from the following table:

	Carbo-hydrates	Protein	Fats
Entire grain	73.7	12.2	1.7
Bran	53.9	15.4	4.0
Shorts	56.8	14.9	4.5
Middlings	60.4	12.1	4.0
Red dog	56.2	19.9	6.2

PRODUCTION AND DISTRIBUTION

105. The world's production. — For the five years 1908–12, the world's wheat crop has been approximately 3500 million bushels. Of this amount, Europe produced over 1800 million bushels, or more than 50 per cent of the world's crop. North America ranks second, with a yield of 822 million bushels, a little less than one-fourth of the world's crop. The other continents contributed as follows: Asia, 480 million bushels, South America, 185 million bushels, Australia, 85 million bushels, and Africa, 75 million bushels. Of the European countries, Russia is the leading wheat-producing country, producing an average annual yield, during the above five years, of 594 million bushels. Austria-Hungary ranks second, with 233 million bushels, France third, with 316 million bushels, Italy and Germany each produce 170 million bushels, and Spain 130 million bushels. Of the other European countries, Roumania and the United Kingdom alone produced comparatively large amounts. In North America, the

United States produces 643 million bushels, or almost 80 per cent of the total crop, Canada 168 million bushels, and Mexico 11 million bushels. The United States, for the five years 1908–12, was the world's largest wheat-producing country, while Russia was a close second. In South America Argentina produces over 90 per cent of the total wheat crop of that continent. In Asia, British India produced 320 of the 480 million bushels produced by that continent. In Africa, almost all the wheat is grown in Egypt and Algeria.

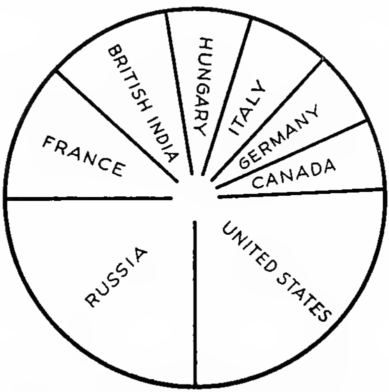

FIG. 41. — Wheat crops of the leading countries of the world.

106. Production in the United States. — About one-half of the wheat crop of the United States is produced in the North Central States, west of the Mississippi River, including Minnesota, Iowa, Missouri, North and South Dakota, Nebraska, and Kansas. About one-sixth of the crop of this country is produced in the North Central States east of the Mississippi, including Ohio, Indiana, Illinois, Michigan, and Wisconsin. The far West produces about one-sixth of our crop, while all of the rest of the states taken together produce only about 100 million bushels. For the five years 1908–12, North Dakota was the leading wheat-producing state, with an average annual yield of 90 million bushels. Other states producing large amounts were Kansas, 70 million bushels, Minnesota, 56 million bushels, Nebraska, 45 million bushels, and Washington, 44 million bushels. About one-half of the wheat produced in the United States is spring wheat.

107. Yield per acre. — The average annual yield per acre of wheat in the United States for the ten years 1903–12 was 14.1 bushels. During the same time, Germany's acre yield was 30.1 bushels, England's, 32, that of France, 21, and Russia's, 9.7 bushels. It is interesting to note that the two largest wheat-producing countries of the world obtain the lowest acre yield, and it is interesting also to speculate as to how long it will be, if the time ever does come, before these two countries, with their extensive acreage, will be able to bring their yield per acre up to Germany's present standard. At the present time the yearly world's production is none too great for the needs of its bread-eating nations, and yet the population of these nations is increasing steadily. Since almost all of the available wheat lands of the world, with the exception of a few countries, are now under cultivation, it would seem that the only means by which this increased population may be supplied with bread is in making our present wheat fields produce more abundantly.

108. The world's supply and demand. — The success or failure of the wheat crop has a more powerful influence upon the world at large than has the success or failure of any other field crop. From the time the farmer sows the seed until the crop is received by the miller, the bread-eating world anxiously watches the crop, receiving with thanksgiving news of a bountiful harvest. Unfavorable conditions of weather for its growth or harvest in any considerable area at once becomes news of international interest. The reason for this unusual interest held by the bread-eating nations is not far to seek. Wheat is an international crop, the price of which is fixed by the supply upon the world's markets. The price of the grain in countries having a surplus is dependent upon the competitive offers from importing nations. The United Kingdom, being the largest importer of wheat, fixes, to a great extent, the price of that crop in all wheat-producing and exporting countries. The United Kingdom imports annually about 180 million bushels. Germany demands 85 millions, Belgium, 70 millions, The Netherlands, 50 millions, and smaller amounts enter the ports of Italy, France, Switzerland, Sweden, Greece, Denmark, and other countries.

In all about 550 million bushels, almost as much as is produced in the United States, annually enter into international trade. The principal countries supplying this demand, with their average annual exportation for the five years 1907–11, are Russia, 140 million, Argentina, 95 million, the United States, 55 million, Canada, 50 million, Roumania, 40 million, India and Australia, 35 million each, and Belgium, 20 million bushels. It will be noted that the United States is a wheat-exporting country, but statistics show that her annual exportations are becoming less each year. Considering the present rate of increase in population, it is interesting to speculate upon the length of time that will elapse before the United States becomes a wheat-importing nation. It is interesting also to note that the exports of Argentina, which produces but one-fourth as much as the United States, are almost twice as great as the exports of this country. Argentina has great possibilities as a wheat-producing country, and undoubtedly will in the future have an important part in feeding the world.

109. Wheat districts of the United States. — When one glances over the market report from one of the large markets, it will be noticed that prices are quoted for several kinds of wheat. Thus quotations will be found on hard winter, red-winter, hard-spring, and the like. In order to understand the report, it is necessary to know something of the nature of the several kinds of wheat, the sections of the country in which they are grown, and their uses. In studying this interesting subject it will be found that wheat grown in one section of the country may be very different from that grown in another section. Based upon the character of the wheat produced, the United States may be divided into five districts somewhat overlapping, each producing a wheat differing in several respects from that produced in other sections. A brief discussion of the several districts and the character of the wheat grown in them will not only be interesting, but will be helpful in enabling one to understand the market classifications.

110. Semi-hard wheat district. — This district includes all of the states east of the Mississippi River, with the exception of northern Wisconsin. It also includes almost all of Missouri and Arkansas and eastern Texas. The wheat grown in this section of the country has a medium hard, rather starchy kernel. The color may be either red, amber, or white, red being the most common. Almost all of the wheat of this section is winter wheat. In the extreme northeastern part a small amount of spring wheat is grown, but it is used locally, very little, if any, finding its way to the large markets. The spring wheat of these states is quite similar in character to the winter wheat of the remainder of the section. The wheat of the northwestern part of this section is slightly harder than that produced in the Eastern and Southern States. Wheat which finds its way to the markets from the semi-hard wheat districts is classed on the market as "red winter" wheat. Most of the red-winter wheat that appears on the market is produced in the North Central States. In the Eastern and Southern States wheat is grown only in small amounts and is used locally. When, therefore, the market report speaks of "red-winter" wheat, it refers to that grown in Ohio, Indiana, Illinois, Kentucky, Missouri, Michigan, southern Wisconsin, and Pennsylvania. The most important varieties of semi-hard wheats are Poole, Gypsy, Mediterranean, Fultz, and Fulcaster.

111. Hard-winter district. — This district includes chiefly Kansas, Oklahoma, southern Nebraska, southern Iowa, and northern Missouri, although Montana, Idaho, Utah, and Oregon are producing large quantities. The boundaries of this district, especially the eastern boundary, are subject to change from year to year, due to seasonal variations, which influence the quality of the wheat. Thus southern Iowa wheat may sometimes be classed as "hard-winter," and at other times "red-winter." The wheat produced in this section has hard, narrow, medium-sized grains. It has excellent bread-making qualities, being considered superior for this purpose to the semi-hard wheats. The chief difference in the appearance of the wheats of these two sections is in the hardness and shape of the grain. The kernel of the hard-winter is much harder, containing very little white starch, and it is somewhat longer and narrower than the grains of the semi-hard or red-winter wheats. Wheat grown in this section is classed as "hard-winter" wheat on the market. The most important varieties of hard-winter wheat are Turkey and Karkov, the former of which was introduced from Russia some thirty years ago.

112. Hard-spring wheat district. — This section includes Minnesota, North and South Dakota, northern Wisconsin, Iowa, and Nebraska, and parts of Montana and Colorado and Canada. The wheat produced in this section is sown in the spring and has rather small, short, hard grains. It is the most highly prized for bread-making of any wheat grown in the United States. This section produces over 30 per cent of the total crop of the United States and is the center of the milling district. The wheat of this section differs from that of the hard winter district in that it is spring sown, the kernels are harder, somewhat shorter, and it makes a slightly better quality of bread flour. There are two important varieties of hard spring wheats, namely, — the fife and blue-stem, while a third, the bearded fife, or so-called "velvet chaff," is also commonly grown.

113. Soft wheat district. — This district in a general way includes the states west of the hard winter and hard spring districts. The wheat of this section is both fall and spring sown, and the kernels may be either red or white in color. The largest part of the crop of this section is spring sown, and produces white kernels. California, Washington, and Oregon produce most of the wheat grown in this section. Scattered portions of the Rocky Mountain States produce small amounts by means of irrigation. The wheat of this section is characterized by a soft, plump, starchy red or white kernel. The district is sometimes called the white wheat district, because most of the wheat has white, starchy kernels. The wheats of this section are not well adapted to the making of bread flour, and are used largely for export to the Orient, and in the making of pastry flour. Much of the wheat produced in this section is the *Triticum sativum compactum*, or club wheat, a most important variety of which is Little Club, known also as California Club, Washington Club, Walla Walla Club, Silver Club, and the like. Other varieties commonly grown are Oregon Red-chaff, Dale's Glory, and Crookneck Club. The leading common wheats in the soft wheat district of the West are White Australian, a beardless variety largely grown in California, Sonora, a beardless brown-chaff variety grown in California and Oregon, and Palouse Bluestem, a semi-hard spring variety, closely related to fife wheat, and grown in Washington and Oregon. Some few varieties, the most common of which are Dawson's Golden Chaff and Gold Coin, grown in Ohio, New York, and adjacent states, grade on the market as soft wheats.

114. Durum wheat district. — Durum wheat is grown principally in the east and central parts of the Dakotas, in Colorado, Montana, Kansas, Nebraska, and in smaller areas in adjacent states. This section, therefore, overlaps both that of the hard winter and the hard spring districts. Durum wheat is grown largely in sections of these states where conditions are not favorable for the growing of hard winter or hard spring wheat. It will grow in more arid sections and with less rainfall than will produce a profitable crop of either of the other sorts. Usually when either hard winter or hard spring varieties can be grown with profit, they are preferred to durum. The important varieties of durum wheat are Kubanka and Arnantka. For some years after its introduction durum wheat sold at a discount ranging from 25 to 15 cents per bushel below common hard wheat. This prejudice has gradually decreased, however, and during the past year durum wheat has sold at a premium over equal grades of hard spring common wheat.

ADAPTATION

115. Climatic adaptation. — The wheat plant has a wide climatic adaptation which in no little measure is responsible for its world-wide importance. If it were a plant adapted only to certain restricted climates, it never could have gained the place of preëminence which it now holds among the nations of the world. In a general way, however, the world's wheat crop is grown in regions of cold winters. Exceptions to this are to be found in India and Egypt and in California. Wheat, for its best development, requires that the plants make their early growth during the cool part of the growing season. This is true for both fall and spring varieties. If planted in the season of the year when early growth is made during hot weather, little stooling results and low yields are secured. While wheat has a wide climatic range, climate has a marked influence upon the quality of it. The division of the United States into wheat districts, which has just been discussed, has been due largely to the influence of climate in the various sections of the country upon the physical character of the grain. Wheat of the best quality is produced in sections having a cool and rather wet growing season during the early life of the plant, followed by rather hot, dry, sunshiny weather during the ripening period. When these conditions prevail, the largest yields are secured and the grain is of the best quality. Under these conditions of growth the kernels are rather hard and flinty and contain a relatively high percentage of protein and low percentage of starch. In sections where rainfall is plentiful and damp weather prevails during the ripening period, the kernels are soft and starchy, containing a relatively high percentage of starch and low percentage of protein. This difference in the physical character of the kernel is due, in part, to the fact that if favorable growing weather prevails during the ripening period, the plant continues its growth until the starch cells of the kernels are completely filled, which gives to the kernel a light color and a soft, starchy endosperm. If, however, hot, dry weather prevails during the ripening period, the plant ripens prematurely, and before all of the starch cells of the kernel have been filled by the transfer of starch from the leaves and stem to the kernel. The starch cells, therefore, not being completely filled, give to the kernels a hard and flinty texture and a rather dark color. In the Pacific Coast States, where soft wheats are produced, rather little rain falls during the growing season, but it falls in abundance during the winter, and since the soils of this section have great water-holding capacity, the plant is well supplied with moisture during its full period of growth. Some of the difference in the physical characters between hard and soft wheats may perhaps be due in part to a difference in the size of the starch cells, as revealed by microscopic examination, those of the soft wheats being the larger.

116. Adaptation to soil. — In addition to its adaptation to climate, wheat will grow well under greatly varying soil conditions. The soil, unlike climate, has no noticeable effect upon the quality of the grain, but it is of considerable importance when the yield is considered. Like almost all crops, wheat yields the best on fertile soils, although good yields may be secured on rather poor types of soils if proper fertilization and cultural methods are employed in growing it. As a general thing, wheat is better adapted to the so-called "grass lands" or clay loam soils, than to the more fertile "corn soils" that are abundantly supplied with organic matter. Winter killing is less likely to occur on clay than on loamy soils, and comparatively better yields of wheat are secured on this type than are obtained from corn soils.

METHODS OF CULTURE

117. Place in the rotation. — In the corn belt states where both corn and oats are grown in the rotation, the usual sequence is corn, oats, wheat, hay. When wheat, is the only grain crop in rotation, the wheat follows corn, and it is in turn followed by hay. While a corn, wheat, and oat rotation is usually a three-year rotation, it may, by cutting hay from the field for two years, be extended to four years. In parts of the Great Plains area, wheat is grown in continuous culture, largely because farming operations are so extensive that a rotation cannot well be practiced. As the population increases, the size of farms will decrease and after a few years, perhaps, a well-defined rotation will have become the usual practice there.

118. Preparing the seed bed. — The method of preparing the seed bed for wheat, of course, will be influenced by the rotation practiced and whether it is seeded in the fall or spring. In the winter wheat sections, when a four-year rotation is followed, the oat stubble land must be prepared for wheat. The most common method, perhaps, is that of plowing the land a few weeks before the time of seeding. In recent years the disking of the land instead of plowing has become a common practice. Whether plowing or disking is the method employed, an important factor, probably the most important factor in many cases, is the handling of the soil in such a way as to retain as much of the season's rainfall stored in the soil as possible. Moisture is often a factor which determines whether or not the plants will make a successful growth before winter. The handling of the soil in such a way as to retain moisture and to permit its rise from the subsoil by capillarity is of even more importance in preparing

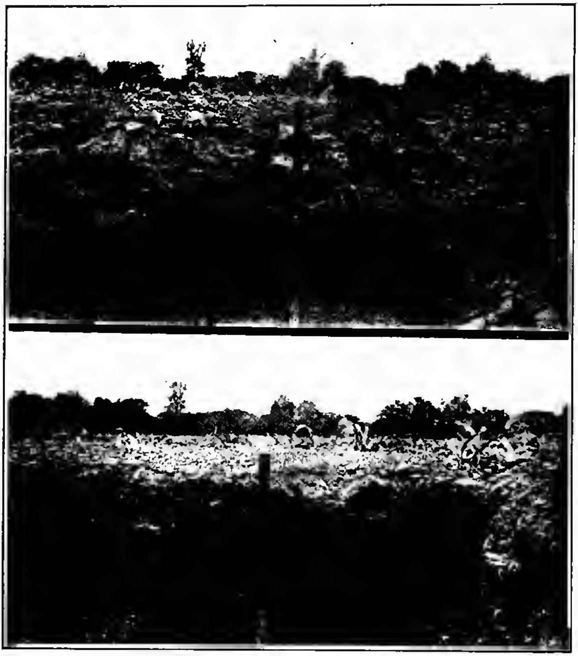

Fig. 42. — Cross section of a poorly and of a well prepared seed bed.

the land for fall wheat than for corn. Corn is planted in the spring when showers are frequent, and usually rain falls in sufficient quantity within a few days of the planting to supply the needed water for early germination, while at wheat-planting time rain falls rather infrequently in many sections, and unless the soil is prepared so as to permit the water to come up from the subsoil to supply water necessary for germination, the latter may be delayed for several weeks. In preparing the soil for wheat, the same general principles will be involved as were discussed in the corresponding part of the chapter on corn. Oat stubble should be plowed or disked as soon as the oats can be removed from the field, and the land further prepared by frequent harrowing so as to prevent rapid loss of moisture until the seed is planted. Sometimes it is advisable and entirely practical to disk the land before plowing it. This renders the further preparation less difficult and often saves much time as compared with plowing only. In the three-year rotation, wheat most often follows corn. Usually corn land cannot be given much preparation before seeding the wheat, since the corn remains on the field until, or even after, the wheat is sown. However, much can be done to prepare the seed bed for wheat, both in pulverizing the soil and keeping it free from weeds by careful cultivation of the corn crop. Sometimes a light drag may well be run ahead of the drill to loosen up the soil. This practice is often followed when the wheat is drilled in the standing corn. If an early variety of corn is grown, it may usually be put into the shock before wheat seeding, in which case a disk or cultivator may be employed to prepare the ground for sowing. For spring wheat the land may be either plowed in the fall or early in the spring. The preparation of the seed bed from fall or spring plowed land does not differ from the practices already described.

119. Preparation of wheat for seeding. — Wheat to be used for seeding should be run through the fanning mill to remove the weed seeds, dirt, chaff, and damaged kernels. After the wheat has been thoroughly cleaned by the use of the fanning mill, it is usually profitable to treat it for the prevention of stinking smut, a fungous disease that does considerable damage and sometimes destroys as much as 10 per cent of the crop. This fungus will be described elsewhere in the chapter, and only the method of treating the seed for its control will be discussed here. The fungus spores of the stinking smut of wheat and of the loose smut of oats may be killed by treating the seed grain in the following way: Take a pound of formalin (formaldehyde, 40 per cent), dissolve it in 50 gallons of water, spread the grain out on the clean floor, and wet it thoroughly with the solution, using about three quarts to a gallon for each bushel of the grain. The work can be done easily and thoroughly if one person shovels the wheat over while another applies the solution with the sprinkling can, then stack the grain up in a pile or in a long rick, and cover over with carpets and blankets to retain the fumes from the formalin, and allow to remain for two or three hours, or even over night. Then spread the grain out to dry before seeding. It should not be returned to the same bags unless they have been treated with the solution, as they may contain spores that will again infect the grain. The drill box also should be sprayed with the solution.

120. Time and rate of seeding. — The time of seeding wheat, of course, varies with the locality. In the winter-wheat districts the seeding is done early enough in the fall to permit the plants to become well established before winter. In the red-winter wheat section almost all of the wheat is seeded during September; in the northern portion the seeding is done during the early part of the month, while in the southern portion it is usually delayed until the last of September or even until October. In the Southern States it may be seeded even later than that. If seeded too early, too much growth is made before cold weather, and many of the plants are likely to be winter-killed; but if delayed too long, sufficient growth cannot be made to enable the plants to withstand the winter. The practice of the best farmers of any section may usually be used as a guide for the proper time of seeding. Spring wheat usually does better if the seeding is done early, since the plants make their best growth during the cool weather of spring. Early seeding also avoids to a considerable extent the attacks of insects and permits the crop to ripen and be harvested before the more severe storms of late summer.

121. Method and depth of seeding. — Almost all of the wheat in the United States is now seeded with a grain drill, in some few places, however, broadcasting being still practiced. Seeding with the grain drill is to be recommended in almost all cases. The depth of seeding depends to some extent upon the condition of the seed bed. In a well-prepared bed the seed should not be put down deeply into the ground, usually one to two inches being a sufficient depth. Some farmers plant the seed deeply, in order, as they believe, to insure a deep root system and prevent winter killing. Deep seeding, of course, does not insure a deep root system, as has previously been explained. It is necessary in a poorly prepared seed bed to put the seed down somewhat deeper in order to place it where it can get sufficient moisture to germinate and also in order that there may be enough loose soil to cover it.

122. Cultivation of wheat. — Wheat is not usually cultivated after seeding, but some growers follow the practice of harrowing fall-sown wheat in the spring. This breaks up the surface crust and prevents the evaporation of moisture. Experiment station tests of this practice seem to indicate that harrowing wheat is profitable if the season is a dry one, this practice sometimes increasing the yield as much as 6 or 7 bushels per acre. In these experiments, harrowing was not found to decrease the yield during any season. Rolling the wheat in the spring has also given good results, in some cases better than harrowing.

HARVESTING AND STORING

123. Harvesting. — In some part of the world, wheat is being harvested during each month in the year. In the

FIG. 43. — Harvesting wheat with a grain binder.

southern part of the United States wheat harvest begins in May, and as the season advances progresses northward, the more northerly fields being cut in August. Almost all of the wheat crop in this country is harvested as soon as it is ripe. However, in certain sections of the wheat growing districts along the Pacific Coast it is allowed to stand in the field for several weeks before harvesting. In the corn belt states the harvesting must be done as soon as the crop is ripe, or much will be lost from shattering. Sometimes it is advisable even to cut it before it is fully matured in order to prevent loss from shattering. Wheat may be cut without loss in yield or injury to the quality after the straw has turned yellow and the grain is in the hard dough stage. When cut at this time, the bundles should be promptly set up in shocks, or else the hot sun will stop the transfer of starch from the leaves

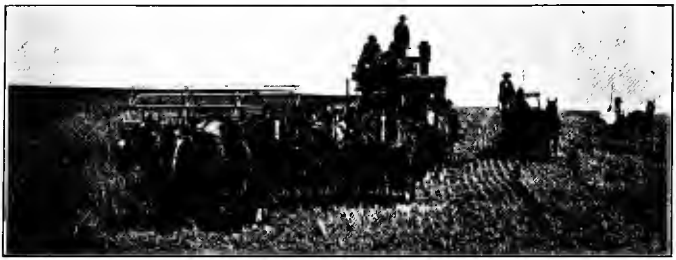

Fig. 44. — A combination harvester and thrasher at work in the far West.

and stem to the grain. Prompt shocking is desirable also to prevent bleaching and injury from rain and dew and usually it should be done if possible the same day the wheat is cut. Wheat shocks usually are made somewhat larger than those of oats, since the grain and straw dry out more rapidly. Usually twelve bundles are set together to form a shock. Thrashing may be done directly from the field or the bundles may be stacked or stored in the barn for later thrashing. On the large wheat farms of the Western States a combination harvester and thrasher is employed. This outfit represents a considerable investment of capital and also requires considerable motive power, usually

28 mules or a tractor engine being required. It can be used with profit only when extensive acreages are grown in one field.

124. Storing of wheat. — Thrashed grain may be stored safely in any tight bin or granary. Owing to the dry weather of the Pacific Coast States, thrashed grain is frequently allowed to remain in the field until marketed, or even after marketing it may be stored by piling the

FIG. 45. — Thrashing wheat in the Northwest.

bags in great heaps out in the open. The moisture content of thrashed grains varies with the humidity of the atmosphere. When wheat is shipped from a dry to humid climate, frequently the increase in weight is enough to pay for the transportation.

IMPROVEMENT OF WHEAT

125. Opportunities for improvement. — With the acre yield of wheat less than 15 bushels in great agricultural countries like the United States and Canada, it would seem that there is an abundance of opportunity for increasing our production. Much that has been said and done about this important problem has been along the line of soil improvement, and comparatively little has been done in the way of improving the plant itself. The importance of the problem is so far-reaching that it would seem advisable to employ both methods in order to bring about a larger production. Much is possible along the line of plant improvement, and every wheat grower should be content only after he is satisfied that further improvement is impossible.

126. The variety test. — No one best method for the improvement of the small grain crops has yet been advanced. There still remain great opportunities for improvement in methods and the extending of their practices. From our present knowledge of crop improvement, the first step in this direction is the variety test. The variety test is so easily conducted that no wheat grower should long be in doubt as to whether or not he can increase his production by securing seed of a different variety from that which he is now growing. Frequently an increase of several bushels per acre may be secured by the growing of a better adapted variety. It is the purpose of the variety test to determine which variety or strain is best adapted to a given soil for a series of years. The variety test may be conducted with few or with several varieties. Any farmer can conduct a test with a few of the most prominent varieties without great inconvenience. The variety test consists in growing several varieties side by side under uniform conditions of soil and culture. The farmer may find it convenient to seed one or two rounds of each variety with the drill, comparing the yield and the quality of the crop at harvest time. More accurate results are secured if one variety is used as a check, as was explained in the

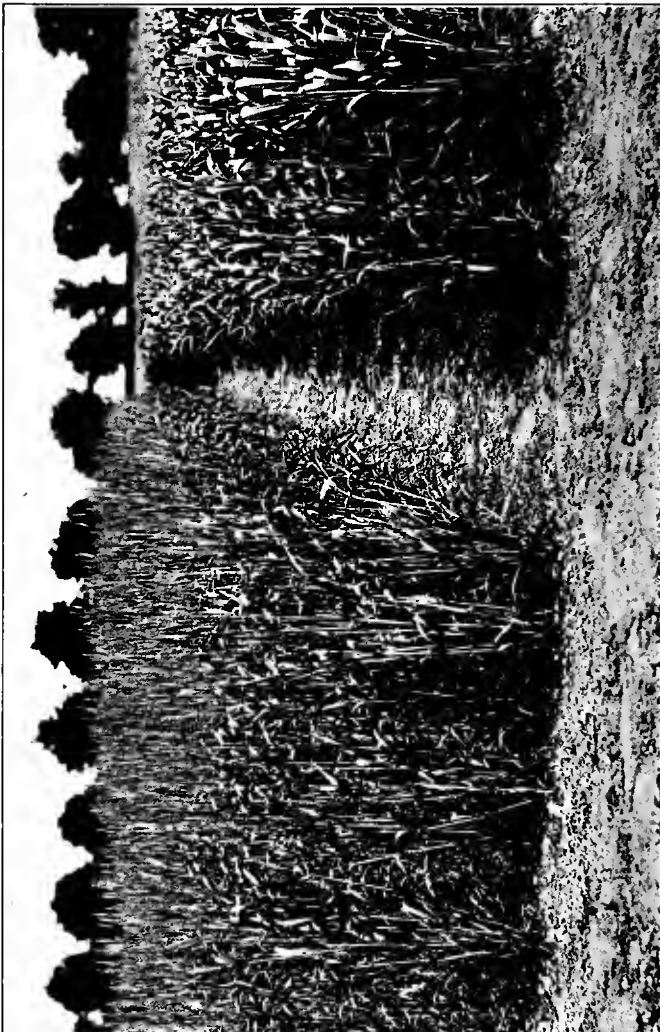

FIG. 46. — Variety test of wheat showing difference in earliness. Plot at left is marquis, an early type developed by C. E. Saunders of the Dominion of Canada Experimental Farms, which is proving very successful in the far Northwest, where the growing season is very short.

paragraph on the improvement of corn. More careful experimenters will desire to measure off accurately a fraction of an acre for each variety. The test is most valuable when it has been carried on for several years on the same farm, since the influence of seasonal conditions may be more accurately determined.

127. The head-row test. — When the best variety has been selected, still further opportunity for improvement is to be found in the selection of the highest yielding plants in this variety. Individual plants like ears of corn vary markedly in their ability to yield. If, therefore, the high-yielding plants can be found and used for perpetuation, great opportunities for increasing the yield are possible.

Fig. 47. — Head-row test at the Ohio Station showing variation in erectness of heads.

The method of making this selection is known as the head-row test. This test consists in going into the field at harvest time and selecting under normal conditions of growth a number of the most promising individuals. From 25 to 1000 heads, representing as many plants, may be selected. Their ability to yield is then determined by planting a short row, usually about four feet long, from each head the next season. A check system should be used to secure a reliable test, and a composite sample from the general seed may be used for planting the check rows, usually every tenth row being planted as a check. At harvest time each row is carefully studied, special notice being given to winter killing, stiffness of straw, time of ripening, and other qualities. If each row is harvested and thrashed separately, comparative yields may be secured. The grain from the most promising rows is used to plant a larger crop the next season, which will give another opportunity for study and selection of the most promising strains. In a few years enough seed will be secured to seed a small field, and later the entire crop, if the selection proves to be more desirable than the

Fig. 48. — Head-row test showing varieties in yield of straw and grain (Ohio Experiment Station).

seed from the general crop. This method of improvement has great possibilities. At some of the experiment stations strains have been developed from single heads that not only outyielded the parent variety, but also were superior to it in the stiffness of the straw and other qualities. Wheat improvement by the head-row method is less difficult than that of corn by the ear-row method, since wheat is usually self-fertilized and no precautions are necessary to prevent intercrossing as must be taken in corn improvement.

FIG. 49. — Harvesting wheat plots at Cornell University.

128. Wheat judging. — Samples of thrashed grain may be judged from the standpoint of its use as seed or for flour or bread-making qualities. Usually in competitive shows wheat is judged from the milling standpoint. Before one can judge wheat quickly and accurately from any standpoint, it is necessary to become familiar with the points that are of importance in determining the value of the sample. This familiarity can be gained from careful study or long experience. The student, necessarily, on account of limited time, must gain his knowledge by careful study. This study should be such as to enable him to quickly see in a sample both the good and bad points, and with both in view to arrive at an accurate decision. By carefully analyzing several samples, especially prepared for the purpose, experience will be gained that will enable the student to analyze more easily any sample, without making the actual separations.

FUNGOUS DISEASES AND INSECT ENEMIES

129. Fungous Diseases. — Wheat is attacked by three important and several minor fungous diseases. The most important are the smuts. There are two kinds, namely, the loose and the stinking smuts. The loose smut, while it is widely spread, is not as destructive as the stinking smut. In the field, the loose smut is easily recognized, since it has converted the heads into black, powdery masses before they appear above the leaf sheath. The spores are soon blown away by the wind and only the naked stem remains at harvest time. It may be controlled by a hot water treatment of the seed, but this treatment is rather unsatisfactory and is not generally practiced.

The stinking smut is not so readily recognized in the field, but at thrashing time the presence of the dusty, ill-smelling spores indicates its presence. If a grain of wheat affected by the stinking smut be cut open, it will be found to contain no endosperm, but in its place the black, stinking spores. Methods for its treatment have been given elsewhere. (See page 132.)

The rusts of wheat occasionally damage the crop to a considerable extent. They are recognized by the rusty brown and black spores that attack the stem and leaves of the plant during any stage of its growth. The damage done by rusts depends to a considerable extent upon weather conditions. Some seasons the damage may be little, while in favorable years for its growth the crop may be almost entirely ruined. There is no effective remedy for the control of the rusts.

The scab attacks the glumes of the plant, and is widely distributed. It seldom causes serious loss, although occasionally much shriveled wheat results from its ravages.

130. The Insects. — The Hessian fly is probably the most destructive of the insects that attack the wheat plant. It is found in the main wheat-growing regions of eastern United States, Canada, and many other principal wheat-growing countries of the world. The adult has the appearance of a mosquito, and the female lays her eggs in irregular rows on the lower leaves of the wheat plants soon after they are up. In a few days the eggs hatch and the small, reddish larvæ, which later turn white, crawl down the stem between the stem and the leaf sheath, and when located there, cause a small enlargement on the plant at the point of attack. In a few weeks they reach the pupa stage, in which form they resemble a flax seed, and in this form they pass the winter. In the spring the adult appears and lays eggs for another brood. The first indication usually of the presence of the insects is when the young plants turn yellow, and in later growth, when the straw falls. The most effective method of control is the delaying of the seeding of the wheat for a week or ten days after the normal date of seeding, and usually the females will have come and gone before the wheat is up. A trap crop may be seeded early in the season and then plowed under deeply after the eggs have been laid. It is estimated that the annual loss of wheat in the United States from the attacks of this insect is over 4 million bushels.

131. The Chinch Bug. — During the winter the chinch bugs hibernate in the grass or under rubbish, and in the spring the females fly to the wheat fields, where each lays from 100 to 200 eggs on the base of the wheat plants. In about three weeks the eggs hatch and the young insects commence to sap the juices from the plants. The bugs pass through six stages before they become full grown. They live on the wheat for some time, or until harvest, when they migrate to the oats or corn. Although the adults have wings, they travel on foot from plant to plant and from field to field. The eggs for the second brood are laid on the corn plants, and when the insects mature, they fly to the grass lands for the winter. The control of this pest is accomplished in most cases by burning the grass and rubbish early in the spring, thus destroying the adults before the eggs are laid. Since they travel on foot, it is sometimes possible to keep them from passing from one field to another by spreading a narrow strip of tar between the infected field and the one to be protected.

Many of the insects may be killed by placing post holes every few rods and connecting them with strips of tar. The insects will follow the tar and finally fall into the holes, where they may be destroyed. Other insects are in certain seasons very destructive to the crop, but the ones discussed are the most important.

CHAPTER VI

OATS

THE cultivation of oats is of more recent date than that of wheat and barley. They were not grown by the ancient Greeks and Egyptians, but probably were cultivated at an early date by the less civilized people that inhabited east central Europe, which is thought to be the original home of this crop. Oats were less important than wheat and barley in the early development of southern Europe, but came into importance with the civilization and development of the central and northern portions of this country, and have until the present time been one of the important cereals in these sections. Cultivated oats have probably been derived from a wild species, *Avena fatua,* which is found growing wild in many parts of the country. The oat plant is closely related to the tall oat grass which is cultivated to some extent in Europe and in the United States for forage. It is also closely related to the wild oat, *Avena sterilis,* which in many parts of the country is found growing wild.

132. Botanical characters. — The oat, *Avena sativa,* like the other cereals, is an annual grass with jointed stems and a fibrous root system. The roots in their manner of growth are similar to those of wheat, although as a rule they do not penetrate the ground so deeply. The stems are somewhat coarser and larger in diameter than those of wheat, and are greatly influenced in number and in the height to which they grow by environment. Usually one seed produces from three to seven stems and their height varies from 2 to 5 or more feet, the average probably being about 3½ feet. The height of the stems depends to a considerable extent upon the fertility of the soil, and to some extent upon the variety and the rate of planting.

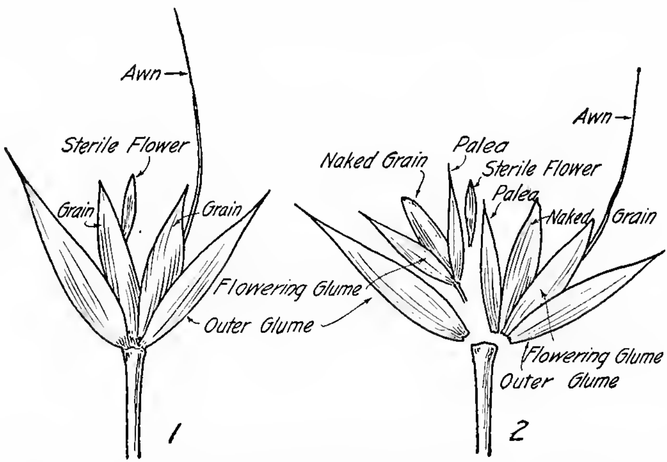

FIG. 50. — Spikelet of oats. Number 1 shows parts in position, Number 2, spikelet dissected.

133. The leaves. — The leaves are broader and more numerous than those of wheat, and the blade varies in length from 6 to 15 inches. On account of their large and more numerous leaves, oats are not as desirable a nurse crop for clovers or grasses as is wheat or barley. The proportion of straw to grain is more variable than that of wheat, varying in this respect from 1.3 to 4 or more pounds of straw for each pound of grain.

134. The flower. — The inflorescence is in the form of a panicle, which consists of a central stem or rachis, the nodes of which are comparatively few and far apart, and from each node several small branches are given off. The branches coming from a single node are called collectively a whorl, the number of whorls, therefore, corresponding to the number of nodes, which varies from 3 to 6. The number of branches per whorl varies from 2 to 5 or more. The branches are of various lengths, those of the lower whorls being longer usually than those of the upper whorls. The branches from the same whorl vary in length, some of them rebranching. The spikelets are carried at the end of rather long pedicels. The number of spikelets per panicle may vary from 30 to 70 or more. Each spikelet is made up of two large, chaffy outer glumes which inclose two or more flowers, usually only two of which produce kernels. The flowers are made up of three stamens and a branched, feathery stigma and ovule. The flowers open only for a few hours, and almost always fertilization has been effected before they open. Thus oats are usually self-pollinated and there is little danger of mixing when two varieties are grown side by side.

The developed kernel remains tightly inclosed within the flowering glume and palea. The two kernels of a spikelet are of unequal size, the lower one being the larger. If three flowers develop, as is quite commonly the case, the third kernel is the smallest of the three, and usually is so small as to be of little value. In some varieties the flowering glume bears a small awn, or beard, which, unlike that of wheat or barley, does not come from the tip of the glume, but arises from a point about two-thirds of the distance from the base. The oat grain, as the term is commonly used, refers to the flowering glume and palea, or the hull together with the inclosed kernel. The proportion of hull to kernel varies with the variety and with

FIG. 51. — Side panicle of oats.

the environment of growth. The percentage of hull varies from 20 to 40 or more per cent, the average being about

30 per cent. When grown under unfavorable conditions, the percentage of hull is relatively high, while favorable conditions for growth produce short, plump grains, with a relatively low percentage of hull. The size, shape, and color of the grain vary with the conditions of growth, and with the variety. The most common colors are white and yellow, although quite a few varieties are black, gray, or red in color. The legal weight per bushel in most states is 32 pounds. However, the weight per measured bushel varies with the variety, the season, and the time of cutting, and due to these factors, will sometimes show a range of from 20 to 50 pounds per bushel.

FIG. 52. — Branched panicle of oats.

"Clipped oats" is a market term employed to define oats that have had a part of the hull clipped off by machinery to reduce the percentage of hull and increase the weight per bushel. The standard weight per bushel for clipped oats in most markets is 45 pounds.

135. Types of oats. — Oats may be divided according to the appearance of the panicle into two classes, spreading or open, and side or closed. In the spreading sort the branches of the panicle stand out at different angles from the rachis, giving the panicle an open appearance, while in the side oats the branches grow more or less upright, giving a closed appearance, and are arranged on one side of the rachis. The spreading type is the more commonly grown. Oats may also be classified into spring and winter varieties. The winter varieties, like winter wheat, are seeded in the fall and harvested the next summer. Winter varieties are grown only in sections of the country having mild, open winters, like those prevailing in the Southern States and along the Pacific Coast. Oats are sometimes divided into early, medium, and late varieties, based upon the time of ripening. Usually the early varieties have short straw and small grains, while the later varieties grow taller and as a rule have larger and plumper grains. Sixty-day and Burt are well-known early varieties, while the Swedish Select, Siberian, Big Four, and American Banner are the more common medium and late varieties. On the market, oats are classified according to the color of the grain, as white, black, and mixed oats.

USES OF OATS

136. The grain as food. — By far the greater part of our oat crop is used for feeding live stock. Oats are relatively high in protein and are therefore useful for feeding to young animals, as they furnish a large amount of muscle-building material. They have long been held in high esteem for feeding horses, particularly those at heavy work, many horsemen preferring them to any other grain feed. For horses they are not usually ground, and they may either be fed alone or in combination with other grains. They are highly prized for feeding sheep, especially ewes and growing lambs. They may also be fed to hogs and cattle, and for this purpose they are usually ground, often in combination with other grains. Not a little of our oat crop is used for human food, almost all of that which is used in this country being in the form of "rolled oats." Rolled oats are prepared for use by removing the hull and then flaking the kernels by running them between heavy rollers to press them into thin flakes. In this form they are boxed and placed on the market. To prepare them for serving, they must be cooked in water for some time in order to break down the cellulose and render the starch grains thoroughly cooked. Only the best grades of oats are used for making rolled oats, and grain for this purpose commands the highest price on the market. Oats have long been used in Europe for food, especially in Scotland, where they hold an important place in the dietary of the people, being used there largely in the form of oat meal or ground oats.

137. Use as forage. — Oat straw is highly prized for feeding live stock, since it is more readily eaten and contains greater feeding value than the straw from other cereals. It is frequently used as roughage for keeping stock over the winter, but it should not be used extensively for feeding growing stock, milch cows, or horses at work. Oat straw is also valuable for bedding, since it is rather less harsh than other straws, contains no beards, and absorbs liquids quite readily.

Sometimes oats are cut for hay or used for pasture or for soiling purposes. When used for hay, they should be cut when the grains are in the dough stage. Oat hay is very palatable and possesses high feeding value. The quality and feeding value is greatly improved, however, if field peas are seeded with the oats. The rate of seeding and time of cutting this combination crop is discussed in the paragraph on field peas. Oats may be used to supply quick temporary pasture for all kinds of stock, and when grown for that purpose or for hay, a large growing, broad leafed variety should be selected.

PRODUCTION AND DISTRIBUTION

138. The world's production. — The world's production of oats in bushels is greater than that of any other cereal, but on account of the lighter weight per bushel is exceeded in total number of pounds by corn and wheat. The world's annual production for the five years 1907–1911 is approximately 4000 million bushels, or slightly greater than the amount of corn and wheat grown. Of this amount the United States produced the largest amount, having an average annual production of 945 million bushels. During the same period European Russia produced annually 885 million bushels, Germany, 585 million bushels, Canada, 315 million bushels, France, 303 million bushels, and Austria-Hungary, 254 million bushels. Other countries in which the crop is important, but which, on account of their smaller acreage, do not have a large total production, are the United Kingdom, Belgium, Denmark, and Sweden.

139. Production in the United States. — In the United States oats rank second to corn in the number of bushels produced, but are exceeded in value by corn, cotton, hay, and wheat. A large proportion of the oat crop of the

United States is produced in the Central, North Central, and adjacent states. Iowa is the largest producer, with Illinois a close second, each state devoting more than 10 per cent of her total land area to this crop, and together producing more than one-fourth of the total crop for this country. Other states devoting large areas and having a large production are Wisconsin, Minnesota, Nebraska, Ohio, Indiana, Michigan, the Dakotas, Kansas, Pennsylvania, Texas, and Missouri. The area devoted to oats in the Southern States of the United States comprises less than 12 per cent of the total acreage of that section, and furnishes less than 9 per cent of the total production of the United States.

140. Yield per acre. — The highest yield per acre is obtained in Germany, where for the ten years 1902–1911 the average annual yield per acre is 51.4 bushels. The United Kingdom ranks next with 44.7 bushels per acre for the same period. France secures 30 bushels, Austria-Hungary, 31, and the United States, 29.4 bushels per acre. While the average yield per acre is relatively low for the United States, some few states, those that grow but small acreages, usually by the aid of irrigation, produce yields rivaling those of Germany. The state of Washington for the ten years 1902–1911 has an average annual yield of 47.6 bushels per acre. This record was made, however, on a comparatively small acreage artificially supplied with water, and is not to be compared with the yield secured by other states on larger areas without irrigation. The great oat-producing states, however, secure only from 25 to 35 bushels per acre, while in the Southern States the average yield per acre is less than 22 bushels.

141. Exports and imports. — For the five years 1907–1911 the United States exported annually 2,090,000 bushels of oats and imported annually 1,665,000 bushels. Much of the export goes to European markets, where a crop shortage usually exists. The import is largely from Canada, and smaller amounts come from northern Europe for seed purposes. Sometimes in years of crop shortage here, oats are imported from countries other than Canada, usually from Argentina.

ADAPTATION

142. Climate. — Oats are best adapted to a cool, moist climate, and reach their best development in Great Britain, Norway, Germany, Canada, and the northern part of the United States. They do not grow well in hot climates unless favored with an abundance of rainfall, and are therefore not as productive in the southern part of the United States as they are farther north. Not only does the climate affect the yield, but it also has a considerable influence upon the physical character of the grain. Varieties grown in warm climates are usually less plump and have a lighter weight per bushel than those grown in cooler climates. When grown in warm climates, frequently long awns are produced and the grains are often a gray or dun color, with a high percentage of hull. Northern grown varieties more often have short, plump grains, with a short awn, low percentage of hull, and high weight per bushel. Sometimes growers secure their seed every few years from states farther north, with a view to improving the crop and increasing the yield above that secured from native seed. Experiments at the Ohio and Iowa stations indicate that little improvement may be expected from this practice. At the Ohio Station seed secured from northern states did not produce better than home grown seed of the same variety.

143. Soils. — Oats have a wide adaptation to soils, and fair yields may be secured on almost all types of soils in cool, moist climates. They have a wider adaptation to soils than almost any of the other cereals. Of course much better yields are secured from fertile than from poor soils, but compared with other cereals good yields may be secured on relatively poor lands. Oats draw rather more heavily upon the moisture of a soil than any of the other cereals, and soils that retain moisture well are best adapted to their culture. On very fertile soils they are likely to produce a rank growth of stem, and quite frequently, under such conditions, lodge badly and produce correspondingly more straw than grain. This tendency to lodge is a serious objection to their use as a nurse crop for clovers or grasses, since the latter may be smothered out by them. On fertile soils the grower should select a short strawed, early variety which may be harvested before summer storms lay it low.

METHODS OF CULTURE

144. Place in the rotation. — In the corn belt states oats usually follow corn in the rotation. A common four-year rotation is corn, oats, wheat, and hay. When wheat is omitted, corn, oats, and hay form the usual sequence. The rotation may be extended to cover four years by allowing the meadow to stand for two years. In the South, where winter oats are principally grown and cotton enters into the rotation, a common sequence is cotton, corn, and oats. Frequently a catch crop of cowpeas or bur clover is used between the corn and oats, and also between oats and cotton. When the oat is the only small grain grown in the rotation, it is frequently used, especially in the corn belt states, as a nurse crop for clovers and grasses. Oats are not so good for this purpose as wheat or barley, because they start growth early and grow rapidly, drawing heavily upon the moisture in the soil, thus frequently preventing the grass and clover from getting a good start. Oats, having wider leaves than wheat and barley, are likely to produce too much shade to render them an ideal nurse crop. In fertile soils, they are more likely to lodge and smother out the young plants. Another reason why oats are not so desirable as wheat and barley in which to seed grasses and clovers is that they do not ripen so early as either of the other two, and are therefore not removed from the field until later in the season, thus retarding the new growth until late in the summer. Many farmers succeed in getting good stands of grasses and clovers in oats, but where this practice is followed, the best results are obtained by using an early variety of oats.

145. Preparing the seed bed. — Perhaps none of the grain crops are seeded with as little preparation of the ground as are oats. This is due in part to the hardiness of the plant and in part to the desire to get the crop in early so as not to delay the planting of other spring crops, such as corn. In many places, oats are seeded on the corn ground without any previous preparation. Sometimes they are sown broadcast and covered with a disk while in other cases they are sown with a disk drill. Some farmers follow the practice of breaking up the soil with a disk or spring tooth harrow, and then leveling it with a smoothing harrow before seeding. Still others plow the land and further fit it with the harrow. The best practice to follow will depend largely upon the nature of the soil, and upon the amount of time available for seeding the crop. On some types of soil the increase of yield obtained by plowing the land, over that secured by disking, or even entire lack of preparation, is not enough to pay for the extra labor involved. At the Ohio Station an experiment on silt loam soil, extending over a period of four years, resulted in higher yields from the practice of disking than from either no preparation or plowing. On some types of soil it is probable that disking would not result in an increased yield sufficient to justify the extra labor, while with other soils, particularly those which are weedy, plowing may be desirable. Oats may either be sown broadcast and covered with a disk or spike toothed harrow, or they may be sown with a grain drill. The latter method is to be recommended, as a more uniform stand may be secured and usually a larger yield is obtained.

FIG. 53. — Broadcasting oats — the old way of seeding.

Commercial fertilizer and barnyard manure are not usually applied to the oat crop in the corn belt states. Experience has shown that larger returns from the fertilizers may usually be obtained if they are applied to some other crop in the rotation. Fertilization of oats frequently causes rank growth of straw without a corresponding increase of grain, and with the rank growth, lodging frequently results. Fertilizers may best be applied to the corn or wheat lands, except with very poor soils, where it may be desirable to fertilize the oats also.

146. Time of seeding. — Oats are a cool weather crop and best results may usually be obtained from early rather than later seeding. Early seeding may be regarded as that done as soon as the soil is dry enough in the spring to get on to it with team and implements. In a time of seeding test at the Ohio Station, for a three-year average, the earliest seedings outyielded the latest seedings by 18.37 bushels per acre. The weight per bushel was also influenced to a considerable extent by the time of seeding, the earlier seedings having heavier weight per bushel. This result was largely due to the fact that the earlier seeded plants completed their growth before hot weather, while those seeded later did not fill out as well on account of the hot weather. In the South, where winter oats are grown, fall seeding is practiced. The time of seeding varies with the latitude, in the northern part of this section the seeding being done in late September, while farther south it is delayed until late October.

Fig. 54. — Seeding oats with a drill.

147. Rate of seeding. — Before seeding, the oats should be run through a fanning mill equipped with proper screens to remove small and light kernels, sticks, trash, and weed seeds. This not only insures a more uniform rate of seeding, but also prevents the use of inferior seeds.

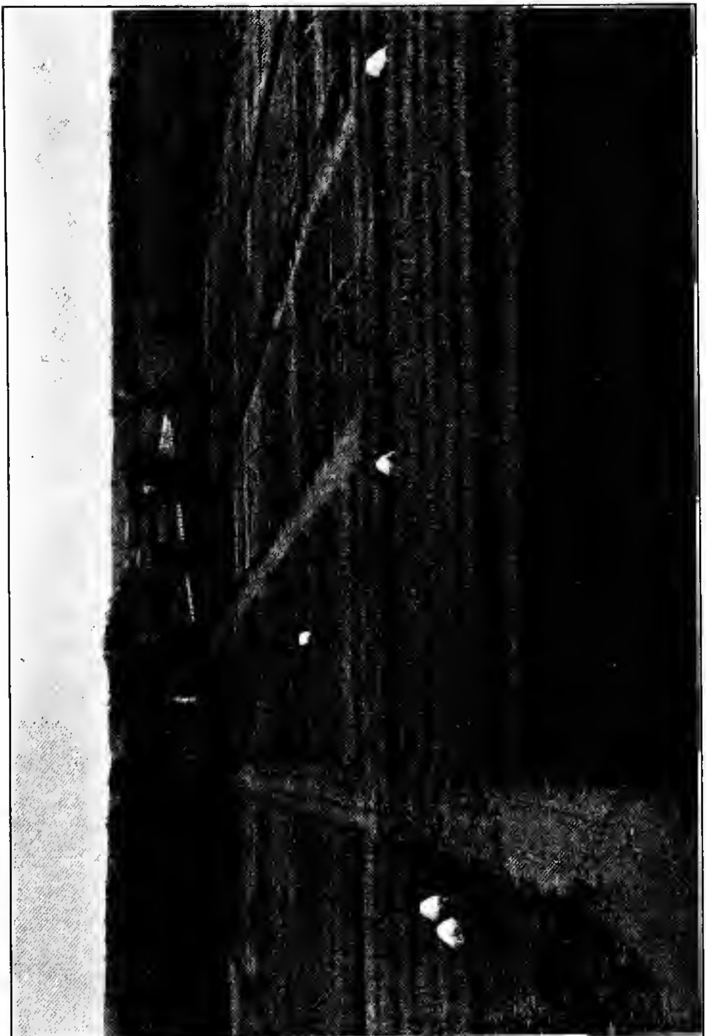

Fig. 55. — Testing varieties of cereals, oat plots in the foreground.

The usual rate of seeding oats varies from 6 to 10 or more pecks per acre, the most common rate being 8 or 9 pecks. The rate of seeding will depend to some extent upon the size of the kernels. Varieties with large kernels should be seeded more thickly than those with small grains, since there are not so many of the former per bushel. The variation of a few pecks in the rate of seeding does not usually affect the yield materially, since the plant adjusts

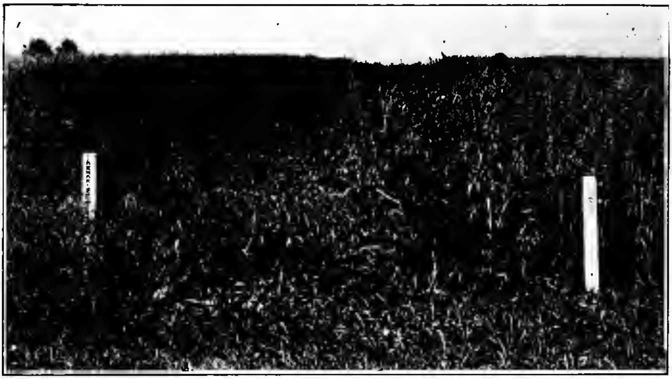

FIG. 56. — Variation in stiffness of straw of two varieties of oats.

itself to the environment by tillering. When seeded thinly, more tillers are produced, thus thickening up the stand.

148. Harvesting. — The same methods are employed in harvesting the larger part of the oat crop as have been described for harvesting wheat. The time of cutting to secure the best quality of grain is after the grains have reached the hard dough stage, and the heads have turned yellow. If cut before this time, the grains will be shriveled, resulting in light weight per bushel. If cutting is delayed too long, the crop may become overripe and loss will occur by shattering. Oats usually contain more moisture at the time of cutting than wheat, and in order that they may dry thoroughly, the bundles are set up in smaller shocks than wheat. Usually 7 to 9 bundles form a shock. The shock should be well formed, since the

FIG. 57. — Treating seed oats for smut. The formalin method.

straws are not so stiff as those of wheat, and the shocks are more likely to go down, which will often result in injury to the quality of the grain from weathering. Oats may either be thrashed from the shock as soon as they have dried out, or they may be stacked or stored in the mow for later thrashing.

149. Improvement of oats. — The same methods for the improvement of oats are employed as have been described in the paragraph on the improvement of wheat.

Great variation in the earliness of maturity, stiffness of straw, resistance to rust, and abundance of yield are to be found in almost all varieties. A great opportunity for improving the crop is therefore within reach of each grower if he will but take advantage of it.

INSECT ENEMIES AND FUNGOUS DISEASES

150. Insect enemies. — There are no important insects which confine their attacks to the oat plant. Several insects that are destructive to wheat are also troublesome to oats, chief among which are the chinch bugs, grasshoppers, and the army worms. The most important of these insects and the methods for their control have been discussed in the chapter on wheat, and as the same methods may be employed to prevent their ravages on oats, they need not be discussed again.

FIG. 58. — Covered and loose smut of oats.

151. Fungous diseases. — The most destructive diseases that attack the oat crop are the rusts and smuts. There are two kinds of rusts, the leaf rust and the stem rust, so called because they most commonly attack those parts of the plant. The leaf rust is more common than the stem rust, and is identified by the red spores on the leaves at harvest time. In seasons favorable for their development, the spores are frequently so plentiful as to adhere to the harvesting machinery and the clothing of the harvesters. There are two kinds of smuts that attack the oat plant. The loose smut is more common and far more destructive than the covered smut. The loose smut may be recognized in the field by the black powdery spores that attack the panicle and prevent the grains and glumes from developing. The covered smut is similar in appearance to the leaf smut, but it does not attack the glumes, affecting only the kernels, which are replaced in the glumes by masses of black spores. Methods for controlling these smuts are the same as those employed in controlling the stinking smut of wheat and have been described in connection with this disease of wheat (page 132).

CHAPTER VII

BARLEY

THE history of the development of barley in its relation to man coincides with that of wheat. Both of these cereals have been closely identified with the progress of civilization, and the people of many nations, both ancient and modern, have depended upon them not only for food for their beasts of burden, but also for themselves. How long barley has been grown is not known, but evidence that it is one of the oldest of cultivated grains is to be found in the history of the earliest nations of which we have knowledge. Specimens of barley have been taken from the tombs of the ancient Egyptians, and coins used by these people bear figures of barley heads. The literature of the early writers of Egypt and also the earlier books of the Bible contain references to this plant. Barley was used at that time for making bread, and also, it is said, in the making of certain drinks. Botanists generally agree that the original home of barley was in the western part of Asia, where wild forms of it are still to be found. The people that inhabited this country in early days probably were the first to discover its usefulness and to cultivate it. From western Asia barley was introduced into almost all parts of Europe, where it was the chief bread plant, it is said, until the sixteenth century. Barley was introduced at an early date into America and was used by the colonists as food both for man and beast.

152. Botanical characters. — Barley, *Hordeum sativum*, has much the same appearance as wheat, differing from the latter slightly in the length of the culms, the shape of the leaves, and the structure of the spike. The roots of barley are somewhat less extensive than those of

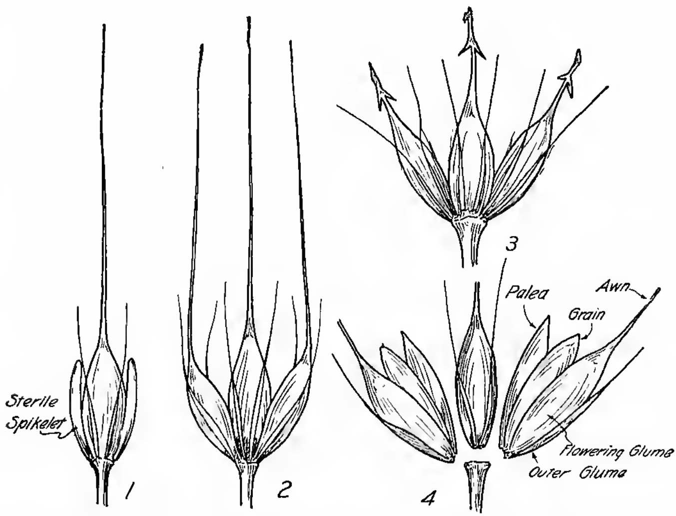

FIG. 59. — Spikelets of barley: *1*, two-rowed type; *2*, the six-rowed bearded; *3*, six-rowed beardless; *4*, showing three spikelets and the relative position of parts.

wheat, and do not grow so deeply. The culms are not usually as tall, and the percentage of straw to grain is less than that of wheat. Barley produces rather more culms per plant than wheat, under favorable conditions producing as many as 15 or more per plant. The leaves are somewhat broader than those of the other cereals. The more marked characters that distinguish it from wheat are the arrangement and structure of the spikelets and the shape of the glumes. The spikelets are but one-flowered, and are inclosed in the flowering glume and palea, both of which, in all varieties except the hull-less, cling to the kernel after thrashing. The kernels, after the glumes or hulls are removed, have much the same appearance as wheat kernels, being creased on one side like wheat, but having more rounded sides and a more pointed tip. The flowering glumes bear stiff, sharply barbed awns, which vary from 3 to 6 inches in length. The awns or beards of barley are much stiffer and are more disagreeable to handle than those of wheat or rye. The outer glume is awl or bristle shaped and varies in length from $\frac{3}{4}$ to $1\frac{1}{4}$ inches in length. The spikelets are sessile and three are produced from each joint of the rachis, differing in this respect from both wheat and rye. The percentage of hull in barley varies from 10 to 25 per cent or more, the average being about 15 or 16 per cent. The character of the endosperm varies from mealy to glassy or vitreous. The character of the endosperm also varies with the variety, the stage of maturity at which the plant was, cut and the climate. The fully matured kernel usually is more mealy in character than the immature one, and contains

FIG. 60. — A head of two-rowed barley (side view).

a higher percentage of starch and a lower percentage of protein than those of glassy texture. The chemical composition of the hulled kernel is about the same as that of wheat. When the hull is also considered, the percentage composition is changed on account of the crude fiber of the hull. The legal weight per bushel in most states is 48 pounds. The weight per bushel may vary a few pounds either way, a high weight per bushel being associated with high percentage of starch.

FIG. 61. — A head of six-rowed barley.

153. Types of barley. — Barleys may be divided into two classes, namely, two-rowed and six-rowed. The basis for this classification is to be found in the appearance of the spikelets on the rachis. In the six-rowed type, three spikelets, each of which produces one kernel, are produced at each joint of the rachis. In the two-rowed type three spikelets are produced at each joint of the rachis, but only the center one produces a kernel, the two lateral spikelets not fully developing. A head of the latter type has the appearance of having only two rows, one on either side of the rachis, while the former type gives the appearance of having six rows, three on each side of the rachis. The two-rowed varieties usually grow a little taller than the six-rowed, and the kernels are somewhat larger and longer than those of the latter type. In the United States the two-rowed varieties are largely grown in the

Dakotas, the Chevalier and Hanna being the most prominent varieties. The two-rowed types are more commonly grown in Europe, while in this country the six-rowed varieties are more common, the principal varieties of which are Manchuria, Oderbrucker, and Bay Brew.

Barleys may also be divided into the bearded and beardless varieties. The beardless varieties are not so commonly grown as the bearded. They may also be divided into spring and winter varieties. The winter varieties are not so hardy as winter wheat and are largely grown in the Southern States or on the Pacific Coast. The spring varieties are of both the two and the six rowed types, and are grown in the northern half of the United States. While in most varieties of barley the hull adheres to the kernel after thrashing, in some few the hull is shed during thrashing like wheat. The hull-less varieties are usually named after the color of the grains. Thus the common varieties of this type are white hull-less and black hull-less. Hull-less barleys weigh sixty pounds per bushel.

USES OF BARLEY

154. The making of malt. — Over 50 per cent of the barley crop produced in the United States each year is used for the making of malt, which is used in the manufacture of beer and other malt liquors. Malt is the grain artificially germinated so as to induce certain changes in its composition. When the grain germinates, a nitrogenous ferment, diastase, which exists in the kernel, is increased in amount. The diastase acts upon the starch of the kernel, changing it into a soluble sugar and dextrin. The object of malting is to obtain the largest amount of sugar possible by converting the starch of the barley grain into sugar, which is then dissolved and changed into alcohol by fermentation. The process of changing barley into malt is divided into four stages: steeping, couching, flooring, and kiln-drying. The barley when it comes to the maltster is first cleaned to remove all foreign matter and broken or cracked kernels. It is then steeped or soaked in large tanks for two or three days, or until the kernels may be crushed with the fingers. The grain is then removed to the couching floor, where it is spread out in a layer about 20 inches thick. In from 20 to 36 hours the grain heats and begins to germinate. It is then spread out in a layer 10 to 12 inches thick and turned every few hours, the layer being gradually reduced in thickness to about 4 inches. During this time the grain continues to germinate, and when the plumule is about three-fourths the length of the grain, the largest amount of diastase is present and the germination is stopped by removing the grain to a large kiln, where it is heated to a temperature sufficient to kill the germ. The sprouts are then removed by a special machine. They are placed on the market under the name of malt sprouts and are used extensively for stock food. After the sprouts are removed, the dry malt is crushed between rollers, and other cereals, principally rice and corn, are added. The barley produces more than enough diastase to change its own starch into sugar, so a small quantity of other cereals may be added to increase the amount of starch. The dry mash together with the other cereals is then placed in the mash tub and when water is added and the mixture is heated to a temperature of 150° Fahrenheit the diastase rapidly changes the starch into sugar. A liquid known as " wort " results which contains the sugar in solution. The mash tub has a sieve-like bottom upon which the hulls settle, permitting the liquid to be drawn off below, the hulls forming a filter. After the liquid is drawn off, the residue that remains in the tub is placed on the market and sold as " brewers' grain," which is used extensively for stock feeding. The wort is then boiled with hops to prevent it from souring, and later is cooled and yeast is added. In a short time fermentation takes place, which forms the malt liquor. The different varieties of malt liquors are formed by varying the different processes in malting.

155. Good malting barley. — Barley is better adapted for the making of malt than other cereals, because it contains a greater amount of ferment than other grains, and also because it contains a lesser amount of undesirable albuminoids. The husks are also of service in protecting the plumule during germination, and later they serve as a filter when the wort is removed from the tub. A good malting barley should have uniform, plump, starchy kernels. The vitality should not be less than 95 per cent and the husks should be pale straw color and not possessed of deep wrinkles. Musty, dirty barley, or that containing many foreign seeds, is not desirable for malting. On the market malting barley commands the best prices, there often being a difference of 30 cents or more per bushel between the price paid for malt and feeding barley.

156. Feeding value. — The feeding value of barley, when the hull and kernel are considered, is about equal to that of corn, and it is quite extensively used in some sections of the country for that purpose. It may either be ground into meal or fed whole. In the Central West barley is used largely for feeding hogs, cattle, and sheep. On the Pacific Coast, where little corn or oats is grown, it is used extensively for feeding horses. Barley straw, while comparatively nutritious, is not generally used for feeding on account of the beards, which make it unpalatable to animals. In some parts of the Western and Southern States barley is quite extensively cut for hay. Barley hay has high feeding value, and if cut before the beards become stiff, makes a palatable feed. When cutting for hay is delayed until the beards are stiff, injury to the mouths of the animals to which it is fed sometimes results. In some places barley is grown for pasture and is frequently used for hogs and sheep.

PRODUCTION AND DISTRIBUTION

157. The world's production. — The world's production of barley for the five years 1907–1911 was approximately 1400 million bushels. Of this amount, approximately 400 million bushels, or over one-fourth, was produced in Russia. The United States ranks next in total production, the average annual production for the above five years being approximately 165 million bushels. The other countries producing large amounts, in order of their production, were: Germany, Austria-Hungary, Japan, Spain, the United Kingdom, and Canada. Of the total production in the United States, California produced over 20 per cent and Minnesota over 19 per cent. The other states producing large amounts in order of their importance are: Wisconsin, North Dakota, South Dakota, Iowa, and Washington. While barley is produced in many other states, the acreage is comparatively small, about 85 per cent of the total production being produced in the above named states. The average yield per acre for the United States is approximately 25 bushels, a considerably higher one than that of wheat and rye.

158. Exports and imports. — The average annual export of barley from the United States for the ten years 1902–1911 has been approximately 10 million bushels. Almost all the export grain went to European countries for malting purposes. During the same ten years, the average annual import of barley has been approximately 80 million bushels, some of which was imported from Europe for use as seed, much of the remainder came from Canada. The average farm price per bushel on December 1st for the same period has been 53.6 cents per bushel, with a range of price varying from 40 to 86 cents per bushel.

ADAPTATION

159. Climate and soil. — Barley is best adapted to a warm, dry climate. It requires less water during the growing season than wheat, oats, or corn, and may be grown in places where the climate is not adapted to the growing of corn or oats. While best adapted to warm climates, it may be grown farther north, as the required length of the growing season is less than that for oats and wheat. While it grows best on comparatively dry soil, good yields may be obtained where there is abundant rainfall, if the soil is well drained. Barley grows best on well-drained loams. It is more greatly influenced by the fertility of the soil than is almost any other grain crop. On poor soils the straw is short and the yield of grain is low, while on fertile soils it grows taller and produces more abundantly. While this is generally true of all crops, the variation is probably greater with barley than with other crops. Barley will withstand a more alkaline condition of the soil than oats or wheat and may therefore be grown in certain sections of the West where the latter crops cannot be grown successfully.

METHODS OF CULTURE

160. Preparing the soil. — The methods employed in preparing the soil for barley will, of course, depend upon whether it is to be seeded in the fall or spring, and upon the preceding crop. Barley may replace either oats or wheat in the rotation, usually following corn, potatoes, or some other cultivated crop. It is commonly used as a nurse crop for grasses and clover, and because of its short straws and early maturity, is often preferred for this purpose to either oats or wheat. Fall seeding requires a well-prepared seed bed, and if the preceding crop can be removed in time to permit of plowing, better results will be obtained than if the seed bed is prepared without plowing. When winter barley follows cowpeas, soy beans, or potatoes, a good seed bed may usually be prepared by disking and harrowing without plowing. When winter barley follows corn, usually no preparation can be given the seed bed, but much can be done to favor the crop if the corn is well cultivated during its growing season, to conserve moisture and free the field from weeds. In the seeding of spring barley the seed bed may best be prepared if the land is plowed in the fall. If it is necessary to delay the plowing until spring, it should be done early in the season and worked down so as to present a fine, mellow surface and a rather firm sub-soil. Barley requires a somewhat finer and more mellow seed bed than oats, and usually more care must be taken in preparing the soil, if a good crop is to be expected. In parts of the country where there is little rainfall during the growing season the soil should be handled in such a way as to conserve as much moisture as possible.

Fig. 62. — A field of Manchurian barley at Indian Head, Canada.

161. Seeding. — The small and shrunken kernels and weed seeds, together with other foreign matter, should be removed by a fanning mill from the barley before seeding. Barley may either be seeded with a grain drill or sown broadcast. The former method is to be preferred in all cases, as by its practice higher yields are secured, and winter barley that is seeded with the drill is less likely to be winter-killed. The rate of seeding with the grain drill varies from 6 to 8 pecks per acre. When broadcast, a somewhat heavier rate is to be recommended. In sections of the country having little rainfall, a lower rate of seeding, sometimes as low as 3 pecks per acre, gives better results than a heavier rate. The time of seeding spring barley is slightly later than that for oats, since the young barley plants are not so hardy as those of wheat. Winter barley is seeded usually in September or early October.

162. Harvesting. — Barley is at the proper stage of maturity for cutting when the straw and heads are a golden yellow color, and the kernels are in the hard dough stage. If cut while the straw is still green, the kernels will later become shriveled and will retain an undesirable color. If the barley is grown for the market, great care should be exercised in shocking so as to prevent bleaching or weathering, which greatly injures the appearance, and thereby decreases the market value. The shocks should be well formed so that they will not be blown over by the wind, and well capped so as to shed the rain. If a thrasher is available, the crop should be thrashed as soon as the bundles have dried out. Sometimes, however, it is necessary to wait some time for the thrashers, in which case the barley can be best protected from weathering and discoloring by stacking. It should not be stacked, however, until the bundles are well dried out, or else they may mold or become musty in the stack.

INSECT ENEMIES AND FUNGOUS DISEASES

163. Insect enemies. — The chinch bug and the Hessian fly are the most troublesome enemies of growing barley. These insects, together with methods for their control, are discussed in the chapter on wheat, and need not be repeated here.

164. Fungous diseases. — Barley is attacked by several diseases, the most important of which are the rusts and the smuts. There are two kinds of rust, the leaf rust and the stem rust, which sometimes do the crop considerable injury. They may best be controlled by early seeding and the growing of early maturing varieties, which may usually be harvested before the rusts cause serious injury.

Barley is attacked by two kinds of smut, the loose smut and the covered smut. The loose smut may be controlled by treating the seed by the hot water method discussed in the chapter on wheat, while the covered smut may be controlled by the formalin treatment similar to that employed in treating wheat for stinking smut (page 132).

CHAPTER VIII

RYE

RYE has not been cultivated nearly so long as has either wheat or barley. It was not known in ancient Egypt and Greece, and according to Roman writers who lived about the beginning of the Christian era, it was at that time a new plant in that country. The original home of rye is thought to have been in northeastern Europe, where wild rye, which is probably either the ancestor of our cultivated rye or a closely related form, may be found growing wild. With the development of agriculture in Europe during the past 1500 years, the culture of rye was extended, and it has held a place of great importance in the agriculture of many nations. Within the last half century, however, the culture of rye in all rye-growing countries has been declining, as the culture of some of the other cereals such as wheat, corn, and oats has been extended.

165. Botanical characters. — Rye, *Secale cereale*, in its botanical characters and relations, its general appearance and methods of culture, resembles wheat more closely than do any of the other cereals. It differs from wheat in that when the kernel germinates, it produces four instead of three temporary roots. The culms are longer and more slender than those of wheat, sometimes reaching a height of 6 or 7 feet on fertile soils. The spikelet has but two flowers, each of which usually produces a kernel.

The spike of rye may be distinguished from that of wheat in that the outer glumes are long and narrow, and not boat-shaped like those of wheat. The flowering glumes are always awned, and as the plant ripens, the flowering glume and palea spread apart, exposing part of the kernel. The spike is usually longer than that of wheat, sometimes reaching a length of 6 or 7 inches. The number of spikelets varies from 20 to 30, and unlike wheat, the lower spikelets are fertile and produce kernels. The rye kernel is longer and narrower than that of wheat, it is less plump, and the furrow or crease is less marked. The structure of the kernel is similar to that of wheat, while in chemical composition it contains somewhat less protein and fat. Rye flour, however, contains gluten, and light, coarse bread may be made from it. There are both spring and winter varieties, the latter being the one most commonly grown.

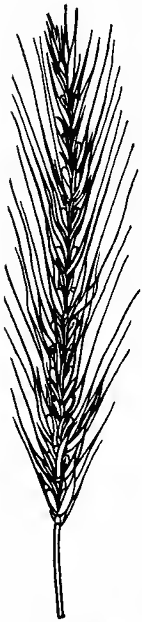

Fig. 63.—Head of rye.

USES OF RYE

166. Use of the grain. — The principal use of rye is in the making of bread for human consumption. In Russia and Germany, rye bread is more commonly eaten than that made from wheat. Germany devotes about 10 per cent of her cultivated land to rye, and only 3.5 per cent to the growing of wheat. Rye bread has always been held in high esteem by the Germans, and until recently was used in the rations of the soldiers of the Germany army. About 20 years ago, however, on account of the shortage of rye, wheat bread was issued in the soldiers' rations, and since that time its use has gradually increased. In the United States only a small portion of the rye crop produced here is used in the making of bread. Rye bread is not held in such high esteem by Americans as it is by the Germans and Russians, and much of the use of the rye for this purpose in the United States is due to demands for it by the foreign population. Rye flour does not contain a large amount of gluten, and does not make such a light colored nor so large a loaf as that made from the wheat flour. Much of the rye in this country is used in the making of alcoholic beverages. The grain is also used to some extent for feeding live stock, usually being ground and fed in combination with other grains to hogs or horses.

167. Use as green manure and forage. — Rye holds an important place as a green manure crop. Its hardiness and ability to grow upon poor soils make it especially valuable for this purpose, since it grows well on those soils that are most greatly in need of assistance. Rye is also used for pasture and as a soiling crop. As a soiling crop it is especially valuable for early spring feeding. While it will yield the largest amount of green feed if cut when in full head, it will yield a very fair amount of palatable forage if cut earlier. As a pasture crop, it is available both in the fall and spring. If seeded rather early in the fall, usually it may be pastured for some time in the fall and again for a few weeks in the spring, without materially reducing the yield of grain. Sometimes the crop is sown especially for pasture during the early part of the year, and is plowed up in time for seeding a crop of late potatoes or some other late crop. It may also be pastured for several weeks in the spring and plowed under in time for corn. Rye straw is of little use as feed, but is highly prized for use as bedding. Much of the straw is used in the manufacture of paper, baskets, boxes, hats, mats, and other similar articles.

Fig. 64. — Plowing under rye for green manure.

PRODUCTION AND ADAPTATION

168. Production. — The world's annual production of rye for the five years 1907–1911 was approximately 1500 million bushels, being slightly greater than that of barley, and slightly less than one-half that of wheat, and less than one-half that of oats for the same time. Of the world's crop, about one-half was produced in European Russia and about one-fourth in Germany. The production of rye slightly exceeds that of wheat in Russia, while in Germany over three times as much rye is produced as wheat. The other countries producing comparatively large amounts are Austria-Hungary, Australia, France, Spain, and Sweden. Some rye is produced in the other European countries, but the amount is small as compared with that of the countries named above. In the United States the rye is exceeded in value by all the other cereals. Of the world's production for the five years 1907-1911 the United States produced but 31 million bushels. Of this amount almost 50 per cent was produced in the three states, Pennsylvania, Wisconsin, and Michigan. Other states producing comparatively large amounts are Minnesota, New York, Nebraska, and Illinois. While rye is grown in almost every state, it is of little importance as a grain crop in all excepting those named above. In some states rye is grown more for green manure and for pasture than for grain, and is therefore not included in the above consideration. The yield per acre in the United States for the ten years 1902 to 1911 was 15.9 bushels. The yield per acre during the same period in Russia was approximately 12 bushels, in Germany, 26.5 bushels, and in Austria-Hungary, 20 bushels.

169. Adaptation. — Rye is adapted to a wide climatic range. It is more hardy than wheat and will stand more severe winters, so it may be grown farther north. It may also be grown in the South, and seems to be little affected by warm weather. Rye may be grown successfully on almost all types of soil, being especially adapted to light, sandy soils. It is sometimes called the grain of poverty because it can be grown on soils too poor, or where the climate is too severe, to grow the other cereal crops successfully. Because of its ability to grow on poor soils, fields of fertile soil are usually reserved for the other cereals, and rye is grown on the poorer and less desirable ground. While rye grows fairly well on poor soils, much larger yields may be obtained on fertile soils, and it will respond well to fertilization on poor soils.

FIG. 65.—Rye seeded in corn at the last cultivation for use as fall pasture and green manure.

METHODS OF CULTURE

170. Seeding. — The cultural methods for rye are very similar to those described for wheat, and need not be repeated again. Rye may be seeded somewhat earlier than wheat, as it is less troubled by the Hessian fly. It is desirable to seed rather early if the crop is to be pastured in the fall. It may be seeded in the standing corn before cutting, or the seeding may be delayed until after the corn is in the shock. Sometimes rye is seeded in the corn at the time of the last cultivation. However, usually not much is gained by seeding as early as this, since the plant will make but little growth until the corn ripens. The usual rate of seeding is from 1.5 to 2 bushels per acre.

171. Fungous diseases and insect enemies. — The most common as well as the most harmful fungous disease of rye is ergot. The spores of ergot enter the ovule when the plant is in bloom, gradually develop, replacing the ovule, and when mature, the growth from them is several times longer than the seed. The decrease in yield of grain due to ergot is slight, the chief injury from it being the ill effects produced on live stock that consume grain infested with it. The only remedy is to remove from the field before cutting the heads that are affected by it. Many of the grasses and occasionally wheat are also affected by ergot. Rye is less seriously troubled with insects than wheat, and little or no difficulty is usually experienced with them.

CHAPTER IX

RICE. BUCKWHEAT

RICE

Rice is one of the oldest of cultivated cereals and has held an important place in the dietary of the Chinese nation from time immemorial. For thousands of years before the dawn of the Christian era and continuing down to the present day, rice has been the staple article of food for the people of China. It is probable that China is its original home, and from there it was carried into Japan and India, and later, in the fifteenth century A.D., it was introduced into southern Europe. Its first introduction into the United States was in the Virginia colony in 1647, when it was brought into South Carolina. From this time on it has been grown to some extent in the United States.

172. Botanical characters. — Rice, *Oryza sativa*, is one of the members of the great grass family, grown for its grain. It is closely related to wild rice, another species of the same genus, which grows wild in the tropical regions of both hemispheres. It is also a near relative of Canadian rice, a wild species that grows in rocky places throughout North America, and one which was used extensively by the Indians as food. Rice is an annual, with a shallow, fibrous root system, growing from 2 to 6 feet in height, the average height being from 4 to 5 feet.

Like other cereals, it stools or tillers abundantly under favorable conditions. The seeds are borne in a loose head or panicle, somewhat more compressed than that of oats. The spikelets are one-flowered and attached to the branches of the panicles with a short pedicel. The outer glumes are short scales or bristles, and the flowering glume and palea, varying in color from light to dark yellow or brown, tightly envelop the kernel which remains attached when the grain is thrashed. The flowering glume sometimes bears an awn. When the glumes are removed, the kernel is slightly furrowed, is hard and vitreous, and white in color. There are two general types of rice; namely, the lowland and the upland. The lowland rice is grown in low, level fields which can be irrigated from rivers or lakes. The upland rice is grown without irrigation as corn or cotton is grown. Almost all of the rice grown in this country is of the lowland type.

Fig. 66. — A panicle of rice.

173. Uses. — It is a difficult task to tell the story of the rôle that rice has played in the dietary of the race. For centuries it has been the "staff of life" to the people of southern Asia and to-day is one of the most important starchy foods of all civilized nations. The United States, while producing a larger amount, finds it necessary to import about 200 million pounds yearly to meet the demands within her borders. In China, Japan, and other Oriental countries rice is the chief food of the people, and is supplemented with seeds of millets, sorghums, and soy beans. The dietary for the average citizen of these countries is, therefore, quite different from that of the citizens of our country. When rice is thrashed, the hulls or glumes remain on the kernel, but before it is placed on the market they are removed, and in this country the kernels are polished by special machines to give them the glossy appearance demanded by our trade. In polishing the kernels, much of the food value is lost because in the process the germ, which contains the most of the oil, is removed. The by-products of rice are the hulls, which are of little value, and the bran or rice polish, which is of considerable value as a stock food. The straw is not palatable and is of little use for stock food or for any purpose other than for fertilizer.

PRODUCTION AND DISTRIBUTION

174. The world's crop. — In the tropical and semi-tropical regions of both hemispheres, rice is a very important crop, the total annual production for the world being approximately 150 billion pounds. Of this amount Asia produces about 135 billion pounds. The principal rice-producing countries of Asia are India, with an annual production of 80 billion pounds, China, with 40 billion, Japan, 16 billion, and the Philippine Islands producing 800 million pounds. Europe produces about 1 billion pounds annually, Italy and Spain producing by far the bulk of this crop. South America, principally Brazil and British Guiana and Peru, have an annual production of approximately 400 million pounds. The United States has an annual production of about 700 million pounds.

Of this amount, Louisiana produces over one-half, Texas, about one-third, Arkansas, more than one-fifth, the remainder of the total crop of this country being produced in comparatively small acreage of the remaining Gulf States and California. The rice industry in the United States started with small acreages in South Carolina in colonial days, and later it was introduced and grown in a small way in Georgia. These two states produced the bulk of this crop until after the Civil War. After the war, the rice industry declined in these states, but the acreage increased in the Southern States along the Mississippi, which up to this time had produced but little. Portions of these states, on account of their location in relation to rivers and the presence of good wells, are well adapted to the growing of rice, and the industry has developed rapidly within the past two decades.

The average yield of rice per acre in the United States is about 32 bushels of rough rice, weighing 45 pounds per bushel, which is equivalent to about 1000 pounds of cleaned or hulled rice. The average price per bushel received by the grower is about 75 cents, varying of course from year to year, depending upon the demands and the abundance of foreign-grown product on the market. The value of the rice crop in the United States is, in round numbers, approximately 17 million dollars.

ADAPTATION AND CULTURAL METHODS

175. Adaptation. — Rice is a tropical or semi-tropical plant, and requires a long, hot growing season, with moist, humid climate. It is grown therefore only in low-lying regions, with a plentiful supply of moisture and long growing season. Almost all of the rice is grown on soils that can be supplied with water by irrigation. Soils that can be irrigated and drained so as to quickly remove the water when desired, and that become firm after draining, so that machinery and animals can pass over them, are best adapted to rice culture. Low-lying fields along rivers and near lakes in tropical or semi-tropical regions are by virtue of their location well adapted to rice culture. The upland types of rice grown on non-irrigated lands may be grown upon any soil that will grow corn or cotton.

176. Cultural methods. — In the culture of lowland varieties of rice, the field is plowed either in the spring or

Fig. 67. — Harvesting rice in Arkansas.

fall and worked down into a fine seed bed. The seed may be sown broadcast or drilled in with a grain drill. The grain drill gives better results, since the seed can be placed at a uniform depth in the soil, which favors uniform germination and growth. From one to two bushels of seed are required per acre. Seeding is done any time from the middle of April to the last of May. The growing season is long, and if late seeding is practiced, the harvesting is delayed until late fall. Some growers begin the seeding early and extend the operation for some time, in order that a larger acreage may be grown and harvested with a minimum of equipment. When the rice plants are seven or eight inches high, the field is flooded with water to a depth of four to six inches. The flood water is maintained over the field until the grain is in the dough stage, when it is drained off to allow the soil to dry sufficiently to bear up the harvesting machinery. The crop is usually cut with a grain binder, the grain being handled in the same manner as any small grain crop. The rice is thrashed with an ordinary thrasher and stored in bags or barrels holding 162 pounds. The grower usually reckons his crops by barrels rather than by bushels, as is the custom with wheat or oats.

BUCKWHEAT

Buckwheat has been cultivated for many centuries in England and in European countries, where it has furnished a considerable portion of the bread flour of the poor classes of people. It was introduced into the United States in colonial times and for many years was an important article of diet in the New England and Central States. Buckwheat gets its name from the German Buchweizen, which means beechwheat. It was called beechwheat by the Germans because of the resemblance of the grains to beechnuts.

177. Description. — Buckwheat, *Fagopyrum esculentum,* belongs to the Polygonaceæ, or dock family, which includes in its membership such troublesome weeds as the dock, sorrel, and smartweed. Buckwheat, therefore, is not a true cereal, but because of its similar cultural requirements and adaptation, it is usually classed with them. Buckwheat in the character of its root system is unlike the cereals in that it has a tap root. The tap root extends down rather deeply into the soil, and from the upper portion of it several branches are given off. The total root development as compared with that of the cereals is not large. The plant produces but one stem from each seed, and does not thicken up the stand by tillering as do the cereals. It has other means, however, of adapting itself to the environment. The main stem branches more or less freely, depending upon the thickness of planting and other environmental factors. The stems grow from two to five feet in height, the average probably being about three. The leaves are arranged alternately, and the petioles vary in length from extremely short to as much as four inches or more. The leaves are heart-shaped, somewhat longer than they are broad, and vary in length from two to four inches.

Fig. 68. — Buckwheat in bloom.

The flowers are borne at the top of the stem upon peduncles that grow out from the axils of the leaves. The flowers are peculiar in that they have no petals. The sepals of the calyx, however, are rather large and have the appearance of petals. The color of the flowers is pinkish white, tinged with red. They appear long before the plant is full-grown, and they continue to appear until the plant is killed by frost. The plant at harvest, therefore, may contain both flowers and mature seeds. A field of buckwheat in bloom is a beautiful sight and furnishes pasture for all sorts of bees and nectar-loving insects.

The mature seed is three-angled, inclosed in hull of gray or brown color, and varies in size with the variety, usually being about one-tenth of an inch along each edge. The legal weight per bushel in most states is 48 pounds.

178. Uses. — Buckwheat cakes have long been accorded a place of high favor on the breakfast menu of winter days. Formerly their excellence was known only to the rural population, but now they have won a place of favor on the tables of the city dwellers. Almost all of the buckwheat produced is used in the making of buckwheat flour, which now commands a high price on the market. Buckwheat middlings, a by-product of the milling of the flour, are highly prized for stock food. The straw, if protected from the weather, is readily eaten by live stock.

179. Production. — The buckwheat crop in the United States for the ten years 1903–1912 shows an annual average production of approximately 16 million bushels. Only about 800 thousand acres are devoted to this crop, almost all of which are in the northeast quarter of the United States, Pennsylvania and New York producing in 1912 over 80 per cent of the total crop. Other states producing relatively large amounts are, Michigan, with 1 million bushels, West Virginia, with 880 thousand bushels, Virginia, 516 thousand, Ohio, 410 thousand, Wisconsin, 290 thousand, and Maryland, 210 thousand bushels. Other states having small acreages of buckwheat are the New England States, Illinois, Indiana, Minnesota, and Iowa.

The yield per acre varies from 10 to 50 bushels, the average yield being probably about 20 bushels. The average farm value of buckwheat per bushel for the past ten years has been about 60 cents.

180. Cultural methods. — Buckwheat is best adapted to a cool, moist climate. High temperature and excessive rainfall during the later period of growth is disastrous to the crop, as such weather blasts the flowers. Buckwheat will grow on a great variety of soils, and is especially well adapted to those which are thin and light. Most frequently it is grown on soils too poor or rough to produce good yields of other crops. The preparation of the seed bed usually is given little attention, but experience has shown that the crop will respond to more considerate treatment with sufficient increase of yield to more than compensate for the extra labor. The land is usually plowed as for the cereals, but too frequently the plowing is delayed until late in the season, which results in a seed bed of poor physical condition. Early plowing and proper preparation to secure a firm, well-pulverized seed bed is most likely to result in a profitable yield.

181. Seeding. — Buckwheat will mature in a shorter season than any of the other grain crops. If favorable weather prevails, it may be harvested in 8 to 12 weeks after seeding. The seeding is usually done in June or early July, and it may be sown broadcast or put in with the grain drill. The grain drill is to be recommended, as by its use a more uniform rate of seeding is secured. The rate of seeding varies from 3 to 5 pecks per acre.

182. Harvesting. — The crop should be cut before the first heavy frost. In New York and Pennsylvania almost all of the crop is cut with the grain binder, a hand cradle, or a self-rake. It is allowed to dry in the swath for a few days before it is set up in the shock. Thrashing may be done with the grain thrasher, but much of the crop in this country is thrashed with the flail. The most common varieties of buckwheat are Japanese and Silver Hull.

CHAPTER X

THE PERENNIAL GRASSES.—TIMOTHY, BLUE-GRASS, REDTOP

TIMOTHY

THE grass timothy derives its most common name from Timothy Hanson of Maryland, who is said to have introduced it from England in 1720. It is also known in some parts of the country, particularly in New England, as Herd's grass. This name comes from John Herd, who, it is said, found it growing wild in the swamps of New Hampshire early in the eighteenth century. Because of the appearance of the head, the grass is sometimes called meadow cat's tail. Whether Herd or Hanson should have the credit for discovering the adaptability of this grass to American agriculture cannot be determined. Both of them perhaps deserve particular credit for calling attention to its value and assisting in its distribution. Timothy has been cultivated in this country for two centuries and is by far the most important hay grass, furnishing almost all of the hay found on the eastern markets. It is also of considerable importance in Europe, but it does not attain there the importance that it does in this country.

183. Description. — Timothy, *Phleum pratense*, is a perennial and has the characteristic fibrous root system of the members of the grass family. Compared with other forage grasses, it may be said to be deep rooted.

Underground root stalks or stolons are common, although many plants do not have them. The culms or stems are usually erect. Sometimes, however, they are decumbent at the base. Several stems usually are produced from one root system. This is due to the production of tillers from the nodes near the ground, similar to the stooling of the cereals. When the plant is not crowded, the tillers in turn produce several stems, and when growing under field conditions ordinarily from 6 to 15 stems are produced by a single plant. The culms vary from 2 to 5 feet in height, depending upon the fertility of the soil and upon other factors affecting growth. The node at the base of the culm is often enlarged into a tuber. This condition is common when the plant is growing on dry soils. When growing in wet or moist lands, the tuber is small, or in some cases not present at all. This character distinguishes timothy from the other forage grasses.

Fig. 69. — Timothy in bloom.

The leaves number from 2 to 8 and have a long sheath and blade in comparison with those of other grasses. The leaf blade is flat and rather rough, and varies with different plants in length and width. Timothy, when compared with other forage grasses, has a rather high percentage of leaves to stems, although the proportion may vary somewhat with individual plants or strains or with the thickness of the stand, thick seeding producing fine stems and slightly higher percentage of leaves. The inflorescence carried at the top of each culm is a spike. The spike or head varies from 2 to 12 inches in length, the most common forms being from 3 to 7 inches.

The spike is made up of a large number of one-flowered spikelets. The compactness of their arrangement on the rachis varies considerably. When compactly arranged, the spike appears full and rigid. When the spikelets are farther apart, it has a slender appearance.

The appearance of timothy seed is unlike that of any other cultivated grass, and it is easily identified. This fact renders adulteration difficult. The seed after thrashing is usually inclosed in the flowering glume and palea, although much of it, sometimes as much as 50 per cent, is freed from the glume during the operation and appears naked. The legal weight per bushel in the United States is 45 pounds.

184. Distribution and adaptation. — Timothy may be found growing throughout the temperate regions of the world. As a cultivated grass, it is of considerable importance in England and in Europe. In the United States it is extensively grown in that section of the country north of a line drawn from the southern boundary of Maryland, and east of the Missouri River. Within this section, known as the timothy belt, no other grass rivals it as a hay plant, and nowhere else in the world is it so well and so favorably known. Its importance in this section makes it the most important hay grass in the United States. New York produces the greatest amount of timothy hay, while Pennsylvania, Iowa, Ohio, and Indiana follow closely in its production. So important is timothy hay that, until recently, it has been the only hay on which there has been a market quotation. Much of the hay produced in this section is shipped to the large cities, to those within and also those without the timothy belt, and it is the market hay in the cities in the eastern half of the United States. Timothy is also grown quite extensively in many of the mountain valleys of the far West, especially in Washington and Oregon. Timothy grows best on moist clay or loam soils, and is not well adapted to loose or sandy soils. It does not grow well in the South, and a stand there rarely lasts over one year.

185. Cultural methods. — There are several methods of seeding timothy in common practice. The most common method is that of seeding it with wheat, either in the fall with winter wheat, or in the spring. When seeded in the fall, the seed may be spread either in front of or behind the drill hoes. Usually the spreading of the seed in front of the drill hoes gives the best results. However, if favorable weather prevails and soil conditions are good, seeding behind the drill hoes may give equally good results. Seeding in the fall with wheat gives the timothy an opportunity to become well established before winter, and usually a good stand is secured by following this practice. If it is desired to grow mixed hay, that is, timothy and clover together, the clover may be seeded in the spring, early enough so that the seed will be covered by alternate freezing and thawing. Another method of seeding in common practice is that of seeding both timothy and clover in the spring. Usually the seed is mixed in the proportion desired and then sown together. When this is done, the seeding may be done early in the spring so that freezing and thawing will cover the seed, or it may be delayed until the ground is dry, and in that case the seed should be covered with a light harrow. Good results are obtained by either method. Some growers object to covering the seed with the harrow, contending that the latter will injure the wheat. Experience and experiments, however, show that instead of injuring the wheat, harrowing often increases the yield a few bushels per acre. Timothy may be seeded alone or with clover in the spring with oats. Oats, however, on account of the dense shade produced by their broad leaves, do not provide as favorable conditions for the growth of timothy and clover as do wheat or rye. Timothy may also be seeded alone, that is, without a nurse crop. When seeded alone, the most favorable time is in late summer or early fall. With a well-prepared seed bed, seeding at this time usually gives an excellent stand, which may be expected to produce a good crop of hay the next year. When seeded with a nurse crop, either in the fall or in the spring, no hay may usually be expected until the next season. When seeded alone, 15 pounds of seed per acre is the usual application. Experiments carried on by several stations indicate that a heavier rate of seeding does not insure an increase in yield of hay. When seeded with clover, 8 or 9 pounds of timothy with 7 or 8 pounds of red clover and 2 pounds of alsike per acre make a desirable mixture.

186. Cutting for hay. — The stage of growth at which timothy is cut for hay varies in different localities, and even among different farmers in the same locality. It has been found that the time of cutting influences, to a considerable extent, the amount and quality of the hay. At the Missouri Experiment Station timothy was cut at five different stages of growth. The stages at which the cutting was made were: (1) plant in full head; (2) in full bloom; (3) seeds formed, bloom shed; (4) seeds in dough stage; (5) seeds ripe. It was found that the time of cutting influenced the yield, the digestibility, and palatability of the hay. It also influenced to some extent the convenience of harvesting and the permanency of the stand. Results of the experiments indicate that the highest yield of hay of the best quality is obtained when the grass is cut between the time when it is in full bloom and the stage at which the seeds are just formed. While the later cuttings are more easily cured in the field, due to the fact

FIG. 70. — Cutting timothy hay.

that they contain much less water than the earlier cuttings, the hay is not of as good quality as the earlier cuttings. Late cutting is favorable for the storing up of nutrients in the tuber at the base of the culm, and therefore more favorable for a permanent stand. Timothy is not a good pasture grass. The sod does not stand tramping well, and close grazing materially lowers the yield of succeeding crops. Sometimes timothy is grown for seed rather than for hay. When grown for seed, it should not be seeded so thickly as for hay, usually only nine or ten pounds per acre being used. The crop is cut with a grain binder or with a self-rake, and the bundles are either set up in shocks or hauled to the barn. The yield of seed per acre varies

FIG. 71. — Plots of timothy at Cornell University, showing variation in manner of growth.

from 3 to 20 bushels, the average probably being about 10 bushels. After thrashing, the straw is of some value as feed, though it is greatly inferior to timothy hay when cut at the proper time.

187. Improvement of timothy. — Much has been accomplished by systematic selection in the improvement of the small grains, but it does not seem to have occurred to many growers that forage grasses may be improved by the same means. The Cornell Experiment Station is one of the few that has engaged in this work. The results of their experiments show that much is possible by selection, and it will be only a short time probably until seed of heavy yielding strains or varieties of timothy may be purchased on the market. By selecting desirable plants and propagating them, the yield and quality of the grass has been greatly increased above that of the average.

KENTUCKY BLUE-GRASS

The name Kentucky blue-grass is given to this common and useful grass, not because it is a native of Kentucky, but because nowhere else does it grow so luxuriantly and nowhere else is it held in such high esteem. In some places it is called June-grass because it makes its best growth during this month. In England, where it is quite common, it is called smooth-stalked meadow-grass. In some places, too, it is called green-grass, while in other localities it is called simply blue-grass.

188. Description. — Kentucky blue-grass, *Poa pratensis*, is a strong perennial. Unlike most grasses, it becomes more productive as the years go by, provided it is favored with good care. The roots of Kentucky blue-grass do not penetrate deeply into the soil and it is easily affected by drought. The plant is provided with numerous creeping underground root stalks, which give rise to new plants, and it is able thus to thicken up a thin stand. The underground root stalks grow so vigorously that other grasses, excepting the most persistent ones, are soon crowded out. A good blue-grass sod is firm and tough and stands tramping and grazing well. The culms are comparatively few in number and grow from a few inches to three and one-half feet in height, depending upon the soil. They are quite commonly from 15 to 24 inches high. The culms of blue-grass are round and smooth, and the smooth character gives to it the name of smooth-stalked meadow-grass, by which it is known in England. The leaves are smooth, narrow, and bright green in color. The culm leaves are few in number and from 3 to 6 inches in length, while the basal leaves grow in abundance and are much longer than the culm leaves, usually from 1 to $2\frac{1}{2}$ feet. The inflorescence is an open, spreading, branched panicle, varying from 3 to 9 inches in length. The spikelets are larger and fewer in number than those of redtop, and contain rom 3 to 5 flowers. The panicle during certain periods of its growth is tinged with red, giving to it the appearance of redtop. The seeds remain inclosed in the glumes, and as they come from the thrasher contain a mixture of chaff and weigh but 14 pounds per bushel, which is the legal weight in most states. Well-cleaned seed may weigh as much as 25 pounds per bushel. The seed found on the market is usually very low in vitality, which is due in a large measure to the method of harvesting and drying the seed.

FIG. 72. — Kentucky blue-grass.

189. Distribution and adaptation. — Kentucky blue-grass is probably a native of Europe, and although no records are to be found, it was probably introduced into America many years ago. It is said that the early settlers of Virginia and Kentucky looked upon it as a dangerous weed, and prophesied that it would some day drive the farmers out of the country. How great would be the surprise of these same men, could they but see to-day the fine pasture it makes, and learn how highly we prize Kentucky blue-grass! While this grass may be found here and there over almost all of the United States, it is cultivated as a hay and pasture grass only in the timothy region, and in those states just south of this region. In the South it does not endure the hot weather and is soon killed out. Its distribution outside of the timothy region is confined largely to limestone soil. On a narrow strip of land running south of the Ohio River, through central Kentucky, and extending to the middle of Tennessee, blue-grass is found at its best. The famous blue-grass region of Kentucky is known far and wide for its famous pastures. In Virginia, too, fine blue-grass pastures are found in the fertile limestone valleys. Blue-grass is the basis of all permanent pastures and lawn mixtures throughout the corn belt states. It finds its greatest field of usefulness in that section of the country west of the New England States and east of the Missouri River. Here it holds the same position as a pasture grass that timothy does as a hay grass. Blue-grass grows best on clay or clay loam soil, and does not do well on loose, sandy soil. Being a shallow-rooted plant, it requires moist soils, but does not thrive in wet soil. It is easily affected by drought and fails to grow during dry weather. Blue-grass is sensitive to acid soils and does not grow well on them until this condition is corrected by the use of lime. It grows best on the limestone soils of the corn belt states and in the blue-grass region of Kentucky, which is underlain with limestone.

190. Uses of blue-grass. — As a hay grass, it cannot compare favorably with timothy, either in yield or palatability. The short stems and few culm leaves hold down the yield so that it is seldom that more than one-half ton of hay is secured per acre. The hay is dry and unpalatable, and animals do not relish it. Kentucky blue-grass is preëminently a pasture and lawn grass. As a pasture grass in the corn belt states, it has no rival. It furnishes a palatable and nutritious pasture, starts early in the spring, and grows late into the fall. It makes a dense, firm sod that stands pasturing well and becomes more dense and productive with age. There are, however, two serious objections to blue-grass as a pasture grass. It does not furnish pasture during the dry, hot part of the summer, and it requires several years to become well established. Its desirable qualities, however, so far outweigh its defects, that there is no danger of its losing favor. As a lawn grass in the blue-grass section it has no rival. It makes a beautiful, dense turf that improves with age and when supplied with water during the summer, retains its beautiful green color from early spring until late fall.

In certain sections of the country, the seed crop is important. Almost all of the seed used in the United States is harvested within a radius of 40 miles of Lexington, Kentucky. The seed is harvested either by hand or horse-drawn machines. The harvester most commonly used is a machine run by horses that combs or strips the spikelets from the panicle and collects them in a bag. The machines are wide and collect the seed from a strip 15 to 25 feet wide at one time. The stripping begins when the panicle turns yellow, which, in central Kentucky, is soon after the first of June. After the seed has been collected it is put into piles or long ricks to cure. The low vitality of much of the seed on the market is due to the heating of the seed in the curing process, sometimes reaching a very high temperature. Experiments have indicated that better methods of curing yield seed with a good vitality. In the purchase of blue-grass seed, it is important that the percentage of germination be ascertained, else the purchaser may get a high proportion of seed that will not grow.

191. Cultural methods. — When sowing blue-grass for pasture, it is seldom seeded alone, since it requires two or three years to make a dense sod. It is usually seeded in combination with other grasses and clovers, which will furnish pasture until the blue-grass becomes established, when it will crowd them out and replace them. In this way pasture may be had soon after seeding without waiting for the blue-grass to become established. When seeded alone, 40 pounds of seed per acre is considered a full seeding, although if the seed is of good vitality, half this amount is enough. When seeded with other grasses, a mixture of 10 pounds of blue-grass, 10 pounds of timothy, 3 pounds of redtop, 2 pounds of meadow fescue, 3 pounds of alsike clover, and 2 pounds of white clover per acre makes a desirable combination. White clover grows well with blue-grass and is often seen with it in permanent pastures.

When seeded alone, it is well to sow in the fall with a nurse crop, wheat or rye being desirable for this purpose. When seeded in combination with other grasses, the mixture may be sown in the fall, or the grass seed only may be applied at this time, and the clover added early in the spring. When a blue-grass pasture becomes thin, it may be renovated without plowing it up by disking and sowing a mixture of clover and blue-grass seed. It is usually advisable to apply barnyard manure or commercial fertilizers to the field before reseeding. The clover will furnish pasture for a few years, during which time the blue-grass will make rapid growth and thicken up the stand by means of its creeping root stalks.

CANADA BLUE-GRASS

192. Canada blue-grass, *Poa compressa*, is sometimes known as wire-grass, and flat-stalked meadow-grass. It is closely related to Kentucky blue-grass, is bluer in appearance, and in some localities goes by the name of bluegrass. It may be distinguished from Kentucky blue-grass by its flat stems, blue color, and closed panicle. The grass is distributed very generally over the Kentucky blue-grass region, but is of importance only along the northern boundary of the United States, particularly in New York State. Canada blue-grass will grow under more adverse conditions of soil and climate than will its near relative, Kentucky blue-grass. It will grow well on acid soils, soils of a sandy nature, and those low in fertility. It is therefore useful in localities where Kentucky blue-grass does not thrive. As hay grass, it is highly prized where it is known. Live stock prefer it to timothy, but it does not yield nearly so well. It furnishes good pasture, but does not start so early in the spring nor does it grow so rapidly as Kentucky blue-grass. It is highly prized as a lawn grass, and makes a beautiful sward if kept closely mowed.

REDTOP

In mid-summer the panicle of this grass has a reddish purple color, from which it gets its common name of red-top. In Pennsylvania and the Southern States it is also known as Herd's grass, the term redtop being sometimes applied to some of the other members of the same genus with the characteristic reddish purple panicles.

193. Description. — Redtop, *Agrostis alba*, is the most varied of any of the cultivated grasses. Some forms are small and slender, while others grow strong stems, with coarse, broad leaves. The largest forms are the varieties used for hay or pasture. Redtop has a shallow root system, made up of many underground root stalks, which form a firm, dense sod. Because of the numerous stolons, it is a valuable grass for binding soil to prevent it from washing. The culms vary from one to four feet in height, and are usually erect, though they are sometimes decumbent. The nodes of the culms take root when they come in contact with the ground. The leaves are not as numerous as those of timothy. The inflorescence is an open, much branched panicle, and the spikelets are small and contain but one flower. During the early stages of growth the panicle is contracted and green in color, but as the plant matures, the panicle expands and takes on a reddish purple color. Redtop bears a resemblance to blue-grass, but can be distinguished from it by the smaller and more numerous spikelets having only one flower, while blue-grass has 3 to 5 flowers per spikelet. Blue-grass is an earlier grass and comes into full bloom about six weeks before redtop blooms. Redtop seed varies considerably in quality; as it comes from the thrasher it contains much chaff and

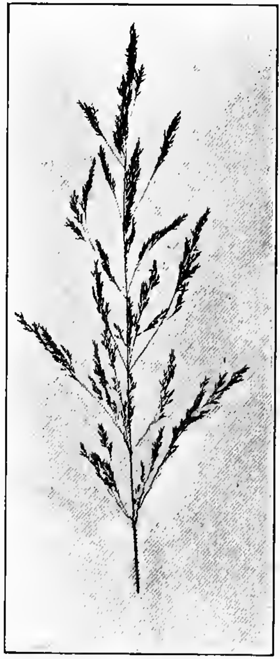

Fig. 73. — Redtop.

weighs only about 12 pounds per bushel. Recleaned seed weighs about 35 pounds per bushel.

194. Adaptation and distribution. — Redtop is probably more widely distributed than any other cultivated grass. It will grow in greatly varying conditions of soil and climate. It is hardy in the North and thrives in the warm climate of the Southern States. While redtop is grown in almost every state in the Union, it is of importance only in comparatively few places. It is well adapted to low, wet, or undrained soils, and will also grow on soils that are of acid reaction. It is well adapted, too, to heavy clays. In the timothy and blue-grass sections and also in New England, it is used in pasture and meadow mixtures. It is grown in the mountain valleys of the Western States where the soil is too wet for other grasses. In a few counties of southeastern Illinois and adjacent counties across the river in Kentucky, it is an important crop. In this section it is grown for the seed. In the South, where it is known as Herd's grass, it is accorded much favor, since it is one of the few grasses that will remain green the year around.

195. Uses. — As a hay grass, redtop is generally looked upon with disfavor, especially in the timothy region. It is, however, next to timothy the most important hay grass of this section. When hay is grown for the market, redtop is especially in disfavor, and a small amount mixed in with the timothy decreases the price of the hay. Chemical analysis shows that redtop is equal if not better than timothy in feeding value. Redtop hay, however, lacks palatability, it deteriorates in quality if over-ripe, and does not as a general rule compare with timothy in yield. In the New England States, redtop is largely used in combination with other grasses for hay. It is slow to start growth in the spring or after cutting, but it is very useful in mixture for seeding permanent pastures, since it will grow in places too wet or too acid for the other grasses of the mixture. For pasture it ranks near blue-grass in palatability, and live stock eat it quite readily. Where soils wash badly, redtop, because of its numerous creeping root stalks, is a valuable grass to bind the soil and prevent washing. When grown for seed it is a profitable crop, because it can be grown on soil that will not give a profitable return from other crops.

196. Cultural methods. — The seed of redtop varies more in quality and price per bushel than other grass seed. Usually one pound of well-recleaned seed is worth as much for seeding as four or five pounds of the uncleaned seed. When seeded alone, 15 pounds of well-cleaned seed is regarded as a full seeding. It may be seeded in the same way as described for timothy. In pastures or wood lots having low, wet areas, redtop may be useful to improve the herbage. The seed may be scattered over these areas in February and March and the freezing and thawing will cover the seed.

CHAPTER XI

OTHER PERENNIAL GRASSES

ORCHARD-GRASS

ORCHARD-GRASS derives its name from the fact that it grows well in the shade, and for this reason is commonly grown in orchards. In England it is known as cocksfoot from the resemblance of the panicle to a cock's foot.

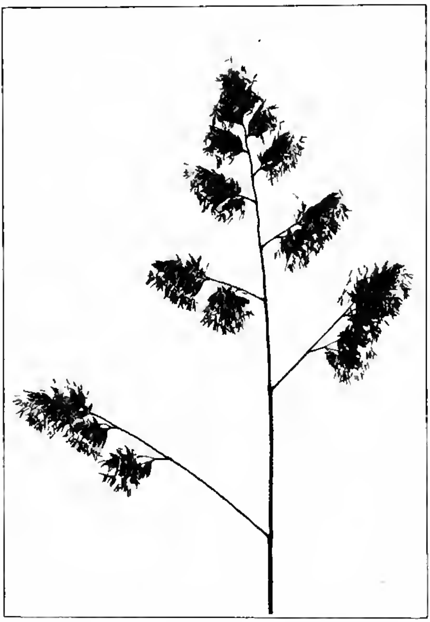

FIG. 74. — Orchard-grass in full bloom.

197. Description. — Orchard-grass, *Dactylis glomerata*, is a perennial with a strong tufted habit of growth. It has no creeping root stalks like red-top or blue-grass, but tillers are produced from nodes of the culm just above the ground. The root system grows to a medium depth, not so deep as timothy, and not so shallow as blue-grass. The culms are inclined to be coarse and vary from $1\frac{1}{2}$ to 3 feet in height. The leaves are abundant on the culm, but the blades are large and thick. The inflorescence is a one-sided spreading panicle with a spikelet arranged in dense clusters. The spikelets have from three to four flowers, and the seeds when they mature remain within the glumes. The keel of the flowering glume extends into a short, slightly curved awn. The legal weight per bushel is 14 pounds, although when well cleaned a bushel may weigh as much as 22 pounds.

198. Distribution and adaptation. — Orchard-grass is one of the commonest grasses in England and Europe. In the United States it has a wide distribution, but is of the most importance here in the states just south of the timothy region, especially in West Virginia, Virginia, Kentucky, and Missouri. Orchard-grass will grow on almost any type of soil, but grows most luxuriantly on fertile, well-drained soils. It will withstand severe winter cold, but is often injured by late spring frosts.

199. Uses. — Orchard-grass is important as a hay grass only outside of the timothy region. Orchard-grass hay, according to analysis, is equal to timothy in feeding value, but unless it is cut at the proper stage of growth and well cured, the live stock will not eat it as readily. For the best quality of hay, the grass should be cut when in full bloom. After this time it rapidly becomes woody and deteriorates in palatability and feeding value. The quality of the hay depends also upon the thickness of seeding; when seeded thinly, it is coarse and woody. Under favorable conditions it yields two cuttings of hay per year. It ripens at the same time red clover does and if they are seeded together, the mixture, if cut at the proper time, makes valuable hay. As a pasture grass, it is eaten by live stock almost as readily as timothy. It makes a desirable mixture with meadow fescue and white clover. It has to recommend it as a pasture grass the fact that it is one of the first grasses to start in the spring and grows late in the fall. It also grows well during the hot months of summer and quickly springs up after pasturing or cutting.

In a few localities of West Virginia, Ohio, Kentucky, and Indiana, it is grown for the seed. When grown for the seed, it is cut with the grain binder and handled much like a grain crop. The straw after thrashing has some feeding value, and the after growth either makes excellent fall pasture, or is cut for hay. The yield of seed per acre varies from 8 to 25 bushels, the average being about 15 bushels. The price received by the grower varies from one to two dollars per bushel.

200. Cultural methods. — Orchard-grass in many sections of the country is sown broadcast on winter wheat in January or February, the freezing and thawing covering the seed. Sometimes it is seeded in the spring with oats. When seeded alone, the usual practice is to apply the seed to a well-prepared seed bed in late summer or early fall. Usually no crop can be expected the first season, either when seeded with a grain crop or alone. The rate of seeding will depend on the purpose for which the crop is grown. When a seed crop is desired, 14 or 15 pounds per acre are used, and if hay or pasture is the object, the rate is increased to twice as much as for seed.

BROME-GRASS

While brome-grass is the most common name applied to this grass, it is also known, and its seed is sometimes sold, under the names of smooth brome, awnless brome, Hungarian brome, and Russian brome-grass. Brome-grass is a native of Europe, and was introduced into the United States about 1882 by the California Experiment Station. Its usefulness does not seem to have been appreciated in this country until it received favorable comment in Canadian agricultural publications, and it was from Canada that our seedsmen got their first supply of seed.

201. Description. — The genus *Bromus,* to which brome-grass, *Bromus inermis,* belongs, contains many useful grasses, but also some of doubtful reputation. Chess or cheat, the common weed pest of the wheat field, is a near relative of the useful brome-grass. There are several other members of the genus *Bromus* that are useful as forage grasses, but they are of minor importance as compared with brome-grass.

FIG. 75. — Brome-grass.

Brome-grass is a deep-rooted, strongly stoloniferous plant. The creeping root stalks branch out in all directions, producing at the nodes a bud which usually produces another plant, and in this way the plants quickly form a thick, firm sod. Because of its deep-rooting character, the plant is able to withstand drought to a remarkable degree. The culms of brome-grass are, when compared with those of other tame grasses, rather short and thick. The leaves are broad, thick, and abundant and grow largely from the nodes near the ground. The flowers are carried in a wide-spreading panicle from 4 to 8 inches in length, made of numerous spikelets, which are large and contain from 6 to 10 flowers each. The seeds of brome-grass, when thrashed, are retained in the flowering glume and palea. The legal weight per bushel for the seed in the United States is 14 pounds.

202. Distribution and adaptation. — Brome-grass is a native of the north temperate regions of Europe and Asia, where it has been grown for many years. In the United States it does not do well south of the latitude of St. Louis, except in high altitudes. It withstands cold well and is hardy far up in Canada. Brome-grass is noted for its ability to withstand drought, but does not do well in extremely dry climates. It is therefore a valuable grass for the semi-arid regions of the West, and for the cool climate of the Great Plains area of the Northwest and in Canada. While it will grow on a variety of soils, it is not well suited to sandy or loose soils, and does best on moist loams. Brome-grass has not yet become a successful competitor of timothy in the timothy belt.

203. Usefulness. — Brome-grass is classed among the best hay grasses of Europe. In the United States it is given high rank, but because only small quantities are found on the market, it does not rival timothy. The hay is palatable and is readily eaten by all kinds of live stock. Brome-grass will produce a fine crop of hay for two or three years, after which time it becomes sod-bound and sends up few culms, but continues to produce many short leaves from the nodes near the ground, and thus furnishes excellent pasture. Unlike almost all other grasses, it furnishes an abundance of pasture during the dry summer months, starting early in the spring and growing until late in the fall. It recovers quickly after cutting or grazing and because of the thick, firm sod which it makes, stands tramping well. In palatability it is surpassed only by blue-grass.

204. Cultural methods. — Brome-grass is usually seeded in the spring with a light seeding of one of the grain crops. Twenty pounds of well-cleaned seed per acre is the usual rate of seeding. It makes but little growth the first year, but usually will furnish considerable pasture during the latter part of the season. The seeding may be done in late summer or early fall, in which case a considerable growth may be expected the next year. When the crop is grown for seed, it should not be cut until fully mature, for if cut prematurely the vitality is impaired. Formerly much of the seed used in this country was imported from Europe. Within recent years, however, considerable quantities of it have been produced in the Great Plains area of the United States. The yield of seed varies from 200 to 400 pounds per acre. After thrashing, the straw may be used for feeding, and if not badly weathered, it is relished by most classes of live stock. Because of the many branching stolons, this grass is sometimes difficult to eradicate. This objection, however, may be largely overcome if the land is plowed deeply and planted to a crop that requires considerable tillage during the growing season.

THE FESCUES

There are several species of the genus *Festuca* that are of agricultural importance. The most common form is meadow fescue, *Festuca elatior*. Another variety, which grows taller than the meadow form, is called tall fescue.

205. Description. — Meadow fescue is a perennial having long, fibrous roots which grow deep into the ground. It is not stoloniferous, neither does it grow in prominent tufts or bunches like orchard-grass. The culms are rather short, when compared with those of other grasses, varying from $1\frac{1}{2}$ to 3 feet in height. In the tall fescue, the culms are usually from 3 to 6 inches taller than those of meadow fescue, growing under the same conditions. The leaves of both species have a distinguishing shiny appearance, and are an intensely dark green in color. Not many leaves are produced on the culms, but basal leaves grow in great abundance. When the plant is young, the panicle is closed, but as it reaches maturity it becomes more spreading and slightly drooping. The spikelets are fairly large and contain several flowers.

FIG. 76. — Meadow fescue.

206. Adaptation and distribution. — Meadow fescue is of great importance only in three or four counties in eastern Kansas and western Missouri, although it is grown more or less in meadow and pasture mixtures in the North Central and New England States. In some of the valleys in Washington and Oregon, tall fescue attains considerable importance. Meadow fescue will grow on a variety of soils, but is especially adapted to those of the stiff clay type.

207. Uses. — While this grass is used both for meadows and for pastures, it is probably better adapted for pasture than for hay. It makes a compact, leafy sod, which stands tramping well. It grows early in the spring and late in the fall. In palatability it rivals Kentucky bluegrass. It is grown principally for the seed in certain parts of Kansas and Missouri, where it ranks next in importance to the small grain crops. This section supplies the demand of the United States for meadow fescue seed; and when more is grown than is needed here, the surplus is often exported. When grown for the seed, it is cut with the grain binder and bound in sheaths. The production of the seed varies from 3 to 25 bushels per acre, the average being about 10 or 12. The weight per bushel varies from 12 pounds in seed that is not well cleaned, to as much as 25 pounds in well-cleaned seed.

208. Cultural methods. — Meadow fescue seed is commonly low in vitality, the standard of germination being 75 per cent, although it frequently goes much lower than this. When seeded alone, from 30 to 40 pounds per acre is used, the amount depending upon the cleanness of the seed and upon its vitality. It is not often sown alone, except when grown for seed. More often it is seeded with other grasses for hay or pasture, and when seeded this way, from 2 to 10 pounds per acre is used, depending upon the kind of mixture desired.

BERMUDA-GRASS

Bermuda-grass was introduced into this country in the early part of the nineteenth century. In all probability it did not come from the Bermuda Islands, as its name would indicate, there being evidence that it was shipped in with some foreign merchandise through the West Indies.

209. Description. — Bermuda-grass, *Capriola dactylon*, is a strong perennial with a dense stoloniferous root system, composed of both above and below ground stolons. It therefore quickly forms a thick, firm sod. The culms, which are usually short, produce only a few leaves, but basal leaves grow in abundance. The inflorescence is made up of from three to five one-sided spikes, from 1 to

3 inches long. The spikelets are one-flowered, and seldom mature seed in the United States, excepting in the extreme southern parts where favorable conditions exist.

210. Distribution and adaptation. — Bermuda-grass is a tropical or warm-country plant and may be found growing throughout the warm regions of the world. In the United States its field of usefulness is confined to the cotton growing states and those adjacent to them. It grows best during the hot months in summer, and will stand extreme periods of drought. It grows on almost all kinds of soil, and has special adaptation to light, sandy soils. Bermuda-grass does not love the shade, but grows well in the waste lands, if kept free from shrubs and weeds.

211. Uses. — While many grasses grow well in the South, none can compare in importance and usefulness in this section with Bermuda-grass. On good soils and under favorable climatic conditions, Bermuda-grass grows large enough to be cut for hay. Under such conditions it can be cut three or four times during the season, and while the yield of hay per cutting is not large, the amount obtained from all of the cuttings together makes it a profitable hay crop. The hay made from it is of excellent quality, equal to, if not better than timothy in palatability and feeding value. As a pasture grass it takes first rank. Bermuda-grass is useful also as a lawn grass, but since it does not grow well in the shade, it is not desirable for shaded lawns or parks.

212. Cultural methods. — Almost all of the seed used in the United States is imported from Australia, and it is very expensive and unreliable in quality. It is fortunate, therefore, for the farmers of the South, that the grass can be propagated by planting pieces of the sod containing a piece of the underground root stalks. Several methods of planting the bits of sod are in common practice. They may be spread in the growing corn and covered at the last cultivation, or the field may be plowed and marked off with furrows two feet apart and the sod dropped in the furrow and covered. Sometimes the bits of sod are dropped in the furrow as the ground is being plowed. Probably the most interesting method is that of having a barefoot boy carrying the pieces of sod in a basket, pass over the field soon after a rain, dropping the sod and pressing it into the soil with his foot. So vigorously do the root stalks grow out in all directions, that a dense sod is formed within a short time.

JOHNSON-GRASS

213. Johnson-grass, *Sorghum halepense*, was introduced into the United States about 75 years ago and rapidly spread over the Southern States. It is known in some localities as Means grass. The plant is strongly stoloniferous, growing from 4 to 7 feet in height, bearing long, broad, flat leaves. The panicle resembles that of the millets, bearing the spikelets in pairs. The seeds, when thrashed, are naked and resemble those of the sorghums in appearance. The weight per bushel is 45 pounds. This grass is common in the Southern States, where in many places it is regarded as a weed, because of the difficulty of eradicating it. As a hay grass, it is one of the best in the South. It yields more than any other; in favorable localities three full cuttings can be made per year. The quality of the hay is excellent, being preferred by live stock to timothy. It does not sell readily on the market, because the seeds carried with the hay cause it to be introduced into localities where it is considered a serious pest. As a pasture grass, it is very productive, but does not stand tramping well and is not so good for this purpose as is Bermuda-grass.

THE RYE GRASSES

214. Perennial rye grass, *Lolium perenne*, is a native of Europe and is sometimes called English rye grass. It is perennial in duration and grows somewhat in tufts. It grows luxuriantly in fertile and moist soils, but on dry soils it is of little value. In England it is one of the most important grasses, entering into mixtures for both pastures and meadows. In the United States it has never been of much importance, excepting in a few places in the Pacific Coast States. It makes a good quality of hay and is relished by live stock.

215. Italian rye grass, *Lolium italicum*, is a biennial, although in some places it lives but one year. It is of little importance in the United States excepting in the Pacific Coast States, where it is frequently found in meadows. On account of its duration, it is not adapted for permanent pastures. It is a rapid grower and compared with the perennial rye grass has coarser, taller stems and is lighter in color.

CHAPTER XII

THE ANNUAL GRASSES FOR GRAIN AND FORAGE

THE MILLETS

THE term "millet" as employed in general usage includes a number of species, all of which are members of the grass family, and may be grown either for grain or for forage. In Japan, China, India, and other parts of Asia, they are grown largely for the grain, and therefore belong to the cereals. In the United States, however, they are generally grown for forage, and are most often classed with the forage crops. The millets, while including several distinct species, have in common the fact that they are all annuals, similar in their habits of growth and cultural requirements. The millets commonly grown in America may be divided into three principal groups, namely, the fox-tail millets, the broom-corn millets, and the barnyard millets.

216. The fox-tail millets, *Chætochloa italica.* — This group of millets gets its name from the resemblance of its members to the common fox-tail weed from which they are supposed to have been derived. Members of this group are the most commonly grown, and are also the most important of the millets in the United States. They are all erect, hot weather plants, with a spike-like head, which distinguishes them from the other groups. They are rather drought resistant, growing best on fertile soils, although a fair yield may be expected on relatively poor soils. There are three important varieties of fox-tail millets, namely, common, German, and Hungarian.

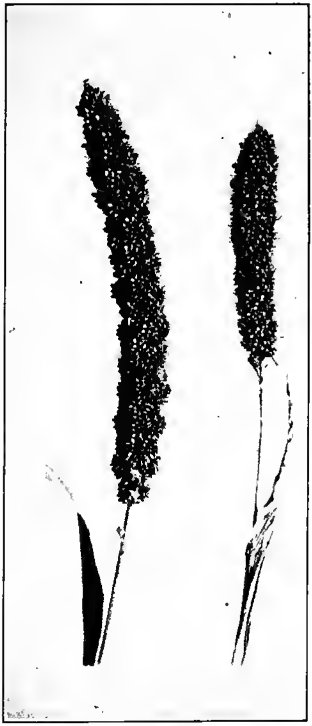

Fig. 77. — Common and Siberian millet.

217. Common millet. — This variety was the first to come into general use in this country and is still probably the one most commonly grown. Several slender stems, which grow from 2 to 4 feet in height, are produced by each plant. The leaves are narrow and dark green in color, the spike grows almost erect, is compact with numerous bristly hairs, and the seeds are somewhat larger than those of Hungarian or German millets and are yellow in color. Common millet is the earliest of the three varieties, and is adapted to the Northern States, although it will do well elsewhere. It is better adapted to medium fertile soils than the German millet, although larger yields are obtained under more favorable conditions. It is almost always grown for hay and under favorable conditions will yield from 2 to $2\frac{1}{2}$ tons per acre.

218. Hungarian millet. — This millet is sometimes known as, and the seed is often sold under the name of, Hungarian grass. Hungarian millet was introduced into the United States soon after the introduction of common millet, and it is now one of the important varieties, being grown almost exclusively for hay. It differs from common millet in having a shorter and more erect spike and the seeds are either yellow or purple. Like the common millet, it produces several culms from a single seed. It requires a little longer season and is not quite so drought resistant as the common millet, although under favorable conditions it may be expected to yield a little more hay. The hay, however, is not quite so good in quality as that made from common millet.

FIG. 78. — German millet.

219. German millet. — This millet is a large, rank growing variety, with short, broad leaves, and a nodding spike. The seeds are yellow and are smaller than those of the common and Hungarian millets, and although it sometimes produces tillers, usually but one stem grows from each seed. German millet is a late variety, requiring a longer growing season than the common and Hungarian millets. It is not adapted to poor or medium fertile soils, but for good yields must be sown in fertile, moist soils. It yields more per acre than the common or Hungarian, but the hay is coarser and is of not quite so good quality, although when it is properly made, live stock eat it quite readily.

220. The broom-corn millets. — Broom-corn millet, *Panicum miliaceum,* is so named because of the similarity of the head, which is in the form of a panicle, to that of broom-corn. The broom-corn millets are grown extensively in southern Europe and in many parts of Asia, but they have never been extensively grown in the United States, and are not nearly so important here as the fox-tail varieties. Some varieties, however, are grown rather extensively in the Northwest, where, on account of the short season and dry climate, they provide a good substitute for corn. The varieties of broom-corn millets vary more or less in their habits of growth, but the group as a whole, when compared with fox-tails, do not produce as much forage as the latter, but produce more seed. The stems are large and often hollow, and the leaves are covered with hair, giving a coarse, rather unpalatable forage. The seeds are large and variously colored, the colors of red, white, and yellow being especially prominent. They are valuable plants for many sections of the Northwest,

FIG. 79. — Broom-corn millet.

since they produce a good yield of grain in a short, dry season. Sometimes as many as 60 bushels are produced per acre. When grown for the grain, millets are handled in much the same way as the small cereal crops.

221. The barnyard millets, *Panicum crus-galli.* — The barnyard millets is the name given to a group of plants, most of which are varieties of the single species known as barnyard grass, which is a common weed, growing wild in moist, rich soils throughout the United States. Varieties of barnyard grass are grown for both grain and forage. In Japan they have received the most favor, and are there an important crop, being grown for the seed which is used for human food. In the United States, the barnyard millets have not been grown to any considerable extent. Recently, however, the Massachusetts Station imported from Japan a variety known as Japanese millet, which, when tested at that station, gave a higher yield of forage than any of the other varieties of millets. The seed of this variety is put upon the market under the name of "billion dollar grass" and extensively advertised as a great forage grass. Experience has shown, however, that while the barnyard millets ordinarily give a heavy yield of forage, the quality of the hay is quite inferior to

FIG. 80. — Barnyard millet.

that made from the fox-tail millets. The plant grows rather tall and has a more or less open head, free from bristles. It does not withstand drought well, requires a fertile moist soil, and is better adapted for use in the silo or as a soiling crop than for making hay.

222. Pearl millet, *Pennisetum spicatum.* — While classed as a millet, this plant more closely resembles sorghum or corn than do the millets. It grows from 5 to 12 feet in height, the spike is from 6 to 15 inches long, very compact and almost cylindrical, resembling the "cat-tail" flag, which grows wild in swampy places (in fact, it is sometimes called cat-tail millet), and the leaves closely resemble those of sorghum. Pearl millet requires a rich, moist soil, and a long, hot growing season for its best growth. Under these conditions it suckers abundantly and produces a large yield of forage, which may be cut several times during the season. Pearl millet is important only in the South.

223. Uses of millets. — Millets have been grown for centuries in India, China, and Japan, where they are used as human food. Indeed, it is said that millet enters into the dietary of over one-third of the inhabitants of the globe. When used for food, it is usually boiled or parched, and is eaten alone or with milk and sugar. It is considered a nutritious and digestible food. In the United States, millet is used only as a feed for domestic animals. It is most commonly used as hay, and compares favorably in digestibility and nutritive value with timothy. It may be fed to cattle, sheep, and horses, usually in combination with other forage, since, if fed alone, it sometimes produces injurious effects on the kidneys of the animals. It is sometimes used as a soiling crop, especially in sections where the silo has not come into general use. Under favorable conditions it may be cut for this purpose in from 40 to 50 days from the date of seeding. The common and Hungarian varieties are the ones best adapted both for hay and for soiling. Millet may also be used for pasture, either alone or in combination with other annuals, like cowpeas and soy beans. Massachusetts Station has recommended it for the silo, and their experience shows that it can be preserved in excellent condition in the silo. When grown for its seed, which is used for feeding domestic animals, the yield varies from 15 to 60 bushels per acre. Millet is not usually grown in the regular rotation except in the Northwest. It finds its greatest usefulness as a substitute for corn and hay crops when they fail. It is then found valuable as an emergency hay crop.

224. Cultural methods. — Millets grow best on rich, fertile soils, but certain varieties, as the common and Hungarian millets, may produce good yields on the soils of medium fertility. They are rapid growers, but, on account of their small seeds, require a well-prepared seed bed. Seeding should be delayed until the soil is well warmed up, usually until just after corn planting. Seed may either be sown with a drill or sown broadcast and harrowed in. For most varieties 3 pecks per acre is considered a full seeding for hay, a thinner rate producing coarser stems which do not make as good a quality of hay. Japanese millet is seeded at the rate of 2 pecks per acre. The quality of the hay depends largely upon the time of cutting. It rapidly deteriorates after the seeds have reached the dough stage, hay cut after that time becoming less palatable and less digestible. The best quality of hay may be had if the crop is cut between the time that the heads begin to appear and before they reach full bloom. The hay is cut and harvested in much the same way as timothy, although a little more difficulty may be experienced in curing it.

THE SORGHUMS

Cultivated sorghums have been derived from a wild grass, *Sorghum halepense,* which may be found growing in tropical and semi-tropical parts of the Eastern Hemisphere. Sometime in the distant past varieties of this grass were found to be useful to man as food. Selection of the best individuals for seed through all of the succeeding generations has greatly changed the progeny from the original form of the grass, and increased their value. The sorghums of to-day, therefore, like many of our other cultivated crops, owe their present form and great usefulness to long years of selection. How long ago and by what people sorghums were first used is not known. Mention of them in the ancient records of the people living in the valleys of the Tigris and Euphrates rivers, and in India and Egypt, indicate that they are among the oldest of cultivated plants.

225. General description. — While there are three main classes of sorghums, and many varieties of each class, they all have certain characters in common. The sorghums have a strong, fibrous root system and are known as plants with great feeding capacity and a general ability to withstand drought, some varieties being especially adapted to sections with little rainfall. The culms are tall, varying in height from four to twelve feet. In appearance the plants are much like corn, and like those of corn, the culms are solid. The leaves are long, but not so wide as those of corn, and they have a glossier appearance. The inflorescence, or head, is carried at the top of the stem, and varies in shape from a rather compact spike-like panicle, as in the kafirs and some other grain sorghums, to a loose, long branched panicle, as in the broom-corns. The grains of the sorghums differ from those of the cereals in that they are rounder. They vary in size and shape with the varieties, but in general they are much smaller than corn kernels, and usually red or white in color.

226. Classes of sorghums. — Sorghums may be divided into three main classes, namely, saccharine, nonsaccharine, and the broom-corns.

THE SACCHARINE SORGHUMS OR SORGO

227. Description and varieties. — The saccharine or sweet sorghums are so called because of the high percentage of sugar contained in the juices of the stems, which distinguishes them from the other two groups. When the word "sorghum" alone is used, it usually refers to the members of this group, which are sometimes known locally as "cane." The sweet sorghums are used both for forage and for the making of sirup or molasses. They grow from 5 to 10 or more feet in height and have numerous, rather broad leaves. The head varies in size and shape from an open panicle, in appearance much like a corn tassel, as in Amber sorgo, to a compact spike-like panicle, as in Sumac sorgo. Their soil requirements are similar to those of corn, although they may be grown successfully on soils too poor to grow a good crop of corn. The sweet sorghums are grown quite extensively both for forage and for sirup in the South and Southwest. They do not hold an important place as a forage crop in the North, although within the past few years they have been more generally grown. Many farmers, however, grow a small area for the production of sirup for table use.

228. There are several varieties of sweet sorgos, which may be divided into four groups, namely, Amber, Orange, Sumac, and Gooseneck. The basis for this division is the form of the head and the color and covering of the seed. The members of the Amber group are earlier than the other three, and are usually grown in the Northern States both for sirup and for forage. The Ambers have loose, open panicles, and the seeds are covered with black or deep red glumes, giving to the seed and head a black appearance. The Orange sorgos are from two to three weeks later in maturing, and are distinguished from them by a medium compact head and the yellow seeds projecting beyond the dark red-black glumes. The Sumac or Redtop sorghums have small red seeds projecting beyond the small glumes, giving the head, which is short and compact, a red appearance. They mature about the same time as the Orange sorghums. The Gooseneck sorghums are so called because the stem that supports the head is often curved, permitting the latter to hang downward. The stalks of the sorghums of this group are rather large and full of sweet juice, which, when boiled down or evaporated, forms sorghum molasses.

229. Cultural methods. — Sorghum plants grow slowly at first, and for this reason they require a well-prepared seed bed that is free from weeds. Unless the weeds are destroyed before the crop is seeded, they are likely to crowd and shade the young sorghum plants, with disastrous results to the latter. Sorghums require warm growing weather and are usually not planted until a week or two after corn may be planted. When grown for sirup, the seeds may be drilled in rows, three or three and one-half feet apart. The amount of seed used should be such as to give twice or three times as many plants per acre as are desired of corn plants to the acre, which result may be had by using from 10 to 20 pounds of seed. When grown for hay, the seed may either be closely sown with a drill, which requires about one bushel of seed per acre, or it may be drilled in rows as it is for sirup, which requires only about one-third as much seed. If weeds are plentiful, it is best to cultivate during the early part of the

FIG. 81. — Cutting sorghum — one of the best forage crops for the Middle West.

growing season, although good crops may sometimes be grown without cultivation.

230. Harvesting for sirup. — Harvesting for sirup should be done when the seeds are in the late milk stage, since at this time the stems contain the best quality of juice. The heads and leaves should be removed from the stems before the latter are passed through the mill, since they impart a disagreeable taste to the sirup. They may be removed before the plants are cut by cutting the heads and stripping the leaves from the standing stalks, or they may be removed after cutting. The juice is then pressed from the stalks by running them between heavy rollers. The juice is collected and reduced to the desired consistency by evaporation over steam. The yield of sirup varies from 70 to 300 gallons per acre, the average being about 125 gallons.

231. Harvesting for forage. — When grown for forage, the crop may either be cut and fed green, or made into hay. When used for soiling, it may be cut as needed from the time the heads appear, until it is ripe. When cut for hay, more palatable forage and greater feeding value per acre will be secured if the crop is cut when the grains are in the late milk stage. The feeding value of the hay decreases from this time until maturity. The best quality of hay is secured when the hay is cured in small cocks or windrows, which practice prevents the leaves from becoming sunburned. Considerable time is required for curing sorghum hay on account of the large amount of juice in the stems. Sometimes the crop may best be cut with a corn binder and the bundles set up in shocks to cure. This method facilitates handling and also promotes excellent conditions for curing while in the shock. Sorghum hay is of good quality and is relished by almost all kinds of stock. The yield varies from 2 to 10 tons per acre.

THE NONSACCHARINE SORGHUMS

232. Description. — The common nonsaccharine sorghums may usually be distinguished from the sweet sorghums by their shorter and more stocky stems, which usually contain little sap, although in some varieties the stems are rather juicy but scarcely sweet. The nonsaccharine sorghums, unlike the sorgos, are grown principally for grain, and by many agronomists are grouped with the cereals; but because they are so closely related to the forage and sirup sorghums, and because the cultural methods of the two classes are so similar, they are discussed together in this chapter. The nonsaccharine or grain sorghums are extensively grown in India, China, and Africa. In the United States they are grown rather extensively in the southern half of the Great Plains area, which may be defined as the area lying between the Rocky Mountains and a line drawn from Central Nebraska to the Mexican border. This area will include western Kansas, Oklahoma, and Texas, and the portions of Colorado and New Mexico that lie east of the Rocky Mountains. The grain sorghums are particularly well adapted to this area, which is noted for its low rainfall, which averages about 20 inches annually, almost all of which falls between the months of April and September. In this section of the Great Plains area, the grain sorghums hold a place of importance similar to that held by corn in the corn belt states. They are able to grow and produce a profitable crop of grain under conditions of rainfall that prohibit the growing of corn or other grain crops. The total area devoted to the growing of grain sorghums is approximately as much as that devoted to the growing of rye, but the area devoted to the former is not widely scattered over many states as is the culture of rye. The grain sorghums may be divided into two groups, namely, the kafirs and the milos.

233. Kafir. — The kafirs or kafir "corns" differ from the sweet sorghums in that their stems are lower, short-jointed, and stocky. They grow usually from five to eight feet in height, having broader leaves than the sweet sorghums, and a more cylindrical head that always stands erect. While the stalks do not usually contain much juice, in some varieties they are quite juicy. Usually the seeds are white, pink, or red, the varieties of kafir being known as white kafir, red kafir, and the like.

234. Milo. — Milo or milo "maize" resembles kafir in general appearance, but differs from it in that the plants are less leafy, the heads are shorter and more rounded, and the seeds are much larger, slightly flattened, and usually yellowish brown in color. The milos are earlier, more drought-evasive, and have lower water requirements than the kafirs, and it is said that they will produce profitable yields in sections having an annual rainfall of only 10 to 15 inches. The milos are somewhat earlier maturing than the kafirs, but the forage which they provide is less palatable on account of their fewer, smaller leaves and more pithy stems.

235. Cultural methods. — Kafirs and milos are planted much as corn is, usually in rows $3\frac{1}{2}$ feet with plants 4 to 10 inches apart in the row. About 3 to 4 pounds of seed are required to plant an acre. Sometimes the planting is done with a lister, which gives the best results on certain soils and under certain seasonal conditions. The time of planting kafirs and milos is usually a little later than that of corn, since the former are warm weather plants and do not make much growth until the soil is well warmed up. Harvesting is usually done with a corn binder, in which case the plants are bound into bundles and set up in shocks like corn. Sometimes only the heads are harvested, which may be done either by cutting them off by hand with a knife, or in the case of kafir by means of an attachment to a wagon known as a "header," which removes the heads and conveys them to the wagon. The heads may be fed without thrashing, or the grain may be thrashed from them by means of a thrasher. When cut with the binder, they may be thrashed, as are the small grains, or fed in the bundle. Almost all of the grain is used in the feeding of

Fig. 82. — Heading kafir in Texas.

live stock, and it has a feeding value equal to rather more than 90 per cent that of corn. The stalks are about equal to corn stover in feeding value, and may be used as roughage.

THE BROOMCORNS

236. Description. — The broomcorns differ from the other sorghums principally in the shape of the head, which is an umbelliform panicle made up of many long, tough branches. After the immature seeds have been removed, the panicle is called the " brush," and when several panicles are neatly tied with wire on the end of a long stick, they become the broom which is indispensable to the housewife. Broomcorns are of two general types, namely, standard and dwarf. Standard broomcorn is a tall plant with brush from 20 to 28 inches in length. Dwarf broom-corn, as its name indicates, does not grow so tall, usually only from $3\frac{1}{2}$ to 6 feet, and the brush varies in length from 12 to 22 inches. Brush from the standard varieties is used in the making of large house or stable brooms, while that from the dwarf varieties is used for the making of whisk brooms and other small brooms and brushes.

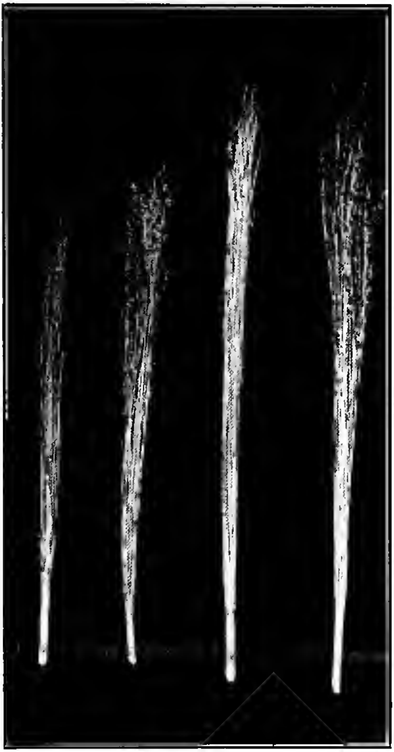

Fig. 83. — Dwarf and standard broomcorn.

237. Adaptation and importance. — Broomcorn may be grown on any soil that will produce a good crop of corn. Extremely fertile soils, however, produce a coarse brush not desirable for the best brooms. Light, sandy soils are well adapted to growing the dwarf varieties. The climatic adaptations of broomcorn are similar to those of the other sorghums, but localities in which frequent rains occur at the time of harvest are not well adapted to this crop, because rain at this time injures the quality of the brush. Oklahoma, Illinois, Kansas, and Texas are the states leading in the production of broomcorn, in 1909 the production of these states being over 90 per cent of the entire broomcorn crop of the United States. The yield of brush per acre varies greatly, from 500 to 800 pounds of the standard and from 200 to 400 pounds of the dwarf varieties being considered good yields. The price varies from year to year with the supply. In years of large production the price goes down, while in years of small production the price is high. In 1909, a year of partial crop failure, the price reached $200 per ton, while in other years, of overproduction, the price has sometimes fallen as low as $25 or $30 per ton. The average price for the standard type is probably from $80 to $100 per ton, while that of the dwarf is often higher.

238. Cultural methods. — Standard varieties are planted in rows from 3½ to 4 feet apart, with the plants from 3 to 5 inches apart in the rows. The rows for dwarf varieties may be made 3 to 3½ feet apart, with the plants from 2 to 4 inches apart in the rows. Broomcorn should not be planted near other sorghums, if seed is to be saved from the field, since it readily mixes with the other sorghums. The seed is usually planted just after corn planting, since it requires the soil to be well warmed up before it will grow readily. The cultivation during the early stages of growth is similar to that of corn.

239. Harvesting. — For the best quality of brush, the harvesting should be done at the time when the flowers are in full bloom. The heads from the standard varieties may be more easily removed if the plants are bent down or "tabled." The heads may then be removed with a sharp knife, and laid on the table formed by the bent-over stalks, for partial curing. The dwarf varieties need not be tabled, and the heads are usually pulled out. The heads, after cutting or pulling, are sorted, the crooked or coarse strawed heads being laid aside to use in the making of cheaper brooms. The immature seeds and glumes are then removed from the heads by a combing device or thrasher, after which the brush is dried or cured in the shed, to prevent bleaching. After curing, the brush is pressed into bales of 400 to 500 pounds, and in this form is placed on the market.

CHAPTER XIII

THE LEGUMES IN GENERAL

THE Leguminosæ family is one of the most interesting of the great group of flowering plants. The family is a very large one, containing over 10,000 species, which have been grouped into 487 genera. Members of this family may be found growing in all parts of the world where flowering plants exist. They are to be found in the hottest parts of the tropics and in the cold climates of the North. They vary in size from the tiny plants that grow unnoticed by the wayside, to the giant trees of the forest. The most prominent trees that belong to this family are the locust, mahogany, and Kentucky coffee tree. About one-fourth of the members of the Leguminosæ family are woody plants, most of which grow in the tropics. The remainder are herbaceous and are more widely spread over the world. Botanists have divided the members of this family into three sub-families, namely, Cæsalpineæ, Mimoseæ, and Papilionaceæ. The species included in the first two groups are almost entirely tropical and hold little of importance for the agriculturalist; the Papilionaceæ, however, includes some of the most important and useful plants that engage the attention of the farmer.

240. Description. — The Papilionaceæ, or pea family, as it is sometimes called, usually regarded not as a family, but as a sub-family of the Leguminosæ, is so named because of the resemblance of the flowers of this group of plants to a butterfly, the Latin name of which is *papilio*. The plants of this sub-family are divided into several genera, about a dozen of which contain the important agricultural species. In the older use of the term "legume" it included all of the members of the Leguminosæ, but it is now frequently used in agricultural literature as including only the cultivated members of Papilionaceæ. While the members of Papilionaceæ vary greatly in size, shape of their parts, and in their manner of growth, they have several features in common that distinguish them from the grasses and other families containing agricultural plants. Unlike the grasses, they have a tap root which varies in depth of growth and manner of branching. In some species, as in the white clover, the stoloniferous habit is more or less strongly developed, while in others, as the pea or bean, no stolons are present. The leaves consist of three or more leaflets carried on a leaf-stalk or petiole with stipules or leafy outgrowths at its base, the size and shape of the stipules being a feature of importance for the identification of many species. As in the grasses, the leaves are arranged alternately and spirally on the stem and branches.

241. The flowers are one of the characteristic features of the Papilionaceæ, and, as was pointed out, bear a fancied resemblance to a butterfly. The flowers are made up of calyx, corolla, stamens, and pistil. The corolla is made up of five petals which are unequal in size. The largest and most conspicuous one is called the standard. The two that grow out laterally, one from each side, are at more or less right angles to the standard, and are known as the wings. The other two are more or less coherent along one margin and form a boat-shaped structure called the "keel," in which the stamens and pistil are inclosed. There are usually ten stamens, nine of which are grown together a considerable part of their length, forming a tube with a split along one side which is filled by the tenth stamen. Inclosed within the stamen tube is the ovary, which contains from one to many ovules. The flowers may arise singly, as in the cowpea,

Fig. 84. — Flowers of alfalfa.

or they may be distributed along a stem, forming a raceme, as in vetch, or from the end of a branch in a whorl, forming an umbel, as in red clover, or they may be arranged along a branch in a head-like cluster or spike, as in the crimson clover.

The fruit is a legume or a pod, which, when mature, usually splits open along both edges. From the form of the fruit the family Leguminosæ gets its name.

Another way in which the legumes are markedly different from the grasses is in the structure of the seed. The seeds of the grasses have a relatively small embryo, and a large endosperm, while those of the legumes have a very large embryo, which completely fills the seed coat. It is due to the absence of the endosperm and to the large proportion of embryo, which contains a high percentage of nitrogen, that the legumes are so highly prized for their nitrogenous feeding value.

242. Pollination. — Unlike most members of the grass family in which the pollen is spread by the wind, the flowers

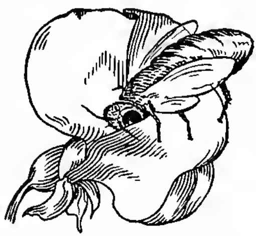

Fig. 85. — Legume flower.

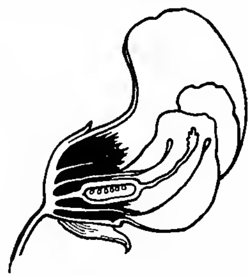

Fig. 86. — Cross section.

of the legumes are so constructed that they require the services of certain insects to carry the pollen for them. The following quotation from Percival tells how, with their conspicuous flowers, they attract the insects, and in return for the nectar given them in payment for their visit, they unwittingly extract from them a friendly service. "The flowers of the Papilionaceæ are all specially adapted for insect pollination. The 'standard' acts as a conspicuous attractive banner. The 'wings' and 'keel' petals are often interlocked near their bases in such a manner that when an insect of sufficient weight alights on the 'wings,' the latter are pressed downwards and these in turn depress the 'keel' petals; the stamens, style, and stigma are by this movement forced out at the apex of the 'keel,' and the pollen is brought into contact with the underneath part of the insect's body. The insect visiting other flowers brings the pollen on its body into contact with the stigma of the flower, which, on account of its length and position, is generally forced out first from the apex of the 'keel'; cross pollination is thus effected.

"Some plants, such as the garden and field pea, sweet pea, the vetches and trefoil, while undoubtedly possessing flowers specially adapted for insect pollination, are capable of self-pollination, and are fertile and able to produce seeds when insects are excluded. Others, such as the red, white, and crimson clovers and the broad bean, are more or less sterile when insects are prevented from visiting the flowers."

243. Much controversy has arisen regarding the importance of insects in the pollination of the clovers, and their influence on the seed crop. Several experiment stations have conducted tests to determine whether or not insects are responsible for the clover seed crop. The test consists in protecting small areas of clover by frames covered with wire screen. In some of the cages are placed insects of various kinds, while in others no insects are permitted to visit the flowers. The report on the following page of a test conducted on red clover by the North Dakota Station shows the importance of insects.

The results show that the bumble-bees were responsible for about 95 per cent of the seed formed in the protected cages. While heads selected growing in the fields showed a larger percentage of seeds per head, it was pointed out that the bumble-bees in the cages, being confined, were not under normal conditions:

Treatment	No. of Heads	Flowers per Head	Seeds per Head	Percentage of Seed-producing Flowers per Head
Protected (no insects)	14	103.5	5.9	5.7
Hand-rubbed	3	111.	2.6	2.3
Field	10	134.	83.6	62.4
Miscellaneous insects (flies, moths, small bees)	70	93.5	2.2	2.4
Bumble-bees (5 per cage)	68	92.5	43.5	47.

Some farmers contend that there are not enough bumble-bees during any one season to bring about pollination in all of the flowers that produce seeds. Dr. Hopkins, in reply to this argument, says that he has observed a bumble-bee going through the motion of putting its bill into a clover bloom and withdrawing it, thirty-four times per minute, operating during this time upon seven heads. It is possible, as is indicated in the experiment above quoted, that insects other than bumble-bees may bring about some pollination, and it is also probable that self-pollination is effected in some cases. Scientists generally agree that the bumble-bee is largely responsible for the pollination of the clovers, and that their number in a given season has some close correlation with the yield of clover seed obtained.

Recently there has been placed on the market a pollinating machine, which, it is asserted, when run over a clover field in bloom, will so rub the clover heads as to cause self-pollination. The North Dakota Station, in the experiment reported above, found that the rubbing of the heads did not produce pollination. Experience with the machines seems to indicate that they are of little service in the pollination of clover.

244. Relation to soil fertility. — The great favor now accorded the legumes as field crops is not due to a recent recognition of their importance in maintaining soil fertility, for many centuries ago Roman writers on agricultural topics attested to their soil-enriching value. In more recent times, in the first half of the eighteenth century, Jethro Tull, an Englishman, wrote a treatise on agriculture, in which he called attention to the increased yields obtained from grain crops on soils that had previously grown legumes. While it was early known that the legumes possessed some soil enriching virtue not possessed by the non-leguminous crops, the reason for it was a matter of no little speculation.

245. It was thought by many that the peculiar value of the legumes was due to the fact that they possessed roots that penetrated deeply into the subsoil and thus were able to secure much of their nourishment from a depth beyond the reach of other crops. A part of this plant food was thought to be stored in the roots and stubble near the surface, later to become available to succeeding crops. Liebig, a German chemist, held the opinion that plants received their nitrogen and carbon from the air, and that the clovers, on account of their broad leaves, were able to take up more nitrogen than the other crops. This theory, however, was not long accepted as explaining the matter, for Boussingault, in France, in 1851, and Laws and Gilbert, in England, in 1857, demonstrated, by a series of experiments, that the free nitrogen of the air was not available to the legumes. In 1883 Atwater, at the Connecticut Experiment Station, grew a number of kinds of plants in pots, analyzing the soil before planting, and then analyzing the plant, together with the soil, at the end of the experiment. He found that, while in most cases there was no gain in nitrogen, in some there was an increase of as much as 50 per cent. In every case where there was a gain in nitrogen, it was in a pot where a legume had grown. Three years later, 1886, Hellriegel, a German scientist, solved the perplexing problem. By a series of pot tests with legumes, he found that in sterile soil there was no gain in nitrogen, the plants growing for only a short time before they withered and died. On the other hand, in those pots to which a small quantity of water, leached from a soil that had previously grown the legume successfully, was added at the beginning of the experiment, the plants grew vigorously and there was an increase in the nitrogen content above that which was contained in the seed. Upon examination it was found that the plant showing a gain in nitrogen invariably possessed tubercles or nodules on the roots, while none were to be found on those that showed no gain in nitrogen. Hellriegel therefore advanced the theory that the bacteria in the nodules have a direct relation to the taking up of free nitrogen by the plant, which has since been established by numerous experiments. Hellriegel, however, was not the first to observe the nodules on the roots of legumes, for in 1687 Malpighi, an Italian, wrote about them, calling them galls. For many years the nodules were thought to be the result of disease on the roots. Later, however, they were supposed by some to be enlargements of the roots in which reserve plant food was stored. In 1866 a Russian botanist discovered that the nodules were filled with bacteria. Beijerink was the first to isolate the bacteria and grow them in pure culture on artificial media. He named them *Bacillus radicicola.*

It is very interesting to know that while the soil-enriching value of the legumes was known soon after the dawn of the Christian era, it has taken almost 1900 years to discover to what this peculiar virtue is due.

246. Bacteria in relation to legumes. — The exact relation that exists between the bacteria in the nodules and the host plant is not definitely known. Present information on this subject, however, shows that the plant and the bacteria enter into a partnership, the result of which is mutual benefit. This relationship is called symbiosis. The bacteria which are in the soil enter the plant root through the root hair and work their way further into the root, which, because of their presence, makes an abnormal growth, forming a nodule. When once in the root, the bacteria rapidly increase in numbers by division, and as they increase the nodule enlarges. The mutual benefit of this partnership is derived from barter, in which the bacteria trade nitrogen to the plant, in return for all of the other elements necessary to their growth. The advantage of this partnership is to be found in the fact that the plant is unable to use the free nitrogen of the air, while the bacteria draw it in large amounts from this source and use it to build up their own structure, and when they die the nitrogen from their decomposed bodies becomes available to the plant. It seems that the greater percentage of the bacteria are not long lived, but soon die, supplying the plant with this necessary element of plant food. Support for this belief is to be found in the fact that the nodules are smaller, softer, and nearly empty of bacteria at the end of the growing season. However, not all of them die. Some few remain alive, and as the roots decay, find their way back into the soil until another plant comes forth with which to form a new partnership.

247. Bacteria in relation to different legumes. — Since the bacteria may enter any of the root hairs, there is no uniformity in the arrangement of the nodules on the roots. There are, however, characteristic shapes of nodules for the various species of legumes. This is due to the fact that each species has a slightly different kind of root development, and, when penetrated by bacteria, they produce distinguishing types of nodules. It may be due also in part to the fact that the same kinds of bacteria do not work on all kinds of leguminous plants, but that each species enters into partnership with a special variety of bacteria. Thus we have the red clover variety of bacteria, the soy bean variety, etc. The bacteria that form the nodules on the roots of red clover will not grow on the roots of the soy bean, and *vice versa.* Sometimes, however, one variety of bacteria may form nodules on two or more species of legumes; thus the same bacteria will grow equally well on the roots of alfalfa, sweet clover, and bur clover. It is probable that the various kinds of leguminous bacteria are not distinct species, but varieties of *Bacillus radicicola.*

248. Adaptation and distribution of bacteria. — Certain conditions of the soil seem to retard the growth, and in some cases completely prevent the activities of the leguminous bacteria. The different varieties of bacteria of course have widely differing adaptations, but almost all varieties are sensitive to acid soils. While the variety that grows on the roots of alsike clover may grow in acid soils, they grow much better in soils well supplied with lime. The variety that grows on the roots of alfalfa and almost all other cultivated legumes is almost dormant in acid soils. Neither do they thrive in wet soils, and frequently drainage is necessary to secure their services for many leguminous crops. Under certain conditions the partnership between the plant and the bacteria, even though the latter are present, is not perfected. When the soil contains nitrogen in large amounts, the plant draws its supply from the soil, and the bacteria lose many of their activities and put forth little effort to penetrate the plant root. It is not usually desirable, therefore, to use nitrogenous fertilizers in connection with leguminous

Fig. 87. — Applying lime to the land.

crops. Sometimes, however, when the soil is especially deficient in this element, a light application of nitrate of soda is beneficial in starting the plants so that they may make sufficient growth for the forming of symbiotic relations with the bacteria.

The bacteria are distributed over the country in various ways. The most important agencies are wind, water, and the transportation of hay and seeds. The diminutive size of the bacteria makes possible their wide distribution by the wind in connection with small particles of soil, leaves, and other vegetation. The water also carries them long distances in the time of high water. The shipment, from one place to another, of hay and seeds to which the bacteria may cling, is also an important agency in their distribution.

249. Inoculation. — In sections of the country where a legume has been grown for many years, the bacteria that work upon its roots may usually be found in almost all soils. Thus, when red clover has been grown for years in a community, no difficulty is usually experienced from a lack of the proper variety of bacteria. Sometimes, however, the bacteria of certain crops are not generally distributed, especially in sections of the country where the legume is a new crop. Thus the variety that forms the nodules upon the roots of alfalfa is not generally distributed in all parts of the country. When they are not present, if the best results from the crop are to be secured, they must be supplied artificially. While the crop may sometimes be grown without the aid of the bacteria, it is not usually desirable to do so, because the plants then must draw upon the nitrogen supply of the soil, and, like non-leguminous plants, they then become soil exhausters instead of soil builders. Supplying the bacteria artificially is called inoculation.

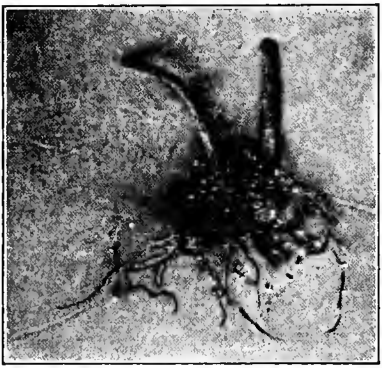

Fig. 88. — Nodules on the roots of soy beans.

250. Methods of inoculation. — The general methods employed in inoculation are: by applying prepared cultures, by sowing a small quantity of seed with other crops, and by adding to the field a small quantity of soil containing the bacteria.

The first method is that of securing from the United States Department of Agriculture, the State Experiment Station, or from a commercial firm, pure cultures of the bacteria, which, when put into suitable growing media, multiply very rapidly. The solution containing the bacteria, after a sufficient number have been produced, may be applied to the seed, which is sown in the usual way, after drying. It may also be used in sprinkling a small quantity of soil, which is then spread over the field and harrowed in.

The second method has been practiced successfully by many farmers, especially in inoculating for alfalfa. This method consists in sowing a small quantity of seed on the field two or three years before it is seeded to the permanent crop. Sometimes two or three pounds of alfalfa seed are mixed with the red clover seed and sowed with it. A small amount of seed may be sown with the oats in the spring. Some bacteria are carried to the soil with the seed, and here and there over the field there will be a few plants that will become inoculated, and after a time the soil of the entire field will become inoculated.

251. The third method is more generally employed, and is the one that is usually recommended. This method consists in getting soil from a field that has previously grown the crop successfully and spreading it over the field to be inoculated. Thus the bacteria will be introduced with the soil, and they will be present to begin their work on the plant roots as soon as the latter are large enough. In getting the soil from an old field, one should be sure that it contains the desirable bacteria.

If a plant is carefully dug out and the roots examined, the presence of the nodules will insure the presence of the bacteria.

The amount of soil to apply will depend upon the ease of getting it. If the soil is close at hand, a liberal application should be made, but if it is necessary to transport it some distance, a smaller amount, carefully spread over the field, will usually introduce a sufficient number of bacteria to insure inoculation. From 200 to 800 pounds per acre may be used, the amount depending upon the ease of procuring it. The soil should be taken from the first four or five inches of the surface soil, and spread over the new field late in the afternoon, or on a cloudy day. Direct sunlight is a strong bactericide, and if the soil is spread over the field in direct sunlight, many of the bacteria may be killed. The soil should be harrowed immediately after the application. The grower should exercise care in getting the soil, as fungous and bacterial diseases, or weed seeds, may be introduced at the same time as the desirable bacteria.

CHAPTER XIV

THE CLOVERS

PROBABLY no other group of forage plants is so well and so favorably known throughout a considerable part of the country as are the clovers. They are to be found in meadows and pastures, in lawns and along the roadsides, where with their sweet smelling blossoms and oval leaves they are set forth in deep contrast to the odorless flowers and long narrow leaves of the grasses with which they are growing. The favor accorded them, however, is not due to their beauty alone, for they are among the most useful and valuable plants. The farmer probably thinks first of all of their value and perhaps not at all of their beauty. The clovers belong to the genus *Trifolium* of the *Leguminosæ* family. Often in common usage the term clovers includes other members of this family that do not belong to the genus *Trifolium*, such as alfalfa and the sweet clovers. The only true clovers, however, are members of this genus, and while alfalfa and sweet clover are closely related to them, they may not properly be classed as clovers. There are over 200 species of this genus found growing throughout the world, and more than 60 species are found in America. Of this number, however, only those of agricultural importance will be discussed in this chapter.

RED CLOVER

252. History. — This "Red Plumed Knight," as it has been dubbed by one of its admirers, is a native of Persia, and from there it spread through the greater part of Europe, where for many years it has been an important factor in the maintaining of a permanent system of agriculture. It was introduced into Pennsylvania, probably from Holland, almost 150 years ago. Since that time the area of its culture has gradually extended and now it holds a most important place in the esteem of the American farmer. While it is most commonly known as red clover, it is also known as broad-leafed clover, common clover, medium clover, and medium red clover. It is called medium clover or medium red clover to distinguish it from the mammoth clover, which it closely resembles.

253. Description. — Red clover, *Trifolium pratense*, is the most commonly grown and is perhaps the most valuable species of the genus *Trifolium*. It has a large, well-developed root system, made up of a tap root, which may extend several feet into the ground, and numerous lateral branches which grow out from it a few inches below the surface of the ground. The tap root grows almost directly downward and undoubtedly is of great service to the plant in obtaining water from the deep subsoil in time of drought. Sometimes the tap root is broken off by the alternate freezing and thawing during a severe winter, and the plant, thus released from its anchorage, is pushed up out of the ground for some distance. This is known as heaving and is decidedly injurious to the plants, sometimes destroying entire fields of them. When the clover plant is quite young, the crown, that is, the short stem and top of the tap root, may be quite a little distance above the ground. To protect it from the sickle or from grazing animals, the tap root as if possessed with forethought contracts or shortens up, thus drawing the crown down into the soil. Like other legumes, red clover forms a partnership with a certain species of bacteria and they work together in harmony. The nodules produced by the bacteria are at first almost spherical, but later they become pear-shaped. They are not so large as the nodules found on the roots of peas or beans, but they are more numerous.

FIG. 89. — Red elover.

254. The main stem of the red clover plant is made up of many very short internodes, and seldom grows over an inch or two in height. From the nodes, however, many leaves grow out, and later branches grow out between them and the main stem. The number of branches produced varies with the conditions of growth, but usually from 6 to 18 are produced. From the nodes of the main branches other branches are produced, which in turn give rise to still other branches, so that when full grown, a many branched, bushy plant results. The plants vary in height with conditions of growth, but usually they are from 15 inches to 2 feet high. Some plants grow almost erect, while with others some or all of the branches may be decumbent at the base.

255. The leaves are large and dark green in color, possessing prominent V-shaped white markings. They are usually arranged in threes all of which grow out from the end of the petiole. The leaves and stems are covered with a fine hair or down, which is more abundant when the plants are young. At the end of each branch is carried the flowering head, usually ovoid or spherical in shape, from 1 to 2 inches in length and composed of from 75 to 200 small red or pink flowers, closely crowded together.

256. The seeds vary greatly in size and are yellow and purple in color. Red clover seed is not often adulterated, although weed seeds are frequently found in it. The standard of purity is 98 per cent and the germination from 85 to 90 per cent. The legal weight per bushel is 60 pounds. Sometimes some of the seeds are so hard and the seed coat is so impervious that when planted they are not able to absorb the amount of moisture necessary for germination. Such seeds are called "hard seeds," and in newly harvested seed, in which they are the most abundant, they may sometimes amount to as much as 40 or 50 per cent. The hard character is lost in time, and when the seeds are sown a year or two later, almost all of them will germinate. A germination test before sowing may enable the grower to avoid a poor stand from this trouble.

257. Distribution. — Red clover is adapted to temperate climates and is grown throughout the temperate regions of Europe and parts of Asia. In the United States it may be found in almost all parts of the country, but as an important cultivated crop it is confined to the northeastern part of the country, and in the western parts of the Pacific Coast States. It grows at its best in what is known as the northern corn belt states. Here it is usually grown in the rotation, either alone or in combination with timothy and other grasses. It is best adapted to well-drained loam soils, which are sometimes called corn soils. While it

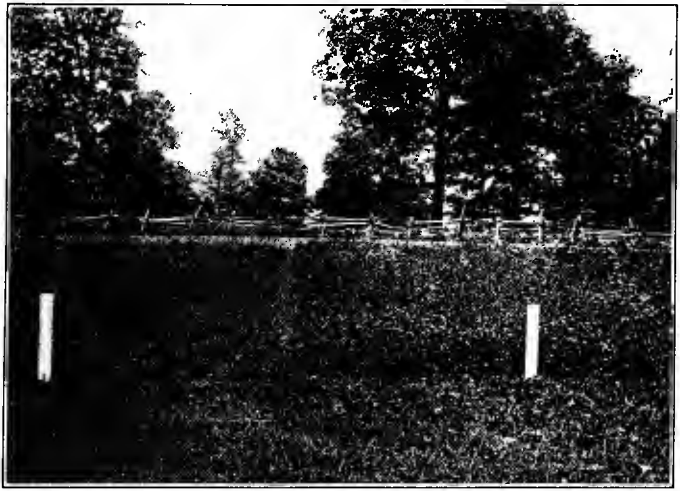

FIG. 90. — Effects of lime on growth of red clover. Plot at left received no lime; the one at right received an application at the rate of 1000 pounds of quick lime per acre.

may be grown on soils of all degrees of fertility, except the very poorest, it is not well adapted to clays, as are the grasses. Red clover cannot withstand severe cold nor extreme heat, and for that reason is not an important crop in Canada nor in the Southern States of the United States. Alfalfa is more drought-resistant and largely takes the place of red clover in the semi-arid regions of the West. Red clover will not grow in wet soils as will alsike, which is used as a substitute for it in undrained or lowland areas. Soils deficient in lime are not well adapted for the growing of red clover, and sometimes a stand cannot be obtained on such soils until they are treated with lime.

258. Uses. — Red clover is one of the most valuable of forage crops and may be used for hay, pasture, or for feeding green from the field. As a hay plant it is especially valuable on account of the high percentage of protein which it contains. It is excellent forage, therefore, to feed in combination with low protein grain rations. It may also be used in combination with low protein forage, such as corn stover or timothy hay. As a pasture plant, it furnishes excellent grazing for all kinds of live stock. It is objectionable as a pasture for horses because of its tendency to produce slobbers when they are pastured upon it exclusively. It also produces bloating in cattle when they are not accustomed to it, but if they are allowed to eat of it but sparingly at first, little trouble of this sort may be expected. Clover does not stand tramping well, neither does it thrive after close cropping. As a pasture it is best used in combination with timothy or other grasses, which largely overcome the above objections to it. As a soiling crop, it yields fairly well, but it cannot compare in that respect with corn or sorghum, although it possesses greater feeding value than either of these two. After being cut for soiling purposes, new plants spring up and a second cutting may be made during the season.

One of the reasons why red clover is regarded with such favor where it is grown is because of its value in maintaining the fertility of the soil. Being a legume, it is able to use nitrogen from the air; and when it is plowed under or returned to the field in the form of manure, a considerable amount of this element, which may then be utilized in the growing of other crops, is added to the soil. It is especially valuable for this purpose because, being a biennial or a short-lived perennial, it is well adapted to a short rotation.

259. Cultural methods. — Red clover is usually seeded with a nurse crop, the reason for this being that if seeded alone it cannot be expected to produce a full crop the first year. Thus the grower would lose the use of the land for the season. However, if it is seeded with a nurse crop, the clover makes its first year's growth along with the nurse crop without decreasing the yield of either of them. The choice of a nurse crop will depend largely upon the crops that are grown regularly in the rotation. Most often the clover is seeded with the small grain crop, which may be wheat, oats, rye, or barley, the choice depending upon the grower's rotation practice. When wheat enters the rotation, clover is usually seeded with it. When oats, rye, or barley replace wheat in the rotation, it is seeded with them. When seeded with wheat or rye, the clover may be applied either in the fall with the wheat, or it may be sown in the early spring. When seeded in the fall, the clover is usually spread by the seeding attachment in connection with the grain drill, which may be adjusted to scatter the seed either in front of or behind the drill hoes. When seeding in the fall, best results are usually obtained if the seeding is done early. At the Ohio and Indiana stations seedings made later than early September were usually unsuccessful.

260. When seeding is delayed until spring, the seed may be applied with a hand seeder in late February or early March, in which case the alternate freezing and thawing of the ground will sufficiently cover it, or the seeding may be done later, when the soil is dry enough, and covered with a light harrow. If the latter method is followed, the seeding should not be delayed until too late in the spring, or else the wheat will become too large to permit of the proper covering of the clover seed. Some growers object to covering the seed with the harrow, contending that by this practice the wheat will be injured, but various experiments have proven that, instead of being injured, more frequently the yield is increased, due probably to the cultivation which assists in conserving moisture. When seeded with a spring grain like oats or spring barley, the application is made along with the grain as in the fall seeding with wheat. Rye is the most favorable nurse crop, because it does not shade the ground as much as wheat or oats, and it is less likely to lodge and smother the young clover plants later in the season. Oats produce more shade than either wheat or barley, and are not regarded as a favorable crop with which to sow clover. However, if a short-strawed early variety is grown, little trouble may be expected.

261. Sometimes clover is sowed in the corn at the time of the last cultivation. The chances for a successful stand by this method are doubtful, unless the soil is in almost perfect physical condition and free from weeds, and unless the seeding is followed by frequent rains. On fertile soils in sections with a plentiful rainfall this method is quite successful. When seeded with a small grain crop, the clover may be pastured after the removal of the grain, during late summer and early fall, without injury to the crop which will make hay or pasture the following summer. Clover is sometimes seeded in combination with timothy or other grasses for hay or pasture.

Usually the seed may be mixed in the desired proportions and applied together, as is the practice when clover is seeded with a nurse crop. Twelve pounds of seed per acre is considered a full seeding when the clover is seeded alone. When mixed with timothy, from 6 to 10 pounds of the clover seed may be mixed with the same amount of timothy. Sometimes it is desirable to add a few pounds of alsike or white clover seed, in which case the amount of red clover seed is reduced correspondingly.

262. Making clover hay. — The proper time to cut for hay is when the plants are just past full bloom and a few of the blossoms have turned brown. If cutting is delayed

Fig. 91. — Cutting clover hay that gave a yield of over $3\frac{1}{2}$ tons per acre.

very long after this time, many of the leaves, which are easily broken off when the plant is ripe, will be lost and the quality of the hay thereby greatly injured. If possible, the clover should be cut in the afternoon, since the plants then contain less water than they do in the morning, and a shorter time will be required for curing. Ordinarily, when the hay is first cut, it contains from 65 to 80 per cent of water, and before it may be stored in the stack or mow with safety, the moisture content should be reduced to 18 or 20 per cent. The curing of the hay is greatly facilitated by the use of the tedder, which may be used the next morning after cutting as soon as the dew is off. The time required for the clover to cure will depend upon its maturity, upon the dryness of the ground under it, and upon the sun and air. Under favorable conditions it may be dried out sufficiently for storing in 20 to 24 hours after cutting. If only a small acreage is grown, or if plenty of labor is at hand, the leaves may be better saved and a slightly better quality of hay may be secured if the hay is piled into small cocks, when in a semi-cured condition, for a few days before storing.

FIG. 92. — Using the tedder on a heavy hay crop.

263. Cutting for seed. — Red clover is grown primarily for the seed in but few localities. The seed is usually harvested from the second crop, that is, from the plants which spring up after the hay crop has been removed. This practice makes possible the harvesting of two crops, one for hay and one for seed, during the same season. Small amounts of seed are produced on many farms in the clover growing sections of the country, but the greater part of it is produced in Ohio, Michigan, Wisconsin, Indiana, Illinois, Iowa, Kansas, and Missouri. The yield of seed per acre varies greatly from year to year, depending much upon weather conditions and upon whether or not certain insect enemies are present. The largest yields of seed are usually obtained when the hay crop is cut early. If plenty of rain to start the second growth follows the cutting, and then if dry weather prevails during the last period of growth, the production of seed is favored. If wet weather prevails throughout the growing season, the plants grow tall and rank, the heads mature little seed, and the second crop is quite likely to be more valuable for hay or pasture than for seed. Early cutting of the first crop is favorable to a large production of seed because in this case the seed of the second crop forms early and may thus escape the attack of the second brood of clover seed midge. When the first crop is harvested for seed, it is best to clip or pasture the field during the fore part of the season in order to delay the blooming period until the bumble-bees are more plentiful and in order to avoid the attack of the first brood of the clover seed midge. Clover should be cut for seed when the heads have turned brown and the seeds are in the dough stage. A mower, with an attachment to the cutter bar for bunching, or a self-rake, may be used. After cutting, the clover may be piled up into small cocks or allowed to cure in the bunches for a week or ten days, after which it is ready to thrash. The straw remaining after the seed has been removed is of little value as feed. The yield varies from a peck to as much as 5 bushels per acre, 2 bushels being probably an average yield. The seed sells on the market for from 5 to 10 dollars per bushel, which when considered in connection with the value of the hay crop secured the same season, makes the return per acre very profitable. However, many farmers prefer to pasture the second crop of clover and buy their supply of seed on the market.

MAMMOTH CLOVER

264. Mammoth clover, *Trifolium pratense* var. *perenne.* — This clover is considered by almost all agronomists to be a variety of red clover. Some, however, give it the rank of a distinct species. Evidence of its being a variety of the red clover is to be found in the fact that it crosses with it quite readily, producing various intermediate forms. It is so like red clover in its appearance and manner of growth that it is sometimes difficult to distinguish one from the other, especially when individual plants are considered. In almost all cases it may be distinguished from red clover by its larger, ranker growth, and its more perennial character. Another way in which it differs from red clover is that it is from 3 to 4 weeks later in maturing and produces but one crop during the season. In other respects it is quite similar to red clover; even the seeds have no visible difference, and they cannot be told apart. Mammoth clover is sometimes called big clover, perennial red clover, and sapling clover.

265. Uses of mammoth clover. — Mammoth clover may be used for feeding live stock in the form of hay, pasture, or as a soiling crop. It is not generally highly regarded for hay because of its rank growth of large, coarse stems, which do not make so fine a quality of hay as red clover. However, if grown on rather poor soils, the quality of the hay may be as good as that of red clover, and being a more vigorous plant, the yield from it is greater. The cutting, however, should not be delayed after the plant is in full bloom if a good quality of hay is to be expected. Usually it produces little or no after growth, and is of little value for fall pasture. Mammoth clover is probably more often grown for green manure than for hay or pasture. As a soil improver, it has no equal in the corn belt states, since it produces a great volume of stems and leaves, which, when plowed under, add large amounts of nitrogen and humus to the soil. Unlike red clover, mammoth clover seeds abundantly the first crop, and often a seed crop may be removed before plowing it under.

266. Cultural methods. — Mammoth clover has adaptations to soil and climate similar to those of red clover.

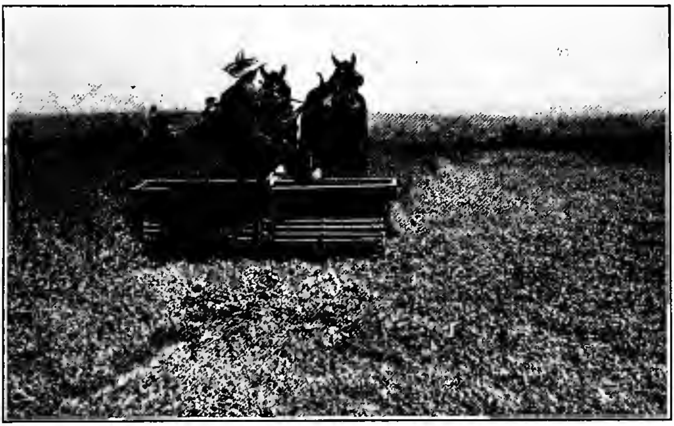

FIG. 93. — Rolling down clover to be plowed under for green manure.

It is, perhaps, somewhat better adapted to the poorer types of soil than red clover, which increases its importance as a green manure crop, since it will grow well on those soils that most greatly need assistance. The method and rate of seeding is similar to that described for red clover. When grown for both seed and green manure, it is desirable to harvest the seed in such a manner as to remove as little of the plant as possible. This may be done by rolling down the plants with a heavy roller a few days before harvesting the seed. At this time the plants are nearly mature, and the main stems will not straighten up again, but in a few days the ends of the branches bearing the heads will turn upward, and they may then be cut off without removing much of the plants. The field may then be plowed and the clover turned under to fertilize the soil. Mammoth clover seeds abundantly, probably because it is less likely to insect ravages than red clover, and also because the bumblebees are more plentiful when it is in bloom.

WHITE CLOVER

White clover, *Trifolium repens*, is sometimes called Dutch clover or little Dutch clover, because of its prominence in the pastures of Holland.

267. Description. — White clover is a low growing plant, perennial in habit and under favorable conditions living for many years, differing in these respects from both red clover and alsike. It has a shallow root system, usually almost all of the roots being found in the first 8 or 9 inches of soil. The stems do not grow erect, but lie along the ground, forming runners which root freely at each node. It therefore spreads rapidly and makes a firm turf, which makes it well adapted to pastures and lawns. The leaves and flowering heads grow on long, upright stalks which arise from the prostrate stems. The length of the leaf and flower stalk depends upon the conditions of growth. If grown alone, they do not grow as tall as if grown with grasses or clovers. This is due to the tendency of the plant to place its flowers and leaves high enough so that they will not be completely shaded by other plants. The length of the leaf and flower stalks varies from a few inches to a foot or more. The flowering head is smaller than that of either red clover or alsike, and the corolla of the flowers is white in color during early growth, and turning to light brown as the plant matures. When favored with cool, moist weather the plant blooms throughout the growing season. Seed is produced abundantly and the plants, when grown for seed, yield 5 to 15 bushels per acre. The seeds are heart-shaped, similar to but smaller than those of alsike, and are yellow in color. The proportion of hard seeds is relatively high and sometimes

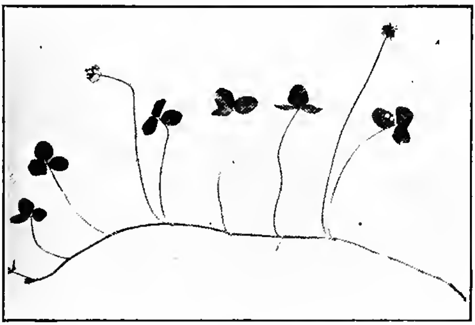

Fig. 94. — A trailing stem of white clover.

they may lie in the ground for several years before germinating.

268. Adaptation and uses. — White clover is more universally distributed than any of the common clovers, and may be found throughout the temperate regions of the world. It is probably a native of Europe or Asia and has been introduced into the other countries, perhaps by the seeds being carried in with those of other legumes or grasses. The seeds are light and easily carried and are not usually digested when eaten by animals, which fact probably assists in the distribution. The creeping nature of its stems and its perennial character makes possible its rapid increase when once seeded, even though only a few seeds may be dropped at first. White clover is less sensitive to climate than red or alsike clover, and has a much wider distribution. It grows on almost all soils, but thrives best on moist, fertile, well-drained soils. It does not grow well on soils deficient in lime or extremely lacking in fertility. When white clover grows abundantly in fields or along the roadside, this fact is usually taken as an indication of a productive soil. White clover does not grow tall enough to be of value as hay. It finds its greatest usefulness in mixtures for permanent pastures and parks and lawns. It is well adapted for growing with blue grass, and together they make the finest of pasture and the most beautiful lawns in parks and yards. In the South it grows well with Bermuda grass, both plants remaining green throughout the winter in the extreme South.

269. White clover is found in almost all of the permanent pastures of England and Europe, where it is highly regarded. It is seldom seeded alone, except when grown for seed, but usually is seeded with other legumes and grasses. In eastern Wisconsin it is seeded with barley in the rotation and it is in this section that most of the seed is produced. Because of the small size of the seeds, and the tendency of the plant to spread by runners, the rate of seeding is comparatively light. When seeded in mixtures for pastures, 2 pounds of seed per acre are sufficient for a good stand. For the seeding of lawns, the rate should be increased to 4 to 6 pounds per acre. No permanent pasture in the blue grass sections is complete without the presence of white clover, and in almost all seed mixtures for permanent pastures, white clover may well be included.

ALSIKE CLOVER

Alsike clover, *Trifolium hybridum*, is a native of Europe and gets its name from the village of Syke or Alsike in Sweden. It is also sometimes called Swedish clover. Alsike clover was formerly thought to be a hybrid from the crossing of white and red clovers, but it is now known to be a distinct species. It was introduced into the United States many years ago, and it is now grown throughout the Northern States of this country except in the arid regions of the West, and in southern Canada.

Fig. 95. — Alsike clover. Note manner of branching.

270. Description. — Alsike clover is more perennial in its character than red clover, sometimes living for 5 or 6 years. It resembles red clover in its manner of growth and white clover in the appearance of its leaves and blossom. Its root system is more fibrous than that of red clover, and it does not heave as badly. The roots are not as large and usually do not extend so deeply into the ground as those of red clover. The branches are more slender and, when grown on fertile soils, are inclined to be decumbent at the base. The nodes, coming in contact with the ground, take root, giving to it somewhat of a creeping habit. The leaves are smaller than those of red clover and neither the leaves or branches are covered with the hairy down as is the case with the latter. The flowering heads are smaller than those of red clover, and the flowers are pink or white in color, closely resembling those of white clover. The seeds are more or less heart-

FIG. 96. — A side-delivery rake.

shaped, are slightly larger than those of white and somewhat smaller than those of red clover. They vary in color from yellow to green, the most common color being yellowish-green. The seed weighs about 90 pounds to the measured bushel, but on the market 60 pounds is regarded as a bushel.

271. Adaptations. — Alsike clover is more hardy than red clover and may be grown in sections too cold for red clover to endure the winter, but it does not grow as far south as the latter. It is adapted to much the same types of soil as red clover, although it is able to grow on soils too wet for the latter to thrive. Another way in which it differs from red clover is its ability to withstand a slightly acid condition of the soil. It is therefore better adapted than red clover to sections of the country having wet or acid soils. In many parts of the clover-growing region, the soils have become so deficient in lime that red clover

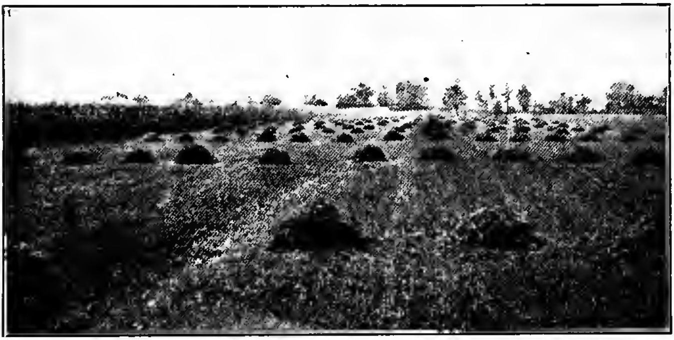

FIG. 97. — Curing clover hay in the cock

is no longer a sure crop, and it is being replaced in the rotation to some extent by alsike. While alsike is grown throughout the northern part of the United States, it is of the most importance in the tier of states just south of the Canadian line.

272. Uses and cultural methods. — Alsike is not usually grown alone, except when grown for seed, but is most commonly seeded in combination with other clovers or grasses for hay or pasture. Because of its finer stems, alsike hay is of finer quality and is more easily cured than red clover hay, and because of the absence of the hairy down on the stems and leaves, is less dusty when cured. It does not yield as much per acre as does the red clover. Usually it is grown in small amounts with red clover, but replaces it when soils are acid or wet. It ripens well with timothy and makes with it a good quality of hay. Alsike makes but little second growth and furnishes but little pasture after the hay crop is cut unless favored with good growing weather. It is excellent for mixtures for temporary pastures, but is not so well adapted to permanent pastures as is white clover. The cultural methods are the same as those described for red clover, except in regard to the rate of seeding. When seeded alone, 10 pounds per acre is regarded as a full seeding, and in mixtures from 2 to 6 pounds are used.

CRIMSON CLOVER

Crimson clover, *Trifolium incarnatum*, is also known as Italian clover, German clover, French clover, scarlet clover, and carnation clover. It has been cultivated from early times in southern France and northern Spain, and within the past century has become generally distributed in other parts of Europe. It was introduced into southeastern Pennsylvania in the early part of the nineteenth century and has come into general cultivation only within the past two or three decades.

273. Description. — Unlike the other commonly cultivated clovers, crimson clover is an annual, maturing seed within the year from the date of seeding. It has a strongly branched tap root which penetrates the ground under favorable conditions to a depth of three or four feet. The tap root gives off many secondary branches, which also extend some distance into the soil. The tubercles are formed on the roots during the early stages of growth, and the plant is noted for the large amount of nitrogen gathered during its short life. The main stem, like that of red clover, does not grow very tall, but gives off numerous branches or stools, sometimes as many as 100 being given off from a single plant. The stems or stools give off but few branches and vary from 1 to 3 feet in height, giving the plant a bushy appearance. The leaves and stems are covered with an abundance of fine hairs. The flowering head is carried at the apex of the branches, and, unlike those of red clover, they are some little distance above the topmost leaf. The flowering head is elongated or cone shaped, and from 1 to 2 inches long. The flowers are usually scarlet or crimson in color, which gives to the plant its most common name. Certain varieties, although they are not commonly grown, have white or yellow flowers. The flowers at the base of the head open first and those at the apex are the last to bloom. The seeds are larger than those of the other clovers described in this chapter, and may be easily distinguished from them by their globular shape and yellow or straw color.

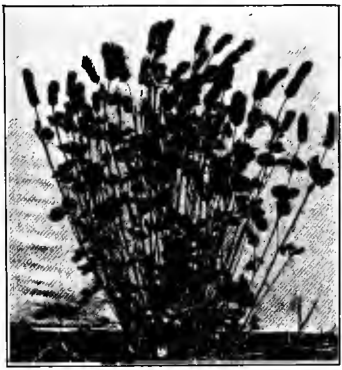

FIG. 98. — A crimson clover plant.

274. Adaptation and distribution. — Crimson clover is a tender plant and does not thrive in latitudes having cold winters. It is easily killed by hard freezing, and for this reason cannot be generally grown excepting in places of mild winter. In the United States, it is grown extensively in the Atlantic Coast States as far north as New Jersey. In the northern corn belt states, it seldom withstands the winters, and is of little importance. It grows well on almost all types of soils, but thrives best on the loams. Crimson clover will grow on soils of a very sandy nature, but sometimes it is necessary to add mineral fertilizers to this type of soil to secure a good crop. Crimson clover, like red clover, does not grow well on wet soils; but it is less sensitive to a deficiency of lime, growing well on soils that turn litmus paper red.

275. Uses of crimson clover. — Crimson clover is used to some extent for hay in the states along the Atlantic coast, and it is said to make an excellent quality of hay when properly cut and cured. According to chemical analysis, it has about the same feeding value as red clover. The hay, however, is of coarser quality and is not so palatable as that of red clover, although many farmers prefer it to the latter. Its palatability and feeding value is influenced to a considerable extent by the time of cutting. If allowed to stand too long, the stems become woody and the calyx surrounding the seed pod becomes stiff and sharp, which makes it objectionable for feeding. Sometimes hair balls are formed from the hair of stems and leaves, and cause digestive troubles in animals to which it is fed. If cut for hay about the time it is in full bloom, and properly cured, the above objections are largely overcome. The curing is rather difficult on account of the high water content, but may be well accomplished by piling in rather small cocks and allowing to remain for a few days. When ready for storing, the cocks should be opened up and thoroughly dried out. Crimson clover furnishes good pasture during the late summer and fall, and it may be pastured again in the spring. It is also valuable for soiling, being available for feeding just after the rye is fed and before the first cuttings of alfalfa. The principal use of crimson clover is to build up the fertility of the soil, by the addition of nitrogen and the increase of the supply of humus by plowing it under for green manure. Crimson clover takes up, on an average, about 140 pounds of nitrogen per acre during the year, about one-third of which remains in the roots. Being a large, quick growing plant, it adds much organic matter to the soil when plowed under. It is also an excellent cover crop for orchards and is used extensively for this purpose.

276. Cultural methods. — Crimson clover may be grown as a crop in a regular rotation or it may be used as a catch crop. As a catch crop it is most often seeded in summer with buckwheat or in corn at the time of the last cultivation. Crimson clover grows rapidly, and if seeded in midsummer, will make most of its growth before winter. In this case, if it is used as a green manure crop, it may be plowed under early in the spring with good results, or it may be allowed to stand until it starts to bloom before plowing it under for a crop like corn or potatoes. Some farmers harvest the crop of hay and plow under only the clover stubble for corn or late potatoes. When used as a catch crop, it is usually seeded in the corn at the last cultivation and plowed under the next spring. The entire crop may be plowed under or a crop of hay may first be removed, and after plowing, corn may then be planted. Thus corn may be grown for two successive years with a legume sod to be plowed under for the second crop, and sometimes for both crops. This is possible in a four-year rotation of corn, corn, wheat, and red clover, using crimson clover as a catch crop in the first corn crop. Crimson clover may be seeded in the spring, but usually it is seeded in summer or early fall. The rate of seeding varies from 12 to 20 pounds per acre, 15 pounds being considered an average seeding.

FUNGOUS DISEASES AND INSECT ENEMIES OF CLOVERS

277. Common enemies. — The clovers are not usually seriously affected by fungous diseases, although leaf spot and leaf rust and root and stem rot sometimes cause serious injury. The entomologists list almost a hundred insects that do more or less injury to the clovers. Many of them, however, are not widely distributed, and the injury they do is comparatively small. The three most common and injurious enemies are the clover root-borer, the leaf weevil, and the seed midge.

278. Clover root-borer. — The clover root-borer is a small, black beetle that lays its eggs in May or June in cavities in the crown of the plant or down the side of the roots. The eggs hatch and a small grub-like larva burrows into the roots, eating out great cavities and greatly weakening the plant. The larva changes to the pupa stage, from which the adult beetle emerges, but it remains in the root of the clover until spring, when it comes out to lay its eggs. The most effective means of controlling this insect is to plow the field as soon as the hay has been removed, thus depriving the larvæ of their food, causing them to starve. The root-borer attacks chiefly red clover and mammoth clover, but it also injures alsike clover and alfalfa.

279. The clover-leaf weevil. — The presence of this insect in a clover field may be detected by the large, round notches which are eaten in the edges of the leaves; the larvæ and adults may then be found hiding at the base of the plant under leaves or rubbish. Both the larvæ and adults are shy creatures, working almost entirely at night, and if by chance they are found at work during the day, they immediately cease their activities and drop from the plant to the ground as if dead. The adults are stout, brown colored beetles with a strong snout. They lay their eggs in early fall on the plant or in the debris near its base. The larvæ, which at first are white, change later to a dark green color, and become partly grown before winter. They remain dormant during the winter, and when spring comes, they again feed on the leaves and reach maturity in May or June. The adult beetles also feed upon the leaves and stems of the clover. Fortunately, these destructive insects are largely held in check by a fungus which grows upon their bodies, causing death. If not held in check by the fungus, they may be controlled to some extent by plowing the field soon after the removal of the hay crop. All kinds of clovers are more or less affected by the leaf weevil, but it prefers the red and white clovers to the alsike.

280. The clover-seed midge. — Low yields of clover seed are quite frequently due to the clover-seed midge. The adult is a little fly, smaller than a mosquito, which lays its eggs beneath the glumes of the clover head. The larvæ when they hatch burrow into the flower and eat the developing seed. There are usually two broods each year, the larvæ from the first brood becoming full grown about the time red clover is ready to cut for hay. The second brood feeds on the second growth, the one usually cut for seed, and may be so numerous as to destroy the seed crop. The best means of controlling the insects is to remove the hay crop rather early, allowing the second crop to appear before the second brood of midges come on. By this means large yields of seed may be had, whereas if the hay is cut at the usual time, the insects may greatly reduce the seed crop. Red and mammoth clovers are most greatly affected by the midge.

CHAPTER XV

ALFALFA

WHILE alfalfa is comparatively a new crop to the American farmer, it has been grown for centuries by farmers in other lands. Indeed, so far as we know, it is the oldest of cultivated leguminous forage crops, its culture in the eastern Mediterranean regions having been established long before the Christian era. Probably it was first cultivated in Persia, from which country it was introduced into Greece during the war between these two nations over 400 years B.C. From Greece it was carried to the Romans, whose armies, as they went forth to battle, carried it with them and were responsible for its introduction into many European countries. When it first came to the United States we do not know, but probably in colonial days or soon thereafter, since we know that Thomas Jefferson grew it in Virginia. Its culture on the eastern coast of the United States, however, did not attract much attention, and it was grown there but little. In 1851 it was

FIG. 99. — An alfalfa plant.

introduced from South America into California, where it soon met with great favor. From California it rapidly spread eastward until a few years ago, it again reached the Atlantic Coast States, coming this time from the West.

281. Description. — Alfalfa, *Medicago sativa*, is a perennial plant with an upright manner of growth and a deep root system. One of the distinctive features of alfalfa is the extent of its root system, which is characterized by a strong, deep-growing tap root, with comparatively few feeding roots near the surface of the ground. Ordinarily the tap root does not branch, but sometimes two or three or more strong branches, often as large as the tap root itself, are given off from it a few inches below the surface of the ground, and they grow downward almost, if not quite, as deep as does the tap root. Wonderful tales have been told about the depth to which alfalfa roots will extend into the ground. One account relates the finding of them while digging a tunnel over one hundred feet below the surface of the ground, and many incidents are known where they have penetrated the ground to a depth of more than twenty feet. Alfalfa is a native of dry lands, and many years ago developed a deep-rooted character to secure a supply of water from the moisture in the deep subsoil. The roots of alfalfa will not grow more than a few inches below the water table, and the depth to which the roots may penetrate the soil, therefore, may be determined by the position of the water table.

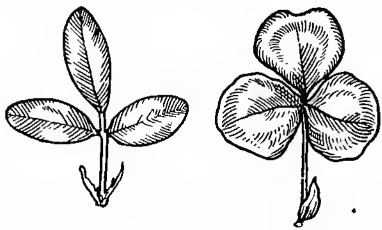

FIG. 100. — Arrangement of leaflets of alfalfa and clover.

The roots are able to penetrate rather impervious subsoils, but usually grow deeper in those of a loose, open character. The usual depth of the root system is from 3 to 12 feet.

Fig. 101. — Alfalfa roots.

282. The stems of the alfalfa plant, which bear short, leafy branches, arise from the crown or woody top of the tap root. The stems may be given off a little below the surface of the ground, thus forming a branched crown. The number of stems per plant varies from 3 to 15, and in rare cases individual plants may produce over 100 stems. The plants vary in height, the average height probably being from $1\frac{1}{2}$ to 3 feet.

The leaves are smaller and rather more narrow and more pointed than those of red clover. They differ from those of the clovers, too, in that the three leaflets, which are arranged together as in the clovers, do not all grow out from the end of the leaf branch in alfalfa, but the two lateral leaves of the group grow out oppositely from a point some little distance down the stem.

The flowers are purple, and are carried in elongated clusters or racemes, which grow out from various points on the stems and branches. The flowers are similar in shape to those of red clover, and both honey bees and bumblebees are agents in their pollination. The seeds are produced in spirally twisted pods, which may have from one to three coils, containing from one to eight seeds. The seeds are nominally kidney-shaped, although the coil may compress them into other shapes. They are uniform in color, usually light green, although unfavorable weather at harvest time may cause them to take on a darker green color. They are slightly larger than those of red clover, and this difference, together with their characteristic shape and uniform color, serves as a means of distinguishing one from the other.

283. Varieties. — Since alfalfa has become an important crop in this country, progressive growers and experiment stations have attempted to produce varieties or strains that will be better adapted and will yield larger returns than the ordinary alfalfa under certain conditions of soil and climate. Thus, a variety with unusual drought-resisting qualities would be well adapted to certain regions of the West, and would probably give larger yields than ordinary alfalfa under the same conditions. Some progress has been made also in selecting for a higher percentage of leaves, to increase the value of the hay. For the most part, the progress that has been made in the way of securing better adapted varieties has been accomplished by importing seeds or plants from other countries having climate and soils similar to the section where better adapted varieties are desired. Usually the variety is given the name of the country from which it was imported. Thus we find such varieties as Turkestan, Peruvian, and Arabian. Another variety, called Grimm alfalfa, grown in the Northwest, is named for the man who introduced it, and it is said to be more hardy than common alfalfa. Turkestan is also a hardy and drought-resisting variety, and is well adapted to certain sections of the semi-arid West, although it is no better in humid climates than ordinary alfalfa.

284. Distribution. — Alfalfa is now grown to some extent in all countries having temperate climate. It is grown over wide areas in Europe, Asia, and North and South America. It is an important crop in many of the South American countries, especially in Argentina, where it is said to occupy more than one-sixth of the cultivated land. In the United States alfalfa has come into great favor, and its acreage has increased at a remarkable rate within the past thirty years. It is now grown in almost every state, but by far the greater acreage is to be found in the states west of the Mississippi. According to the 1910 census, 4,707,000 acres are devoted to growing alfalfa in the United States, 4,500,000 of which are west of the Mississippi, the New England States devoting less than 1300 acres to the crop. The comparatively small acreage devoted to alfalfa in the states east of the Mississippi is due, in great measure, to its recent introduction, to a general lack of appreciation of its value, and to a lack of knowledge of its cultural requirements. While almost all of the states west of the Mississippi have large acreages devoted to alfalfa, Kansas, Colorado, California, and Idaho have the largest acreages.

285. Adaptation to climate. — Alfalfa has a wide adaptation to climate, as is made evident by the study of its distribution. It is, however, better adapted to warm than to cool climates, but the area of its successful growth has gradually been extended and now reaches well up into Canada. Alfalfa, on account of its deep-rooting habit, is adapted to semi-arid sections, and when once well established, will withstand severe drought. In sections with an annual average of less than 20 inches of rainfall, it is necessary to irrigate if good yields are to be expected.

286. Adaptation to soils. — Alfalfa will grow in many different kinds of soil, but in order to produce a successful stand, it must, above all, be well-drained soil. Alfalfa seems to be sensitive to an excessive amount of moisture in the soil during the growing season. Soils that are water-logged or that have water standing over them during part of the growing season are not suitable for this crop until this condition is remedied by drainage; but soils that have natural drainage, or that have porous sub-soils, giving natural sub-surface draining, are well adapted to the crop. Soils that have a watertable or a stratum of rock near the surface of the ground are not well adapted because the roots will thus be prevented from penetrating very deeply into the subsoil. Alfalfa does not grow well in acid soils, and when this condition exists, lime must be applied before a successful stand can be expected. If neutral or blue litmus paper turns red when placed in a sample of damp soil, the latter is acid, and lime should be applied. The amount to apply per acre will depend upon the degree of acidity. An application of one ton of finely ground limestone or one-half ton of burned lime per acre will meet the requirement of almost any acid soil. There must be a sufficient amount of lime in the surface soil. Some soils that have limestone in the subsoil will not grow the crop successfully until the surface soil is given a liberal application of lime.

287. The soil must be fertile and well supplied with organic matter. While the growing of alfalfa adds nitrogen to the soil, the plant is not able to use the nitrogen from the air until it has made a fair amount of growth; consequently it must depend upon the nitrogen in the soil to tide it over until it is able to draw upon the supply in the air. Soils for alfalfa should have enough available plant food to permit the plants to reach the stage where they can make use of the nitrogen in the air. Poor soils are usually in a poor physical condition, and do not provide a suitable place for the growth of bacteria. The physical condition of such soils may be greatly improved by applying barnyard manure and plowing under green manure crops a few years previous to the seeding of alfalfa. Organic matter not only improves the physical condition of the soil, but it also prevents heaving and winter-killing. The bacteria that produce the nodules on the roots of the alfalfa plant should be present in the soil, for it is due to these bacteria that nitrogen is gathered from the air. When they are not present, if the plant makes a successful growth, it must secure its nitrogen from the soil. In order to grow alfalfa without the aid of these bacteria, it is necessary to have a very fertile soil and one that is well supplied with nitrogen. However, it is not usually desirable to do this. Sometimes the bacteria that grow upon the roots of alfalfa are not present in the soil and it then becomes necessary to supply them artificially. As a rule it is best to inoculate a new field unless one is certain that the bacteria are present.

The methods employed in inoculating the soil for alfalfa are the same as have been discussed in Chapter XIII. The bacteria that grow upon the roots of sweet clover and bur clover will also grow upon the roots of alfalfa. Soils that have successfully grown these crops may be used for inoculating alfalfa fields.

288. Use of Alfalfa. — The reason why alfalfa is so highly esteemed is not difficult to see. The farmer, as a business man, considers both the cost of production and the returns from each crop he grows. If he considers alfalfa in this way, he must note the fact that three, and sometimes four or five cuttings of hay per year may be reasonably expected, and that the life of the stand varies from 5 to 15 years, depending upon conditions for growth. It will be readily seen that the annual expense of preparing the seed bed, of the purchase of seed and seeding that is necessary in the growing of general farm crops, makes the cost of production of alfalfa relatively low. Unlike many crops with a relatively low cost of production, alfalfa is a bountiful yielder of forage, possessing a high per cent of protein, which gives it high rank in feeding value. Experiments conducted by some experiment stations show that alfalfa compares favorably with wheat bran in the feeding of dairy cows. Other experiments, while not giving it an equal value with wheat bran, have given it a high rank among the feeds of farm animals. The growing of alfalfa not only makes possible the production of protein on the farm for balancing the feeding ration, but also, since it is a leguminous crop, supplements the work of clover in maintaining soil fertility. It is especially valuable as a soil improver because of its extensive root growth, which, when it decays, makes drainage channels for air and water and opens up passages for the roots of succeeding crops that do not penetrate the soil so readily.

289. Almost all of the alfalfa produced in the United States is used for hay. Alfalfa hay is relished by all kinds of live stock, including hogs and chickens. The yield of hay per acre varies greatly with soils and climate. The fact that several cuttings per season may be had makes possible a relatively high yield. Each cutting on good soils, if favored with sufficient rainfall, may yield from one to two or more tons per acre, giving a total production of from 3 to 8 tons. Alfalfa is used to some extent as pasture, and is especially valuable for hogs. Cattle, when pastured upon it, are subject to bloating, but if the same precautions are taken as were suggested for pasturing them on red clover, little trouble need be experienced. Alfalfa does not form a compact sod, and does not stand tramping nor close grazing well, and when used for this purpose, a sufficient acreage should be grown to permit of changing the stock from one field to another from time to time to allow the new growth to come on. Alfalfa is an excellent soiling crop, since new growth comes on rapidly after cutting and a small acreage will feed a comparatively large number of animals.

CULTURAL METHODS

290. Preparing the soil. — The manner of preparing the seed bed for alfalfa will depend largely upon the preceding crop. There seems to be no one best way of seeding alfalfa. Good stands may be secured when greatly varying methods of seeding are practiced. In some sections of the country seeding in the corn before or just after the last cultivation has been very successful. Likewise, seeding in the wheat or oats in the spring after the manner of sowing clover has been successful in some places. In many localities these methods have not met with success, and a more careful preparation of the seed bed is necessary. If this method is followed, the land should be plowed early and cultivated carefully with a harrow or cultivator until the weeds are killed and then the seed will be sowed in a seed bed free from weeds and at the same time well supplied with moisture. Sometimes it may be possible to follow early potatoes with alfalfa. This practice accomplishes almost the same results that a bare fallow does. By cultivating the potatoes throughout the growing season, almost all of the weeds are killed, and enough moisture is retained to start the alfalfa. This practice also permits the removing of a crop from the field, avoiding in this way the loss of the use of the land as is the case when bare fallow is practiced. If alfalfa follows potatoes, the land need not be plowed again, but should be well worked down and allowed to settle for a couple of weeks before seeding. Alfalfa seems to require a rather compact seed bed, and if the soil is allowed to settle and become compact, the chances for a good stand are greatly increased.

291. Seeding. — There is much adulterated seed on the market which, if purchased, not only increases the price of the alfalfa, but may introduce very troublesome weeds into the field. It is well to get samples of seed and prices from several different places, and to test the seed for purity and vitality. This method will enable the purchaser to get the best seed at the lowest price. Being a perennial plant, alfalfa may be seeded at any time during the growing season. If early spring seeding is practiced, a nurse crop can sometimes be used to advantage. Probably the best crop to use for this purpose is spring barley, seeded at the rate of $1\frac{1}{2}$ bushels per acre. Oats may be used as a nurse crop if they are removed early for hay, since, if allowed to ripen, they may smother out the alfalfa. A nurse crop is not generally recommended for any other than early spring seeding. If fall seeding is to be practiced, the seeding should be early enough in the fall to enable the plants to make several inches of growth before winter. The growth from late fall seeding is frequently injured during the winter.

The rate of seeding will depend upon the quality of seed and upon the condition of the seed bed. In an experiment on the rate of seeding conducted at the Ohio Experiment Station, seed was sown at various rates, ranging from 5 to 25 pounds per acre. The 10 and 15 pound rates gave the best results, there being very little difference between them. If the seed is of good vitality and the seed bed is in good condition, 15 pounds of seed per acre is considered enough.

292. Cultivation. — The problem of keeping a stand, to many farmers, especially to those east of the Mississippi River, has been a bigger problem than that of getting one. Weeds seem to be the greatest factor with which the grower has to contend in keeping a stand. Many farmers say they have solved the weed problem by practicing a system of cultivation. Some farmers cultivate each spring with a spring tooth or disk harrow, just before the young shoots start to grow; others not only cultivate in the spring but after each cutting throughout the season. This practice kills the weeds and at the same time loosens up the soil, incorporating any vegetable matter that may have accumulated from fallen leaves or from other sources. It has been demonstrated that alfalfa will not be injured by severe cultivation, after it is once well established. In one experiment, a plot was cultivated five times with a spring tooth harrow early in the spring, and the alfalfa showed no bad effects from the cultivation, while most of the weeds in the field were killed. Cultivation, however, is to be recommended only for fields in which the alfalfa plants have become well established, usually after they are two years old. Sometimes weeds are troublesome in fields during the first year, in which case the fields should be run over with the mower, clipping off the plants and weeds. The mower should be set to run rather high, usually about 4 inches. If the plants turn yellow and cease to grow during the first year, they should be clipped off with the mower so that they may start a new growth. Frequently, however, when the plants turn yellow, it is because the proper bacteria to furnish them with nitrogen are not present.

293. Making alfalfa hay. — Alfalfa should be cut for hay when the new shoots for the next crop start out from

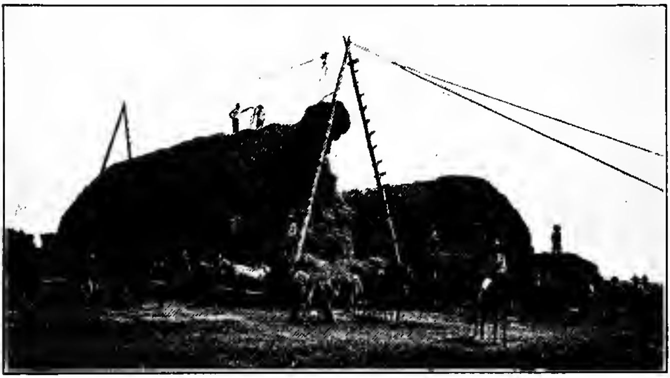

Fig. 102. — Stacking alfalfa in New Mexico.

the crown of the plant. Usually this occurs about the time the plants begin to bloom, although the bloom may sometimes be farther advanced before the new shoots appear. When the shoots appear, the crop should be cut promptly, since, if the cutting is delayed until after this time, the leaves begin to drop from the plant and the quality of the hay is reduced. Cutting at this time is also more favorable for the next crop for, if cut before the new shoots appear, the plants will be greatly weakened and sometimes destroyed, and if cutting be delayed until after this time, the second crop is put back, which, in the course of the year, may mean one less cutting. The last cutting in the fall should nôt be made so late that the plants will not be able to make a growth of 8 or 9 inches, to protect the crowns during the winter.

Composition of Alfalfa Hay

	Ash	Fat	Protein	Crude Fiber	Carbohydrates
Stem	4.99	0.81	6.35	54.33	27.79
Leaves	14.48	2.96	23.33	13.15	41.16

It will be seen from the table that the leaves are much richer in fat, ash, protein, and carbohydrates than the stems, and for that reason form the most valuable part of the hay. The leaves of alfalfa, when dry, like those of other leguminous hay plants, are easily broken off. It is necessary, therefore, if the best quality of hay is to be secured, that the harvesting be done in such a way as to retain as many of the leaves as possible. This may be done by handling the hay in a semi-cured condition as far as possible. Cutting may be done either in the afternoon or morning, as was suggested for the making of red clover hay, and the hay allowed to cure for a short time before it is raked up. The following day it may be piled in small cocks and allowed to cure for a few days before hauling to the barn or stack. Alfalfa hay does not turn water readily, and the best quality is secured when the cocks are covered with canvas caps while curing to protect them from the rain and dew. In the eastern half of the United States, almost all of the hay is stored in sheds or barns, but in the West, where large acreages are grown, much of it is stored in large stacks. To reduce the bulk for hauling to market or shipping, the hay may be baled when taken from the stack or barn. Alfalfa meal, which has recently appeared on the market, is the finely ground hay, which may be fed with less waste. Its feeding value, is, of course, the same as that of hay.

FIG. 103. — Canvas covers employed to protect alfalfa cocks from rain.

294. Harvesting the seed. — Alfalfa does not produce much seed in humid climates. Almost all of the seed grown in the United States is produced in the semi-arid regions of the West or on irrigated lands. The production of seed seems to be limited to a considerable extent by the amount of soil moisture. There must be enough moisture to enable the plant to mature its seed, but not enough to cause the new shoots to start out from the crown before the seeds are ripe. If the new shoots start out before the seeds are ripe, the yield of seed is greatly reduced. Only in certain sections of the West are moisture conditions favorable for the production of a good seed crop. On irrigated lands, where the moisture supply may be controlled, alfalfa seed is an important crop. The yield of seed is also influenced by the rate of seeding, the best yield being obtained when the crop is seeded thinly, either in rows or broadcast. The crop is harvested when most of the seed pods have turned brown. It may be cut either with a self-rake or a buncher; and if a machine

FIG. 104. — Farmers examining alfalfa test plots at the Ohio station.

for hulling it is available, the seeds may be thrashed out immediately, or it may be stacked after curing for some time in the bunches so as to prevent heating in the stack. The yield varies from 2 to 5 bushels per acre, which at present prices makes it a profitable crop.

295. Insects and diseases. — While many insects feed on alfalfa, seldom are they numerous enough to cause serious loss. Sometimes in the West, however, the grasshoppers become so numerous as to cause serious injury to the crop. They may be controlled to some extent by disking the field early in the spring to destroy the egg sacs, and later in the season by the use of a "hopperdozer."

The most common fungous diseases of alfalfa are the leaf spot, leaf rust, and root rot. The root rot is commonly found in the South, where it also attacks the cotton plant and as the spores remain in the soil there is no way of controlling it except by seeding in fields free from it. The leaf spot is quite injurious to the crop in many places and may be best controlled by clipping and removing the crop from the field, and encouraging new growth which may be vigorous enough to overcome the attack. No practical method is known for controlling the leaf rust of alfalfa.

CHAPTER XVI

THE VETCHES, SWEET CLOVERS, AND OTHERS

THERE are several kinds of vetches, but only two, hairy vetch, *Vicia villosa*, and common vetch, *Vicia sativa*, are of agricultural importance in this country.

296. Hairy vetch. — This species is also known as sand vetch and winter vetch. It is a winter annual, with long, trailing, vine-like stems, which are not strong enough to grow erect unless supported by other plants. The leaflets are arranged in pairs on a rather long midrib, which terminates in a tendril. The flowers are produced in racemes which grow from the axils of the midribs and are bluish-purple in color. The seed pods, when they mature, are straw colored and from 1 to 2 inches in length and about ½ inch wide. The seeds are black, round or spherical in shape, and about one-half the size of a pea. The roots are inclined to be fibrous and produce an abundance of tubercles, the bacteria in which are active late in the fall and early in the spring, thus making the plant a great nitrogen gatherer.

297. Adaptation and uses. — Hairy vetch is very hardy and is able to withstand severe cold during the winter. It grows well on almost any well-drained soil, but is especially adapted to rather sandy soil. The most common uses are as a cover crop and as a green manure crop for plowing under to improve the soil. As a cover crop, it is often used in orchards, and as a green manure crop, it is especially adapted for following truck or other early maturing crops. It is sometimes used for hay, but unless seeded with rye or wheat, the stems trail on the ground and become fastened together by the numerous tendrils into a dense mat, making harvesting difficult. When grown with one of the cereals, the stems are held erect and the hay is more easily handled. When seeded with rye or wheat, vetch makes an excellent soiling crop for use in the spring or early summer. It is sometimes pastured in the fall and spring, but does not stand tramping well, and is more valuable as hay. As a green manure crop, it has considerable merit. In the amount of nitrogen and organic matter added to the soil, it has few rivals. When grown for plowing under, it should be seeded with rye, which will not only add considerable organic matter, but the vetch is less twined together and is more easily turned under. Hairy vetch is sometimes a troublesome weed, particularly in wheat fields. The seeds ripen about the same time as wheat, and are not easily separated from the thrashed grain, either by the air blast or with screens.

Fig. 105. — Vetch, showing flowers, leaves, and tendrils.

298. Cultural methods. — While hairy vetch may be sown in the spring, it is most commonly seeded in the summer or early fall. If seeded in the summer or fall, it matures seed the next year about the time of wheat harvest. If seeded in the spring, the seeds are matured late the following fall. When seeded alone, it may be put in with the grain drill at the rate of about 40 pounds per acre. It is best, however, to use only about 25 or 30 pounds of vetch and add to it about 4 pecks of rye, this combination making a desirable crop for forage or green manure. The time of the seeding will depend upon the preceding crop. If it follows early potatoes, the seeding may be done as soon as the potatoes are harvested. If corn precedes it, it may either be drilled in the standing corn or seeded after the corn is cut. Unless the corn is an early variety, allowing early cutting, the season may be too far advanced for a successful seeding of vetch. When grown for seed, the rate of seeding should not be more than 2 pecks per acre. The yield

Fig. 106. — A sample of hairy vetch.

of seed varies from 3 to 9 bushels per acre, and at present prices, $10 per bushel, is a profitable crop. Most of the seed used is imported.

299. Spring vetch. — Spring vetch closely resembles hairy vetch in its general appearance and manner of growth. It is an annual, and differs from hairy vetch in the size and shape of the pods and in the size of the seed. The seed pod is black in color and is longer and only about one-half as wide as that of hairy vetch, but

Fig. 107. — A field of vetch in full bloom.

the seeds are somewhat longer than those of the latter. It is less resistant to cold than hairy vetch, and for this reason is less commonly grown in the northern part of the United States. In Western Oregon and Washington, however, where it is grown as a winter crop with oats or wheat for hay, it is of considerable importance. In the South it is grown largely for green manure or as a winter crop with cereals for forage. Spring vetch is regarded with high favor in England as a soiling crop, and is more commonly grown there than the hairy vetch, while in this country the reverse is true.

THE SWEET CLOVERS

The sweet clovers are natives of Central Asia, and have been cultivated for many centuries in southern Europe, where they have been used chiefly for bee pasture, and to some extent for forage and green manure. Sweet clover was introduced into the United States in colonial days, but was until within recent years, and still is, in some sections of the country to-day, considered a troublesome weed. There are two common species of sweet clover, white sweet clover, *Melilotis alba*, and yellow sweet clover, *Melilotis officinalis*.

FIG. 108. — A sweet clover plant.

300. Description. — White sweet clover is also known as Bokara clover and Melilotis. In its appearance and manner of growth it resembles alfalfa; in fact, when the plants are young, they can scarcely be told apart. The sweet clover, however, grows taller than alfalfa, the stems sometimes reaching a height of 8 or 10 feet. The stems are coarser and more woody than those of alfalfa, and not so abundantly supplied with leaves. White sweet clover is a biennial, the first year growing from 1 to 3 feet in height, the next year growing much larger and producing numerous white flowers in the form of racemes. The plants bloom all summer long during the second year of their growth and mature an abundance of seed, which

Fig. 109. — Sweet clover requires an abundance of lime in the soil. The plot at the left was limed before seeding. Both plots were seeded at the same time.

closely resembles that of alfalfa. The root system is similar in structure and extent to that of alfalfa. During the first year, the tap root is enlarged by the storing of reserve plant food for starting the second year's growth. Nodules are produced on the roots in abundance by the same variety of bacteria that live on the roots of alfalfa.

301. Distribution and adaptation. — Sweet clover is now found in almost all parts of the civilized world.

In the United States it is found in almost every state. It possesses wide adaptation to soils and climate, growing equally well in the North and South. In most places it is considered a weed, and may be found growing in waste places, along roadsides and railroad embankments, in gravel pits and stone quarries. In some few sections

FIG. 110. — Sweet clover growing by the roadside.

of the country, it has recently become highly prized as a cultivated crop. Sweet clover, like alfalfa and red clover, is extremely sensitive to acid soils, producing the most luxuriant growth on well-drained limestone areas.

302. Uses of sweet clover. — The large, rank growth of stems and the well-developed root system have recently called attention to its value as a soil improver. Few plants add so much organic matter to the soil, and at the same time produce such an extensive root system supplied with nitrogen-gathering bacteria. Sweet clover is also used in some localities for hay, but on account of the large, woody stems and a characteristic bitter taste, it is hardly probable that it can successfully compete for this purpose with alfalfa. It should be cut for hay before the first flowers appear in order to yield hay of the best quality. It is handled much the same way that alfalfa is handled. Sweet clover may be used for pasture or soiling, but on account of its unpleasant bitter taste, live stock have to become accustomed to it before they acquire a liking for it.

303. Cultural methods. — Many farmers have experienced difficulty in securing a stand of sweet clover in cultivated fields, although it may grow abundantly along the roadside. There are two reasons for the frequent failure to secure a successful stand. Sweet clover requires a firm, compact seed bed, and the young plants do not grow well on loose soil, as do most of the other cultivated crops. Another reason for frequent poor stands is the poor quality of the seed secured on the market. Sweet clover seed contains many hard seeds that do not germinate readily, sometimes as much as 60 per cent of it failing to germinate for this reason. The seeds should always be tested for germination and the rate of application made to correspond with the percentage of germination. Sometimes failure to secure a stand may be due to the lack of sufficient lime in the soil, which should be tested with litmus paper before seeding, unless it is known to be well supplied with lime. The seed may be sown broadcast on fall sown grain fields in early spring while the ground is honeycombed, or it may be seeded alone on a firm seed bed in late spring or summer. The usual rate of seeding is from 20 to 30 pounds per acre, and it must be increased if a large number of hard seeds are present. Sweet clover may be seeded in midsummer or early fall with vetch for green manure. They make an admirable combination for this purpose, and since both are legumes, they add nitrogen to the soil and at the same time supply an abundance of organic matter.

304. Yellow sweet clover. — Yellow sweet clover is similar in its habits of growth and requirements to the white sweet clover. It differs from it in being a less rank grower, having finer stems and yellow flowers which appear from two to three weeks earlier than those of the white sweet clover. Yellow sweet clover is better adapted for hay than for green manure.

BUR CLOVERS

305. Bur clovers, *Medicago maculata*, and *M. denticulata.*— These plants are natives of southern Europe and have been introduced into the southern part of the United States, where they are grown for pasture and hay and for soil improvement. Toothed medic (*M. denticulata*) is grown largely in California and the other Southwestern States, while the Southern bur clover is more common in the Gulf States. The bur clovers are closely related to alfalfa, belonging to the same genus, *Medicago*. They are low growing annuals, the stems trailing along on the ground unless seeded thickly or grown with grasses or cereals, which hold them up. The flowers are small and yellow and form clusters about the stem. The seeds, when mature, are incased in a round, prickly pod, from which they are not usually removed for seeding.

306. Uses and cultural methods. — Southern bur clover is most useful as a cover crop to occupy the soil after the cotton has been removed. It is also used as a pasture, and when grown with Bermuda grass, furnishes abundant pasture of excellent quality. It may be seeded in Bermuda sods by scattering the burs over the sod in the fall or by plowing shallow furrows four or five inches apart, dropping the seeds in and covering them lightly with soil. The plants start to grow about the time the Bermuda grass is killed by the frosts in the fall, and in mild climates they grow throughout the winter. The first year after seeding clover in the Bermuda grass sod the plants are not numerous enough to furnish much pasture but will reseed the field for the next year, when the new plants will furnish pasture late in the fall and early in the spring. For a hay crop, on account of its low growing habit, it is best seeded in the fall with oats or wheat, which combination may be cut the next summer and will yield a good tonnage of excellent hay.

When used as a green manure crop, from 50 to 60 pounds of the burs are sown per acre. The plants grow during late fall and early spring, making a good growth before being plowed under for a cultivated crop. The bacteria that produce the nodules on the roots of bur clover do not seem to be widely distributed, and frequently it is necessary to inoculate the soil before nodules are developed. The bacteria which work on the roots of bur clover also live on the roots of alfalfa and sweet clover, and soils that have produced these crops successfully may be used for inoculating the bur clover.

JAPAN CLOVER

307. Japan clover, *Lespedeza striata.* — This plant is a native of eastern Asia and was introduced into the United States early in the '60's. During the Civil War it was carried by the armies for feeding their horses and was spread over most of the Southern States east of the Mississippi River. Since that time the area of its growth has been extended somewhat, and it is now found growing from New Jersey westward to central Kansas and southward to the Gulf.

308. Description. — Japan clover is a low growing annual, usually from 6 to 10 inches in height, although under very favorable conditions it may reach a height of 3 feet. When the plants are seeded thinly on the ground, the stems are prostrate; but when the stand is thick, the plants support each other and are erect. The stems are fine and the leaves are carried in three's and are almost sessile on the branches, which spring from the main stems. The flowers are pink and nearly sessile. The seed when ripe shatters badly, and during harvesting enough is left on the ground to reseed the field. The roots are fine and comparatively shallow and produce nodules abundantly.

309. Uses and cultural methods. — Japan clover will grow in almost all types of soil and is especially well adapted to poor soils, furnishing pasture on waste and barren places where other pasture plants will not grow well. It is able to withstand severe drought and furnishes forage during the entire season from spring until the frost kills it in the fall. As a pasture plant it is highly prized on account of its high feeding value, and it is well adapted to growing for this purpose with Bermuda grass and redtop. In pastures it reseeds itself, and although not a perennial, furnishes pasture year after year. Until recently it was grown only for pasture, but now on good soils, where it makes a good growth, it is frequently cut for hay. Usually it will furnish two cuttings during the season, although the second crop may best be cut for seed. On good land it yields from one to two tons of hay per acre. It seeds abundantly, and yields from 5 to 10 bushels per acre, the market price of which is from $3 to $4 per bushel. Almost all of the seed on the market is produced in Louisiana and Mississippi. When a new field is to be seeded down with bur clover, it may best be done in the spring by scattering from 15 to 20 pounds of seed per acre and covering it with the harrow.

CHAPTER XVII

LEGUMES FOR FORAGE AND GRAIN

Of the cultivated legumes in this country, peas and beans rank next in importance to the clovers and alfalfa. In the Orient they hold a place of greater importance than any other group of legumes. There are many kinds of peas and beans, but only the important ones will be discussed in this chapter.

THE SOY BEAN

310. History. — The soy bean is probably a native of China or Japan. It has been grown in those countries for centuries, and holds an important place in the dietary of the people. It was introduced into Europe about a century ago, and for many years thereafter it was grown only as an ornamental plant and in botanical gardens. From Austria-Hungary in 1875 came the first published report of an experiment with soy beans, in which the writer urged their more extensive culture and pointed out their great usefulness. In the United States soy beans have been grown in a very small way for a great many years, but only within the last 20 or 25 years have they occupied a position of any importance. During this time they have spread rapidly over the country and have steadily gained in favor, until now they are regarded by many as one of our most important crops.

311. Description. — The soy bean, *Glycine hispida,* is a summer annual with a branched, upright, rather woody stem, which grows from 2 to $3\frac{1}{2}$ feet or more in height. The leaves are trifoliate, rather large, and quite abundant. The flowers, which are clustered in the axils of the leaves, are small and inconspicuous and are either white or purple in color. Soy beans are ordinarily self-pollinated, although insects may produce cross-pollination. The pods, when they develop, are short as compared with those of the cowpeas, being from 1 to $2\frac{1}{2}$ inches in length, containing from 2 to 4 seeds. The stems, leaves, and seed pods are covered with short hairs, usually reddish brown in color. In general appearance the soy bean is more like the peas than like the beans. The root system of the soy bean consists of a large tap root, with comparatively few lateral branches. The root growth is rather slight when compared with that of most of the other legumes, but the tubercles that are formed on them are large and abundant.

FIG. 111. — A soy bean plant.

There are almost a hundred varieties of soy beans grown in the United States. They vary greatly in the character of the plant, size and shape of the seed, and in the length of season required for their growth. Many of them have been imported from the Orient and retain their Oriental names. Others are named so as to indicate the color of the grain and the length of season required for growth. Thus we find such varieties as Early Yellow, Medium Yellow, Medium Green, etc. There is a great difference among the varieties in the amount of leaf and stem growth, and also in the retention of leaves and the

FIG. 112. — A field of soy beans.

shattering of the grain. Certain varieties are, therefore, well adapted for forage, while others may be better adapted for the production of grain.

312. Distribution and adaptation. — While soy beans have a rather wide distribution throughout the United States, they are best adapted to a climate similar to that required by corn. They do not grow well as far north as the field bean grows, and in the South are largely replaced by the cowpea. They are, therefore, principally grown in the section of the country north of Kentucky and Kansas. Soy beans will grow well in almost all types of soils. They grow well on rather poor soils if the nodule-forming bacteria are present, under these conditions producing a rather small growth of leaves and stems, but a relatively high yield of grain. On very fertile soils the growth of leaves and stems is large, and is frequently accompanied by relatively low yields of grain. Soy beans are not so sensitive to wet soils as many legumes, although they grow best on well-drained land; neither are they as sensitive to acid soils as clover and alfalfa, although limestone soils are most favorable for their growth.

313. Uses. — In China, Japan, and other Oriental countries soy beans hold an important place as a supplement to rice in the dietary of the people, but in the United States they have never attained much favor as human food, probably on account of the characteristic flavor which they have after cooking, that is not relished by Americans. In Europe oil is extracted from the grain, which, after being refined, is used in combination with other oils for culinary purposes. The crude oil is used for paints, varnishes, soap, and also for lubricating purposes. In this country the grain is almost entirely used for seed and for the feeding of live stock. As a stock food soy beans may be utilized as grain, hay, soiling, and pasture. The great demand for seed, on account of the rapidly increasing acreage devoted to the crop, has resulted in nearly all of the crop being harvested for grain, which is sold for seed. It cannot be long, however, before the production of grain will exceed the demand for seed, which will result in the price per bushel being based upon the feeding value. Soy beans are almost equal in feeding value to gluten meal, cotton seed meal, and other concentrates. They may be fed to all classes of live stock, usually being ground and fed in combination with other seeds.

314. Soy beans, because of their erect growth, are more easily handled as hay than are cowpeas. The hay, to be of the best quality, must be handled in such a way as to retain as many of the leaves as possible, since the greater part of the nutrients is carried in them. Soy bean hay of good quality compares favorably in feeding value with alfalfa hay. Soy beans hold an important place as a soiling crop, since they furnish forage in late summer or early fall when the pasture is shortest. Sometimes they are fed with some non-leguminous forage crop, such as millet or sorghum, to furnish protein in the ration. Frequently soy beans are grown for the silo, but experience has shown that while they alone do not make good silage, in combination with corn they make a desirable mixture for this purpose. Silage made from soy beans alone, when fed to dairy cows, imparts a disagreeable odor to the milk. When mixed with corn, at the rate of 2 tons of corn and 1 ton of soy beans, this objection is overcome, and the feeding value of the silage is increased over that of silage made from corn alone. Soy beans are not well adapted for pasture and are not often grown for this purpose. Sometimes they are grown for hog pasture, but they are not as good for this purpose as is rape. Hogs are often turned into the field after the crop is harvested to gather the shattered beans, and sometimes they are allowed to gather the entire crop. As a green manure crop, soy beans are about equal to clover in the amount of nitrogen added to the soil if the entire crop is plowed under. If only the roots and stubble are considered, soy beans add only about one-sixth as much nitrogen as the roots and stubble of red clover. Soy beans, however, have the advantage of making their growth in a comparatively short period of time.

315. Cultural methods. — The bacteria that form the nodules on the roots of the soy beans are not so generally distributed as those that work on the roots of the clover. In many cases, especially in sections where the crop is new, it is desirable to inoculate the soil. If the land has not previously grown the crop, usually but few nodules will be produced the first year without inoculation, and the crop will have to make its growth from the nitrogen in the soil. It is especially desirable to inoculate soils that are low in nitrogen. If the crop is grown without inoculation on the same field for two or three years, the soil will usually become inoculated from the few bacteria that may be carried to the field with the seed, which will multiply to a sufficient extent to effect the inoculation of the entire field. Ordinarily no fertilizer is applied to the soil for the growing of soy beans, although it may be profitable to treat poor soil with barnyard manure or mineral fertilizers. The seed bed required for soy beans is similar to that required for corn.

316. Seeding. — Soy beans should not be seeded until rather late in the season after the danger from frost is past, and the soil is well warmed up. In most places, this will be about the time corn planting is finished. The rate of seeding will depend upon the use to be made of the crop. If it is grown for the grain, the usual method is to seed in rows 28 to 30 inches apart, using about 3 pecks of seed per acre. If grown for forage, the largest yield and the best quality of hay, on account of the fineness of the stems, may be obtained when the seed is drilled close at the rate of 6 to 8 pecks per acre, the exact rate depending upon the variety, some kinds having smaller seeds than others. Soy beans rapidly decrease in vitality with age, and seeds more than one year old should always be tested before seeding. When drilled close, no cultivation is given the plants, but when seeded in rows, they should be cultivated frequently during the period of early growth.

317. Harvesting. — The best quality of hay may be secured if the plants are cut at the time the pods are well

FIG. 113. — Soy beans growing in corn.

formed and before many have matured. If cutting is delayed until after this time in most varieties, many of the leaves, which form the most valuable part of the hay, will be lost, and the stems will become woody and unpalatable. On account of the ease with which the leaves are broken off when dry, the curing should be done in the cock. After cutting, the plants are allowed to lie in the swath for a day or so, and the drying can then be completed with less loss of leaves by cocking. After a few days in the cock, the hay may be stored. When used for silage, the cutting may be delayed until the beans are well formed, as the loss in this case is slight, since the handling is completed while the plants are green.

When soy beans are harvested for the seed, they should be cut after the pods have turned brown or black and one-half or more of the leaves have fallen. A mower with a side delivery attachment or a self-rake may be used, which will prevent the shelling and loss of the beans by the passing of the mower wheels over the cut swath. After cutting they should be piled in cocks and allowed to cure until ready for thrashing. When thoroughly dry, they may be thrashed by tramping or with a flail, although large acreages are best thrashed with an ordinary grain thrasher, by removing the concaves and running the machine at a slow rate of speed. After thrashing, the beans should be spread out to dry before bagging or bulking in the bin. The yield of grain per acre varies from 10 to 25 bushels, the average probably being about 15 bushels.

THE COWPEA

The cowpea is said to be a native of India or Persia, and from there to have been introduced into China at an early date. It was not known in Europe until about the middle of the sixteenth century. In the United States it was introduced into South Carolina or Georgia early in the eighteenth century. It was not of great importance in this country, however, until within the last few decades, but now it is the most important legume of the Southern States.

318. Description. — The cowpea, *Vigna unguiculata*, is an annual with a habit of growth varying with the variety from a single upright, branching stem to a profusely trailing form. Almost all varieties have the trailing habit of growth, and under favorable conditions of climate and soil some of them produce stems 15 feet or more in length. The stems are marked with longitudinal grooves, and the color of the stems is associated with that of the leaves, varying in this respect from pale to dark green. The leaves are trifoliate and are larger than those of the soy bean. The flowers are borne singly and are much larger than those of the soy bean, being more nearly the size of those of the sweet pea. The flowers are whitish, violet, or yellow in color, and rival the sweet pea in beauty. The pods are long, straight, or slightly curved, and many seeded. The seeds vary greatly in size and may be either smooth or wrinkled. They vary also in color, the common colors being white, yellow, green, brown, and mottled. The stem, leaves, and pod of the cowpea, unlike those of the soy bean, are not covered with hair. In appearance the cowpea more closely resembles the field and garden bean than it does the soy bean.

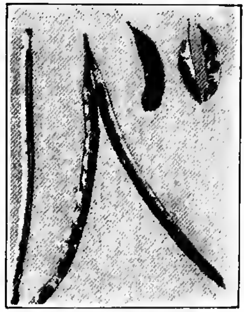

FIG. 114. — Pods of cowpeas and soy beans.

The root system of the cowpea consists of a well-developed tap root, which gives off lateral branches from the upper part. These grow out horizontally for some distance and then grow downward rather deeply. The roots of the cowpea are more extensive than those of the soy bean, being more numerous and penetrating more deeply into the soil.

There are some 15 important varieties of the cowpeas grown in the United States, and they vary much in their habits of growth, most of them being intermediate between the erect and the extremely long vined varieties. They also vary greatly in their adaptation to soils and climates and in their retention of leaves and the coarseness of their stems.

319. Adaptation and distribution. — Cowpeas are well adapted to a warm climate and a long growing season. For this reason they are better adapted to the southern than to the northern part of the United States. Only a few of the earlier varieties mature as far north as central Ohio. Cowpeas are a very important crop in the South, holding a place there similar to that held by red clover in the North. They will grow on almost all types of soil. They are more sensitive to wet soil than are the soy beans, but they are less affected by lack of lime, and have on this account a wider distribution than soy beans. They grow well on rather poor soils, and for this reason are valuable for green manure.

320. Uses. — The cowpea is used in much the same way as the soy bean. In China it is even more commonly used in human diet than the soy bean. Like the latter, it may be used for the feeding of live stock and for green manuring. The hay, when properly made, is of equal feeding value with alfalfa hay, although it is not quite so palatable. It is an excellent soiling crop, and the combination of cowpeas and corn, when grown for this purpose, yields from 10 to 25 tons of forage per acre. Like the soy bean, it is not a first-class pasture crop, but is sometimes used as pasture for sheep or hogs.

One reason why this crop is so valuable in the South is its usefulness as a green manure crop in building up the soil fertility. When the entire crop is plowed under, the large growth of vegetable matter, containing a large amount of nitrogen, is added to the soil. It is also of great value in building up the soil when grown for hay or grain, since it has a rather deep root system and considerable nitrogen is added to the soil if only the roots and stubble are plowed under. If the crop is used for hay, much of the vegetable matter finds its way back to the soil as barnyard manure.

Fig. 115. — Cowpeas and corn make excellent forage.

321. Cultural methods. — The cultural methods employed in growing cowpeas are similar to those described for soy beans, except perhaps in the rate of seeding which is usually a little lighter for the cowpea. When seeded in rows, 3 to 4 pecks per acre are required, and from 4 to 8 pecks when drilled. In the South, and also in many sections farther north, cowpeas are frequently seeded with other crops like corn, sorghum, or millet. When seeded with other crops they are used either for hay or for soiling. Cowpea hay is rather difficult to cure, but when grown in combination with millets or other crops, the curing is accomplished with less difficulty. Sometimes cowpeas are seeded in the corn at the time of the last cultivation, and used either for pasture after the corn is harvested or plowed under the following spring for green manure. Usually a good crop of hay may be secured after

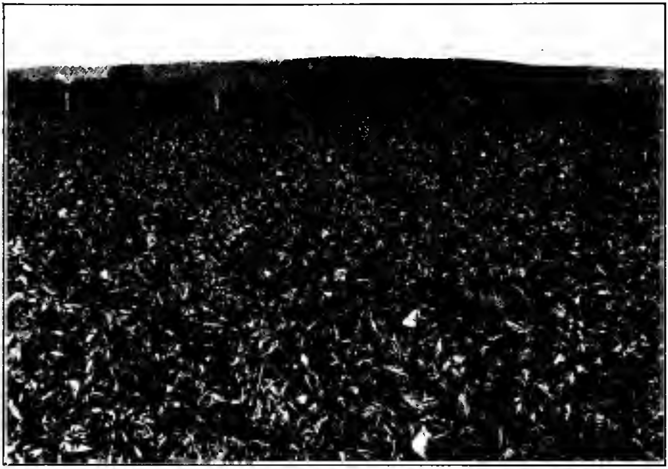

FIG. 116. — A field of cowpeas.

a small grain crop, if the cowpeas are seeded promptly after the grain is removed. Cowpeas should be cut for hay soon after one-third of the pods are ripe, for if cutting be delayed much longer than this, many of the peas will be lost and the stems will be less palatable.

THE FIELD PEA

The field pea is a native of Italy and has been grown in America for many years. It is sometimes known as the Canadian field pea, and this name is applied not because

Canada is its native home, but because it first came into general use there and from there was introduced into the United States.

322. Description. — The field pea, *Pisum sativum*, is a summer annual, with hollow, sparingly branched stems, which grow from 2 to 5 feet in height. The plants in the early stages of growth are erect, but later become decumbent unless supported. The leaves are large, from 5 to 7 inches long, and carried in pairs. Large, leafy stipules develop at the base of the leaves, and the midrib terminates in a tendril, which gives the plant somewhat of a climbing habit. The flowers, which are large and usually white or purple in color, are borne on short flower stalks arising from the axils of the leaves. The pods, which are flat and from 2 to 4 inches long, contain several seeds, which, when mature, are usually green in color. The leaves, stem, and pods are smooth, and when green are very succulent and are relished by all kinds of live stock.

FIG. 117. — Canada field peas.

323. Distribution and adaptation. — Field peas are adapted to a cool, moist climate, and make their best growth during the early part of the growing season. They may be grown far up in Canada, and are especially adapted to southern Canada and the Northern States of the United States. Field peas do not do well in warm climates, and are not usually profitable south of the soy bean section. Any soil that will grow oats will also grow field peas. They are, however, best adapted to clay loams, well supplied with lime. While they grow well on moist soils, wet soils are unfavorable to their growth. They do not thrive on light, dry soils, and when grown on very fertile soils an excessive growth of vine is produced, with a corresponding decrease in the yield of grain.

324. Uses. — The field pea is highly prized as a feed for live stock. It may be used as hay, pasture, or for soiling, and the grain may be fed to all kinds of live stock. Usually the grain is ground and fed in combination with other grains. A mixture of field peas with wheat bran or wheat middlings makes a good feed for milch cows, growing hogs and sheep, because of its high protein content. In Canada, field peas are used by many stockmen during the first half of the fattening period, and this is said to be responsible for the superior quality of meat produced there. When grown for the grain, the straw, if in good condition, makes fair roughage for cattle and sheep. Field peas are usually seeded with oats or other grains when grown for hay, and on account of the high protein content of the peas, together they make a forage of high feeding value for all kinds of live stock. As a soiling crop, for which purpose it is usually seeded with oats, it becomes available early in the season, about the time pastures are declining, and affords a highly nutritious and palatable food. Field peas may be grown with oats for pasture, and may be cropped off several times during the season if sufficient time for new growth intervenes. As a green manure crop, field peas are especially valuable, since they may be grown farther north than most legumes and at the same time they add a large amount of nitrogen and humus to the soil, although they have but a short period of growth.

325. Cultural methods. — The field peas are hardy and vigorous growers, and do not require a very fine or well-prepared seed bed. The seeding is sometimes done by sowing them broadcast on the ground before plowing and covering them by shallow plowing. Better results, however, are obtained if the seed bed is first prepared and the seed drilled in with the grain drill. When seeded alone, from 2 to 3½ bushels, depending upon the size of the peas, are required per acre. More often, however, they are seeded with oats, from one to two bushels of peas with 1 to 1½ of oats making a desirable combination. Field peas are cool weather plants, the seeds germinating at low temperature, and for best results, seeding should be done early in the spring, usually as soon as the ground may be prepared.

326. Harvesting. — When grown for hay, the peas should be cut when in full bloom, but if grown with oats, the cutting should be done when the oat grains are in the dough stage. The peas, when grown alone, are rather difficult to cure, but when grown with oats, this difficulty is largely overcome. The best quality of hay may be obtained if it is cured in the cock, as are soy beans or cowpeas. When grown with oats, from 2 to 3 tons of hay may be expected per acre.

When grown for grain, the harvesting may best be done with a mower equipped with a side delivery attachment or a self-rake. The grain may be thrashed with a grain thrasher, if the concaves are removed and the machines run at a low rate of speed. The yield of grain varies from 15 to 40 bushels per acre, the average being about 20 bushels in sections favorable to their growth. One objection to a more general use of the field pea is the relatively high price of the seed, which usually commands a price of from 3 to 4 cents per pound.

FIELD BEANS

327. Field beans. — There are two important species of field beans grown in the United States, the common or native bean, *Phaseolus vulgaris*, and the lima bean, *Phaseolus lunatus*. They are closely related to the soy bean and the cowpea and resemble them in general appearance and manner of growth. Field beans are annuals that grow best in cool, moist climates and on loamy soils. They are grown for their ripened seeds, which form a common article of human diet. In Michigan, New York, California, and in some sections of other states they are quite important field crops and are usually grown in a regular rotation. They may be seeded with a drill in rows 28 or 30 inches apart or they may be hilled to permit of cross-cultivation. The cultivation is similar to that given the soy bean. In harvesting, the vines are cut off below the surface of the ground by means of a bean puller. They are then allowed to cure for a short time, after which they may be hauled to the barn for storage, or direct to the thrasher. Sometimes they are handled in the field much the same as hay, being raked up with a long rake and loaded with a hay loader. After thrashing they are cleaned and graded for the market. The straw is valuable as feed for sheep or cattle.

THE PEANUT

328. Description. — An interesting member of the legume family is the peanut, *Arachis hypogœa*. Many persons who eat peanuts do not know that they are closely related to peas and beans and that the plants, in symbiosis with bacteria, produce nodules on the roots like other legumes. The peanut is a rather low growing annual with more or less trailing stems and with the unusual habit of maturing its fruit underground, differing in this respect from other cultivated legumes. The plants vary in height from one to two feet, and in the erectness of the stems with variety, some varieties growing almost erect, while others are more or less prostrate. The flowers are small and yellow in color, and are produced on small stems growing from the axils of the leaves. After the bloom falls, the flower stem elongates and grows into the ground. The tip end soon enlarges and becomes the pod which incloses the nuts.

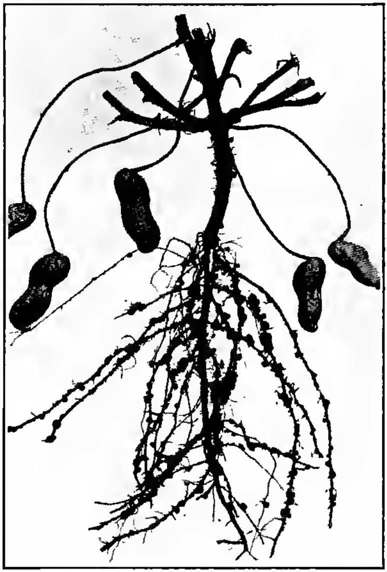

Fig. 118. — Root of peanut plant, with pods.

329. Adaptation. — The peanut is a tender plant, and is easily killed by frost. It is grown successfully only in warm climates with long growing season. In the United States, they are grown principally in Virginia and North Carolina, certain parts of Tennessee, Arkansas, and Alabama, and in a smaller way in almost all sections of the Southern States. They are also grown extensively in India, Africa, and South America. Peanuts, since they produce the nuts underground, are best adapted to a loose, loamy soil. Peanuts of the best quality have light shells and grow in light, sandy soils. Heavy soils are not suitable for growing them, because the nut-bearing stems cannot penetrate the ground readily and because heavy soils stain the hulls. The best yields are produced on soils well supplied with lime, and it is often necessary to supply lime to those deficient in this element before a profitable crop can be grown.

330. Uses. — "Fresh roasted peanuts" is a familiar phrase to any one who has attended a circus or a county fair, and salted peanuts are on sale in almost every confectionery store. Many bushels are consumed annually in these forms, and large amounts are used in the making of peanut oil and in the feeding of live stock. Peanut oil is similar to olive and cottonseed oils, and the making of it is an important industry in certain parts of Europe. Few peanuts are used in the United States in the production of oil, but large amounts are used annually for the feeding of live stock. They are readily eaten by almost all kinds of live stock, but are most often fed to hogs. Sometimes the hogs are turned into the field about the time the nuts are ripe and allowed to harvest the entire crop. When grown for the market, the vines are used for hay and as much as 2 or 3 tons may be secured per acre. Peanut hay is relished by all kinds of live stock, and makes a palatable and nutritious feed.

331. Cultural methods. — Peanuts are planted in the spring as soon as the soil is well warmed up. They may be drilled in rows 30 to 36 inches apart, or they may be planted in hills to permit of cross-cultivation. Seeds of the small varieties are planted without removing them from the hulls, but usually those of the large varieties are removed from the hull before planting. One peck of hulled seeds or 6 pecks in the hull are required to plant an acre. In the large varieties from one and one-half to two pecks of hulled nuts will be required per acre. Cultivation during early growth is similar to that given peas or beans. When the peanuts are mature, they must be promptly harvested, or they may start to grow. Harvesting is done by an implement similar to a potato digger, which raises them from the ground. The vines, with the nuts attached, are then put in stacks, which are built around a frame work, to allow them to dry rapidly. After they have been in the stack for a few days, the nuts are then removed from the vines, either by machinery or by hand, and placed in large bags ready for the market or for feeding. If grown for market, the nuts are sorted and only the best grades are marketed, while the poorer grades are used for feeding. The yield varies from 30 to over 100 bushels per acre, 60 bushels being considered a good yield.

CHAPTER XVIII

THE ROOT CROPS AND RELATED PRODUCTS

THE term root crop is applied to a class of plants which store up during the first season the excessive nutrients not needed for the immediate use of the plant, in the enlarged tap root and base of the stem. The storing of the food supply is a provision by the plant for the nourishing of the next generation, in the case of annuals, and for the production of a seed stalk in the biennials. In some cases, the food is stored up in thickened leaves, as is the case in cabbage, while in kohlrabi it is stored only in the thickened stem. In the case of rape the excess of nutrients is stored in the slightly thickened leaves. While rape and kohlrabi are not grown for their roots, they are closely related to the root crops and are usually classified with them.

With the exception of rape and sugar beets, the root crops discussed in this chapter do not hold an important place in American agriculture, but in England and on the Continent they are very important crops. In the United States the use of the silage crop largely takes the place occupied by root crops in the feeding of live stock in Europe. The fact that about 90 per cent of the root plants is water and also that they require a large amount of hand labor in their culture has been responsible for their unpopularity in this country.

332. The beet family. — The beet, *Beta vulgaris*, has been developed by long selection for a special purpose into four distinct types. They are: first, the garden beet, grown for table use; second, chard, grown for its leaves, which are used as greens; third, the sugar beet, grown for the sugar; and fourth, mangel-wurzels, grown for feeding live stock. Only the last two types will be discussed in this book.

THE SUGAR BEET

333. History. — While beets have been cultivated for many centuries, it was not until the middle of the eighteenth century that they were found to be of value as a source of sugar. This fact was discovered by a German chemist who, having analyzed several different plants, found that the beet contained the highest percentage of sugar of the plants analyzed. Many difficulties were encountered in the extraction of the sugar, and it was not until 1812 that beet sugar appeared on the market, and then only in small quantities. Since beet sugar first appeared in a commercial form, great progress has been made in the methods of manufacture and in the improvement of the beet by selection for higher sugar content. To-day the beet sugar business is a great industry, employing great armies of men, women, and children, the product of whose labor holds a most important place in the feeding of the nation. Sugar beets were first introduced in the United States in 1839, but they were not grown successfully, and no permanent place was accorded them in the agriculture of this country until 1869, when they were first successfully grown and a sugar factory was established in California.

334. Description. — The beet plant has large, broad leaves which spring from the crown of the enlarged tap root. The enlarged root, or the beet, grows almost entirely underground, differing in this respect from the mangel-wurzel. The root is broadest a short distance beyond the rounded crown, and from this point tapers gradually to the tip. The flesh and stem of the beet are white. The sugar content varies from 5 to 20 per cent, 15 per cent being considered a good sugar content, and the crop is usually not profitable when the percentage of sugar falls below this amount. There can be found no more striking example of the possibilities of crop improvement by the method of selection, than is afforded by the increased sugar content of the beet accomplished by this method. When the German chemist determined the sugar content of the beet in the middle of the eighteenth century it contained less than 6 per cent of sugar. Since that time, by the selection of plants for high sugar content, many crops now yield from 15 to 20 per cent.

Fig. 119. — A sugar beet.

335. Production. — The world's average annual production of beet sugar for the years 1907–1911 was 6700 thousand tons. Of this amount Germany's annual production was slightly more than 2 million tons, or almost one-third of the world's production; Russia, during the same period, producing approximately 1400 thousand tons, and Austria-Hungary 1250 thousand tons, the total production of these three countries being more than two-thirds that of the entire world. The average annual production of the United States for these years was 433 thousand tons. For this five-year period the world's production of beet sugar was slightly less than that of cane sugar.

In the United States, Colorado is the leading beet sugar producing state, her average annual production for the years 1911–1912 being 170 thousand tons; California is next with 150 thousand tons, and Michigan third with 110 thousand tons. These three states during the two years mentioned produced over two-thirds of the total beet sugar production of the United States. Other states in which small amounts are produced are Idaho, Utah, Wisconsin, Ohio, Indiana, and Illinois.

336. Adaptation. — Sugar beets do not have a wide distribution when compared with other farm crops. Soil and climate are important factors in growing beets with high sugar content, and consequently these factors determine to a considerable extent the area of their profitable culture. The beet grows best on sandy or sandy loam soils, but is not adapted to clays, muck, or peaty soils. The beet is able to resist considerably more alkali in the soil than most other crops and is grown in many slightly alkaline soils of the West. Neither soils that form a hard crust at the surface after a rain nor shallow soils with an impervious subsoil are suitable for their growth. The beet requires an abundance of sunshine during the growing season, and is therefore not adapted to localities where much cloudy weather prevails.

CULTURAL METHODS

337. Preparing the land. — Since the beet grows almost entirely underground, a deep seed bed is necessary. The soil should be plowed to a depth of 8 to 12 inches, and sometimes, with the use of a subsoiler, it may be plowed to a depth of 15 inches. When soil conditions will permit, fall plowing is recommended. In the Western States beets frequently follow alfalfa, and on account of the deep rooting habits of the latter, this practice is desirable. The preparation of the land after plowing is important. A firm, fine, moist seed bed should be secured if possible. Handling of the soil so as to conserve moisture is important. No labor should be spared to obtain a seed bed free from weeds, as the slow growth of the plants at first gives the weeds an opportunity to flourish and hand labor is then necessary to eradicate them.

Fertilizers and barnyard manure are frequently used on beet lands. Barnyard manure should be well rotted when applied. High grade complete fertilizers are most frequently used, although on soils that are deficient in only one element of plant food an application of a single element may then be advisable.

338. Seeding and cultivation. — Beets are usually seeded solid in rows 14 to 30 inches apart. The seed of the beet is produced in " balls " which contain from 1 to 5 seeds. It is impossible therefore to regulate the rate of seeding to get the desired number of plants. Deep planting of the seed is likely to cause a poor stand and usually from $\frac{1}{2}$ to $1\frac{1}{2}$ inches is deep enough if the land has been well prepared. The seeds germinate in from 5 to 10 days, but the plants grow slowly at first. Since it is impossible to seed at the desired rate, the plants must be thinned. This is done by first " blocking " with a hoe, which consists of cutting out the plants in the row, leaving small bunches 8 or 10 inches apart. After blocking, further thinning is necessary, which consists in removing all of the plants but one in each bunch. Both the blocking and the further thinning require hand labor, as does also much of the cultivation during the early period of growth. Frequent cultivation in the early growing season is important, as at this time an abundant moisture supply is desirable for the beets.

339. Harvesting. — The harvesting may be divided into four operations, namely, lifting, pulling, topping, and hauling. Lifting consists of plowing near the beets to loosen the soil so that they may easily be pulled. The

FIG. 120. — Many foreigners, men, women, and children, are employed by growers of sugar beets.

pulling is done by hand, as is also the topping, which consists of removing the tops at the point of the lowest leaf scar with a sharp knife. The part of the beet that grows above the ground is not desired by the sugar factory, since it has a low sugar content and a high percentage of minerals, which crystallize the sugar during the process of manufacture. After the tops are removed, the beets are then hauled to the factory, or to the point of shipment if the factory is some distance away. At the factory the sugar is extracted and placed upon the market. The beet pulp, that part of the beet which remains after the sugar is extracted, is used as stock food. It contains only about 10 per cent of nutrients, but is very succulent and is highly prized for dairy cows.

340. Seed production. — Almost all of the seed used in this country is imported, less than 3 per cent being homegrown. The beet is a biennial, producing seed the second year. In countries of mild winters, it lives through the winter season, but where the winters are cold it is necessary to store them in pits or cellars and to reset them the following spring. The great increase of the sugar content of the beet has been due to the method of selecting the seed beets. Usually a sample is taken of the beet at the end of the first season's growth to determine the sugar content, and only those beets of high sugar content are used for seed production. From 1200 to 1500 pounds of seed may be secured from an acre of beets.

MANGEL-WURZELS

341. Description. — Mangel-wurzels are sometimes called cow beets, field beets, or mangels. There are several varieties of mangels, differing in size, shape, and color. The long and intermediate long types require a deeper soil than the tankard and globe types. Mangels grow best on deep, well-drained, fertile soil. Clay soils, because of their compact nature, are not well adapted to the growing of them. Mangels require a moist soil, but they do not thrive in wet soils, and they grow best where there is an abundance of sunshine during the growing season. In the United States they are grown in the North Atlantic States, where cereals are not profitable, and in a small way in New York, Michigan, and Wisconsin.

342. Uses. — They are used almost entirely as stock feed, and are fed largely to cattle and sheep. In preparation for feeding, they are either cut up into small pieces with a corn knife, or shredded by a machine. They are usually fed in connection with grain or concentrates, and are valuable as feeds because of their succulence and their laxative effect. The tops of the mangels which are removed at harvest time are also used as feed.

343. Cultural methods. — The seed bed for mangels must be well prepared and free from weeds. It is usually best when possible to plow the land deeply in the fall and prepare the seed bed the following spring by repeated disking and harrowing. The seed of mangels is slow to germinate and the young plants grow slowly at first, giving weeds, if they are present, a chance to become well established before the mangels are up. It is almost necessary, therefore, to have the field free from weeds before the seeding is done. The seed of mangels, like those of sugar beets, is produced in a " ball " which contains from 1 to 5 seeds. It is impossible, therefore, to regulate the rate of seeding to get the desired distribution of plants. This must be done by thinning when the plants are about 2 inches high. The seed is drilled in, either with a beet seed drill or with a grain drill. The rows should be made 28 or 30 inches apart to permit of cultivation. If a grain drill is used, this can be accomplished by using every third drill hoe, the remainder being stopped up. From 8 to 12 pounds of seed per acre are required. The seed should be covered about one inch deep, and the seeding should be done as soon in the spring as the weather will permit.

344. The cultivation consists in thinning to the desired stand, usually one plant per foot, and further cultivation to keep down the weeds. Mangels should be harvested as soon as they cease growing, which is indicated by the dropping off of the outer leaves, since they are injured by severe frosts. They may be removed from the ground by a beet puller or pulled by hand after the ground has been loosened by the plowing of a furrow close beside the row. The tops are removed by twisting or cutting them off with a knife. Mangels should be stored soon after harvesting in a place where they will not freeze, a root cellar usually being employed for this purpose. Twenty tons per acre is probably an average yield, but sometimes as many as 30 tons are secured.

TURNIPS AND RUTABAGAS

345. Description. — The turnip, *Brassica rapa*, and the rutabaga, *Brassica campestris*, are closely related plants, similar enough in their habits of growth and cultural requirements to be considered together. Like the mangel, the useful part of the plant is the thickened stem and root. Different varieties vary in color, form, and size. Rutabagas are larger than turnips and yield much more per acre. The most common varieties of Rutabagas are the Green Top and the Purple Top, and of the turnip, the Cow-horn, Purple Top, and White Globe are the most commonly grown. The flesh of the turnip is usually white, and that of the rutabaga is yellow. The turnip, being smaller, matures more quickly than the rutabaga.

346. Cultural methods. — Turnips and rutabagas do not require as long a growing season nor as much sunshine as beets, and are usually grown in cool, damp climates. They grow well on sandy soils, and, like mangels, do not do well on stiff clays. The preparation of the seed is similar to that described for mangels. Rutabagas should be seeded about the same time as mangels, using from 4 to 6 pounds of seed per acre. Turnips are usually sown in midsummer, sometimes being preceded by another crop. Two or three pounds of seed are required per acre. Turnips are sometimes sown broadcast and not cultivated during the growing season. When seeded broadcast, about 4 pounds of seed are required per acre.

347. Uses. — Turnips are grown in a small way on many farms for household use. In some sections of the country, they are grown in larger areas and are used for feeding live stock. Rutabagas are not as commonly grown as turnips in the United States, but are more common in Canada. Both turnips and rutabagas are quite extensively grown in England, where they are used as stock feed. Since turnips do not keep as long as rutabagas, they are usually fed first when both crops are grown. Sometimes these crops are not pulled and stored, but are harvested by hogs which are turned into the field. The yield secured from turnips varies from 5 to 10 tons per acre, and from rutabagas, from 15 to 25 tons per acre.

THE CARROT

348. The carrot, *Daucus carota*, may be distinguished when growing in the field from the root crops previously described by its numerous, finely divided leaves. The varieties vary in size, shape, and color of the roots, the common colors being red, orange, white, and yellow. Some varieties are decidedly tapering, while others are cylindrical for a considerable part of their length. Carrots are adapted to a wider range of soils and climate than beets or rutabagas. They grow best on a deep, sandy loam, but are quite productive on other types of soil. The cultural methods are in most particulars similar to those described for mangels. The seed is usually of low vitality and requires a longer time to germinate, and the younger plants grow more slowly than the mangels or turnips. It is particularly important, therefore, that the field be free from weeds before the seeds are sown. Six or seven pounds of seed are required per acre, and the seeding should be done as soon as the soil warms up in the spring.

Carrots yield from 20 to 30 tons per acre. The roots are handled and stored in the same manner as described for mangels. The top of the carrot is of special value, having higher feeding value and yielding more abundantly than the tops of other root crops. Carrots are fed to all kinds of live stock, being especially prized for horses.

RAPE

Rape is a native of northern Europe, where it has been grown for many years as a forage crop. It was introduced into the United States several years ago, where it has been grown in a small way in several localities. It has only been within the past few years that its great usefulness has become appreciated, and it has, during this time, rapidly gained in popular favor and extended culture.

349. Description. — Rape, *Brassica rapus*, is closely related to both cabbage and rutabaga, and is grown for the stem and leaves. The leaves of rape are similar in appearance to those of rutabaga, while the root system is very similar to that of cabbage. There are two types of rape, namely, annual and biennial. The annual or summer type is grown for the seed in England and on the Continent, but is not grown in the United States. The biennial type is a larger, ranker growing plant and is grown for forage. The biennial type produces seed only in mild climates where the plant lives through the winter. A small amount of seed is produced in the Pacific Coast States, but most of the seed used in this country is imported from England and the Continent. When grown for seed, the biennial type produces as much as 1000 pounds per acre. The Dwarf Essex is the best known and the most important variety of the biennial or winter rape.

350. Distribution and adaptation. — Rape is a cool weather plant and is especially well adapted to the northern part of the United States and Canada, where it is grown most extensively. Rape grows best in moist, fertile soils. It is especially adapted to soils rich in organic matter, and for this reason does not do well on stiff clays or heavy soils. It is a gross feeder, and is able to utilize a large amount of plant food not available to many other crops. The roots penetrate deeply into the soil and draw heavily upon the soil water, which the plant needs in large amounts.

351. Uses. — In this country, rape is used almost exclusively as a pasture crop. Sometimes, however, it is used as a soiling crop. Rarely, if ever, is it cut and dried for hay. As a pasture crop, it is especially valuable because of the large yield of forage and short season of

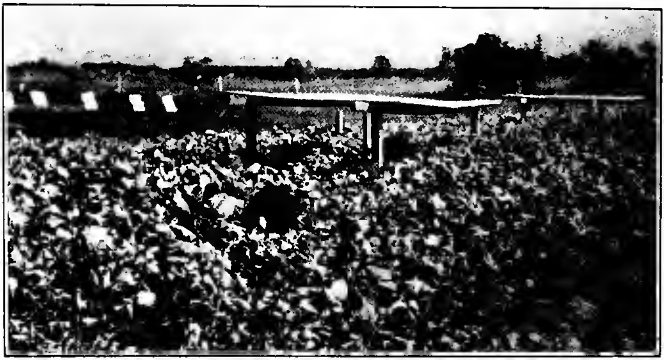

FIG. 121. — Pasturing hogs on rape.

growth. It furnishes forage when other pastures are not usually productive, and is high in feeding value and succulence. The yield varies from 10 to 25 tons per acre. Rape is especially valuable as a pasture for sheep and hogs. Cattle do well on it, too, but it is objectionable for milch cows because it imparts a flavor to the milk. It is said that this objection may be overcome by feeding the cows after milking. Sheep and cattle when pastured on it are subject to bloating until they become accustomed to it. It is advisable to allow both cattle and sheep the run of a grass pasture in connection with the rape. This practice, in a large measure, prevents bloating and also provides a variety of forage. Animals usually do not relish rape at first, and it requires some time for them to acquire a taste for it. To prevent overeating, or bloating, after the animals acquire a taste for it, it is best to allow them to have access to the rape pasture only during short periods at first, gradually extending the time as they become accustomed to it, until they are on full time. The largest yields are obtained and much waste is prevented if the animals are not given the run of the entire field, but confined to a limited area by means of movable fences or hurdles. The area may be extended as necessary by moving the fences.

352. Cultural methods. — Rape may be seeded alone or in combination with other crops. When seeded alone, the soil should be well worked down into a fine seed bed. The time of seeding will depend upon the time that the pasture is desired. Rape is a rapid grower and is usually ready to pasture in from 8 to 12 weeks from the time of seeding. For early pasture, the seeding may be done as soon as the danger of frost is over. If pasture is desired throughout the season, it may be supplied by successive seedings a few weeks apart. When seeded alone, rape may be either broadcast or drilled in rows. When broadcast, 4 or 5 pounds of seed per acre are required, and when drilled in rows 28 to 30 inches apart, 2 or 3 pounds per acre are required. Usually it is best to seed in rows. This method permits of cultivation during early growth, and also less waste occurs during pasturing, since the animals will follow the rows and are not likely to tramp down as many plants as when feeding on broadcast fields. As much, if not a little more, forage can be produced in rows than by broadcasting. When grown for soiling, it is always desirable to seed in rows, since cutting and harvesting are more easily accomplished.

353. Rape may follow small grains, as a catch crop. After the wheat, barley, rye, or oats has been removed, the field may be disked and seeded to rape. Seeded in this way, with favorable conditions of soil and climate, a goodly amount of late pasture may be secured. In sections where there is plenty of rainfall, rape may be seeded in the corn at the time of the last cultivation, with good results. Rape may be seeded in the spring with the small grains, and pastured after they are harvested. When seeded with oats, it is usually desirable to broadcast the rape after the oat plants are an inch or two in height, since if seeded with the oats the rape will make enough growth to be troublesome during harvesting. After the oats are removed, the rape will grow rapidly, and may be pastured in a few weeks from the time of cutting the oats. Rape may be seeded with spring wheat in the same manner, or it may be sown broadcast on winter wheat after the wheat has started to grow in the spring. A light harrow may be used to cover the seed when it is sown with oats or wheat.

CHAPTER XIX

THE FIBER CROPS

COTTON

Herodotus, the Greek historian who lived in the fourth century B.C. and was a noted traveler in his day, wrote of "tree wool" that was grown in India and used there for clothing. The tree wool of India, described by this historian, is none other than cotton which had probably been grown there for many years before his visit. From India it was introduced into Egypt and other parts of northern Africa. It is said that Alexander the Great brought it from India and introduced it into southern Europe. Columbus found cotton growing in the West Indies; and when Cortez with his band invaded what is now Mexico, they found the natives there wearing clothes made from it. Records of the early explorers who visited Central America and Brazil and Peru in South America show that here, too, the cotton plant was known. It is probable that cotton is a native of the tropics of both hemispheres, and has for centuries been cultivated to some extent and used by the people of these countries for clothing. India for many centuries was the most important cotton-growing country, but within the last one hundred years has given way to the United States. Cotton does not seem to have been grown by the Indians that occupied the section of the country now renowned for its extensive cotton fields.

It was cultivated by the colonists at as early a date as 1764, when eight bales of it were exported to Liverpool. The crop, however, was not an important one in this country until after the Revolutionary War. The history of cotton cannot well be told without recording the name of Eli Whitney, who in 1792 invented the cotton gin. Whitney's invention marked a new era in the history of the cotton crop. Previous to this the yield of cotton was small, and its use was limited largely because it was necessary to prepare it by hand for weaving. The invention of the gin and its improvement in later years made possible the great cotton fields of to-day, which supply the large portion of the civilized people of the world with cheap and serviceable clothing.

Fig. 122. — A cotton plant.

354. Description. — The cotton plant belongs to the Malvaceæ or Mallow Family, which includes the many species of mallow and also the hollyhock and the Rose of Sharon, a highly prized shrub for the beautifying of landscapes. The cotton plant varies greatly in form and in its manner of growth, ranging in height from low growing plants to trees 20 feet high. The larger tree-like plants, while they produce fiber, are grown only as a curiosity. The cotton grown for the fiber in the southern part of the United States is a shrub-like plant, varying in height from 2 to 6 feet, the average under field conditions being probably $3\frac{1}{2}$ feet. Cotton is a perennial in the tropics, but in this country it is an annual. It has a well-developed tap root which penetrates three feet or more into the soil, depending upon its nature. The lateral or feeding branches are given off within 3 or 4 inches of the surface and do not penetrate deeply; the plant is therefore shallow rooted when compared with corn or wheat. Sometimes if the soil is fully drained and the watertable is near the surface of the ground, the tap root may grow down to a point near the watertable and then grow horizontally. In poor soils the tap root frequently is small and is hardly distinguishable from the small feeding roots.

355. The stem and leaves. — The stem is erect, with branches coming out from the several nodes between the leaf and the stem. The branches from the nodes near the bottom of the plant are long, but each succeeding branch is usually shorter, so that those near the top are quite short, giving the plant a somewhat conical shape. There are two kinds of branches, namely, the vegetative, those which do not produce bolls or fruit, and the fruiting branches. Usually two branches grow from each node on the main stem, although quite frequently one of them does not develop. The fruiting branches have few leaves, while the vegetative branches bear them in considerable numbers. The stem and branches are solid and woody and vary with the different varieties in their manner of growth. The length and character of the branches are factors of considerable importance in the identification of varieties. The leaves are arranged alternately and vary in size and shape even on the same plant. Those near the base of the plant are heart-shaped, while the ones near the top are deeply lobed; usually there are three lobes, although five are quite common.

356. The boll and fiber. — The flowers are large and conspicuous and are attached to the fruiting stems by short branches. The flowers have five large petals and five small sepals. The flowers open in the early morning and are at first white or creamy yellow in color, taking on a reddish tinge the second day and gradually becoming darker until they wither and the petals fall the third or fourth day, leaving the enlarged base of the pistil, which is really the seed pod, enveloped in the leafy bracts. The seed pod or boll develops as the plant matures, and finally the bracts fold backwards and the several compartments of the boll separate, exposing at first a mass of fiber which retains the shape of the compartment in which it was compressed, but in a short time dries and expands into a large, white, fluffy mass. This white mass is made up of many tiny fibers which, when separated from the seed, become the cotton of commerce. Each fiber is in reality a single elongated tube-like cell which has collapsed and become twisted so that it resembles a long corkscrew. The twists in the fibers are of great importance because they assist in holding the fibers together, which makes possible the spinning of them into long, stout threads. The number of twists in the fiber varies with the maturity, the immature fibers having only a few, while the number increases with the ripening of the plant, until, when fully mature, as many as 500 per inch have been found. The value of the fiber is influenced to a considerable extent by the number of twists it contains, since those with few twists do not make a strong thread, and can be used only in the making of cheap fabrics. The length of the fiber varies with the variety and the environment in which the plant was grown, but the average length of the upland fiber is about 1.2 inches. The value of the cotton crop is determined by the length, strength, fineness, and maturity of the fiber. The number of seeds in a boll varies from 30 to 50. In the upland cotton they are covered with a white or greenish fuzz in addition to the longer fibers which surround them in the boll. The percentage of seed to lint or fiber varies considerably, but the average is approximately 2 to 3 pounds of seed to one pound of lint. The legal weight per bushel of the cotton seed is 32 pounds.

KINDS OF COTTON

357. American upland cotton, *Gossypium hirsutum.* — This type of cotton is by far the most important in the United States and when a cotton planter refers to "cotton" he has in mind the upland type. This type may be divided into two classes, namely, the short fiber varieties and the long fiber varieties. The important difference between them is the length of the fiber, that of the short fiber varying from $\frac{3}{4}$ to $1\frac{1}{8}$ inches and the long fiber from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches in length. Usually the long fiber varieties do not yield as much lint as the short fiber varieties, but the value per pound is greater.

358. Sea island cotton, *Gossypium barbadense.* — This species of cotton differs from the upland cotton chiefly in the larger growth of the plant, more deeply lobed leaves, smaller and more pointed bolls, and black seeds covered with fuzz. The lint is considerably longer and is more valuable, being used in the making of the finest cotton fabrics. The yield per acre is less than the upland varieties and it is more difficult to pick and gin, but the difference in the price per pound makes it a more profitable crop where it can be grown. Sea island cotton requires an even, moist climate where frost is scarcely known. It is grown in the coast lands and warm, moist parts of South Carolina, Georgia, and Florida, and in the islands off these coasts.

359. Other varieties. — Besides these two important American grown varieties, there are the Egyptian cotton, which is a variety of the sea island type, and India cotton, which is a distinct species, both of which are of considerable importance in their respective countries. Neither of them is grown to any extent in the United States.

MARKETING AND USES

360. Preparation and uses of the fiber. — After the seed cotton is harvested, it is carried to the cotton gin. This machine separates the seed from the lint, which comes out in great sheets of billowy whiteness, and is then compressed by powerful hydraulic presses into bales weighing 500 pounds each, 24 pounds of this weight being the wrapping cloth and bands around the bale. This is the form in which the producer sells his cotton to the local buyer, from whose hands it is sent to the mills either in this country or abroad. Before the cotton is ready to be spun into yarn, however, it must first go through the processes of cleaning, carding, and drawing. The cotton gin has not been able to remove all the dirt and leaves with which the cotton has come in contact in picking, and sometimes it leaves a few seeds in, so after the bale is opened the cotton is fed between several sets of one-edged knives, which free the lint of a great deal of dirt but without injuring the fiber. The carding machine removes still more of the dirt and lays the fibers in a parallel position. The cotton is now in the form of a loose rope or sliver about

3 inches in diameter. Several slivers are then run together and the resulting rope is drawn out until it is about $\frac{1}{8}$ of an inch in diameter, and in this form it is called "roving." The roving, which is then wound on bobbins, goes to the spinning frame, there to be drawn out by the spindles into threads varying in fineness from the coarse denim or ticking warp to yarn so fine that it looks as though it would snap at the slightest touch. We need only to take a trip through one of our present day dry goods shops to become acquainted with the almost unlimited variety of different materials that can be woven from cotton. From the coarse unbleached muslin at 6 cents a yard to the fine and dainty batiste or lawn at a dollar a yard is a wide step in quality and price. To fill in the gap there are hosts of ginghams, fine and coarse madras, dimity, and other materials in various designs, colors, and prices. The difference in the original fibers, the difference in the preparation of the fiber and in the spinning, weaving, and finishing, gives us a range of cotton fabric to fill almost any textile need.

361. Uses of the seed. — Until recently the fiber was considered the only marketable part of the cotton crop. The seed was used for planting and the surplus was spread on the soil for fertilizer. Within the past few years, however, cotton seed has attained a considerable value on the market, and now the cotton grower has the market value of the seed to add to that of the fiber in determining the profit of his crop. From enough seed cotton to make a bale of fiber, about 1000 pounds or one-half ton of seed is separated by the gin. The seed thus separated is usually sold by the grower to the cotton oil mills, where the cottonseed oil is extracted. Before the oil is extracted, however, the seed is reginned, a process which removes from it the fine fuzz or linter, which is used in the making of cotton batting, carpets, rope, or twine. About 35 or 40 pounds of linter is removed from a ton of seed. The hull is then removed from the seed and the inside, or " meat," is heated to a high temperature for a short time to melt the oil, and it is then subjected to powerful hydraulic or steam pressure which forces out the oil and compresses the meat into a firm cake. About 40 gallons of crude oil may be removed from a ton of seed. The oil is refined into various grades and placed directly upon the market or sold to manufacturers. The best grades of oil are used as a substitute or adulterant for olive oil or salad oil for culinary purposes. It is also used in the making of cottolene, a substitute for lard, and butterine, a substitute for butter. Cotton oil products are wholesome and valuable for culinary purposes, although there now exists some prejudice against their use. The lower grades of cottonseed oil are used in the making of soap.

362. The oil cake, which remains after the extraction of the oil, is highly prized as a feed for cattle and sheep. It contains about 35 per cent of protein and is useful to supply this principle in the making up of rations for live stock. Sometimes the seed hulls, which were removed before the oil is extracted, are ground up with the meal cake and together they are placed on the market as feeding stuff. The hulls are also used alone as feed or fertilizer, for which purposes they are not very valuable, and also in the making of paper. The oil is the principal and most valuable product of the seed. The hull, linter, and meal are by-products derived from the seed in the extraction of the oil, but are of considerable value and add greatly to the net profit derived from the crop.

PRODUCTION AND ADAPTATION

363. The world's production. — The world's production of cotton for the five years 1907–1911 shows an average annual production of approximately 20 million bales, or about 9500 million pounds. Of this amount the United States produces approximately 12 million bales, India 3 million, and Egypt about 1300 thousand bales. Much smaller amounts are produced in South America, principally in Brazil and Peru, Mexico, Turkey, and China. The United States is, therefore, the leading producer of cotton, not only producing more than any other country, but more than all other countries taken together. The mills which furnish the world with cotton fabrics draw their supply largely from the United States and smaller amounts from India, Egypt, and other countries. The United States, therefore, to a considerable extent, controls the cotton industries of the world. Much of our production is exported to supply the foreign mills. For the five years 1907–1911 almost two-thirds of the cotton produced in this country was exported, much of it going to England where

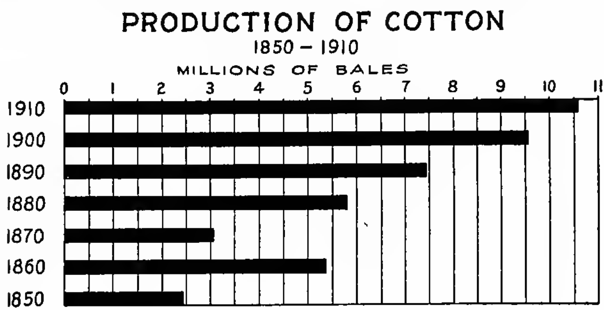

FIG. 123.

the making of cotton cloth is one of the important industries.

364. Production in the United States. — In the United States cotton production is confined to the Southern and Gulf States of southeastern United States, which is referred to as the "cotton belt." In this section of the country cotton is the principal money crop and is closely associated with the prosperity of the farmers and the success of all kinds of business. Growing from a small industry at the time of the Revolutionary War in the Carolinas and Georgia, its culture has greatly spread with increasing acreage into the states to the west of the original cotton region, until now the production of cotton is second in value only to corn and contributes mightily to the nation's wealth.

Texas devotes nearly 40 per cent of her improved land area to cotton, and produces more than one-fourth of the cotton of the country and more than 15 per cent of the world's crop. Georgia, Mississippi, Alabama, and South Carolina each devote over 35 per cent of their improved lands to cotton, and taken together, produce almost one-half of the cotton of the country. Arkansas, Oklahoma, North Carolina, and Louisiana each devote considerable area to this crop, and when their production is added to that of the above mentioned states, together these nine states produce over 95 per cent of the cotton crop of the United States and over one-half of the cotton crop of the entire world. The ten-year average yield of cotton per acre varies from 166 pounds in Texas to 225 pounds in North Carolina, and the average yield per acre for all of the states for the same period is approximately 185 pounds.

365. Adaptation. — Profitable cotton production is limited by temperature, rainfall, and the character of the soil. Cotton is extremely sensitive to temperature, requiring for its best growth a long, hot growing season without marked changes in the temperature. The length of the growing season for cotton from the time it is planted until the crop is harvested is approximately 6 to 7 months, during which time, for most favorable growth, the mean daily temperature should increase until the vegetative growth is made, after which time it should decrease, which is favorable to the production of the fruit. Cotton cannot be profitably grown in the northern part of the United States because of the short growing season and frequent changes of temperature. Cotton for its best growth requires frequent rains during the period of vegetative growth, and little or none during the fruiting and harvesting season, although if too much rain falls during the period of early growth, the plants quite frequently grow large and rank without a corresponding growth of fiber and seed.

366. Probably no important crop can be grown with favorable results on such a large variety of soils. In the cotton belt it is grown on sandy clay, sandy loam, limestone, and black alluvial soils, and with good cultural methods profitable crops may be secured on any of them. It grows best, however, on a clay or sandy loam soil, rich bottom lands often producing an excess of stalk, while sandy types are often too greatly lacking in fertility for the production of a good crop. Sandy and other types of poor soils may be made by proper fertilization to yield a very profitable crop. So completely has the growing of the cotton absorbed the attention of the grower that little else has been grown. Within recent years, however, injury to the soil resulting from continuous cropping has been made plain by lower yields and depleted soils. Rotations are now being practiced more generally, the growing of live stock is becoming more important, and the use of barnyard manure is increasing, all of which will in time show a marked influence upon the yields obtained. Commercial fertilizers are more commonly used in the South than in any other section of the country. They have made possible the growing of profitable crops of cotton on naturally poor soils, and have been used with success on almost all types of soil, resulting in larger yields of cotton. On soils depleted of humus and low in nitrogen, fertilizers having a high percentage of nitrogen give the best results. Both potash and phosphoric acid are applied with profit on most soils, especially when used in connection with barnyard manure.

METHODS OF CULTURE

367. Preparing the land. — The time of plowing the land for cotton depends largely upon the system of crop rotation that is in practice. In many cases, cotton follows cotton, which means that the preparation of the land for the next year's crop consists first of disposing of the stalks of the preceding crop. This is usually done in one of two ways: either they are raked down and burned or they are cut up with the stalk cutter and plowed under. The latter method is to be recommended, since to burn them is to rob the soil of humus. Sometimes a catch crop of vetch or bur clover is seeded in the fall and is plowed under early in the spring. When a rotation of crops is practiced, the time of plowing will depend upon the preceding crop and upon the nature of the soil. Fall, winter, or spring plowing may be practiced, and, in a general way, the same general principles must be considered that were discussed in the preparation of land for corn. Fall plowing when it can be practiced is considered by many growers to be the best practice, especially when stalks from the preceding crop are to be plowed under. A common method of plowing for cotton is that of "bedding" the field, which is done by throwing together several furrows, making narrow beds two or three feet wide, with a narrow strip of unplowed land between the beds. This method is in common practice where the land is poorly drained and the furrows at either side of the bed serve to carry off the surplus of water. Deep plowing, when it can be practiced, is to be recommended, since it provides a larger and more favorable area for the roots. When commercial fertilizers are used, they may be applied broadcast before plowing or may be placed in the shallow furrow before bedding. Sometimes the fertilizer is not applied until after the land is plowed; but when this is done, it should be applied a week or 10 days before the seed is sown, since some of the fertilizers injure the seed if applied with it. The preparation of the land after plowing should be such as to make a finely pulverized but compact seed bed.

368. Planting and cultivation. — Cotton is planted in rows varying in width from 3 to 5 feet, depending upon the fertility of the soil and upon the variety grown. Small growing varieties may be planted more closely than large, rank growing plants, and the rows may be closer together on fertile than on poor soils. On soils of medium fertility, with medium sized plants, the rows are commonly 4 feet apart. The seeds may be planted in hills or scattered along in a row, the latter method being the more common practice. The seed is planted with a one-row planter, at the rate of from 1 to $1\frac{1}{4}$ bushels per acre. If all the seeds grow, the plants are much too thick and must be thinned out. The thinning is done after the plants are a few inches high by hoeing out the surplus and leaving plants 12 or 16 inches apart in the row. Cultivation may be done at first with a light harrow or weeder when the plants are a few inches in height. These implements may drag out a few plants, but if thinning is delayed until after such cultivation has been done, the injury to the plants is not great. Further cultivation during the remainder of the growing season should be frequent and shallow. This may be done with cultivators similar to those used in the cultivation of corn, the single cultivators being commonly employed.

369. Harvesting. — Most of the cotton crop is harvested by hand. Men, women, and children pass down the rows and pick off the fiber in which the seeds remain, placing it in bags or baskets which they carry with them. When the bags are full they are emptied into a wagon which hauls the loose cotton to the gin. Many attempts have been made to build machines to pick the cotton, some of which have been successful, but their use has not become general. The difficulty with machine harvesters is that they pick leaves and trash along with the cotton. Then, too, the cotton does not all ripen at the same time, and in order to gather it in the best condition, it is necessary to make two or three pickings. The machine in passing over the field during the first picking may destroy or damage much of that which is not ripe. Usually the first picking is a light one, the bulk of the crop being gathered at the second picking. Hand picking, while expensive, enables the grower to gather the crop as it ripens, and also to keep the fiber free from leaves and trash.

370. Insects and diseases. — The cotton grower must contend with numerous injurious insects and diseases. The most common and injurious insects are the boll weevil and the boll worm, which do considerable damage to the crop in many sections of the cotton region. The boll weevil is a small insect, about one-half inch long, which lays its eggs in the bolls soon after the blossoms fall. The larvæ which hatch from them eat out the center of the boll. The most effective means now known of combating them is the removal of the affected bolls and their destruction, and the growing of early varieties which mature before the insects become numerous.

The cotton boll worm is closely related to the corn ear worm, and affects the cotton plant by eating the leaves and the immature seeds in the boll. The same methods as were recommended for the control of the boll weevil may be employed to control the boll worm. Sometimes arsenical poisons may be sprayed on the affected plants with good results. The important diseases of cotton are the wilt and the root rot. Rotation of crops is recommended as the most effective means of controlling them.

FLAX

Flax culture begins with the recorded history of the Egyptians and the Hebrews, who used this fiber in the making of clothing, many years before the dawn of the Christian era. So far as is known, its original home was somewhere in the eastern Mediterranean country, whence it was introduced into Asia and Europe and later was brought to the United States. For many years it was grown only for the fiber, but more recently the value of the seed as a source of oil has brought about the rapid increase of its culture in many places for this purpose.

371. Description. — Flax, *Linum usitatissimum*, belongs to the Linaceæ or Flax family, of which it is the most important species. One or two other species are cultivated to a small extent in some parts of the world, and several grow wild both in America and Europe. Flax is an annual with a single upright stem, which branches freely when the plants are seeded thinly, but slightly or not at all when they grow close together. The plant has a long, fine tap root, with a few small lateral branches. It grows from $1\frac{1}{2}$ to 3 feet in height, depending upon the variety and upon the environment in which it grows. The leaves are simple and almost sessile and arranged alternately. The flowers are rather large and light blue in color. The seed pod is usually ten-seeded, the seeds are lens-shaped, with a smooth, polished surface, and vary from yellow to brown in color. The stem of flax is made up of three parts, namely, the bark, composed of several layers, the wood, and the pith.

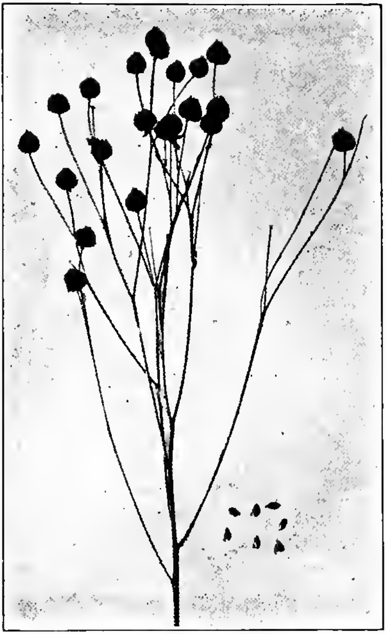

FIG. 124. — Seed pods of flax.

372. Uses of flax fiber. — In preparing the flax fiber for use, the plant is first freed from the seed capsules, after which the bast, that part of the bark used for the fiber, must be separated from the central woody portion of the stem by a process, the first step of which is called "retting." There are two principal methods employed, namely, cold water retting and dew retting, the latter being the one most commonly used. In dew retting the straw is spread out on the ground and exposed to the weather for several weeks. Next it is collected and subjected to the "breaking" process, which is the removing of the fiber from the wood. The fiber thus removed is freed from the rest of the bark and adherent parts of the wood by "scutching" or beating with paddles. The final process is the "hackling" or combing, which separates the fibers into the "flax line" which is the long and valuable fiber, and the "tow," the short tangled fibers used in the weaving of coarse linen. The fiber is then packed in bales, in which shape it goes to the mill.

FIG. 125. — A bundle of flax and types of fiber.

Fabrics made from flax are characterized by snowy whiteness, when freed from impurities, a luster similar to that of silk, and great strength or tenacity. As has been mentioned before, linen is one of the oldest textiles of which we know, having been used by the ancient Egyptians for the wrappings of mummies and for the making of priests' garments. Linen of good quality becomes more beautiful with laundering, and on account of the length of the fiber, which is commonly from 10 to 12 inches, it does not become fuzzy with wear as do cotton materials.

373. Use of flax seed. — Flax seed has a large, oily embryo, which yields from 30 to 38 pounds of oil per 100 pounds of seed. The removing of the oil is done by crushing the seed and heating it to 165° F. and either subjecting it to high pressure or treating it with naphtha to extract the oil. The oil is known on the market as linseed oil, and is used largely for paints and varnishes, for which purpose it is highly prized on account of its quick drying properties. It is also used in making printer's ink and in the manufacture of a substitute for rubber.

The part of the seed remaining behind after the removal of the oil is linseed meal, which is highly prized as stock food because of its high protein content, which is from 20 to 25 per cent.

374. Production and distribution. — Flax is grown to some extent in almost all agricultural countries. Russia produces approximately two-thirds of the world's crop of fiber, while Austria-Hungary, France, Belgium, and the Netherlands are responsible for almost all of the remaining third of the world's crop. In the production of flax seed, Argentina in South America ranks first, producing about one-third, and the United States ranks second, producing about one-fifth of the world's crop. The total production for the world is about 100 million bushels of seed and 1500 million pounds of fiber.

In the United States, North Dakota produces about one-half of the total crop, while Minnesota, South Dakota, and Montana produce the greater part of the remainder of the crop. Very little flax is grown in the United States for fiber, it being grown for seed almost exclusively. The yield of seed per acre varies from 3 to 12 bushels, the average probably being about 8 to 10 bushels. The price per bushel varies from one to two dollars, the average being about $1.50.

375. Adaptation. — Flax grows well on almost all types of soil, but sandy loams or loose types produce the best yields. So far as climate is concerned, flax may be grown for seed in any place that produces wheat successfully. When grown for fiber, the best results are obtained in cool, moist climates. In the United States, since flax is grown for the seed alone, it is handled much like a grain crop. It is usually of greater importance in new agricultural sections, and often is the first crop seeded on a newly plowed prairie. It is one of the best crops with which to break in new ground, and is at the same time adapted to the extensive cultivation necessarily practiced in these sections.

376. Cultural methods. — The usual practice of preparing a prairie sod for flax is to give it a shallow plowing either in the fall or early spring and work it down with the roller and harrow. Sometimes when large acreages are to be seeded in a short time, the seeding is done with little or no preparation of the soil, other than plowing.

The usual method of sowing the seed is with a grain drill, which is so regulated as to place the seed about 1 inch deep. From 2 to 3 pecks of seed are required per acre when the flax is grown for the seed, and from 6 to 8 pecks when it is grown for the fiber. A thin rate of seeding encourages the plants to branch freely, which favors a large yield of seed, while a thick rate permits little or no branching and causes the production of long, straight stems, which yield a long fiber. The flax seed may be sown as soon as the danger of frost is over in the spring.

The length of the growing season is from 90 to 100 days. Flax is attacked by a wilt fungus which can be controlled to considerable extent by treating the seed before planting with formaldehyde in the same manner which was recommended for treating the seed wheat for smut.

Flax when grown for seed is harvested with a grain binder and thrashed with a grain thrashing machine. The harvesting, therefore, is very similar to that of wheat or oats. When grown for the fiber, the plants are pulled by hand, tied into small bundles, and put into the shock to cure. The seed is thrashed from the bundles without injuring the straw by rubbing or by special machinery.

HEMP

377. Hemp, *Cannabis sativa*, is a member of the Moraceæ or Mulberry family and is therefore closely related to the hop and osage orange, which are also members of this family. Hemp is a large, rank growing, annual plant, bearing the pistillate and staminate flowers on separate plants. The pistillate or seed-bearing plants are more branched and do not produce as desirable fiber as the staminate or pollen-producing plants. The plants grow from 10 to 15 feet in height under favorable conditions, and mature seed in from 100 to 110 days. Hemp thrives best in temperate climates and may be grown on any soil adapted to the growing of corn. The seed is sown just before corn planting, usually broadcast or drilled in with a grain drill, at the rate of 4 to 5 pecks per acre. When seeded in this way, no cultivation is necessary, as the plants grow rapidly and give the weeds little chance to compete with them. In fact, in fields known to be very badly infested with weeds sometimes the crop is seeded for several successive years to smother them out, which it does very effectively. The crop may be cut with a mower or self-rake when the plants are not too large, but tall plants must be cut by hand as corn is harvested, because they are too large and woody for the mower. After cutting, the hemp is allowed to lie on the ground for some time in order to separate the fiber from the woody stem.

The fiber is removed from the stem and handled in much the same way as was explained in the case of flax. In many parts of Europe the crop is grown for both seed and fiber. From 10 to 25 bushels of seed may be grown per acre. It contains from 30 to 35 per cent of oil which is used in paint, varnishes, and for culinary purposes. The yield of fiber may be from 500 to 1600 pounds per acre, and it is valuable for making coarse cloth, ropes, twines and carpet warp. Hemp is not grown extensively in the United States, the principal regions of production here being the blue-grass region of Kentucky and Tennessee and certain parts of New York, Nebraska, and Iowa. In central and western Asia, and in many parts of Europe, the crop is an important one.

CHAPTER XX

THE POTATO

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The " Irish " potato is one of the few valuable crops used for human food of which America can claim to be the original home. In the valleys of the mountains of Chili, South America, the potato was found growing wild by the earliest travelers to the new world. They found the natives cultivating it so generally that it seemed to be an old crop. These early travelers carried some of the tubers back to Spain and from there the potato was taken to Italy. Here it was grown rather commonly and found its way northward into the Netherlands. It was probably first grown in North America in what is now Virginia and North Carolina during the latter part of the sixteenth century. Between 1580 and 1590 the potato was introduced into Great Britain from Virginia by Sir Thomas Herriot, a companion of Sir Walter Raleigh. Potatoes were first planted in Ireland near Cork. In the year 1846 there was a failure of the potato crop in Ireland which caused great suffering, and many people left the country and came to America, to such an extent were they depending upon it for food.

378. Production. — At present the United States is far behind the countries of Europe in the production per acre. The United States has an average yield per acre of 89.8 bushels, Germany 197.3 bushels, and Great Britain 186.4 bushels. In the United States potatoes rank fourth in the number of bushels produced among the staple crops, corn being first, oats second, and wheat third. The states ranking the highest in gross yield of potatoes given in order of production are New York, Michigan, Maine, Wisconsin, and Pennsylvania. The states having the highest average yield per acre given in order of priority are: Maine, 225 bushels per acre; Idaho, 200 bushels; Montana, 180 bushels; Nevada, 180 bushels; Utah, 180 bushels; Washington, 170 bushels; Colorado, 160 bushels.

379. Description. — Naturally the potato is an annual plant; it springs up from a seed, grows, blooms and produces seed and dies in one season. Under cultivation, however, it has become a perennial plant by means of the tubers. The flowers vary in color, some being white and others purple. Some varieties seldom bloom, and those which do bloom rather freely rarely set fruit in the eastern and central part of the United States. In some sections, however, these same varieties set fruit quite commonly. The true fruit, or seed ball as it is often called, is round and about the size of a ground cherry. When cut open it is found to be full of seeds and has a structure similar to a tomato. The part which we eat is simply an enlarged underground stem. It does not grow on the true roots but on the end of a stolon; rootlets are never found coming from a tuber or from the stolon which bears it. Every tuber has a number of "eyes" on the surface, some varieties having a much larger number than others. In some varieties they are shallow, in others deep, and in all cases they are much more numerous at the "bud end" than where the stolon is attached to the tuber. If we examine them closely, we will see that they are arranged in a spiral form. Now if we can imagine this tuber elongated or drawn out, these eyes would simply represent buds on an underground stem, each of which could send up a shoot or plant. Practically all of the higher plants have a means of storing up food in some place in their tissues, which can be used at a time when they need a surplus to start them into growth from a dormant condition. Sometimes it is in the form of starch, or it may be sugar or oil. In the apple tree this food is found about each bud, in the currant considerable food is stored in the roots; but in the potato a large amount of starch is stored in an underground stem which becomes greatly enlarged — the tuber. The amount of starch varies from 12 per cent to 20 per cent in most commercial varieties.

CULTURAL METHODS

380. Soil. — The prime essential of a potato soil is to have it well drained. The loose and mellow condition of the soil is of greater importance with this crop than a large amount of native fertility. While the potato can be grown on a variety of soils with success, the medium light soils are usually best. A gravelly or sandy loam well filled with humus is ideal because it affords good drainage and yet supplies a liberal amount of moisture which is necessary for a large crop. A light, sandy soil is usually preferred for early potatoes. If a soil is not naturally well drained, then tiling should be put in before maximum results can be expected. When water stands for a part of the growing season in pockets in the soil, many of the plants will die out. This can be seen in the irrigated sections in the west.

381. Rotation. — Because of the serious diseases and insects which attack the potato, it is well to practice a systematic rotation of crops. Potatoes following clover is usually considered an advantageous rotation, because, with this practice, the soil not only has a good supply of humus but an additional supply of nitrogen which can be utilized. An old sod turned under may cause considerable trouble from white grubs, which sometimes practically destroy a potato crop; but when a short rotation is practiced, this trouble is not so likely to become serious. Potatoes, wheat, and clover; or potatoes, strawberries, and clover will make a good three or four year rotation. When planted on sod land, the plowing should be done in the fall and the land well worked down in the spring with a disk and smoothing harrow before planting.

382. Planting the seed. — The time of planting varies in different sections of the country. Generally the seed should be planted by May 20 for best results; however, in some sections it is June 20 before the late potatoes are planted.

383. Sun sprouting. — It is often difficult to keep potatoes from sprouting badly and shrinking in early spring before time for planting. This problem can often be solved by rubbing off all white sprouts and placing the potatoes in the sunlight for two or three weeks before planting. They can be spread out on the barn floor, or shelves can be built upon the south side of the barn or other building for containing them, and they may then be spread out in a single layer and left exposed to the light until they are wanted for planting. A short green sprout will develop in place of the long white ones usually seen in the cellar. The potato thus treated can be planted as late as the first of July and yet a good crop may be secured. It is desirable to select the seed stock for the following season from this late planted crop, which, however, would not need to be sun sprouted before planting. The tubers which have been sun sprouted are usually cut with one sprout to a piece; the growth is very rapid and a higher percentage of stand is secured than from unsprouted seed. The tubers thus grown keep better, shrink less, and are much slower in sending out the white sprouts than ordinary seed.

384. Northern grown seed. — While it is often stated that northern grown seed is much superior to "home" grown seed or that grown south of a given point, yet a number of experiments have not shown this to be the case. If the seed of a given variety is of equal maturity, free from disease, and of equal quality in other respects, little difference in results will be noticed.

385. Rate of planting. — Various quantities of seed are used per acre, depending on the distance of planting, somewhat on the variety in question, and method of cutting the seed. Twelve to fourteen bushels of seed is a common quantity used. Medium size tubers are selected and cut two eyes to the piece. Seed pieces are dropped every twelve to fifteen inches in the row, and the rows thirty-three to thirty-six inches apart. In some sections they are planted in hills and cultivated both ways. The seed pieces are covered three to four inches deep.

386. Fertilizers. — In order to secure the largest possible yield of any crop, there should at all times be a sufficient quantity of moisture and plant food. It is as great a disadvantage to a plant to be stunted at any period of its growth as it is to an animal. But the amount of artificial plant food which a crop requires can only be determined by experimenting on every farm. We know that potatoes use a large amount of potash in growing, but many soils (clay soils especially) are oftentimes so rich in potash that very little or none need be supplied artificially. While an excess of nitrogen may cause the potatoes to "run to tops," and set few tubers, yet some nitrogen can usually be used to advantage. Soils very often contain less available phosphoric acid than is necessary for the fullest returns in potatoes, and phosphoric acid is usually supplied in some form. Larger returns over a series of years are more likely to be secured by using a complete fertilizer than by using any one or two of the elements separately. A fertilizer which will analyze about 4 per cent of nitrogen, 6 per cent of phosphoric acid, and 10 per cent of potash is one that is commonly used in large potato growing districts. The per cent of potash on many soils could be reduced to 6 to 8 per cent.

387. Varieties. — The selection of varieties of all kinds of fruits and vegetables is always of interest to lovers of plants, and is a question of great importance. However, as late as 1771 there were only two varieties of potatoes recorded, one white and one red variety. But the multiplication of varieties in recent years has been enormous, and there have been many hundreds of varieties on the market. There are more than one thousand named varieties on the market at the present time. Many of these have proved inferior to our standard sorts and many others have proven to be old varieties renamed.

Each locality must test the standard varieties and decide which will do best under its conditions. Because a variety does well in Maine is no proof that it will do well in Illinois or Colorado, neither does the success of a variety on a clay loam indicate positively what it will do on a sandy or muck soil on an adjoining farm. The confusion which often occurs regarding varieties of potatoes in many cases is caused by the fact that there are several distinct types or groups of potatoes, and in each group there are many varieties which very closely resemble one another. The following types are among the best known: Early Ohio type, including Early Ohio, Early Six Weeks, Acme, and Ohio Junior: Early Rose type, including Early Rose, Northern Star, Early Fortune, Bovee, Sensation, Algoma, Early Breakfast, and Early Michigan. Green Mountain type, including Green Mountain, Gold Coin, Uncle Sam, and Happy Medium. Rural New Yorker type, including

Fig. 126. — Harvesting potatoes in Ohio.

Rural New Yorker, Carman No. 3, Sir Walter Raleigh, Banner, President Roosevelt, and Prosperity. A few of the well-known varieties which do well in some sections of the United States are given in about the order of their maturity: Early Petosky, Irish Cobbler, Bliss Triumph, Early Ohio, Early Rose, Early Thoroughbred, Bovee, Algoma, Burbank, Green Mountain, Vermont Gold Coin, Carman No. 3, Sir Walter Raleigh, Rural New Yorker, White Pearl, and Peachblow.

388. Much is said about the "running out" of varieties

and many persons find an all sufficient excuse in that idea for their failures. The better growers, however, believe that good culture and care of the seed stock will keep varieties in a productive state over many years. In some sections the ravages of disease are so severe that it is almost impossible for growers to grow their own seed, but

FIG. 127. — A potato digger.

each year they must send for seed to some section which is known to be free from the trouble. Varieties which at one time flourished in the East and later failed to produce good crops, supposedly because they had "run out," are now among the most prolific sorts in the regions farther West.

389. Harvesting. — Because the potato is likely to be injured by frost the crop should be dug and stored before heavy freezes. Ordinarily late potatoes are dry when the vines die down, indicating maturity of the tubers. However, when the vines have died down as a result of late blight, it is well to wait some ten days before digging, as the chances of rot in storage are thereby greatly lessened. Potatoes should be dug when dry and placed in storage at once. In a small way potatoes are dug with a fork or potato hook, but on a larger scale the potato digger drawn by horse power is commonly used. The potato box or crate is largely used at present to replace the rougher handling in bulk by pouring from baskets into the wagon bed and shoveling into the cellar or storage.

390. Storage. — Potatoes freeze easily and the temperature in storage should never reach the freezing point. While 34° F. is recommended as a safe storage temperature the tubers will have a better cooking quality if stored at a temperature somewhat higher, ranging from 35° to 40° F.

Ordinary cellars are usually utilized for storage. Where this is done, it is well to construct a flue for conducting air into the cellar from the outside at the level of the cellar floor and have an opening at the top of the cellar to allow the warm air, laden with gases and impurities, to pass off. The cellar should be kept dark and some means of artificial heat should be provided in case there is danger of freezing. The loss in storage from fall till April or May will vary from 5 to 12 per cent, 10 or 12 per cent being common. This loss is due to loss of moisture and respiration. If the potatoes are diseased, the loss will be in excess of this figure.

391. Insects. — The Colorado beetle (*Leptinotarsa decemlineata*) which is the familiar striped "potato bug," is the best known and probably the most troublesome of the potato insects. Many of our most destructive insects have been imported from other countries, but this one is a native of the Rocky Mountain region. It feeds on the buffalo bur in its native, wild state, but it also attacks a number of our garden crops, among which are the tomato, egg plant, tobacco, and pepper, as well as potatoes. The eggs are bright yellow and are laid in clusters on the potato leaf. The eggs hatch and the young larvæ begin feeding at once on the leaves, and may entirely devour them if not checked by some poison. The leaves should be entirely coated with the spray as soon as the eggs hatch, as the younger the bugs are the more easily they are killed. Arsenate of lead is used in the proportion of $3\frac{1}{2}$ to 4 pounds to 50 gallons of water, or where it is preferable, about $\frac{1}{2}$ pound of Paris green to 50 gallons of water may be used. Bordeaux mixture is also offensive to them and commonly used in conjunction with these poisons, with the double purpose of controlling certain diseases and assisting in combating the potato beetle and also the flea beetle. It requires about 100 gallons of the spray per acre. It is applied by a spray machine drawn by horsepower, or a hand sprayer may be used successfully on small patches.

392. The Flea Beetle (*Crepidodera cucumeris*). — This tiny flea-like beetle is seen on tomatoes and potatoes when they are small and tender and easily injured. Instead of eating the edges of the leaves, as the potato beetle does, they eat them full of holes and may do as much injury as the Colorado beetle. While it is difficult to control them, yet Bordeaux mixture, to which some arsenate of lead has been added, forms a thin plaster over the leaves which is not to their liking and thus causes them to seek other food. They are much worse where potatoes are grown more than one year in succession on the same ground, so for this reason rotation of crops is desirable.

393. The June Beetle (*Lachnosterna spp.*). — The common white grubs or larvæ of the May beetles or June bugs are one of the most common pests in field and garden. They are troublesome on newly plowed sod lands, especially when the land had been in grass for a number of years. It is not uncommon to find the potato crop practically ruined under such conditions. They are difficult to control, and rotation of crops, late fall and early spring plowing, allowing swine to work over the land, and allowing chickens to run on a newly plowed field, are means used to control them.

DISEASES

394. Early Blight (*Alternaria solani*). — This is an old disease which has probably been more or less destructive for many years. It begins to make its appearance on the plants about the time they are in blossom or sometimes when the plants are quite small. It is distinguished by small round grayish patches which later turn brown. The spots increase in size and many of them may coalesce and form large irregular patches. The punctures made by the flea beetles and other insects seem to favor the entrance of the fungus into the tissues of the plant. While the disease is not followed by the rotting of the tubers, it decreases the yield greatly. Some seasons it lessens the yield by many millions of bushels.

395. Late Blight (*Phytophthora infestans*). — This disease has proved to be one of the most destructive and widespread of all diseases of the potato. It is found in all countries of the world where the potato is grown. The disease appears as an irregular dead area on any portion of the leaf, but commonly it first appears at the tip or on the margins of the leaf. There is often a noticeable and offensive odor from a field affected with the blight, especially if the air is filled with moisture. In order to control the disease the plant should be sprayed thoroughly with Bordeaux mixture.[1] Spraying should be begun when the plants are six to eight inches high and repeated every ten days to two weeks throughout the season, making in all about five applications.

396. Scab (*Oöspora scabies*). — This disease is quite common in all potato growing sections. The irregular, cankered-looking spots which may more or less cover the tubers are familiar to every one who has ever grown potatoes. This disease is known to live over in the soil for several years and a change of soil is necessary; no potato crop following for four or five years would be advisable. It is not difficult to keep this trouble in check if precautions regarding seed and rotation are taken each year. The seed should be treated before planting, with one pint

[1] This spray is prepared by dissolving 4 lbs. copper sulphate and 4 lbs. stone lime and adding water to make 50 gal.

of corrosive sublimate (bichloride of mercury) in thirty gallons of water. Place the potatoes in a gunny sack and suspend in the solution for two hours. Then empty them out on the floor or in the sun to dry before planting. Various methods are used for treatment, but the above is satisfactory and possibly as easily done as any.

397. Dry Rot (*Fusarium oxysporium*) is widespread over the potato regions of this country and Europe. It is a fungous disease which attacks the base of the plant, penetrating into the roots and tubers and causing the final wilting and early maturity of the plant. It causes a further development of dry rot in storage. There is a tip burn and yellowing of the leaves, together with a rolling up of the foliage. Affected tubers can be determined by cutting off the stem end slightly and observing a browned ring near the skin and occasionally a browning going entirely through the tuber. Spraying will not control the disease, but care in selecting disease-free seed and planting on soils which have not become inoculated with the disease will be the proper precautions to keep it under control.

CHAPTER XXI

MEADOWS AND PASTURES

HAY and pasture crops are usually considered by the general farmer, especially in the corn belt and Southern States, as holding a place of minor importance to the cereals or special money crops. In some sections of the country hay is the chief money crop, but even where it is depended upon for a large part of the farm income, it seldom receives the attention accorded other money crops. Few farmers, even in the hay growing sections of the country, have attempted to increase the yield of their meadows and pastures by methods similar to those employed to increase the yield of grains. Fertilizers and manures are rarely applied to meadows or pastures, the general opinion prevailing that a larger return may be received from fertilizers when they are used in connection with other crops. This opinion, however, has not been verified by experiments. Based upon experiments at the Pennsylvania Station, Professor Hunt makes the statement that the same amount of money used in the purchase of fertilizers for grass lands will bring a greater profit than when applied to corn or wheat, and at the same time will make the soil more productive for succeeding crops. Experiments conducted at other stations and the experience of progressive farmers show that meadows and pastures will respond to fertilization and improved methods of culture quite as readily as will general field crops.

Many meadows and pastures can, by improvement in the methods of culture, and the application of fertilizers and manure, be made to yield twofold. Pastures that furnish but a scanty growth of forage can be made to furnish an abundance of grazing for twice the number of animals they now support. Many fields that are now devoted to the cereals, especially in sections of poorer types of soils, could be made to produce grass more profitably.

398. The rotation. — Whether or not meadows or pastures can be grown as regular crops in rotation will depend largely upon the topography of the country and the systems of farming followed. Where very extensive systems of farming are practiced, hay and pasture crops are usually grown in continuous culture, being the last crops to take a place in the rotation. In rolling or hilly sections of the country, the land that is too steep or rough to put under the plow is devoted to grass. When land is so steep that serious loss is likely to occur by washing if it is plowed, continuous culture is to be recommended. But where land can be cultivated without loss from washing, the grass lands should form a part of the regular rotation. In the corn belt states, meadows regularly form a part of the rotation. Where hay is the principal money crop, frequently continuous culture is practiced. Hay is kept in the meadow as long as a fair crop can be secured, and then the field is put under cultivation for a year or two, after which it is seeded down to meadow again. This method of hay production, when followed for a number of years, is not profitable, as the yields usually become less each year until finally a profitable crop is no longer obtained. Where continuous hay farming is practiced, usually little live stock is kept on the farm, so that little barnyard manure is available for fertilization, and since few farmers purchase commercial fertilizers for this crop, the result is a gradually decreased yield. When land is better adapted for hay production than for grains or other crops, the largest profits are received by growing hay for the market. This system of farming is made far more profitable and permanent if fertilizers are regularly applied to the grass lands to return to the soil the elements removed

FIG. 128. — Hauling hay to market.

by the crop. Methods of fertilization of grass lands will be discussed in another paragraph.

399. Grass mixtures. — When hay is grown for the market, the highest price is usually received when it is made from one grass rather than from a mixture of several grasses. Thus, timothy hay commands a better price than hay made from a mixture of timothy and redtop. When hay is grown for home use, or when grasses are seeded for pasture, a mixture of grasses sometimes is desirable, and will usually produce a higher yield than one grass grown alone. Some grasses are shallow rooted while others grow medium deep, and still others penetrate quite deep into the soil. For this reason, the roots of several grasses more completely occupy the soil and together produce a larger yield than a single grass. There are some grasses which start early in the spring, while others do not start growth until later in the season; certain ones grow well during the hot, dry part of the season, while others produce little forage at this time; still others grow later in the fall than the majority of grasses, and certain kinds may be better adapted to some portions of the field than others. Thus not only does a greater production and a more continuous growth result from a mixture than from a single grass, but also a greater variety of herbage is obtained. In selecting grasses for a pasture, those best adapted to the field to be seeded should be chosen. Thus if the field is low and undrained and likely to be wet, the principal grass of the mixture should be one adapted to wet soils. Redtop usually forms the principal part of such a mixture. If the land is lacking in lime, this element should either be supplied before seeding, or such grasses as grow well on acid soils should enter into the mixture. Grasses used as mixtures for hay should ripen at the same time, or some may become dry and unpalatable before the rest of the crop is ready to cut. In seeding grasses for a permanent pasture that requires some time to become established, such as Kentucky blue-grass, other quick growing grasses should be seeded with it to furnish forage until the blue-grass becomes established. In mixtures for pasture, clovers may be included, white clover being desirable in almost all permanent pastures. The clovers, besides giving variety to the herbage, add nitrogen to the soil, making it more productive. The adaptations of the various grasses and legumes are discussed in the chapters relating to them and may be consulted in making selections of mixtures for hay or pasture.

400. Testing the seed. — The securing of a successful stand of grasses and legumes depends largely upon the quality of the seed used in the seeding. Seeds of the grasses and legumes are comparatively expensive, and

Fig. 129. — Examining seeds for purity.

failure to secure a stand results not only in the loss of the value of the seed, and also perhaps in the loss of the use of the land for some time, but frequently breaks up the regular rotation. It is therefore important that only good seed be purchased. Another factor to consider in the purchase of grass and legume seed is its purity. Frequently seeds of other grasses or weed seeds are found in commercial grass and legume seeds. Few farmers desire to propagate weeds, especially if they are extremely troublesome ones. To pay grass seed prices for weed seed is poor economy, and extreme precautions should be taken to secure pure, viable seed of the variety desired. Frequently as much as 10 per cent or more of commercial grass or legume seed is weed seed. This, of course, means that with each 100 pounds of seed purchased, 10 pounds are weeds, which results not only in their introduction into the pasture or meadow, but also increases the actual cost of the seeding. To insure the purchase of pure seed, a small quantity of seed from several dealers, together with their prices, may be secured for a purity test.

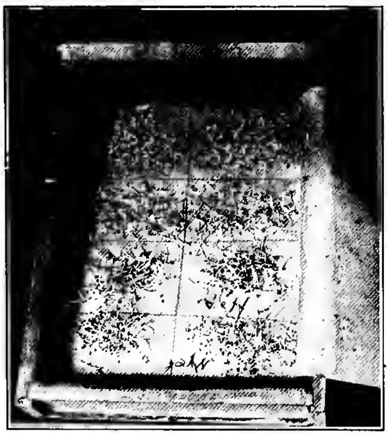

FIG. 130. — Method of making vitality test of grass and legume seeds.

401. The purity test consists in separating from a sample the weed seed and other foreign matter and determining by weight the amount of pure seed. Not more than one or two per cent of foreign matter should be found in good seed. After a purity test, the grass of legume seed should be tested for germination. Many kinds of grass seeds are frequently of poor vitality. The test may be made by using the corn germinator box, filling in about two inches with sand and adding enough water to thoroughly moisten it. The grass seed may then be tested between or upon blotting paper placed upon the sand. Large grass and legume seeds may best be placed between blotters, while small seeds, like those of redtop and blue grass, are best germinated on top of the blotter. The sand in the box serves as a reservoir to supply moisture to the blotter, thus keeping the seeds moist. Excessive evaporation, which results in the rapid drying out of the sand and blotter, may be prevented if the box is covered over with a piece of paper. The temperature at which grass seed germinates best varies with the different grasses. Blue-grass germinates best if the temperature falls to 40° F. during some period of the day with a maximum temperature of 70°. Legumes usually germinate in from 6 to 10 days, while grasses require a longer time, blue-grass requiring 28 days. The accompanying table gives the temperature, position of seed in the tester, and length of time required for the test:

Kind of Seed	Position in Tester	Temperature	Days Required for Germination
Alfalfa	B–B	20° C.	6
Clover, alsike	T–B	20° C.	6
Clover, crimson	B–B	20° C.	4
Clover, mammoth	B–B	20° C.	6
Clover, red	B–B	20° C.	6
Clover, white	T–B	20° C.	6
Bermuda-grass	T–B	20–35° C.	21
Brome-grass	B–B	20–30° C.	10
Blue-grass	T–B	20–30° C.	28
Meadow fescue	B–B	20–30° C.	10
Orchard-grass	B–B	20–30° C.	14
Redtop	T–B	20–30° C.	8
Rye grass	B–B	20–30° C.	14
Timothy	T–B	20–30° C.	8

B–B — between blotters. T–B — on top of blotter.

After the germination test has been completed, the results of both the purity and germination tests may be consulted, together with the price lists of the dealers, and a selection can then be made. In case it is impossible to secure seed of good vitality, the rate of seeding should be regulated according to the percentage of viable seeds.

402. Seeding. — The time, rate, and manner of seeding has been discussed in connection with several grasses and legumes in preceding chapters. In general, it may be said that since grass and legume seeds are small, they require a firm, finely pulverized seed bed. Very small seeds should not be covered deeply, if at all, while the large seeds may be covered lightly with a light harrow or weeder. The time of seeding varies with the different grasses, but usually they may be seeded at any time during the growing season, late summer seeding almost always giving good results, especially in the corn belt states.

403. Care of grass lands. — In the sections of the country where hay and pasture crops enter into the regular rotation, weeds frequently make a rank growth after the removal of the grain or nurse crop. Weeds crowd the young plants, compete with them for the soil's moisture, and usually grow so rapidly as to produce a dense shade and retard the growth and sometimes kill out the young grass and legumes. To prevent the weeds from shading the grass and also to prevent them from seeding, they should be cut with a mower once or twice after the nurse crop has been removed. If this practice is followed for a few years, the weeds will be prevented from seeding and after a time will be eradicated from the farm. Weeds allowed to seed year after year soon become so abundant as to form a considerable portion of the hay at harvest time. This trouble may be prevented and the fields freed from meadow weeds by frequent clipping after the grain crop has been removed.

404. Pasture lands may also be greatly improved in quality and abundance of yield if clipped with the mower two or three times during the season. Clipping not only destroys the weeds, but also cuts off the dry grass, giving the animals a better opportunity to graze upon the young and tender growth. In many permanent pastures this practice will require that stones, shrubs, and bushes be removed from the field, but the increased yield will doubtless more than pay for the labor required in this operation. Many permanent pastures and meadows after long service become unproductive. Mossy growth appears, large, bare patches become evident and the grass grows reluctantly. Such pastures have for a long time been in need of fertilization. Mossy growth is usually associated with a lack of lime in the soil, and if upon testing with litmus paper, it is found that this element is lacking, it should be applied before further fertilization is attempted. The kind of lime to apply will depend upon the cost price, although when ground limestone is available, it is usually the most convenient form to apply. From one-half to two tons or more of ground limestone per acre, depending upon the acidity of the soil, may be applied with profit. The application may best be made in the fall, winter, or early spring. If barnyard manure is available, a liberal application with the manure spreader will greatly increase the productivity of the pasture or meadow. If manure is not available, or only in small amounts, it may be supplemented with commercial fertilizers. A high grade complete fertilizer is perhaps the best for grass lands in which little or no clover is growing. Grasses require large amounts of nitrogen, and unless clovers are growing with them to supply this element, they should be applied in the form of a complete fertilizer or nitrate of soda. Nitrogenous fertilizers, especially nitrate of soda, should be applied in the spring after the grass has started growth. From 100 to 150 pounds of nitrate of soda per acre may be applied with good results on impoverished fields, and a lesser amount on fields in good condition. If a complete fertilizer is used, 400 pounds per acre of a fertilizer analyzing 4 per cent nitrogen, 10 per cent phosphoric acid, and 2 per cent of potash is considered a good application. Liberal application of barnyard manure and frequent clipping of pastures will greatly increase their productivity, while fertilizers are a necessity for continuous profitable yields of hay from permanent meadows.

405. Temporary pastures. — Frequently the permanent or regular pasture does not supply the needs of all of the animals kept on the farm, and quick growing temporary pasture may be used to supplement it. The crop used for temporary pastures will depend to some extent upon the animals for which they are to furnish forage. Temporary pastures are perhaps most useful for hogs or sheep. Rape, cowpeas, soy beans, field peas, rye or wheat may be used for this purpose. A temporary pasture may be planned that will furnish forage from early spring to late fall if several small fields are available, or if a large one can conveniently be divided by temporary fences. Rye may furnish pasture early in the spring followed by field peas alone or with oats, two or three seedings of which a few weeks apart will furnish pasture until rape, soy, beans or cowpeas are available. Thus a few acres may afford pasture for a large number of animals throughout the growing season.

406. Substitute hay crops. — Failure of the regular seeding or unusual demands for hay may require substitute or supplementary hay crops. Sometimes, too, the market price of timothy, clover, or alfalfa hay is such that the regular hay crop may be marketed with profit, a substitute crop supplying home needs. Such crops are to be found in the field peas, alone or with oats, millets and sorghums. The time and method of seeding these crops have been discussed in the earlier chapters.

CHAPTER XXII

MARKETING OF GRAIN

THE marketing of grain or of any other crop has as its basis the principle of barter or trade. The producer trades his crop or that portion of it not required for his needs for some other commodity which he needs but does not produce, or produces in insufficient quantities. In former times the traders met at a common market place at stated times and there bartered their goods. Later on, money as a medium of exchange simplified the matter of trading and made possible the great specialization in production which exists to-day. The yields of the great wheat fields of the Northwest and of the cotton plantations of the South more than supply the local demand, and must be marketed where these crops are not produced or where production does not equal consumption. So it may be said that the North supplies the cotton grower with a considerable portion of his wheat flour, and in return looks to the cotton grower for the various products of the cotton fields. In this case, actual exchange of commodities has not taken place, but the sale of one crop for money makes possible the purchase of another or its products.

The average grain producer knows but little about the devious route taken by his bag of grain after it leaves his hands until it reaches the ultimate consumer. He should know more about the part taken in the world's business by the products of his labor after it leaves his hands, and how it reaches and supplies the consumer through the complicated system of distribution that has been built up around it. A most interesting story it is, if told in detail, sometimes containing the element of romance and not infrequently that of tragedy. We shall not touch upon the stories of fortunes won and lost in the grain market, but shall attempt to explain in a simple manner the

FIG. 131. — A typical country elevator.

general working plan of the great system of grain marketing, touching briefly upon each division of the business and the function which it performs.

407. The country elevator. — The function of the country elevator is to purchase from the farmer his surplus of grain or hay and to start it upon its way to the consumer. Country elevators may sometimes store the grain for a time, awaiting better shipping facilities or a more favorable market. There are three kinds of country elevators, based upon their systems of management, namely, the independent, the coöperative, and the line elevator. The independent elevator is one at a country shipping point owned and controlled by one or more individuals. The management of such an elevator is independent or not connected with other elevators or large market centers.

408. The coöperative elevator is one owned and operated by an association of farmers. A coöperative or farmers' elevator usually has some advantages over other elevators in the securing of grain from the farmers, many of whom are stockholders in the company and share in its profits. Sometimes as many as 50 or 100 farmers around a shipping point may hold stock in such an elevator, which insures for it a large supply of grain. Many farmers, also, who are not stockholders prefer to sell their grain to a coöperative company, since it is operated by farmers, preferring to do business with farmers rather than independent dealers or line elevators. All coöperative elevators are not successful, however, as might appear from what has been said. Failure is frequently due to inexperience of the managers in business affairs, which results in poor management. Sometimes, too, jealousy springs up between the stockholders, and this frequently results in the company's bankruptcy.

409. The line elevator differs from the independent dealer and the farmers' company in that it is only one elevator of many along a certain line or lines of railroad, and owned and managed by a concern having headquarters in one of the large central markets. The line elevator at any one shipping point is in charge of an individual who is employed by, and receives directions for management from, the headquarters in the central market. A line elevator company, therefore, may control many elevators along one or more railroads; and when their combined receipts are considered, it will be seen that they handle immense quantities of grain. Line elevators are more common in new and comparatively undeveloped country than where farming has long been in practice. They perform the useful function of buying the producer's grain in sections of the country where independent dealers or farmers' companies have not yet become established. A prejudice usually exists against the line elevators, the opinion prevailing that they do not pay the best prices, and usually, as the country develops, they come into competition with independent dealers and coöperative companies. Many line elevators are, however, doing successful business where other companies exist, and are most commonly found in the West Central and Northwestern States.

All three types of country elevators perform essentially the same function in the grain trade, namely that of purchasing from the producer at any time he desires to sell his surplus of grain.

410. Terminal markets. — A few years ago the surplus grain of a community was usually sold to the local mill, but with the improvement of shipping facilities, there have developed a centralization of storage elevators, mills and places of marketing, and now only the smaller mills depend entirely upon the local supply of grain, almost all large mills buying additional amounts of it needed for their mill at the terminal markets.

Grain purchased by country elevators is usually shipped to the terminal or primary market. Such markets are located in large cities of easy access by rail or boat from the sources of production. At the terminal markets, the country elevator men or their representatives meet the exporters, millers, and others who desire to purchase large quantities of grain. Such terminal markets of the

FIG. 132. — A terminal elevator in Chicago located so as to ship grain by rail or boat.

grain trade are located in Chicago, Minneapolis, Duluth, St. Louis, Toledo, and other points.

411. Terminal elevators. — Terminal elevators, which are located at the large terminal markets, have immense storage capacity and are usually located so as to be able to receive or ship grain both by rail and by boat. The operators of these elevators usually carry on two distinct lines of business. They rent storage room to country dealers or others who have grain they wish to store, and they act as brokers, buying grain and reselling it. In this line of business they may either resell immediately or very soon after buying, or they may store the grain for a time, awaiting a more favorable opportunity to sell. The terminal elevators frequently mix large quantities of grain of high grade with small quantities of poor grain, the mixing being such as not to reduce the grade of the former. This operation is one of the sources of profit.

412. Grain inspection. — Buyers of grain at the terminal markets buy it in such large quantities, sometimes hundreds of thousands of bushels, that it is neither possible nor desirable for them to personally inspect each car of grain they purchase. Since grain varies greatly in quality, and since the quality has a direct relation to the value of it, it is desirable that the purchaser as well as the seller have some means of determining the quality of a certain lot of grain without personally inspecting it. This is made possible by a system of grain inspection in which a lot of grain arriving at the terminal market is inspected and given a grade by official inspectors. The grades are so defined that the purchaser knows in a general way the quality of the grain as determined by plumpness, hardness, presence of foreign matter, weight per bushel, and other qualities of importance in estimating its value. There are usually four distinct grades. The method of describing the grades may be gained from the following description of the grades of hard winter wheat:.

No. 1 Hard Winter Wheat shall include all varieties of pure, hard winter wheat, sound, plump, dry, sweet, and well cleaned, and weigh not less than 61 pounds to the measured bushel.

No. 2 Hard Winter Wheat shall include all varieties of hard winter wheat, of both light and dark colors, dry, sound, sweet, and clean, and weigh not less than 59 pounds to the measured bushel.

No. 3 Hard Winter Wheat shall include all varieties of hard winter wheat of both light and dark colors, not clean and plump enough for No. 2 and weigh not less than 56 pounds to the measured bushel.

No. 4 Hard Winter Wheat shall include all varieties of hard winter wheat of both light and dark colors. It may be damp, musty, or dirty, and weigh not less than 50 pounds to the measured bushel.

Similar grades are described for the other classes of wheat and also for the other grains. Sometimes grain reaches the terminal market in such poor condition that it is not given a grade, but is sold by sample, in which case a small sample is sent to the trading floor so that the purchaser may see it before making the purchase.

413. Methods of inspection. — Two systems of grain inspection are in practice at terminal markets. "Track inspection" is the inspecting and grading of the grain at the car in the railroad yards or on the boat. A sample is taken from the car or boat, and the inspector, after examining it and determining the weight per bushel, gives the grain a grade. The inspector records in a book or on a card the number of the car and the name of the dealer to whom consigned, together with the grade he has given it. Track inspection is not always satisfactory, since the inspector is likely to be influenced in his judgment by extremes of weather, such as severe heat or cold, and when in doubt as to the grade of a certain lot, he has no one to consult or to check up his work. Track inspection for this reason is in many of the markets being replaced by "office inspection." In office inspection samples of grain to be inspected are collected from the cars, boats, or warehouses and taken to the office, where a corps of inspectors, working under uniform conditions, determine the grade. In this system of inspection, the collectors are divided into groups, the number of the collectors in each group

Fig. 133. — Inspecting grain in the room of the Illinois State Grain Inspection Department at Chicago.

being in proportion to the grain received by the railroad or dock to which they are assigned. Each group is usually placed in charge of a chief sampler, who is held responsible for the performance of the men in his charge. Usually two-quart samples are taken from several parts of the car; the sample is then bagged and together with the name of the railroad, the number of the car and the person to whom it is consigned, it is sent to the office for inspection. If the car is "plugged," that is, contains grain of inferior quality in the bottom or in one end of the car and which is covered over with grain of better quality, more samples are taken in order to get as near as possible a composite sample representative of the car as a whole.

414. Samples are taken with a long, hollow tube with holes regularly arranged along the side. A plunger fits into the tube, closing up the openings along the side. In taking a sample, the tube is pushed down into the grain and the plunger is then removed. This allows the grain to run into the tube through the holes in the side, and thus a sample is obtained containing grain from various depths in the car. If the car is damaged or leakage has occurred, the collector notes the amount lost and the condition of the car, which information is of use to the owner in an attempt to collect damages from the railroad. The grade given a sample of grain by the inspectors is used as a basis for sale. If the shipper is not satisfied with the grade given by the inspectors, he may appeal the decision to a board of arbitration made up usually of members of the grain exchange. This board has the power to regrade the sample, their decision being final.

415. Methods of sale. — At the terminal markets there are usually organized grain exchanges, which are organizations of individuals interested in the sale or purchase of grain, who meet regularly for the transaction of business. The place of meeting for the transaction of sales is usually called the "floor" or the "pit." Men who have grain to sell or who desire to purchase may go on the floor in person if they are members of the exchange. More frequently, however, sales are made through commission men. Commission men are persons who act as agents for the seller or buyer, and receive as their compensation a stipulated commission, usually 1 to 3 per cent of the cash value of the transaction. The amount a commission man is able to earn depends, therefore, upon the volume of his business.

Country elevators usually sell their grain through commission men. Line elevator companies who sell in large amounts may make their sales through a member of the firm who is a member of the exchange. Millers usually purchase their supply of grain either direct from large country elevators or through a commission man on the floor of the exchange at the terminal market.

416. Kinds of contracts. — There are three kinds of contracts for straight sales on the floor of most grain exchanges. The "to arrive" contract, which is made largely with country elevators, is that made with the understanding that the grain will arrive within 15 days from the date of the transaction. The "to arrive" contract is the usual method of selling carload lots, although line elevators often do not sell each car separately, sometimes selling "round lots to arrive," which may mean from 10 to 100 thousand bushels. Country dealers, when a car of grain is started on its way to the terminal market, wire or write their representative to sell for them "to arrive" a stipulated amount of a certain grade of grain. Sometimes the country dealer has reason to believe that the price of grain may advance by the time the car reaches its destination, in which case the commission man is instructed to sell "on track." This means that the grain at the time of the sale is in the railroad yards of the terminal market. Delivery is made by giving to the purchaser the bill of lading. If upon arrival of the grain at the terminal market the country dealer desires to await a more favorable market, the grain may be stored in one of the terminal elevators, for which a storage charge is made. In almost all states all public elevators are required by law to receive grain for storage at a uniform storage charge as long as available storage room remains. The country dealer may keep his grain in store as long as the storage charges are paid. When he desires to sell, his representative on the floor sells on the "in store" contract, and makes the delivery by turning over to the purchaser the warehouse receipts. Of the three kinds of contracts, the "to arrive" and "on track" are most often used by the country dealer in disposing of his grain.

417. Systems of credit. — Farmers usually demand cash payments from the country elevator at the time of delivery. If the grain dealer must wait until he resells the grain on the permanent market, a large working capital is necessary, since it may be two weeks or even longer before he is able to secure returns from it. At harvest time, and at other times when much grain is being received at the country elevator, the dealer may have a large amount of money invested in grain on the way to the market. In order to reduce the necessary working capital of the country elevator man, there often exists between the dealer and his representative at the terminal market a system of credit in which the country dealer takes the bill of lading to which is attached a draft drawn against the commission man, to the local bank and receives credit for the amount of the draft. The amount of the draft in relation to the value of the grain depends upon the agreement established beforehand between the commission man and his customer. In a steady market sometimes he will allow the country dealer to draw upon him for as much as 80 per cent of the value of the shipped grain. Thus, if the country dealer has shipped grain valued at a hundred thousand dollars, he may, by this system of credit, immediately have made available $80,000 for the purchase of more grain. When the grain arrives, the amount of the draft, together with the commission charges, is deducted from the gross receipt from the sale. The system of credit existing between the country dealer and the commission merchant is a valuable service to the country dealer.

418. Price of grain. — Country elevators usually receive by mail each morning prices of grain from the terminal market, or if a sudden change occurs, they may receive the new quotation by wire from their representative. The price offered for grain at the country elevator is based upon the price prevailing at the permanent market. In quoting prices to local sellers, the country dealer deducts from the terminal market price the cost of freight, the commission charges, a reasonable margin which differs with the different grains according to the amount of risk run in handling them, and a fair profit, including cost of operating the local elevator. Thus, if the freight cost to the primary market is 3 cents per bushel, the commission charge 1 cent, and the margin and profit and cost of operation 5 cents per bushel, the price offered by the local dealer will be 9 cents less than the price at the terminal market.

419. Prices at the terminal market. — Prices of grain that prevail at the terminal market are dependent upon several factors, chief among which are: the favorableness of weather and other conditions for growing the world's crop, the probable yield, the supply and demand of importing countries and the yield and prevailing price of substitute crops. All of these factors have an appreciable influence upon the prevailing prices. Weather, insects, and diseases play no small part in establishing the market price of a crop. So important are these facts that some commission and brokerage houses employ experts to make a canvass of the principal producing areas of the crops in which they are interested, sometimes sending them into foreign lands. Most commission firms, however, depend upon government weather and crop reports and other information which they frequently

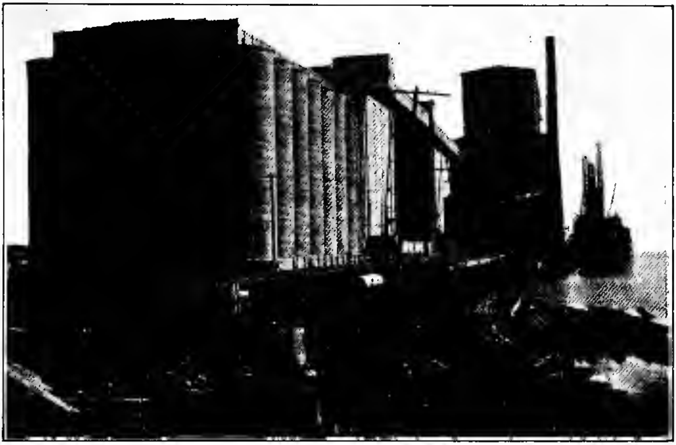

FIG. 134. — An elevator and concrete storage bins at Baltimore, Md. Grain is exported from here.

receive from country elevators throughout the country. The crop reporting system of the Bureau of Statistics of the United States Department of Agriculture is very complete, by which reports are received from all parts of the country from representatives or agents of the bureau. Some 50,000 agents and representatives are employed in collecting and sending to the Department these crops reports. The information thus received is issued to the public in monthly crop reports. From the several sources of information grain dealers are usually able to tell with unusual certainty the possible and probable yields from leading crops. How all of the factors mentioned at the beginning of the paragraph may affect market price of the grain crops cannot be explained here. Each, however, has some influence upon the ever changing market quotations.

FIG. 135. — Unloading grain at a Danish port.

420. Export trade. — The exporter of grain usually has headquarters at one of the seaboard markets, such as Baltimore or New York. He may buy grain on the floor of the local exchange, from commission men representing large dealers in the Middle West, or he may go in person to the terminal markets of the Middle West and buy his grain, or he may secure it through his representative there. Some exporters have headquarters at the terminal instead of the seaboard markets. The exporter sells abroad through a commission man on the floor of foreign exchanges. In the purchase of grain for export, the shipper must consider the cost of the grain at the seaboard, storage, insurance on the boat, freight charges, and the market price at the foreign market.

APPENDIX

A BRIEF LIST OF REFERENCES

Cereals in America . . . . Hunt
Corn Crop . . . . Montgomery
Corn . . . . Bowman & Crossley
The Study of Corn . . . . Shoesmith
Wheat . . . . Doudlinger
The Story of a Grain of Wheat . . . . Edgar
Forages and Fiber Crops . . . . Hunt
Grasses . . . . Spillman
Meadows and Pastures . . . . Wing
Forage Crops . . . . Voorhees
Alfalfa . . . . Coburn
Clovers . . . . Shaw
The Book of Grasses . . . . Francis
Cotton . . . . Burket
From the Cotton Field to the Cotton Mill . . . Thompson
Hemp . . . . Boyce
The Potato . . . . Fraser
The Potato . . . . Grubb
Corn Plants . . . . Sargent
Plants and Their Uses . . . . Sargent
Agricultural Botany . . . . Percival
Botany for Secondary Schools . . . . Bailey
Plant Physiology . . . . Duggar
Manures and Fertilizers . . . . Wheeler
First Principles of Soil Fertility . . . . Vivian
Soil Fertility and Permanent Agriculture . . . . Hopkins
Plant-Breeding . . . . Bailey
Genetics . . . . Walter
Southern Field Crops . . . . Duggar
Field Crops . . . . Wilson and Warburton

Broom-corn Culture . . . . McCALL
Bacteria in Relation to Country Life . . . . . . LIPMAN
Fungous Diseases of Plants . . . . DUGGAR
Plant Diseases . . . . STEVENS AND HALL
Insects Injurious to Staple Crops . . . . SANDERSON
Produce Exchanges — Annals American Academy of Political and Social Sciences, September, 1911.
Weeds of Farm and Garden . . . . PAMMEL
Cyclopedia of Agriculture, Vol. II . . . . BAILEY
Laboratory Manual of Cereal and Forage Crops LIVINGSTON AND YODER
A Laboratory Manual of Agriculture . . CALL AND SCHAFER
Bulletins of Dominion of Canada Experimental Farms, Ottawa.
Bulletins of State Experiment Station.
Bulletins and Year Book of United States Department of Agriculture.

These books may be obtained through most bookstores and publishing houses.

A list of the various state experiment stations together with the post office is given below. Students or instructors may usually secure from the director of the station a list of available bulletins from which he may select the ones desired. Such a list may also be secured from the Bureau of Publications, United States Department of Agriculture, Washington, D.C.

AMERICAN AGRICULTURAL EXPERIMENT STATIONS

Address Experiment Station at Post Office given.

ALABAMA —
College Station: *Auburn*
Canebrake Station: *Uniontown.*
Tuskegee Station: *Tuskegee.*
ALASKA — *Sitka.*
ARIZONA — *Tucson.*
ARKANSAS — *Fayetteville.*
CALIFORNIA — *Berkeley.*
CANADA — *Ottawa.*
COLORADO — *Fort Collins.*
CONNECTICUT —
State Station: *New Haven.*
Storrs Station: *Storrs.*
DELAWARE — *Newark.*
FLORIDA — *Lake City.*
GEORGIA — *Experiment.*
HAWAII —
Federal Station: *Honolulu.*
Sugar Planters' Station: *Honolulu.*
IDAHO — *Moscow.*
ILLINOIS — *Urbana.*
INDIANA: *Lafayette.*
IOWA — *Ames.*
KANSAS — *Manhattan.*
KENTUCKY — *Lexington.*
LOUISIANA —
State Station: *Baton Rouge.*
Sugar Station: *Audubon Park, New Orleans.*
North Louisiana Station: *Calhoun.*
MAINE — *Orono.*
MARYLAND — *College Park.*
MASSACHUSETTS — *Amherst.*
MICHIGAN — *Agricultural College.*
MINNESOTA — *St. Anthony Park, St. Paul.*
MISSISSIPPI — *Agricultural College.*
MISSOURI —
College Station: *Columbia.*
Fruit Station: *Mountain Grove.*
MONTANA — *Bozeman.*
NEBRASKA — *Lincoln.*
NEVADA — *Reno.*
NEW HAMPSHIRE — *Durham.*
NEW JERSEY — *New Brunswick.*
NEW MEXICO — *Mesilla Park.*
NEW YORK —
State Station: *Geneva.*
Cornell Station: *Ithaca.*
NORTH CAROLINA — *Raleigh.*
NORTH DAKOTA — *Agricultural College.*
OHIO — *Wooster.*
OKLAHOMA — *Stillwater.*
ONTARIO: *Guelph.*
OREGON — *Corvallis.*
PENNSYLVANIA — *State College.*
PORTO RICO — *Mayaguez.*
RHODE ISLAND — *Kingston.*
SOUTH CAROLINA — *Clemson College.*
SOUTH DAKOTA — *Brookings.*
TENNESSEE — *Knoxville.*
TEXAS — *College Station.*
UTAH — *Logan.*
VERMONT — *Burlington.*
VIRGINIA — *Blacksburg.*
WASHINGTON — *Pullman.*
WEST VIRGINIA — *Morgantown.*
WISCONSIN — *Madison.*
WYOMING — *Laramie.*

Composition of the Principal Field Crops and their Products

(Adapted from Henry's Feeds and Feeding)

	Protein	Crude Fiber	Nitrogen Free Extract	Ether Extract
Alfalfa	14.3	25.0	42.7	2.2
Barley, grain	12.4	2.7	69.8	1.8
Barley, straw	3.5	36.0	39.0	1.5
Barley, brewers' grain (dry)	19.9	11.0	51.7	5.6
Barley, malt sprouts	23.2	10.7	48.5	1.7
Barley, hay (cut in milk)	8.8	24.7	44.9	2.4
Broom-corn seed	10.2	7.1	63.6	3.0
Buckwheat	10.0	8.7	64.5	2.2
Buckwheat straw	5.2	43.0	35.1	1.3
Carrot	1.1	1.3	7.6	0.4
Clover, red	12.4	21.9	38.8	4.5
Clover, mammoth	10.7	24.5	33.6	3.9
Clover, alsike	12.8	25.6	40.7	2.9
Clover, white	15.7	24.1	39.3	2.9
Clover, crimson	15.2	27.2	36.6	2.8
Clover, Japan	13.8	24.0	39.0	3.7
Corn, dent	10.3	2.2	70.4	5.
Corn, flint	10.5	1.7	70.1	5.
Corn, gluten meal	29.3	3.3	46.5	11.8
Corn, gluten feed	24.0	5.3	51.2	10.6
Corn, stover	3.8	19.7	31.5	1.1
Corn, fodder (green)	1.8	5.0	12.2	0.5
Corn, silage	1.7	6.0	11.0	0.8
Cotton seed	18.4	23.2	24.7	19.9
Cotton seed meal	42.3	5.6	23.6	13.1
Cotton seed hulls	4.2	46.3	33.4	2.2
Cowpea	20.8	4.1	55.7	1.4
Cowpea hay	16.6	20.1	42.2	2.2
Flax seed	22.6	7.1	23.2	33.7
Linseed meal (new process)	33.2	9.5	38.4	3.0
Kafir corn seed	9.9	1.4	74.9	3.0
Kentucky blue-grass	7.8	23.0	37.8	3.9
Mangel	1.4	0.9	5.5	0.2

Composition of the Principal Field Crops and their Products — *Continued*

	Protein	Crude Fiber	Nitrogen Free Extract	Ether Extract
Meadow fescue	7.0	25.9	38.4	2.7
Millet seed	11.8	9.5	57.4	4.0
Millet hay (Hungarian)	7.5	27.7	49.0	2.0
Oats	11.8	9.5	59.7	5.0
Oat straw	4.0	37.0	42.4	2.3
Oat hay (cut in milk)	9.3	29.2	39.0	2.3
Orchard-grass	7.9	28.6	47.5	1.9
Peanuts (hulled)	27.9	7.0	15.6	39.6
Potato	2.1	0.6	17.3	0.1
Redtop	8.0	29.9	46.4	2.1
Rice	7.4	0.2	79.2	0.4
Rice hulls	3.6	35.7	38.6	0.7
Rice polish	11.7	6.3	58.0	7.3
Rye	10.6	1.7	72.5	1.7
Rye straw	3.0	38.9	46.6	1.2
Rye grass, perennial	10.1	25.4	40.5	2.1
Rye grass, Italian	7.5	30.5	45.0	1.7
Sorghum seed	9.1	2.6	69.8	3.6
Sorghum silage	0.8	6.4	15.3	0.3
Soy bean	34.0	4.8	28.8	16.9
Soy bean hay	15.4	22.3	38.6	5.2
Sugar beet	1.8	0.9	9.8	0.1
Timothy hay (in full bloom)	6.0	29.6	41.9	3.0
Turnip	1.1	1.2	6.2	0.2
Vetch hay	17.0	25.4	36.1	2.3
Wheat, spring	12.5	1.8	71.2	2.2
Wheat, winter	11.8	1.8	72.0	2.1
Wheat, high grade flour	14.9	0.3	70.0	2.0
Wheat, low grade flour	18.0	0.9	63.3	3.9
Wheat, bran	15.4	9.0	53.9	4.0
Wheat, middlings	15.6	4.6	60.4	4.0
Wheat, shorts	14.9	7.4	56.8	4.5
Wheat, straw	3.4	38.1	43.4	1.3

REVIEW QUESTIONS

CHAPTER I

I. Why is the classification of plants of interest to the student of farm crops? What is a species, variety, genus, family, order, class and division?

II. Discuss some of the variations found within the plant kingdom, in regard to (*a*) size, (*b*) structure, (*c*) habitation, (*d*) food requirements, (*e*) usefulness to man of the various plants.

III. How may one determine the proper classification of an individual plant? How does the botanical name assist one in identification?

IV. How may plants be classified with respect to their length of life, their usefulness to man and their culture? What are field crops, and how may they be classified? Name several members of each group. Discuss the relative importance of each group of field crops.

CHAPTER II

I. (*a*) What is meant by the term "rotation of crops"?
  (*b*) What is meant by the term "continuous culture"?

II. Compare yields of wheat obtained from rotation and continuous culture at Rothamsted. The same for barley.

III. What effect has continuous culture had upon the yield of corn at the Illinois Station? At the Ohio Station?

IV. Compare results obtained at the Ohio Station with corn and wheat fertilized and unfertilized in continuous culture. Make same comparison in rotation culture.

V. Why do rotations of crops give better yields than continuous culture? Give six reasons.

VI. What factors must be considered in planning a rotation?

VII. Does rotation alone maintain the fertility of the soil? Why?

VIII. Give eight rotations commonly recommended.

CHAPTER III

I. What evidences have we that corn is a native of the western hemisphere?

II. How does the corn plant differ from and what characters has it in common with the other cereals? To what great family of plants does it belong?

III. What is the function of the three groups of roots possessed by the corn plant? At what time in the life of the plant is each of them most useful? What factors influence the extent of the root system? Does deep planting insure a deep root system?

IV. What factors influence the growth of the stem? Is the height of the stem constant for a variety or type of corn?

V. How many growing leaves does one find on a medium-size plant? What percentage of the total dry weight at maturity is leaf?

VI. How do the flowers of the corn plant differ from those of wheat and barley? Describe the flowers of corn, as to their structure and position. What are the silks, and what functions do they perform? Why are there always an even number of rows on an ear? In what part of the ear are the first kernels formed? What is meant by the term "cross-pollination"? What provision has been made to render self-pollination difficult in the corn plant? What weather conditions may influence pollination?

VII. How many ears are normally produced on a stalk of corn in your section? When two ears are produced, which one develops first? What factors may influence the number of ears produced on a stalk?

VIII. What are the stages in the development of the kernel? Draw on the blackboard a cross section of a corn kernel showing the arrangement and the relative proportion of parts. What are the common colors of corn kernels? Where is the color pigment located?

IX. What can you say of the ancestry of the corn plant? What significance has the occasional variation one finds in the corn fields? Can you secure a number of variations and explain their probable significance?

X. Draw on the board a cross section of a kernel of each type of corn showing the characteristic shape, proportion and arrangement of parts. How do the different types of corn get their names? Where is each type grown, and how do you account for this distribution? Discuss the usefulness and importance of each type.

XI. What are the important uses of corn? Name several manufactured products made from it. What is gluten feed and gluten meal?

XII. What is the average annual world's production of corn for the four years 1908 to 1912? At current market prices what is its value? What are the leading corn-producing countries of the world? In what ways may an increase in production be brought about? What is meant by the term "corn belt" states? What is the average yield per acre in the United States? In the corn belt? In your state? In your county?

XIII. What soils and climates are suitable for growing corn? What are the principal factors that limit the production in various parts of United States?

CHAPTER IV

I. When does corn do best in the rotation? What can you say of the practice of continuous culture? What kinds of soil may usually be profitably fertilized for corn? How should the fertilizer be applied?

II. What are the benefits derived from plowing? What are the special advantages of fall plowing? What can you say of late spring plowing?

III. How would you prepare a seed bed on fall plowed land? On spring plowed land? What can you say of the use of the roller in preparing a seed bed?

IV. What does the farmer mean by the term a "stand of corn"? What is a perfect stand, and what factors must the farmer overcome to secure it? Make a germinating box and carry through a germination test of several ears of corn. Explain the precautions necessary to take in order to secure a useful test.

V. What can you say of the practice of grading seed corn?

VI. Discuss early *versus* late planting of corn.

VII. Discuss deep *versus* shallow planting of corn.

VIII. Upon what factors does the rate of planting depend? How does the corn plant adapt itself to a given rate of planting? What factors must be considered in determining whether to drill or hill the corn?

IX. What is the purpose of cultivation? Under what conditions may the weeder or harrow be useful in the cultivation of corn? Discuss deep *versus* shallow cultivation. Upon what does the frequency of cultivation depend?

X. What different methods are employed in harvesting the corn crop in the United States? When should corn be cut for the shock? For the silo? Do you think "hogging off" of corn is a good method of harvesting?

XI. About how much moisture is there in ear corn at harvest time? A year after harvesting? Upon what factors does the amount of moisture depend? When is there the greatest shrinkage of corn in store? What sort of storage should be provided for ear corn?

XII. In what two ways may the production of corn be increased? Which do you consider the more important? How would you conduct a variety test? What is the practical value of it? Is it a good practice to import seed corn from other states?

XIII. What methods of seed selection are now in practice? Which is the best method? Why? What objections are there to the other methods?

XIV. What is an ear-to-row test? Upon what fact is it based? How would you conduct such a test? What factors may influence the value of the test? What is the use of the check rows? Why does one not select seed corn from the ear-to-row test?

XV. What is a breeding plot, and how is it conducted? What is a multiplying plot? What are the practical advantages of a corn show?

XVI. Give the life history and methods of controlling the insect enemies of corn. The fungous diseases.

CHAPTER V

I. Discuss the antiquity of wheat. What can you say as to its usefulness to man in early days of civilization?

II. What are the distinctive botanical characteristics of wheat?

What are some of its close relatives among our cultivated crops? Based upon the time of seeding, what groups of wheat are found in the United States?

III. Compare the roots of wheat with those of corn with respect to extent of development, location in soil, depth of penetration and size.

IV. Describe the appearance of the wheat plant during the early stages of growth. Where does growth take place resulting in the elongation of the stem? What is stooling, and upon what conditions does it depend? What is the proportion of grain to straw? What influences have fertilizers upon this ratio?

V. Draw on the board a spikelet of wheat showing all of the parts in their relative positions. How many spikelets grow from each joint of the rachis? What factors influence the number of spikelets per head? What is a sterile flower? Sterile spikelet? What are the common shapes of wheat heads? Are they variety characteristics or due to soil and climate?

VI. Compare the flowers of wheat with those of the corn plant. Is wheat cross-pollinated? Draw a longitudinal section of a wheat kernel showing the position of parts. What becomes of each part in the making of flour?

VII. Give the characteristics of each type of wheat. Give their distribution and uses.

VIII. Tell the story of the evolution of the flour mill. Describe briefly the process of modern milling, giving the various products resulting therefrom. What are the different grades of flour, and what determines them? Discuss the quality of bread made from the different bread wheats. What are the characteristics of a good bread wheat?

IX. What countries are the principal contributors to the world's wheat crop? What regions in the United States produce large amounts? How does the yield per acre of wheat in the United States compare with that secured in other lands? Why does the world at large manifest so much interest in the wheat crop? What can you say of the relation of production to consumption of wheat in the world to-day? What of the future? What bread-eating nations produce more wheat than they consume? Which are forced to import wheat to meet their needs?

X. Name the wheat districts of the United States, and describe the kind of wheat produced in each. What reasons are there for this condition? Why do buyers of wheat on the market pay so much attention to where the wheat was grown?

XI. What conditions of climate and soil are best suited for the production of wheat? Are these factors as important in the distribution of wheat as they are in the distribution of corn? How does climate affect the quality of the wheat produced?

XII. What place does wheat usually occupy in the rotation? Where is continuous culture of wheat in common practice?

XIII. What general principles of preparing the seed bed discussed in the chapter on Corn should be considered in preparing land for wheat? What important difference is to be considered in preparing land for corn and for wheat? How would one prepare an oat stubble for seeding wheat? A corn field?

XIV. How should seed wheat be prepared for sowing? Describe the formalin treatment for smut. Upon what factors does the time of seeding wheat depend? Does deep seeding protect wheat from freezing out during the winter? At what stage of development should wheat be harvested? What effect has exposure to weathering upon the crop?

XV. Why is the problem of wheat improvement so important? What methods may be employed? How should a variety test be conducted? What is the practical value of such a test? How does the head-row test of wheat differ from the ear-row test of corn? What points are considered by the miller in valuing wheat for the making of flour?

XVI. Give the life histories and methods of controlling the insect enemies of wheat. The fungous diseases.

CHAPTER VI

I. Tell something of the history of the cultivation of oats.

II. (*a*) Compare the botanical characteristics of oats with those of wheat. (*b*) What is a panicle? (*c*) What different type of panicles do we find in the oat plant? (*d*) Are oats likely to become mixed when two varieties are grown side by side?

III. (*a*) How does the thrashed grain of oats differ from that of wheat? (*b*) About what percentage of the total weight is hull? (*c*) What factors influence the percentage of hull? (*d*) What is the legal weight per bushel, and what variation from it may be expected? (*e*) What are clipped oats?

IV. How may oats be classified? What types are grown in your section?

V. Discuss use of oats as (*a*) feed for animals, (*b*) human food, (*c*) other uses.

VI. What are the leading oat-producing countries of the world? What part of the world's crop is produced in the United States? What states lead in the production? Compare yields per acre obtained in the United States with those of other countries. Does the United States export oats?

VII. Discuss the adaptation of oats to soil and climate.

VIII. What place may oats occupy in the rotation? (*a*) Discuss its usefulness as a nurse crop for grasses and clovers. (*b*) Discuss the preparation of the seed bed for oats, and the use of fertilizers and manures in oat culture. (*c*) What factors influence the time and rate of seeding? (*d*) Outline a method for the improvement of the oat crop.

IX. How would you treat seed oats to prevent loose smut?

CHAPTER VII

I. Discuss the ancient culture of barley, and compare it in this respect with that of wheat.

II. (*a*) Compare the botanical characteristics of barley with those of wheat and oats. (*b*) How do the spikelets differ from those of wheat and rye? (*c*) What percentage of the barley grain is hull? (*d*) How does the stage of maturity at which barley is harvested affect the character of the endosperm?

III. Describe the types of barley and the basis upon which the classifications are made.

IV. (*a*) Discuss the uses of barley. (*b*) What are important by-products of the malting process? (*c*) What advantages does barley possess over other cereals for malting? (*d*) What are the characteristics of a good malting barley?

V. (*a*) Compare the world's production of barley with that of wheat, oats and corn. (*b*) What are the leading barley producing countries? (*c*) What part does the United States play in the world's production? (*d*) Discuss the distribution of barley in the United States. (*e*) Exports and imports.

VI. Discuss (*a*) the methods of preparing land for barley, (*b*) time, rate and methods of seeding.

VII. What insect enemies and fungous diseases are troublesome in growing barley? How may they be controlled?

CHAPTER VIII

I. Discuss the culture of rye with respect to its (*a*) original home, (*b*) importance in early agricultural development, (*c*) importance in recent times.

II. Compare the botanical characteristics of rye with those of wheat.

III. Discuss the uses of rye (*a*) as human food, (*b*) as green manure and forage.

IV. (*a*) What is the world's production, and what countries are important producers of rye? (*b*) Discuss the production of rye in the United States with respect to (*a*) total production, (*b*) distribution, (*c*) yield per acre, (*d*) uses.

V. Compare the soil and climatic adaptation of rye (*a*) with those of wheat and barley, (*b*) with respect to cultural methods.

CHAPTER IX

I. (*a*) Discuss the early history of rice. (*b*) Compare it botanically with the other cereals.

II. (*a*) What are the important uses of rice? (*b*) How is it prepared for the market? (*c*) What are its by-products?

III. (*a*) Discuss the world's supply and demand of rice. (*b*) What countries produce it in large amounts? (*c*) How does the United States rank as a producer of rice? (*d*) Discuss its distribution in the United States. (*e*) Its yield per acre.

IV. (*a*) To what climate and soils is it adapted? (*b*) Compare the methods of its culture with those of wheat.

V. (*a*) Why is buckwheat classed with the cereals? (*b*) Compare its botanical characters with those of the cereals. (*c*) How does it thicken up a stand when seeded too thinly?

VI. What are the uses of buckwheat? How does buckwheat flour differ from wheat flour?

VII. Discuss (*a*) its production in the United States, (*b*) its cultural methods, (*c*) its yield per acre, (*d*) methods of harvesting.

CHAPTERS X AND XI

I. Discuss the history and common names of each of the following: (*a*) Timothy, (*b*) Kentucky blue-grass, (*c*) Canada blue-grass, (*d*) redtop, (*e*) orchard-grass, (*f*) Brome-grass, (*g*) the fescues, (*h*) Bermuda-grass, (*i*) Johnson-grass.

II. Discuss and compare the above grasses with respect to the following: (*a*) nature and extent of the root system, (*b*) nature and extent of the stem and leaves, (*c*) inflorescence, (*d*) seed, (*e*) length of life, and (*f*) influence of environment upon these characters.

III. Discuss and compare the distribution and adaptation of the above grasses with respect to: (*a*) soils, (*b*) climate, (*c*) factors limiting production, (*d*) distribution and value in the United States.

IV. Compare the methods of culture of the above grasses with respect to (*a*) preparation of seed bed, (*b*) time and rate of seeding, (*c*) use of nurse crop, (*d*) mixtures with other grasses and clovers.

V. Discuss and compare the (*a*) time of harvest, (*b*) quality of hay, (*c*) quality of pasture, (*d*)after growth, (*e*) number of crops, (*f*) yield and value.

CHAPTER XII

I. To what group of field crops do the millets belong? What determines their classification?

II. What are the fox-tail millets? Discuss the three varieties with respect to (*a*) general appearance and botanical characteristics, (*b*) earliness, (*c*) adaptation to soils, (*d*) to climate, (*e*) extent of culture, (*f*) use, (*g*) yield.

III. Compare the broom-corn millets with the fox-tails with respect to (*a*) botanical characteristics, (*b*) adaptation, (*c*) uses, (*d*) yield.

IV. Discuss the barnyard millets from the standpoint of (*a*) use as forage, (*b*) adaptation to soils and climate, (*c*) extent of culture.

V. Discuss the methods of seeding millets. Their harvest.

VI. What has been the probable origin of our cultivated sorghums? What are the groups of sorghums, and how do they differ in their botanical characteristics?

VII. Compare the saccharine and non-saccharine sorghums with respect to (*a*) adaptation to soil, (*b*) climate, (*c*) methods of culture, (*d*) uses, (*e*) extent of culture, (*f*) yield and value.

VIII. Compare the kafirs with the milo in respect to their (*a*) distribution, (*b*) adaptation, (*c*) cultural method, (*d*) uses and value.

IX. (*a*) What relationship exists between the millets and broom-corns? Give the botanical characteristics of the broom-corns. (*b*) Discuss them as to (1) adaptation, (2) extent of culture, (3) value, (4) cultural methods.

CHAPTER XIII

I. (*a*) Tell something of the membership of the Leguminosæ family. (*b*) How does the Papilionaceæ group get its name? In common usage the term "legume" refers to which members of the Leguminosæ family?

II. Compare the following botanical characteristics of the legumes with the grasses: (*a*) root system, (*b*) stem development, (*c*) leaves, (*d*) flowers, (*e*) fruit, (*f*) seeds.

III. Dissect a flower of the pea or bean, noting the arrangement of parts and their functions. How do we know that insects play an important rôle in the pollination of certain legumes.

IV. Tell the story of the discovery of the relationship of the legumes to the nodule bacteria. How do both the legume and the bacteria profit by their close relationship? Does each legume have a certain type of bacteria with which it lives in symbiosis?

V. How do the bacteria become distributed over such large areas? What methods of inoculation may be employed?

CHAPTER XIV

I. To what genus do the true clovers belong?

II. Discuss the history of the red clover. By what other names is it known? Answer the same questions for alsike, white, crimson and mammoth clovers.

III. Compare the following botanical characteristics of the above clovers: (*a*) root system, (*b*) extent and development of stems, (*c*) leaves, (*d*) flowers, (*e*) seeds, (*f*) length of life.

IV. Compare them with respect to (*a*) adaptation to soils, (*b*) climates, (*c*) rotations, (*d*) uses, (*e*) after growth, (*f*) methods and rate of seeding, (*g*) harvesting.

V. Give the life histories of the insect enemies of clovers. How may they be controlled?

CHAPTER XV

I. Discuss the history of alfalfa as a farm crop.

II. Discuss alfalfa with respect to (*a*) extent and development of root system, (*b*) stems and leaves, (*c*) flowers and seeds, (*d*) varieties.

III. What can you say of the distribution of alfalfa in (*a*) Europe? (*b*) South America? (*c*) The United States?

IV. What are its climatic adaptations? Discuss fully its adaptation to soils.

V. What are the principal uses of alfalfa? Why is it considered a valuable and profitable crop? Does it lend itself to short rotations?

VI. Discuss the cultural methods of alfalfa with respect to (*a*) preparing the land, (*b*) time of seeding, (*c*) rate of seeding, (*d*) use of nurse crop, (*e*) cultivation, (*f*) time of cutting for hay, (*g*) use as pasture, (*h*) cutting for seed, (*i*) yield of hay and seed.

CHAPTER XVI

I. Compare the two vetches with respect to (*a*) botanical characteristics of plant and seed, (*b*) cultural methods, (*c*) length of life, (*d*) distribution, (*e*) adaptation, (*f*) uses.

II. Give the botanical characteristics of the two sweet clovers. Discuss them with respect to (*a*) adaptation, (*b*) uses, (*c*) cultural methods.

III. Where are the following legumes grown, and of what importance are they in those localities: (*a*) Japan clover, (*b*) bur clover?

CHAPTER XVII

I. Compare the soy bean with the cowpea in respect to the following: (*a*) history, (*b*) botanical characteristics of root, stem, leaves and flowers, (*c*) varieties, (*d*) distribution, (*e*) adaptation to soils and climates, (*f*) uses.

II. Discuss them with respect to (*a*) cultural methods, (*b*) time and rate of seeding, (*c*) cultivation, (*d*) harvesting, (*e*) yield.

III. How does the field pea differ from the cowpea and the soy bean in respect to (*a*) general appearance, (*b*) botanical characteristics, (*c*) distribution and adaptation, (*d*) cultural methods, (*e*) uses, and (*f*) yield.

IV. Where are field beans and peanuts grown as farm crops? Discuss their adaptations and cultural methods. Their yield value and uses.

CHAPTER XVIII

I. What are the general characteristics of the root crops? What are the important root crops? What are the important groups of the beet family?

II. (*a*) How has the sugar beet been developed? (*b*) What is the sugar content of good beets? (*c*) What is the world's production, and what part of it is contributed by the United States? (*d*) What are the climatic and soil adaptations of the sugar beet? (*e*) Discuss the cultural methods of sugar beets with respect to (1) preparation of land, (2) time and rate of seeding, (3) cultivation, (4) harvesting, (5) marketing, (6) seed production.

III. Discuss the mangel-wurzel, carrot, turnip and rutabaga with respect to (*a*) adaptation, (*b*) cultural methods, (*c*) uses, (*d*) value, (*e*) yield.

IV. (*a*) Is rape a true root crop? (*b*) To what garden crop is it closely related? (*c*) Discuss rape with respect to (1) adaptation, (2) use as hay, (3) use as pasture, (4) cultural methods.

CHAPTER XIX

I. Tell something of the history of the cotton plant. (*a*) To what family of plants does it belong? (*b*) Give its characteristics, with respect to (1) roots, (2) stem and leaves, (3) boll and fiber, (4) seed. (*c*) Describe the three types of cotton.

II. What is the principal use of the fiber? How is the fiber prepared for the market? How is it manufactured into cloth?

III. What use is made of the cotton seed? What yield is secured per acre? What is its value?

IV. What is the world's production of cotton, and what part of it is contributed by the United States? What is the cotton belt of the United States?

V. Discuss the adaptation of cotton to soils and climate.

VI. Discuss its culture with respect to (*a*) preparing the land, (*b*) planting and cultivation, (*c*) harvesting.

VII. What are the troublesome insect enemies?

VIII. What are the distinctive botanical characteristics of flax? How does it thicken up a stand?

IX. What are the uses of the seed? What articles are made from the fiber? How is the fiber prepared for market?

X. Where is flax grown for seed? Where for fiber? Which is the most important use? What are the soil and climatic adaptations? Discuss the cultural methods employed.

XI. Discuss hemp with respect to (*a*) botanical relationships, (*b*) characteristics, (*c*) adaptations, (*d*) distribution, (*e*) uses, (*f*) cultural methods, (*g*) yield.

CHAPTER XX

I. Tell of the early history of potato culture in the United States and in Europe.

II. How does the United States compare with European countries as a producer of potatoes? In what states are potatoes an important field crop, and what are their acre yields?

III. How is the potato propagated? What is the tuber? Where is the seed produced? Why is it not used in propagation? Compare the chemical composition of the potato with that of corn.

IV. Discuss the types of soil best suited for growing potatoes. What place do potatoes occupy in the rotation?

V. What is sun sprouting? What are its advantages? Compare Northern grown with home grown seed.

VI. What is the usual rate and depth of planting potatoes? What fertilizers may be used to advantage?

VII. What are some well-known varieties of potatoes? Which ones are grown in your locality?

VIII. Discuss the "running out" of potatoes.

IX. When should potatoes be harvested? What sort of machinery may be employed in harvesting them? Discuss the storing of potatoes.

X. Give the life histories and methods of controlling the insect enemies of potatoes. The fungous diseases.

CHAPTER XXI

I. What importance does the farmer usually attach to the meadows and pastures in comparison with other field crops? What has been the result?

II. Discuss their fertilization with manure and chemical fertilizers. Results of continuous cropping without fertilization.

III. What are the advantages of grass and legume mixtures for (*a*) hay, (*b*) pasture? What factors must be considered in forming the mixtures?

IV. How may grass and legume seed be tested for germination? For purity? Are these tests important?

V. Discuss the care of grass lands for best results. How would you go about improving a run-down meadow or pasture?

VI. Can you plan a scheme by which temporary pasture may be available throughout the growing season?

VII. What is the value of substitute hay crops?

CHAPTER XXII

I. What has made possible the great specialization in crop production that is found to-day? Why was this impossible in the early days of agricultural development?

II. What are the three types of country elevators? What is their function, and how are they of service to the farmer? Discuss the methods of management of each type.

III. What is a terminal market? A terminal elevator? What function does the latter perform?

IV. Why is grain graded on the market? How is it done? What are the methods of sale at the terminal market? The kinds of contracts? Systems of credit? Upon what does the price of grain depend?

V. How does our surplus grain reach the foreign markets?

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