Issued November 30, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 260.

B. T. GALLOWAY, *Chief of Bureau.*

THE AMERICAN BEET-SUGAR INDUSTRY IN 1910 AND 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 18, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 260 of the series of this bureau a manuscript entitled "The American Beet-Sugar Industry in 1910 and 1911," prepared by Mr. W. A. Orton and other workers in this bureau.

This continues the series of reports on the progress of the beet-sugar industry issued by the department for several years past.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE AMERICAN BEET-SUGAR INDUSTRY IN 1910 AND 1911.

THE WORK OF THE BUREAU OF PLANT INDUSTRY ON SUGAR BEETS.

GENERAL STATEMENT.

The work of the United States Department of Agriculture on sugar beets is centered in the Bureau of Plant Industry in so far as it relates to problems of crop production, such as culture, improvement, extension of area, and control of diseases.

Other bureaus of the Department of Agriculture handle other phases of this industry. The Bureau of Chemistry, through its Sugar Laboratory, investigates the methods of analyzing beets and the other products of manufacture, and investigates also the manufacturing processes as they affect the composition of the finished product and by-products. It also investigates the chemical composition of beets grown in various localities, with special reference to the effect of environment on the same, and is making studies of the rarer carbohydrates as they occur in the various products of the industry; the Bureau of Entomology deals with all insect enemies of the sugar beet; the Bureau of Statistics compiles the statistics of the sugar industry in connection with its work on other crops; while the Bureau of Soils has included in its soil surveys several important sugar-beet areas.

The sugar-beet work of the Bureau of Plant Industry is conducted under the clause of the appropriation act reading, "For the investigation and improvement of sugar-producing plants, including their utilization and culture." This includes studies of sugar cane and other minor sugar plants.

For purposes of administration this work is united with that on cotton and truck-crop diseases, forming the "Office of Cotton and Truck Diseases and Sugar-Plant Investigations," which is one of 30 subdivisions of the Bureau of Plant Industry. Other offices cooperate to promote the sugar-beet work. The Office of Farm Management conducts studies of farm organization and farm practices in sugar-beet districts; the Office of Congressional Seed Distribution furnishes seed for trials in new localities and assists in the breeding and production of American beet seed and the cooperative trial of standard varieties; the Office of Western Irrigation Agriculture carries cn at its field stations on the reclamation projects a number of cultural experiments with sugar beets; and the Office of Dry-Land Agriculture does similar work at its field station at Mitchell, Nebr. Assistance is also rendered by the Laboratory of Plant Pathology in dealing with bacterial diseases of beets and by the Office of Agricultural Technology on diseases due to nematodes. The Office of Drug-Plant, Poisonous-Plant, and Physiological Investigations is just completing a study of the relation of oxidases to the curly-top of beets. The large and highly specialized organization of the Bureau of Plant Industry and the cordial cooperation of other bureaus in the Department of Agriculture give it unusual advantage in attacking problems requiring the combined attention of specialists in several lines.

OUTLINE OF PROJECTS.

The work on sugar beets falls into four groups of projects: Culture, Diseases, Improvement, and Extension.

BEET CULTURE.

The cultural work is at present done mainly in the western irrigated districts by Dr. C. F. Clark, Dr. C. O. Townsend, Mr. Harry B. Shaw, and others. It includes studies on the depth of plowing, the distance of planting, cultivation methods, the water requirements of beets, and the most effective rotations. Uniform standardized experiments covering these points are under way at the principal stations. All this work is comparatively recent, as it requires field stations, which were not available during the earlier years.

Closely affiliated with this line of work are the farm-management studies and beet-farm surveys being made by Mr. L. A. Moorhouse. The office also has a representative, Mr. E. C. Rittue, detailed for demonstration work in the Arkansas Valley, with headquarters at Holly, Colo.

BEET DISEASES.

The investigations on sugar-beet diseases are older, dating back to July 1, 1901, when Dr. C. O. Townsend began his work. The principal troubles include:

(1) The leaf-spot (*Cercospora beticola*), which occurs in the Eastern States and as far west as Colorado. It has been shown that this disease can be controlled in Michigan by spraying with Bordeaux mixture and a bulletin is in preparation by Dr. Townsend giving the results of early experiments. The serious epidemics of recent years in the Arkansas Valley have led us to undertake an exhaustive study

of this disease and its relation to environmental factors, in the hope of discovering methods of control better suited to western field conditions. This work is now centered at Rocky Ford, Colo., in charge of Miss Venus W. Pool, who is assisted by Mr. M. B. McKay.

(2) Curly-top, a disease induced by the attack of the leaf hopper (*Eutettix tenella*), received much attention during the years 1902 to 1909. At present the control of this trouble is under investigation by the Bureau of Entomology, but the Bureau of Plant Industry is endeavoring to learn the real nature of the effect produced by the insect. Work on the curly-top is being done in the field by Mr. Shaw and in the laboratory by Mr. F. J. Pritchard and Dr. E. W. Olive, of the South Dakota Agricultural Experiment Station.

(3) Damping-off, or seedling troubles, and root-rot have been studied at intervals for some years. This line of work has been extended and will occupy the entire time of Mr. H. A. Edson.

(4) Crown-gall and another related bacterial disease have now been studied quite exhaustively by Dr. Erwin F. Smith, Dr. Townsend, and Miss Nellie A. Brown. Important as is this disease to other plants, it is not serious on sugar beets, and our work on this and other minor beet troubles is at present limited, in order to concentrate our efforts on important projects.

(5) The sugar-beet nematode (*Heterodera schachtii*) and the root-knot nematode (*H. radicicola*) were found some years ago by Dr. Ernst A. Bessey to threaten to establish themselves in our beet districts; hence, in order to adequately plan measures for their control, a general survey of the situation is being made the present summer by Mr. L. P. Byars.

IMPROVEMENT OF THE SUGAR BEET.

The improvement of the sugar beet by breeding includes several related projects under the general charge of Mr. Pritchard, with the cooperation of other members of the staff.

The most important project is that for the production of American varieties adapted to our various climatic conditions. This work has been under way for several years, with the principal center at Fairfield, Wash., in cooperation with Mr. E. H. Morrison and under the general direction of Mr. J. E. W. Tracy. The work in Washington has now been completed and the field headquarters removed to Madison, Wis., with branches at several other points. Mr. J. F. Reed, who has been employed on this work for some years, has resigned to engage in private work and is succeeded by Mr. C. M. Woodworth, formerly of the South Dakota Agricultural Experiment Station.

The results of the single-germ breeding, to which attention has been drawn in previous reports, are now being reviewed, to secure an accurate measure of the progress attained. The details of this work have been attended to, for the most part, by Mr. Rittue and Mr. J. M. R. Adams.

In all the beet breeding the results are being recorded in a way that will throw light on the fundamental principles of heredity involved.

To promote the establishment of an American beet-seed-growing industry, the bureau is testing the adaptability to this crop of a number of different localities, including the Shenandoah Valley of Virginia and points in Wisconsin, Michigan, Utah, and other States.

The laboratory equipment needed to make the analyses for the breeding work outlined is quite extensive. Provision will be made by Mr. W. B. Clark for making 60,000 determinations of sugar content at Madison and a somewhat less number, with other coordinate tests, at Garden City, Kans., in addition to those done for us by the Bureau of Chemistry at Washington.

EXTENSION OF THE BEET-SUGAR INDUSTRY.

Much work is done each year on the extension of the beet industry. Seeds are sent out to cooperating farmers, with directions for beet culture, and samples are obtained in the fall for analysis. By these means, supplemented by field surveys, information is secured concerning the adaptability of new sections to beet growing. There is a heavy correspondence on many questions of a varied and general nature.

VARIETY TESTS.

For several years the bureau has conducted comparative tests of the standard varieties of sugar beets. All those kinds or brands in use by two or more sugar companies in the United States are included. Only 11 varieties are included in the tests of the present season, and these varieties are planted at the following points: Holland, Blissfield, and St. Louis, Mich.; Decatur, Ind.; Waverly, Iowa; Madison, Wis.; Garden City, Kans.; Rocky Ford, Holly, and Longmont, Colo.; and Ogden, Utah. Mr. Tracy has had supervision over this work since its inception.

FIELD STATIONS.

The principal points where field work is being done are Garden City, Kans., Madison, Wis., Ogden, Utah, and Rocky Ford, Colo., as follows:

Garden City, Kans.—In cooperation with the United States Sugar and Land Co. Here a new brick laboratory building and 20 acres of land are furnished by the cooperators and the bureau maintains a staff of three or four workers. The character of the building is shown in figure 1. This laboratory is in charge of Dr. Townsend.

Madison, Wis.—In cooperation with the United States Sugar Co. Rented quarters in the factory building are utilized as a chemical and breeding laboratory. The field work is on rented land near by. The pathological studies of Mr. Edson on damping-off and root-rot are being conducted in the laboratory of the University of Wisconsin.

FIG. 1.—Sugar-beet laboratory at Garden City, Kans.

Ogden, Utah.—Work by Mr. Shaw and Mr. Adams on beet culture and breeding and on curly-top is under way on 5 acres of rented ground.

Rocky Ford, Colo.—In cooperation with the American Beet Sugar Co. For the leaf-spot investigations a special laboratory, in charge of Miss Pool, is maintained at this point in the building of the cooperating company. A greenhouse has been built for the work and additional field plats are utilized as needed.

GENERAL REVIEW OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.

By W. Blair Clark,

Assistant Chemist, Office of Cotton and Truck Diseases and Sugar-Plant Investigations.

INTRODUCTION.

As a result of the development of beet growing in Europe it was early concluded that the most favorable belt for the production in this country would be found to lie along either side of the summer isothermal line of 70° F. The earlier publications of the Department of Agriculture on the subject of sugar-beet growing[1] contained maps showing the location of this theoretical sugar belt. This isothermal line is also shown on the two maps which accompany this article, but it is felt that the growing of sugar beets here has now developed to a stage at which we can profitably place the emphasis on those places where success has actually been attained on this continent.

At the present time commercial sugar-beet growing in the United States has been somewhat extensively developed in three main localities, which may be conveniently designated as the California, the Intermountain, and the Great Lakes regions. Beet growing is conducted in the southern and central parts of California. The Intermountain region includes Colorado, Utah, and Idaho, with recent outlying developments in extreme western Kansas and Nebraska, with possible development in Nevada in prospect. The Great Lakes region includes Michigan and Wisconsin, together with adjacent parts of Ohio, Indiana, and Illinois. Besides these three thoroughly established sections, there are a few scattered factories, some of which give indications of considerable future growth in the localities represented, while the experience of others seems to show that little can be expected from the sections where they are situated. The most promising of these isolated factories are in the upper Mississippi and the Missouri Valleys, in Minnesota, Iowa, southeastern Montana, and eastern Nebraska.

[1] Bulletin 52, Division of Chemistry, U. S. Dept. of Agriculture, 1897.

CLIMATOLOGICAL CONDITIONS.

In the two accompanying maps (Pls. I and II, in pocket) the beet-growing sections of the several States are shown shaded in red, and the factory locations are given in the same color. A few factories were not operated the past season, and these locations are designated by circles instead of solid dots. Factories which have been permanently closed or dismantled within the last few years are shown in black. No effort has been made to show the locations of the earlier factories that failed.

In explanation of the shading which shows the beet-growing areas it should be said that these sections are indicated only in a general way. On a map of this scale it would be impracticable to do more than to indicate in a general way the counties and parts of counties where beets are produced in a greater or lesser quantity. In California, for example, except in the section around Los Angeles, the country is quite rough and the agricultural operations are of necessity confined to the valleys and the lower slopes. In the Intermountain region the same condition prevails, with the additional restriction that the ground must lie so that it can be irrigated. In the Great Lakes region, where considerable areas are covered by shading, it must be remembered that not every farm grows beets and that some parts of counties thus shown may produce few or none.

RAINFALL.

On Plate I the heavy red lines show the mean annual rainfall in inches for the different parts of the country. For example, all the localities where the average annual rainfall is 40 inches are joined by one of these lines; all localities where the average is 35 inches are joined by another line. All points located between these two lines have an annual precipitation averaging between 35 and 40 inches. By devoting a little study to these lines the reader can readily compare the rainfall in different parts of the country.

But in studying rainfall it is not sufficient to know merely the total annual precipitation for a given locality. There are two other points a knowledge of which is of equal importance with this. These are the distribution of the rainfall throughout the year and the expected variation from the mean. The beet crop for its proper growth and maturity requires a good supply of moisture during the planting and growing seasons, but it will not begin to store sugar in quantity until the beets have been subjected to a season of dry weather at the end of their growing period. Last year the Arkansas Valley crop was materially reduced because of the lack of irrigation water in abundance early in the season. In the Great Lakes region, on the other hand, prospects for a bumper crop were effaced by rains which continued throughout most of the harvesting period.

The average rainfall for each month and the frequency with which variations from this average may be expected to reach a given value at a number of selected stations in the beet-growing regions are shown graphically along the upper and lower margins of Plate I. The zigzag line that delimits the colored portion of each diagram indicates the mean precipitation for each month of the year as determined from observations extending over the number of years shown by the figures in heavier type at the bottom of each column. The scale of inches by which the zigzag line is located may be seen along the left margin of the diagram. Small light-face figures in the columns for the various months (those above the red being just above the scale lines, while those within the colored portion are just below these scale lines) show the number of seasons of the entire number on record in which the rainfall during the particular month noted was more or less than the number of inches indicated by the line to which the figure is adjacent. Perhaps this explanation can be better understood by citing a concrete example. Referring to the diagram relating to Findlay, Ohio, it will be observed that the highest average rainfall of the year occurs in June, the precipitation for that month being 4 inches, as shown on the scale. The number at the bottom of the column is 19, such being the number of years covered by the records from which this average was calculated. Now, in this same column the figure "5" just above the line indicating a 5-inch precipitation means that in 5 seasons out of the 19 on record the June rainfall was more than 5 inches; similarly the "1" above the 8-inch line means that in only one of these years did it reach or exceed 8 inches. Passing below the red margin, the "9" just below the 3-inch mark indicates that in 9 out of the 19 years June had less than 3 inches rainfall; while the "0" a little lower in the column shows that not once during the whole period did the precipitation fail to reach 1 inch for the month, although in both February and October the precipitation was less than 1 inch in 4 of the 19 years.

Thus, one can ascertain from these diagrams not only the mean precipitation for each month of the year, but also the number of seasons in a series in which the variations from this mean will be extreme, this latter constituting one of the essential factors in calculating the average crop results of a period of years. It remains but to add that the stations for which these diagrams have been prepared are fairly typical of the sections in which they are located. The first four, for example, all belong in the southern section of the Great Lakes region, previously defined, and it will be readily seen that they are quite similar, both as regards the mean monthly precipitation and the variations therefrom.

LENGTH OF THE GROWING SEASON.

The length of the growing season is another element in determining crop results. This subject is treated graphically on Plate II. The heavy red lines on the map connect points having growing seasons of equal average length, ranging from the shortest season in the North to those of greatest length in the South. As the length of the growing season is chiefly limited by the latest killing frosts in the spring and the earliest in the fall, tables are printed on the margin of this map showing such data for a number of selected stations in the beet-growing sections.

The frost data for 43 selected stations is given in tabular form on the lower margin of the map. In this table the first line of figures shows the number of years during which the record has been kept. Three dates in the spring have been arbitrarily selected, and in the column devoted to each station the number of seasons of those on record in which the last spring frost was subsequent to these dates has been entered. Thus, at Findlay, Ohio, in 13 of the 19 on record, killing frosts occurred after April 30, while in only two years such frosts came later than May 20. Similarly, only once did a killing frost come before September 20, while 10 are recorded previous to October 5. As only one of these frosts was before September 20, it is obvious that the remainder, i. e., 9, occurred between September 20 and October 5. In other words, practically half the growing seasons at this station are terminated between September 20 and October 5, and one-fourth of the seasons end between October 5 and 20.

Passing to the lower lines of the table, showing variations in the length of the growing season, it is observable that at no time during the 19 years of the record at Findlay was the season less than 130 days. For 8 years, or nearly half the number recorded, the period during which active growth might continue was between 150 and 170 days. A very cursory study of this chart will show that, excluding the subtropical Arizona and California sections, practically all our sugar beets are grown in places where the length of the season is seldom less than 130 or more than 170 days.

PROGRESS IN THE SECTIONS.

Following the above general survey we may now enter into a more detailed discussion of the several regions mentioned.

CALIFORNIA.

California was the first State in which commercial success was assured by the establishment of satisfactory relations between technically equipped growers and manufacturers, although it was not the first State in which efforts were made to produce beet sugar. The factory at Alvarado is the oldest in the United States now in operation. During the 1911–12 campaign 10 factories in the State were making sugar. As may be seen on Plate I, some of these factories are quite closely bunched; whether too closely for the good of the industry remains to be seen.

The exceptional soil and climatological conditions in California seem peculiarly adapted to the production of beets with a high sugar content. While their reported yield per acre is not so great as that of some other States, the sugar content is decidedly in excess of any other, so that with an acreage considerably less than that of Michigan the total yield of sugar is much more. The calculated yield per acre for the past season was very nearly 3,310 pounds. Many of the California soils are very retentive of moisture, so that with an annual rainfall far below that of the central and eastern part of the country beets can be grown successfully without irrigation. The little rain which they have is usually so nicely distributed through the early and middle seasons of growth as to leave almost ideal conditions for the period of ripening, with its accompanying storage of sugar in the cells. This ripening process is also materially assisted by the alternation of cool nights and warm days, a condition which seems best suited to the formation and storage of sugar in this plant.

Beets are reported as being grown in practically every one of the western counties from Alameda, which touches San Francisco Bay, south to San Diego, while Glenn, Butte, Solano, and Yolo Counties are listed in the reports of the Sacramento River valley.

Statistics for the entire production of this and other States are given in Table X (pp. 69–70), while the climatological data are shown on Plates I and II (in pocket).

THE INTERMOUNTAIN REGION.

The principal beet-growing territory of the intermountain region is included in Colorado, Utah, and Idaho, with outlying sections in western Kansas and Nebraska. There is also a small section in eastern Oregon, on which the 1911 crop was probably the last that will be raised, and a new factory has just been completed at Fallon, Nev. It is expected that the coming crop will open the production for the last-named field. This entire region is a part of the country where successful agricultural operations are dependent upon irrigation. It may be conveniently subdivided into the Salt Lake section, including central and northern Utah and the southeastern corner of Idaho; the Grand Valley in western Colorado, the Rio Grande and San Luis Valleys in south-central Colorado, the Arkansas Valley in southeastern Colorado and southwestern Kansas, the Platte Valley in northeastern Colorado and western Nebraska, and the Snake Valley in southern Idaho and eastern Oregon. The expectation is that the Carson Sink area will furnish most of the beets for the Fallon, Nev., house.

Salt Lake section.—The beginnings of successful sugar production in the Salt Lake section were at Lehi, Utah, in 1891. The next factory was built at Ogden in 1898, and the remaining mills have been erected since 1901, that at Elsinore, which began to make sugar during the 1911–12 campaign, being the most recent addition.

In many ways the conditions in this section seem almost ideal for farming. With a rich fertile soil and abundant irrigation water under complete control, the farmer is enabled to handle his crops to the very best advantage possible. However, it is not an unmixed good, for this section is occasionally subject to blighting winds and unseasonable frosts which play havoc with the crops. Sometimes, also, the mountain rainfall and snowfall, which supply the irrigation water, are deficient. On the whole, however, the conditions are among the best that are to be found anywhere, and while the sugar content of the beets is not quite so good as in California the yield of beets per acre is better. During the past season the estimated yield of sugar per acre was about 3,275 pounds, which is not far short of the California figure.

A noticeable feature of the Utah and Idaho production is the smallness of the individual growings. The plats probably do not average more than 5 acres each. In this way practically the entire work of planting, cultivating, and harvesting is kept within the grower's family, so that the labor problem is much less acute than in some other sections.

During the past season beets were grown in Boxelder, Cache, Weber, Davis, Salt Lake, Utah, Wasatch, Carbon, Sanpete, and Sevier Counties in Utah and in Oneida County, Idaho.

Grand Valley.—Only one factory is located in the Grand Valley, that at Grand Junction, Colo. It began operations in 1899. While this section is comparatively small in acreage and tonnage, it is reported to be gradually increasing. The length of territory covered, however, is quite extensive, some shipments being made from points a hundred miles distant. The growing is confined, of course, to the valleys. Delta, Mesa, Montrose, and Garfield Counties in Colorado and Emery County, Utah, are all represented.

Rio Grande and San Luis Valleys.—The factory at Monte Vista, Colo., made its first run during the season just closed. It opens up a new territory in the San Luis and upper Rio Grande Valleys. Beets for the first campaign were grown in Rio Grande, Saguache, and Costilla Counties.

Arkansas Valley.—The entire growth of the industry in the Arkansas Valley section has taken place since 1900, the year in which the two oldest factories, those at Rocky Ford and Sugar City, began slicing. Seven factories now operate in this territory, including the one at Garden City, Kans. For economic reasons one or two of them did not run during the past season. Owing to a short crop it was cheaper to transport beets to one factory and keep it busy rather than to operate two, both on part time.

The beets of this section are grown in El Paso, Pueblo, Otero, Crowley, Bent, and Prowers Counties, Colo., and in Hamilton, Kearny, Finney, and Gray Counties, Kans. In another article in this report Mr. Moorhouse gives an interesting discussion of the conditions in this valley; hence nothing further will be said here on the subject.

Platte Valley.—The Platte Valley territory in northeastern Colorado and western Nebraska contains 10 factories, all under the management of one company. The oldest of these factories began slicing in 1901. The beets of this section are grown in Larimer, Weld, Adams, Morgan, Washington, Logan, and Sedgwick Counties, Colo., and Scotts Bluff County, Nebr. The past season is reported as about normal in the total quantity of beets produced, while the quality was improved and the crop worth more to the growers. It would appear that concerted action on the part of the Colorado growers has enabled them to command a somewhat better price than formerly for their output.

Snake Valley.—In the Snake Valley territory the only encouraging signs at present are in eastern Idaho, factories being at Sugar City, Idaho Falls, and Blackfoot. The counties supplying beets for these three centers are Bonneville, Fremont, Bingham, and Cassia. Production began in 1903, since which time both the quantity of beets grown and the price paid to the farmers for them have increased. The establishment of a factory at Nampa, in western Idaho, seems to have been ill advised. No efforts were made to grow beets there for the past campaign. Operations at La Grande, Oreg., have also been discouraging. The short run made there the past season is reported to be the last, as the factory is to be moved to Burley, Idaho. The beets were raised in Union and Wallowa Counties.

Statistics pertaining to production in the Intermountain region are given in Table X.

THE GREAT LAKES REGION.

For convenience the Great Lakes region may be subdivided into an upper and a lower section. The former includes the northern parts of Michigan and Wisconsin, while the latter takes in the southern portions of these two States and northern Ohio, Indiana, and Illinois. The first commercial experiments which really foreshadowed the success of the beet-sugar industry were made in this region, but the success portended by those experiments was not actually forthcoming here until after it had been attained in the West. While the oldest of the present factories dates only from 1899, no less than 25 operated in this territory last season, and several others are projected for the near future.

Conditions in this region are, of course, quite different from those in the Snake Valley, particularly with regard to moisture. This region being in the humid section of the country, irrigation is not practiced. Normally, the length of the growing season is sufficient and the rainfall is ample and suitably distributed throughout spring and summer, with dry, increasingly cool, fall weather to afford conditions needed for maturing sugar. It is to be noted, however, that in the case of the last crop this normal condition of affairs was seriously altered. A fine growing season was followed by an unusually rainy ripening and harvesting period, so that what had given promise of being the greatest crop ever produced turned out very poor in quality, although of fair tonnage. Many tons of beets were so poor that the factories were unable to work them after having received and paid for them.

In Michigan and Wisconsin beets are raised in practically all except the extreme northern counties; they have been introduced into most if not all of the northwestern counties of Ohio; and the number of growers throughout the northern counties of Indiana and Illinois is increasing sufficiently to justify further investment in factories.

So far, the development has been very much less in the upper section than in the lower. Only three of the factories, those at Charlevoix and Menominee, Mich., and Chippewa Falls, Wis., are in this section; and it is reported that the factory at Charlevoix is soon to be moved to Ohio. The factory at Menominee, Mich., receives its beets chiefly from Wisconsin, some coming from as far south as the middle of the State. Expansion in the Lakes region seems to be tending southward rather than toward the north. The factory at Findlay, Ohio, made its first run for the 1911–12 crop; others are building at Rossford (near Toledo), Ohio, and Decatur, Ind., while plans are being promulgated for still others at Pigeon, Mich., and Columbus and Ironville (Toledo), Ohio.

Production and other statistical data are given in Table X, while information concerning the climatology is given on Plates I and II.

ISOLATED FACTORIES.

A few widely separated factories remain for detailed consideration. With but one exception these factories are all located in what may ultimately develop into the most extensive beet-growing territory in the United States, the Missouri-Mississippi Valley region. At present this portion of the country is devoted chiefly to extensive methods of agriculture, but with the continued growth in population, involving both a larger number of people per square mile and the need for a greater quantity of food, more intensive methods will become necessary. And in the drift toward such methods sugar beets will undoubtedly become of increasing importance.

Minnesota.—One of these scattered factories is at Chaska, Minn. The beets are being grown for it in Carver, Scott, Le Sueur, Rice, McLeod, and Martin Counties. The tonnage per acre and the sugar content have both been good, and it is expected that the 1912 crop will be more than double that of 1911.

Iowa.—Beets for the factory at Waverly, Iowa, come from Mitchell, Humboldt, Hardin, Wright, Cerro Gordo, and Butler Counties. This area covers a range wide enough to supply more than one factory when a sufficient number of farmers in these counties can be induced to make contracts. Neither the yield nor the quality reported for the past season was of the best, but this factory began slicing only in 1907, and reports show that in that time both the yield and the quality have been improving. The experience of all localities goes to show that it takes several seasons of trial before the farmers generally are able to produce really good beets in profitable quantity.

Nebraska.—The small factory at Grand Island, Nebr., has been in operation since 1890, but for some reason growth in that section has not been very rapid.

Montana.—The factory at Billings, Mont., is one of the largest and is said to be one of the most profitable in the country. Most of the beets are grown in Yellowstone County, a few in Carbon. For the past season a greater yield than ever before was reported and of greater value per ton to the grower. The beets of this section are the only ones that rival those of California in sugar content.

Arizona.—The factory at Glendale, Ariz., has operated under more or less disadvantageous conditions ever since its establishment in 1904. Uncertainty about irrigation water has made it difficult to obtain a sufficient acreage. Last year the yield per acre was fairly good, but the sugar content was not of the best; yet improvement in these respects is noted.

Canada.—Three factories are operated in Canada. Two factories are in the Province of Ontario, at Wallace and Berlin; the third is at Raymond, Alberta. The last mentioned has not been heard from at this writing, but the factories at Wallace and Berlin both report an increase in the yearly output. At Berlin in particular, the tonnage of beets in the 1911–12 campaign was nearly double that of the previous one and almost trebled that of 1909–10.

BY-PRODUCTS.

Considerable advance has been made in this country in the use of the by-products of the beet-sugar industry, but we are still far behind Europe in this important respect. For the present at least, the tops and pulp are the most important of these by-products. But the molasses, where recovery processes are not used, the exhausted lime, and the waste wash waters from the factories are of value.

TOPS.

A crop of 12 tons per acre of beet roots, containing about 22½ per cent of dry digestible substance, is accompanied by about 9.6 tons of fresh tops, containing approximately 15 per cent of dry digestible substance. This gives a total of 4.14 tons of dry digestible substance per acre, a growth that is equaled by few if any other farm crops.

At present practically the only manner in which the nutritive value of these tops is utilized is by feeding them on the field. Under such conditions their market value is reckoned at $2 to $4 per acre. This practice is decidedly wasteful, however, and their value would be much greater if siloed in trenches and fed to the stock gradually and in a way that would avoid the loss due to trampling underfoot by the cattle. There are few cases wherein the saving effected would not more than balance the cost of siloing the tops.

Taking $3 per acre as the average market value of the tops when fed in the field, the 1911 crop of 473,877 harvested acres would have an estimated value slightly in excess of $1,420,000, while that of the 1910 crop would have been a little less than $1,200,000.

PULP.

At the present time three methods are practiced for the utilization of the exhausted pulp. In two of these methods the pulp is used wet and in the third it is dried. In one of the wet methods the water with which the pulp is flushed out of the diffusion cells (with still more added if necessary) is used as a floating medium with which to pump it out into large pit silos, where after fermentation it is fed to fattening cattle. In some instances this feeding is done by the sugar company as a side issue to its own operations, while in other cases the pulp is sold to cattle feeders who have their pens near the factory.

By the other wet process the pulp flushed out of the diffusion cells is drained and squeezed slightly, from which there results a mass containing about 90 per cent water and of which the weight is about 40 per cent of that of the beets from which it was produced. In this condition the pulp can be transported for short distances either in bags or bulk, and when so treated it is usually sold to neighboring farmers, who haul it home and feed immediately or silo it.

The present selling price of such pulp ranges from 25 to 35 cents per ton. In making up the estimates here given it is taken at 30 cents per ton.

The 10 per cent of dry substance in the squeezed pulp is about one-tenth protein and nine-tenths carbohydrates. Most of it is fed after fermentation in the silo, which involves considerable nutritive loss. A much more economical method of handling is to dry the pulp before it has had an opportunity to ferment. A number of factories now follow this method. The dried material contains about 8 per cent digestible protein and from 70 to 80 per cent of digestible carbohydrates. Pound for pound, its dry substance is of greater food value than that of fermented pulp. In use it should be wet before feeding. This dried pulp is found to be particularly valuable as a dairy feed. Like corn silage, it may be used to lessen the amount of corn, bran, and other concentrates in the ration.

One ton of beets will produce approximately 90 pounds of dried pulp. Of the 5,062,333 tons of beets sliced during the 1911–12 campaign very nearly 1,850,000 tons were worked in factories which report pulp driers as a part of their equipment. From these figures it is estimated that about 83,000 tons of dried pulp were produced during the campaign. A conservative estimate would place the factory value of this pulp at $15 per ton, which would make the aggregate value of dried pulp $1,245,000. The remaining beets, somewhat in excess of 3,200,000 tons, would have made more than 1,285,000 tons of wet pulp, with an estimated value of $385,580, which, added to the value of the dried pulp, makes a total of $1,630,580 for all pulp.

MOLASSES.

Factories using the Steffens osmose recovery process have practically no molasses left. With the osmose process about 2 per cent remains, while where such processes are not in use the exhausted molasses, under favorable operating conditions, amounts to about 3 per cent of the weight of beets sliced. Sometimes, where the purity has been low or the beets have been injured by late rains or early freezes, the molasses may reach double this figure. Of the more than 5,000,000 tons of beets handled during the last campaign, nearly 2,830,000 tons were sliced by factories which do not report the operation of either of the recovery processes mentioned. Of this amount, 1,320,620 tons were worked in the southern part of the Great Lakes region, where conditions were abnormally bad for the season, and from the somewhat incomplete data at hand it has been estimated that their molasses output was 4.5 per cent of the weight of the beets. This would give approximately 59,428 tons of molasses, which at a factory valuation of $10 per ton would have a total value of $594,280. In the Western States, where the season was more favorable to the production of good beets, 1,508,798 tons were sliced, the quantity of molasses being about normal. For the figure mentioned, i. e., 3 per cent of the weight of beets, this would give 45,264 tons, with a factory value of $452,640. Adding these two amounts gives $1,046,920 as the total estimated value of the molasses production.

This molasses contains about 50 per cent by weight of sugar and a varying proportion of alkaline and alkaline-earth salts of organic acids. It finds a somewhat varied use, a portion being fermented for the manufacture of alcohol and vinegar. It is being increasingly used for feeding purposes, as at the present price of $10 to $10.50 per ton it constitutes one of the cheapest elements of a mixed feed. Experiments have shown that in the feeding of draft animals molasses can be substituted for grain, pound for pound, up to about 4 pounds per day per head. On most of the Cuban plantations all of the draft and riding animals, including horses, mules, and oxen, receive no feed whatever during the six months' harvest season except molasses and sugar-cane tops.

Feeding tests show that molasses possesses a tonic value in addition to the nutritive value of its contained carbohydrates. Besides being a good energy-producing feed for draft animals, it increases the milk production of cows and improves the appetite of fattening steers causing them to eat more heartily of other feed.

LIME AND WASTE WATER.

So far, the lime and waste-water by-products of the sugar factory have been but little utilized in this country. In only a few sections is their fertilizing value beginning to be appreciated. Where lime is needed, and many farmers who do need it fail as yet to recognize the fact, that from the sugar factory supplies the need in a cheap and efficient form.

The waste water from the factory also possesses considerable value for fertilizing purposes, although it can not be profitably conducted to any great distance from the factory. In using it care should be exercised lest it infest the ground with weeds. It is pretty sure to carry some seeds, as it contains the washings from the uncleaned beets, and if these seeds are present in considerable quantity the expense involved in counteracting their distribution over the ground may more than offset the fertilizing value of the water.

SUMMARY OF THE BY-PRODUCTS.

In the following summary of the by-products, as at present utilized, it must be remembered that the returns on which such estimates are based are as yet quite incomplete; hence the figures must be looked upon as only rough approximations. With this understanding, the values previously given are here brought together in the following statement:

Approximate value of the by-products of the sugar-beet industry, 1911–12.

Tops, at $3 per acre	$1,420,000
Dried pulp, at $15 per ton	1,245,000
Wet pulp, at 30 cents per ton	385,580
Molasses, at $10 per ton	1,046,920
Total	4,097,500

COST OF GROWING SUGAR BEETS.

No special effort has been made to collect an exhaustive amount of data upon this subject, but the receipt of many inquiries on the subject has shown a demand for the data presented in Table I. The figures are believed to be both typical and reliable for the places indicated. In the three columns headed "Great Lakes section," the subheadings "Minimum," "Average," and "Maximum" refer to the various column footings and not to any individual items found in the columns.

TABLE I.—*Analysis of the cost of growing an acre of sugar beets.*

Materials and operations.	Great Lakes section.			Intermountain section.		California.
	Minimum.	Average.	Maximum.	Western Nebraska.	Western Colorado.	
Seed	$1.50				$2.40	$1.65
Rental of implements	.55	$2.00				
Plowing	2.00	1.75	$2.00	$2.67	3.00	2.40
Preparation of seed bed	1.00	1.40	4.00			
Harrowing				.80	.75	[1] 1.25
Leveling				.27	1.00	
Rolling				.16		.50
Planting	.40	.40	.50		.75	.35
Cultivating	1.50	3.20	[2] 2.50	[3] 2.00	[1] 2.50	[4] 1.75
Irrigating and furrowing				[5] 2.40	[6] 3.50	3.75
Hand labor	18.00	18.00	20.00			15.45
Thinning and bunching				6.00	6.00	
Second hoeing				2.50	2.50	
Third hoeing				1.50	1.50	
Pulling and topping				10.00	10.00	
Plowing out	1.50	1.75	2.00	2.00	3.00	
Hauling for delivery	5.50	7.00	7.50	9.72	6.60	4.80
Ditch maintenance				2.50		
Total, except rent of ground[7]	31.95	35.50	38.50	42.50	43.50	31.90
Assumed yield per acre ... tons	11	14	12	16.2	11	12
Assumed hauling distance ... miles		2.5		2.5		
Assumed wage, man per day					$2.25	
Assumed wage, man and team, per day				$4.00	$4.50	

[1] Cultivated 3 times.
[2] Cultivated 5 times.
[3] Cultivated 4 times.
[4] Cultivated twice.
[5] Irrigated 4 times and furrowed twice.
[6] Irrigated and furrowed 5 times.
[7] Ground rent, whether cash or shares, is usually reckoned at about one-fourth the delivered value of the crop.

SUGAR PRODUCTION AND CONSUMPTION IN THE UNITED STATES.

Having reviewed briefly the present state of the beet-sugar industry in our country it will be interesting to make some inquiries as to future probabilities and possibilities, as well as to compare our development along this direction with that in Europe. Tables XII and XIII may be taken as a starting point. These tables show the annual consumption of sugar in the United States during the last 25 years, the amount received each year from the various sources, and the percentage contributed by each of these sources, also the yearly per capita consumption and the percentage of the world's crop used in the United States. Without attempting to exhaust the general information obtainable from these tables, attention is directed especially to certain features therein.

Within the past 25 years the total consumption of sugar per annum has considerably more than doubled. This increase has more than kept pace with the increase in population, as is shown by the larger number of pounds used per capita. During this same period the proportion of the world's crop taken by the United States has steadily decreased, from more than one-fourth in 1887 to less than one-fifth in 1911. Of special interest is the fact that during these years the home-grown beet-sugar crop has increased from practically nothing to a point where it has averaged a trifle over one-eighth of our consumption for the past five years. Is it destined to occupy a still larger place in the agricultural economy of the land? For more than 80 years economists have looked forward to a time when we should produce all the sugar needed for home consumption, with perhaps a surplus for export. While we are still far from having reached such a goal, the following figures show how easy it will be physically to do so as soon as the economic conditions therefor shall be ripe.

Present importations from entirely foreign territory now approximate 2,000,000 short tons annually. A home beet-sugar production sufficient to cut off this importation should not affect the home cane-sugar industry adversely, because that has so nearly reached its limit that any possible growth it may have from now on will not equal the annual increase in the country's consumption. With our present low average production of 10 tons of beets per acre and about one-eighth of the weight of beets extracted as sugar, it would require 1,600,000 acres to produce this additional 2,000,000 tons per year. As the acreage harvested last year was a little less than 475,000, it is seen that a total of 2,000,000 acres planted to beets would free us from dependence upon foreign-grown sugar. This round number of 2,000,000 acres makes a very conservative allowance for increased yield due to improved methods and seeds. Table II, compiled from the 1910 census statistics, gives the number of farms, the number of acres of improved land, and the average number of acres of improved land per farm in the States in which it is known that sugar beets can be successfully raised.

TABLE II.—*Number of farms and acreage of improved land in States adapted to growing sugar beets.*[1]

State.	Number of farms.	Improved land.	Improved land per farm.	State.	Number of farms.	Improved land.	Improved land per farm.
		Acres.	*Acres.*			*Acres.*	*Acres.*
California	88,197	11,389,894	129.1	Nebraska	129,678	24,382,577	188.0
Colorado	46,170	4,302,101	93.2	Nevada	2,689	752,117	279.7
Idaho	30,807	2,778,740	90.2	North Dakota	74,360	20,455,092	275.1
Illinois	251,872	28,048,323	111.4	Ohio	272,045	19,227,969	70.7
Indiana	215,485	16,931,252	78.6	South Dakota	77,644	15,827,208	203.8
Iowa	217,044	29,491,199	135.9	Utah	21,676	1,368,211	63.1
Kansas	177,841	29,904,067	168.2	Wisconsin	177,127	11,907,606	67.0
Michigan	206,960	12,832,078	62.0	Wyoming	10,987	1,256,160	114.3
Minnesota	156,137	19,643,533	125.8				
Missouri	277,244	24,581,186	88.7	Total	2,460,177	278,719,622	113.3
Montana	26,214	3,640,309	138.9				

[1] Does not include New York, Pennsylvania, and the New England States, many portions of which are also adapted to growing sugar beets.

An inspection of the footing of the first figure column of Table II shows that if factories were so located that every farmer in these States could plant just 1 acre of sugar beets some of the cane sugar from our noncontiguous territory would have to seek another market. If one farmer in four in these States were to plant a 3-acre patch and give it the care that could readily be bestowed upon so small a plat it would be unnecessary for us to buy foreign sugar. Two-thirds of 1 per cent of the improved land in this area is all that would be required to accomplish this result. More than that acreage lies idle, absolutely unused, every year. Any one of the States of Illinois, Iowa, Kansas, Missouri, Minnesota, Nebraska, or Ohio could produce all this sugar and then have the beets occur only once in a 10-year rotation; several of the others could do it alone on a 5-year rotation.

In Table III the acreage devoted to various crops in the entire country is compared.

TABLE III.—*Comparison of crop acreages, 1911.*

Rank.	Crop.	Acres.	Rank.	Crop.	Acres.
1	Corn	105,825,000	8	Flax	2,757,000
2	Hay	43,017,000	9	Rye	2,127,000
3	Wheat	49,543,000	10	Tobacco	1,013,000
4	Oats	37,763,000	11	Buckwheat	833,000
5	Cotton	36,045,000	12	Rice	696,000
6	Barley	7,627,000	13	Sugar beets[1]	474,000
7	Potatoes	3,619,000			
				Total	291,339,000

[1] Acreage harvested in 1911.

From this table it can be seen that devoting the proposed 2,000,000 acres to sugar-beet production would have an utterly insignificant effect in reducing the acreage of other crops. If they were grown in properly considered rotations with any of these crops except cotton and rice the effect of the beets in increasing the yield of the others would much more than counterbalance the acreage taken from the latter. All that is necessary, so far as acreage is concerned, in order to make us independent sugar producers is to bring the crop to a parity with flax or rye.

A comparison of Table II, showing the improved land in the various beet-producing States, with the acreages reported in Table X will show the proportion of land already devoted to this crop in those States where sugar beets are being grown in the greatest abundance at the present time. Colorado and Utah have nearly 2 per cent of their improved land in beets, Idaho 0.5 of 1 per cent, Michigan and California less than 1 per cent, and Wisconsin about 0.2 of 1 per cent, while the total area for all the States that might be growing them is less than one-sixth of 1 per cent. The German Empire for the 10 years from 1896 to 1905 devoted an average of a little over 1 per cent of its cultivated ground to the crop, while in the Province of Saxony during the same period 4.25 per cent of the soil was given over to it. And they are raising thousands of tons more of other crops now than they were able to produce before they began to grow beets, because of the effect of the beets upon the soil. Their average beet production during this same 10-year period was 13.8 tons per acre for the Province and 12.8 tons for the Empire. The thorough working of the soil necessary for growing profitable beet crops increases the yield of everything else grown on the same ground.

In summarizing this part of the discussion, then, we may say that under stable economic conditions and a knowledge on the part of the farmers of the value of beets in their rotation systems, less than 1 per cent of the available sugar-beet land devoted to the crop would render us as a nation independent of foreign production.

THE SUGAR BEET IN EUROPEAN AGRICULTURAL ECONOMY.

By W. A. Orton,

Pathologist in Charge of Cotton and Truck Disease and Sugar-Plant Investigations.

INTRODUCTION.

Practically one-half of the world's supply of sugar is furnished by the sugar beet. An equal quantity is extracted from sugar cane. The sugar made from the sugar maple, sorghum, palm, and other plants is not enough to be considered in the world's market.

The sugar from cane is of course produced in tropical and subtropical countries. The greater part of the beet sugar comes from central Europe. Germany leads with over 2,800,000 tons annually. Next in order come Russia with 2,250,000 tons, Austria-Hungary with 1,678,000 tons, France with 783,000 tons, Belgium with 312,000 tons, and Holland with 239,000 tons. All these nations produce sugar for export. The United States ranks fifth in this list, with 600,000 tons of sugar from beets, although it stands at the head of the list in the quantity of sugar consumed.

Table IV.—*Production and consumption of beet sugar, with area and yield of the sugar-beet crop of several European countries and of the United States for the year 1910–11.*[1]

Country.	Sugar production.	Sugar consumption.	Area of sugar beets sown.	Yield of sugar beets per acre.	Sugar obtained from beets.
	Short tons.	*Short tons.*	*Acres.*	*Short tons.*	*Per cent.*
Germany	2,854,812	1,406,129	1,169,755	14.84	16.31
Russia	2,324,486	1,462,431	1,614,780	8.93	16.12
Austria-Hungary	1,678,566	641,296	913,159	12.38	14.85
France	783,925	745,610	571,805	10.63	12.90
Belgium	312,196	116,269	150,176	14.53	14.31
Holland	239,073	126,803	122,638	12.96	15.04
United States	510,172	3,611,266	398,029	10.17	12.61

[1] Table IV was compiled from the corrected figures of the International Association for Gathering Sugar Statistics, as published in the American Sugar Industry and Beet Sugar Gazette, January, 1912, p. 24, and February, 1912, p. 21. The column showing "Sugar consumption" was calculated from that published in Licht's Monthly Report, dated Magdeburg, December 9, 1910, and given in Hearings before the Committee on Finance, United States Senate, Sixty-second Congress, second session, on H. R. 21213, 1912, table 5, p. 687.

It will be seen that the culture of the sugar beet plays a very prominent rôle in the agriculture of northern Europe and that it occupies a correspondingly prominent place in the national economy. The industry from its foundation has been fostered by national legislation in every country of Europe. It is thoroughly protected from the competition of the more cheaply produced tropical sugars and is by means of excise taxes made to yield large sums for the support of governments. In Germany the income from sugar taxes from April 1, 1911, to March 31, 1912, reached 170,123,486 marks, or $40,489,000.[1] Europe as a whole derives $200,000,000 per annum from taxes on sugar, yet this is a minor factor in their national economy in comparison with the wealth added by the beet-sugar industry, the money saved by the home production of all the sugar consumed, the receipts from heavy exports of sugar, the employment of many thousands of people, and the indirect agricultural benefits which have accrued from beet culture.

It is primarily the agricultural side of the question with which this paper deals. We shall inquire what the results have been to European farms and farmers from a hundred years of beet culture, and our interest will be quickened by finding at the start that the large acreage required for beet production has not lessened the production of grain and other crops, but that on the contrary a large increase both in total yield and in the average yield per acre has resulted. A considerable portion of this increase is credited to the effects of beet culture, which has become such an indispensable part of European agriculture that it would be continued, in consideration of the indirect returns, even if there were no direct profits from the sale of the beets.

SIGNIFICANCE OF THE EUROPEAN SITUATION TO THE AMERICAN INDUSTRY.

A discriminating study of the sugar-beet industry of Europe and the factors influencing it will help American farmers in two ways. One is by suggesting improvements in methods of culture; the second is by indicating systems of farm management or lines of economic development along which we may advance in the future.

The essential features of European methods of beet culture have already been adopted here. That we shall gain greatly by further direct application of foreign experiences in cultural methods is hardly to be expected. It is undeniable, however, that the general character of our own methods can be greatly improved, but our higher cost of labor and our cheaper land make it probable that advances in the reduction of the farm cost of beets per ton will be made along different lines than in Europe, where land values are very high and labor is very cheap.

It is otherwise with the improvement of our agricultural systems. In this respect we have yet to establish beet culture on a truly perma-

[1] Die Deutsche Zuckerindustrie, vol. 37, No. 17, April 26, 1912.

nent basis, and while we can not reproduce in America the conditions of German estates, we shall receive many helpful suggestions from a study of their organization.

American agriculture in general has hardly passed its developmental period. We are, however, nearly done with the conquest of new, hitherto untilled territory and must rapidly readjust ourselves to a permanent system of farming. It will be necessary to produce far larger yields per acre of all staple crops in order to feed our increasing population and to give an adequate profit on the cost of intensive cultivation. It will also be necessary to conduct our farming operations in such a manner that the fertility and productive capacity of the soil will not be diminished, but will, on the contrary, be increased from year to year. All these things are possible. They have all been accomplished in other lands and by progressive farmers here. The means by which such problems have been solved and a practicable adjustment of them to American economic conditions constitute one of our large problems for the immediate future. This general betterment of our agriculture will be attained through advances along several lines. Better and more productive varieties will be bred and disseminated, cultural methods improved, fertilizers used more generally and in a rational manner, and plant diseases brought under control; but still greater progress will result from the adoption of improved systems of farm management and business organization.

More attention must be given to the influence on the fertility of the soil of the crops used in rotations, as well as to the production and utilization of by-products for stock feeding.

These points, although long thoroughly appreciated in Europe, have not been understood in this country. Mr. Truman G. Palmer, secretary of the American Beet-Sugar Association, has done more than any one else to point out to Americans the indirect benefits from beet culture. Impressive data which he has collected have been published in congressional documents.[1]

In addition to his very detailed information regarding European conditions Mr. Palmer has tabulated the observations of 115 American farmers who have kept records of their crop yields before and after beet culture. His table, here reproduced, shows remarkable increases in the yields of other crops grown in rotation with sugar beets.

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[1] Beet Sugar. S. Doc. 204, 57th Cong. 1903.

The Beet-Sugar Industry of the United States. S. Doc. 530, 60th Cong. 1908.

The Beet-Sugar Industry as Affecting American Agriculture. Address Delivered at the Twentieth Session of the Trans-Mississippi Commercial Congress, Denver, Colo., August 17, 1909.

Indirect Benefits of Sugar-Beet Culture. S. Doc. 76, 62d Cong. 1911.

Statement of Mr. Truman G. Palmer in Hearings before the Committee on Finance, United States Senate, 62d Cong., 2d sess., on H. R. 21213, 1912, pp. 693–796.

TABLE V.—*Benefits from beet culture to other crops grown in rotation on 115 American farms.*

Crops.	Average yield per acre.			
	Before beets.	After beets.	Increase.	
			Actual.	Per cent.
Wheat......bushels..	28.88	43.07	14.19	49.1
Corn............do....	41.6	53.1	11.5	27.6
Oats............do....	40.9	60.6	19.7	48.1
Barley.........do....	38.97	59.14	20.17	52.0
Rye................	....	....	....	39.0
Potatoes...bushels..	151.97	222.2	70.25	46.2
Hay...........tons..	5.7	7.7	2.0	35.0
Beans.....bushels..	15.66	20.26	4.6	29.5

In Europe great stress is laid on the benefit derived from the inclusion in the rotation of a hoed root crop, such as sugar beets, potatoes, or mangels, and the tendency is constantly toward an increased acreage of these cultivated crops and a corresponding reduction in the area occupied by meadow and pasture. The most intensively farmed districts have a larger proportion of their total area under cultivation. Thus, for example, the Province of Saxony has 60.6 per cent of its area tilled ("Acker and Garten"), while the German Empire as a whole has 48.6 per cent, a difference of 12 per cent. It should be noted that the number of cattle kept is increased rather than decreased as the farming becomes more intensive, the by-products from the root crops furnishing forage to replace that formerly grown in meadows and pastures. In the highest development of this system practically all the land is tilled and the cattle are kept the entire year in stables or yards and fed on by-products and purchased concentrates, e. g., beet pulp, beet tops, distillery mash, and straw for roughage, and cottonseed meal, rape meal, peanut meal, and linseed meal, etc., for concentrates.

The German farmer seeks by every profitable means to increase his plantings of root crops. We shall gain by the same practice, and the sugar beet, more than any other crop, will be the one most generally profitable to use, especially north of the corn belt, for the reason that it is the only crop for which we can find a safe, certain, and profitable market for a greatly increased production.

The potato crop stands in the same relation to intensive agriculture as the sugar beet; but it is better adapted to the lighter loams and sandy soils, while the best results with beets are obtained in the heavier soils. Potatoes are more largely planted than other root crops in all northern countries. In Germany their utilization for stock feeding and for industrial purposes, such as the manufacturing of starch, alcohol, and dried potatoes, greatly exceeds the human consumption of this staple. In the United States, until we have similar outlets for surplus production, we can not greatly increase our potato acreage.

Mangels and other roots are extensively used abroad for stock feeding, particularly in Great Britain; but such developments can hardly be expected here, where we have a cheaper substitute in corn silage. The sugar beet remains the only root crop for which a large and certain market can be found. For all localities where soil and climate are suitable for sugar-beet culture this crop promises to play an important rôle in our future agricultural development.

Hitherto sugar beets have been considered by American growers chiefly as an end in themselves. They have been grown for the direct returns derived from the sale of beets for making sugar. In many districts they have been planted more or less continuously on the same land, with a resulting decrease in productivity. There has been a tendency toward specialized beet growing, whereby a few men handled large acreages. Some factories have been forced to engage in the cultivation of beets on a large scale to insure themselves an adequate supply. In the earlier years the pulp was not always in sufficient demand by the farmers and was fed to cattle on the factory grounds or disposed of in other ways that have not returned the fertilizing constituents to the soil. The molasses and lime cake have been an incubus. The leaves and tops have been left on the field or grazed off by cattle owned by another than the beet grower. The result is that up to the present we have not secured the fullest measure of benefit from our beet-sugar industry. This is perhaps the natural condition during the developmental stages of beet culture; but in the present period of transformation and reorganization of our agriculture we should seek to profit from every means for increasing our production and conserving soil fertility.

With due recognition of the fundamental agricultural principles involved and with adequate tariff protection the conditions in the near future will become favorable for a very rapid expansion of the beet-sugar industry in the United States. If this is to be of the greatest good to the country at large, the raising of the beets should not be developed as a specialized business, but should be undertaken in limited acreages by general farmers and in rotations with grain and other crops. The indirect benefits of beet culture can thereby be fully realized.

The United States has such large areas fully adapted to beets that only those districts possessing a favorable soil and climate need attempt to establish factories. Experience shows that beets grown south of the summer isotherm of 70° F. are likely to be deficient in sugar content. Even in the Northern States some communities will develop potato culture and others fruit or truck growing for city markets, while the rougher or mountainous districts will continue stock raising and dairying. In general, however, sugar-beet culture will have its greatest development in our leading agricultural districts along the northern border and north of the corn belt, where there are large areas of fertile loamy soils. It should be noted in this connection that beets thrive with less rainfall than many other crops and are on this account at an advantage in our Northwestern States.

EUROPEAN FARM ORGANIZATION.

In studying the means by which European agriculture has developed yields so greatly in excess of ours and at the same time steadily increased the fertility of their soil we must be impressed first by the more complex business organization of the farm and the systematized planning and interrelationship of the crops. A large German farm presents certain resemblances to a factory. It has its alcohol distillery, where the surplus potatoes are converted into alcohol, an operation which is done on a very small margin of direct profit in consideration of the indirect return which comes from feeding the mash to cattle and the return of their manure to the land. It grows sugar beets for a neighboring factory and often owns a share of this beet factory. The leaves and pulp are all fed to cattle.

In the province of Saxony sugar beets constitute on the average 4.29 per cent of the total area, or 271,900 acres, as compared with 413,000 acres for wheat, 820,000 acres for rye, 378,000 acres for barley, 541,000 acres for oats, and 490,000 acres for potatoes.[1]

Rotations of crops are universal. They vary considerably and are subject to change to suit market and seasonal conditions, but in general beets are not planted oftener on any field than once in three or four years. It appears that the more highly organized and developed the agriculture, the longer the rotations. In earlier times beets were planted oftener and in less developed sections of Europe to-day they are planted more frequently, but this practice has always been disadvantageous. The sugar-beet nematode,[2] an eelworm parasitic on the roots of beets and some other plants, was spread by continuous beet culture. Land became "beet tired" and rotations were forced upon the farmers. Wherever long rotations are now universal the nematode problem has become less serious, and there are only a few fields where beets can not be grown. Oats also are kept off such infected land, as they harbor the nematode.

The danger from this same sugar-beet nematode confronts American growers also. The pest has already been introduced and is present in restricted areas in the West. It will undoubtedly become common unless active measures are taken to combat it. Whether our farmers will profit from the experience of German growers before they are themselves hard hit is a question for the future to determine. We

[1] Landwirtschaft und Landwirtschaftskammer in der Provinz Sachsen, 1896–1905, p. 17.
[2] *Heterodera schachtii.*

are also likely to suffer from the root-knot nematode, a related parasite producing galls on the roots, especially on the lighter beet lands, though this also can be controlled by a suitable rotation.

EFFECT OF BEET CULTURE ON THE PRODUCTIVENESS OF THE SOIL.

That the culture of the sugar beet has played an important rôle in the improvement of European agriculture and that it is to be credited with much of the increased returns from other crops is firmly believed by German writers. We quote, in a free translation from one of the most eminent authorities, Prof. K. von Rümker, of the University of Breslau:[1]

"The high yields which are secured from cereals and other crops in beet localities date from the introduction of rational beet culture, which is therefore the direct and indirect cause of this increase in the gross and net returns of the whole agriculture, and thereby also in the land values in the above-mentioned localities.

"Since the introduction of beet culture, despite a reduction of the acreage of grain, the total grain yield has been increased. It is shown by Briem that since the introduction of beet culture on the estate of Groena in Anhalt there has been harvested from 200 hectares as much grain as formerly grew on 250 hectares. Dr. Lilienthal shows from the books of eight estates in different localities that the introduction of beet culture has increased the yield of wheat 5.95 bushels per acre, the yield of rye 1.59 bushels per acre, the yield of barley 6.51 bushels per acre, and the yield of oats 5.77 bushels per acre. The number of cattle on these eight estates before and after the introduction of beet culture was as 100 to 114.94, the gross income from the cattle before and after is as 100 to 124.80, and the net income of the whole of the agricultural operations in the eight cases is as 100 to 132.22. This difference rises in one case as high as 100 to 170.61.

"As important as was the introduction of clover culture, it does not compare with the progress derived from beet culture on the heavy soils and from potato culture on the lighter soils."

The beneficial effects of sugar-beet culture on general agriculture have been so long established and accepted as a matter of fact in Germany that it is difficult to find any recent experiments bearing on this point.

In years past, however, this question was worked out there with much exactness, by comparison of crop yields on farms before and after the introduction of beet culture and by comparing the results on beet farms with those from adjacent estates where no beets were grown.

Such detailed results are given by Humbert, from whom a single table is quoted from among several given in his book

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[1] Rübenbau und Zuckerkonvention, Berlin, 1903.

TABLE VI.—*Increased yields after beet culture.*[1]

Crops.	Average yield for 10 years—				Net gain in bushels per acre.
	Of 3 nonbeet estates.		Of 6 beet estates.		
	In kilograms per hectare.	In bushels per acre.	In kilograms per hectare.	In bushels per acre.	
Wheat	2,015.00	29.96	2,659.83	39.56	9.60
Rye	1,710.00	27.25	1,898.16	30.25	3.00
Barley	1,550.00	28.81	2,421.66	45.02	16.21
Oats	1,543.33	43.03	2,480.00	69.16	26.13
Peas	1,375.00	20.45	2,107.50	31.34	10.89
Potatoes	12,333.33	183.35	14,583.66	216.85	33.50

[1] Humbert, Gustav. Agrarstatistische Untersuchungen über den Einfluss des Zuckerrübenbau's auf die Land und Volkswirtschaft, unter besonderer Berücksichtigung der Provinz Sachsen, Jena, 1877, p. 46.

The author from whom the above table is quoted emphasizes that on account of the smaller number of nonbeet farms it was the intention to favor them rather than to handicap them. The accuracy of the figures is therefore strengthened by several considerations: (1) The natural quality of the soil was on the whole better on the nonbeet farms than on the farms growing beets. (2) The operating expenses on the nonbeet farms were less in proportion to the income. (3) The management of the nonbeet farms was as rational and the cultivations as intensive as could be found under similar conditions anywhere in Germany. (4) The yields of the products, especially beets reported only from the beet farms, are too low rather than too high.

Humbert summarizes as follows:

"The influence of beet culture, as shown in this summary, is uniformly favorable, stimulating and making more profitable every branch of agriculture.

"The results justify the conclusion that beet culture has been in every way favorable and that it has in many respects exerted the strongest influences upon the agriculture and general prosperity of the fatherland. Its extension has been a source of wealth for whole Provinces. It has been the principal forerunner of intensive agriculture, which has expanded rapidly wherever there are sugar factories.

"The main advantage of beet culture is that it always improves the soil and its harvests, for it permits and even requires a deeper preparation and more frequent cultivation, thorough weeding, and exceptionally heavy fertilizing.

"The yield of every crop is higher on the beet farms than on the nonbeet farms. The total yields of grain are a full third higher in the former, which thus produced and marketed absolutely and relatively more breadstuffs than the nonbeet farms.

"The extension of the area planted to hoed crops requires a more complete utilization of the land available for tillage, it does away with fallowing, and permits a reduction of the area in forage crops, because the by-products from the beet factory and potato distillery are valuable for feeding and enable more live stock to be kept. Although the total number of cattle on the nonbeet farms may exceed those on the beet farms, the latter market more animal products, because their stock is sold sooner and the more liberal feeding results in heavier gains in weight.

"What the distilleries and starch factories are to the light, infertile soils; what stock raising is to the meadows of the fertile coast regions, river valleys, and mountain districts; what vegetable growing is to places with favorable location and soil conditions; all that beet culture has become to the better deeply tillable areas with temperate climate and moderate rainfall."

Later results by Woge fully confirm these conclusions. Table VII gives comparative yields on a German estate for 5 years before beet culture was introduced and for 10 years thereafter.

Woge points out, as did Humbert, that the highest yield of the nonbeet farms is lower than the lowest yield of the beet farms.

TABLE VII.—*Increased yields after beet culture on the Bennigsen estate.*[1]

Crops.	Nonbeet farm, average yield, 1869–1874.		Beet farm, average yield, 1880–1890.		Net gain in bushels per acre.
	In kilograms per hectare.	In bushels per acre.	In kilograms per hectare.	In bushels per acre.	
Rye	1,780	28.36	2,558	40.76	12.40
Wheat	1,650	24.55	2,774	41.25	16.70
Oats	2,214	61.74	2,700	75.30	13.56
Barley	1,248	23.20	2,340	43.50	20.30
Beans and peas	1,868	27.77	4,165	61.93	34.16
Potatoes	14,696	218.50	16,000	237.90	19.40
Rape	1,302	20.74	2,733	43.55	22.81

[1] Woge, Richard. Einfluss des Zuckerrübenbaues auf die Landwirtschaft unter besonderer Berücksichtigung einiger im Fürstenthum Calenberg gelegenen Güter, Leipzig-Reudnitz, 1892, pp. 23–30.

INDIRECT BENEFITS.

Prof. von Rümker[1] thus details the indirect benefits from culture of root crops:

"To grow sugar beets successfully, a deeper furrow is absolutely necessary. This involved the removal of stones and other obstructions to the working of the soil. It also led to the introduction of power plows, which, as is well known, not only do the work more rapidly, but do it more perfectly than team plows. The need for deep cultivation brought about improvements in all soil-working implements and stimulated the manufacture and sale of agricultural machinery. The old types of harrows, rollers, cultivators, drills, etc., suffice no longer. New and better models, adapted to different types of soil and kinds of work, have been developed and introduced. The

[1] Rübenbau und Zuckerkonvention, Berlin, 1903.

result of this specialization naturally has been an enormously improved and increased service from these implements, with a corresponding lightening and saving of both animal and human labor.

"The system of planting in rows was extended to all other cultivated crops. Hand and broadcast sowing was followed quickly by hill and drill planting. Row seeding has the advantage not only of economy of seed and its uniform distribution and depth of planting, securing a quicker and more uniform germination, a more uniform development and ripening, and a larger and qualitatively better harvest, but it makes it possible to rid the fields of weeds and, through cultivation, to keep the soil open and aerated.

"It is thereby possible to influence most favorably the physical condition of the soil, to conserve its water supply, and to promote the activity of the soil bacteria, thereby influencing the fixation of atmospheric nitrogen. In short, the introduction of cultivated crops has proved in physical, chemical, and physiological ways so exceptionally beneficial that the increased cost of production has been paid, and in most cases with good interest.

"The deeper and more carefully one learned to work the soil for the beet crop the greater became the need of more liberal and careful manuring. The development of our knowledge of plant nutrition which followed the work of Liebig was opportune, as it showed how to cheaply and effectively supplement farmyard manure with commercial fertilizers, so that the growth not only of beets, but of all agricultural crops, was improved.

"This development led to a demand for improved varieties of farm crops which would yield better than those previously in cultivation and thereby return a larger profit.

"The laws levying taxes on sugar were fortunately so framed as to encourage the production of beets richer in sugar. Surprising results were accomplished by the method of individual selection based on the polariscope test. A simultaneous improvement of factory methods assisted in increasing the sugar production, so that the weight of beets required to give 1 hundredweight of sugar decreased from the 18 to 20 hundredweight[1] originally needed to 7⅓ hundredweight for Germany in 1901–2.

"The results obtained with beets stimulated work on other crops. The highly bred grains of England were introduced and further improved, until even in the sixties the grain yields of Germany excelled all other countries. Beginning in the early eighties, new and more productive potatoes have been originated, and the higher and more uniform yields of all crops permitted a more effective utilization of the improved cultural conditions resultant from sugar-beet culture.

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[1] In the early years of the sugar industry, in the period from 1872 to 1904, the lowest average extraction was 8.15 per cent of beets. W. A. O.

"These improved varieties were not only more exacting in their requirements as to preparation of the soil, manuring, and planting, but also as to care and protection from unfavorable climatic condition and parasites. Plant diseases and insect pests became more destructive as the agriculture became more intensive, with the result that, in consequence of the efforts made to study and combat them, plant pathology has made great advances; and although it is still only at the beginning of its development, a considerable number of workers are prepared to hasten to the aid of the farmer and assist him in warding off invasion.

"The entire development of our modern intensive agriculture, here only briefly outlined, traces its origin to the building up of a rational sugar-beet industry. From it each department mentioned received the first impulse toward progress, and link by link the chain of improvements was forged, benefiting branches of agriculture which have next to no relation to beet growing. It is consequently no exaggeration to say that the sugar-beet industry was and is the high school of modern intensive farm management."

EFFECT UPON THE LIVE-STOCK INDUSTRY.

"The live-stock side of agriculture and its business organization have also been deeply influenced by sugar-beet culture. The beet farms discontinued the breeding and raising of young cattle and took up dairying and the fattening of beef animals and the production of mutton in place of wool. Between those sections of the fatherland possessing a beet-sugar industry and those without it a division of labor was developed which was advantageous to both sides. The districts where poorer soil or unfavorable climatic conditions prevented the addition of another crop to the rotation grew the live stock, which was later sent to the factory districts to be milked or fattened.

"The large amount of team work done on the beet farms made them the best market for draft oxen, which were supplied from the mountainous districts of Germany where stock raising is the principal industry."

EFFECT UPON THE BUSINESS ORGANIZATION OF THE FARM.

"The farm organization was deeply affected by the beet industry in that the old fixed rotations were given up for a more elastic succession of crops, as in market gardening, retaining the rotation principle only in so far as it appeared physically necessary or financially advantageous. In the main, however, adjustments were made to the state of the market to a much greater extent than before.

"In this way a very important new movement came into force, namely, business planning and accounting. Careful bookkeeping was adopted on the farm, accounts were kept of each branch of the work, mistakes were more quickly discovered, losses were avoided, and profits realized which without the accurate farm balance sheet unquestionably would have been overlooked.

"It should also be remembered that beet culture and the sugar industry enlarge the opportunities for rural employment of a large number of adults and children, and that they have brought about a material increase in farm wages.

"The valuable by-products of the beet field and sugar factory have increased the supply of domestic feeding stuffs to such an extent as to limit the purchases of foreign materials by many millions. Without the pulp, molasses, leaves, etc., it would have been impossible for large numbers of farmers to increase their holdings of live stock to the present extent."

THE BEET INDUSTRY THE FOUNDATION OF MODERN AGRICULTURE.

"The significance of the beet industry as a source of revenue to the State is not treated in detail here, as it might be objected that the State would always obtain the income which it needed and would be indifferent as to the source of the money. Nevertheless, it could not be without value, as a matter of national economy, to maintain a rural industry which increases the tax-paying ability of the country. It is the farming communities which practically constitute our home market, and to maintain their ability to buy and consume is important to the urban industries, especially when foreign countries shall have closed their doors to German exports, an occurrence that will surely take place some day.

"In short, we see from this sketch that beet culture is actually the foundation of our modern intensive and businesslike farm management, that it has not only greatly promoted agriculture, but that it has in large and small, in whole and in part, elevated our whole rural life, promoted stock raising, stimulated farm planning and bookkeeping, improved the intellectual and material conditions of the regions concerned, and contributed indirectly to the welfare of other parts of the country. The sugar-beet industry is the lever that has raised and supported our modern farm management. He who raises the ax against it could strike no more dangerous blow against agriculture, against the possibility of providing our people to the greatest possible extent with home-grown foodstuffs, and against an important part of our national wealth."

Sugar-beet culture is, therefore, a significant factor in our national economy as well as in our agriculture, and on account of its peculiarly beneficial general influence can not be replaced by anything else.

RELATION OF ADAPTATION TO THE IMPROVEMENT OF SUGAR-BEET VARIETIES FOR AMERICAN CONDITIONS.

By F. J. Pritchard,
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INSTANCES OF ADAPTATION.

The adaptation of sugar-beet varieties to our diversities of climate, season, and types of soil would undoubtedly considerably increase our production of sugar. European varieties are bred especially for European conditions, and retain many of their adaptations to the previous environment when brought to America. With some crops such after effects are beneficial, especially the quality of earliness in truck crops, as shown by the popularity of northern-grown seed for early-maturing varieties in southern latitudes, but more often they are a decided disadvantage because they prevent a thorough readjustment to the new conditions. Corroborative proof is shown by the lower average yield from exchange of seed between different localities and the poor quality of southern varieties when grown in the North. In fact, the change may be so violent that the variety fails to fruit, as was observed by the writer when corn from Mexico was grown at Ithaca, N. Y., and when sugar beets were planted in several localities in the United States. Deterioration in yield and quality is common to farm crops when transferred to a decidedly different environment, as shown by the results of variety tests all over the world. Each variety has its own special environment in which it thrives best, and variety tests do not show which is the best variety but merely which gives the best combination of yield and quality in a certain locality. What, then, should we expect when sugar-beet seed bred for a long season and comparatively equable climate, as in the Province of Magdeburg, Germany, is imported annually for both the eastern United States and the dry, irrigated sections of the West? It is no argument to say that several of these varieties are used in various parts of the United States and do about equally well, for they have all been bred for practically one environment and should be expected to exhibit similar behavior. Moreover, they are not all equally valuable for any given locality, as shown by Hans Mendelson, of the Great Western Sugar Co., who found that Klein Wanzleben's Old

Type gives them the highest average results. Obviously, we shall never know our possibilities until we have determined the comparative merits of adapted varieties in each locality having different climatic conditions.

METHODS OF ADAPTATION.

Adaptation is effected by a direct change of type which appears in all individuals alike and is induced by a new environment or by diverse variations accompanied by selection. Cereal rusts are cited by Klebs as an instance of gradual adaptation. When grown in the far North these rusts have a very short period of development; when taken into southern regions they retain this quality for a time but lose it completely in later generations. Duggar [1] states that where corn is introduced from higher latitudes it matures later and later each year and the plants grow taller, thus adapting themselves to the longer season. Lyon [2] experimented with two varieties of corn, Snowflake White and Early Yellow Rose, obtained from western Iowa but grown two years subsequently in central Nebraska. He found that when planted at the Nebraska Agricultural Experiment Station beside the parent stock the corn from Nebraska seed was a foot shorter than the Iowa corn, accompanied by one-tenth reduction in leaf area and a relatively larger ear. Obviously, all these variations were directly adaptive, because there was very little, if any, opportunity for selection. It thus appears that reduced foliage and a relatively large root system, as claimed for sugar-beet varieties adapted to dry areas, may have been acquired by direct adaptation.

The action of new environment in producing variation generally has a tendency toward diversity rather than toward a uniform change in one direction known as local adjustment or place effect. As expressed by Pfeffer,[3] "External conditions act not so much as direct formative, as indirect inducing agents, and thus produce vital changes, leading to an attainment of new hereditary peculiarities." Klebs [4] holds similar views, as he believes both variations and mutations owe their existence to external agents, which, as shown by his experiments, are not always adaptive. Every beet field shows a multiplicity of diverse variations in size, shape, quality, and habit of growth of the various individuals composing it and in the component characters of foliage and root. But since the commercial demand requires a large, rich root, individual plants possessing these qualities are best adapted to the local conditions, economically speaking, and no off plant or rogue should be saved for growing seed.

[1] Duggar, J. F. Corn Culture. Bulletin 134, Alabama Agricultural Experiment Station. 1905.
[2] Lyon, T. L. Modifications in Cereal Crops Induced by Changes in their Environment. Proceedings of the Twenty-eighth Annual Meeting of the Society for the Promotion of Agricultural Science, 1907, p. 145.
[3] Pfeffer, Wilhelm. The Physiology of Plants [translated by A. J. Ewart], vol. 1, 1900, p. 33.
[4] Klebs, Georg. Studien über Variation. Archiv für Entwicklungsmechanik der Organismen, vol. 24, 1907.

CHARACTERS AFFECTED.

Practically all characters are susceptible to the influence of external conditions. Such characters as size and yield are readily modified by environment, as they are largely dependent upon the food supply and favorable factors for assimilation, but even more fundamental characters as form, structure, and the relative position of parts are also amenable to external conditions, as shown by Stockard,[1] who found that a small excess of magnesium chlorid added to sea water caused the eyes of developing embryos of the minnow, Fundulus, to approach a median plane, giving them the appearance of cyclopean monsters. Herbst [2] also found that by the addition of lithium salts to sea water containing eggs of echinids, he was able to change the whole course of morphogenesis of the larvæ. A similar anomaly was discovered by Babák,[3] who found that tadpoles receiving vegetable nutriment developed an intestine nearly twice as long as when fed on animal food, apparently an adaptation to digestibility. Practically all plants show more or less adaptive growth to external stimuli. If a mesophytic plant grown under semiarid conditions should put forth its usually abundant leafage without a corresponding increase in root system, it would soon die from evaporation; and, likewise, if a xerophytic plant grown in a humid habitat maintained its former size relation between roots and foliage, it would soon be overburdened with water from excessive root pressure. The plant or variety which succeeds best in a new environment is the one which adapts itself most readily. While all plants have this capacity in a certain degree, there are decided limits to which it can extend in a single season, as without doubt the more numerous adaptations come from diverse variation and selection.

INHERITANCE OF VARIATIONS.

Whether variations induced by external agents are inherited is a question of the highest importance to all breeders of plants and animals. Klebs believes that every organism inherits a definite specific structure and within its physiological elasticity fluctuating variations occur, but when the variations proceed beyond the limits of this elasticity they become hereditary. Darwin,[4] though championing natural selection as the chief factor in evolution, was fully aware of the hereditary influence of food and other external agents, for he says: "In my opinion the greatest error I have committed has been

[1] Stockard, C. R. Journal of Experimental Morphology, vol. 7, no. 2, 1909, p. 285. Cited by Bourne.

[2] Herbst, Curt. Experimentelle Untersuchungen, etc., auf die Entwicklung der Thiere. Zeitschrift für wissenschaftliche Zoologie, vol. 55, pt. 3, 1892, p. 446.

[3] Babák, Edward. Experimentelle Untersuchungen über die Variabilität der Verdauungsröhre. Archiv für Entwicklungsmechanik der Organismen, vol. 21, 1906, pp. 611–702.

[4] Darwin, Charles. Life and Letters [edited by Francis Darwin]. vol. 2, pp. 338 and 408.

[in] not allowing sufficient weight to the direct action of environment, i. e., food, climate, etc., independently of natural selection." Again he says: "There can now be no doubt that species may become greatly modified through the direct action of the environment." It has since been proved repeatedly by experimental evidence. Weismann, Standfuss, Merrifield, and Fischer have all obtained specific hereditary alterations in the color patterns of Lepidoptera by the use of abnormal temperatures. Pictet [1] changed the color pattern of the moth *Ocneria dispar* by feeding the young caterpillars on walnut leaves, their normal food being the leaves of oak or birch. When the first generation was fed on walnut and the second and third on oak, the effects of the walnut were still apparent in the last generation. Pictet experimented with 21 species and 4,965 individuals and in nearly every case some change from the normal type could be directly traced to the influence of the food. Fully as interesting are the experiments of Waltereck,[2] who found that the head of the crustacean Daphnia was broadened by excessive feeding but gradually returned to the original size when the young were restored to the normal nutritive conditions, though the larger size persisted when the overfeeding covered a period of two years. Klebs [3] by controlling external factors was able to induce marked alterations in the floral organs of Sempervivum—double flowers and other aberrations commonly classed as teratological—which were transmitted through seed of the parent. Two species of the fern Asplenium have acquired special morphological characters from growing on serpentine soil, and are classed as distinct varieties. By growing their spores in ordinary soil, Sadebeck [4] found the first generation lost a little of its serpentine character, the second generation a little more, and after five or six generations the character was lost completely. Somewhat similar hereditary deviations have been reported by Strohmer,[5] Briem, and Stift, who claim that the soil not only affects the quantity and quality of sugar-beet seed grown upon it, but all the beets raised from this seed and even those of the second generation.

ADAPTATION AND PRODUCTION.

Whether adaptation arises as a direct response to environment or through elimination of poorly adjusted individuals, it usually leads to increased production. There are some exceptions, possibly from

[1] Cited by Morgan, T. H. *See* "Experimental Zoology," 1907, pp. 29-33.

[2] Sonderabdruck a. d. Verhandlungen der Deutschen Zoologischen Gesellschaft, 1909.

[3] Klebs, Georg. Alterations in the Development and Forms of Plants as a Result of Environment. Proceedings of the Royal Society of London, vol. 82, ser. B, No. 559, 1910, p. 547.

[4] Sadebeck, Richard. Berichte über die Sitzungen der Gesellschaft für Botanik zu Hamburg, pt. 3, 1887, p. 74.

[5] Strohmer, F., Briem, H., and Stift, A. The Influence of the Soil on the Seed Production of Sugar Beets. Oesterreichisch-Ungarische Zeitschrift für Zuckerindustrie und Landwirtschaft, 1895, p. 25. Reviewed in Experiment Station Record, vol. 7, 1895, p. 300.

storage of more favorable nutrients in the new seeds, but as a rule such experiments have not been planned to eliminate the effects of breeding and, hence, are not always reliable. Shepperd [1] planted seed wheat grown 1 to 9 years in North Dakota beside wheat of the same parentage brought directly from Minnesota and in 46 trials obtained an average increase of 2.3 bushels per acre in favor of the Dakota-grown seed. From experiments in the Office of Grain Investigations of the United States Department of Agriculture, Warburton [2] found that local seed, in general, "outyields that from a distance, even when the original stock is the same." Lyon [3] found this invariably true for Kherson oats and Turkey Red wheat, and in a similar test with 16 varieties of corn he obtained an average increase of 5.4 bushels per acre from home-grown seed. By placing side by side first-year and second-year plantings of each variety of cotton, Cook [4] invariably obtained higher yields from the second planting, and he believes that the selection of seed for local adjustment would increase the cotton crop 10 per cent. The foregoing experiments show the possibilities of improving the present European varieties of sugar beets for our local conditions by adaptation. The humid sections of the East, the irrigated sections of the West, and even areas where dry farming is practiced should each have their own specially adapted varieties.

German seedsmen frequently claim that the best variety of sugar beets is the one which maintains its high yield and quality under diverse conditions, but this is not a biological possibility. A variety may be composed of distinct families or strains, each having slightly different powers of adaptation so as to maintain a high average production under certain seasonal variations, which probably is what the Germans mean, but such a variety is not, strictly speaking, a superior cosmopolitan mixture adapted to wide extremes and is only preeminent under certain local conditions.

OUR PRESENT NEEDS AND PROSPECTS.

Obviously the most profitable results would be obtained from American varieties composed of strains highly bred for the climate and soils tributary to each factory, but owing to the concentration of capital necessary for the commercial production of seed the best varieties we can hope for, in the immediate future at least, are those giving the highest average results, either in the direction of maxi-

[1] Shepperd, J. H. Eleventh Annual Report of the North Dakota Agricultural Experiment Station, 1900, pp. 64–65.

[2] Warburton, C. W. Improvement of the Oat Crop. Circular 30, Bureau of Plant Industry, U. S. Department of Agriculture, 1909.

[3] Lyon, T. L. Loc. cit.

[4] Cook, O. F. Local Adjustment of Cotton Varieties. Bulletin 159, Bureau of Plant Industry, U. S. Department of Agriculture, 1909.

mum percentage or yield of sugar per acre, depending upon the needs of any particular factory, in a general section of the country in which similar climatic conditions prevail.

There is no better illustration of a lack of adaptation than the frequent failures of European varieties of sugar beets to produce seed in America. Similar experiences were met during the early history of the industry in Bohemia [1] and Moravia, where sugar-beet breeding was at first a failure. The early breeders came from the vicinity of Quedlinburg and Erfurt and expected to obtain as good results in three or four years as those of old-established firms. Failing in this they attributed the lack of success to climate and soil and claimed the latter was not suitable for seed production. Capable breeders, however, receiving much support from prominent Austrian and Bohemian sugar factories, as shown by the reports of numerous discussions in the conventions, continued to struggle against these difficulties until they attained marked success, which shows that early failures were due chiefly to lack of adaptation.

When we compare the climate of the Province of Magdeburg, Germany, with its long season, relatively cool midsummer weather (mean July temperature below 70° F.), and low humidity, with our short season and hot July weather, it is not surprising that the beets show great diversity in America and fail to produce seed in paying quantities. But if we purpose to rid ourselves of the uncertainty of obtaining seed and wish to build up a truly American industry, we must breed our own varieties of sugar beets and grow our own commercial seed just as France, Germany, and other European countries have done. By making numerous selections from an immense number of seed beets we can hasten adaptation and facilitate breeding.

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[1] Urban, Jos. Die Veredelung der Zuckerrübe. Blätter für Zuckerrübenbau, no. 12, 1909, p. 177.

FARM PRACTICE IN THE ARKANSAS VALLEY, COLORADO.

By L. A. Moorhouse,
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PHYSICAL CHARACTERS OF THE ARKANSAS VALLEY.

The agricultural region in Colorado known as the Arkansas Valley extends from Canon City to Syracuse, a distance of 200 miles. The river from which the valley takes its name has its source in the mountain range which forms the Continental Divide; the stream, fed from the snow fields to the north and west and emerging from the Royal Gorge, courses in an easterly direction through the valley. The Arkansas Valley in Colorado has an estimated area of nearly 30,000 square miles. More than one-fourth of the State lies in this drainage basin, which includes the southern plains and portions of the eastern slope of the Rocky Mountains.[1] The elevation in this district varies greatly. Canon City, which is located at the base of the range, has an elevation of 5,329 feet; while at Holly, which is well out toward the eastern part of the State, the altitude is only 3,380 feet, a difference of approximately 2,000 feet.

The lands on either side of the river in the valley proper are dependent upon this stream for their supply of water; it is an irrigated country and has been developed through the utilization of these waters. The area which lies beyond the valley in the open plain is used for pasture purposes, although dry farming has been advocated for these lands. Thus far growth in this respect has been somewhat intermittent. The reasons for this feature will be found in the discussions which will be presented in other parts of this paper. Originally the entire country was an open range devoted exclusively to pasture. Gradually small portions of the valley land were brought under cultivation; water was applied through the irrigation ditch; the productiveness of the soil was demonstrated; then more extensive tracts were broken with the plow. Alfalfa grew luxuriantly; the environment appeared to be ideal for this forage plant. Other crops were tested and there was a ready response; thus the country was soon transformed from an open pasture into districts where many farms are being operated.

[1] Summary of the Climatological Data for the United States, by Sections; Section 7, Region Drained by the Arkansas in Colorado. Weather Bureau, U. S. Dept. of Agriculture.

The past 12 years have witnessed the introduction and development of the beet-sugar industry. The first factory was built at Rocky Ford in 1900. Five other manufacturing plants have since been erected, and the sugar beet has become one of the staple crops of the valley.

CLIMATE OF THE ARKANSAS VALLEY.

The Arkansas Valley is essentially a semiarid district. The average annual rainfall[1] at Holly in the eastern portion is approximately 15 inches. Passing in a westerly direction through the valley, a slight decrease in the precipitation will be observed; at Las Animas the average annual record is 11.65 inches; between this point and the foothills a small increase is noted. The general average for the valley is not far from 12 inches. Fully 75 per cent of the rainfall occurs during the period from April to September. The records of the Las Animas station show that in the average season 4.55 inches of rain falls during the first three months of this period; the summer months give 4.70 inches as an average of many seasons. In the main the greater part of the summer rainfall comes early, and when the showers are heavy the crops are benefited directly. Since so great a part of the rain falls during the spring and summer, it follows that the winter precipitation is exceedingly low. As a matter of fact, the moisture which is available in a normal season does not make any appreciable addition to the stores within the soil. The fields are usually dry and lumpy when they are plowed in autumn, and if winter irrigation is not given they will remain in this condition until spring. A dry surface is not mellowed to any great extent by the frosts of winter. In cases where it is desirable to have the fields in prime condition early the following season, winter irrigation is a necessary step on the part of the farmer; it may not be possible to winter irrigate every farm, but the suggestion is sound, nevertheless.

Owing to the prevalence of fairly strong winds, especially in the spring, some attention must be given to the conservation of the moisture which has been stored within the soil. Careful, systematic tillage will aid in overcoming some of the difficulties which might otherwise interfere with the progress of the farm. Soil blowing must also be controlled as far as possible. Precautionary measures are an outgrowth of a close study of the prevailing climatic conditions. It may be noted as well that high temperatures are common in the valley throughout the summer months, but the dry atmosphere serves to ameliorate the intense heat and for this reason the extremes are not uncomfortable.

[1] The averages here given are taken from the Weather Bureau report previously cited.

IRRIGATION IN THE ARKANSAS VALLEY.

The most important source of the water which passes down the Arkansas River and its tributaries is found in the snows upon the mountains lying adjacent to their drainage basin. Occasionally, local torrential rains supplement the quantity of water which comes from the melting snow and ice. When such storms do occur, they bring an excessive flow of water, and this excess at times puts many of the smaller streams beyond control. Ditch banks are washed out, headgates are damaged, and crops are destroyed, entailing extra work for repairs and necessitating additional expense. Apart from the points here mentioned, the chief interest of the man who has farming land in the valley under ditch, centers in the quantity of water which comes down the river at various seasons. Measurements have been made and the discharges have been recorded at a few points. Table VIII gives the discharge of the river at Pueblo, Colo., for the 10-year period 1898 to 1907, inclusive, except for certain months as follows: November and December, 1903; January, February, and March, 1904; December, 1906; and January and February, 1907. The drainage area includes 4,600 square miles.[1]

TABLE VIII.—*Discharge of Arkansas River at Pueblo, Colo.*

Month.	Cubic feet per second.			
	Maximum.	Minimum.	Mean.	Per square mile.
January	625	178	370	0.080
February	2,610	150	477	.104
March	775	46	350	.076
April	2,910	95	504	.109
May	11,100	201	1,430	.311
June	6,980	225	2,550	.554
July	5,380	60	1,350	.294
August	8,320	60	730	.159
September	1,370	46	394	.086
October	1,520	31	442	.096
November	1,350	232	436	.095
December	698	178	396	.086
The entire period	11,100	31	786	.171

During the time when these records were made, the maximum discharge occurred in the month of May, while the minimum was reported for the month of October. Snow accumulates at the higher altitudes throughout the fall and winter months. With the increasing temperatures of the spring months, the snow begins to melt; the smaller streams enlarge; and the discharge of the river rises possibly to the maximum. It has been noted that very heavy rainstorms occur at infrequent intervals in the valley. These storms influence the flow of the stream very much at times.

[1] Compiled from records of the United States Geological Survey, by M. O. Leighton, Chief Hydrographer.

In order to utilize the available water from January to December, provision should be made for the storage of the surplus flow when the streams from the mountains afford an excess due to rapid melting, or when torrential rains coming later in the summer swell the stream beyond its banks. This storage can be accomplished only by turning the surplus into large reservoirs and holding it until a time of need. Then, too, the river furnishes some water during the autumn months; just how far this flow can be used for fall irrigation has not been determined. It is certain that the crop of the following season can be benefited by late fall or early winter irrigation.

SOIL TYPES.

The Arkansas Valley possesses a variety of soil types. These types, for the most part, have a strong retentive power for water, and they contain liberal quantities of plant food, but this fact should not lead the grower to assume that the very best crops can be harvested indefinitely without giving his fields proper care. Planting sugar beets or cantaloupes, or even wheat or oats, for several years in succession upon the same piece of land with no return in the form of manure will undoubtedly throw the soil out of condition, and smaller crop yields will be the direct result. Even though the supply of mineral plant food may seem to be almost inexhaustible, such a course in soil management will consume the organic matter within the plowed surface and will leave the cultivated land defective from a physical standpoint. Organic matter is especially beneficial in these soils. Witness the increased returns through the application of farm manure or the better yields in cases where green manures have been incorporated with the soil. In the many tests that have been made, mineral fertilizers have failed to bring any appreciable response; but farm manure has not left any doubt concerning its value. A part of the increase in yield can, no doubt, be traced to the physical effect of the organic matter of the manure. It improves the texture of the top soil; water enters more readily and is stored more effectively; air also has freer access to the plant roots. If the soil is clayey in nature, humus will make it less tenacious. The operations of the field, particularly cultivation, can under such conditions be done with greater ease. Organic matter not only changes the texture of the soil, affording a more congenial home for the plant, but as it decomposes it acts upon the otherwise unavailable plant food of the soil, thereby placing a larger supply of soluble material at the disposal of the crop.

TYPES OF FARMING.

The cattle range was the starting point for the agricultural industries of the valley. In the beginning, small tracts of land were broken; grain, either wheat or oats, was usually the first crop; then alfalfa was sown, irrigation projects were developed, and a system of general farming was adopted. Alfalfa and grain were the first crops in the rotation. Later, cantaloupes were found to be adapted to the soil and climatic conditions of the valley; thus, a cultivated crop was introduced into the system. Orchards were planted and another type of farming was made possible. The sugar beet was tested and pronounced a success; factories were built, and the farmer had another source of income at hand. After the beet crop was harvested, tops were available for roughage. The supply of pulp was preserved in the factory silo; the broad valley produced abundant crops of alfalfa, and it was natural to find the feeder with herds of cattle and flocks of sheep making preparation to utilize the produce of the land.

In sections where the cantaloupe was grown most successfully, other truck crops were eventually planted. The tomato and the garden pea may be mentioned. The canning industry followed and has experienced a healthy growth. The fame which some of these crops gained, notably the cantaloupe, created a demand for selected seed, and a seed breeders' and growers' association was the outcome. Within the past two or three years other crops have been added to this list; cucumbers are now raised extensively for seed purposes in parts of the valley. Where truck crops are grown, the farms are comparatively small. The poultry industry has been extended on many of these small farms, as well as on the orchard lands. Here in the valley, two farm types have developed, namely, the small farm with its variety of crops, and the large farm with its general crops. Each has its set of problems for solution. Some of these problems are intricate and will require careful study; others are less difficult and it is probable that their solution can be effected quite readily.

MODIFICATIONS IN PRESENT SYSTEMS OF FARMING.

From the statements which have been made it will be seen that the valley produces a very large quantity of roughage, and these foodstuffs when properly combined make an excellent ration either for fattening stock or for other classes of farm animals. During the winter season of 1910–11 large numbers of sheep were fed along the valley of the Arkansas. The following spring there was a slump in prices on the sheep market, and many who were engaged in this work lost money. It was estimated that this loss amounted to $1 per head, or approximately $350,000 for the valley, but in spite of these losses the sheep-feeding business will undoubtedly be continued on an extensive scale for some years to come. The same thing will be true in connection with the feeding of cattle for the block.

Farmers should be interested in plans which will insure against some of these losses. A regular monthly income is preferable to a cash payment which may come once a year through the sale of sheep or cattle or by marketing a crop of wheat. If several crops are grown on the farm, a few of them may be placed directly on the market, while others may be put through a manufacturing process, and a high-priced product can be secured. The salable crops, together with the butter, eggs, or live stock, will provide a regular income for the owner or the tenant. Even if one crop does happen to be short on account of a lack of water at the right time or because a plant disease develops or insects come to check the plants in their growth, the remaining crops ripening at a different period will have a chance to mature and there will not be a total loss. Furthermore, such a system will extend the working season and will give the laborer steady employment from the beginning to the end of the year. It would seem that greater attention might well be given to the dairy industry in the valley. There is a growing demand for the products of this industry within the State of Colorado. Then, too, markets on the outside are not far distant. Each farm could then consume the rough feeds which are raised and the accumulated manure would assist materially in maintaining the yields of the various crops which are used in the rotation. All of these items deserve consideration.

METHODS OF CROPPING.

The variety of crops which are adapted to the soil and climatic conditions of the Arkansas Valley gives the man who wishes to plan a diversified system an opportunity to exercise his skill in working out the details not only for the crops which are to be placed upon the market directly, but provision must also be made for the live stock of the farm. Most of the cropping systems that are in actual operation have a fair proportion of the land in alfalfa, and these fields yield large quantities of nutritious hay. If dairying were to become a part of the farm plan (and it offers several advantages for this section as a whole at the present time), then some changes must be made in the rotations which are now in vogue. In Table IX four rotation plans are given, and from these four a new or suggested fifth plan has been devised, as explained further on.

Table IX.—*Arrangement of cropping systems.*

Period.	Rotations.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	
					Crops.	*Acreage.*
Three to five years	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa	One-third.
First year	Cantaloupes.	Wheat	Cantaloupes.	Cantaloupes.	Cantaloupes.	One-sixth.
Second year	Beets	Beets	Beets	Beets or cantaloupes.	Beets	Do.
Third year	Oats or barley.	...do	Cucumbers	Beets	Indian corn.	Do.
Fourth year	Alfalfa	Wheat or barley.	Wheat or barley.	Oats or barley.	Oats or barley.	Do.
Fifth year	...do	Reseeded to alfalfa along with the wheat, the barley, or the oats.				

Rotation 1 has been adopted on a large farm. It is an exception in one respect to the types which follow, and may be classified as a short rotation. Alfalfa is seeded with oats or barley; the field is watered systematically and a strong growth is secured the first season; the following year three or four cuttings of alfalfa hay are taken from the field; the third year brings the alfalfa around to the breaking period and the land is planted to cantaloupes and cucumbers. It is doubtful whether the alfalfa has a chance to make as large crops under this plan as it does where it remains down for a period of three to five years. Alfalfa is essentially a deep-rooted plant, and these roots can scarcely develop fully within so short a time.

Rotation 2 is essentially a grain and sugar-beet system. In sections where the sugar-beet acreage is large this form is sometimes extended, the root crop being repeated for three, four, and even five years in succession. Barley or oats may be sown in place of the wheat as the first crop after breaking the land, and in reseeding the land to alfalfa any of the cereals which have been mentioned may be used. The claim has been made that the very best crops of beets can be harvested after the land has been devoted to this crop for three or more years. The real benefit comes through efficient, continuous tillage, thus placing the soil in proper physical form. There are other phases, however, which should not be overlooked; the advantages of the plan may be overbalanced by the development of disease or through the increase of the insect enemies of the crop. With these checks in view, the grower can not afford to take unnecessary risk. A well-planned rotation should be selected and followed as far as practicable.

Rotations 3 and 4 are almost the same. In the former the sugar beet appears once in the series, while in the latter beets may be grown on the same piece of land for two years in succession. It is also possible in No. 4 to substitute cantaloupes for beets; this gives the root crop only one place in the cycle. Other minor changes can be made readily in either of these forms. The cucumber is grown for commercial seed. It is a crop that will follow alfalfa equally as well as the cantaloupe. Both crops appear to have special adaptations for this place in the rotation; perhaps the date of planting may be the chief reason. The alfalfa roots give some trouble at times, especially with the first cultivations of an intertilled crop, but this difficulty does not seem to be encountered when the cantaloupe or the cucumber is selected as the initial crop in the rotation. Rotations 3 and 4 can be worked out on the small farm just as easily as on the larger tracts. In fact, No. 4 was suggested by a farmer who is cultivating between 20 and 30 acres of land. If necessary, a place can be found for other crops, but some adjustment may have to be made. The canning factory has opened a market for new crops, such as the tomato and the canning pea. On the smaller farms, the grower may not wish to set aside very much land, relatively speaking, for cantaloupes or cucumbers; the sections formerly allotted for the vines can be subdivided, making two additional plats, one for tomatoes and one for peas.

No. 5 is given as a suggested plan; the proportions which are set down under acreage will be used merely to illustrate the rotation which has grown out of the former plans. In applying this schedule to a 40-acre tract, it will be seen that 13⅓ acres are assigned for alfalfa, and 6⅔ acres for each of the other crops in the series. This does not leave any space for the farm dwelling, the outbuildings, or for an orchard and a garden. If 4 acres are assigned for these purposes, the farm plan will stand as follows: 12 acres in alfalfa, 6 acres in cantaloupes, 6 acres in sugar beets, 6 acres in Indian corn, and 6 acres in oats or barley. To rotate the crops will necessitate breaking 6 acres of alfalfa land each year. A similar acreage of land will be seeded to alfalfa annually along with the oats or barley; this will leave each patch of alfalfa intact for two complete seasons. The land which is set apart for cantaloupes may be divided into two or three equal parts, and cucumbers as well as tomatoes may be represented in the truck-crop list. Such a division may insure a more uniform revenue from year to year; when one crop is low in price the others may bring more than an average return.

Indian corn has not been grown very extensively in the Arkansas Valley, but in sections where it has been planted excellent crops have been produced. It should be utilized for supplementary feeding; especially is this true of the farms on which dairy cows are being fed. Corn silage can be combined with alfalfa hay in such proportions as to form a very desirable ration. The beet tops and the beet pulp, if carefully preserved, will provide roughage during the fall and winter months, and the corn silage will serve for spring and summer feeding. The demand for dairy products in Colorado has been constantly growing within recent years; and it would seem that the industry ought to receive some encouragement, particularly in districts where the leading staples have been losing ground. By-products, such as beet tops and beet pulp, which are bringing very little to the grower at the present time, could, under a system of dairy farming, be made to yield a substantial return. More of the alfalfa hay could be fed on the farms of the valley; the supply of available manure would increase; with the application of this material better physical conditions would prevail in the soil types which are being cultivated; and an increase in crop yields would eventually be observed. The industry would also provide continuous work for the farm labor.

THE USE OF MANURE.

In the application of farm manure, or in turning under green manure, two or three points should be observed: (1) The requirements of the crop which is to receive direct benefit should be considered. Land upon which an exhaustive crop is to be planted, if it has been in cultivation for several years, should receive special care. Manure properly applied to such land will influence the returns appreciably. (2) The manure should be scattered at such a time that it will not have a detrimental effect upon the water-holding power of the soil. The work can be done early in the season, at least several weeks and preferably a few months prior to planting. If the manure is incorporated with the soil and water is applied as a winter irrigation, the organic matter will have a chance to decay and to become a part of the soil long before it is time to put in the seed. Under such conditions the capillary movement of the soil moisture will not be interfered with and seed germination should take place readily. Furthermore, this part of the work ought to be done systematically, so that all of the fields of the farm will be treated regularly; where the supply of manure is not adequate, green manuring crops may be grown and plowed under as a substitute for this by-product of the farm. To provide green manure, it will be necessary to modify the rotation so as to make room for the extra crop which is to be utilized for improvement purposes.

TILLAGE METHODS.

In preparing land for the cultivated crops that are common in this part of the State, some of the fields are plowed during the fall and winter months; on other farms spring plowing is the practice. Alfalfa sod is usually broken as soon as the winter season has passed. This work with some consists of two operations: (1) The surface is scalped to a depth of 3 or 4 inches and the field is worked down with a disk harrow; (2) after standing for a few weeks, until the tops are partly decayed, the land is given another plowing. With the second plowing the depth is increased from 3 or 4 inches to 7 or 8 inches. If the supply of water is plentiful and the land is to be planted to vines, the breaking might be postponed a few weeks for the purpose of allowing the alfalfa to grow up and make a partial crop of hay. The field may then be irrigated, and the spring growth can be turned under with the first plowing, which should not be shallower than 6 inches; it is possible that better results can be obtained by turning to a depth of 9 inches. After plowing, the land is brought into suitable tilth by using a disk harrow, the leveler, and the smoothing harrow in turn. Owing to the fact that the rainfall is uncertain, the fields are irrigated prior to planting. A full supply of available moisture brings about prompt and complete germination of the seed; first-class stands are obtained regularly only in this manner. Water is sometimes applied immediately after the seed has been placed in the soil.

THE SUGAR BEET.

The management of land for sugar beets deserves special attention. The factors which aid in securing a large crop are occasionally, if not frequently, overlooked; it is an easy matter to dismiss lightly such work as early, deep plowing, the preparation of an ideal seed bed, thinning for the purpose of obtaining a perfect stand, or gauging the proper amount of water during the growing season. If these things are worked out in detail, and the results are observed by the grower, it is certain that the minor parts in the production of the crop will be carried out at the opportune time. Although a low average yield has been reported for the beet crop in the valley within the past three or four years, a few farms have produced exceptionally good yields; there seems to be good reason for the belief that if excellent returns are possible on small tracts under proper cultural methods, the same methods can be applied on more extensive tracts with corresponding results.

The benefits of deep plowing in the fall or early winter are more readily apparent on lands which are given an irrigation either prior to or immediately after turning. The frosts of winter have very little effect upon a dry surface, and the fields are usually dry after harvest; but if the soil is thoroughly moistened, then the repeated thawing and freezing leaves the surface in a mellow condition. In such a field it is not a difficult task to prepare a suitable seed bed in the spring of the year. The depth to which the soil is plowed governs to some extent the development of the plant roots. In case the soil is heavy and compact, a shallow stirring will give the plant a limited area in which to grow, and a short, stunted root will be produced. This stunting will not only effect a reduction in the yield per acre, but it will also have a bearing upon the composition of the crop. Another decided advantage may be gained by deep tillage: Water can be absorbed rapidly by the soil only where the surface permits a ready penetration; more effective storage will also be afforded under such conditions. The moisture which passes deeply into the soil will return again to feed the growing plant.

Early spring tillage should follow the deep fall or winter plowing. This step is taken in order to conserve the moisture which has been stored in the course of the first irrigation. There is, perhaps, no better implement with which to do the initial work in the spring than the disk harrow. It pulverizes the surface completely and leaves the field in excellent condition for leveling. By repeating this treatment two or three times one may obtain the desired tilth which is characteristic of a first-class seed bed. The next step, planting, involves a careful examination of the planter in order to determine whether it will deliver the required amount of seed regularly. The test may be made by placing some seed in the box; then by setting the planter and driving it over a hard, smooth surface the seed will drop where it can be seen. An examination will show the quantity of seed which is being delivered. If the quantity is sufficient to produce a full stand of plants, the planting may be started in the field. The planter should be watched from the beginning of the operation until the work has been completed. Any defective work will be in evidence at a later time in the season. It may also be stated that straight rows are necessary if the right kind of work is to be done with the cultivator. As soon as the planting has been completed the field is furrowed out for irrigation. Where the land is somewhat rolling in character, or even in a field that is comparatively level, the use of a sled made of small logs will assist materially in getting the first run of water through uniformly.

As soon as the plants are large enough the beets should be thinned to the proper stand. It is customary to block the rows with a hoe, and the bunches which remain are then thinned out so that the stand will approximate one strong plant every 8 inches in the row. The more vigorous plants should be saved in preference to the weak, immature ones; however, if the work is to be done properly, careful supervision must needs be given. It has been suggested that something might be accomplished in the encouragement of better work through the payment of a premium; obviously, low yields can in many cases be traced to poor work in thinning. If a first-class stand of beets is mutilated in the thinning process to such an extent that 25 per cent of the stand has been destroyed, it is almost certain that the final yield will be reduced from a possible maximum almost to the same extent. It is, therefore, highly important that the work be done in accordance with the specified plan.

Throughout the early life of the plant regular cultivation will facilitate growth, and such tillage may, in a measure, take the place of some of the water. Fields are often irrigated and no attempt is made to break up the crust which forms on the surface after the land has dried out more or less; thus, when a second or a third run is made the water can not pass readily into the soil, and crop growth is not stimulated as it should be. More than one advantage can be gained by giving the surface a cultivation at such times. These advantages are shown in the greater storage of water, the better aeration of the soil, and the increased activity of the bacterial life in the soil. The extra growth will pay well for the additional work.

SUMMARY.

To improve the present returns from the beet fields of the Arkansas Valley several fundamental features must be observed. These may be stated in brief:

(1) Fall plowing and autumn or winter irrigation are necessary in the preparation of a first-class seed bed.

(2) A well-planned rotation should be selected, the roughage should be fed on the farm, and the manure should find its way back to the respective fields.

(3) Thorough preparation of the seed bed is essential; early work will assist in retaining soil moisture.

(4) Even, regular planting will insure the stand of beets; the thinning ought to be given careful supervision.

(5) Regular intertillage can not be omitted without incurring losses; care should be exercised in the use of the irrigation water.

LOST MOTION IN THE SUGAR-BEET INDUSTRY.

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INTRODUCTION.

Recently much attention has been drawn to the fact that one of the important sources of economic waste is no less due to a loss, or inefficient application, of motion than to an actual waste or misuse of material.

In many directions studies are being made of the methods of the most rapid and efficient workers to ascertain the factors of such skill. Almost without exception the difference between a workman of this character and a slow, inefficient worker is that the latter generally expends time and energy in unnecessary motions or makes movements that are awkward and indirect. In some industries it has been found that the various operations involved in the manufacture of an article are poorly coordinated, or the machinery badly arranged. It has been found that better system eliminates unnecessary motion, and attention to this point has often made all the difference between profit and loss. For example, Gilbreth, by an analysis of the motions involved in bricklaying, was able to reduce the motions of the bricklayer from 18 to 5, in this way greatly increasing the output of each bricklayer, with less effort to the individual, and the added stimulus of augmented pay. In like manner a close study was made of the methods and motions employed in structural painting. It was found possible so to reduce the movements of the workmen and systematize the method of working that the observant contractor was able to underbid his competitors and still make a good profit. Brandeis offered to show the railroads of this country how they could save $1,000,000 a day. It was chiefly through the elimination of unnecessary motion that he proposed to accomplish this result. The critical study of motion is now being brought to bear on many industries, and has become recognized as an important science in itself.

The fact should be emphasized that the misapplication of motion is equivalent to loss of motion. For example, the application of a little more labor at one point may save a great deal at another, or may result in a yield so much greater that it would far more than compensate for the additional labor.

Is it not possible that a scrutiny of agricultural methods will reveal losses of motion? As a beginning, let us make a brief survey of the sugar-beet industry. Under what have hitherto been the most favorable conditions the sugar beet is a comparatively costly crop to raise, owing chiefly to the fact that intensive methods must be employed to insure success. Some of the points discussed may perhaps apply to other crops as well.

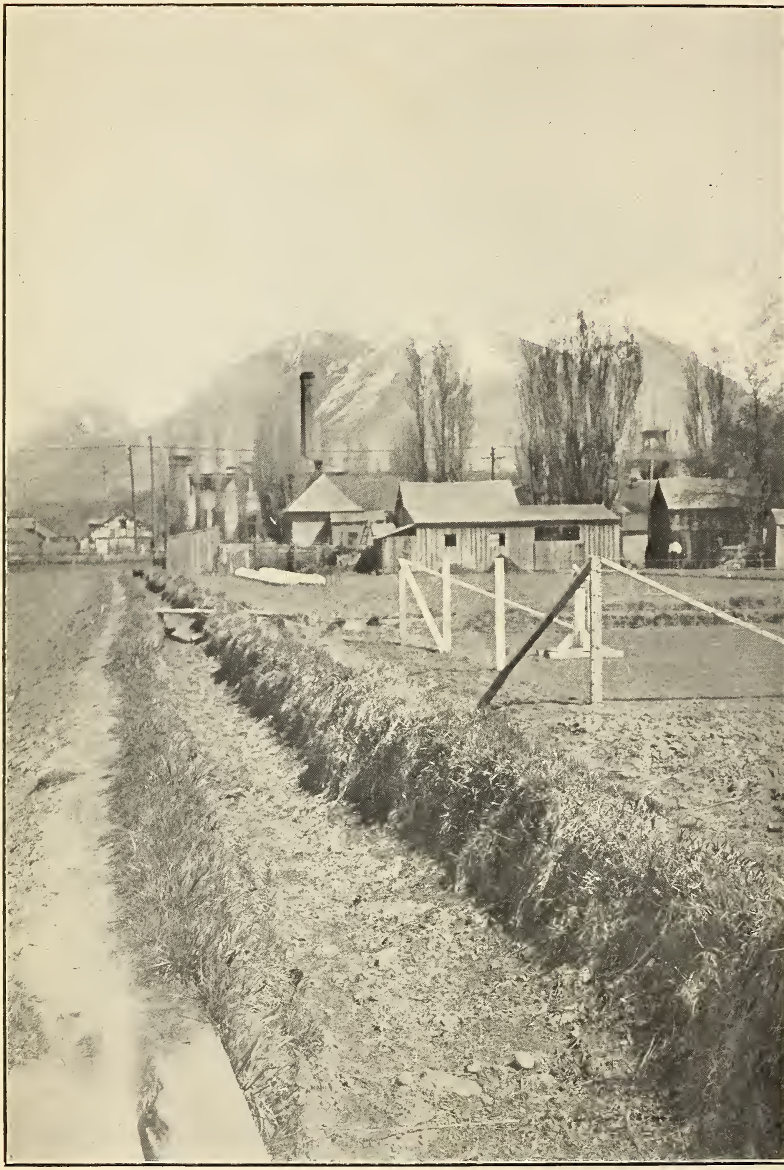
EXAMPLES OF LOST MOTION.

Loss of material and motion in the application of manure.—In the preparation of the soil for the beet crop it is observed that the practice of hauling manure during the winter and at odd times and dumping it in heaps here and there over the fields is still quite general. Later these piles of manure are scattered with forks. This practice is distinctly wasteful of motion and material. Almost twice as much labor is involved as would be necessary to scatter the manure broadcast directly from the wagon, even though done with forks. A much greater saving of motion would be effected through the use of manure-spreading attachments on the wagons. The labor thus saved in one season on a farm of moderate size would be enough to cover the additional cost of a manure spreader, for labor is costly in this country. The practice of dumping the manure in heaps (Pl. III, fig. 1) and leaving it thus for an indefinite time is bad; rains leach much of the valuable constituents of the manure into a very small patch of ground. In this spot beet seedlings may be killed, or if they survive they may be overstimulated and produce too much foliage and a low sugar content. In addition, manure thus applied is usually quite irregularly distributed. If the manure can not be applied broadcast at once, it would be much better to conserve it in bulk, with provision to save the leachings.

Inefficient method of blocking and thinning.—Blocking and thinning is a costly operation as at present practiced. There is yet no prospect of avoiding hand labor to thin beets, but it is believed that the blocking might much better be done with suitable machines. It could be done with greater exactness and far more rapidly with a machine than by hand. It is at times almost impossible to get the necessary labor for blocking and thinning beets, thus delaying the operation and causing a loss of yield. Several machines have already been invented to perform this operation, and if they are found to be practical implements they should be brought into general use. The objection is frequently raised that a machine will not discriminate, that it will cut out many of the few remaining plants in spots where

FIG. 1.—FIELD SHOWING MANURE DEPOSITED IN SMALL HEAPS TO LIE FOR MANY WEEKS BEFORE BEING SPREAD.

FIG. 2.—IRRIGATION DITCH ALMOST OBSCURED BY GROWTH OF WEEDS.



PERMANENT LATERAL IRRIGATION DITCH WHOSE BANKS ARE KNIT TOGETHER WITH GRASS; EASILY KEPT FREE FROM WEEDS.

the stand is poor, thus leaving a gap of varying size in the row whereas the laborers who perform this operation by hand would leave such plants, although they might be irregularly spaced. Granting that this unevennness of stand sometimes happens, it is believed that few beet growers realize how far short of the theoretically correct number of beets are left in the field, even when the stand is practically perfect to start with, after the blocking and thinning have been done by the ordinary hand methods. Especially is it so when no real supervision of this work is provided for. This is one of the most important operations so far as the tonnage of the crop is concerned, but it is too often very carelessly done. To the writer's knowledge blocking machines have been tried, but because some gaps have occasionally been left in the manner already indicated it has been concluded that it would not pay to continue their use. It is believed that such a conclusion is not founded on correct knowledge. A few gaps in the rows here and there would not reduce the total number of plants to anything like the extent that even the ordinary hand blocking and thinning does. A perfect stand would be represented by a plant every 8 inches in the row. On this basis the best stand left after thinning that the writer has been able to discover equaled 88 per cent of the perfect one, while the ordinary field, even among good beet growers, does not grade much better than 50 per cent of a perfect stand. The field showing 88 per cent was blocked and thinned by the owner himself, who is a successful truck farmer. The difference in tonnage between this field and the acreage for the locality was very marked. Furthermore, the introduction of machine blocking should stimulate the growers to greater effort to secure perfect stands. This result may frequently be accomplished by more care in the preparation of the soil for seeding—very often the soil is left far too lumpy.

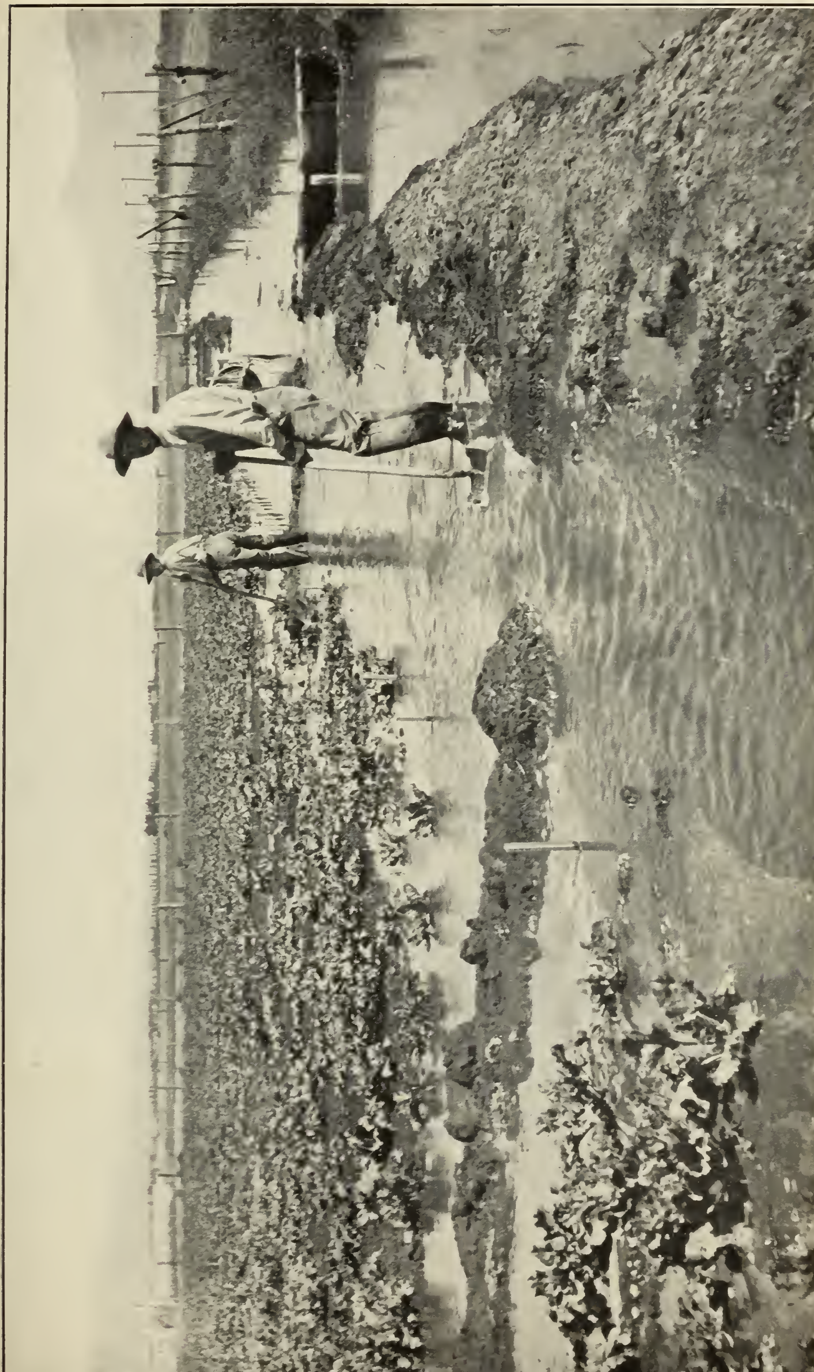
Weeds.—A great deal of the weeding can be done with horse weeders and cultivators. In the irrigated beet districts too much motion is applied in one direction through the lack of a little in another. It is a common and decidedly bad practice in these irrigated districts to pay practically no attention to weeds along banks of ditches and laterals; also along watercourses supplying the ditches. (Pl. III, fig. 2.) The weeds shed their seeds into the ditches, where they are carried along and finally spread broadcast over the fields with every irrigation. Further, the weeds harbor many kinds of injurious insects. The labor involved in cutting these weeds just before they mature their seed, perhaps twice during a season, would be far less than that now involved in ridding the fields of the weeds carried there as seed by the irrigation water. It would be still better to sow some forage crop along the banks of watercourses to bind the soil and protect the banks as shown in Plate IV. The labor of mowing the banks would be amply repaid by the forage yield.

Irrigation.—It is well known in the irrigated areas that one essential for the proper and economical application of water is that the surface of the fields should be as smooth as possible and free from undulations, especially across the line of water flow; it should have a grade suited to a steady, even flow of water, and the ditches or laterals should be carried to the highest points in the field. Frequently the writer has seen portions of a field adjacent to the ditch lower than portions some distance away. This necessitated the construction of temporary levees or ridges at every irrigation to carry the water across, and resulted in flooding the lower tract adjacent to the ditch. A little more labor with a float or light scraper would have permanently removed this source of waste motion. (Pl. V.)

Harvesting.—Another costly operation incident to beet growing is that of harvesting. A really successful beet topping and harvesting machine is much to be desired. Several such machines have already been devised both in this country and in Europe. Some of them promise, with minor improvements, to meet the needs.

At present practically all the operations of pulling, topping, and loading are done by hand. But even so, it does not appear that everywhere the best methods of hand labor are employed. The most systematic and rapid method with which the writer is acquainted is as follows:

In general a two-horse beet digger or lifter is used; with this machine the beets are thoroughly loosened and lifted almost out of the ground. The laborers then throw 7 to 9 rows of beets into one windrow; advancing up the rows and handling two or four rows at once, they throw the beets upon the middle row so that the roots shall all lie in one direction; they then return down the other side of the central row and throw the beets from four rows on that side. (Pl. VI, fig. 1.) Next, taking beet knives heavy enough to sever the crown at one stroke, but not too heavy to handle without fatigue, they start at one end of the windrow, kneeling or stooping, and follow to the other end. Instead of dropping the beets in a continuous row, however, they throw them into a pile in advance; as the pile is reached another is started, and so on. This leaves a series of beet piles ready for loading. Should it not be possible to haul the beets immediately, it would pay to cover each pile of beets with the leaves, thus preventing loss of weight through evaporation. This method has the advantage that the tops are left in compact windrows convenient for hauling to a silo, or for feeding fresh to stock. In some localities the toppers follow each single row of beets; standing erect most of the time, they stoop and pick up the beets by jabbing them



FIELD OF BEETS UNDER IRRIGATION, SHOWING LOCATION WHERE LABOR IS REPEATEDLY LOST DURING EACH SEASON THROUGH LACK OF A LITTLE ADDITIONAL GRADING.

FIG. 1.—FIELD OF BEETS IN MICHIGAN, SHOWING A GOOD SYSTEM OF PULLING AND TOPPING BY HAND.

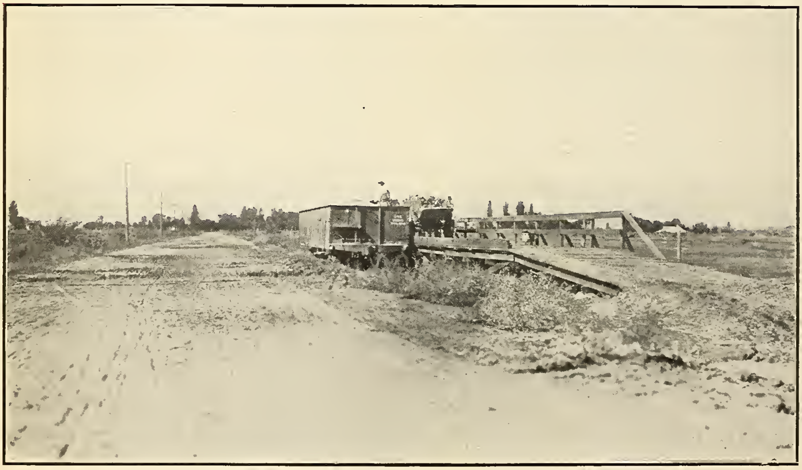


FIG. 2.—A POOR TYPE OF LOADING STATION. THE BEETS MUST BE LOADED IN RAILROAD CAR WITH FORKS.

with a heavy knife having a sharp beak at the tip; with the left hand the beet is then seized and removed from the knife beak and topped with the right hand: the beets as they are topped are thrown in small heaps. (Pl. VII.) This method appears to the writer to be much inferior to the other. The beaked knife is a dangerous tool; accidents have occurred in which the workman's leg has been seriously injured. There is a great amount of lost motion in stooping from the erect posture, straightening up again, and seizing the beet from the knife. Although this method does not require the pulling and throwing of the beets into windrows, that feature is equalized by the greater number of times the man must cross the field when taking but one row at a time. The probable loss of motion and of time is about 25 per cent.

Roads.—An extensive literature on the subject of roads is already in existence. The bulletins and circulars of the Office of Road Inquiry, Department of Agriculture, are available and give ample detailed information. The need of road improvement is a crying one. This fact is especially apparent in many of the more sparsely settled Western States. Roads generally are much wider than is necessary or desirable; a wide strip is left unused on either side and becomes a breeding place for weeds and injurious insects. It has been proposed, and in at least one State put into practice, to cultivate these roadside strips and raise upon them some profitable crop. On the roadsides in many parts of Europe the much narrower strips are covered with greensward and planted with fruit trees that are a source of profit to the communities in which they are grown. Most of our country roads are, much of the time, badly rutted, exceedingly dusty in dry weather, and almost indescribable, owing to mud, in wet weather. As compared with a good, hard-surfaced road it has been calculated that only about one-half as much can be hauled by the same team on these bad roads as would be practicable on good ones.

It is practicable to make fairly good dirt roads, but to do so it is necessary to make liberal use of good, heavy rollers. Only too commonly it is the practice simply to scrape or grade the dirt toward the middle of the roadway, and, after smoothing it off, leave it entirely without rolling. Within a few days the loose dirt becomes deeply rutted. It would be a great improvement to put broad tires on all wagons and to make the axles of the hind wheels longer than the front ones, so that the two pairs of wheels would not track. Such tires would not only prevent cutting ruts, but would actually consolidate the roads in a manner similar to the work of rollers; furthermore, hauling is much easier over indifferent roads with broad than with narrow tires. "The Missouri Agricultural Experiment Station made a series of tests extending from January, 1896, to September, 1897, in order to thoroughly and scientifically ascertain the value of wide tires as compared with narrow ones. They were made with two wagons, one with 6-inch tires, the other with standard 1½-inch tires, both wagons of the same weight, and each loaded with 2,000 pounds. It was found that the same power needed to draw the narrow-tired wagon, with its 2,000-pound load on a gravel road, would have pulled a load of 2,482 pounds on the wide-tired wagon. The same power required to draw the 2,000-pound load on narrow tires over dirt and gravel roads when they were dry and hard was found sufficient to draw a 2,530-pound load on the wide-tired wagon under the same conditions; and it was shown that when these roads were deep with mud but partly dried at the surface by a few hours' sun the same power required to draw the 2,000-pound load over them on the narrow tires would pull a load of 3,200 pounds on the wide tires."[1] It is practicable to clamp wide tires on the narrow-tired wheel. It has been conservatively estimated that the annual loss to this country through bad roads is not less than $500,000,000.

Beet dumps.—Badly constructed beet dumps cause great loss of motion. It is highly probable that there are no beet districts wherein some of the farmers are not obliged to ship their beets by rail or water after hauling them to a loading place. This at best means a double handling of the crop. Only too often the loading or dumping station, as it is called, is merely a grade running up to a low platform. (Pl. VI, fig. 2.) The wagon is hauled upon the platform, thus bringing the top of the wagon to about the level of the top of the railroad car. The beets must then be forked from wagon to car—a slow, laborious operation. The grade should always be such as to carry the wagon above the car, so that the beets may be dumped in bulk from endgate or hinged side directly into the car. The farmers should be in a position to demand properly constructed loading platforms. It would even pay them to construct them at their own expense, if necessary. At the factory this matter is greatly emphasized. (Pl. VIII, figs. 1 and 2.) All beet sheds should be so constructed that the beets may be dumped from wagon and car in bulk. The practice of dumping beets in great piles at loading stations is very wasteful of motion and should by any possible means be avoided. The management of loading stations and factory bins should be so organized as greatly to reduce the necessity for the farmers to wait in line to dump their beets. Instances have come to the writer's knowledge where hours have been thus wasted. Sometimes the railroads are guilty in failing to furnish sufficient cars to keep the beets moving. So also should the practice be less frequent of com-

[1] Circular 31, Office of Road Inquiry, U. S. Dept. of Agriculture, pp. 35–36.

A

B

C

TOPPING BEETS WITH A BEAKED KNIFE, A METHOD INVOLVING MUCH LOST MOTION AND DANGER TO THE WORKMAN.

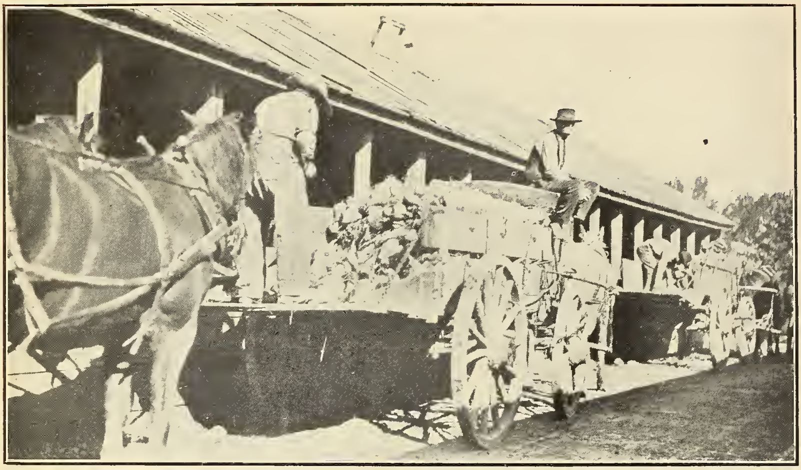


FIG. 1.—WAGONS TO BE UNLOADED WITH FORKS.

FIG. 2.—RAILROAD CAR TO BE UNLOADED WITH FORKS.

POOR TYPES OF BEET SHEDS.

pelling the farmer to silo his beets in the field because the factory can not take care of them as fast as delivered. There should be shed accommodation in proportion to the capacity of the factory and the probable supply of beets, except in case of unusual emergencies. To be sure, the farmer, when called on to silo part of his crop, receives some compensation for the extra labor involved but none for the loss in tonnage through drying of the beets. The industry is founded on the cooperation and good will of the growers. They should receive every reasonable consideration.

These instances are not imaginary ones or at all uncommon. On the contrary, they are rather widespread. A recognition of them may be a step toward their removal or reduction, with a consequent saving of motion, time, and money.

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SUGAR STATISTICS.

On the following pages will be found several tables of statistics relating to the sugar industry. Statistics for which the sources are not otherwise indicated have been compiled in this office from data obtained by special correspondence with the factories and growers.

As the usual annual report of the department upon the beet-sugar industry did not appear last year, the full crop statistics of 1910 for the several States are here reprinted. These statistics, made up from data collected by the department, were published in the Crop Reporter for October, 1911.

TABLE X.—*Beet-sugar crop in the United States.*

FOR THE YEAR 1910–11.[1]

State or year.	Factories.		Area harvested.	Yield.	Value per ton.	Beets worked.	Analysis.		Sugar manufactured.	Recovery.		Loss of beets.
	Number.	Run.					Sucrose.	Purity.		Beets.	Sucrose.	
		Days.	*Acres.*	*Short tons.*		*Short tons.*			*Short tons.*	*Per cent.*	*Per cent.*	*Per cent.*
California	8	114	90,500	10.20	......	923,100	18.20	82.78	139,890	14.18	77.90	4.02
Colorado	13	63	81,412	10.62	......	864,474	15.19	83.40	103,092	11.92	78.50	3.27
Idaho	3	53	13,178	8.39	......	110,556	16.82	87.38	14,269	12.91	76.75	3.91
Michigan	17	100	117,500	10.28	......	1,207,700	16.08	86.15	139,215	11.53	71.70	4.55
Utah	5	82	26,767	11.42	......	305,773	15.80	85.71	38,490	12.59	79.65	3.21
Wisconsin	4	76	16,772	9.14	......	153,327	16.75	84.14	18,130	11.82	70.60	4.93
Other States	11	68	51,900	9.29	......	482,362	15.66	82.69	57,086	11.84	75.59	3.82
Total or average	61	83	398,029	10.17	......	4,047,292	16.35	84.35	510,172	12.61	77.10	3.74

FOR THE YEAR 1911–12.[2]

State or year.	Number.	Run.	Area harvested.	Yield.	Value per ton.	Beets worked.	Sucrose.	Purity.	Sugar manufactured.	Recovery: Beets.	Recovery: Sucrose.	Loss of beets.
California	10	98.5	99,545	10.42	5.54	1,037,283	18.95	....	161,300	15.55	82.04	3.40
Colorado	14	63.3	86,437	11.07	5.55	957,142	15.44	....	124,800	13.04	81.22	2.40
Idaho	3	91	17,052	12.11	5.02	206,367	16.65	....	26,730	12.95	77.80	3.70
Michigan	17	122	145,837	9.90	5.74	1,443,856	14.59	....	125,500	8.69	59.55	5.90
Utah	6	96	33,950	13.03	4.81	442,310	15.98	....	57,280	12.95	81.04	3.02
Wisconsin	4	106	23,241	11.02	5.51	256,124	14.23	....	23,640	9.23	64.86	5.00
Other States	12	83	67,815	10.61	5.48	719,251	15.16	....	80,250	11.16	73.60	4.00
Total or average	66	94+	473,877	10.68	5.50	5,062,333	15.89	....	599,500	11.84	73.92	4.05

[1] From the Crop Reporter for October, 1911, except the percentages of sucrose and loss, which are computed.

[2] Compiled in the office of Cotton and Truck Disease and Sugar-Plant Investigations.

TABLE X.—*Beet-sugar crop in the United States*—Continued.

ANNUAL STATISTICS FOR 11 YEARS, FROM 1901–2 TO 1911–12.

State or year.	Factories.		Area harvested.	Yield.	Value per ton.	Beets worked.	Analysis.		Sugar manufactured.	Recovery.		Loss of beets.
	Number.	Run.					Sucrose.	Purity.		Beets.	Sucrose.	
		Days.	*Acres.*	*Short tons.*		*Short tons.*			*Short tons.*	*Per cent.*	*Per cent.*	*Per cent.*
1901–2	36	88	175,083	9.63	$4.50	1,685,688	14.8	82.20	184,605	10.95	74.00	3.85
1902–3	41	94	216,400	8.76	5.03	1,895,812	14.6	83.30	218,406	11.52	78.90	3.08
1903–4	49	75	242,576	8.56	4.97	2,076,494	15.1	....	240,604	11.59	76.75	3.51
1904–5	48	78	197,784	10.47	[1] 4.95	2,071,539	15.3	83.10	242,114	11.69	76.42	3.61
1905–6	52	77	307,364	8.67	[1] 5.00	2,665,913	15.3	83.00	312,920	11.74	76.74	3.56
1906–7	63	105	376,074	11.26	[1] 5.10	4,236,112	14.9	82.20	483,611	11.42	76.65	3.48
1907–8	63	89	370,984	10.16	[1] 5.20	3,767,871	15.8	83.60	463,628	12.30	77.84	3.50
1908–9	62	74	364,913	9.36	[1] 5.35	3,414,891	15.74	83.50	425,884	12.47	79.22	3.27
1909–10	65	83	420,262	9.71	......	4,081,382	16.10	84.10	512.469	12.56	78.02	3.54
1910–11	61	83	398,029	10.17	......	4,047,292	16.35	84.35	510,172	12.61	77.10	3.74
1911–12	66	94	473,877	10.68	5.50	5,062,333	15.89	....	599,500	11.84	73.92	4.05
Average:												
1901–2 to 1905–6	45.6	82.4	227,841	9.13	......	2,079,089	15.02	82.90	239,730	11.53	76.78	3.49
1906–7 to 1910–11	62.8	86.8	386,052	10.13	......	3,909,510	15.78	83.55	479,153	12.26	77.84	3.52
First 10	54.2	84.6	306,947	9.75	......	2,994,300	15.40	83.27	359,441	11.90	77.28	3.50

[1] S. Doc. 22, 61st Cong., 1st sess.

TABLE XI.—*Beet-sugar crop in Canada.*[1]

Crop of 1911–12.		Sugar production, 1904–5 to 1911–12.			
Data covered.	Amount.	Year.	Yield.	Year.	Yield.
			Short tons.		*Short tons.*
Harvested ... acres..	12,000				
Beets handled ... short tons..	95,520	1904–5	9,000	1908–9	7,800
Yield per acre ... do....	7.96	1905–6	12,800	1909–10	9,860
Sugar manufactured ... do....	10,700	1906–7	12,730	1910–11	8,700
Recovery, beets ... per cent..	11.20	1907–8	8,900	1911–12	10,700

[1] Statistics for 1911–12 are based in part on direct reports from the factories and in part on estimates in Willett and Gray's Weekly Statistical Sugar Trade Journal for April 3, 1912. The statistics of production for 1904–5 to 1911–12 are from the last-mentioned source.

TABLE XII.—*Commercial cane and beet-sugar production of the world, 1812–1911.*[1]

Year.	Total.	Cane.	Beet.	Cane.	Beet.	Year.	Total.	Cane.	Beet.	Cane.	Beet.
	S. tons.	*S. tons.*	*S. tons.*	*P. ct.*	*P. ct.*		*S. tons.*	*S. tons.*	*S. tons.*	*P. ct.*	*P. ct.*
1812–13..	....	....	3,849	......	....	1859–60..	1,875,234	1,446,274	428,960	77.1	22.9
1836–37..	....	....	40,777	......	....	1860–61..	2,062,215	1,675,815	386,400	81.3	18.7
1840–41..	1,288,000	1,232,000	56,000	95.65	4.35	1861–62..	2,246,974	1,793,374	453,600	79.8	20.2
1850–51..	1,568,000	1,344,000	224,000	85.8	14.2	1862–63..	2,177,496	1,664,536	512,960	76.4	23.6
1853–54..	1,591,025	1,365,905	225,120	85.9	14.1	1863–64..	2,094,023	1,605,703	488,320	76.7	23.3
1854–55..	1,547,635	1,347,155	200,480	87.0	13.0	1864–65..	2,193,422	1,587,502	605,920	72.4	27.6
1855–56..	1,583,119	1,317,679	265,440	83.2	16.8	1865–66..	2,429,136	1,667,536	761,600	68.6	31.4
1856–57..	1,690,319	1,410,319	280,000	83.4	16.6	1866–67..	2,265,096	1,543,816	721,280	68.2	31.8
1857–58..	1,861,723	1,456,283	405,440	78.2	21.8	1867–68..	2,536,656	1,832,428	704,228	72.3	27.8
1858–59..	2,120,724	1,691,764	428,960	79.8	20.2	1868–69..	2,501,105	1,775,546	725,559	71.0	29.0

[1] Statistics for 1812–13 are from report of the minister of the interior of France; for 1836–37, from Jules Helot's "Le Sucre de Betterave en France," 1800–1900, p. 209; for 1840–1851, from Monthly Summary of Commerce and Finance, February, 1901; for 1853–1904, from Special Reports of the Census Office; Manufactures, pt. 3, 1905 (issued 1908), p. 451; for 1904–1912, from Willett and Gray's Weekly Statistical Sugar Trade Journal. Data for 1905–6 and succeeding years include production for British India, while exports are reported for other years.

TABLE XII—*Commercial cane and beet sugar production of the world*—Contd.

Year.	Total.	Cane.	Beet.	Cane.	Beet.
	S. tons.	*S. tons.*	*S. tons.*	*P. ct.*	*P. ct.*
1869–70..	2,794,720	1,861,708	933,012	66.6	33.4
1870–71..	2,830,452	1,791,436	1,039,016	63.3	36.7
1871–72..	2,970,741	2,008,125	962,616	67.6	32.4
1872–73..	3,321,168	2,061,904	1,259,264	62.1	37.9
1873–74..	3,200,527	1,917,174	1,283,353	59.9	40.1
1874–75..	3,272,659	1,967,482	1,305,177	60.1	39.9
1875–76..	3,408,999	1,895,968	1,513,031	55.6	44.4
1876–77..	3,098,223	1,884,435	1,213,788	60.8	39.2
1877–78..	3,487,985	1,921,808	1,566,177	55.1	44.9
1878–79..	3,937,097	2,201,909	1,735,188	55.9	44.1
1879–80..	3,734,380	2,131,714	1,602,666	57.1	42.9
1880–81..	4,086,709	2,130,628	1,956,081	52.1	47.9
1881–82..	4,309,387	2,258,013	2,051,374	52.4	47.6
1882–83..	4,723,198	2,356,560	2,366,638	49.9	50.1
1883–84..	5,455,609	2,853,235	2,602,374	52.3	47.7
1884–85..	5,711,165	2,903,764	2,807,401	50.8	49.2
1885–86..	5,474,941	3,027,192	2,447,749	55.3	44.7
1886–87..	6,174,871	3,142,423	3,032,448	50.9	49.1
1887–88..	5,695,178	2,959,040	2,736,138	52.0	48.0
1888–89..	5,851,304	2,778,384	3,072,920	47.5	52.5
1889–90..	6,780,714	2,772,896	4,007,818	40.9	59.1
1890–91..	7,307,562	3,213,168	4,094,394	44.0	56.0
1891–92..	7,485,517	3,619,348	3,866,169	48.3	51.7
1892–93..	7,203,405	3,410,608	3,792,797	47.3	52.7
1893–94..	8,265,445	3,955,415	4,310,030	47.9	52.1
1894–95..	9,238,258	3,932,950	5,305,308	42.6	57.4
1895–96..	7,903,168	3,146,614	4,756,554	39.8	60.2
1896–97..	8,644,472	3,182,880	5,461,592	36.8	63.2
1897–98..	8,579,275	3,207,965	5,371,310	37.4	62.6
1898–99..	8,883,029	3,354,891	5,528,138	37.8	62.2
1899–1900	9,587,321	3,423,049	6,164,272	35.7	64.3
1900–1901	10,772,532	4,083,586	6,688,946	37.9	62.1
1901–2...	12,204,178	4,569,537	7,634,641	37.4	62.6
1902–3...	10,980,859	4,641,787	6,339,072	42.3	57.7
1903–4...	11,573,715	4,753,511	6,820,204	41.1	58.9
1904–5...	10,698,952	5,185,530	5,513,422	48.5	51.5
1905–6...	15,625,111	7,541,661	8,083,450	48.2	51.8
1906–7...	16,224,402	8,223,326	8,001,076	50.7	49.3
1907–8...	15,553,082	7,744,218	7,808,864	49.8	50.2
1908–9...	16,313,857	8,554,637	7,759,220	52.4	47.6
1909–10..	16,711,014	9,333,007	7,378,007	55.8	44.2
1910–11..	19,044,256	9,456,668	9,587,588	49.6	50.4
1911–12..	17,665,304	9,962,951	7,702,353	56.4	43.6

TABLE XIII.—*Per capita consumption of sugar in various countries.*

[From Willett & Gray's Weekly Statistical Sugar Trade Journal, January 5, 1911, there credited to Otto Licht's Monthly Report, dated Magdeburg, December 9, 1910.]

Country.	Population.	Consumption per head.
		Pounds.
Germany	64,724,000	43.45
Austria-Hungary	51,018,000	25.14
France	39,450,000	37.80
Russia	128,171,000	22.82
Belgium	7,386,000	32.36
Holland	5,826,000	43.53
Sweden	5,476,000	53.90
Norway	2,350,000	41.78
Denmark	2,726,000	77.75
Italy	34,270,000	9.33
Spain	19,750,000	14.20
Roumania	6,860,000	9.50
Finland	2,969,000	32.45
Bulgaria	4,253,000	7.05
Greece	2,636,000	7.52
Servia	2,821,000	7.58
Turkey in Asia	24,050,000	12.89
Portugal and Madeira	5,700,000	14.12
Switzerland	3,559,000	64.10
England	45,472,000	86.30
Total Europe	459,527,000	32.60
United States (Willett & Gray, 1910)	91,972,266	81.60

TABLE XIV.—*Beet-sugar factories of the United States and Canada.*

Name of company or factory.	Location of factory (Pls. I and II, in pocket).	Built in—	Daily slicing capacity.
ARIZONA.			
			Tons.
The Southwestern Sugar & Land Co., main office, Phoenix.	Glendale	1904	800
CALIFORNIA.			
Alameda Sugar Co., main office, Hansford Building, San Francisco.	Alvarado	1879	800
Los Alamitos Sugar Co	Los Alamitos	1896–97	700
Spreckles Sugar Co., main office, 60 California Street, San Francisco.	Spreckles	1897–1899	3,000
Union Sugar Co., main office, Hansford Building, San Francisco.	Betteravia	1899	1,000
American Beet Sugar Co., main office, 32 Nassau Street, New York. Pacific coast office, 16 California Street, San Francisco.	Chino	1891	900
	Oxnard	1898	2,000
Sacramento Valley Sugar Co	Hamilton City	1906	700

TABLE XIV.—*Beet-sugar factories of the United States and Canada*—Continued.

Name of company or factory.	Location of factory (Pls. I and II, in pocket).	Built in—	Daily slicing capacity.
CALIFORNIA—continued.			*Tons.*
Southern California Sugar Co	Santa Ana	1908	600
Anaheim Sugar Co	Anaheim	1910–11	600
Holly Sugar Co., main office, Boston Building, Denver, Colo.	Huntington Beach	1910–11	750
Total (10 factories)			11,950
COLORADO.			
American Beet Sugar Co., western office, 1530 Sixteenth Street, Denver.	Rocky Ford	1900	1,000
	Lamar	1905	400
	Las Animas	1907	700
Holly Sugar Co., main office, Boston Building, Denver.	Holly	1905	600
	Swink	1906	1,200
National Sugar Manufacturing Co	Sugar City	1900	500
The Great Western Sugar Co., general offices, Sugar Building, Denver:			
Eaton factory	Eaton	1900–1902	600
Greeley factory	Greeley	1901–2	600
Loveland factory	Loveland	1901	1,200
Windsor factory	New Windsor	1903	600
Longmont factory	Longmont	1903	1,200
Fort Collins factory	Fort Collins	1903–4	1,200
Sterling factory	Sterling	1905	600
Brush factory	Brush	1906	600
Fort Morgan factory	Fort Morgan	1906	600
Western Sugar & Land Co	Grand Junction	1899	600
San Luis Valley Beet Sugar Co	Monte Vista	1910–11	600
Total (17 factories)			12,700
IDAHO.			
Utah-Idaho Sugar Co., main office, Salt Lake City, Utah.	Idaho Falls	1903	1,200
	Sugar	1904	1,200
	Blackfoot	1904	600
	Nampa	1906	750
Total (4 factories)			3,750
ILLINOIS.			
Charles Pope, 332 South Michigan Avenue, Chicago	Riverdale	1905	350
INDIANA.			
Holland-St. Louis Sugar Co	Decatur	1911–12	1,000
IOWA.			
Iowa Sugar Co	Waverly	1907	500
KANSAS.			
United States Sugar & Land Co	Garden City	1906	900
MICHIGAN.			
Michigan Sugar Co., general offices, Saginaw:			
Bay City plant	Bay City	1899	600
Caro plant	Caro	1899	1,200
Alma plant	Alma	1899	750
Carrollton plant	Carrollton	1902	800
Sebewaing plant	Sebewaing	1902	600
Croswell plant	Croswell	1902	600
West Bay City Sugar Co	Bay City, Station A	1899	600
Holland-St. Louis Sugar Co., main office, Holland	Holland	1899	350
	St. Louis	1903	600
Owosso Sugar Co., main office, Bay City:			
Owosso plant	Owosso	1903	1,200
Lansing plant	Lansing	1901	600
German-American Sugar Co	Bay City, Station A	1901	650
Mount Clemens Sugar Co	Mount Clemens	1902	600
Menominee River Sugar Co	Menominee	1903	1,200
Holland-St. Louis Sugar Co	St. Louis	1903	600
Continental Sugar Co., main office, 528 Garfield Building, Cleveland, Ohio: Blissfield works	Blissfield	1905	700
West Michigan Sugar Co	Charlevoix	1902	600
Western Sugar Refining Co	Marine City	1900	350
Total (17 factories)			12,000

TABLE XIV.—*Beet-sugar factories of the United States and Canada*—Continued.

Name of company or factory.	Location of factory (Pls. I and II, in pocket).	Built in—	Daily slicing capacity.
MINNESOTA.			*Tons.*
Minnesota Sugar Co	Chaska	1906	600
MONTANA.			
The Great Western Sugar Co., main office, Sugar Building, Denver, Colo.	Billings	1906	1,200
NEBRASKA.			
American Beet Sugar Co., western office, 1530 Sixteenth Street, Denver, Colo.	Grand Island	1890	350
The Great Western Sugar Co., main office, Sugar Building, Denver, Colo.	Scottsbluff	1900	1,200
Total (2 factories)			1,550
NEVADA.			
Nevada Sugar Co	Fallon	1910-11	500
OHIO.			
Continental Sugar Co., main office, 528 Garfield Building, Cleveland:			
Fremont works	Fremont	1900	500
Findlay works	Findlay	1911	600
German American Sugar Co	Paulding	1910	700
Total (3 factories)			1,800
OREGON.			
Amalgamated Sugar Co., main office, Ogden, Utah	La Grande	1898	400
UTAH.			
Amalgamated Sugar Co., main office, Ogden:			
Logan works	Logan	1901	600
Ogden works	Ogden	1898	400
Lewiston works	Lewiston	1905	600
Utah-Idaho Sugar Co., main office, Salt Lake City	Lehi	1891	1,200
Cutting station	Springville	1891	
Do	Spanish Fork	1891	
Do	Provo	1891	
Utah-Idaho Sugar Co	Garland	1903	1,200
	Elsinore	1910-11	500
Total (5 factories)			4,500
WISCONSIN.			
Wisconsin Sugar Co., main office, Milwaukee	Menomonee Falls	1901	500
Chippewa Sugar Co., main office, Milwaukee	Chippewa Falls	1904	600
Rock County Sugar Co	Janesville	1904	600
United States Sugar Co	Madison	1906	600
Total (4 factories)			2,300
CANADA.			
Dominion Sugar Co. (Ltd.), main office, Wallaceburg, Ontario:			
Wallaceburg plant	Wallaceburg, Ontario	1901-2	850
Berlin plant	Berlin, Ontario	1901-2	600
Knight Sugar Co	Raymond, Alberta	1904	400
Total (3 factories)			1,850
NOT IN OPERATION.			
Pacific Sugar Corporation, main office, Corcoran, Cal	Visalia, Cal	1905-6	400
	Corcoran, Cal	1907-8	600
Washington State Sugar Co., main office, Spokane, Wash.	Waverly, Wash	1899	500

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Map of the United States, Showing Areas where Sugar Beets are Grown, Sugar-Factory Locations, and Precipitation Data.

FROST DATA FOR THE SUGAR BEET SECTIONS.

		N.W. OHIO		SOUTHERN MICHIGAN				N. ILL.	SOUTH'N WISCONSIN			N. WIS.		N. MICH.		MINN.	IA.	NEB.
		FINDLAY	WAUSEON	ADRIAN	ALLEGAN	LANSING	ALMA	SYCAMORE	WAUKESHA	MADISON	LANCASTER	DOWNING	SHAWANO	MENOMINEE	CHARLEVOIX	SHAKOPEE	WAVERLY	GRAND ISLAND
YEARS OF RECORD.		19	42	10	18	14	11	19	18	18	18	9	11	11	10	14	16	16
SPRING FROSTS AFTER	APRIL 30	13	36	10	17	11	11	14	15	8	10	9	9	11	10	10	10	8
	MAY 10	5	23	4	12	4	7	6	8	2	4	9	8	4	8	8	3	4
	MAY 20	2	10	1	7	1	1	2	7	0	2	6	6	2	1	6	1	1
FALL FROSTS BEFORE	SEPT. 20	1	9	1	2	0	2	4	0	0	3	6	3	1	0	4	1	3
	OCT. 5	10	28	4	11	3	6	9	7	4	11	9	8	8	1	11	6	6
	OCT. 20	14	38	8	17	11	10	16	14	13	15		11	11	7	14	14	13
DAYS IN GROWING SEASON LESS THAN	110		1	0	1	0	0	0	0		0	3	0	0	0	1	0	0
	130	0	14	3	6	1	4	3	2	0	3	8	6	3	1	4	1	1
	150	6	28	3	10	2	9	7	7	1	7	9	9	9	5	12	5	4
	170	14	38	8	17	12	11	16	11	8	14		11	11	10	14	12	11
		SOUTHERN LAKE SECTION										NORTHERN LAKE SECTION					CENTRAL PLAINS	

		MONT.	NEB.	N. E. COLORADO			S.W. KANS.	S.E. COLORADO				W. COLO.	UTAH		IDAHO		ORE.	NEV.
		BILLINGS	GERING & SCOTTSBLUFF	FORT MORGAN	GREELEY	FORT COLLINS	GARDEN CITY	HOLLY	LAMAR	LAS ANIMAS	ROCKY FORD	GRAND JUNCTION	FILLMORE	CORINNE	IDAHO FALLS	BOISE	LA GRANDE	FALLON
YEARS OF RECORD.		12	16	13	17	20	17	11	17	19	20	20	19	15	7	13	16	7
SPRING FROSTS AFTER	APRIL 30	12	16	12	12	16	6	5	6	12	13	3	17	13	7	4	16	7
	MAY 10	6	11	7	5	9	4	3	0	6	5	2	16	10	5	2	13	7
	MAY 20	3	3	6	1	4	2	1		1	1	0	8	3	4	1	9	5
FALL FROSTS BEFORE	SEPT. 20	8	4	4	4	9	2	2	2	3	3	1	8	3	6	0	11	2
	OCT. 5	12	13	11	12	16	4	4	6	8	9	3	16	9	7	2	14	4
	OCT. 20	14	15	15	15	19	13	11	15	18	19	11	19	14		6	16	6
DAYS IN GROWING SEASON LESS THAN	110	2	2	2	0	1			0	0			5	2	4		6	0
	130	7	7	3	3	10	0	0	1	2	0	0	12	2	5	0	12	4
	150	10	15	8	12	14	5	3	2	8	9	2	17	10	7	1	15	5
	170	12	15	12	15	19	11	10	12	15	16	5	18	13		4	16	7
		YELLOWSTONE VALLEY	PLATTE VALLEY				ARKANSAS VALLEY					GRAND VALLEY	SALT LAKE BASIN		SNAKE VALLEY			

	CALIFORNIA								ARIZONA
	CHICO	WOODLAND	LIVERMORE	KING CITY	SANTA MARIA	LOS ANGELES	ANAHEIM	CHINO	PHOENIX
	15	15	15	15	15	15	13	15	16
JAN. 31	12	10	9	5	7	0	3	7	13
FEB. 28	11	4	6	3	4		2	2	4
MAR. 31	4	1	2	2	1		1	0	0
NOV. 20	5	2	3	3	3			0	3
DEC. 10	8	10	5	6	7	0	0	4	9
JAN. 1	11	15	10	6	11	1	2	6	16
250	6	1	3	3	3		1	0	2
275	10	4	6	3	5		1	1	3
300	10	7	7	4	5		2	4	9
325	10	11	9	5	8	0	2	6	13

MAP OF THE UNITED STATES, SHOWING AREAS WHERE SUGAR BEETS ARE GROWN, SUGAR-FACTORY LOCATIONS, FROST DATA, AND LENGTH OF THE GROWING SEASON.