U.S. DEPARTMENT OF AGRICULTURE.

REPORT

OF THE

CHIEF OF THE DIVISION OF CHEMISTRY

FOR

1890.

BY

H. W. WILEY.

FROM THE REPORT OF THE SECRETARY OF AGRICULTURE FOR 1890.

WASHINGTON:
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REPORT OF THE CHEMIST.

WASHINGTON, D. C., *December* 22, 1890.

SIR: I have the honor to submit herewith a brief report of the work of my Division during the past year.

I am, respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

STUDIES ON THE SEPARATION OF SUGAR FROM SORGHUM JUICES.

For many years attempts have been made by the division to secure a more perfect separation of the sugar from the non-sugars in sorghum juices. Extensive practical experiments were made in this direction at Fort Scott in 1886, in the practical application of the process of carbonatation.

This process consists in the addition to the mill or diffusion juices of large quantities of lime, from 1.5 per cent to 3 per cent of the weight of the juice, according to the amount of impurities present. The lime is then precipitated by blowing through the liquid a current of carbonic acid derived from a limekiln or coke furnace, or even from the chimneys of the boiler furnaces. The result of this process was entirely successful in respect of the yield of sugar, but on account of the blackening of the molasses, which was at that time a valuable by-product, it met with no favor from sorghum sugar manufacturers, but on the contrary was condemned by them as being unsuitable for the purpose.

Subsequently extensive laboratory experiments were made looking to the precipitation of the crystallizable sugar in the juices as sucrates of lime. The process employed in the Steffen method of separating sugar from beet-root molasses was the one tried for this purpose. While these experiments were successful in separating the crystallizable sugars in the form of a precipitate, they were not wholly so in securing a separation from the non-sugars, the greater part of which were also thrown down as lime compounds or carried down mechanically with the precipitated sugar. This process was, therefore, abandoned as not being practical.

The destruction of the reducing sugars or glucoses present by boiling with excess of quicklime was next tried. This process was entirely successful in so far as destroying the glucoses was concerned, but it had no effect whatever upon the other carbohydrates, of an amorphous nature, present in the juices. Inasmuch as the glucoses exert the least unfavorable influence of the non-sugars present in the juices the process was at once seen to be inapplicable from a practical point of view. The experience of the Department, and of manufacturers of sugar, has shown that the reducing sugars known generally under the term of glucoses, exercise a much less influence in preventing the crystallization of the sugars than was formerly supposed. In fact, it is supposed that could all other disturbing influences be removed, the glucose might be unobjectionable in securing an almost complete crystallization of the sucrose present in the juices. It would furnish a mother liquor in which the crystallizable sugar would be highly insoluble and from which it would easily separate. Having abandoned, therefore, the methods of separation above noted, there remained to be studied some process which would separate as nearly as possible the gummy amorphous bodies from the juices without precipitating the sugar. The property of alcohol to produce precipitation in sorghum juice was made use of in the further study of this problem. On account, however, of the large amount of alcohol, which would be required to treat the juices in their natural state, or as they come from the diffusion battery, it was decided to apply the process at a later period of manufacture.

In order to carry out this idea the juices of sorghum were treated precisely in the manner in which they are ordinarily in a sugar factory. The natural acidity of the juices was carefully neutralized with lime and the temperature raised to the boiling point. The scums which were formed were carefully removed and the juice boiled in an open dish, until all greenish scums and coagulated matters were separated.

The inversion of sugar which takes place during the boiling, which lasts only a few minutes, was not noteworthy. The juices were next concentrated in vacuo until they reached a density of 45° to 50° Brix. After cooling, the sirup thus formed was mixed with an equal volume of 95 per cent alcohol, which was sufficient to produce a complete precipitation of the gummy amorphous matters. These matters were separated by passing through a filter press, forming a hard, firm cake, easily separated from the filter cloth. The filtered sirup was limpid and of an exceptionally pleasant flavor. Evaporating in vacuo after removal of the alcohol, it readily crystallized during evaporation, forming a massecuite of good grain and absolutely free from gum and capable of being treated most easily in a centrifugal.

From very poor sorghum juices from immature cane, having a purity of only 60, a most excellent article of massecuite and sugar was made by the above process.

In regard to the quantity of matters separated by alcohol, some determinations were made with the following results:

Percentage of gum secured by alcohol—	
Experiment 1	2.08
Experiment 2	1.88
Mean	1.98

The juices from which these separations were made contained about 16 per cent of solid matters; thus the percentage of matters secured by alcohol on the whole amount of solid matters present was 12.5

It is seen from the above data that from each 100 pounds of sorghum juice about 2 pounds of gum can be separated.

The difficulties which have been encountered in manufacturing sugar from sorghum juices have been chiefly due to the presence of these gums. Their removal, therefore, if it can be accomplished on a manufacturing basis, would at once place sorghum in a high rank as a sugar-producing plant.

The alcohol which is used in precipitation can be almost wholly recovered by subsequent distillation. Our experiments show that the total loss need not exceed 5 or, at most 10 per cent, of the quantity of alcohol used. One of the most encouraging and at the same time least expected results of the work has been the demonstration of the fact that the gum separated in the manner above described is completely fermentable, yielding almost one half its weight in alcohol. It thus appears that from the gums themselves a sufficient amount of alcohol may possibly be derived to supply the whole waste of alcohol which would take place in the process of manufacture. Any additional quantities of alcohol which might be needed could be easily obtained from the molasses after the extraction of all the crystallizable sugar. In other words, the process which has been demonstrated as thoroughly practical in the laboratory, so far as can be foreseen for the operation of an actual trial on a manufacturing scale, is capable of being conducted with economy, and a proper stock of alcohol once being provided the wastage therein in the process of manufacture could be wholly, or in great part at least, supplied by the refuse matter which otherwise would be a manufacturing waste.

Experiments were also made to determine the quantity of alcohol necessary to precipitate the total gum matters and also the strength of the alcohol required with the following results:

SORGHUM SIRUP, OF 44° BRIX AT 60° F.

On adding 15 cubic centimeters of 80 per cent alcohol, to 25 cubic centimeters of juice, the main part of the amorphous matters was precipitated.

Series of experiments.

[Comparison showing quantities of alcohol of 70, 80, and 90 per cent and of methyl alcohol (crude) necessary to precipitate 25 cubic centimeters of sirup, of 44° Brix at 60° F.]

	70 per cent.	80 per cent.	90 per cent.	Methyl alcohol.
	cc	*cc*	*cc*	*cc*
Chief precipitation of amorphous bodies	20	15	10	12
Total precipitation of those bodies	35	25	20	20

The portion of the amorphous bodies which is soluble in water becomes, in part, redissolved before filtration when precipitated with 70, and rather less so with 80 per cent alcohol.

The separation of the amorphous bodies can be attained on the manufacturing scale with 80 per cent alcohol by the application of 1 volume of alcohol to 1 volume of sirup of 44° Brix.

In order to illustrate the practical application of the method on a manufacturing scale in the manufacture of sorghum sugar the following theoretical data are given:

A normal sorghum juice may contain at 18° Brix 12 per cent of sugar; a normal sorghum sirup may contain at 44° Brix 29.33 per cent of sugar, which is equal to 29,330 pounds of sugar in 10,000 gallons of sirup. Of this, 29,330 pounds (from 7,280 to 13,000 pounds), or about an average of 10,000, has been obtained by the methods of manufacture in use.

By the use of alcohol for the removal of the amorphous bodies which prevent the crystallization of the sugar, the *minimum* per cent of sugar, which, after this process would be obtained, may be put at 80 per cent (87 per cent is usually computed from pure juices), or 23,464 pounds.

10,000 pounds, at 4 cents		$400
23,464 pounds, at 4 cents	$938	
Cost of alcohol lost in the work	84	
		854
Value of product, usual method	400	
Value of product, alcohol method	854	
A gain of		454

In this estimate the material from which the alcohol is made is not regarded as of any value, since it otherwise would be wasted. If the molasses be used as a source of alcohol, then the item for the cost thereof must be increased.

On account of the ease with which a heavy sirup can be preserved it has also been thought possible that during the manufacturing season the whole apparatus of the factory could be directed to making sirup alone which could be preserved and worked into sugar subsequently.

Inasmuch as it is highly important, in working a sorghum crop, to have it taken off in as short a time as possible, any scheme which will tend to simplify the operation during the harvesting season is worthy of consideration.

It is true that the storage of a whole crop of sirup would require considerable room and the cost of tanks or cellars in which it is to be held would be an item which could not be neglected. However, it must not be forgotten that by the storage system the machinery of the factory could be operated during a much longer period. For instance, it is well known that the harvesting operations and the manufacture of sugar must be chiefly conducted during the months of September and October. The manufacture of sirup into sugar, however, could be continued through the winter months, or if they were found too cold, the work could be safely left until the beginning of spring, when the factory could be again set in operation.

The whole of the apparatus for manufacturing the alcohol and for treating the sirup therewith could, therefore, be built on a much smaller scale than if it were necessary to treat the sirup as soon as it was manufactured during the months of September and October. With the sirup already made and stored in cisterns a very small force would be sufficient to convert the whole of it into sugar and at a very small expense. It would thus be possible for one factory to take care of a much larger crop of cane than it could possibly do were the whole of the manufacturing operations to be conducted at once.

The sirup as made and as it passes into cisterns could be subjected to the influence of sulphurous acid or some other anti-ferment which would be sufficient to preserve it perfectly from fermentation, even if there were danger of such a decomposition without any antiseptic treatment.

The storage capacity of a factory which would work 20,000 tons of sorghum cane will be seen from a perusal of the following data: Assuming of 20,000 tons of chips and 10 per cent marc we have, 11,782,030 pounds sirup at 55° Brix=volume of 149,988 cubic feet, requiring a cistern 20 by 86.5 by 86.5 feet. At 75° Brix=8,640,380 pounds=volume of 100,213 cubic feet, requiring a cistern 20 by 75 by 75 feet.

In the event of boiling from 55° to 75° Brix, the water evaporated will be, on 20,000 tons of cane chips, 3,141,650 pounds, or 377,150 gallons. Basing calculations on Yaryan's figures, the coal consumption (at 8½ pounds water per pound coal) in again evaporating from 55° to 75° Brix will be 369,600 pounds, using live steam altogether, as would be necessary in the contemplated division of the season. Hence the loss of coal occasioned by boiling to 75° Brix as a means of preserving and subsequent dilution would be 133,261 + 369,600 = 502,861÷2,240=225 tons, plus incidental losses, radiation, time, etc.

Placing the value of coal at $4 per ton, which is rather a high average, it is seen that the total additional expense, so far as fuel is concerned, involved in manufacturing the sugar after the harvesting of the crop, would be only about $900 a year, a very insignificant item when compared with the value of the time gained.

In order that this method of production of sugar may become possible, it will be necessary for the revenue laws to be changed so as to allow the preparation of the alcohol used in the process to be carried on without tax. This could be easily done without any danger of defrauding the revenue. The alcohol could be made under bond, given by the sugar manufacturer, that it should be used only for the purpose of separating the gummy matters from the sorghum juice, and should in no case enter commerce for any purpose whatever. In making this alcohol the manufacturer should be allowed to erect such apparatus as may be necessary, and this apparatus could be under the direct inspection of revenue officers in order that they might be able to see that the conditions of the bond were faithfully carried out.

It is earnestly recommended that the revenue laws be so amended as to allow a trial of this process by the sorghum-sugar makers of the country. If this can not be done without a further illustration, the law, at least, should be so adjusted as to permit the Department to make an experiment on a small scale with this method in connection with the work which it is now doing in the experimental station for the improvement of sorghum cane and the manufacture of sugar therefrom.

It is important also that the Department be empowered, by a special grant, to carry out these experiments in a practical way. From the best estimates which are now at my disposal I should say that a grant of $25,000 would be entirely sufficient to subject this process to an experimental trial. The magnitude of the interest involved is so great that it is hoped that no objection will be made to this experiment.

Not only is the increase in the output of sugar from sorghum cane to be taken into consideration, but also the improvement in the quality of the product. The sugar will be of a finer grade and much more easily separated from the molasses. The molasses instead of being, as it is now, a waste product scarcely marketable, and in many cases only fit for cattle food, will be suitable for table use and especially for mixing. in case compound sirups are desired. The flavor of both the sugar and the molasses produced is of the finest quality and of such a nature as to render it difficult to believe that it could have been made from sorghum, which, under ordinary circumstances, affords a molasses which is totally unpalatable.

This process having been outlined above in such a way as to indicate its true character, it is hoped it may be given to the sugar manufacturers of the country without interference from any patents which may be attempted to secure its provisions for private benefit. As our patent laws now stand any process which has not been in use for two years may be covered by letters patent, but in this case it must be distinctly proved that the inventor is, as he claims in his application, the true discoverer of the process. This process having been discovered and operated by the Chemical Division of this Department, is unpatentable, except by the Department, for the common use of the people.

THE COMPOSITION OF THE BODIES PRECIPITATED BY ALCOHOL FROM SORGHUM SIRUPS.

The existence of starch and allied bodies in sorghum juices has long been a matter of demonstration. It was deemed desirable, however, in connection with the practical work of separating from sorghum juices the mucilaginous and dismorphous bodies present to inquire more particularly into their nature. As has already been indicated, the chief melassigenic or molasses-forming properties of the non-sugars present in sorghum juices must be attributed to the gums, mucilaginous bodies, and difficultly crystallizable carbohydrates present therein. The percentage of alkaline salts in the ash of the sorghum is so small compared with that of the ash in beets as to reduce the molasses-forming properties of the salts of the ash to the lowest possible degree. Quantitative determination of the amount of bodies precipitated by alcohol from the normal expressed juice of sorghum cane shows that about 2 per cent of the total weight of the juice of the cane belong to this class of bodies. The precipitation was made in juices in which a portion of the albuminous matter, together with the chlorophyll present, had been removed by coagulation with heat and careful skimming. This quantity of precipitate may therefore be regarded as that which would be retained in the sorghum juices during the process of manufacture, and finally appear in the massecuites and molasses.

An account of the details of the work which has been done on these bodies would be of interest only to professional chemists and it is therefore omitted. It was found that they were composed chiefly of mucilages and gums, together with certain nitrogenous bodies and difficultly crystallizable carbohydrates, related to the starch series, and including some starch.

A full description of this work will be found in Bulletin No. 29. The work outlined above was done in co-operation with Mr. Walter Maxwell.

CHEMICAL CONTROL OF SORGHUM SUGAR FACTORIES.

The Department made no direct experiments during the season of 1890 in the manufacture of sorghum sugar. The work done was confined solely to chemical supervision of the processes of manufacture. To secure as wide an experience as possible in this direction chemists were detailed from the Department for the factories at Fort Scott, Topeka, Conway Springs, Attica, and Medicine Lodge, Kansas. A summary of the chemical work done, together with such data as were accessible, will be found following:

ATTICA.

Work at this station was started on the 19th of September and and continued, at intervals, until October 25. On this latter date one of the lower doors of the diffusion battery cell was broken and it was not thought worth while to repair the battery for the remaining portion of the crop. A very small quantity of cane remained unworked. The many difficulties encountered in the working of this house would render it unjust to make the results a test of the possibilities of manufacture of sorghum sugar.

The cane crop was much shortened by a severe drought, which set in about a month after the planting and continued unbroken for sixty days. The yield of cane per acre was reduced from 12 to 15 tons of last year to 5 and even 3 tons per acre. Chinch-bugs were also quite numerous and did considerable damage. Hot winds, the most dreaded enemy of the farmer in that region, were prevalent during the continuation of the drought. Not only was the crop shortened by the continued dry weather, but also the supply of water for the factory was inadequate, the small stream upon which dependence was placed having been completely dried up. Under these conditions the factory was not operated continuously, but only during the day.

The necessity of better cultivation of the cane fields was fully manifested in a number of instances. The fields which received poor cultivation were almost devoid of crops, while those which received the best cultivation yielded a fair crop in spite of the hot and dry weather. It was not until October 12 that there were sufficient rains to insure an ample supply of water for operating the factory, but at that time it was not possible to get enough cane to operate the factory.

The seed which had been received from the Department of Agriculture produced, in all cases, the best cane grown in the locality, averaging 4 and 5 tons per acre above all other varieties. The loss of a large quantity of sugar in the battery was owing to the heaters which leaked very badly. Another serious loss occurred between the clarifiers and double effects. This was due to the inability of the double effects to evaporate the juice extracted so that some of the thin juice was left sometimes as long as 12 hours before being concentrated and, of course, fermentation took place.

Special attention was given to studying the characteristics of the cane showing that certain physical properties are associated with high percentages of sugar. By studying these properties carefully, it is possible for every farmer to go into his field and be able to determine certainly whether his cane is ripe or not. The most striking of these properties is found in the last joint of the cane bearing the seed head. By stripping the cane of its covering a yellow coloration will be observed extending more or less along the length of the joint as the cane nears maturity. By the extent of this coloration one is able to select the very best or the very poorest canes in the field almost as accurately as though tested by a polariscope. It is found that the cane which has the highest sucrose, lowest glucose and highest purity has this coloration extending one-half the length of the joint. Should it be found to extend the full length, it shows that the cane has already commenced to deteriorate. On the other hand should no coloration be visible, it shows that the cane is not yet mature. These observations have extended over one season of rather remarkable characteristics and hence they may not prove equally applicable to a crop grown in a season with the ordinary amount of rainfall.

The analyses of the sorghum at Attica were commenced on the 9th of September and continued until the 24th of October. During this period one hundred and fifteen average samples, as taken from the field, were analyzed with the following mean results:

In the juice.

Per cent sucrose	14.26
Per cent reducing sugars or glucose	1.53
Purity coefficient	71.91
Maximum per cent sucrose	17.95
Minimum per cent sucrose	5.85
Maximum per cent reducing sugars or glucose	3.43
Minimum per cent reducing sugars or glucose	.55
Maximum purity of juice	90.80
Minimum purity of juice	35.83

Between the dates of October 6 and 9 the purities of the juices were remarkably high, averaging about 85, and the percentages of sucrose therein were almost 16, showing that at that season the cane was in the best condition for manufacture. The analyses, however, for the whole season show a cane well suited for the manufacture of sugar, and which should yield, if all the sugar could be obtained, except the quantity which would naturally stay in the molasses, quite 200 pounds to the ton of clean cane.

Many of the farmers found the growing of cane profitable, while in other cases quite a number failed to make any profit or cultivated the cane at a loss. The figures representing one farmer's account with the company will illustrate what may be secured in a poor season in the growing of sorghum cane.

Total weight of cane grown ....pounds..	357,735
Total weight of seed grown ....do...	74,915
Amount received for the cane	$357.74
Amount received for the seed	$35.18
Total receipts for the crop	$392.92

Against this sum the following expenses are to be charged:

Cost of planting	$37.50
Cost of cultivating	50.00
Cost of harvesting and delivering to mill	175.00
Total cost, as charged	262.50

Leaving a net profit of $130.42. The number of acres cultivated in this crop was 30, and on the numbers given above the profit per acre would be $4.35. It will be noticed in the above that no charge has been made for the rent of the land, which is, of course, a legitimate expense which must come out of the calculated profit per acre. The value of the land upon which this cane was grown is not known to me, but, judging from the average value of land in that locality, it may safely be put at $20 to $25 per acre; hence a deduction of $2 per acre should be made for rent of land, leaving a profit per acre of only $2.35 instead of $4.35.

The analyses of the samples of chips taken from the shredders as they pass to enter the battery, which samples give a fair estimate of the quality of the chips entering the diffusers, show, as is usual in all cases, a less saccharine strength than average samples of field cane. The reason of this difference is twofold. In the first place the samples of the first chips must of necessity give a better representation of the crop than any possible selection of single stalks or number of stalks of cane can give. In the second place, in spite of the best clarifying apparatus, particles of the blades and sheaths enter the shredder with the pieces of cane, and the juices of these are expressed afterward and mingle with the juices of the cane. Forty samples of these chips were analyzed during the season with the following mean results:

In the juice.

Sucrose	per cent..	12.56
Glucose	do....	1.99
Purity		63.20

Thirty-two samples of the diffusion juices, representing the mean composition of the juices during the season, were subjected to analysis with the following mean results:

Sucrose	per cent..	7.99
Glucose	do....	1.20
Purity		66.48

Thirty-two samples of the exhausted chips, representing the mean composition of the whole mass of exhausted chips during the season, were analyzed, the analyses showing that they contained 0.60 per cent of sucrose.

Twenty analyses of the filtered and clarified juices, representing the mean composition of the clarified juices of the whole season, showed the following average constitution:

Sucrose	per cent..	8.11
Glucose	do ...	1.01
Purity		67.46

Seventeen analyses of the sirups before entering the strike pan, representing the average composition of the whole sirup worked during the season, gave the following mean results:

Sucrose	per cent..	32.91
Glucose	do....	7.12
Purity		63.11

Eight analyses of the massecuites, representing the average composition of the whole mass produced during the season, gave the following mean results:

Sucrose	per cent..	54.89
Glucose	do....	12.32
Purity		62.35

Five analyses of the second massecuites, boiled from the first molasses after the separation of the first mass of crystals, showed the following mean composition:

Sucrose	per cent..	47.52
Glucose	do....	12.77
Purity		55.65

The total amount of field cane purchased during the season was 1,305.3 tons. After cleaning, the total weight of cane which entered the diffusion battery was 900.2 tons.

The theoretical percentage of sugar in the clean cane, as calculated from the juice of the chips, was 238.6 pounds.

The quantity of sugar obtained in a merchantable form can not be accurately known until the official report of the State Inspector is known. The quantity, however, in proportion to the total amount present was extremely small and probably did not exceed 75 or 80 pounds per ton.

The enormous losses, therefore, in manufacturing sorgum sugar which have always been noticed in practice are illustrated in a very emphatic manner by the results of the season's work at Attica. Such losses are due to the natural wastage during the process of manufacture, and are, of course, raised to an unusual degree where lack of skill exists in the manipulation of the factory. The chief losses, however, as heretofore, have been due to the character of the juice itself, presenting in its constitution peculiar difficulties in the separation of the crystallizable sugar present.

OPERATIONS OF THE TOPEKA FACTORY.

The Topeka Sugar Factory, which was destroyed by fire last year, was rebuilt during the present season and operated for the manufacture of sugar.

Difficulties of various kinds, but in no wise inherent to the process of manufacture, caused delays in the operations of the factory and rendered its work expensive. The supply of steam was not sufficient for the full working extent of the rest of the machinery, and the multiple effect pans were provided with very low domes, which rendered successful boiling difficult. Moreover, the fuel employed was of particularly bad quality. The pumping arrangements were found inadequate to provide an abundant supply of water.

The crop of cane was somewhat later in maturing than usual, due to the autumnal rains following a very dry summer. The crop ripened in a very irregular way, thus causing to be delivered to the factory canes in various stages of maturity. The amber cane reached its maximum maturity about the middle of September, and the orange cane about the middle of October.

The battery work was extremely irregular, the percentages of dilution ranging from 8 to 14, and the percentages of extraction of sugar from 80 to 95 per cent. The percentages of sucrose in the exhausted chips vary from 0.05 per cent to 2 per cent; the number of diffusion cells worked daily varied from twenty-three to one hundred and four, and the loss of time daily by stoppages was from two to fourteen hours. Under such irregular conditions of work, due generally to the causes already mentioned, it is not strange that attempts at the successful manufacture of sugar were fruitless.

Cane contracted for by the company was..........acres..	1,200
Cane delivered to the mill was.....................do...	1,000
Cane delivered.....................................tons..	6,412
Yield of cane per acre.............................do...	6.41
Total amount of sugar made.....................pounds..	278,687
Yield of sugar, per ton of field cane..............do...	43.57

By the term "field cane" is meant the cane with its blades and tops. The average amount of clean chips afforded by such cane is 75 per cent. of the total weight. The amount of clean cane, therefore, entering the battery under this estimate was 4,809 tons. The yield of sugar, per ton of clean cane chips, was therefore nearly 58 pounds.

The sampling of the chips entering the battery was made in the usual way so as to secure a fair average of the cane worked. The analyses of these samples were commenced on the 10th of September and were continued until the close of the house on the 8th of November.

Forty-seven samples of fresh chips were analyzed with the following mean results:

In the juice.

Total solids	per cent	15.97
Sucrose	do	10.15
Glucose	do	2.14
Purity		63.56

A mere glance at these figures will show that the cane was in a very poor condition for sugar making purposes. This was due to the causes already stated, namely, the autumnal rains which prevented the cane from properly maturing, and the fact that the fields were planted with mixed seeds so that some of the cane was mature at a much earlier period, and doubtless the principal cause was imperfect cultivation. The poor character of the chips for sugar making purposes is illustrated in a striking way by comparing the analyses of them with the analyses of chips from cane in other parts of the State. Considering the character of the material worked, the yield per ton must be considered as quite satisfactory.

Twenty-seven analyses of the exhausted chips were made, showing a mean percentage of sugar therein of 1.77. This result shows very poor battery work. A mean percentage of sugar in the exhausted chips of more than 0.5 per cent shows some grave defect in the method of working. This defect is usually due to imperfect chips; the shredders become dull, allowing large pieces of cane to go through unshredded, the internal portions of which are protected from the diffusion process. With chips properly prepared and the temperature of the battery properly regulated there is no difficulty whatever in securing extraction which will leave 0.5 per cent or less of sugar in the bagasse.

Fifty analyses of average samples of the diffusion juice were made with the following mean results:

Total solids	per cent	12.99
Sucrose	do	8.54
Glucose	do	1.67
Purity		67.39

Forty-eight analyses of the clarified juices were made with the following mean results:

Total solids	per cent	13.23
Sucrose	do	8.91
Glucose	do	1.57
Purity		68.49

Twenty-five analyses of the sirups entering the vacuum pan were made with the following mean results:

Total solids	per cent	38.58
Sucrose	do	25.24
Glucose	do	3.94
Purity		64.69

For convenience of reference the work of the factory was divided into three periods, namely: First period from September 10 to 20; second period from September 20 to October 15; third period from

October 15 to October 30, not including the last two days of the run in November. The mean data for the three periods are as follows:

Fresh chip juice.

	First period.	Second period.	Third period.
Total solids ....per cent..	16.58	16.09	16.67
Sucrose ....do.....	10.02	10.38	11.18
Glucose ....do.....	2.68	1.81	1.84
Solids not sugar ......do.....	3.94	3.90	3.65
Glucose ratio..................	26.15	17.44	16.45
Purity coefficient	60.43	64.51	67.67

The means for the whole season, excluding the November run, are:

Total solids ....per cent..	16.32
Sucrose ....do....	10.54
Glucose ....do....	1.92
Solids not sugar ....do....	3.86
Glucose ratio..	18.22
Purity coefficient	64.56

The constant improvement of the material entering the battery from the beginning to the end of the season is strikingly illustrated by the above figures. We find the same fact true of sorghum that is illustrated in sugar cane, that the longer the season for manufacturing can be delayed the richer the material in sugar will become. With an average of 10.5 per cent sugar in the juice and 9.45 per cent sugar in the cane, the total amount of sucrose in a ton of clean chips is 189 pounds and the amount obtained in a merchantable form of the raw sugar, as indicated above, is 58 pounds, which would amount to about 55 pounds of pure sugar.

The results illustrate the striking loss of sucrose in the juice in sorghum sugar manufacture heretofore carried on, viz., a loss of 134 pounds of sucrose for each ton of clean chips worked. This loss, as has already been pointed out repeatedly, is due to the pernicious effects of the reducing sugars and organic matters not sugars present in the juice, such organic matters, as shown by our work during the present year, having amounted to 3.86 per cent. It is perfectly safe to say that the total loss of sugar in the molasses was almost exclusively due to the presence of these gummy matters in the juice. It is evident at once that the financial success of sorghum sugar manufacture must follow some method of work which would elminate these sources of loss.

CONWAY SPRINGS.

The large factory at Conway Springs having been abandoned after two seasons of unsuccessful operation, the only work which was done at that place consisted in an attempt to make sugar in a small way by milling and open evaporation.

The results, easily predicted, only serve as another illustration of the futility of attempting sorghum sugar manufacture without any of the appliances or conditions necessary to success.

The promoters of the enterprise, however, desiring to have some chemical work done, a chemist was employed for the season. Chemical work was commenced on the 25th of September, and practically concluded on the 25th of October. During this time the mill was in operation only at irregular intervals, and there was found a total lack of proper preparation. The whole process, in fact, was characterized by unscientific methods.

The cane showed a great deterioration from the quality produced in the preceding years, but the cause of this inferiority is not clearly evident.

Forty-two analyses of samples of cane from the field showed in the juice the following percentages:

Total solids .... per cent..	18.1
Sucrose .... do....	10.4
Glucose .... do....	4.4
Purity	57.5

Twenty-four samples of juices taken from the mill during the period it was in operation showed the following numbers:

Total solids .... per cent..	16.5
Sucrose .... do....	9.5
Glucose .... do....	4.5
Purity .... do....	57.6

The utter unfitness of these canes for sugar making purposes is at once evident. As a natural result of the poor quality of the raw material and inadequate methods of manufacture pursued, no sugar at all was produced, and even the molasses made was of a very inferior quality.

RESULTS AT FORT SCOTT.

The general operations of the Parkinson Sugar Company, and the results obtained, are set forth in the following report of the manager, Prof. J. C. Hart:

The spring of 1890 was all that could be desired by the sorghum growers. The winter had been mild, with just enough rain to make the ground work well, and the larger part of our cane ground was plowed before the first of March. The first planting was done March 28, and this cane did remarkably well, ripening the first week in August. The weather continued favorable until July, when it became very hot and no rain fell for several weeks. Cane was forced to head prematurely, especially on high ground and thin soil. In September there were heavy rains, and canes that had ripened early threw out from one to four new heads, which grew much taller than the original stalk and occasioned loss of sugar. The September rains brought on the late cane, so that the tonnage was good, though the quality was not what it would have heen had the season been uniform. Work was begun in the sugar house August 19 and continued till November 1, a total of sixty-nine working days.

Acres of cane	1,100
Tons of cane	7,575
Tons for sugar	7,100
Pounds sugar	356,000
Gallons sirup and molasses	117,000

The chemist's report has not yet been made and I can not give the quality of the cane as compared with last season, though the density will average somewhat higher this year, and purity of diffusion juice about the same as last; that is, 62. Diffusion juice to September 15, from Amber, only shows a density of 11.35: September 15 to October 1, part Amber and part Orange, 13; and for October, all Orange, the density was 14.2. The amount drawn in October was 50 litres less than in September, but allowing for that the yield from Orange was better than from Amber. I received from the Department several selected seed heads which were grown at Sterling in 1889. I give the analyses of a few varieties as compared with last season:

Amber, 235; average seven analyses, 1889, sucrose, 13.51; Amber, 235; average twelve analyses, 1890, sucrose, 13.1; Brix, 17.3.

Maximum density August 16, 1890, 18.5; maximum purity August 14, 1890, 80.6; maximum sucrose August 25, 1890, 14.1.

Stalks small, but the variety is valuable for its high sucrose and early maturity. Seed heads of all tested stalks saved, together with several bunches not tested.

Cross of Amber and Link's Hybrid, 161; average nine analyses, 1889, sucrose, 15. Cross of Amber and Link's Hybrid, 161; average nine analyses, 1890, Brix, 17.7; sucrose, 12.8. First ripe canes, September 5; 17.7 Brix; 12.9 sucrose. Maximum sucrose, 13.9 October 7. A good variety, but rather slender and falls easily.

Cross of Amber and Orange, 293; average five analyses, sucrose 17.38. Cross of Amber and Orange, 293; average seventeen analyses, Brix 18.71; sucrose 14.21.

First test, September 5, Brix 18.6, sucrose 15, was ready for working ten days earlier and is valuable as an early cane, as it is stockey, stands up well, and holds its purity much better than Amber. On October 14 it showed Brix 21.44, sucrose 15.6, and October 24 Brix 18.9, sucrose 12.3.

India and Orange, 320; average ten analyses, 1889, 15.97 sucrose; average six analyses, October 1890, Brix 18.62, sucrose 14.43. This is a heavy cane and will be valuable.

Folger's Early, 205; 1889, Brix 19; no sucrose given. Twelve analyses, 1890; Brix 18.6, sucrose 13.78. First analysis, August 25; was ripe a week earlier and is very valuable as an early variety, being tall and strong.

Black African, Undendebule, 254, and Honduras gave good results, but need further trial to determine their value for this locality.

Beet seed was obtained from the Oxnard Beet Sugar Company and several plots were planted as soon as the seed arrived, which was May 20.

A very poor stand was obtained owing to heavy rains immediately following the planting. Web worms destroyed a large part of the crop. Twelve analyses in October gave Brix 16.05, sucrose 13. Beets taken from the field December 12 tested 17.76 Brix, 15.67 sucrose.

OPERATIONS AT MEDICINE LODGE.

Manufacturing operations at Medicine Lodge commenced on the 18th of August and continued until the end of October. The machinery in use last year had been thoroughly overhauled and placed in excellent working order. No delays, of any consequence, were experienced in working the apparatus, and, for the first time in the history of the manufacture of sorghum sugar, the losses due to delays were reduced to a minimum.

The crop of sorghum cane was grown in a season of great drought, which prevented the corn crop from maturing. The evil effects of the drought were felt also on the cane, but in spite of it a crop of considerable magnitude was produced. On the 25th of August the long period of drought and hot winds was broken by copious rains and from that time until the end of the manufacturing season frequent rains fell. The cane in the fields readily ripened after the rains and many fields which were considered worthless redeemed themselves and produced considerable quantities of merchantable cane. The high red loam of the uplands produced a better crop than the low bottom lands, both in quantity and quality. In addition to this, the first frost affected only the bottom lands and the cane on the uplands had fully three weeks longer season on this account than the cane on the lowlands.

Interesting observations were made on the effect of the drought upon the different varieties of cane. The Early Orange and Link's Hybrid gave about the same tonnage under similar conditions and also had about the same content of sugar. If there was any advantage it was in favor of the Link's Hybrid. The varieties Undendebule and Honey Dew gave disappointing results; the tonnage was light, sucrose and purity low, and the cane rapidly deteriorated after a light frost. A new variety of cane, which may be called, provisionally, Medicine Lodge Orange, made a splendid showing. The seed head of this variety is small, compact, and does not spread or open on reaching maturity. The stalk is perfectly formed and resembles very nearly that of the Early Orange, from which it can be distinguished only by its earlier ripening. It contains a high percentage of sucrose, low glucose, and endures a dry season remarkably well. It ripens in from 90 to 100 days from the time of planting. It is also hardy and does not deteriorate rapidly after frosts.

The Black African was one of the best varieties tested during the season. This variety not only has high sucrose and purity, and low glucose, but is a large cane and endures drought well. Its tonnage was nearly double that of the other varieties and it maintained its high percentage of sucrose longer than any other variety tried.

As a result of the agricultural experience of the season, it seems best to plant only the early maturing varieties on the lowlands while the late maturing varieties should be planted on the uplands.

The results of the mean analyses of the cane chips entering the battery for the season show the following numbers:

In the juice.

Total solids	per cent..	18.29
Sucrose	do....	12.62
Glucose	do....	2.24
Purity		69.86

The exhausted chips contained 0.81 per cent sucrose; the mean polarization of the first sugars made was 91.8 and of the second sugars made 91.2. The mean percentage of sugar in the cane extracted for the whole season was 93.6. The mean percentage of marc or fiber in the cane was 12.2.

In regard to the analyses of the Link's Hybrid variety, the means of four hundred and thirteen analyses show the following numbers:

In the juice.

Total solids	per cent..	19.72
Sucrose	do...	13.59
Glucose	do...	1.85
Purity		70.00

Four hundred and sixty-two analyses of the Early Orange during the season show the following data:

In the juice.

Total solids	per cent..	20.20
Sucrose	do....	13.20
Glucose	do....	1.96
Purity		65.24

Eighty-seven analyses of the Medicine Lodge Orange gave the following data:

In the juice.

Total solids	per cent..	20.18
Sucrose	do....	15.60
Glucose	do....	1.87
Purity		78.82

Thirteen analyses of the Undendebule gave the following data:

In the juice.

Total solids	per cent..	18.80
Sucrose	do....	12.45
Purity		65.93

Thirteen analyses of Honey Dew showed for the season the following results:

In the juice.

Total solids	per cent..	17.42
Sucrose	do....	11.43
Glucose	do....	2.98
Purity		64.19

Following are the mean analyses of the Black African for the month of November:

In the juice.

Total solids	per cent..	19.88
Sucrose	do....	13.90
Glucose	do....	2.04
Purity		71.98

Samples of cane were taken from 1,973 loads brought to the factory and examined with the following mean results:

In the juice.

Totol solids	per cent..	19.31
Sucrose	do....	13.30
Purity		69.14

Nine hundred and forty-one miscellaneous analyses of the cane from farmers in different parts of the county were made with the following mean results:

In the juice.

Total solids	per cent..	19.83
Sucrose	do.....	15.12
Glucose	do.....	2.21
Purity		71.01

The summary of the season's work will give a fair idea of what was accomplished:

Working days		35
Clean cane worked	tons..	3,957
First sugar obtained, per ton of clean cane	pounds...	101.1
Second sugar obtained, per ton of clean cane	do....	22.5
Total yield, per ton of clean cane	do.....	123.6
Sugar obtained, based on total amount in cane,	per ct.	51.4
Molasses made, per ton of clean cane	galls..	13.8
Total weight of sugar made	pounds..	489,357

DIFFICULTY OF MAKING SORGHUM SUGAR IN SMALL QUANTITIES.

It is to be regretted that certain hallucinations seem to constantly follow the development of the sorghum sugar industry. This Department has pointed out repeatedly the insurmountable difficulties attending the production of sorghum sugar in a small way and with crude apparatus and unscientific methods. The record of the past season at the various points where the Department was represented by its chemists tends to confirm the views in this regard so often expressed heretofore. Thus the development of this industry has had to contend not only with natural difficulties but with the discouragement attending numerous failures, although such failures were altogether due to causes which would have resulted as disastrously in connection with any other industry. In some cases, as in the experiment at Conway Springs for instance, the promoters testified to the honesty of their convictions by investing their own private funds without any public aid. While such an investment is certain to be followed by financial loss, what is far worse from a public point of view, it will prejudice the community against the whole business, and prevent people from viewing in the proper light processes which really give promise of success.

It is evidently the duty of the Department to caution farmers, and to reiterate what has been so often stated, that with our present knowledge, and with the present degree of development of the sorghum cane, it is an utter impossibility to produce sugar profitably in a small way and without an ample and suitable equipment. That a good article of table sirup can be made with moderate facilities, and profitably, has long been known, and I conceive it to be the duty of the Department to encourage such work as that, and to discourage in every possible way attempts to make sugar under conditions and with apparatus suitable only for the manufacture of sirup. It is unfortunate that in spite of the unsatisfactory results a glowing report has been published of the season's work at Conway Springs, and still more unfortunate to find it published in an influential sugar journal without any comment whatever, thus lending to it an air of authority which it is feared may prove to some extent injurious.

If the alcohol method of treating sirups should prove to be a success, it might then be profitable in some localities to make a thick sirup in some small way for delivery to a central factory. Such a method might be advisable in cases where cane would otherwise have to be hauled a long distance to the central factory. These possibilities, however, are still in the future, and do not call for discussion at the present time.

CULTURE EXPERIMENTS AT STERLING.

The experimental work of the Department at Sterling was continued during the year 1890 on the same general lines of work as those followed in previous years. The whole year was unexceptionally dry. Planting was commenced on the 1st of May and finished on the 23d. Before the last of the planting was completed the ground had become so dry that the seed of the last plots planted remained for a long time in the ground without germinating. Not only did this cause a late maturity of the canes whose germination had been deferred, but also produced an uneven ripening of all the plots thus affected. Some of the seed which germinated as soon as planted produced canes ripening long before those from the delayed germination. Planting was done by hand and the seed covered by a hoe.

The land varied widely in quality, from fairly fertile spots to barren sandy knolls. Much of it had not been in cultivation for several years, and part of it had been in sorghum for many years. In addition to these disadvantages of soil and season, a severe frost on the 13th of September killed all the cane in the greater part of the experimental plots. This frost was almost a month earlier than the average of the locality. After the frost the working force of the station was brought down two-thirds and the total amount of work done was probably only about one-third what it would have been had the frost been delayed for another month. In many of the plots, however, the analyses were kept up for some time after the frost, selecting for this purpose stalks here and there which still showed green leaves. In some cases the canes which had been frostbitten rapidly deteriorated, and in no case did they improve, but in some instances they remained quite stationary in quality for a considerable length of time. It was noticed in many cases that the canes retained their sugar content in quite a constant manner for five weeks after the frost had destroyed nearly all the leaves. The comparison of varieties under such circumstances must be more or less unreliable, and hence the analytical work of the station is not as indicative in its results as it was during previous years. The experimental plots occupied in all about 165 acres. The different plots were sowed in plots 25 feet wide, leaving about 25 feet between them to avoid mixing. This is probably not a sufficient distance, but on account of the large number of plots with which it was desired to experiment, it was not possible to plant them farther apart without extending to undue proportions the total area under cultivation.

One hundred and twenty-seven plots were planted with seeds from foreign countries, received through the Department of State in response to a request from the Department of Agriculture. Two hundred plots were planted with seed selected at the station last year by the analyses of single canes. Twenty-six plots were planted from seeds which were received from Dr. Peter Collier, director of the Experiment Station at Geneva, New York. Four hundred and fifty-five plots were planted with seeds from canes which showed evidences of being crosses of Link's Hybrid and Early Amber. Each of these plots was planted with seed from a single head and were grown in the hope of finding among them canes showing new and desirable qualities. Some of these plots gave remarkably fine canes of new types having from 14 to 16 per cent of sugar, while others were inferior in every respect to each of the parent forms. In all, twenty of these plots seemed sufficiently good to justify preservation and the seed was saved from them for future growth.

All the one hundred and fifty-three plots planted with foreign seed, including two varieties, unnamed, from Australia, produced fine canes of good quality.

Of the various crosses first selected in 1888, planted in 1889 and again in 1890, several having proved unusually good during the three years of trial, will be retained for further experiment. Most of these new varieties are now well established and uniform in their characteristics, but there are some which still show a persistent tendency to reversion. Special data which were obtained with the Colman cane and with numbers 160, 161, and 289, are of such a character as to fully justify the whole of the labor which has been expended by the Department at the station in the development of new varieties from crosses. These four varieties possess qualities for sugar making superior to all other known varieties of sorghum, and these characteristics have been secured by careful attention to scientific principles of selection and propagation which have been practiced at Sterling from the first. There is still opportunity for a large amount of judicious work in selecting from varying seedling canes, having juices of greater purity, for there are wide differences in this respect, and it will require several years more to develope among them characteristics sufficiently uniform to justify their selection as sugar-producing plants.

Many varieties which had given good results in previous years were planted in a large number of plots in different soils and at various times in order to determine their average value. The stand of cane was almost perfect except where destroyed by drift sand. The seeds selected at the station have often shown a vitality of 98 per cent at the time of planting. With such seed and due care in sowing it would seem possible, so far as the experimental work has shown, to have a good stand of cane without either thinning or replanting. Neither was done this year. No fertilizers were used and no suckers nor offshoots removed. With the exception of small plots, which were hoed twice, the cultivation was such as any careful farmer would give his crop. In such hot and dry seasons as this was there seems no doubt that deep and close cultivation after the canes are large injures them. On the other hand, frequent and shallow cultivation, even after the canes are well grown, favor their development on principles of soil physics which are well understood.

The yield of cane per acre was not nearly so large this year as in the season of 1889, but was better than in 1888. In general all the varieties which have been subjected to careful selection showed a larger percentage of available sugar in the juice than any other of the previous years. Another point mentioned is that the character of the juices in the sorghum appears to vary less with the season than does the yield of cane. As an instance of this characteristic, developed by the experiments, we may cite the variety of cane known as 161. In 1889 seventeen analyses of this variety were made, extending from September 4 to October 26. The average percentages given were as follows:

Sucrose	per cent..	13.24
Reducing sugar	do....	.45
Solids not sugar	do....	3.56
Purity	do....	76.75

In 1890 twelve analyses of the same variety were made, extending from August 12 to October 21, showing the following mean percentages:

Sucrose	per cent..	14.81
Glucose	do....	.69
Solids not sugar	do....	3.77
Purity	do....	76.85

One of the most marked effects of selection, as practiced at Sterling, has been manifested in the earlier maturing of the cane. Some of the different varieties grown during the past year ripened two or three weeks earlier than was the case with the progeny of similar but unselected seed. Judging from the work already done sorghum cane may be developed in any particular direction by continuous selection of the qualities desired. If, for instance, a high sugar content be desirable, by continued selection for high sugar only, this property of the cane may be made persistent, and the same is true of low glucose or low non-sugars.

The work of the station during the year comprised 2,500 analyses of average samples of sorghum, in large quantities, taken from the plots, and about 9,000 polarizations of the juices of single selected canes. Twelve thousand selected seed heads from the best varieties were wrapped separately and descriptive tags attached to them for the purpose of continuing the work, not only at the station, but by distributing these seed heads to those interested in such researches. By planting a single seed head and saving all the seed produced therefrom a very large field of cane can be produced from each of these 12,000 heads in 1892. In other words, from these 12,000 selections it would be possible to produce seed enough to plant all the sorghum cane which will be required by all the factories in the United States in 1892. These 12,000 heads have been divided into four classes.

Those coming from canes which give a juice of from 80 to 85 per cent purity, irrespective of sugar content, were placed in the first class: those having a purity of 75 to 80 in the second, and those from 70 to 75 in the third class, and the whole of the remainder in the fourth class.

The seed selections were taken from the following varieties: Early Amber, Undendebule (Nos. 1 and 2), Colman cane (cross of Orange and Amber), Folger's Early, Planters' Friend, Early Orange, Link's Hybrid, No. 160, No. 161, No. 110, No. 112, No. 208, No. 244, No. 289, and No. 350.

The method of making selections may not be devoid of general interest. The method pursued at Sterling was as follows:

Many thousands of canes of the particular kinds selected are run separately through hand mills and the juice from each one put in a tin can. These juices are then roughly tested by a hydrometer, giving reading, representing the percentage of total solids contained in them. If this reading is below a certain fixed standard the seed head from this cane is at once rejected, the standard of the juice being kept high enough to insure a rejection of the majority of the canes. If the first reading is satisfactory, the can and the seed head of the cane furnishing the juice therein receives a number. For instance, in the variety No. 112, 765 canes were found which came up to the required standard. These were again assorted by subjecting them to analysis and 185 samples were found to contain over 15 per cent of sugar. These seed heads were then saved and all the others from the variety rejected. From those which were saved another selection was made on the purity of the juice and 121 were found to have purities ranging from 75 to 80. These seed heads were preserved and all the others rejected. Thus of the many thousands of the canes of No. 112 submitted for examination only 121 seed heads were saved to distribute for planting next spring. With the force at the command of the station it was possible to test 3,000 canes per day. Of course it is not expected that canes showing a high percentage of sugar, say 18 per cent in the juice, will give seed which will on planting give a cane uniformly possessing this high quality. Were this true it would be possible to permanently secure and perpetuate each accidental variation showing a high percentage. Nevertheless, it is true that seed selected in this way has a tendency to produce a larger number of high-testing canes than before, and thus by continued selection it is possible to develop finally a permanent type showing a decided increase in sugar-producing power.

It must also be taken into consideration that in cases of seed selection the development of the particular varieties of cane should be largely influenced by the environment, that is, by the soil and climate; hence it is illogical to suppose that seed which has been selected in this way and permanently established at Sterling will do equally as well in a soil and climate radically different. It is the object of the Department in this work not to select and establish varieties which will do equally well in all parts of the United States, but to illustrate the methods of establishing varieties in one particular locality, so that the particular variety of cane which is suitable to any one locality may be speedily and scientifically established by selection in other places. In many cases the seeds which have been sent from Sterling, and which continue to give there the best results, have produced canes of much inferior quality in Louisiana and Mississippi, as will be seen by data given from those localities in another place. After three years of study of all the heads of sorghum which could be obtained, amounting in all to nearly one thousand, it does not seem premature to give a list of those varieties which may be called the best. It must be understood, however, that this list is for a soil and climate similar to those in Western and Central Kansas, and this list can not be regarded as being absolutely correct for other and widely different localities.

From the results already obtained Early Amber will be suitable for earliest planting and manufacture or for very late planting when such is unavoidable. Earlier maturing varieties than Amber have been studied but none of them can as yet be recommended. Folger's Early has improved by selection, and No. 160 and No. 161 ripen soon after Amber and are much superior to it in many respects. Undendebule, Colman, and the well-known Link's Hybrid complete the list. To these may also be added Orange cane and its different varieties, which have proved so successful for manufacture but which did not deport themselves as well under selection as the heads mentioned. With the exception of Early Amber, all of these can be recommended in respect to high sugar content, good purity, and persistency of type. Folger's Early has a relatively high glucose content, but the purity is about the same as that of the others. Link's Hybrid is somewhat later in maturing and has a tall slender stalk which is liable to be blown down. This latter defect it shares with Nos. 160 and 161.

It is hoped that in the course of a year or two No. 161 can be hastened enough in maturing to take the place of Amber. The belief is entertained that these varieties, excepting Amber, are not superior to those commonly grown for sugar making, but selection on the lines already explained will probably result in considerable further improvement.

Hitherto the work of selection has been carried on mainly in the direction of high sugar and low glucose percentages, and in this respect its success has been most gratifying. In the future it seems evident that more particular attention must be paid to the purity of the juice, unless indeed Congress should see fit to permit the introduction of the process, for making sorghum sugar, by removing the gummy matters, which is proposed in another part of this report. Unless this can be done the greatest hope of the success of the sorghum-sugar industry lies in the direction of securing a juice of high purity and especially one low in the organic matters not sugar. It would be better, therefore, in this respect, to base at least one line of selection in this direction so as to eliminate as far as possible the gummy matters in the cane. The average purity of the juices of the sorghum which have been manufactured so far is not much, if any, above 65, while with sugar cane it is about 80 and with the sugar beet even higher. Of the varieties already selected and established the Colman and No. 161 give the best results in regard to purity, the number expressing the purity varying between 75 and 80. The importance of having a pure juice will be at once realized when it is known that the amount of sugar which is secured from a given weight of cane does not depend solely upon the contents of sugar in the juice but upon the amount of this sugar which the gummy and other uncrystallizable bodies in the juice will allow to crystallize. This was well illustrated in the work of the Department at Fort Scott, Kansas, in 1886. From sorghum cane the juice of which averaged 7.7 per cent and less than 60 purity only 21.5 pounds of commercial sugar per ton of clean cane were made, while from sugar cane sent from Louisiana containing 10.45 per cent of sugar and having a purity of 73, and worked by precisely the same processes and under the same control, 144 pounds of sugar were made per ton.

It appears true of sorghum juices that the non-sugars, consisting of the glucose and solids not sugar taken together, may be in all about 4 to 5½ per cent of the juice. It has been shown by the three years' selection at Sterling that the glucose percentage can be reduced to a point at which it may be practically neglected, viz., to about one half of 1 per cent. The selection for the purpose of reducing the organic bodies not sugar has not been carried far enough to determine whether or not similar success can be expected. At the present, however, it appears that there is a kind of reciprocity existing between the glucose and solids not sugar so that as one is increased the other is diminished the sum thus remaining about a constant quantity. As a rule the varieties which have a low glucose content have a high content of organic solids not sugar, and the reverse is true. If this should be the correct view it would make the problem of selection a more difficult one and the wiser plan would be to pursue it in the direction of reducing the organic solids not sugar and increasing the glucose, provided the manufacture of sugar is to be carried on as it now is; while if the alcohol process for the separation of the organic solids in sugar should come into use then the wiser plan would be to pursue the selection with reference to diminishing the glucose to the least possible degree. The separation of the organic bodies not sugar, by alcohol, would leave a juice of remarkable purity and capable of yielding the maximum percentage of crystallizable sugar. It is highly probable, however, that all the non-sugars may finally be much reduced in amount by continued selection.

The results of the station work show that Early Amber, Folger's Early, and the various varieties of Orange have comparatively high glucose, and, as a rule, low percentages of solids not sugar. This accounts for the fact that in practice the Orange, although having a high percentage of glucose, has given uniformly good results. On the other hand, Undendebule, Colman cane, No. 161, Sorghum Bicolor, and Link's Hybrid show generally low percentages of glucose and high percentages of organic solids not sugar.

In general, therefore, it may be said that the lines of selection as indicated above will depend upon the method of manufacture to be pursued. If the method remains as it is, then without any question the direction of the lines of selection should be toward securing a juice of greater purity even should the sucrose content itself suffer. It is far better for the manufacturer to have a sorghum juice containing 12 to 13 per cent of sugar in the juice and a purity of 85 than to have one from 16 to 18 per cent sugar in the juice with a purity of 65.

I have already said that the cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrate or other organic body exercising a higher melassigenic power than invert sugar or any form of levulose or dextrose, and the results of the research carried on in the laboratory during the past eighteen months have disclosed to us the exact nature of this body and also revealed the method of separating it as indicated in another portion of this report.

Mr. John Dymond and Dr. W. C. Stubbs estimate that a fair average of Louisiana sugar cane, in the juice, would be as follows:

Solids....per cent..	15.00
Sucrose....do....	12.00
Glucose....do....	1.50
Purity....	80.00

It would be of interest to compare these numbers with the averages of the sorghum worked in the four sugar houses at Attica, Medicine Lodge, Conway Springs, and Meade during the season of 1889, and also to compare it with the general average of the Colman cane during the present season:

	Louisiana sugar cane.	Factory sorghum.	Colman cane.
Total solids....per cent..	15.00	17.46	19.48
Sucrose....do....	12.00	11.08	14.88
Glucose....do....	1.50	2.37	.84
Solids not sugar....do....	1.50	4.01	3.76
Purity....do....	80.00	63.45	76.37

It is easy to see from the above figures that the Louisiana cane yields a much larger percentage of sugar than sorghum. At the same time a glance will show that the removal of 3.76 per cent of the solids not sugar in the Colman cane would at once place it in the first rank of sugar-producing plants as compared with the others given above.

In the selections made at Sterling particular attention has always been given to the constitution of the sugar content. A variety which retains such a long time a high percentage of sugar in the field is of course preferable to one which rapidly loses its sugar content after having become fully ripe. The former allows more latitude for harvesting the crop, and also permits those canes which from various causes mature later than others, time to attain their maximum content before they are harvested, so that when they are finally worked they are in good condition. There are considerable differences in this respect among the different varieties. Some, as for instance the White African, and even the Early Amber, begin to retrograde soon after maturity; others are much more constant. Of all the varieties tried No. 161 has proved the most durable. One plot of this variety has held up its sugar content for seventy days, the longest period ever known, and, in spite of exceptionally adverse climatic conditions. Colman cane, which ripens somewhat later, is second in this respect. It seems probable that both these varieties will continue to disclose this good quality and will keep their sugar until second growth is far advanced. With this latter point is closely connected another, viz., the preservation of sugar content in the canes after they have been harvested. It is probable that the two are correlated and that the kind which keeps better in the field than others will also hold up its sugar content better after harvesting. It is very difficult for factories to so arrange cutting, hauling, and manufacture to insure the selection of all the canes suitable after harvesting. The losses, therefore, in this respect are very great at every factory and the glucose ratio differs widely between field and diffusion battery.

If varieties of cane could be produced which might be cut and left for a week or so before working without serious damage it would be a great step forward in the sorghum sugar industry. Work in selection on this line was planned, but owing to the press of other work and early frost it was abandoned during the present season.

In general, it appears that all the varieties of sorghum which have been tested may be divided into several classes. First, those varieties which have only a fair percentage of sugar and low glucose, as for instance Sorghum Bicolor, which for three years has had an average in its working period of 12.50 per cent of sugar and less than 1 per cent of glucose. Second. Varieties which have a less percentage of sugar and comparatively high glucose with a low percentage of solids not sugar. This variety is illustrated by the Early Orange, which for three years has shown during its working period about 14 per cent of sugar and 2 per cent of glucose. Third. Varieties which have high sugar content and low glucose. This variety is illustrated by Undendebule No. 1, which has shown for three years during its working period 15.50 per cent of sucrose and 0.70 of glucose. No. 161 has also shown good results in this direction, having for two years an average of 15 per cent sugar and about 0.50 per cent glucose. Fourth. Varieties with a moderate percentage of both glucose and sucrose. This class is illustrated by No. 250, an African variety which has given for two years an average of 12.50 per cent sucrose and 1.25 per cent glucose.

In respect of the detailed studies of the different varieties grown at Sterling, reference will be made to the bulletin of the Department, No. 29, which will contain all the data collected from the Sterling station during the present year.

EXPERIMENTS WITH SORGHUM NEAR COLLEGE PARK, MARYLAND.

The experiments made in 1889 near College Park were rendered entirely nugatory by the exceptionally wet season, which prevented planting the cane at the proper time, interfered with its cultivation, and retarded its maturity. Hoping to obtain better results it was decided to continue the work, on a small scale, during the present season. Four acres of land were leased from Mr. D. M. Nesbit, and this land was divided into eight equal portions. The land was in the form of a parallelogram, the length lying east and west and was twice as long as it was wide. An attempt was made to secure land of a perfectly uniform nature, but even in so small a portion as 4 acres this was found to be impossible. The western part of the land was a gravelly loam, while about 1½ acres of its eastern portion was much more sandy and less fertile than the western part.

The eight subdivisions were planted north and south and were numbered by the letters of the alphabet beginning on the west side with plot A and continuing to the east end to plot H, each plot containing half an acre. In an eastern and western direction the plots were divided into five equal portions and the numerals from 1 to 40 were applied to the small plots made by the crossing of the eight north and south divisions with the five east and west divisions, each plot containing one-tenth of an acre.

The method of plotting the field and the number of each plot are shown in the diagram.

On plots 1, 6, 11, 16, 21, 26, 31, 36, 3, 8, 13, 18, 23, 28, 33, 38, Link's Hybrid was planted; on plots 2, 7, 12, 17, 22, Early Amber; on plots

4, 9, 14, 19, 24, 29, 34, and 39, Undendebule; on plots 27, 32, 37, Red Liberian; on plots 5, 10, 15, and 20, Early Orange; on plots 25, 30, 35, and 40, Improved Orange and two rows of Early Orange to finish out the plot of which there was not enough Improved Orange seed to complete.

The principal object of the experiment was to determine the influence of different kinds of artificial fertilizers on the composition of the cane. The fertilizers employed and the method of distributing are indicated in the following scheme:

N

W | E

1	6	11	16
2	7	12	17
3	8	13	18
4	9	14	19
5	10	15	20

S

A B C D

Link's Hybrid:
Plots 1, 6, 11, 16, 21, 26, 31, 36.
3, 8, 13, 18, 23, 28, 33, 38.

Early Amber:
Plots 2, 7, 12, 17, 22.

Undendebule:
Plots 4, 9, 14, 19, 24, 29, 34, 39.

N

W | E

21	26	31	36
22	27	32	37
23	28	33	38
24	29	34	39
25	30	35	40

S

E F G H

Red Liberian:
Plots 27, 32, 37.

Early Orange:
Plots 5, 10, 15, 20.

Improved Orange:
Plots 25, 30, 35, 40.

Scheme for distributing fertilizers.

1............Cottonseed meal.
2............Superphosphate.
3............Kainite.
4............Nitrate of soda.
5............(1, 2, and 3) equal portions of each.
6............(2, 3, and 4) equal portions of each.

On A ....No. 5.
On B........No. 2.
On C........Nothing.
On D........No. 3.
On E........No. 4.
On F........Nothing.
On G........No. 6.
On H........No. 1.

Basis of application.

[Pounds per acre.]

No. 1....... 600.
No. 2....... 600.
No. 3....... 600.
No. 4....... 400.
No. 5....... 600.
No. 6....... 600.

In regard to taking samples for analysis the following plan was pursued:

Beginning, for instance, with the Early Amber, which was the first to ripen, samples of the cane were taken by cutting about one hundred canes of Early Amber from each of the different lettered plots on which it was planted, viz: A, B, C, D, and E. These canes were thrown together, well mixed, and divided into four parts, and one part sent to the laboratory for analysis. In this way samples were taken from each of the plots under the influence of each kind of fertilizer on the same day. On September 11 five samples of Early Amber were sent to the laboratory for analysis, including one sample from each of the lettered plots on which the Amber was grown. On the 19th, 24th, and 30th of September, and the 3d and 10th of October, samples were taken in the same way from each of the plots of Amber. The other varieties were treated in the same way when they approached maturity, the object being to secure a study of the characteristics of the cane at about that period at which it would be used for manufacturing purposes if grown on a large scale.

The character of the cane was rather disappointing, with the exception of the Early Amber, indicating a crop which would have been unprofitable for manufacturing purposes.

With the exception of the Early Amber the growth of cane was luxuriant on all the plots except those at the extreme eastern end in the poor ground. The Early Amber, as is usual with this variety, was very small as compared with the other varieties, and yet the yield per acre was fair. The mean analyses of the Early Amber variety for the different plots are as follows:

	A	B	C	D	E
Total solids .... per cent..	17.5	17.7	17.1	16.7	16.0
Sucrose .... do....	13.4	13.1	12.9	12.1	11.4
Glucose .... do....	1.3	1.7	1.8	2.2	2.5
Purity	76.5	73.9	75.0	72.5	71.0

The analyses of the Early Orange were commenced on the 20th of September; subsequent sets of samples were examined on the 1st, 4th, 13th, 18th, and 30th of October. The mean results were as follows:

	A	B	C	D	E	F	G	H
Total solids.per cent..	14.5	15.3	15.0	14.5	15.5	15.3	15.2	16.1
Sucrose .... do....	7.7	8.9	8.4	8.1	9.9	9.7	9.7	10.6
Glucose .... do....	4.8	4.6	4.5	4.8	4.1	4.2	4.1	4.0
Purity	53.1	57.3	56.1	55.0	64.1	63.0	63.7	64.5

The analyses of Link's Hybrid were commenced on the 22d of September and continued on the 25th and 29th of September and the 6th, 11th, and 29th of October. The mean results obtained were as follows:

	A	B	C	D	E	F	G	H
Total solids.per cent..	14.6	14.9	14.4	14.3	15.8	15.1	14.7	15.9
Sucrose ....do....	10.2	9.5	8.9	9.8	11.8	10.1	10.7	11.3
Glucose ....do....	2.2	3.1	3.9	2.7	1.8	2.8	2.3	2.2
Purity	69.9	64.5	61.4	68.3	74.8	66.5	72.8	71.5

The analyses of Undendebule were commenced on the 26th of September and continued on the 2d, 17th, and 25th of October. The mean results obtained follow:

	A	B	C	D	E	F	G	H
Total solids.per cent..	13.5	14.2	14.6	15.0	15.9	15.6	16.3	16.1
Sucrose ....do....	9.3	8.9	9.1	11.3	11.2	10.2	11.4	10.9
Glucose ....do....	2,4	3.3	3.3	2.1	2.2	2.8	2.6	2.4
Purity	68,4	62.3	62.4	75.3	74.0	65.1	69.6	67.6

The analyses of Improved Orange were commenced on the 16th of October and continued on the 21st and 27th. Following are the means obtained:

	E	F	G	H
Total solids ....per cent..	15.8	15.3	15.4	15.6
Sucrose ....do....	11.3	10.9	10.7	10.7
Glucose ....do....	3.8	4.2	4.0	4.0
Purity	71.1	71,3	70.0	68.5

Analyses of Red Liberian were commenced on the 15th of October and continued on the 20th and 28th. Following are the mean results obtained:

	F.	G.	H.
Total solids ....per cent..	14.4	14.5	15.2
Sucrose ....do....	3.9	4.5	5.2
Glucose........................ ....do....	6.6	6.5	6.2
Purity	26.8	30.4	33.9

In order to obtain a comparison in richness of sugar of the results on all the different plots with the different kinds of fertilizers, the following tabular arrangement has been constructed. Taking the mean results of each variety they have been arranged in the following order:

First, in the order of highest sucrose; the plot giving, for instance, the highest sucrose being placed first and those containing the next subsequent percentages in order below. For instance, in the case of Early Amber, it was found that the highest sucrose was in plot A and there is a regular decrease from plot A, so that this was arranged in alphabetical order, A, B, and so on. In the next group are contained the plots with the lowest glucose beginning with the lowest and continuing to the highest. In the next group are collected the mean purities, beginning with the highest purity and continuing to the lowest purity in order.

Classification of plots in respect of sucrose, glucose, and purity.

Variety.	Highest sucrose.								Lowest glucose.								Highest purity.							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Early Amber	A	B	C	D	E	...	...	...	A	B	C	D	E	...	...	...	A	C	B	D	E	...	...	...
Early Orange.....	H	E	F	G	B	C	D	A	H	G	E	F	C	B	D	A	H	E	G	F	B	C	D	A
Link's Hybrid ...	E	H	G	A	F	D	B	C	E	A	H	G	D	F	B	C	E	G	H	A	D	F	B	C
Undendebule	G	D	E	H	F	A	C	B	D	E	A	H	G	F	B	C	D	E	G	A	H	F	C	B
Improved Orange.	E	F	G	H	...	...	...	...	E	F	G	H	...	...	...	...	F	E	G	H	...	...	..	...
Red Liberian......	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...

An analysis of this table shows that the plots have the following relations:

Plots.	Rank.								Total.
	1	2	3	4	5	6	7	8	
A.....	3	1	1	3	0	1	0	3	12
B.....	0	2	1	0	2	1	4	2	12
C.....	0	1	2	0	1	2	2	4	12
D.....	2	1	0	3	2	1	3	0	12
E.....	5	4	2	0	1	0	0	0	12
F.....	1	2	4	2	2	4	0	0	15
G.....	1	5	6	2	1	0	0	0	15
H.....	6	1	2	4	1	0	0	0	14

Per cent.:

A for first place......................................	25.0
B for first place......................................	00.0
C for first place......................................	00.0
D for first place......................................	16.7
E for first place......................................	42.7
F for first place......................................	8.3
G for first place......................................	8.3
H for first place......................................	50.0

Multiplying each rank of each plot by the number of times it occurs and dividing by 8 will give the mean position of each plot in the series.

A = 6.25	E = 3.00
B = 8.37	F = 7.38
C = 8.63	G = 5.30
D = 6.63	H = 4.38

In reviewing these results the following facts are noticed: With Early Amber the highest sucrose was produced by fertilizer 5, followed in order by 2, 0, 3, and 4. The lowest glucose appears in same order.

The highest purity was found with No. 5, followed by 0, 2, 3, and 4.

With Early Orange the highest sucrose was produced with No. 4, followed in order by 2, 0, 3, and 5.

The lowest glucose was found with No. 4, followed by Nos. 0, 2, 3, and 5.

The highest purity was found with No. 4, followed in order by Nos. 2, 0, 3, and 5.

The above comparison, however, is not strictly just on account of the fact that all varieties were not planted on all the plots. It will be better, therefore, to compare only those plots and varieties which present a complete comparison. These plots are A, B, C, D, and E, and the varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Classification of Plots A, B, C, D, and E, with varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Variety.	Highest sucrose.					Lowest glucose.					Highest purity.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Early Amber	A	B	C	D	E	A	B	C	D	E	A	C	B	D	E
Early Orange	E	B	C	D	A	E	C	B	D	A	E	B	C	D	A
Link's Hybrid	E	A	D	B	C	E	A	B	D	C	E	A	D	B	C
Undendebule	D	E	A	C	B	D	E	A	B	C	D	E	A	C	B

With Link's Hybrid the highest sucrose was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

The lowest glucose was found with No. 4, followed in order by Nos. 5, 2, 3, and 0.

The highest purity was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

With Undendebule the highest sucrose was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

The lowest glucose was found with No. 3, followed in order by Nos. 4, 5, 2, and 0.

The highest purity was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

A general comparison of the numbers is given in the following table:

Plot.	Rank.					Total.
	1	2	3	4	5	
A	3	3	3	0	3	12
B	0	4	3	3	2	12
C	0	2	4	2	4	12
D	3	0	2	7	0	12
E	6	3	0	0	3	12

Multiplying the times each plot occurs in the series by the number of the rank and dividing by 5 we obtain the mean position of each plot.

1 E=5.4 4 B=7.8
2 A=6.6 5 C=8.8
3 D=7.4

Hence it appears that in general results nitrate of soda (fertilizer applied to plot E) has produced the most favorable effects. Followed by this is a mixture of equal parts of cottonseed meal, superphosphate, and kainite. Next in order comes kainite alone. In the next rank we find superphosphate alone, while the plot C, which received no fertilizer at all, showed the poorest results.

These data are more valuable in indicating the methods of studying the effects of intensive culture on sorghum than for the definite knowledge obtained. It is evident at once that only several years of continual investigation would make a solution of the problem possible.

The agricultural data are briefly given in the following resumé:

Plots A, B, C, and part of D were rather light soil, containing a large percentage of sand and having perfect natural drainage; the remainder of the plots was more clayey and compact. The light soil favored the growth of sorghum so that it matured on an average one month earlier than that in the other plots. It is worthy of note that the sorghum showed far greater sensitiveness to difference in soils than a field of maize grown next to it on the same kind of ground. The following statement gives the number of stalks per acre, and the gross weight per acre, including the blades and seed heads, and the net weight per acre including only the clean cane for each variety on the different plots. These weights were all taken on the same day, viz., the 15th of October, and the weight per acre is based upon a carefully measured portion of each plot the whole of which was harvested and weighed in the manner indicated:

Plots.	Link's Hybrid.			Early Amber.			Undendebule.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	22,000	23,500	17,500	20,000	15,000	12,000	23,000	32,000	27,500
B	27,000	29,500	21,500	21,000	10,000	7,500	18,000	27,500	21,500
C	15,000	23,000	17,000	18,000	7,500	6,000	27,000	29,000	21,000
D	21,000	36,000	26,500	18,000	12,500	9,000	23,000	20,000	14,000
E	24,000	37,000	27,000	18,000	6,000	4,500	21,000	22,500	16,500
F	25,000	32,500	24,500	....	....	....	21,000	24,000	16,500
G	21,000	25,500	19,000	....	....	....	17,000	21,500	15,000
H	23,000	28,500	19,500	....	....	....	20,000	22,000	15,000

Plots.	Early Orange.			Improved Orange.			Red Liberian.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	18,000	33,000	25,500	....	....	....	....	....	....
B	21,000	27,500	22,200	....	....	....	....	....	....
C	20,000	22,000	17,000	....	....	....	....	....	....
D	18,000	27,500	21,000	....	....	....	....	....	....
E	....	....	....	17,000	13,500	10,000	....	....	....
F	....	....	....	18,000	14,500	10,500	21,000	30,000	23,000
G	....	....	....	18,000	17,000	11,500	22,000	24,500	19,500
H	....	....	....	17,000	18,000	13,000	14,000	22,500	16,500

EXPERIMENTS AT THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION, STARKVILLE, MISSISSIPPI.

Quite a number of the seed heads selected at the Sterling station in 1889 were sent to the director of the Mississippi Agricultural Experiment Station, Prof. S. M. Tracy, with the request that he cooperate with the Department in testing the value of the different varieties sent in the soil and climate of Mississippi. The cultivation of the samples was undertaken solely at the expense of the Mississippi station, and in the analyses the Department of Agriculture furnished only the hand mill which was used in expressing the juice from the canes. The analyses were made by Mr. L. G. Patterson, the chemist of the experiment station. A review of the analytical data obtained strongly illustrates the statement which has already been made that the production of a superior variety of cane by selection in one locality will not always insure the development of similar canes from seeds which are planted at a great distance from the original station, where the conditions of soil and climate are quite unlike those under which the standard variety of cane has been developed.

In a variety of Red Liberian No. 137, coming from a cane whose juice showed a content of total solids equal to 19 per cent, analyses were made at the Starkville station beginning September 1 and running to September 10, in which the content of sucrose in the juice of the cane varied from nothing to 4.9 per cent, while the glucose varied from 5 to 7.45 per cent. The mean numbers were sucrose 3.0 per cent; glucose 6.07 per cent. It seems hardly possible that a selected seed head could deteriorate so rapidly in being removed to a different locality. Analyses were continued with this variety planted from a seed head from plot No. 138 of the 1889 Sterling number, showing 18° Brix; No. 125 with a sucrose content of 15.04 per cent; No. 135, showing 18° Brix and No. 125 bis with 14.81 per cent of sucrose. These experiments were continued from September 1 to October 2, but in no case was the result comparable with the character of the parent cane. The percentage of glucose was almost uniformly higher than that of sucrose, and the result of the experiments with this series of selected seed heads was a record of most remarkable deteriorations. In several cases the polariscope failed to reveal any sucrose whatever present in the juices of the cane.

The mean percentages obtained in the juice were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
138	12.2	4.8	4.6
125	12.2	4.2	4.7
135	11.8	4.3	4.8
125 bis	14.1	6.0	4.8

Experiments were also made with selected seed heads from the Undendebule variety of cane selected at Sterling last year and of the following descriptions; Plot No. 297 of 18° Brix; No. 31 of 21° Brix; No. 31 of 20° Brix; No. 254 of 15.53 per cent sucrose. These analyses were commenced on the 2d of October and continued until the 4th of October. In many cases good results were obtained, but in no case was the parent cane excelled. With stalks produced from seed head plot No. 254, analyzed on the 3d of October, the sample was found to contain 15.2 per cent of sucrose and 0.54 per cent of glucose, and showing 20° Brix. Many of the other analyses showed fairly good percentages, but the mean of all of them would indicate a general deterioration in the most marked degree from the parent canes. Seed head from plot 31, 21° Brix, is a partial exception.

The mean results follow:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
297	12.0	6.4	1.7
31	18.3	13.1	1.4
31 bis	12.1	6.7	2.0
254	15.6	10.5	1.3

Analyses of the variety Rio Blanco were made on October 4. The samples were taken from canes grown from seed-head from plot 107, of 21° Brix, and from seed head plot 107, of 20° Brix. The results here also showed the most remarkable deterioration. In no case did the Brix of the samples grown equal that of the parent cane.

The means were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
107	13.3	7.8	3.8
107 bis	15.2	9.2	3.5

Experiments were also made with the India and Orange varieties from Sterling, plot 289 of 1889, showing 21° Brix, and from selected seed head 14,175 of India and Orange, showing a sucrose content of 16.42 per cent, the experiments having been made on the 4th and 6th of October. In these cases, also, there was a marked deterioration. In the case of the canes developed from seed head No. 14,175, the highest percentage of sucrose reached was 13, with a glucose content of 1.73 per cent and 18° Brix. This was on the 6th of October. The lowest sucrose content was 4.2 per cent. The average is far below the percentage of sucrose in the original cane, which as before stated was 16.42. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
289	14.7	9.6	2.9
14,175	15.9	10.1	2.8

Experiments made with a variety of Honduras, grown from seed head 12,677, with a sucrose content of 16.72 per cent, showed the same reversion, only in a much more marked degree.

Experiments with Sorghum Bicolor, seed head No. 13,799, with a sucrose content of 13.25 per cent, also failed to develop as rich a cane as the parent, the highest percentage of sucrose found being 12.2, with a percentage of glucose of 0.83.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,799	14.3	8.4	1.1

Experiments were made on the 11th of October with Link's Hybrid variety, from plot 194, seed head 11,586, with a sucrose content of 16.01 per cent. The results also were very poor, the highest sucrose content obtained being 10.3 per cent.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
194	14.7	7.6	4.3

Red Liberian, examined on the 11th of October, from seed-head No. 13,631, showing a sucrose content of 13.52 per cent, gave somewhat better results than the same variety examined earlier in the season, the highest sucrose found being 11 per cent. From the same variety, seed head 13,655, showing 13.97 per cent sucrose, the results were poorer, the highest sucrose content found being 9.1 per cent.

The means were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,631.....	14.4	8.5	1.9
13,655.....	13.7	6.2	4.5

From a cross of Amber and Orange, seed head 13,927 having a sugar content of 16.85 per cent, much better results were obtained. The examination was made on the 17th of October. The percentages of sucrose obtained in the samples examined on that day were as follows: 15.1, 13.6, 14.2, 11.9, 13.5, 13.5, 11.9, 14.1, 13.7, and 12.9.

The percentages of glucose in all except three instances fell below 1, while the purities were very high. This sample appears to have given the best and most uniform results of any examined during the season.

The mean data are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,927.....	17.6	12.5	0.75

On the 18th of October analyses were made of Link's Hybrid again from seed head 11,491, showing a sucrose content of 16.69 per cent, the results being also favorable. The percentages of sucrose were 13.8, 15, 12.6, 13.4, and 14.3, the glucose averaging about 1 per cent, and the purity being high. Analyses of the same plot, continued on the 20th of October, showed results equally good. The means for the two days are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
11,491.....	18.4	13.6	1.2

Samples of Link's Hybrid, from seed head 13,897 with a sucrose content of 15.66 per cent, analyzed on the 20th of October, gave less favorable results, the highest sucrose content found being 14.5 per cent, and the lowest 8.8 per cent. Samples from another plot, grown from seed head 11.558, showing a sucrose content of 16.21 per cent, gave still less favorable results, and the same is true of another plot grown from seed heads Nos. 13,379 and 11,585. The means are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,897.....	[illegible]	11.6	1.5
11,558.....	15.0	9.6	1.8
13,379.....	15.1	9.5	2.4

Red Liberian examined later in the season, namely, on October 29, still showed the same extremely poor characteristics as were manifested in the earlier part of the season, with the exception of canes grown from seed head from plot 127, showing 19°.5 Brix. The means from this plot were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
127........	19.5	14.6	1.2

The analyses were completed on the 31st of October by the examination of a sample of a cross of Amber and Orange from seed head No. 12,142 with a sucrose content of 17.99 per cent. In the three samples examined the sucrose was 15.0, 12.5, and 13.8 per cent, and the glucose 1.01, 2.17, and 1.72 per cent, and the Brix 19°.5, 18°.0, and 18°.0. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
12,142.....	18.5	13.8	2.0

The full discussion of the details of these analyses will be reserved for Bulletin No. 29. In general, however, it may be said that the Red Liberian, which has done fairly well in Kansas, was a total failure in Mississippi with the exception of one plot. The same is true but in a less degree of the Undendebule, although some analyses of this last variety were quite favorable, but the average of them all will show a much lower percentage of sucrose than in Kansas. Rio Blanco, which is a kind of Orange cane, also did very poorly in Mississippi, and the same is true of the cross of India and Orange. The Honduras in Mississippi as elsewhere has shown itself to be a worthless cane for sugar purposes. Sorghum Bicolor also did poorly in Mississippi. The best results obtained were from the cross of Amber and Orange, the one plot of Red Liberian, and Undendebule from plot 254, seed head 13,336, of which the mean analyses showed:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
254........	18.7	14.8	0.57

This brief review of the data obtained at the Mississippi station tends to show that if sorghum sugar culture is to become a success in that locality it will be quite necessary that a line of experiments in seed selection should be carried on similar to those which have produced such excellent results in Kansas. There is every reason to believe that by the pursuit of the same policy all the standard varieties of cane might be developed which would be as suitable to the soil and climate of Mississippi as those which have been developed in Kansas are to the meteorological conditions of that locality. Still, it must not be forgotten that the general tendency of the researches of the Department has been to show that sorghum does better in a semi-arid locality, and that therefore we ought not to expect as high a development in sugar-producing qualities in Mississippi as can be obtained in more arid regions.

EXPERIMENTS WITH SUGAR BEETS.

From Mr. Henry T. Oxnard, the Department purchased 3 tons of sugar beet seed, of which the greater portion was the variety known as the Kleinwanzlebner, grown by Dippe Brothers, of Quedlinburg. In addition to this, however, smaller quantities of the White Improved Vilmorin were purchased, together with the varieties of beets grown by Lemaire and Florimond and Bulteau Desprez. These different varieties were put in 1 pound packages and sent to over one thousand different persons, mostly to those who had made special inquiry for them. Accompanying these packages were directions for preparing the soil and planting and cultivating the beets. Later directions were sent for harvesting and sampling the beets and for sending samples to the Department for analysis. Nearly one thousand different samples of beets were received by the Department, of which the analyses were made and the results communicated to the farmers sending them. In addition to this work a large number of the beet plots was personally inspected by agents of the Department, and particular inquiry was directed to a large number of farmers in regard to the methods of cultivation which they had pursued. Only in a few instances were the directions of the Department followed out to the letter. In most cases the planting and cultivation of the beet seed were conducted according to such methods as the agriculturist might hit upon at the time.

From the information gathered, it was found that the chief variation from the instructions was in the preparation of the soil. In very few cases was a subsoil plow used and most of the beets which were sent to the Department were evidently grown in soil of insufficient depth. In some cases where the exact directions for cultivation were carried out the character of the beets received showed by contrast with the others the absolute necessity of employing the best methods of agriculture for their production. It was not thought best the first year to make any effort to obtain from the farmers the exact yield of their beets per acre. The difficulty of securing such information is almost insurmountable. In the first place the amount of land under cultivation is usually guessed at and in very few cases are exact measurements made. The results, therefore, at best are only estimates unless the absolute control of measurements and weights can be secured. It was thought best, therefore, to depend for estimates of yield upon the actual quality of the beets produced, since it is well known that about 40,000 beets of fair quality can be produced upon an acre. It is therefore fair to presume that the yield per acre would be, within ordinary limits, the weight of the average beet sent for analysis multiplied by 40,000. When, however, it is necessary to speak of beets weighing from 2 pounds upward the rule no longer holds good, as it would be evidently impracticable to grow 40,000 beets of such a size upon an acre. It is fair, however, to estimate the yield upon beets weighing about 1 pound at 40,000 per acre or 20 tons. It is not meant by this that a yield of 20 tons can be obtained by farmers at the beginning, for this is not the case; it is only exceptionally that such a yield can be secured. When, however, the exact methods of beet culture are thoroughly understood and the method of fertilizing and preparing the soil studied, it will not be difficult, with favorable climatic conditions, to secure a yield of beets equal to 20 tons per acre.

For the information of those who might desire hereafter to enter upon the cultivation of the beet, the following brief summary of the methods of preparation of the soil, fertilization and cultivation is given:

The soil which is to be planted in beets, if fertilized with stall manure, should have a dressing of well rotted manure applied in the autumn and plowed under. The plow should be placed at a depth of 8 or 9 inches and should be followed with a subsoiler, which should loosen the ground to the depth of 6 or 7 inches more, without throwing the subsoil on top. The layer of stall manure would thus be placed at a point about half way from the surface to the total depth to which the soil is loosened. If the stall manure be well rotted when applied the soil will be in excellent condition by spring for the reception of the beets. The farmer can not be too strongly cautioned against the application of the stall manure in the spring, nor against its application in the autumn unless in the well rotted condition mentioned above. There are many soils, in fact, in which the application of the stall manure is not at all necessary, namely, those soils which are rich in organic matter and those which have not been exhausted by long years of cultivation.

In regard to artificial fertilizers, the standards for the sugar beet, of course, are those containing phosphoric acid, potash, and nitrogen. The amount of nitrogen applied in artificial fertilizers, however, should be the minimum necessary for the production of a good vegetation. Any additional amount of nitrogen in excess of this quantity tends to produce a larger beet at the expense of its sugar content, and is to this extent injurious.

Phosphoric acid is usually employed in the form of superphosphates which are easily soluble by the growing crop.

Potash salts of organic origin have proved themselves to be the best; those which come from the beet-sugar factory itself being, of course, best suited for the nourishment of the succeeding crop. The potash and phosphoric acid in wood ashes also act with excellent effect. Inorganic potash salts produce a good effect when the soil is deficient therein. Of these inorganic salts kainite and high-grade sulphate are generally employed.

The artificial fertilizers may be applied in the spring if they are thoroughly plowed under by stirring the surface of the soil with an appropriate cultivator. The potash salts, however, should rather be applied in the autumn, inasmuch as it is important that they should be buried as deeply as possible in the soil.

For a full discussion of the principles of fertilization reference must be made to Bulletin No. 27 of the Chemical Division.

Planting.—The beet seed should be planted in rows about 18 inches apart. In very fertile soils the rows are sometimes placed only 16 inches apart. These rows should be made as straight as possible, and the beets are best planted in a small way by a hand drill and on a large scale by a horse drill. When a horse drill is used two or more rows can be planted at once. The rows when the contour of the soil permits are better made north and south than east and west, although this is a matter of no very great importance. It is highly important, however, that they should be perfectly straight, so that the beets will not be injured during cultivation. In some localities it is customary to keep the beet seeds in a moist and warm condition for about forty-eight hours before planting them ; they are thus quite ready to germinate when placed in the soil. This is a perfectly safe process if, at the time the beets are planted, the soil is moist and warm enough to continue the germinating process, but if, on the other hand, the soil should be too cold or too dry, then this previous maceration of the seed might prove injurious to its vitality.

The surface of the soil in which the beets are planted should be, immediately previous to the planting, thoroughly stirred and loosened to the depth of 2 or 3 inches, and all clods should be broken and the surface left comparatively smooth. Much of the cultivation of the beets may be secured before their planting by having the soil in perfect tilth. The thorough plowing and harrowing of the surface just before planting destroys all the weeds which may have germinated, and thus leaves the beets a fair chance with the weeds in the race for life.

It is highly important that the beet seed should be planted very thick, much thicker, in fact, than would be required if they should all germinate. The policy, however, of planting the beet seed just where the beets are expected to grow, and in no greater quantities, would prove most disastrous, since at the best many of the seeds do not germinate, and thus there would be left long distances where no beets would grow. The very best growers of beets use about 15 pounds of seed per acre, although if the seeds were all good probably 3 or 4 pounds might be amply sufficient to obtain a good stand. The advice, therefore, is given to farmers to plant about 10 to 15 pounds per acre, since a little additional expense for seed will be more than compensated for in the uniform stand obtained. The beets should be covered to a uniform depth of about 1 inch. If they are planted much deeper than this it may be difficult for the tender plantlet to reach the surface; if at a less depth dry weather supervening may prevent their germination.

When the beets are fully above ground the spaces between the rows may be thoroughly stirred by the horse hoe, furnished with shields, described in Bulletin No. 27. These shields prevent the young plant from being covered, while the hoe thoroughly stirs the soil between the rows and kills all sprouting weeds. As soon as the beets begin to show three or four leaves the process of thinning should take place. This may be done altogether by the hand and hoe, or partly by a horse hoe. A very common method, when the stand is very thick, is to cross the rows with a slender horse hoe, which will take out about 6 inches of each row and leave about 4 inches untouched. The most healthy beet remaining in the 4-inch piece is left, while all the others are carefully taken out by the hand or hand hoe. This will leave one beet for every 10 inches, which is quite thin enough. In fact, an effort should be made to have a beet every 9 inches in the row in rich soils, while in very poor soils the distance may be left at 10 to 12 inches. In very rich soils it may be brought down as low as 8 inches. This thinning process is the most laborious and expensive of all the processes in beet culture, but is absolutely necessary to secure a good crop.

The surface cultivation can be carried on almost exclusively by horse power, and the ground should be thoroughly stirred between the rows and to a considerable depth at least once a week until the foliage of the beet begins to cover pretty thoroughly the spaces between the rows. If the cultivation of the beet begins about the 20th of May it should continue at least until the 1st of July, and in some instances for a longer time. The more attention which is paid to cultivation the larger will be the yield, other things being equal.

It is highly important that beet growers should realize the immense amount of labor which is necessary to produce a good beet crop. Farmers who are accustomed to growing maize and wheat are apt to think that beets can be grown over large areas much the same way, while, in point of fact, it requires as much labor to grow 10 acres of beets as it would 100 acres of maize. Mistakes are thus often made by beginners in attempting to grow more beets than they can attend to, with resulting failure. All farmers not accustomed to grow beets should begin with small quantities, and when the art has once been learned they will be able to estimate the area which they can successfully cultivate.

STATUS OF THE MANUFACTURING INDUSTRY OF BEET SUGAR IN THE UNITED STATES.

The readers of the agricultural reports are well aware, from what has already been published, of the fact that a beet-sugar factory has been in operation in Alvarado, California, for more than ten years. This factory has proved quite successful and the culture and manufacture of the sugar beet is now an established industry in that locality. For three years another large factory has been in operation at Watsonville, California, and from reports, which are accessible to the Department, this has also proved to be successful. Last year a large sugar factory was built at Grand Island, and as far as manufacturing operations are concerned was completely successful. This factory contains the latest and best forms of machinery suitable to the production of beet sugar and was built and operated upon the most approved plans of sugar technical engineering.

The beets which were brought in for manufacture were uniformly of a high character, as will be seen from a discussion of the analytical data relating thereto further on. The data of manufacture, however, are not accessible to the Department, the factory being purely a private corporation and not feeling disposed to furnish the Department with an itemized account of expenditures and receipts. From the best information accessible to us, however, it appears that about 5,000 tons of beets were received for manufacture and that the amount of sugar made per ton of these beets was probably 240 pounds. If the company should apply for the bounty given by the State of Nebraska, which is 1 cent a pound, it would be possible to give the exact amount from the report of the bounty paid. The Department, however, is not in possession of any facts in regard to this matter and hence only an estimate of the yield can be given.

By the courtesy of the managers of the company the Department was permitted to station a chemist at Grand Island, who had charge of the sampling of the beets as they came to the factory in wagons or carloads. Nearly three thousand analyses of samples were made and the full tabulated reports of these analyses will be found in a bulletin (No. 29) which will soon be issued on this subject, and a brief discussion of them will be found elsewhere in this report.

The proprietors of the factory were so encouraged by the season's work that they have decided to erect another large factory at Norfolk, Nebraska, and work on this factory is now going on.

Manufacturing experiments, on a small scale, with sugar beets, were also carried on during the season just past at Medicine Lodge, Kansas. About 80 acres of beets in all were harvested for the factory, and a summary of the work done will be given in another place and the details published in the bulletin above mentioned.

In general, the following remarks may be made concerning the last season's work in the beet-sugar industry, from a commercial point of view, in Nebraska and Kansas.

The summer in both localities was exceptionally dry. For this reason and on account of lack of knowledge among the farmers in regard to the proper methods of raising beets the average crop was very short. In Nebraska the exact tonnage can not be known, but probably it would not average more than 2 or 3 tons of beets per acre; in Kansas the average seems to have been somewhat higher. In many cases farmers obtained 10 and even 15 tons of beets per acre, showing that even in adverse conditions of season a reasonably large crop may be harvested when all other conditions necessary to the proper growth of the crop are attended to.

As might well be expected from the small yield, the farmers in general were dissatisfied with the season's work. It is not reasonable to expect satisfaction from a crop of so low an average when the labor of growing it is so great; but while the farmers are dissatisfied it must be confessed that a great deal of this dissatisfaction must be attributed to their own lack of knowledge of the subject or to their disinclination to put upon the beet fields the proper amount of labor and culture at the proper time. Instead of being therefore deterred from continuing the production of sugar beets, it would seem wiser on the part of the farmers to study carefully the methods of agriculture pursued by those who made a success of beet culture, and to imitate those methods during the coming season. The fact should not be forgotten, however, that even with the poor results obtained the beet crop was uniformly better than the average of other crops in the same locality.

It would be useless to hold out to the farmer the hope of financial reward from a beet crop which would average only 3 tons per acre; but if from this acre he could produce 10 to 15 tons of beets then his venture would prove financially successful. In order that the manufacture of beet sugar should become an established commercial success, the factories and the farmers must work in harmony. The method pursued in France and in Germany would probably be best suited to bring about this result. In those countries the beet growers themselves are usually shareholders in the factories, and thus participate in the profits. It is probable that the average dividend of German and French beet-sugar factories would not fall much below 20 per cent net on the capital invested. The farmer, therefore, who has even a small interest in such a factory secures a handsome profit on his invested capital. At the same time he has a vote in the board of directors and is personally interested in the success of the factory. In many factories of Europe the stock is thus held by the beet-growers. If, on the other hand, the whole of the factory be owned by the capitalists, then there is a cause for continual conflict between the interests of the farmer and the interests of the manufacturer, although this conflict is perhaps more in theory than practice. Even if the factory be owned exclusively by the capitalists, it is to their interest to work in harmony with the farmers, in order that they may secure a crop of sufficient magnitude to render the operation of their factory profitable.

It perhaps, however, would be unavoidable at the beginning of the industry that a feeling of animosity should exist between the beet-grower and the manufacturer. After a few years the prices to be paid for beets, and other arrangements with the farmers will doubtless be adjusted on a scale of equity and satisfaction to all concerned. In case farmers have no money to put into beet-sugar factories they might take shares of stock and pay for them with beets during the first and second years; in this way they would secure a financial interest in the company, own their shares of stock, and pay for them from the proceeds of the field without investing in ready cash. By adopting some such plan as this it might be possible to get every beet-grower within reach of the factory to become interested as a stockholder.

ANALYTICAL DATA COLLECTED FROM VARIOUS LOCALITIES WHERE BEETS WERE GROWN FROM SEED FURNISHED BY THE DEPARTMENT.

The samples of beets which were sent to the Department in response to the request already noted were immediately analyzed and the results of the analyses communicated to the growers of the beets. These data have been tabulated by States and by counties in States, and will be printed in detail in Bulletin No. 29 of the Chemical Division. Returns were received from a great many States, but principally from Nebraska and Minnesota. A brief summary of the results obtained follows:

Two samples were sent from Missouri, from Bates County. These were of poor quality, containing only 8.4 per cent of sugar, with a purity of 66.8. The beets, however, were of good size, averaging 600 grams (100 grams are equivalent to 3.53 ounces). Two samples of beets were received from Texas, Scurry County. These beets were of better quality than those from Missouri, containing 10 per cent of sugar, with a purity of 69.3. They were, however, very much too large for first-class sugar beets, averaging 1072 grams in weight. One sample of beets was received from Idaho, from Ada County. This sample contained 8 per cent of sugar, with a purity of 68.3, while the beets were extremely small, averaging only 100 grams. Six samples were received from Massachusetts, five from Hampshire County, containing 11.2 per cent sugar, with a purity of 82.8, the average weight of the beets being 468 grams, and one from Suffolk County, containing 16 per cent of sugar, with a purity of 82.8, and weighing 350 grams. Four samples of beets were received from California, Los Angeles County. These contained an average of 14.7 per cent sugar, with a purity of 84.6 and a mean weight of 382 grams.

In order to secure brevity the data obtained for the other States and the localities where the beets were grown have been compiled in the following tables:

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Connecticut:				
Litchfield	2	9.7	76.1	400
Maryland:				
Prince George's	81	12.3	79.7	416
Oregon:				
Jackson	2	15.1	73.4	560
Washington:				
Lewis	1	15.2	84.2	450
Virginia:				
Augusta	19	11.4	76.3	415
Loudoun	2	5.4	53.7	480
Pennsylvania:				
Dauphin	2	8.4	76.7	1,209
Lancaster	7	7.5	72.8	566
Philadelphia	1	10.04	75.2	1,225
Wyoming:				
Carbon	2	12.3	78.8	1,213
Crook	1	16.3	.....	260
Laramie	2	17.3	84.8	508
Illinois:				
Kendall	1	6.5	64.8	832
Pike	1	10.2	71.8	1,368
Platt	1	6.1	61.0	685
Will	4	11.9	75.8	830
New York:				
Genesee	3	12.2	79.4	1,732
Oneida	2	11.1	78.8	423
Warren	2	13.8	84.5	643
Yates	3	11.4	71.7	470
Wisconsin:				
Calumet	3	11.9	81.9	705
Kewaunee	2	13.5	79.6	632
Ozaukee	2	12.7	81.5	505
Vernon	3	13.8	81.6	493
Ohio:				
Butler	1	9.2	76.4	1,017
Erie	1	8.8	71.5	305
Hamilton	1	12.4	80.9	458
Sandusky	3	12.3	76.9	935
Trumbull	7	9.6	77.9	808
Van Wert	2	6.2	67.3	370
Colorado:				
Garfield	1	13.00	74.1	405
Larimer	7	14.00	83.2	644
Mesa	1	14.40	86.4	453
Phillips	3	12.90	71.9	638
Prowers	5	9.80	68.8	519
Pueblo	6	12.80	79.2	578
San Miguel	2	9.90	65.8	820
Yuma	2	9.90	69.5	573
South Dakota:				
Brookings	7	14.4	84.9	472
Brown	1	16.3	80.4	295
Davison	2	12.6	72.3	806
Grant	1	11.0	73.0	856
Hyde	4	13.0	78.8	619
Kingsbury	2	10.5	71.1	553
Meade	2	14.1	74.2	765
McCook	2	10.6	76.4	365
North Dakota:				
Burleigh	1	10.4	70.3	453
Cass	5	13.0	75.5	736
Dickey	2	11.0	70.4	1,060
Morton	1	13.8	73.9	508
Nelson	1	13.6	74.1	675
Ransom	4	10.3	71.3	794
Sargent	2	20.8	.....	218
Stutsman	1	12.5	77.6	570
Traill	7	14.7	76.7	701
Kansas:				
Barber	3	14.7	80.0	363
Bourbon	3	9.3	73.3	1,403
Butler	1	9.7	70.5	685
Kansas—Continued.				
Clay	4	9.3	67.6	611
Douglas	2	8.4	65.1	1,175
Hamilton	2	12.6	76.8	750
Johnson	2	12.4	68.4	295
Lyon	2	4.4	50.6	2,423
Saline	2	7.9	63.2	889
Stafford	1	11.5	75.2	548
Iowa:				
Audubon	1	10.7	74.9	535
Black Hawk	6	12.8	78.2	578
Carroll	6	12.8	78.2	578
Cherokee	2	10.4	68.2	474
Fayette	2	11.3	75.7	750
Harrison	2	10.8	73.1	1,013
Page	1	11.1	72.6	668
Polk	2	8.0	56.0	355
Sioux	3	11.6	72.7	788
Webster	4	14.4	84.8	560
Woodbury	2	9.7	67.0	628
Michigan:				
Clinton	2	11.5	77.2	763
Eaton	2	9.1	......	187
Gratiot	4	12.3	75.7	1,018
Huron	1	11.1	74.7	1,282
Ingham	1	12.5	76.6	1,515
Ionia	2	15.2	82.9	415
Lenawee	2	8.0	60.5	2,193
Macomb	2	15.4	87.5	693
Muskegon	11	12.2	80.9	699
Saginaw	2	12.9	82.0	773
St. Clair	1	10.0	71.5	1,660
Indiana:				
Benton	19	12.0	80.0	697
Cass	6	12.4	71.9	625
Clinton	1	18.1	78.9	430
Decatur	1	5.3	58.9	1,840
Grant	5	8.6	70.3	701
Greene	2	13.4	77.9	303
Hamilton	2	10.2	69.7	506
Hancock	2	6.9	51.8	718
Henry	1	10.6	82.6	780
Howard	1	13.2	70.5	600
Marion	6	9.8	65.6	548
Montgomery	2	7.7	64.4	953
Newton	2	10.0	71.7	543
Pike	1	10.5	75.7	432
Tippecanoe	2	8.3	64.6	603
White	3	8.2	63.3	543
Minnesota:				
Anoka	10	12.6	76.7	637
Becker	3	12.2	73.7	1,410
Blue Earth	8	10.5	74.1	684
Brown	2	8.5	68.1	1,158
Carver	4	11.0	71.1	951
Chisago	5	12.9	79.9	923
Clay	2	13.0	75.2	765
Cottonwood	2	12.3	67.7	898
Dakota	2	14.6	81.1	367
Faribault	2	9.8	64.6	873
Fillmore	2	11.4	74.6	826
Goodhue	6	10.9	71.1	685
Hennepin	6	12.4	77.8	1,216
Houston	1	13.0	80.6	510
Isanti	3	10.0	70.5	1,623
Le Seuer	2	10.8	73.2	508
Lincoln	2	12.3	73.2	1,343
Lyon	2	14.9	78.2	490
Marshall	1	8.5	66.9	740
Martin	7	11.2	73.5	889
McLeod	2	10.9	73.7	943
Meeker	2	11.0	75.0	525
Murray	5	15.2	84.4	415

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.	State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Minnesota—Continued.					Nebraska—Continued.				
Nicollet	1	13.0	75.6	612	Hall	2	16.1	88.8	423
Nobles	2	13.1	76.4	1,268	Hamilton	2	13.3	......	235
Pipe Stone	2	11.0	71.0	1,154	Harlan	4	10.7	68.8	328
Ramsey	12	10.6	81.0	830	Hayes	3	14.2	74.5	913
Rock	1	13.5	79.3	870	Hitchcock	4	14.0	73.0	464
Steele	2	9.3	67.6	1,043	Holt	17	13.5	73.9	777
Traverse	2	17.0	76.3	708	Howard	1	11.9	79.6	810
Wabasha	1	9.8	71.0	280	Jefferson	7	11.8	72.4	434
Washington	3	10.6	76.4	1,103	Kearney	3	20.2	76.1	224
Wilkin	1	14.6	80.6	447	Kimball	1	10.8	70.4	227
Wright	1	10.0	71.4	910	Knox	5	10.7	71.4	868
Nebraska:					Lincoln	9	12.5	75.0	613
Antelope	29	12.5	74.7	419	Loup	2	9.6	66.0	692
Banner	3	11.4	70.4	612	Madison	5	11.6	74.7	523
Blaine	2	12.6	76.3	580	McPherson	2	12.4	76.2	238
Boone	36	10.1	69.2	550	Nuckolls	4	8.5	67.4	347
Box Butte	6	12.2	71.6	666	Pawnee	4	12.7	80.5	693
Brown	1	10.1	69.7	350	Perkins	7	12.4	74.9	857
Butler	2	12.7	68.9	245	Phelps	5	12.4	70.2	305
Chase	8	11.7	70.6	796	Pierce	1	10.9	75.2	565
Cherry	2	8.9	60.5	530	Platte	4	10.0	68.3	369
Colfax	7	11.8	71.3	661	Polk	3	10.9	68.4	533
Cuming	2	10.4	69.8	692	Red Willow	2	8.1	61.2	940
Custer	4	7.0	58.2	550	Richardson	5	9.8	65.4	733
Dawes	3	12.7	73.3	258	Rock	1	14.4	83.1	400
Dawson	2	10.5	73.3	670	Saline	2	7.8	60.1	425
Deuel	1	18.8	....	248	Saunders	4	13.1	75.8	559
Dodge	2	14.8	82.3	600	Scott's Bluff	1	22.7	83.3	333
Dundy	1	10.0	67.7	1,565	Seward	2	11.2	72.3	450
Fillmore	5	11.6	68.7	677	Sheridan	9	11.2	69.8	503
Frontier	7	12.3	74.4	531	Thayer	13	14.6	77.8	632
Furnas	5	12.7	76.0	454	Valley	2	10.6	69.7	503
Gage	6	9.4	68.6	721	Wayne	2	9.0	70.8	413
Garfield	6	15.4	74.8	533	York	9	12.9	72.4	443

In the above summary of the beets sent from Nebraska are not included those which were examined at the Grand Island Sugar Factory under the direction of the Chemical Division, but only those which were sent directly to the Department at Washington for examination. In addition to these two sets of analyses large numbers of samples were examined in the laboratory of the Agricultural Experiment Stations at Lincoln and Madison, Wisconsin.

In a critical study of the summary given above there are many points of interest, a few of which only can be given here, while the others will be given at greater extent in Bulletin No. 29. In judging of the character of a beet for sugar-making purposes three factors must be taken into consideration. First of all, the beet must be large enough to make its growth profitable to the farmer. Experience has shown that a beet which weighs about 500 grams, that is, a little over 1 pound, is best suited to secure the interests of both the farmer and the manufacturer. Therefore, in all cases attempts should be made to grow beets as uniformly as possible of that weight. Having once established the average weight of the beet, the next point to be considered is its content in sugar. In the data given the percentage of sugar is reckoned on the weight of the beet itself and not upon the extracted juice. Sugar beets contain on an average about 5 per cent of marc and 95 per cent of juice. Therefore if the analysis is made upon extracted juice, the number obtained must be multiplied by 0.95 to give the percentage of sugar in the beet.

The question may arise as to how poor a beet can be in sugar and still be profitable for sugar making. This of course is a question which has to be determined by a comparison with many economic problems, the study of which can not be introduced at the present time. In general, however, it may be said that the limit of profit in manufacture will be reached when the percentage of sugar in the beet drops to 12, although it is possible under certain conditions for factories to work economically and profitably on beets having a lower percentage of sugar than that indicated.

With the present degree of perfection in the production of rich sugar-beet seed, and with the knowledge of the scientific principles of agriculture which should guide the beet grower, it is possible, I think, to show that beets can be produced, under favorable soil and climatic conditions, which will contain on an average 14 per cent of sugar. The farmer, therefore, should not be satisfied if his results fall below this standard.

It will be easy to see by comparing the averages given in the above table how many of the beet growers have succeeded in growing plants which will average 500 grams in weight and contain 14 per cent of sugar.

In addition to these two factors, however, a third must be taken into consideration, namely, the purity of the juice. By the purity of the juice, or, as it is expressed in the table, the coefficient of purity. is meant the percentage of pure crystallizable sugar in the solid bodies present in the juice. For instance, if in 100 parts of solids there are 80 parts of pure crystallizable sugar, the coefficient of purity of that juice is said to be 80. The number 80 may be taken as a fair average which should be attained in this country. In the older beet-growing countries a much higher degree of purity can be obtained than this. The degree of purity of the juice is influenced chiefly by the amount of salts represented by the ash obtained on the ignition of the sample. In soils highly impregnated with mineral substances, such as are often found in our western States, the percentage of ash will be found very high, and there will be a corresponding depression of the purity coefficient. In lands, however, which have been long cultivated and scientifically treated from an agricultural point of view, the percentage of ash in the beet will be diminished and the purity coefficient correspondingly raised. The ash of the beet consists largely of phosphoric acid and potash, and these two substances are essential to the proper growth of the beet. It is therefore not expected that the ash of the beet shall be reduced below a certain content, otherwise the growth and maturity of the plant will be retarded. It will not be possible in the space which is at our disposal here to discuss each of the series of data obtained by these analyses, but the above remarks are made for the purpose of enabling anyone who is interested in any particular series or analysis to discuss it intelligently and determine from the numbers given the value of the beets produced for sugar-making purposes. At the present time, for the purpose of fixing a standard of comparison, I would say that the typical sugar beet for sugar-making purposes should weigh 500 grams, contain 14 per cent of sugar, and have a purity of at least 80. With such raw material at his disposal in sufficient quantity, the manufacturer can not fail of success, provided he be supplied with the latest and most improved forms of machinery.

It may also be of interest in connection with the data above given to discuss some of the particular qualities of the beet separately. In general the mistake is made by those not acquainted with the principles of the growth of the sugar beet and manufacture of beet sugar of judging of the possibilities of success by the percentage of sucrose in the beet alone. The danger of relying solely upon this constituent of the beet is at once manifest from the considerations above mentioned. Nevertheless as it is often done, I have collected into tabular form from the analyses given above all of the results showing from 15 to 18 per cent of sugar in the juice. In another table have been collected all the analyses in which more than 18 per cent of sugar was found. In the case of Minnesota 3 samples of beets were found in which the percentage of sugar was more than 18; in the State of Indiana, 1 sample; in Iowa, 1; in North Dakota, 4; in Maryland, 5; in Colorado, 1; in Wyoming. 1; in Nebraska, 13. Of beets showing a percentage of sugar from 15 to 18 in the juice, the following numbers of samples were found: In Illinois, 3; in Minnesota, 15; in Nebraska, 36; in Maryland, 8; in Iowa, 4; in Wyoming, 2; in Colorado, 9; in North Dakota, 4; in Massachusetts, 1; in Wisconsin, 2; in California, 2; in South Dakota, 6; in Michigan, 4; in Kansas, 3; in Washington, 1; in Oregon, 2; in Virginia, 2.

The production of beets containing from 15 to 18 per cent of sugar is not unusual, and such beets may be regarded as strictly normal in constitution, but possessing a particularly high content of sugar. When, however, the content of sugar in the beet exceeds 18 per cent it must be regarded at the present time as something abnormal and due to peculiar conditions affecting the particular locality, or even the particular plant itself. Such beets are usually extremely small in size, and the richness of their sugar content has been acquired at the expense of normal growth. In other cases the effect of a particularly dry season preceding the time of harvest or other very peculiar conditions may affect the sugar content. In many other cases, from the wilted condition in which the beets have been received, it must be admitted that a portion of the water which they contained has dried out between the time of harvest and the time of analysis, thus increasing the apparent percentage of sugar in the beet. It will doubtless be possible hereafter, when the beet has been more fully developed by careful selection, to produce beets normally which contain more than 18 per cent of sugar, but to expect at the present time the production of such beets on a large scale would be unreasonable, and such an expectation would not be realized. Even when we consider the other class, namely, those containing in their juice from 15 to 18 per cent, we must confess that it would be unwise to look for a production of beets on a large scale containing so large a percentage of sugar. In many of the cases of beets of this class the high-sugar content must be ascribed primarily to some of the conditions mentioned for the class above 18.

When, however, the tables are further studied and the remarkably low percentages of sugar are noticed which were sometimes found, it must be confessed that in these cases the abnormally low content of the sugar is also due to the abnormal growth of the beet. In some cases these beets are of great size, weighing 2,000 grams or over, and to this extraordinary growth must be attributed to a certain extent the low content of sugar. In general, it has been found that when beets exceed 500 grams in weight it is difficult to maintain their sugar content at a high standard. When, therefore, the beets become greatly overgrown it is always accompanied with a falling off in content of sugar. In the cases, however, of the small beets, which have shown a low content of sugar, the result must have been due to defective conditions of soil and climate, or to defective methods of planting and cultivation, or to premature harvesting.

When we consider the varying qualities of beets which have been grown from the same seed, we are at once struck with the immense importance of the factor of soil and climate and cultivation in the production of the sugar beet. The fact that the seed of the Klein Wanzlebner variety of beet in the hands of different farmers will show a variation of from 6 to nearly 20 per cent of sugar, it must be confessed that we have in soil and climatic conditions, and in methods of cultivation, a more potent means of influencing the sugar content of the beet than is found in the germ of the seed itself. It can only be expected that a sugar-beet seed which is high bred will be able to reproduce its kind when it has become fully acclimated and has received in its new condition the same scientific treatment and selection which it had in its original home. The great hope, therefore, of uniform production of sugar beets high in sugar-producing power in the United States must be found in the establishment of culture stations, where different varieties of beets can become fully acclimated, and where they can receive the same careful scientific culture and selection which have brought them up to their present state of excellence in Europe.

CHARACTER OF BEETS DELIVERED TO THE GRAND ISLAND FACTORY.

Through the courtesy of Mr. H. T. Oxnard the Department was allowed to establish a laboratory at the sugar factory at Grand Island for the purpose of obtaining information in regard to the character of the beets entering into manufacture. In all about three thousand samples of beets were examined, a sample having been taken from every wagonload and every carload of beets delivered to the factory. These samples were taken in such a way as to give as nearly as possible the average character of all the beets worked. A large number of beets was taken from each sample, and after they had been properly cleaned and dried their average weight was taken. The beets were then rasped, the juice expressed, and an analysis made on the expressed juice. The total solid matter was determined by a specific-gravity spindle, and the percentage of sucrose in the juice was estimated by the polariscope. The purity coefficient was determined by dividing the percentage of sucrose in the juice as indicated by the polariscope by the percentage of total solids as indicated by the spindle.

Average weight of beets.—The average weight of all the beets examined was 200 grams. This small size of the beet was doubtless due to the extremely dry season. The drought throughout the region covered by the sugar-beet fields was the most severe perhaps that has ever been known in the State of Nebraska. Ordinary crops such as corn were almost total failures, and it is a matter of encouragement to note that in such a season the beets, although not making an average yield, yet did fairly well. On the whole, however, it must be confessed that the results from an agricultural point of view were disappointing; but this disappointment must be chiefly attributed to the exceptionally severe drought already mentioned.

It is also doubtless true that in the practice of the new system of agriculture which is required for the proper production of sugar beets many failures were made, and perhaps very few of the farmers practiced that form of agriculture which was best suited to the soil and the season. In a soil which is apt to be dry as in Nebraska too much attention can not be paid to the importance of loosening the ground to a good depth. Deep plowing followed by deep subsoiling, together with such harrowing and other treatment of the surface as will produce a perfect tilth, are absolutely essential to the production of a profitable crop.

The remarkably high percentage of sucrose shown in the juice is an evidence of the fact that the soil and climate of Nebraska are favorable to the production of a beet rich in crystallizable sugar. It must, however, not be forgotten that the extremely high percentage of sucrose in the juice is probably a reciprocal of the small size of the beet due to the dry season. Had the season been favorable to the production of a beet of average size, with a tonnage of from 15 to 20 per acre, the percentage of sucrose in the beets would doubtless have been less. This is well illustrated in the data obtained in the Department from the analysis of sugar beets sent from Nebraska. It is evident from the character of the samples which were received by the Department that the farmers have selected the larger beets to be sent on for analysis. It is seen by comparison of the respective sizes of the beets received for analysis by the Department with those received for manufacture at Grand Island that the beets sent on for analysis were about three times the size of those manufactured into sugar. It will also be noticed that in the beets received for analysis by the Department the percentage of sucrose is low as compared with those which entered into manufacture at Grand Island. It would therefore hardly be just to claim that beets as rich as those manufactured at Grand Island during the past season can be grown in quantities of from 15 to 20 tons per acre. It is not a matter of surprise that many of the farmers who grew beets are discouraged at the results of the first year's work. The planting and cultivation of the sugar beet as is well known are matters which require great labor and expense, and when, therefore, an unfavorable season cuts the crop very short, it is but natural that the farmer should be discontented. It is, however, difficult to see how he could have done better with any other crop, and the fact that in many instances even with the present dry season the farmers of Nebraska were able to grow 10 or even 15 tons per acre, shows that with proper cultivation and proper attention in other ways to the growing crop the evils which attend a severe drought can be greatly mitigated if not altogether avoided. It is not the purpose of the Department to encourage farmers to engage in an industry which does not give promise of success; but it will be a matter of regret to every one who desires to see the success of the sugar industry if the discontent which naturally attends a very unfavorable season should be sufficient to deter farmers from continuing the cultivation of a crop which under ordinary conditions promises so fair a yield as sugar beets. It would be wiser on the part of the farmers to continue the cultivation of the sugar beet until it has been demonstrated at least that even with favorable years it is not profitable. In that case it would be perfectly justifiable in the farmers, of course, to cease the cultivation of a crop which afforded no prospect of financial success.

EXPERIMENTS WITH SUGAR BEETS AT MEDICINE LODGE.

In addition to the analyses and control of the sorghum sugar work extensive examinations were made of the beets growing in the locality of Medicine Lodge.

The season was a peculiar one for beets. At the commencement of the rains, on the 28th of August, the beets were scarcely at all developed and were regarded as a total failure. After the rains commenced the beets grew rapidly and continued to grow vigorously through the months of September and October. About the middle of November the harvesting of the beets was commenced and continued until December. At that time the beets had reached a fair size and developed a high content of sugar. Two hundred and sixty-one wagonloads were brought to the factory and large samples were taken from each of these loads and subjected to analysis. The means of two hundred and sixty-one analyses follow:

In the juice.

Total solids.....per cent..	18.52
Sucrose.....do....	15.12
Purity.....	81.04

Four hundred and eleven miscellaneous analyses of the beets from different plots in the vicinity of Medicine Lodge were made with the following mean results:

In the juice.

Total solids.....per cent.	17.80
Sucrose.....do....	13.20
Purity.....	75.60

The fresh chips entering the battery had a mean sucrose content, in the juice, of 13.90 per cent, much less, as will be noted, than that represented by the analyses from the different loads.

The diffusion juices show a content of 10.45 per cent sucrose and a purity of 81.2.

The working of the beets with the sorghum-sugar machinery was extremely slow, and either from this cause or from the method of liming, which was very heavy without any subsequent use of carbonic acid, the clarification and boiling of the juices became a matter of great difficulty, and they suffered in this process rapid deterioration; for instance, the purity of the clarified juice was only 78.8 and of the sirup 78.3, while the mean purity of the massecuites showed the enormous depression represented by the difference between 78.8 and 59.4. The actual cause of this remarkable deterioration in boiling is not well understood, and the juices boiled with the greatest difficulty, it being almost impossible to prevent them from foaming in the pan. The semisirups also, after standing for a time, deposited a large quantity of mucus or viscous material, and this would lead to the supposition that a pernicious fermentation of a viscous or mannitic nature was the cause of the great loss of sugar during the boiling operations.

It is evident at once that the attempt to make beet sugar without appropriate apparatus must be regarded as futile. Beets of the quality of those delivered at the Medicine Lodge factory, if they had been properly and promptly manufactured, would have yielded almost 250 pounds of sugar to the ton; instead of this the yield was extremely small, the separation from the massecuite very difficult, and the whole manufacturing process disappointing.

In regard to the probability of producing beets in the locality of Medicine Lodge, I am still of the opinion, expressed in Bulletin No. 27, that it is a locality too far south to expect the successful culture of the sugar beet. In using the term "too far south" it is not meant in an absolute sense, but too far south from the zone of the probable beet industry as indicated in the map given in Bulletin No. 27. The actual growing season at Medicine Lodge it will be noticed was not during the summer, but in the autumn after the rains fell and the weather had become cool. Had the early part of the season been wet enough to secure a growth of the beets it is hardly probable that they would have shown the high content of sugar which they did. The splendid results obtained at Medicine Lodge in the working of sorghum cane would seem to indicate the course which the sugar industry should follow in that locality. Everything indicates that the culture of sorghum sugar will prove a success while there is little to encourage the further development of the beet-sugar industry in that locality.

PRODUCTION OF SEED.*

There is, perhaps, no other agricultural crop which has illustrated in so marked a manner the importance of seed selection as the sugar beet. By the careful selection of those variations in the original beet which seemed most favorable to the production of sugar, and the careful selection of beets in the production of seed during the succeeding year, and by judicious and scientific fertilizing for the purpose of increasing the sugar content, there has been a great evolution in the sugar-producing power of the beet which has placed it at the head of the sugar-producing plants of the world.

The influence of the quality of the seed, according to Vilmorin, is absolutely predominant from the point of view of the results obtained in the culture of the sugar beet. The numerous experiments of scientific investigators have shown that remark to be true. In France the firm of Vilmorin-Andrieux & Co. has paid special attention to the improvement of the standard varieties of the sugar beet by the method above mentioned. They have endeavored to produce different varieties of beets of which each one would have all the possible advantages in the different economical and culture experiments to which manufacturers and farmers will submit them.

It is true, without doubt, that the same variety of beet could not be the most advantageous in every case, and that, according to the results to be obtained, it might be an advantage in one place to cultivate a variety extremely rich and in another place one, which, while still rich in sugar, would also produce a heavy yield in pounds. To these different needs different varieties of beets respond. In one case the pure white variety, in another the white variety with green neck or the rose variety with rose neck, or the Vilmorin Improved, a variety which is suitable everywhere and particularly in those countries where the duty on beet sugar is laid directly on the beet. Since the introduction of the new law in France, in 1884, levying the tax upon the actual weight of beet produced, the White Improved Vilmorin beet has recommended itself by its exceptional richness, its great purity, and the ease with which it can be preserved. But in order to meet all the conditions necessary to the greatest success

*Bulletin No. 27, Division of Chemistry, pp. 41–46.

it is essential to find out by experiment that variety of beet, which, in any given locality, fulfills most of the conditions required to produce a high yield of sugar with a minimum cost and one which will be equally profitable to the farmer and manufacturer.

At the present time, it is necessary in this country to go abroad for beet seed of the highest character. Up to the present time the sugar-beet seed which has been grown in this country has been produced without especial reference to the conditions necessary to maintain the beet at a high standard and to improve it as is done in foreign countries. In other words, the sugar-beet seed which one will obtain from American dealers, if it should be that which is grown at home, does not come with the pedigree of the beet, in regard to content of sugar and purity of juice, nor with that assurance of care in cultivation which the professional producers of beet seed in foreign countries bestow upon their work. There is no reason, however, to suppose that it is impracticable to produce beet seed in this country of as high a grade and of as pure a quality as that which can be obtained in other countries. The method of doing this will be briefly indicated.

In growing the beets the greatest care should be taken to secure all the conditions necessary to produce a beet of maximum richness in sugar, coupled with a yield per acre of fair proportions. This can be done by attending to the directions for culture to be given, combined with judicious application of those fertilizers which will tend to increase the sugar content of the beet without unduly increasing its size. The fertilizers which are most suitable for this purpose are carbonate of lime, when it is not present in sufficient quantities in the soil, a small quantity of magnesia, and larger quantities of phosphoric acid with varying proportions of potash and nitrogen, according to the character of the soil in which the beets are grown. No certain rule can be given for the application of fertilizers until the conditions of the season and the character of the soil in each particular locality have been carefully studied experimentally. For this reason, it is certain that in this country, as in others, the business of producing beet seed will be one entirely distinct from that of raising beets for manufacture or from the manufacturing thereof. It is this business which will require not only the highest scientific agriculture but the most careful agronomic skill.

SELECTION OF "MOTHERS."

The beets which are to be used for producing the seed should be selected on account of the possession of those properties which are most suitable to secure the highest results in the production of sugar. In the first place, all beets of irregular or unwieldly shape should be rejected; those selected should be of uniformly even texture, smooth outline, and symmetrical shape.

The sugar content of these beets should be determined by the analysis of others grown in the same plot and of the same seed, and thus obtain the average content of sugar for the whole lot. Only that class of beets showing the highest content of sugar combined with the qualities given above, and the greatest purity of juice, should be preserved. In many cases the beets themselves, which are to be used for propagation of seed, are subjected to analysis by the removal of a cylindrical section by an instrument provided for that purpose and the analysis of this section. In this way the actual sugar content of the beet which produces the seed can be obtained. It is said that good results have also been secured by replacing the portion of the beet removed by sugar at the time of planting, which will afford an additional food product for the earlier growth of the beet in its second year.

Another method of selecting the beets, which has been widely employed, is that of determining their density. A solution of some substance is made in water, such as salt or sugar, of such density as to permit beets of inferior quality to float on the surface and those of superior quality to sink. These heavier beets, other things being equal, contain larger quantities of sugar and are more suitable for the production of seed. The beets, of course, which are to be used for the production of seed must be very carefully harvested so as not to be bruised, leaving the roots as much as possible uninjured, and they must be carefully preserved in silos over the winter until the time for transplanting in the spring. The transplanting and the successful cultivation of the beets need no detailed description.

The character of the beet is also sometimes determined by removing a small portion, as indicated above, for polarization, expressing the juice and determining its specific gravity by weighing in the juice a silver button of known weight.

The absolute necessity of securing a few beets of the highest sugar coefficient and purity for the purpose of producing a crop of seed in third, fourth, or fifth year, according to the number selected, has in the last few years been recognized to a degree unknown before. At first it was the custom to select the beets, by some of the methods mentioned above, in large numbers sufficient to grow in the second year seed for the market. A much more rational method, however, and one which secures higher results, consists in a more careful selection of the mother beets for the purpose, not of producing seed for the market in the second year, but only for the purpose of securing an additional crop of beets in the third year which in the fourth year will produce seed for the market. The methods employed by different seedsmen vary somewhat, but the principle in all cases is the same. The general method may be indicated by that pursued by Dippe in Quedlinburg:*

First year.—Seed planting for mother beets, from seed which came from the highest polarizing beets of different varieties, which have, of course, been kept separate. The planting is in rows 18 inches apart, and the plants are cut away in the rows so as to stand 10 or 12 inches apart. At the time of harvesting the beets are selected out according to form, growth, and leaf formation, as these best approximate the characteristics of the parent variety.

Second year.—In March and April these selected beets are examined in the laboratory † in the following manner:

At a certain point which it is presumed will give an average of the entire beet, a cylindrical piece is cut out, subjected to strong pressure in a juice press, which will give, for example, from 17 grams of beet 10 grams of juice, of which 5 cubic centimeters are diluted with lead acetate and water to 25 cubic centimeters, filtered and polarized. For the different varieties minimum limits are established, and the beets are arranged in three classes according to their polarization:

First, beets which go below the limit and are thrown out; second,

* Stammer, pp. 200, *et seq.*, Lehrbuch der Zucker Fabrication.

† This is not done until spring in order that only well-preserved beets may be chosen.

beets which are above the limit, and fairly good for seed purposes, and, third, beets which show an extra high figure.

These extra good beets are now examined still further, two more cylinders taken out, and the sugar estimated by the extraction method. From this result and the estimation of the sugar in the juice the (apparent) content of juice is calculated. Those beets which do not reach a standard, established for each variety (between 92 and 94), are thrown out, while those that attain it are the chosen "mother beets" of the crop, which are to perpetuate the variety, and which furnish the seed for each new succession, as mentioned in the first paragraph.

In the second year are planted all the beets saved, the extra and medium as well; the former furnish seed for extra mother beets, which are used as indicated for the normal-sized mother beets which furnish seed for a new succession, while the latter are to produce a generation of dwarfs, the seed from both being saved.

Third year.—The seed from the medium and extra mother beets is planted, and the latter produce the mother beets for future breeding purposes, as indicated, but the plants from the former seed, which was planted a little later than would be the case for beets ordinarily, and in soil fertilized with ammoniacal superphosphate and also some guano, in rows 12 inches apart, are cut out to about every 3 to 5 inches. The small beets are very carefully preserved under a thick covering of earth. In the spring of the

Fourth year.—They are uncovered and planted at about 26 to 24 inches apart. The seed from these when harvested in the fall is ready for the market, so that it has taken five years to attain this end.

In the establishment of Branne, in Biendorf, the procedure is similar, but the beets are selected by their specific gravity in the field. A woman sits at a table and cuts from each beet a very small piece and throws it into a solution of salt of known density (for example, with the Klein Wanzleben, 16° Brix). If the piece of beet floats, the corresponding beet is thrown away, but if it sinks the beet is reserved for further investigation in the laboratory. The beets chosen in this way are submitted to further selection by the examination of the juice from a cylinder.

In a somewhat different way, but still by means of the examination of individual beets, is the culture of the Klein Wanzleben variety carried on by Rabbethge, in Klein Wanzleben, whose object is not so much to furnish establishments with all the seed they require for planting, but rather with seed for the production of mother beets, and their own seed from these. The fact that Klein Wanzleben has never yet harvested more than 3 tons of seed in a season indicates the character of the work, which is much to be commended.

The seeds are always taken from mother beets of considerable weight, never from small or dwarf beets, and the aim is not so much to produce individual beets of exceptionally high sugar content, but large beets as well; that is, beets which give the highest yield of sugar from a given amount of land. These roots, which are chosen from a field of the best (Elite) beets, and which possess most distinctly the characteristics of the variety, are weighed and their juice polarized, and this operation is continued until 20,000 beets are chosen which fulfill the requirements as to weight and sugar content.

These 20,000 best mother beets are sufficient to furnish the planting of a hectare (2½ acres), and from them are obtained 40 to 60 hundred weight of the best (Elite) seed, and this gives the following year 60 to 100 hectares of the best (Elite) beets, or 5,000,000 to 7,000,000 plants. From these are finally chosen the 1,500,000 seed-bearers which furnish the planting of 100 hectares and the seed for sale and for the perpetuation of the breed.

An entirely different method of selection is what is known as "family" breeding. Hundreds of specially selected beets, excellent in every way, are planted out separately. The seed of each is gathered and planted separately. If among the beets thus obtained any are found that excel the mother beet in every respect, and this improvement endures through several generations, these are incorporated with the other mother beets and used for breeding. As examples of weight and polarization of the selected beets the following figures for the highest and lowest weights are given, representing the best mother beets of the years 1883 and 1884:

Weight.	Sucrose in juice.	Weight.	Sucrose in juice.
Grams.	*Per cent.*	*Grams.*	*Per cent.*
1.550	11.24	600	15.11
1,450	13.68	600	16.28
1,250	14.29	600	16.28
1,500	15.87	400	16.13
1,450	14.60	550	15.62
1,700	11.76	400	16.83
1,860	14.86	550	16.88
2,100	14.35	400	16.63
1,900	14.60	600	15.63
600	16.13		

Among 200 beets were found only 11 with a weight of less than 500 grams; 12 with a weight of 500 to 600 grams; 29 with a weight of 600 to 700 grams; 21 with a weight of 700 to 800 grams; and finally 127, or 63 per cent, with a weight of over 800 and up to as high as 2,100 grams.

The beets between 700 and 1,000 grams are of nearly identical sugar content, a peculiarity of the Klein Wanzleben variety.

The established normal weight varies, according to the season, between 600 and 900 grams; in the year 1883 it was 897 grams, corresponding to the average of the beets from a field.

A still different method is followed by v. Proskowetz (Kwassiz). The beets from which selections are to be made are placed in a solution of salt showing 17.5° Brix, and those which float are used as fodder; those which sink are analyzed for sugar content by the alcohol extraction method, for which purpose a small quantity, half the normal weight, is cut out with a rasp and polarized in a 400-millimeter tube. Beets which give at least 19 per cent of sucrose form the first class; those showing 18 to 18.9, inclusive, the second, and those from 16 to 18 the third. Beets under 16 per cent are used for fodder.

METEOROLOGICAL CONDITIONS. *

In addition to suitable soil, fertilizing, and cultivation the sugar beet requires certain meteorological conditions for the highest production of sugar. Temperature and rainfall exercise the most

* Bulletin No. 27, Division of Chemistry, pp. 169–177.

pronounced influence, not only on the yield of beets but also on their saccharine qualities.

A mean summer temperature of 70° Fahr. for ninety days is sufficient to push the beet well on to maturity, while a much higher degree than this tends to diminish its saccharine strength.

The experience of beet growers in California indicates that in certain latitudes the beet can flourish with a much less rainfall than has hitherto been deemed a minimum for its proper growth; but this is not conclusive evidence that in all localities so small a supply of moisture would be sufficient. In regions of dry and hot winds, or where the subsoil is less porous, or aerial evaporation much more vigorous, less favorable results would be obtained. Dr. McMurtrie traced his area of beet-sugar limits with an isotherm of 70° Fahr. for the summer months, and a minimum rainfall of 2 inches per month for the same period. By the kindness of the Signal Office I have obtained a record of mean temperatures and precipitation for each month in the year for a period of ten years of those portions of the country in which the culture of the sugar beet is most likely to succeed. Also from the same source a tracing of the mean isotherm of 70° Fahr. for ten years for the three months of June, July, and August. Beginning at the city of New York this isotherm runs nearly due north to Albany, and then curves westward and slightly southwest, touching the edge of Lake Erie near Sandusky. It runs thence in a northwesterly direction to Lansing, Michigan, and thence southwest to Michigan City, Indiana. Thence it continues in a northwest direction through Madison, Wisconsin, to a point a few miles south of Eau Claire, whence it continues almost due west to South Dakota. Entering Dakota the line makes a sharp curve to the north, and near the one hundred and first meridian turns almost due south until it reaches the 33° of latitude in New Mexico, near the Mexican border. Its further tracing across the Rocky Mountains is not necessary here. Extending for 100 miles on either side of this line the map shows a belt extending from the Atlantic to the Pacific, within whose limits the most favorable conditions for growing beets, as far as temperature alone is concerned, will be found.

The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion perhaps all but a small part of it would be excluded by mountains and drought. Beginning at a point midway between the one hundredth and one hundred and first meridan, beets could be grown only in exceptional places without irrigation. On the Pacific coast only that portion of the zone lying near the ocean will be found suitable for beet culture.

On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The zone, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

In respect of the rainfall it is necessary to call attention to the fact that a wet September and October are more likely to injure a crop of sugar beets than a moderately dry July or August. A wet autumn succeeding a dry summer is almost certain to materially injure the saccharine qualities of the beet before it can be properly harvested. In this regard it will be seen from the tables of precipitation that the two Dakotas are more favorably situated than Oregon and Washington.

The rainfall in Oregon and Washing'on for September and October is 2.17. 3.25, and 2.24, and 4 inches. respectively, while in the two Dakotas it is only 1.11, 1.27, and 1.54 and 1.26 inches. The importance of this slight rainfall in securing a safe harvest without danger of second growth is easily recognized.

During the winter months the temperature that is best for beets is one of uniformity and sufficiently low to prevent sprouting or heating in the silo. Sudden and extreme variations are alike injurious—on the one hand causing danger from freezing and on the other from sprouting. On the coast of California the winters are so mild that the beets require very little protection, in fact more from the heat than the cold, while in Nebraska and the Dakotas the temperature often falls so low as to endanger the beets even in well-walled silos.

All these problems in meteorology deserve the most careful consideration from those proposing to engage in the sugar-beet industry, and it is hoped that the subjoined tables may help to elucidate them.

Table showing the average precipitation, for each month of the year, at the stations specified. (Deduced from observations during the period January, 1880, *to December,* 1889.)

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Cornish	4.24	4.47	3.24	2.65	3.36	2.94	4.54	3.19	3.76	3.88	4.43	3.93
Eastport	4.64	4.49	4.68	3.14	4.82	3.72	4.49	2.82	3.16	4.89	4.22	5.26
Gardiner	5.02	5.20	4.27	3.31	3.53	3.09	3.47	2.48	3.62	3.80	3.86	4.64
Orono	4.52	4.64	4.06	2.76	3.60	3.29	3.70	3.33	3.38	3.76	4.44	4.45
Portland	4.22	4.72	3.23	2.90	3.42	3.04	3.96	3.23	3.51	4.02	4.21	4.44
	4.53	4.70	3.90	3.15	3.75	3.22	4.03	3.01	3.49	3.87	4.23	4.54
New Hampshire:												
Antrim	*4.61	*4.27	*3.72	2.80	3.95	3.37	4.53	3.43	4.32	4.00	4.30	4.11
Concord	3.83	3.55	2.79	2.14	2.88	3.03	3.67	2.98	3.74	3.16	3.12	3.41
Hanover	†2.84	†2.55	†1.84	†1.30	†2.70	‡2.90	‡3.38	†2.87	†2.49	†2.48	†3.27	†2.47
Weir's Bridge	3.84	3.73	2.89	2.32	3.14	3.18	4.01	3.17	3.94	3.40	3.68	3.90
	3.78	3.52	2.81	2.14	3.17	3.12	3.90	3.11	3.62	3.26	3.59	3.47
Vermont:												
Burlington	1.68	1.48	1.78	1.67	2.86	2.98	2.82	3.08	3.64	3.12	2.88	1.85
Lunenburgh	2.99	2.49	2.33	1.15	3.14	3.35	3.60	3.25	3.41	3.76	3.10	2.82
Strafford	3.64	3.16	3.14	1.90	3.06	2.95	4.52	3.61	3.70	3.02	3.92	3.28
Woodstock	*3.00	*2.77	*2.68	§1.66	§3.16	§2.24	*3.98	*3.00	‖3.41	*2.68	*2.09	*3.27
	2.83	2.48	2.48	1.60	3.06	2.88	3.73	3.24	3.54	3.14	3.00	2.80
Massachusetts:												
Amherst	4.23	3.72	3.62	2.53	3.59	3.45	4.69	4.08	4.50	3.40	3.77	3.67
Boston	4.81	3.99	3.64	2.73	3.86	2.81	3.51	3.58	3.30	3.62	3.38	3.27
Fitchburg	4.61	3.56	2.66	2.56	3.14	2.79	4.05	3.85	3.74	3.24	3.31	3.31
Lawrence	*5.44	*4.28	*3.91	*2.75	§3.30	§2.84	§4.18	§4.87	§3.59	§3.77	§4.69	§3.58
New Bedford	4.78	4.76	3.99	3.45	3.61	3.07	4.00	4.08	3.45	3.56	3.97	3.93
Springfield	†4.44	†4.36	†3.23	†2.65	†3.48	†3.80	†4.97	†4.09	†3.52	†3.62	†3.72	†3.84
Williamstown	†3.34	†3.25	3.10	†2.60	3.02	2.98	†4.61	†3.72	3.05	2.62	3.24	†3.40
Worcester	‡4.56	‡4.42	‡3.49	‡2.67	†4.13	‡3.63	‡3.38	‡3.33	†3.84	†3.85	†3.96	†4.06
	4.53	4.04	3.46	2.74	3.52	3.17	4.17	3.95	3.62	3.46	3.76	3.63
Rhode Island:												
Narragansett Pier	*5.84	*4.95	*4.28	‡3.27	‡2.88	‡2.69	†3.89	‡3.99	‡3.40	‡4.46	‡4.32	‡3.78
Providence	†6.19	†6.30	†4.33	†3.22	† .67	†2.99	‡4.07	†4.06	†3.29	†4.10	†4.11	†4.59
	6.02	5.62	4.30	3.24	3.28	2.84	3.98	4.02	3.34	4.28	4.22	4.18

* For seven years. † For nine years. ‡ For eight years. § For six years. ‖ For five years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Connecticut:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Hartford	5.10	4.39	3.49	2.53	3.37	2.61	5.02	4.01	3.49	3.97	3.88	4.19
Middletown	3.52	4.95	4.27	2.70	3.17	3.30	5.02	3.59	4.17	4.25	4.02	4.38
New Haven	4.44	4.56	4.30	2.64	3.84	3.14	5.37	4.67	4.04	3.97	3.48	3.97
New London	5.25	5.41	4.46	3.36	3.94	3.47	4.04	4.55	3.77	4.72	4.40	3.77
	4.58	4.83	4.13	2.41	3.58	3.13	4.86	4.20	3.87	4.23	3.94	4.08
Northern New York:												
Albany	2.95	2.56	2.72	2.24	3.13	3.58	3.08	3.67	3.28	3.18	3.46	2.94
Oswego	3.18	2.93	2.49	1.99	3.02	3.61	2.60	2.41	2.66	2.92	3.47	3.66
Rochester	2.61	2.35	2.35	2.16	3.61	3.37	2.30	3.10	2.10	2.63	2.53	2.44
	2.91	2.61	2.52	2.13	3.25	3.52	2.86	3.06	2.68	2.91	3.15	3.01
Northwestern Pennsylvania:												
Erie	3.38	3.79	2.58	2.76	3.46	4.29	2.73	3.29	3.71	4.06	4.46	3.47
Franklin	3.90	3.38	2.52	2.41	3.50	6.12	4.04	3.54	3.27	2.89	2.94	3.25
	3.64	3.58	2.55	2.58	3.48	5.20	3.38	3.42	3.49	2.48	3.70	3.36
Northern Ohio:												
Cleveland	2.44	3.37	2.34	2.20	2.52	4.03	3.47	2.53	3.38	2.56	3.07	2.54
Sandusky	2.14	3.18	2.38	2.34	3.64	4.29	3.08	3.37	2.59	2.51	2.72	2.54
Toledo	2.14	2.55	1.95	1.98	3.78	3.67	3.29	2.41	2.54	2.92	2.74	2.30
Wauseon	2.40	3.17	2.47	2.43	4.58	3.90	3.51	2.65	2.12	3.14	3.26	2.55
	2.28	3.07	2.28	2.24	3.63	3.97	3.34	2.75	2.66	2.78	2.95	2.48
Northern Indiana:												
Logansport	2.14	4.24	2.59	3.04	5.29	5.15	3.71	2.76	3.08	3.03	3.55	3.44
Michigan:												
Adrian	2.25	*3.48	*2.47	2.60	4.44	4.90	3.81	3.24	3.38	3.79	3.44	2.70
Alpena	3.08	2.61	2.27	2.23	3.81	4.21	3.07	3.24	3.57	3.71	3.16	2.90
Escanaba	2.04	1.68	1.59	2.06	3.17	3.84	2.74	3.64	4.16	3.51	2.26	2.44
Grand Haven	2.78	3.21	2.38	2.45	3.21	4.04	3.57	3.23	3.50	3.75	2.75	3.14
Kalamazoo	2.46	2.96	1.87	2.24	4.36	4.96	2.93	2.52	3.06	2.84	2.39	2.93
Lansing	1.96	2.68	2.55	2.24	3.92	4.43	3.17	2.90	3.14	3.21	2.66	1.80
Marquette	3.28	*1.88	1.74	2.68	2.71	3.24	2.74	3.27	4.27	3.06	2.72	2.96
Port Huron	2.34	2.97	2.40	2.00	3.43	3.60	2.62	2.44	2.16	2.76	2.63	2.26
	2.52	2.68	2.16	2.31	3.63	4.15	3.08	3.06	3.40	3.33	2.75	2.64
Northern Illinois:												
Chicago	2.22	3.03	2.19	3.08	3.83	3.53	3.86	3.42	2.88	3.65	2.82	2.42
Riley	2.28	2.66	2.37	2.61	3.25	3.64	3.18	3.44	3.16	3.14	2.00	2.05
Sycamore	†2.12	†2.40	†2.10	†3.70	*4.06	*4.78	*4.68	*3.47	*3.23	*4.21	*2.56	*2.59
	2.21	2.70	2.22	3.13	3.71	3.98	3.91	3.44	3.09	3.67	2.46	2.35
Iowa:												
Cresco	1.47	1.11	1.64	2.27	3.73	*4.53	*5.19	*3.52	*4.26	2.29	1.28	1.50
Davenport	1.55	1.91	2.14	2.38	4.42	4.47	3.85	3.64	3.41	3.75	1.88	1.92
Des Moines	1.31	1.29	1.40	2.94	5.30	5.88	4.02	3.74	3.95	3.66	1.77	1.54
Dubuque	1.83	1.84	2.23	2.73	4.12	4.74	4.66	3.39	4.47	3.22	1.75	2.11
Logan	†1.86	1.26	1.42	3.05	4.49	5.82	5.22	3.93	3.00	2.94	*1.44	†1.32
	1.60	1.48	1.77	2.67	4.41	5.09	4.59	3.64	3.82	3.17	1.62	1.68
Wisconsin:												
Embarrass	2.96	2.65	2.27	2.92	4.45	5.71	5.15	5.58	5.05	4.17	2.94	3.14
La Crosse	1.31	0.99	1.45	2.10	2.80	3.57	5.00	3.85	4.71	2.15	1.32	1.32
Madison	2.08	2.30	2.54	2.92	3.56	4.64	5.36	3.76	3.71	3.28	1.76	2.55
Milwaukee	1.96	2.36	2.16	2.18	2.78	3.95	3.80	2.68	2.71	2.24	1.60	2.22
	2.08	2.08	2.10	2.53	3.40	4.47	4.83	3.97	4.04	2.98	1.90	2.31
Minnesota:												
Duluth	1.26	.34	1.35	2.44	3.50	4.52	3.32	4.14	3.90	3.14	1.76	1.33
Moorhead	*0.82	*0.86	*0.76	*2.18	*2.75	*3.84	*4.37	*2.70	*2.40	*2.25	*0.93	*0.83
St. Paul	1.21	1.00	1.21	2.69	2.58	3.55	3.53	2.99	3.24	1.64	1.22	1.33
	1.10	1.07	1.11	2.44	2.98	3.97	3.74	3.28	3.18	2.31	1.30	1.16
North Dakota:												
Bismarck	0.52	0.61	0.67	1.86	2.11	2.98	2.68	1.98	0.88	1.04	0.52	0.75
Fort Buford	0.66	0.43	0.42	1.11	1.51	3.07	1.96	1.55	0.84	0.80	0.35	0.56
Fort Totten	0.48	0.59	0.38	1.21	2.11	3.84	2.62	2.66	0.80	1.49	1.02	0.75
St. Vincent, Minn	*0.48	*0.50	*0.53	*1.26	*2.00	*3.01	*2.70	*2.28	1.93	1.76	0.56	0.71
	0.54	0.53	0.50	1.37	1.93	3.22	2.49	2.12	1.11	1.27	0.61	0.69

* For nine years. †For eight years. * For six years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
South Dakota:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Deadwood, Rapid City	1.25	1.34	1.78	3.98	4.19	3.66	2.70	2.31	0.86	1.06	1.24	1.12
Fort Sisseton, Wadsworth	0.39	*0.37	*0.87	*1.78	*2.33	*3.50	*3.16	*3.38	*1.30	*1 81	†0.56	*0.52
Fort Sully	0.51	0.43	0.53	1.84	2.10	3.16	2.67	2.23	0.82	0.52	0.36	0.49
Yankton	0.59	0.77	1.05	3.35	4.83	3.14	3.16	3.30	3.17	1.66	0.84	0.87
	0.68	0.73	1.06	2.74	3.36	3.36	2.92	2.80	1.54	1.26	0.75	0.75
Nebraska:												
De Sota	1.00	0.86	1.55	2.29	3.64	4.71	3.86	3.55	2.56	2.45	0.89	1.10
Genoa	0.93	0.67	1.03	2.85	3.96	4.21	4.57	2.86	3.29	1.68	0.66	0.86
North Platte	0.34	0.38	0.70	2.03	3.30	3.58	2.76	2.72	1.57	1.37	0.37	0.55
Omaha	0.82	0.91	1.33	2.93	4.64	5.76	5.26	3.55	3.06	2.97	0.92	0.94
	0.77	0.70	1.15	2.52	3.88	4.56	4.11	3.17	2.62	2.12	0.71	0.86
California:												
Benicia Barracks	2.87	*2.06	*2.75	2.62	0.70	0.30	Trace	Trace	0.25	†1.33	*2.10	4.60
Fort Bidwell	3.51	2.46	2.03	*2.31	†1.11	†1.13	*0.32	*0.09	*0.27	*1.66	1.90	*3.47
Fort Gaston	9.99	6.45	4.30	5.69	2.60	0.96	0.10	*0.04	*0.88	*3.55	4.76	10.68
Los Angeles	2.39	3.38	3.35	1.92	0.41	0.16	0.04	0.06	0.07	1.07	1.67	4.29
Red Bluff	3.05	2.04	2.80	2.54	1.00	0.65	0.01	0.00	0.63	1.83	3.33	5.44
Sacramento	3.15	2.28	3.17	3.01	0.77	0.25	0.00	0.00	0.03	1.29	2.52	4.96
San Diego	1.91	2.38	2.05	1.19	0.50	0.09	0.01	0.05	0.02	0.63	0.76	2.40
	3.82	3.01	2.92	2.75	1.01	0.51	0.07	0.03	0.31	1.62	2.43	5.12
Oregon:												
Albany	7.92	5.70	3.67	3.51	2.27	1.71	0.60	0.40	1.78	3.76	3.98	8.76
Eola	7.16	4.73	3.27	2.73	1.84	1.39	5.48	5.22	1.84	3.40	3.59	7.06
Fort Klamath	3.62	2.44	*1.42	1.52	1.35	‡1.49	5.70	1.14	4.73	†1.68	*1.99	*4.19
Portland	7.28	4.97	3.72	3.66	2.48	1.71	0.61	0.56	1.93	4.31	5.01	9.56
Roseburgh	6.06	3.92	2.30	2.87	1.55	1.48	0.51	0.15	*0.58	3.01	3.18	6.78
	6.41	4.35	2.88	2.86	1.90	1.56	2.58	1.49	2.17	3.25	3.55	7.27
Washington:												
Blakeley	6.25	4.32	4.02	2.81	2.05	1.48	0.83	0.80	2.15	3.73	4.22	7.86
Fort Canby	8.08	7.15	5.94	4.63	3.06	2.37	1.26	0.87	3.35	6.26	6.96	9.84
Olympia	8.68	5.78	4.14	3.83	2.50	1.70	0.71	0.56	2.54	4.31	4.97	9.09
Port Townsend	2.71	1.46	1.33	1.73	1.43	1.28	0.98	0.74	0.90	2.54	2.17	3.08
	6.43	4.68	3.86	3.25	2.26	1.71	0.94	0.74	2.24	4.06	4.58	7.47

* For nine years. † For eight years. ‡ For seven years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified. (Deduced from observations during the period, January, 1880, *to December,* 1889, *inclusive.)*

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	°	°	°	°	°	°	°	°	°	°	°	°
Cornish	18.1	20.4	27.6	41.4	55.3	65.3	68.6	66.5	58.5	45.7	34.7	24.4
Eastport	20.4	21.9	28.1	38.4	47.3	55.8	60.5	60.4	55.8	46.3	37.4	26.5
Gardiner	17.9	20.6	26.7	41.0	53.5	*62.0	67.2	65.0	58.3	46.5	36.8	25.6
Orono	15.4	18.8	27.0	40.0	52.0	62.5	67.0	65.0	57.3	45.1	35.2	23.6
Portland	23.0	25.1	32.0	44.8	54.3	63.9	68.4	72.7	59.9	48.8	39.4	29.2
	19.0	21.4	28.3	41.1	52.5	61.9	66.3	65.9	58.0	46.5	36.7	25.9
New Hampshire:												
Concord	21.5	24.5	30.8	45.3	57.2	65.3	69.4	67.1	60.3	49.0	38.7	28.2
Hanover	*17.5	18.8	26.6	40.6	56.5	64.1	69.3	65.6	58.2	45.6	33.8	22.4
	19.5	21.6	28.7	43.0	56.8	64.7	69.4	66.4	59.2	47.3	36.2	25.3
Vermont:												
Burlington	18.7	20.6	27.5	42.8	58.6	66.6	71.0	69.2	61.6	47.6	37.1	25.6
Lunenburgh	14.5	16.8	24.0	38.8	55.4	63.3	67.3	65.1	57.9	44.2	33.2	21.5
Strafford	15.1	17.6	25.1	41.3	57.1	63.9	69.5	67.5	59.3	46.3	34.8	22.4
Woodstock	12.8	18.1	25.3	40.4	55.7	64.7	68.8	65.3	58.2	45.1	32.6	21.3
	15.3	18.3	25.5	40.8	56.7	64.6	69.2	66.8	59.2	45.8	34.4	22.7

* For nine years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Massachusetts:	°	°	°	°	°	°	°	°	°	°	°	°
Amherst	23.3	25.0	32.1	46.2	57.9	66.6	70.7	68.0	61.4	49.0	39.5	29.6
Boston	26.7	28.1	33.3	44.6	55.7	65.9	70.3	68.5	62.2	50.8	41.8	32.2
Fitchburg	21.9	23.6	29.0	42.8	56.4	65.8	69.7	66.8	60.2	47.3	37.1	27.6
Lawrence	*22.7	*22.7	*31.0	*45.2	*58.8	*67.2	*72.0	*67.2	*59.8	*48.0	†38.4	‡27.6
New Bedford	27.5	28.4	33.1	43.9	54.1	64.1	69.2	67.3	60.1	51.0	42.6	31.8
Springfield	24.0	25.9	32.5	46.8	60.5	68.8	72.8	68.9	63.3	50.4	40.0	§30.0
Williamstown	20.2	22.6	28.2	42.7	56.8	64.6	68.2	64.6	58.7	47.0	37.1	26.6
Worcester	23.4	23.9	30.0	‖42.8	‖55.2	§65.1	§70.0	66.8	§60.7	§48.0	38.7	28.6
	23.7	25.0	31.2	44.4	57.0	66.0	70.4	67.3	60.8	48.9	39.4	29.2
Rhode Island:												
Providence	*25.3	*28.5	*32.2	*45.4	*56.5	*67.6	‡73.1	*69.8	*62.1	*51.2	*41.9	*31.1
Connecticut:												
Hartford	‡22.4	‡24.0	‡30.3	‡46.7	‡59.4	‡67.2	‡72.2	‡68.2	†60.7	*48.6	*39.8	*29.2
Middletown	†24.3	†23.9	†31.4	†46.4	†58.7	†65.9	†70.5	†67.2	‡55.5	†48.4	‡40.4	‡31.0
New Haven	26.5	28.1	33.5	45.7	57.3	66.3	71.0	69.0	63.3	51.7	41.6	32.0
New London	28.9	30.0	35.0	46.0	56.6	65.6	70.5	69.1	63.7	53.0	43.4	34.0
	25.5	26.5	32.6	46.2	58.0	66.2	71.0	68.4	60.8	50.4	41.3	31.6
Northern New York:												
Albany	23.4	25.6	32.1	47.1	60.7	69.0	73.1	70.7	63.8	51.1	40.7	30.0
Oswego	23.3	24.3	28.8	41.5	54.5	62.6	68.4	67.1	61.3	49.0	39.1	29.4
Rochester	23.1	24.0	28.8	42.7	56.6	§62.5	§69.5	§67.4	§62.2	48.7	38.2	29.1
	23.3	24.6	29.9	43.8	57.3	64.7	70.3	68.4	62.4	49.6	39.3	29.5
Northwestern Pennsylvania:												
Erie	26.1	27.2	31.3	43.8	57.2	65.8	70.6	68.7	63.2	51.8	40.9	32.5
Franklin	21.8	23.9	29.1	43.7	56.0	60.2	65.5	62.5	56.8	45.3	34.2	26.2
	24.0	25.5	30.2	43.8	56.6	63.0	68.0	65.6	60.0	48.6	37.6	29.4
Northern Ohio:												
Cleveland	25.3	27.8	32.5	45.1	58.8	66.7	71.1	69.0	63.8	52.1	40.1	31.4
Sandusky	25.8	28.4	33.6	45.4	§59.5	§67.0	§72.9	70.7	64.9	52.5	40.5	31.8
Toledo	25.2	27.9	34.2	46.8	59.8	68.5	73.2	70.2	64.1	52.1	40.3	31.3
Wauseon	24.4	24.9	31.8	46.0	58.5	67.2	71.9	68.9	62.9	49.8	36.9	27.7
	24.4	27.2	33.0	45.6	59.2	67.4	72.3	69.7	63.9	51.6	39.4	30.6
Northern Indiana:												
Logansport	§24.0	‖29.9	‖36.7	§52.9	§64.7	§71.2	§76.2	§73.9	‖67.2	*55.3	§40.0	§30.7
Michigan:												
Adrian	20.3	§25.9	§31.0	45.2	58.4	67.2	71.6	68.4	61.7	49.1	36.6	28.2
Alpena	16.9	16.7	22.9	36.4	49.0	49.0	64.7	63.0	56.7	44.7	33.2	25.0
Escanaba	13.6	20.2	21.2	32.6	45.1	54.4	59.5	57.1	51.2	40.4	28.2	20.1
Grand Haven	23.3	24.2	30.0	43.4	54.7	63.2	68.2	66.3	59.2	49.2	38.0	30.0
Kalamazoo	20.6	23.7	30.3	46.2	57.6	67.1	72.3	69.1	62.4	50.4	36.5	28.1
Lansing	21.1	23.4	30.5	45.8	58.6	68.3	72.7	69.8	62.7	44.8	32.9	22.8
Marquette	14.5	§15.5	21.8	36.6	49.1	57.6	64.2	62.3	56.1	44.5	31.9	23.8
Port Huron	19.2	21.7	28.1	41.5	53.1	63.3	68.3	67.0	60.6	48.8	35.7	26.9
	18.7	21.7	27.0	41.0	52.4	62.5	67.7	65.4	58.8	46.5	34.2	25.6
Northern Illinois:												
Chicago	22.4	26.3	34.1	46.0	56.4	65.4	71.4	70.6	64.2	52.5	39.2	30.2
Rileyville	14.6	19.5	29.1	45.6	56.1	65.7	70.3	67.9	60.2	47.9	33.3	23.1
Sycamore	‖15.3	‖21.0	‡30.4	*46.0	§54.5	§66.8	§71.2	§68.6	§59.9	§48.7	§35.5	§26.2
	17.4	22.3	31.2	45.9	55.7	66.0	71.0	69.0	61.4	49.7	36.0	26.5
Iowa:												
Cresco	7.4	13.6	26.7	44.4	56.2	§66.2	§70.4	§68.1	§58.6	45.8	29.0	18.3
Davenport	19.4	24.9	35.0	50.1	61.2	69.7	74.8	72.2	64.4	52.2	38.2	28.3
Des Moines	16.6	23.1	34.7	50.2	60.9	69.8	74.5	72.1	63.5	51.7	36.6	26.5
Dubuque	16.1	21.7	32.7	48.6	60.1	68.5	73.6	70.9	63.6	50.4	35.7	25.6
Logan	16.5	22.4	35.2	51.7	63.2	71.6	75.9	74.0	65.9	52.4	36.1	26.1
	15.2	21.1	32.9	49.0	60.3	69.2	74.6	71.5	63.2	50.5	35.1	25.0
Wisconsin:												
Embarrass	11.2	15.5	26.4	44.2	59.1	68.0	71.0	68.2	60.9	48.5	32.4	21.2
La Crosse	13.4	19.1	30.5	47.3	59.8	68.5	72.7	69.8	61.4	49.5	34.3	23.8
Milwaukee	17.9	21.9	30.3	42.4	53.3	61.7	68.4	67.4	60.7	49.7	36.0	26.4
	14.2	18.8	29.1	44.6	57.4	66.1	70.7	68.5	61.0	49.2	34.2	23.8

*For seven years. †For five years. ‡For six years. §For nine years. ‖For eight years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Minnesota:	°	°	°	°	°	°	°	°	°	°	°	°
Duluth	7.9	12.4	23.2	37.5	48.1	57.3	65.2	63.6	55.2	44.4	29.5	17.8
Moorhead	2.9	2.9	20.0	40.2	53.6	64.5	67.6	65.1	55.3	39.0	24.9	11.1
St. Paul	9.1	14.9	27.9	45.3	57.8	66.9	71.3	68.6	60.0	47.2	31.0	19.4
	4.7	10.1	23.7	41.0	53.2	62.9	68.0	65.8	56.8	43.5	28.5	16.1
North Dakota:												
Bismarck	3.2	9.2	23.0	41.4	54.9	65.0	69.1	67.0	56.3	43.7	26.6	13.8
Fort Buford	2.6	9.3	24.0	41.7	53.9	64.2	68.0	66.1	54.8	42.6	25.8	10.8
St. Vincent, Minn	*7.5	*0.6	*15.3	*36.6	*51.7	*62.3	*65.0	*62.5	52.6	40.0	21.2	6.2
Fort Totten	*4.5	3.8	17.1	37.7	53.8	64.0	67.3	65.7	55.0	41.3	22.5	8.2
	1.6	5.7	19.8	39.4	53.8	63.9	67.4	65.3	54.7	41.9	24.0	9.8
South Dakota:												
Fort Sisseton	0.4	6.0	21.0	*40.9	*55.2	*65.0	*69.0	*65.1	*56.8	*43.0	*25.4	*11.2
Fort Sully	8.8	15.5	29.6	47.5	58.9	68.9	73.9	72.1	61.9	48.2	30.7	19.1
Deadwood	19.4	22.9	31.3	41.3	50.4	61.1	66.0	65.4	55.2	44.5	32.4	26.0
Yankton	12.6	18.2	30.6	47.0	59.3	69.2	73.5	71.3	61.8	49.6	33.0	22.4
	10.3	15.6	28.1	44.2	56.0	66.0	70.6	68.5	58.9	46.8	30.4	19.7
Nebraska:												
De Soto	14.5	21.5	34.0	50.7	61.5	70.5	74.9	72.6	63.5	51.1	34.4	24.4
Geneva	13.5	20.4	32.3	48.6	60.4	70.0	74.6	72.3	62.8	49.8	33.0	23.4
North Platte	18.6	25.1	35.1	48.5	58.1	68.3	73.2	71.1	62.0	49.6	34.5	27.0
Omaha	16.6	23.4	35.1	51.1	62.2	71.4	76.2	74.4	64.3	52.0	37.0	26.7
	15.8	22.6	34.1	49.7	60.6	70.0	74.7	72.6	63.3	50.6	34.7	25.1
California:												
Benicia Barracks	46.6	*49.6	*54.2	56.9	61.4	65.6	65.8	68.4	*66.6	61.7	54.2	50.3
Fort Bidwell	31.4	33.8	41.4	47.9	*55.9	*63.5	71.0	70.7	62.6	51.2	40.4	35.8
Fort Gaston	41.0	43.7	49.8	†53.8	59.8	65.0	71.8	69.3	63.7	54.5	46.0	44.2
Los Angeles	53.6	54.4	56.2	59.0	62.2	65.9	69.4	70.6	68.7	63.1	58.7	55.5
Red Bluff	45.5	49.1	55.2	59.8	67.5	75.2	82.1	80.5	*74.7	62.7	*52.7	47.5
Sacramento	45.5	49.4	54.7	58.2	63.4	68.2	71.9	71.8	69.6	61.0	52.4	47.5
San Diego	53.5	54.7	56.1	58.8	61.5	64.4	67.2	69.1	67.2	62.6	53.3	56.3
	45.3	47.8	52.5	56.3	61.7	66.8	71.3	71.5	67.6	59.5	51.1	48.2
Oregon:												
Albany	38.6	40.9	47.5	51.8	57.9	61.0	66.3	65.4	62.1	*49.0	43.2	41.8
Eola	37.6	39.8	46.8	50.1	55.8	60.3	60.7	64.4	59.1	51.6	43.7	41.5
Fort Klamath	†26.4	†26.8	‡34.7	†40.0	†49.7	‡56.9	†61.6	†62.1	†51.7	§41.5	†33.2	†30.4
Portland	37.0	40.0	47.	51.8	58.0	62.1	66.4	65.3	60.6	53.0	44.8	41.6
Roseburgh	40.4	41.6	47.5	51.6	57.1	61.4	66.5	65.0	61.4	52.2	44.5	43.2
	36.0	37.8	44.8	49.1	55.7	60.3	64.3	64.4	59.0	49.5	41.9	39.7
Washington:												
Blakeley	38.5	40.3	46.1	50.8	56.0	61.2	63.3	62.7	57.6	51.0	45.1	41.8
Fort Canby	41.0	41.7	46.0	49.0	53.2	56.5	59.0	59.5	57.8	53.0	47.1	44.1
Olympia	37.6	39.0	44.5	48.7	54.5	59.2	62.3	61.9	56.2	50.1	43.8	40.6
Fort Townsend	*38.7	*39.3	†45.2	51.3	55.0	60.0	62.0	61.2	†56.4	*53.4	*44.0	*40.9
	39.0	40.1	45.7	50.0	54.7	59.2	61.6	61.3	57.0	51.9	45.0	41.8

*For nine years. †For eight years. ‡For six years. §For seven years.

Dr. McMurtrie, in special report No. 28, has made a careful study of the climatic conditions in the United States favorable to the production of the sugar beet. Maps are given showing the southern limit of a mean temperature of 70° Fahr. for the three summer months, coupled with a minimum mean rainfall of 2 inches per month for the same period. The tables of temperature and rainfall from which these lines were computed are also given in detail. The observations made on the data collated are as follows:

"We see from this that the sections of the United States most favorable to beet-root culture are confined to the North, including New England, New York, a narrow band south of the lakes, Michigan, parts of Wisconsin, Minnesota, and Dakota. Here the line of the southern limit passes into the British possessions and enters the United States again in Washington Territory, and crossing Western Oregon, passes to the coast to the extreme north of California. In most of this band we find a favorable temperature, and the average rainfall is sufficient in quantity, but we are unable to make any observations concerning the number of rainy days. In California, as the tables will show, the temperature is sufficiently moderate, but, from examination of the figures for the stations for which the rainfall has been recorded, we find it to be remarkably deficient. Here, in order to make the culture a success, it would appear that the intervention of irrigation during the summer months would be an absolute necessity.

"We also note a few counties in the southwestern portion of Pennsylvania, and one county in Ohio, without the general band, where suitable meteorological conditions seem to exist. These counties are surrounded by the red line in the more detailed map that has been prepared, showing the county lines near to or over which the line of the limit of favorable meteorological conditions passes. This map is intended for more ready reference for those who may contemplate establishing the culture in the sections in the near neighborhood of the line.

"Now, I do not mean to assert that the band of country I have thus plotted on the map is exclusively that in which the introduction of beet-root culture may be attempted with prospects of success, but it is certain that within this band the chances of success are greater than they are without it, and it also appears that all the unsuccessful attempts that have heretofore been made to establish the industry have been at points without it. It is therefore advisable that farmers or manufacturers who may design entering upon the prosecution of this industry should study with greatest care these influences which operate with so much benefit or injury upon the profit of the crop. It is evident from what precedes that the beet requires a cool or at least a moderate season for suitable progress in development, that it may not reach maturity in advance of the time for working it into sugar, and under the influence of the rains and elevated temperature of the autumn months enter into a second growth, thereby destroying the valuable constituents which render it so desirable as a sugar-producing crop.

"In this connection it has been suggested that in sections of protracted warm seasons, where the root will develop and attain full maturity in August and during the summer drought, the crop could be taken up before the appearance of the autumn rains, and by slicing and drying the roots preserve them until the arrival of the proper season. This mode of procedure has in fact been recommended to the agriculturists of the south of France, and has, it has been stated, been the subject of experiment in Algeria. The method has the objection of being a rather precarious one on account of the chances of the crop being caught after a long-continued drought by late heavy summer showers that would prove almost as injurious as the autumn rains.*

"After the directions given by Briem and others it is scarcely necessary to recapitulate here the meteorological conditions which appear

*The experiment of drying beets for preservation in Maine, in the fall of 1878, proved quite disastrous financially for those who engaged in the enterprise.

to be required by this culture, yet the conclusions arrived at from our study of the subject, in addition, may not appear superfluous. The conditions, then, are in general, comparatively dry and warm spring months during the time for preparation of the soil, planting, and cultivating the crop; moderate temperature, abundant and frequent rains during the summer months, the time for ultimate development of the crop and its valuable constituents: cool, dry fall, the time for ripening, harvesting, and storing the crop. If these conditions prevail, the results will be good; otherwise they will be but medium or even bad."

The amount of rainfall necessary to the proper growth of sugar beets depends largely on the character of the soil, the mean temperature, and the degree of saturation with aqueous vapor of the prevailing winds. In the coast valleys of California, where the proximity of the sea preserves a low temperature through the summer, and where the porous soil permits the tap root of the beet to descend after moisture and moisture to ascend to the root, excellent beets are grown with little rain. The conditions would be entirely reversed in inland localities with high summer heats, stiff clayey soils, and arid winds.

In general, the amount of rainfall during the summer months in the Northern, Central, and Eastern United States is sufficient to secure a good growth, and therefore it may be said that proper soil and attention being provided, beet culture might be undertaken in such localities with little fear of disaster from drought, save in a few exceptional seasons.

In fact, with thorough under drainage and deep subsoil plowing, it would be possible to secure a good crop of beets in the regions indicated quite independently of the variation in the amount of rainfall.

The chief question, therefore, to be considered, is one of temperature and sunshine rather than of rainfall. In the present state of our knowledge it would not be safe to establish beet factories very far south of the mean isotherm of 70° Fahr. for the three summer months, without a more thorough study of the character of the beets produced than has heretofore been made. The possibility of finding localities south of this line, where sugar beets may be grown with profit, is not denied, but the necessity of further investigation is urgent. There are many places situated only a short distance south of this line where the soil, water supply, cheap fuel, and other local considerations supply peculiarly favorable conditions for beet culture, and in such places the industry would doubtless flourish, although the beet might not be quite as rich in sugar as when grown in a more northern locality. In all cases the length of the growing season should be sufficient for the complete maturity of the beet, and the freezing temperatures of winter should come sufficiently late to allow the beets to be safely harvested and covered.