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Sugar Beets in South Dakota

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SOUTH DAKOTA Agricultural Experiment Station

South Dakota State College of Agriculture
and Mechanic Arts

BROOKINGS, S. D.



Last Time Over.

SUGAR BEETS IN SOUTH DAKOTA

Department of Chemistry

H. C. Sessions & Sons  Printers, Sioux Falls

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Growing Sugar Beet Seed

.... in

South Dakota

A CO-OPERATIVE EXPERIMENT

DEPARTMENT OF CHEMISTRY

JAS. H. SHEPARD, Chemist

The work outlined in this Bulletin was undertaken in co-operation with the U. S. Department of Agriculture, Bureau of Plant Industry, Dr. C. O. Townsend in charge for the Bureau and the writer acting for this station.

The reasons for undertaking the work were two fold. First, there are now good prospects that the sugar beet industry will be established in this state in the near future. The completion of the irrigating project at Belle Fourche will probably be followed by the introduction of this industry there and the erection of a sugar factory. In the second place, work done at this Station in years past has demonstrated that sugar beets of high saccharine content can be successfully grown in this state on an economical commercial basis. Moreover, it has been shown that sugar beet seed of high grade may also be grown. Under these circumstances it was but natural that the growing and improving of sugar beet seed adapted to this section should be undertaken at this time. The Bureau of Plant Industry has furnished all seed and labor in cultivating and harvesting with Mr. J. W. Middleton in charge.

This Station has had supervision of the work and has done all of the analytical work, furnished the ground and storage room for the mother beets. My assistants, Messrs. Koch and Collier, have done the chemical work for the season.

A rather large number of varieties of sugar beet seeds have been used in this year's experiments in order to determine which ones are the most promising. Also a number of stock

beets have been grown for use in crossing with the sugar beets. It is hoped that the hardiness and prolificness in weight of the beets per acre may be increased by this cross-breeding.

But the greatest object to be attained is the creation of a strain or strains of seed that shall give a uniformly high percentage of sugar and at the same time give a satisfactory tonnage per acre. It is not so difficult to breed up a strain of beets giving a high percentage of sugar, but the roots are almost certain to be too small. Again it is easier to produce a strain of beets giving a high tonnage but the percentage of sugar in these is certain to be too small. The factory prefers the small beets with the high percentage of sugar, but the grower objects, especially when the beets are sold at a flat rate per ton at the factory. The grower prefers the larger beets, but the factory does not find them so profitable.

It is very probable that the most satisfactory beet for both parties in this section of the country will be a beet of rather high sugar percentage with roots of medium size, since in order to insure profitable growing it will be necessary to grow the beets in rows rather farther apart than elsewhere, thus allowing easy cultivation with horse power. Owing to the size of the average farm horse, it is doubtful if the rows can be planted closer than twenty two inches. This width of row will tend to increase the size of the roots. If beets with a low sugar content are grown, this increase in size will reduce the percent of sugar lower than the manufacturer might wish.

But, perhaps the most essential thing to be gained in this work will be a strain of beets that will produce individuals with a uniformly high sugar content. From some of the results obtained in this season's work it is evident that the seed sown was not grown from carefully selected mother beets. When individuals from the same strain growing under identical cultural conditions differ among themselves by more than ten percent of sugar in the beet, the inference is almost inevitable that inferior mother beets were used to some extent in producing the seed. That such a strain is possible we may cite the instance of Sta. No. 23 used in this year's tests. It is true that variations

exist in this strain, but the tendency is from low toward a higher percentage of sugar and not toward lower percentages and degeneration. In this variety not a single individual fell below fourteen per cent. From this reasonably good market beet the tendency was uniformly toward a higher plane, reaching a point where the beets contained nearly one fourth their net weight of sugar.

Of sugar beets and stock beets twenty six varieties were grown. Many of the sugar beets were of the Kleinwanzleben type as produced by different growers in different countries from which the American supply of sugar beet seed is drawn. A description of the different varieties follows:—

DESCRIPTION OF VARIETIES OF BEETS GROWN.

The varieties of beets selected for this work are those in use at the various sugar factories in the United States. As will be seen they consist mostly of the Kleinwanzleben types as grown by prominent growers in Europe. But a few were from seeds grown in this country. The names and numbers as given by Dr. Townsend follow:

Sta. No. 1. Govt. No. 17509. Kleinwanzleben, grown by E. H. Morrison, Fairfield, Washington. These proved to be hardy on our plats, and while the average percent of sugar was lower than some other varieties, very few were rejected on account of the sugar in the beet falling below 14%.

Sta. No. 2. Govt. No. 17968. Original Kleinwanzleben, grown by Kleinwanzleben Sugar Co., Kleinwanzleben, Germany. This is also a good variety giving few rejected beets. It also gave twice as large a percentage of beets analyzing 18% sugar in the beet or over as the preceding. The average percent sugar is higher by about one percent, but the average weight is somewhat less.

Sta. No. 3. Govt. No. 17969. Schreiber's Specialitate, grown by G. Schreiber & Sons, Nordhausen, Germany. This variety ranks well with No. 2.

Sta. No. 4. Govt. No. 17970. Elite Kleinwanzleben, grown by Dippe Bros., Quedlinberg, Germany. This ranks well with the preceding, with the average weight a little larger.

Sta. No. 5. Govt. No. 17971. Kleinwanzleben, grown by F. Heine & Co., Hadmersleben, Germany. This variety gave a

larger percentage of rejects, the sugar in the beet is lower, while the average weight only equals No. 1. Also the number over 18% is smaller, thus indicating that the variety is not well selected or that it does not produce uniformly on our plats.

Sta. No. 6. Govt. No. 17972. Kleinwanzleben, grown by C. Baune & Co., Biendorf, Germany. This variety is inferior to No. 5.

Sta. No. 7. Govt. No. 17973. Grown by Utah Sugar Co., Lehi, Utah. This one ranks a little higher than No. 6.

Sta. No. 8. Govt. No. 17974. Kleinwanzleben, grown by Fremont Sugar Co., Sugar City, Idaho. This variety ranks well up with the best. It is somewhat superior to No. 1.

Sta. No. 9. Govt. No. 17975. Kleinwanzleben, grown by Otto Hoerning & Co., Eisleben, Germany. This one scarcely equals No. 5. Why so many inferior beets are produced by some varieties when grown under identical conditions with others which give uniformly high percentages of sugar, is a mooted question. It may be caused by a lax grading of the mother beets by the grower, or it may be due to the violent change of soil and climatic conditions to which the beets are not inured.

Sta. No. 10. Govt. No. 17976. Kleinwanzleben, grown by Henry Mette & Co., Quedlinberg, Germany. This variety averages with the last.

Sta. No. 11. Govt. No. 17977. Kleinwanzleben, grown by Rabbethage & Giescke, Kleinwanzleben, Germany. This ranks with the very best.

Sta. No. 12. Govt. No. 17978. Kleinwanzleben, grown by Wohanke & Co., Prague, Bohemia. This variety ranks with No. 6.

Sta. No. 13. Govt. No. 17979. Kleinwanzleben, grown by K. W. Kuhn & Co., Naarden, Holland. This ranks with No. 9.

Sta. No. 14. Govt. No. 17980. Kleinwanzleben, grown by Otto Breunsted, Schladen-am-Hartz, Germany. This ranks with No. 9, but the beets are somewhat larger.

Sta. No. 15. Govt. No. 18119. Jaensch Vietrix, grown by Gustav Jaensch, Ascherleben, Germany. About equal to the last but the beets were somewhat smaller.

Sta. No. 16. Govt. No. 18233. Knauer's Mangold, grown by M. Knauer & Son, Grobers, Germany. This is a stock feeding beet and was grown with a possible utility for crossing with a true sugar beet in order to increase size and hardiness. Owing to the uniformly high sugar content for a stock beet all under 14% sugar in the beet were rejected, thus placing the rejections.

on a parity with the sugar beets themselves. But it will be noticed that when grown under the same close conditions as sugar beets the weight of the beets average about the same as that of the sugar beets.

Sta. No. 17. Govt. No. 12810. Giant Feeding Sugar Beet or Half Mangel. Seed from D. M. Ferry, Detroit, Mich. This variety was sown for the same purpose as the preceding. The rejections were below 10% sugar in the beet. It makes a poor showing for the intended purpose. A considerable percentage of these beets grew up out of the ground. This of course is inadmissible in sugar beets. Also this variety is not frost-resistant.

Sta. No. 18. Govt. No. 2811. Royal Giant or Half Sugar Rose. Seed from same source as preceding. Many of these beets grew above ground and such were extremely low in sugar. But they can be harvested with a minimum of labor by simply plucking them loose by hand and throwing into the wagon box. They promise to be a desirable sort for stock feeding purposes. But they were more affected by frost than the sugar beets. The low-growing beets were saved and all under 10% were rejected. But a number of high-growing beets were saved for purposes not connected with this investigation.

Sta. No. 19. Govt. No. 2812. French Yellow Sugar, seed from same source as preceding. All beets below 10% were rejected. These are no better than the preceding and the same remarks apply.

Sta. No. 20. Govt. No. 2813. French White Sugar Red Top, seed from same source as preceding. This variety was more affected by frost than any other. None fell below 10%, and the weight was rather above the average.

Sta. No. 21. No Govt. Number. Jaensch Late Victrix, seed grown by Gustave Jaensch & Co., Ascherleben, Germany. These beets averaged low in sugar and the weight was also low so they rank with the poorest of the sugar beets.

Sta. No. 22. No Govt. Number. Kleinwanzleben Old Type, grown by the Kleinwanzleben Sugar Co., Kleinwanzleben, Germany. These beets rank with the best.

Sta. No. 23. No Govt. Number. Kleinwanzleben, Pioneer, grown by the same company as the preceding. This is probably the best variety experimented with. Not only were there no beets below 14%, but the average was practically 18%. Moreover from this variety came the banner beet of the season with a percentage of 24.8% sugar in the beet to its credit.

Sta. No. 24. No Govt. Number assigned. Curly Top Resistant. Concerning this variety Dr. Townsend writes: "The Curly Top Resistant variety I produced in Colorado in co-operation with the Sub-Station at Rocky Ford. I began this work in 1902 by selecting healthy beets in a field where a large percentage of the plants were affected with this disease. Some of the plants selected showed curly top the following season when they were planted out for seed, but by process of selection I obtained last year several pounds of seed. Some of this I planted at Garland, Utah, last season and was pleased to note that there was a very much smaller percentage of diseased plants with this variety than in the other varieties grown in that locality. The original of the Curly Top Resistant is Kleinwanzeleben procured direct from Kleinwanzeleben for commercial purposes at Rocky Ford." These beets were of good size and their average percent was good without violent fluctuations.

Sta. No. 25. No Govt. Number. Jaensch Early Victrix, seed from same source as No. 21. These beets are among the best.

Sta. No. 26. No Govt. Number. Stock Beets, seed from same source as No. 17. These are the most promising beets for cross-breeding purposes. The weight, percent sugar and general thriftiness commend them. A few grew above ground but these can be eliminated by selection. A tabular view of the results obtained in analyzing the different varieties is given in Table II.

CULTURAL AND CLIMATIC NOTES.

The land chosen for the sugar beet plats was a well drained piece of high prairie soil sloping gently to the east. It was one year from the virgin sod, having produced one crop of millet.

This ground was plowed eight inches deep and subsoiled to a further depth of eight inches. The land was firmed immediately after it was plowed in the spring by means of much harrowing with a heavy iron harrow and by the use of a heavy roller. The thorough tramping by the heavy horses used in this work aided materially in packing back the subsoil. Before seeding the ground was thoroughly planked leaving the surface smooth and fine. As the season turned out much less work in packing the soil would have sufficed, since the heavy and persistent rains of a very wet spring tended towards the same result.

The seed was sown with a garden drill in rows eighteen inches apart. It was deemed best to place them thus close in order to give each of these unknown varieties of beets the most favorable opportunity possible of developing a creditable sugar content. It was also thought that any variety failing in this respect to respond to close cultivation might safely be rejected as unfit for this work. Even in the case of the stock beets this severe test was desirable, since any variety failing to make sufficient size under close cultivation would certainly have nothing to offer by way of new blood lines to recommend it in crossing upon the sugar beet proper. The beets were thinned to from six to eight inches in the row.

The spring was late. Heavy rains and snow interfered with the seeding and with the germination of the seed. The first plat was sown May 11th and last May 17th. This was too late for best results. Moreover, the ground was cold and full of water thus delaying growth after the seeds had germinated. Cultivation was attempted May 25th, but the ground was so wet and out of condition that work was practically delayed until June 1st. The first cultivation was finished June 13th. After this time the ground warmed up, good growing weather came, rains ceased and all the plats made a rapid and vigorous growth. Thinning began July 2nd and was finished on the 8th. The last cultivation was finished August 13th. At this time the leaves were so large that they interfered with the cultivator. After this time the plats were given a final hoeing to destroy scattering weeds. This work was finished August 24th. The plats were now perfectly free from weeds and were laid by to finish the season.

The stand obtained was nearly perfect and the beets covered the ground completely. At this time the plats were truly a handsome sight. The first killing frost occurred September 27th. To the best varieties of sugar beets little damage was done but some of the tenderer varieties and some of the stock beets showed the effect of frost very plainly. The second week in October gave evidence that the beets were at or near maturity. Accordingly samples were taken and analyzed. The results obtained are indicated in Table I.

TABLE I.

Station No.	Date Anal.	No. Beets Analyzed	Average Weight Grams	Degree Brix	Per Cent Sugar in Juice	Per Cent Sugar in Beets	Purity Coefficient
1	October	8	427	18.5	16.8	16.0	90.8
2	October	8	299	19.6	17.9	17.0	91.3
3	October	8	300	20.4	18.6	17.7	91.1
4	October	8	260	19.6	17.8	16.9	90.8
5	October	8	299	20.0	17.7	16.8	88.5
6	October	8	317	21.0	17.7	16.8	84.3
7	October	9	350	19.5	17.6	16.7	90.3
8	October	9	317	19.2	17.2	16.3	89.6
9	October	9	296	18.5	17.5	16.6	94.6
10	October	9	337	18.6	17.9	17.0	96.2
11	October	9	301	19.4	18.1	17.2	93.3
12	October	9	299	19.0	16.2	15.39	85.3
13	October	10	320	20.5	17.8	16.9	86.8
14	October	10	356	21.0	17.3	16.4	82.4
15	October	10	332	21.0	18.0	17.1	85.7
16	October	10	303	20.2	17.0	16.05	84.3
17	October	10	255	18.2	15.5	14.7	85.1
18	October	10	219	15.0	12.2	11.6	81.3
19	October	10	243	15.0	12.0	11.4	80.0
20	October	11	404	15.4	12.9	12.3	83.7
21	October	11	338	18.7	17.0	16.2	90.9
22	October	11	257	20.0	17.5	16.6	87.5
23	October	11	332	20.5	18.2	17.3	88.8
24	October	11	378	18.5	16.0	15.2	86.9
25	October	11	298	20.0	17.3	16.4	86.5
26	October	11	322	18.7	16.7	15.9	89.3

The analytical results showed that harvest time was at hand. Consequently on October 14th harvest was begun and it was finished October 23rd. At the time of digging the ground showed the effects of the dry Fall. The soil was hard and somewhat caked but the beets came out clean and bright with no indication of disease. The different plats yielded at the rate of about ten tons per acre. No doubt the yield would have been larger with warmer and earlier spring weather and a somewhat wetter fall. Of course the close planting tended to keep the beets of a medium size as was intended, but it is certain that the proportion of smaller beets would have been decreased by more favorable weather conditions.

As the different plats were harvested the perfect appearing mother beets were gathered and siloed in a cool dry cellar whence they could be easily reached for analysis at a later period.

Each mother beet was finally taken to the laboratory where it was marked with the Sta. No. and also a serial number for

each variety. It was then analyzed and if the analysis showed a proper percentage of sugar in the beet it was returned to the silo. If the percentage of sugar was too low the beet was rejected. In the sugar beets proper no beet giving less than 14% sugar in the beet was saved. It may be possible that in the varieties selected for propagation that all beets under 15% sugar in the beet will be rejected. In some varieties which are not very promising all under 18% will be rejected. In the cases of some of the best varieties of stock beets, Nos. 16, 21 and 26 all under 14% were rejected. In the other stock beets, all under 10% were rejected, but it is doubtful if any of these will be used in this work. The percentage of sugar is too low and the beets are too tender to frost.

It was not thought desirable to publish all the figures secured in analyzing the mother beets. But a summary of the results is given in Table II. The rejections reported are on the figures just indicated. The per cents. sugar in the beets are also averaged including the lowest numbers which will most likely be rejected at planting time. Table II follows:

TABLE NO. II.

Sta. No.	Govt. No.	No. Beets Analyzed	No. Beets Rejected	No. Mother Beets	No. Over 18 Per Cent	Av. Per Cent Sugar in Beet	Av. Weight Grams	Sugar in Beet Lowest per cent	Sugar in Beet Highest per cent
1	17509	381	12	369	54	16.4	373	12.0	22.0
2	17968	188	5	174	56	17.3	342	12.0	21.2
3	17969	175	1	174	50	17.1	354	12.2	21.0
4	17970	182	7	175	37	17.0	363	12.0	21.6
5	17971	102	12	90	9	15.7	373	11.4	20.8
6	17972	100	19	81	4	15.9	338	10.0	18.6
7	17973	100	15	85	7	15.8	350	11.8	21.0
8	17974	84	1	83	33	17.5	366	13.8	22.8
9	17975	53	12	41	5	15.8	368	9.0	19.6
10	17976	59	6	53	4	16.0	351	12.8	21.0
11	17977	56	1	55	19	17.3	385	13.4	19.8
12	17978	67	9	58	3	16.1	366	12.8	20.0
13	17979	50	14	39	5	16.1	348	11.0	18.8
14	17980	40	6	34	1	16.0	384	10.6	19.0
15	18119	50	7	43	3	15.9	349	12.0	18.4
16	18233	40	17	23	..	14.9	393	11.8	17.4
17	2810	25	8	17	..	11.4	338	6.0	13.6
18	2811	25	8	17	..	11.3	314	4.0	12.8
19	2812	25	7	18	..	12.0	310	8.8	14.2
20	2813	25	..	25	..	12.1	422	10.4	14.4
21	.....	45	10	35	..	14.4	379	10.4	16.2
22	.....	40	1	39	12	16.9	373	12.0	20.6
23	.....	30	..	30	13	17.9	358	14.2	24.8
24	.....	50	3	47	3	16.0	404	13.0	18.2
25	.....	25	1	24	4	16.5	412	12.0	20.2
26	.....	170	26	144	8	16.1	417	11.0	20.8

CULTIVATION AND ANALYSIS.

SOWING THE SEED.

Sugar beet seed should be sown as early as danger from freezing is past. In this state it is best to sow as soon after the middle of April as the weather will permit. Owing to the lateness of the spring it was impossible to sow until May 11th, which is nearly three weeks too late.

The seed was sown thickly with a garden drill in rows eighteen inches apart. It is necessary to sow thickly in order to insure a perfect stand. To the beginner it seems a waste to be obliged to destroy nearly nine tenths of the plants. But this is the only way to get a full stand without which the beets will not reach their fullest perfection. It is probable that a width of 22 inches between rows will be found best in this state when commercial cultivation is attempted. This will permit horse cultivation. In the plats last year only hand cultivation was employed and so the narrower rows were adopted.

If sugar beets are sown in very wide rows and thinned to a great distance in the row enormous beets can be grown, but they would be worthless for sugar manufacture. It is necessary to keep the plants crowded together in order to compel them to store up a high sugar content. Hence wide rows and breaks in the rows themselves are to be avoided.

THINNING THE BEETS.

When the thickly growing plants have put out the fourth leaf it is time to thin them in the row. This operation may be divided into two operations. First the beets are "blocked." This is done with a hoe. After the beets have been cultivated with a cultivator having weed knives which cut off all weeds between rows and leaves only a thin strip in which both weeds and beets are growing, each row is gone over with a hoe. A clean cut is made across the row destroying both beets and weeds the full width of the hoe. Then leaving a little square or "block" of about one inch, a second cut is made as before. This leaves from one to a half dozen plants in a block. Then another cut is made, and so on until the whole field has been blocked. The remainder



PLATE I.—Blocking and Thinning.

of the work must be done by hand. This is usually done by boys and women and is tedious work at the best. A boy kneels over or astride the row and quickly singles out the best plant in the block. This he separates and holds down with one hand and at the same time pulls out all weeds and superfluous beets with the other hand. He then presses the dirt around the selected plant and then proceeds in like manner with the other blocks in the row. When this work is properly done each row now contains only single plants standing from six to eight inches apart. The width of the hoe determines the distance apart for the blocks. Plate I shows both blocking and finishing in progress. The man on the right is blocking while the boys are completing the thinning. It will be noticed that the boys do not work on contiguous rows. They leave one between in order to have more room. The rows left are finished next time through.

CULTIVATION AFTER THINNING.

For a day or so after thinning, the beet field presents a very discouraged appearance. But the remaining plants soon recover and erect themselves. It is now time for cultivating. Plate II shows a man with a garden cultivator stirring up the ground which has been somewhat packed during thinning. In field work this is done by horses using special cultivators. This cultivation is repeated several times or whenever necessary until the leaves grow so large that they are damaged. Then it is best to go over the field with a hoe cutting out what few stray weeds may be left. The title page shows the Last Time Over.

In a few days now, so rapid is the growth the leaves fully cover the ground. This stage of growth is prettily shown in Plate III. The field is now left to itself until the beets are ripe and ready for harvest. This condition is plainly shown in Plate IV. It is somewhat difficult for a beginner to decide when this stage arrives. In general the leaves will be somewhat browned and perhaps slightly frayed around the edges and will show unmistakable signs that the end of work is approaching. If frost has occurred some of the leaves may be withered. Un-



PLATE II.—First Cultivation after Thinning.

fortunately the center of Plate IV is occupied with a tender variety of beets not adapted to this state and the leaves are badly damaged by frost. But on the left sugar beets are shown with little damage from the frost. Sugar beets will withstand a very severe frost without injury, a frost that would nearly ruin stock beets.

Beginners often make the mistake of harvesting their sugar beets before they are ripe. Then the sugar content is low and the non-sugars in the juice are high as is shown by the high degree Brix and the low purity coefficient. The sugar is elaborated in the leaves during the warm sunshine days of fall. It may increase one percent in a day or two of favorable weather. When the leaves have turned brownish colored and have lost their bright green color their work is done. No more sugar is elaborated.

HARVESTING AND SELECTING THE MOTHER BEETS.

When the beets are ripe the beets are either forked out by hand or dug by a special horse digger which simply lifts each beet up for an inch or two so that it may be easily lifted out by hand. When the beets are intended for the factory they are thrown in piles and then "topped" by hand. The topping is done with a large knife. At a single cut all the crown of the beet that grew above ground is cut off taking with it, of course, all the leaves. The beets are now loaded in wagons ready for hauling to the factory.

But when the beets are to be used as mother beets for growing seed a different course is pursued. The beets are divided when dug into two classes. First the perfect and typical beets are placed in a pile by themselves and only the leaves are cut close. The remainder are topped as usual and sent to the factory or are used for stock feeding purposes as the case may be.

In selecting mother beets great care must be taken to take only the most perfect and typical beets. A perfect and typical beet must conform to several important requirements. It must not be too large since the sugar content will be too low. It must not be too small since small beets are not profitable

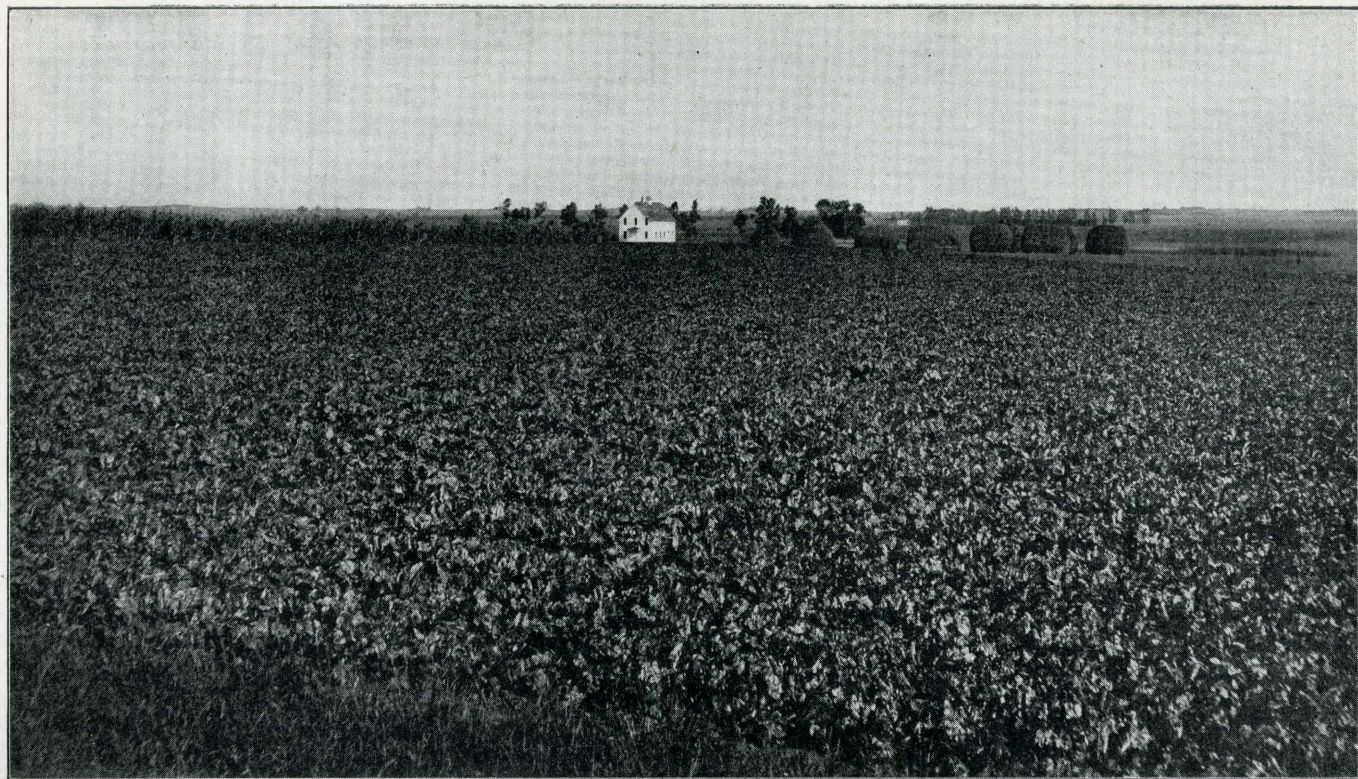


PLATE III.—The Ground Covered.

to the grower and moreover the small size might indicate immaturity. It must not have a divided tap root or large side roots. These are difficult to clean from dirt and are not wanted at the factory. Moreover the richest part of the beet is in the lower part of the root. Consequently a mother beet must not be slim with a long slowly tapering root that goes very deeply in the ground. Such tap roots are sure to break in harvesting leaving the best part of the root in the ground. And lastly the beets must grow entirely below ground since the part that grows above must be cut off to waste in topping. The proper form for a mother beet is that of a sharply narrowing cone with flattened or grooved sides. This form is well shown in Plate V.

But it is not possible to select mother beets entirely by the characteristics just given. Of the two beets shown in Plate V, the one on the right appears to be the better. But alas for appearance! Upon chemical analysis the one on the left is far and away above the other in desirability. The one on the left carries 24.8% sugar in the beet while the other has only 14.2%. Thus the first is better by over 10% sugar in the beet. This leads up to the next step in the selection of mother beets for seed production.

THE ANALYSIS.

In analyzing beets that are not to be saved for mother beets the sample is run through a grating machine which pulps the beets, after which the juice is expressed from the pulp and the juice is used for the analysis. But it is evident that the mother beet can not be treated that way. Its growing powers must be carefully conserved.

The first step is to engrave on the skin of the beet two numbers. The first is the variety number. The second is the serial number of the beet in the variety. Thus in Plate V the upper number 23 refers to the variety. Kleinwanzleben Pioneer. The second number, 5, means that this beet is number 5 of the 30 beets analyzed. These numbers persist even after the seed is ripe, so there is no danger of making any mistake among



PLATE IV.—Ready for Harvest.

the different beets in the same variety or in fact between the different varieties.

The next step is to bore into the mother beet diagonally with a bit that cuts a smooth hole and pulps the borings until a sufficient quantity of pulp for analysis is obtained. In this work we took the half normal weight for our polariscope or 13.024 grams. Plate VI shows how the boring was accomplished. The beet is pressed solid against a block by means of a strap drawn tight by the foot of the operator. As soon as sufficient pulp has been taken the hole is immediately plugged with a cylinder of moist clay. A pile of these cylinders are shown on the table. The borings are caught in an evaporating dish, then weighed in the german silver dish shown on the table and then transferred to the sugar flask, also shown on the table. The sugar dish is rinsed with strong alcohol into the sugar flask and then enough alcohol is added to nearly fill the flask. The alcohol extracts the sugar from the pulp. The extract is next freed from the non-sugars by adding basic lead acetate solution. The flask is filled to the mark with water and its contents are transferred to a filtering apparatus with each unit numbered. This filtering apparatus is shown in Plate VII. The juice comes through clear and water white and is now ready for polarizing. Plate VIII shows the polariscope and the method of reading the percent of sugar. The clarified juice is placed in a glass tube the ends of which are closed by removable glass plates. Such a tube stands by the instrument with one cup removed. The tube is then placed in the instrument and a beam of polarized light is passed through. The sugar rotates the beam to the right which causes the field to be divided into dark and light portions. By means of a suitable screw a quartz prism is slowly moved across the field until the field becomes uniform again, when the percent of sugar is read directly in the upper tube.

If the percentage of sugar in the mother beet is satisfactory it is now returned to the silo where it is kept a few degrees above the freezing point until planting time the next spring. If the sugar content is low the beet is rejected it matters not how good its other characteristics may be.

SUMMARY OF WORK WITH SUGAR BEETS IN PREVIOUS YEARS.

Beginning in 1888 a series of experiments with sugar beets was inaugurated. The results obtained were published in several bulletins which are now entirely exhausted. Owing to the fact that many inquiries are received for those bulletins, it was



PLATE V.—Mother Beets, 24.8% and 14.2% Sugar.

thought best to publish a brief summary of the results obtained.

During the season of 1888 this Station grew several varieties of so called sugar beets. The work was more by way of variety test. The seed was obtained from local seedsmen and the beets produced were really nothing more than selected mangels. They weighed from about two to over four pounds each and they gave from 6.5% to 10.3% sugar in the beet. Imported sugar beet seed of the better strains was not available at that time. The results were published in Bulletin 14.

In 1889 the experiments were of about the same nature as the first, but seed was procured from different American seedsmen hoping to find better varieties. Eight varieties were grown and they proved but little better than the first. The beets weighed from two to fifteen pounds each and the sugar varied from 8.2% to 12.3% in the beet. During this year's trial experiments were made with thick and thin planting. The advantages of close planting were very marked. The results were published in Bulletin 16.

In 1890 we succeeded in obtaining five varieties of genuine sugar beet seed from French and German growers. The United States Department of Agriculture furnished four varieties and the Oxnard Company sent one variety, name unknown. These were all grown at the Station and in addition about one hundred samples of seed were sent to farmers in the state. In addition some farmers secured seed direct from the Department of Agriculture, Washington. The results obtained from farmers as might be expected were not so good as those obtained from the home plats. All kind of cultural mistakes were made and when samples were sent in they were frequently the largest and poorest that the farmer grew. Again some never sent any samples at all. They were used to the free distribution of seeds to farmers by the Government and supposed this work was of the same sort. But in spite of these draw backs about sixty samples were analyzed and some fine results were obtained. From the Station plats the beets gave from 12.9% to 17.3% sugar in the beet and the beets weighed nearly one pound each. But the highest sugar content came from samples sent in from Huron which gave 19.9% sugar in the beet. The results were published in Bulletin 19 from which the following summary is taken:



PLATE VI.—Boring the Mother Beets.

SUMMARY FOR 1890.

Sta. No	VARIETY	LOCALITY.	No. Beets Analyzed.	Per Cent Sugar in Beets	Per Cent Sugar in Juice	Per Cent Marc.	Degree Brix.	Purity Co-efficient
18	Dippe's Vilmorin	Brookings.	4	13.70	14.49	4.75	19.00	76.26
19	do	Brookings.	4	14.50	15.21	4.67	19.40	78.40
20	.....	Jamestown, N D	4	10.10	10.52	4.05	15.00	70.13
21	Dippe's Klein Wanzleben	Jamestown, N D	4	10.70	11.15	4.15	16.40	68.00
22	Oxnard	Boz.	4	15.20	16.00	5.08	20.60	77.67
23	Vilmorin's Imp. White ..	Boz.	4	7.70	7.93	2.94	13.20	60.07
24	.....	Cresbard.	4	13.20	13.85	4.73	18.50	74.86
25	.....	Watertown	4	10.95	11.27	3.80	15.60	72.24
26	Dippe's Vilmorin	Brookings.	4	15.50	16.28	4.87	21.20	76.79
27	.....	Gary.	4	9.80	10.17	3.63	14.80	68.72
28	Dippe's Vilmorin	Brookings.	4	16.60	17.39	4.52	21.50	80.88
29	.....	Jamestown, N D	4	10.45	10.96	4.64	15.20	72.10
30	Oxnard	Brookings.	4	17.85	18.77	4.03	22.60	83.08
31	Pajaro Valley	Brookings.	4	14.65	15.36	4.64	20.40	75.29
32	Simon Legrand	Brookings.	4	15.55	16.34	4.15	20.80	73.56
33	Florimond Desprez	Brookings.	4	13.15	13.67	3.83	17.80	76.80
34	Dippe's Klein Wanzleben	Brookings.	4	16.15	16.93	4.58	20.80	81.39
35	Bulteau Desprez	Brookings.	4	14.75	15.42	4.36	19.70	70.27
36	Dippe's Vilmorin	Brookings.	4	17.00	17.93	5.20	22.40	80.06
37	Dippe's Vilmorin	Brookings.	4	15.55	16.40	4.93	20.80	78.84
38	Oxnard	Brookings.	4	16.80	17.64	4.76	21.80	80.92
39	Pajaro Valley	Brookings.	4	14.60	15.30	4.85	19.80	77.53
40	Simon Legrand	Brookings.	4	17.25	18.19	5.17	22.40	81.21
41	Florimond Desprez	Brookings.	4	12.90	13.45	4.12	17.40	77.30
42	Dippe's Klein Wanzleben	Brookings.	4	12.70	13.22	5.04	21.00	86.76
43	Bulteau Desprez	Brookings.	4	14.90	15.62	4.60	19.70	79.29
44	Oxnard	Brookings.	4	18.90	19.98	5.39	24.60	81.22
45	Pajaro Valley	Brookings.	4	16.00	16.78	5.26	22.00	76.27
46	Simon Legrand	Brookings.	4	15.50	16.32	5.01	19.70	82.82
47	Florimond Desprez	Brookings.	4	15.90	16.80	5.34	20.50	81.95
48	Dippe's Klein Wanzleben	Brookings.	4	18.85	19.99	5.71	24.00	80.93
49	Bulteau Desprez	Brookings.	4	19.50	20.94	6.87	27.20	76.90
50	Dippe's Vilmorin	Brookings.	4	18.00	19.00	5.28	24.70	79.17
51	.....	.....	4	8.40	8.69	3.64	14.50	59.95
52	.....	Huron.	3	12.40	12.91	3.94	18.00	71.72
53	Dippe's Klein Wanzleben	St. Lawrence	4	12.00	12.54	4.28	17.60	71.25
54	Oxnard	Montrose.	4	10.10	10.59	4.65	15.40	68.77
55	White Improved	Huron.	1	13.20	13.82	4.52	19.00	72.63
56	Quedlin berg	Huron.	1	11.20	11.78	4.93	10.50	60.41
57	Vilmorin's Improved ..	Huron.	1	9.50	9.94	4.44	15.90	62.51
58	Quedlin berg	Huron.	1	12.45	13.11	5.06	19.40	68.00
59	.....	Huron.	1	4.50	4.62	2.74	11.00	42.00
60	.....	Huron.	1	8.35	8.74	4.45	14.50	60.00
61	Vilmorin's	Huron.	1	14.10	14.84	4.99	19.50	76.00
62	Quedlin berg	Huron.	1	13.35	14.06	5.06	21.00	67.00
63	Dippe's Klein Wanzleben	Huron.	1	14.00	14.84	5.68	21.00	77.00
64	Quedlin berg	Huron.	1	11.35	11.92	4.13	17.50	68.00
65	Vilmorin	Huron.	1	6.35	6.50	3.76	12.50	53.00
66	Lemaire's	Tracy, Minn.	2	13.95	14.87	6.18	22.00	68.00
67	Lemaire's	Huron.	1	19.90	21.52	7.54	28.00	77.00
68	.....	Aberdeen.	4	15.55	16.48	5.66	23.00	72.00
69	.....	Aberdeen.	4	8.55	8.84	3.26	15.20	58.00
70	Dippe's Klein Wanzleben	Fargo, N. D.	4	12.45	13.00	4.23	17.80	73.00
71	Lemaire's Richest	Fargo, N. D.	4	12.40	12.98	4.54	17.50	74.00
72	Dippe's Klein Wanzleben	Brookings.	4	16.15	17.15	5.87	22.00	78.00
73	Lemaire's	Huron.	4	16.75	17.91	6.46	23.80	75.00
74	.....	.....	4	18.50	19.61	6.02	25.20	77.81
75	.....	Mitchell.	4	18.40	19.64	6.31	27.50	71.05



PLATE VII.—Filtering the Clarified Juice.

In 1891 most extensive preparations were made for giving sugar beets a state wide test. Also steps were taken to grow sugar beet seed from tested mother beets. Six varieties were analyzed and planted.

The state was divided into four regions and upward of a thousand samples of seed were sent out. The Station distributed about 800 samples obtained through the Department of Agriculture and from the Oxnards. Some farmers obtained seed direct from Germany and much interest was evidenced over the whole state. Directions for culture were issued and reports were required from co-operators. In all 263 samples were analyzed. From the data secured it was demonstrated that wherever good land had been selected and the directions as to methods of cultivation had been followed, most excellent results were obtained. About 55 low records were made by mistakes in cultivation, etc. These scored under 10%. About 50 more who did not make such grievous mistakes had beets running just under 12%. The remainder had good marketable beets running all the way from 12% up to over 18% sugar in the beet. This season's work demonstrated beyond peradventure that given the proper seed, good land of which there is plenty all over the state, and good and intelligent cultivation beets of a very high class were certain. It also showed that with poor condition and cultivation poor beets were equally certain.

No average or comparisons between the different sections of the state were possible. Some beets were sent in green, some were monstrous, some were grown on ground only disced and were gnarly and above ground. Each section furnished beets of this description. Also each section furnished splendid beets and in every case the beets were satisfactory.

The results of the season were published in Bulletin 27 and it took 68 pages to cover the ground. It became evident that there was no use in carrying on work with careless people so the number for the next year was limited and applicants for seed had to promise to follow instructions. What was now wanted was careful cultivation.

In the year 1892 beets from home grown seed were first produced. Sheep destroyed three of the varieties selected but the other two produced fine seed which were sown on the Station plats. The Kleinwanzleben mother beets averaged 16.2% sugar in the beet and their offspring gave 18.7%. The Pajaro Valley mother beets averaged 15.4% sugar in the beet and their offspring gave 15.5%. The Simon Legrand mother beets averaged 15.3% sugar in the beet and their offspring 18.2%

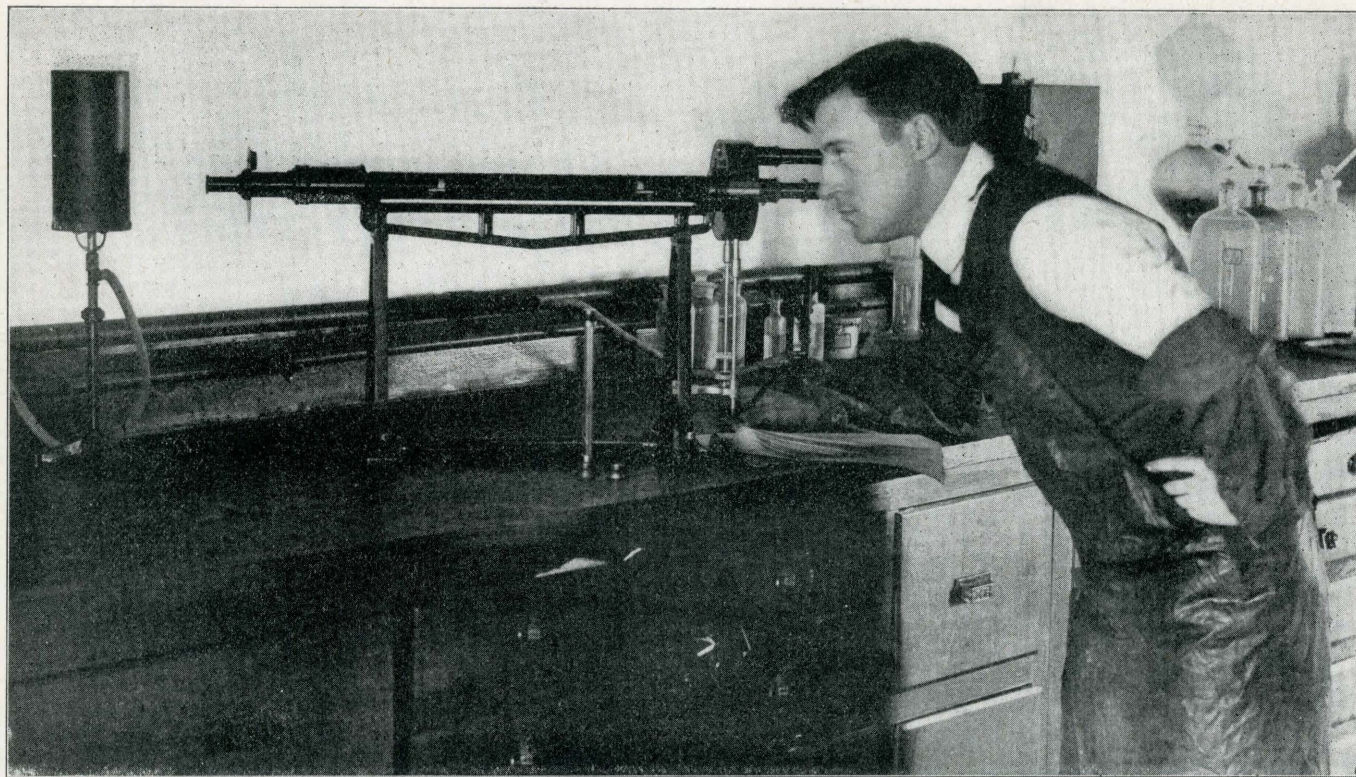


PLATE VIII.—Reading the Per Cent Sugar.

This showing indicates that home grown seed might be expected to equal in every way the best imported seed. This year the Station imported two varieties of seed direct from the grower August Knoche, one of the Vilmorin type and the other a Kleinwanzlebner. Four hundred samples were distributed to farmers who promised to follow cultural instructions. The spring was backward and in many places heavy rains early in May destroyed some plats. But 160 samples were returned and analyzed. Some mistakes in cultivation and some losses from harvesting green gave a few samples low in sugar, but on the whole the results were very gratifying. No marked superiority of any one section of the state over another was developed. Notwithstanding the confessedly poor care given by some of the growers only 27 samples fell below 12% sugar in the beet. The other samples ranged as follows:

Between 12 and 13%	13	Samples
13 and 14%	26	"
14 and 15%	34	"
15 and 16%	28	"
16 and 17%	13	"
17 and 18%	10	"
18 and 19%	6	"
Over 20%	1	"

So satisfactory were these results that we decided not to experiment further along the lines previously followed. Also unfavorable sugar legislation soon followed the completion of this work. The results obtained in 1892 were given in Bulletin 34. At the request of Secretary Wilson work with sugar beets was resumed in 1897. At that time more favorable legislation made it probable that something might be done to introduce commercial sugar beet cultivation in this state.

During the season of 1897 work with sugar beets was resumed. The Department of Agriculture sent this Station 500 lbs. of the Original Kleinwanzlebner sugar beet seed which was distributed to 954 farmers of the state residing in 59 different counties. Samples of beets were returned by 380 farmers from 51 counties and these were analyzed with the exception of 37 samples where instructions had been grossly violated. In such cases the samples were rejected regardless of their sugar content in order that an approximate average for the different regions might be approximated. Thirteen of the rejected samples gave over 12% sugar in the beet. But the reasons for rejection were of the best. As examples, one man planted his beets

in a single row, another made his rows eight feet apart, another manured his beets with hen manure thus raising 38 tons per acre, others did not cultivate at all leaving their beets to struggle with abundant weeds, etc., etc., up to the last crime in the calendar for sugar beet growing. Very many of the samples analyzed received poor treatment. Many did not plow deep enough. One man simply disced his ground, but his sample was rejected. Reports were received from many experimenters who did not send samples. Some lost their plats by cut-worms. Stock destroyed a number, some thought their beets too small and so fed them to stock, supposing that sugar beets should weigh fifteen or twenty pounds each.

The state was divided into ten separate regions this year and reports were tabulated for each region. The report for the work of the season was given in Bulletin 56. Taking it all in all better work was done by the co-operators than in any previous year. The summary for the different regions is given in the following table:

STATE AVERAGES AND TOTALS FOR 1897.

No. beets analyzed.	Av. weight—grams.	Regions.	Tons per acre.	Per cent stand.			Per cent sugar in juice.			Purity coefficient.	Per cent ash in juice.
				Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.	Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.		
29	392	Big Stone Lake region	20.5	81	17.6	15.5	14.53	87.8	88		
226	427	Upper Sioux region	16.9	76	17.1	14.7	13.99	86.	95		
232	425	Lower River region	20.2	77	18.9	16.4	15.56	86.6	1.06		
59	399	Central James River region ...	22.1	67	18.1	15.7	14.92	86.9	1.23		
194	360	Upper James River region ...	18.8	78	18.6	16.	15.22	85.8	1.04		
33	430	Upper Missouri region	13.4	71	18.8	16.4	15.51	86.8	1.13		
75	336	Central Missouri River region.	21.3	77	19.7	16.8	15.91	84.8	1.19		
9	376	White River region	39.	100	19.5	16.	15.20	82.	1.06		
66	281	Black Hills region	12.8	81	20.6	16.8	15.95	81.6	1.12		
28	407	Butte region	33.8	57	22.4	19.6	18.61	87.7	1.24		
951	383	Average and totals	21.9	77	19.1	16.4	15.55	85.6	1.09		

These results were so satisfactory that work was discontinued in testing varieties and regions. It became apparent that the soil and climate of the state are suitable for profitable sugar beet culture. But there are other features which needed investigation, consequently work along a different line was continued in 1897.

For the year 1898 the work in sugar beets took a different turn. Inquiries from capitalists and others interested in sugar manufacture asked for information concerning the cost of production and the profits likely to accrue. Moreover it was desired that larger plats be grown and all the beets accurately weighed. Accordingly seed sufficient to sow from one fourth acre up to one acre was sent out to the individual growers.

The seed used this year was sent by Dr. Wiley, Chief Bureau of Chemistry, United States Department Agriculture, and was of the original Kleinwanzlebner type grown by Dippe Bros., Quedlinburg, Germany.

Instead of sending to applicants five cities as centres were chosen. These cities appointed committees to take charge of the work and good reliable men were chosen to grow the beets. All labor and other expense were carefully noted and the cost of production was obtained as well as yields per acre. On the whole very careful work was done and the returns were satisfactory.

But it should be noted that the growers were at a disadvantage in many ways. They were unskilled and had to employ men to do the work of thinning and topping. Moreover their ground was often very weedy and this cost much more than clean land would. Also the cost of topping was high. All these things would be remedied were a factory established as the proper labor would follow such establishment. Most complete details were obtained and published in Bulletin 62. The summary of the work follows:

SUMMARY FOR 1898

ABERDEEN.

Grower	% Sugar	Purity	Tons Per Acre	Cost Per Acre	Income Per Acre
Thos. E. Williams	20.70	92.05	14.00	\$25.95	\$56.00
Robert Owen	19.10	93.17	12.40	28.30	49.60
J. E. Hickenbotham	16.70	93.30	22.40	40.70	89.60
R. S. Roe	20.60	94.00	18.20	38.80	72.80
Averages	19.27	93.13	16.75	\$33.43	\$67.00

HURON.

Smith & Miller	16.10	79.70	32.90	\$41.82	\$131.60
Smith & Miller	16.70	81.86	14.90	27.15	59.60
Smith & Miller	17.30	82.00	12.50	20.90	50.00
Smith & Miller	19.60	85.83	6.50	19.10	26.00
Smith & Miller	18.40	85.98	7.08	27.70	28.32
C. A. Sauer	18.90	83.21	6.80	31.29	27.20
Averages	17.83	83.09	13.44	\$27.99	\$53.80

YANKTON.

Geo. E. Whiting	20.00	91.74	9.60	\$48.00	\$38.40
Fred Jacob	20.50	93.10	22.30	48.58	89.00
E. G. Edgerton	16.40	89.16	14.20	34.70	57.60
Torger Nelson	19.50	90.70	11.80	34.60	47.20
Averages	19.10	91.17	14.47	\$41.47	\$58.05

SIOUX FALLS.

N. E. Phillips	18.20	88.78	17.00	\$35.65	\$68.00
John Griffiths	17.50	86.21	23.50	50.93	94.00
Averages	17.85	87.49	20.25	\$43.29	\$81.00

BROOKINGS.

E. C. Chilcott	21.20	93.00	11.40	\$53.77	\$45.60
G. W. Roe	17.90	88.74	22.50	40.25	90.00
Hogan Anderson	16.60	88.70	20.40	37.10	81.60
R. N. Crawford	16.90	88.40	12.20	37.00	48.80
Averages	18.15	89.71	16.62	\$42.03	\$66.50
Average for State ...	18.44	88.91	16.30	\$37.64	\$65.33

Note.—After paying the farmer for all his labor and all other expenses liberally, the final average gives him a clear profit of \$27.69 per acre. In addition he would have his tops for feeding and his land would be cleaned of foul weeds.

After this showing it was concluded that a sufficient amount of work had been done by way of experimenting. It was decided to await the coming of factories, when other details could be taken up with profit.

But the faces of capitalists and manufacturers were turned in other directions. They crowded into the sandy and unproductive lands of Northern Michigan and other places, which were equally unlikely of affording permanent success on account of the unfitness of the soil. The dismantled remains of these factories are mute witnesses of the folly of erecting factories where the soil and climatic conditions will not insure a cheap and permanent supply of sugar beets of high saccharine content. South Dakota can afford to await her day.