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THE COMPOSITION AND PRODUCTION OF SUGAR BEETS.

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GROWTH OF SUGAR BEETS.

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G. W. CHURCHILL.

GENEVA, N. Y.

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THE COMPOSITION AND PRODUCTION OF SUGAR BEETS.

L. L. VAN SLYKE, W. H. JORDAN AND G. W. CHURCHILE.

SUMMARY.

I. CONDITIONS REQUIRED FOR THE SUCCESSFUL GROWTH OF SUGAR BEETS.

The following elements determine whether sugar beets can be grown at a profit: (1) Richness in sugar; (2) purity of solids; (3) yield of beets; (4) cost of crop; (5) market price.

(1) Richness in sugar. Analyses of about 140 samples of beets grown in different parts of New York State during 1897 show a variation of sugar in the beets from below 12 to over 18.5 per cent, with a general average of 15.3 per cent. This average is somewhat higher than shown by other states.

The following conditions exercise a marked influence upon the development of sugar in beets: Climate; variety of beet; quality of seed; kind and quantity of plant-food; soil; methods of cultivation; size of beets; and time of planting and harvesting.

(2) Purity of solids. The coefficient of purity is the proportion or percentage which the sugar constitutes of the total solids in the juice, and is found by dividing the per cent of sugar in juice by the per cent of total solids in juice. The higher the coefficient of purity, the larger will be the proportion of sugar crystallized out in manufacture. The purity is influenced by maturity of beet, kind of fertilizers used, size of beet, and portion of root. Immature beets contain sugar of low

purity, also beets grown with excess of highly nitrogenous manures. The sugar in large beets has a lower coefficient of purity than in smaller beets. The portion of beet growing above surface of soil has sugar of inferior purity. The coefficient of purity in the samples analyzed varied from below 75 to over 87, with an average of 82.5.

(3) Yield of beets. Twenty tons of marketable beets an acre may be regarded as a maximum yield in commercial operations. An average of 10 to 12 tons an acre may probably be expected in favorable seasons in this State.

(4) Cost of production. The cost of raising an acre of sugar beets may be placed between \$40 and \$50, when all conditions are favorable.

(5) Market price and profits. There is good reason to expect that beets will bring from \$4 to \$5 a ton according to varying conditions of sugar, purity, etc. In general, a profit of \$5 to \$10 an acre above all expenses may be regarded as a reasonable expectation from the crop.

(6) General considerations. The sugar beet is to be grown as an added crop with a comparatively small acreage at the beginning, increasing as conditions favor. The educational value derived from growing sugar beets is considerable. A farmer who learns to grow sugar beets well will grow other crops better for the experience. The soil on which sugar beets have been grown is left in better mechanical condition than by other crops.

II. THE OUTLOOK FOR THE SUGAR-BEET INDUSTRY.

The following facts may be regarded as favorable to the successful production of beet sugar:

(1) The experience of 1897, so far as a single season can show, appears to demonstrate that our climatic and soil conditions are adapted to the growth of beets which are satisfactory in quantity and quality of yield.

(2) The cultivated lands of central and western New York may be so managed as to compete with any in the United States in those lines for which they are adapted.

(3) The ability of the American farmer to take up a new enterprise successfully is a helpful factor. American inventive genius may also be relied upon to provide implements necessary to cheap culture.

(4) At present there is an unlimited home market at good prices for all the sugar that can be produced; but it cannot be definitely known how long this condition may last.

(5) An added cash crop yielding fair returns is most desirable for our farmers.

The following facts must also be considered in connection with those preceding:

(1) To cultivate a plant so sensitive in regard to its content of sugar as the sugar beet requires such careful attention to details as is demanded by no other crop commonly grown on our farms.

(2) There is danger of regarding exceptional yields as representing the average. An average of 12 tons of beets an acre for the first few years may be regarded as a fair average, if we are to judge by results secured in other places.

(3) There is danger that capital may be inefficiently directed in the erection of factories, as this is a line in which our eastern business men have had no experience. Beet-sugar manufacture should be entered upon with great caution and only after exhaustive study of the problems involved. Farmers should be cautious about taking stock in factories, unless the men who control the enterprises are personally known to and trusted by them.

(4) The question of home and foreign competition must not be ignored. Strong competition will come from the Pacific states until their soils become exhausted. We shall be brought into competition with the lower wages paid in Europe, if at any

time the strong sentiment existing in favor of free sugar comes to find expression in tariff regulations.

Taking all facts into consideration, farmers may not expect to realize unusual profits for any long period of time from the growing of sugar beets. The crop promises to become one which will give satisfactory returns to those who learn to grow it successfully.

III. THE STATION EXPERIMENTS WITH SUGAR BEETS.

(1) Soil used. The soil was a heavy clay loam, in good condition of fertility and cultivation.

(2) Planting, cultivation and harvesting. The land was ploughed and subsoiled 14 inches deep on May 7 and 8. Commercial fertilizer was applied at the rate of 950 pounds an acre. The surface was given careful preparation and the seed sown on May 17 at the rate of 15 pounds an acre. About June 1 the rows of plants were distinguishable and a hand cultivator was run through them, which was soon followed by hoeing and partial thinning. On June 15 a horse cultivator was used and the final thinning commenced. This was followed by two more cultivations. Harvesting began September 22.

(3) Cost of crop. On a basis of wages commonly paid for labor, the cost amounted to \$75.80 cents an acre; on a basis of cheaper labor the cost was \$54.30.

(4) Yield. The yield was 32,548 pounds an acre or about 16 $\frac{1}{4}$ tons. For 1,000 pounds of beets, the loss of weight caused by cutting off the crowns was 73 pounds; and the loss of weight caused by washing off the dirt was 49 pounds. This would make a yield of marketable beets equal to 15 1-10 tons an acre.

(5) Size and composition. The average weight was 12 ounces. The beets contained 15.2 per cent sugar, equivalent to 16 per cent sugar in juice, having a coefficient of purity equal to 81.

(6) Influence of fertilizer. The yield was increased about 6 tons an acre by the use of fertilizer.

PART I.—CONDITIONS REQUIRED FOR THE SUCCESSFUL GROWTH OF SUGAR BEETS.

L. L. VAN SLYKE.

INTRODUCTION.

The growing of sugar beets for the production of sugar is, at the present time, attracting more attention in our State than any other subject connected with Agriculture. Farmers are asking for reliable information in regard to those various phases of the subject which possess special interest for them. They want to know whether the soil and climate of our state are adapted to the successful raising of sugar beets; whether they may have a reasonable assurance of a fair profit, compared with other crops grown by them; and whether there is any degree of certainty that they may be sure of a cash crop and a steady market. The chief elements which determine whether sugar beets can be grown at a profit are the following:

- I. Richness in sugar.
- II. Purity of solids.
- III. Yield of beets an acre.
- IV. Cost of raising and transporting crop.
- V. Market price and profits.
- VI. General considerations.

NOTE. For the most comprehensive treatise published, the reader is referred to Farmers' Bulletin No. 52 on "The Sugar Beet" by H. W. Wiley, Chief of the Division of Chemistry, U. S. Department of Agriculture, Washington, D. C.

I. RICHNESS IN SUGAR.

When beets were first used as a source of sugar, the amount of sugar contained in them averaged about 6 per cent. As a result of careful selection and breeding during a period of many years, the amount of sugar has been increased to an average lying between the limits of 12 and 15 per cent. Many crops of beets show a sugar content of over 15 per cent while, in some exceptional cases, the sugar has been reported as high as 20 per cent and even higher in this State. Farmers must avoid the mistake of regarding exceptional cases as typical. When all the details are known about remarkably high yields of sugar in beets, it is usually found that special conditions exist which cannot readily be duplicated in commercial operations. The question of interest to each farmer pertains to the results he can secure on his farm, working under the conditions involved in growing beets on a commercial scale. From results secured by this Station during the past year with beets grown in various sections of the State, we can present data which ought to be of value in showing how much sugar has been obtained in beets.

Before presenting a summary of our data, we will explain certain terms which it will be necessary to use. In using the term "sugar," we mean the crystallizable sugar that goes by the chemical name of sucrose. The amount of sugar is stated in two ways: "Sugar in beet" and "sugar in juice." One hundred pounds of sugar beets contain, on an average, about 95 pounds of juice, and so the sugar in 100 pounds of beets is contained in 95 pounds of juice. Therefore, the juice is more concentrated with respect to sugar, and when the results are expressed in percentages, the number expressing the per cent of sugar is higher in the juice than in the beet.

We present below in tabulated form the results obtained in making analyses of about 140 samples of sugar beets grown in this State during 1897:

**RESULTS OF ANALYSIS OF SUGAR BEETS GROWN DURING THE SEASON
OF 1897.**

Variety of beet.	Amount of sugar in beet.	Num- ber of sam- ples.	Aver- age amo't of sugar in beet.	Aver- age amo't of sugar in juice.	Aver- age amo't of total solids in juice.	Aver- age co-effi- cient of purity of juice.	Aver- age weight of one beet.
	<i>Per ct.</i>		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>		<i>Ozs.</i>
Klein Wanzlebener.....	11 to 12	4	12	12.7	16.6	76.5	20
" "	12 to 13	11	13	13.7	18.3	75.4	18
" "	13 to 14	10	13.8	14.5	18.3	80.0	14
" "	14 to 15	11	14.7	15.5	19.3	80.3	17
" "	15 to 16	15	15.8	16.6	19.7	84.3	14
" "	16 to 17	11	16.5	17.4	20.4	85.3	16
" "	17 to 18	13	17.6	18.5	21.7	85.2	14
" "	18 to 19	3	18.5	19.5	22.7	85.9	13
Vilmorin Improved.....	11 to 12	3	11.7	12.3	16.4	75.0	16
" "	12 to 13	5	12.8	13.5	17.6	76.7	24
" "	13 to 14	9	13.8	14.5	17.6	82.4	19
" "	14 to 15	8	14.8	15.6	18.8	83.0	16
" "	15 to 16	17	15.6	16.4	20.0	82.0	16
" "	16 to 17	9	16.6	17.5	20.0	87.5	15
" "	17 to 18	6	17.8	18.7	21.9	85.4	18
" "	18 to 19	2	18.6	19.6	23.4	83.8	24

SUMMARY.

Klein Wanzlebener	78	15.3	16.1	19.6	82.2	15½
Vilmorin Improved	59	15.3	16.1	19.4	83.0	17½
Average of all		15.3	16.1	19.5	82.5	16½

Below we present general averages of some of our results giving figures for several different counties. While these results are of interest, they possess little real value so far as they represent general conditions, because we have received too few samples from most counties to afford any fair basis for comparison. Readers are carefully cautioned against drawing any sweeping conclusions from the results presented in this manner.

RESULTS OF ANALYSES OF SUGAR BEETS GROWN IN DIFFERENT
COUNTIES.

County.	Amount of sugar in beet.	Amount of sugar in juice.	Co-efficient of purity.
	<i>Per cent.</i>	<i>Per cent.</i>	
Albany.....	16.2	17.1	81
Broome.....	14.3	15	81.1
Cayuga....	12.9	13.6	74
Chautauqua.....	14.7	15.5	82.4
Clinton.....	15.7	16.5	80.5
Columbia.....	16	16.8	82
Cortland.....	14.4	15.2	79.6
Erie.....	15.5	16.3	82.3
Genesee.....	14.1	14.8	79.2
Lewis.....	14.8	15.6	83.8
Madison.....	15.7	16.5	82.5
Monroe.....	15.2	16	86.5
Oneida.....	15.4	16.2	83.5
Ontario.....	15.5	16.3	82.3
Orleans.....	14.6	15.4	84.2
Oswego.....	14.3	15.1	87.3
Otsego.....	16.3	17.2	86.9
St. Lawrence.....	16.1	17	84.2
Wyoming.....	14.7	15.5	81.6

A few results are not inserted in the foregoing tables, because the beets were considerably dried when received and the results were unduly high and misleading.

From these data it would appear that in making estimates farmers would be wisely conservative in basing their calculations upon beets containing an average not exceeding 15 per cent of sugar. Disappointment will await most of those who, never having grown sugar beets, expect profits from the industry based upon figures that are much above the average actually obtained. It must also be kept in mind that the season of 1897 in New York was most favorable for beet growing and the results secured probably represent conditions better than average.

The average percentage of sugar in beets, as reported in other states, is as follows :

AVERAGE PERCENTAGE OF SUGAR IN BEETS GROWN IN DIFFERENT STATES.

States.	Sugar.	
	In beets.	In juice.
	<i>Per cent.</i>	<i>Per cent.</i>
California, average for 5 years.....	14.2	14.9
Utah, " " " "	12.2	12.8
Nebraska, " " " "	12.8	13.5
Oregon,	14.2	14.9
Washington,	14.0	14.7
Wisconsin,	11.8	12.4

CONDITIONS INFLUENCING AMOUNT OF SUGAR IN BEETS.

Numerous conditions exercise a marked influence upon the development of sugar in beets. Among the most important, we may mention the following :

- | | |
|---------------------|-------------------------------------|
| 1. Climate. | 5. Soil. |
| 2. Variety of beet. | 6. Methods of cultivation. |
| 3. Quality of seed. | 7. Size. |
| 4. Plant-food. | 8. Time of planting and harvesting. |

I. CLIMATE.

Temperature.—According to extended experience, it has been shown that the highest amount of beet sugar is commonly obtained in places whose mean summer temperature is about 70°F.

Rainfall.—The amount of rainfall most favorable to the development of sugar in beets is from two to four inches a month during the summer. Midsummer drought works injury to the development of sugar beets. Rains after the crop has matured and before it is harvested may start a new growth of the beets, by which the percentage of sugar is materially lowered.

Sunshine.—An abundance of sunshine also is essential to the largest development of sugar in beets.

Most of the tillable portions of New York practically fulfill the climatic conditions required for a satisfactory development of sugar in beets.

2. VARIETY OF BEET.

The amount of sugar present in a beet varies, to some extent, with the variety of beet grown. Taking standard varieties, we find greater differences in the sugar content of the same variety grown under different conditions than we do of different varieties grown under uniform conditions. The varieties most commonly grown the past year in this state have been Vilmorin Improved and Klein Wanzlebener. Several other varieties have been grown at this Station. We give below a tabulated statement showing the per cent of sugar contained in different varieties of beets grown during the season of 1897.

SUGAR IN DIFFERENT VARIETIES OF BEET.

Variety.	Average amount of sugar in beet.
	Per cent.
Klein Wanzlebener.....	15.3
Vilmorin Improved.....	15.3
Klein Wanzlebener (grown at Geneva).....	15.7
Vilmorin Improved (grown at Geneva).....	15.5
Demesmay (grown at Geneva).....	12.2
Vilmorin Elite (grown at Geneva).....	14.5
Vilmorin's La Plueriche (grown at Geneva).....	16.6

3. QUALITY OF SEED.

The importance of using only highly bred seed cannot be over-estimated. In Europe the production of sugar-beet seed has become a separate branch of industry. Carefully selected and tested beets containing from 16 to 18 per cent of sugar and of high purity are used for this purpose.

4. PLANT FOOD.

Kinds and amounts.—It is safe to assume that sugar beets cannot be successfully grown on many farms in this state for any considerable length of time without the application of plant-food. Analyses of sugar-beet roots show quite a wide range of variation in respect to fertilizing constituents, as may be roughly indicated in the subjoined table:

FERTILIZER CONSTITUENTS IN SUGAR BEETS.

Constituents.	Pounds in 2,000 pounds of sugar beets.	
	Variation.	Average.
Nitrogen	3 to 5 pounds	4 pounds
Phosphoric acid	1 to 3 "	2 "
Potash.....	6 to 8 "	7 "
Lime.....	1 to 1½ "	1¼ "
Magnesia.....	1 to 1½ "	1¼ "

In basing upon the preceding average the composition of a fertilizer to be used in growing sugar beets, one may plan to use approximately the amount of nitrogen indicated, considerably more phosphoric acid than the analysis gives and a little more potash than is shown by analysis. As a rule, most of our soils contain enough lime and magnesia. As a general guide, we can suggest for use in fertilizing sugar-beet crops a mixture containing

Nitrogen	4 per cent.
Available phosphoric acid.....	6 "
Potash.....	9 "

One hundred pounds of a fertilizer having this composition would supply plant-food needed for the growth of one ton of marketable beet roots. It is probable that in most cases the application of 1,000 pounds of such a fertilizer on each acre of land would satisfactorily maintain fertility, assuming that the soil was supplied with some available plant-food at the start. With large yields of beets, more than 1,000 pounds of such a fertilizer might be required ultimately.

The foregoing estimates are based upon the supposition that all portions of the crop are returned to the soil, except the roots sold to the sugar factory. If the leaves and crowns are not left for the soil, the amount of fertilizer to be applied will need to be increased considerably, since these parts are much richer in plant-food materials than the marketable roots.

Available sources of plant-food.—Stable-manure, well rotted, has been extensively used with good results. It should be used with caution, however, as will be indicated later. It must be remembered also that the exclusive and continuous use of rich

stable-manure may ultimately result in a one-sided nitrogenous fertilization and a gradual exhaustion of phosphoric acid and potash from the soil. Nitrogen can be supplied by stable-manure, nitrate of soda, sulphate of ammonia, fish-scrap, cottonseed meal, bone meal, or slaughter-house refuse, such as dried blood and tankage. Phosphoric acid can be furnished in the form of acid phosphate, bone meal, dissolved bone, etc. Potash can be supplied in any of the forms common in commerce and also by means of the molasses residue of beet-sugar factories. When lime is known to be needed, it can be supplied in the form of quicklime, land-plaster, ground shells, etc. Magnesia, when needed, can be furnished by the press-cake of sugar factories or in the form of German double sulphate of potash and magnesia.

Mixtures of plant-food.—The following mixtures of high-grade materials are offered as suggestions or illustrations of what could be used, the amounts given being for one acre of land :

MIXTURE NO. 1.	MIXTURE NO. 2.
Nitrate of soda..... 60 pounds.	Bone meal..... 500 pounds.
Dried blood..... 200 "	Sulphate of ammonia... 100 "
Fish-scrap..... 150 "	Sulphate or muriate of
Acid phosphate..... 400 "	potash..... 180 "
Sulphate or muriate of potash. 180 "	Acid phosphate..... 100 "

MIXTURE NO. 3.

Stable manure, well-rotted, 8,000 pounds or more applied to the crop preceding the beets, supplemented by Bone-meal, 500 pounds, (or Acid phosphate, 300 pounds), and Sulphate or muriate of potash, 180 pounds.

The phosphoric acid and potash can be applied to the soil at the time of putting in the beet crop.

The cost of these mixtures will probably average from \$10 to \$15 for 1,000 pounds. In purchasing plant-food materials farmers must be governed by the market conditions prevailing at the time of purchase and by other economical considerations.

Special suggestions.—(1) Time of application. Stable-manure and other similar materials are best applied to the crop preceding the beet crop. Readily available forms of plant-food can be applied to the soil when the crop is put in or just before.

(2) Precautions. Excessive application of stable-manure or other nitrogenous materials should be avoided, in order to secure

beets of good quality. Well-rotted is preferable to fresh stable-manure.

(3) Rotation. Beets will, as a rule, give best results in respect to sugar, when grown in rotation with other crops. It is wise not to grow more than two crops in succession on the same soil. A plan of rotation suggested by Dr. Wiley is wheat, beets and clover, one crop of which is cut for hay and the second crop turned under, this to be followed by potatoes, wheat and beets. Beets do best after some cereal.

5. SOIL.

As a rule, good sugar beets can be grown on any soil which will produce a satisfactory crop of wheat, corn or potatoes. Fairly level soil, well drained, is essential for best results.

6. METHODS OF CULTIVATION.

Of the conditions under the farmer's control, requisite to success in growing sugar beets of high quality, there is none of greater importance than the methods employed in preparing and cultivating the soil. Plowing should be done in the late autumn to the depth of not less than 9 inches. A subsoiler should follow the plow, loosening the soil 6 or 7 inches deeper, thus giving a total depth of 15 inches or more. In the spring only the surface needs preparation, and this should be put in very fine tilth immediately before planting. The thinning should be done promptly when four leaves show.

During 6 to 8 weeks of the growing season, the soil should be cultivated once a week at least and in dry seasons more frequently. There is probably none of our common crops which is more exacting than the sugar beet in its demands for careful, prompt and regular attention, if satisfactory results are to be realized.

7. SIZE OF BEETS.

Large beets are inferior for sugar production. The size yielding most sugar weighs from one to two pounds, though factories do not usually reject beets weighing as much as three pounds. The beets which have come under our observation have varied in

weight from seven ounces to three pounds and twelve ounces, the average being a fraction of an ounce over one pound.

8. TIME OF PLANTING AND HARVESTING.

The main consideration to be kept in mind in this State in respect to time of planting sugar beets, is to allow sufficient time for complete maturing. Taking our seasons as they average, the planting can usually be done in May. In planting later than June 1, much risk is incurred in reference to the proper ripening of the crop.

Before harvesting the beets should ripen completely, since immature beets contain less sugar than the ripe ones. At maturity the leaves turn yellowish green and the outer ones bend down about the beet. It requires about 150 days for a crop to develop its highest sugar content, varying, of course, with the character of the season. Harvesting must take place before the second growth commences, since this decreases the amount of sugar.

II. PURITY OF SOLIDS IN JUICE.

While the percentage of sugar contained in a beet is highly important, it is not the only factor that determines the quality of the beet. The *purity* of the solids in the sugar-beet juice must be considered also. Beet juice contains besides sugar other substances in solution. To illustrate, the juice of a certain sample of sugar beets contains 12.8 per cent of sugar and 18.2 per cent of total solids, including sugar and other materials. This leaves 5.4 per cent of solids not sugar. Having the per cent of sugar and the per cent of total solids, how do we state the purity of the juice? We divide the per cent of sugar (12.8) by the per cent of total solids (18.2) and the product, expressed in parts per hundred, is 70; and this we call the "Coefficient of Purity," which may be defined as the proportion or percentage which the sugar constitutes of the total solids in the juice. Thus, in the illustration given, of 100 parts of total solids in juice, the sugar forms 70 parts.

Why is the coefficient of purity regarded as an important element in determining the quality of sugar beets? Because the portion which is not sugar prevents complete crystallization and

recovery of the sugar in the process of manufacture. Experience has shown that for each pound of non-sugar solids, one pound of sugar is not recovered from the juice. In the illustration used above, we have in 100 pounds of juice 12.8 pounds of sugar and 5.4 pounds of non-sugar solids. Then, in this case, we should expect to recover only 7.4 pounds of sugar from the 12.8 pounds present in the juice.

To give another illustration, 100 pounds of juice contains 17.3 pounds of sugar and 19.8 pounds of total solids. The coefficient of purity is 87.5 and the amount of non-sugar solids is 2.5 pounds. From 100 pounds of such juice, 14.8 pounds of sugar could be recovered.

As a rule, sugar is recovered to the extent of 70 pounds for 100 pounds of sugar in the beet root.

From the preceding statements, the importance of the purity of beet juice can be appreciated as an element in determining the practical value of sugar beets for sugar production.

The tabulated statement on page 549 shows the results obtained by us in our season's work.

CONDITIONS INFLUENCING COEFFICIENT OF PURITY.

Most of the conditions which affect the percentage of sugar contained in beets also influence the coefficient of purity. Among conditions specially to be mentioned are the following :

1. Maturity.
2. Fertilizers.
3. Size.
4. Portion of root.

1. MATURITY.

Unripe beets contain a large proportion of non-sugar solid and hence a lower coefficient of purity than ripe beets. Such beets have, therefore, a smaller proportion of sugar that can be recovered.

2. FERTILIZERS.

The excessive application of stable-manure or other nitrogenous fertilizers lowers the coefficient of purity. Soils containing a large amount of organic matter, like drained swamp lands,

and recently cleared forest lands, produce beets having a low coefficient of purity.

3. SIZE.

The size of beets is often closely associated with the amount of nitrogenous plant-food employed. Excessive use of such manures tends to produce a rapid, rank growth of beets, large in size but poor in quality, especially in respect to coefficient of purity. Too great distance between roots in soil also tends to promote growth in size at the expense of quality.

4. PORTION OF ROOT.

The neck or crown of the beet root contains large amounts of non sugar solids. The entire portion of the beet growing above ground is rich in those solids producing low coefficient of purity. It is, therefore, important to have the root grow above ground as little as possible.

III. YIELD OF BEETS.

A very important element to be considered by the farmer who plans to raise sugar beets is the yield. However high in quality sugar beets may be, it is necessary to secure a good yield of roots, in order to realize satisfactory money returns. Reliable data appear to indicate that we may regard 20 tons of marketable sugar beets of high quality as the largest yield an acre that can be realized in commercial operations. Yields are often reported exceeding 25 and 30 tons an acre, but such returns are open to suspicion, so far as they represent commercial conditions. Misleading yields are often obtained by weighing and counting the beets covering a definite small area and basing the estimate for an acre on the data so obtained. Another method employed in figuring out large yields is to obtain the average weight of a few beets and then assume that an acre contains forty thousand beets, each having the same weight as the average obtained. Moreover reports of yields are often based on results secured in growing a fraction of an acre of beets under conditions which are more favorable than those met in working with several acres.

To obtain the fairest idea of yield under commercial conditions,

we can do no better than to study the results furnished by actual operations where sugar beets have been successfully grown for a period of years on a commercial scale. Below we present results reported by the sugar-beet factory at Lehi, near Salt Lake City, Utah, and by the Chino Valley Beet Sugar Company, in Southern California, and also some data derived from German sources.

YIELD OF MARKETABLE BEETS GROWN ON ONE ACRE.

Reports given by	1891.	1892.	1893.	1894.	1895.	Average.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Factory at Lehi, Utah	6.6	6.5	9.7	11.47	11.54	9.16
Chino Factory, Southern California	7.26	7.5	11.7	9.16	11.03	9.33
German factories	12.8	11.2	11.0	13.0	12.4	12.1

There is no reason to believe that the average New York farmer will secure results largely in excess of those reported above. If an average yield of 10 tons an acre can be secured at the start, our farmers will realize larger returns than did those of California and Utah during the first years of their experience. The table above is encouraging in that it shows steady progress on the part of the farmers in securing larger yields. The commercial experience of others should impress our farmers that they are not to expect exceptionally large returns the first year, for this is likely, in the very nature of the case, to prove the poorest in yield; but acquired experience should bring with each year an increased yield. During the past season we secured a yield of 15.1 tons of marketable beet roots an acre on the Station farm.

Those factors which influence the quality of the sugar beet also affect the yield more or less, among which are the variety of beets grown, quality of seed, distance between plants, soil, cultivation, season, etc.

In this connection may be considered the amount of pure sugar produced an acre. Using the same sources of information as those given above, we have the following table:

YIELD OF PURE SUGAR FROM SUGAR BEETS GROWN ON ONE ACRE.

Reports given by	1891.	1892.	1893.	1894.	1895.	Average.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Factory at Lehi, Utah	1162	1227	1719	2336	2539	1797
Chino Factory, Southern California	1510	1680	2621	2198	2670	2136
German factories.			3276	3149	3514	3313

It is a matter of much interest to note that the yield of sugar an acre increased quite rapidly from year to year in the Utah and California factories. This was due not only to an increase in yield of beets but to an increase in the per cent of sugar and coefficient of purity.

Taking the averages obtained by our analyses and assuming the average yield of marketable beet roots to be 10 tons an acre, we estimate that, under these conditions, there would be a yield of about 2,400 pounds of commercial sugar.

IV. COST OF RAISING AND TRANSPORTING CROP.

Numerous factors enter into the cost of raising sugar beets and these will vary in different places. Among such factors may be mentioned the value of land, the cost of labor, and the extent to which hand labor and machine labor are employed. Some of the details of this subject are discussed on page 571, where data are given derived from actual experience in raising beets on the station farm. It may be regarded as a conservative estimate to place the price at which beets can be grown in New York under favorable conditions between the limits of \$40 and \$50 an acre.

The cost of transporting the crop from the farm to the factory must also be considered. The accessibility of a factory is a primary condition which will by itself determine the practicability of raising sugar beets. The cost of transportation is an item which must be calculated by each farmer for the conditions existing in his particular case.

V. MARKET PRICE AND PROFITS.

Provided a factory is accessible, there is a good degree of certainty that for years to come there will be a sure market for all the beets raised. It can not be foreseen definitely what unexpected conditions may arise to affect seriously the price to be paid for beets, but good beets ought to bring the farmer not less than \$4 a ton and from this up to \$5. In general, a profit of \$5 to \$10 an acre above all expenses may be regarded as a fair return from the crop.

VI. GENERAL CONSIDERATIONS.

The sugar-beet crop is to be regarded as an additional one, to which a farmer, properly located, may give a portion of his time. It is not intended to take the place of other crops which one knows can be successfully grown. In commencing farmers will be wise to limit their crop to one or two acres and increase it only as they see their way clear to do so.

The educational value to be derived from growing sugar beets properly can hardly be overestimated. The exacting demands of its successful culture require the best kind of farming. It is reasonable to assume that a farmer who grows sugar beets well will be likely to grow his other crops better than he did before raising beets.

In addition, it is to be remembered that the soil on which a crop of sugar beets has been grown is left in better mechanical condition than by other crops and that it is in better condition for growing other crops.

PART II.—THE OUTLOOK FOR THE SUGAR BEET INDUSTRY.*

W. H. JORDAN.

The forecasting of the future of any new industrial enterprise is a difficult matter. This is so because the conditions affecting production, manufacture, competition and market prices, which are sure to prevail for any length of time, cannot be definitely known; and the discussion now going on throughout the entire State of New York relative to the establishment of beet sugar factories in our midst deals with the usual number of indefinite factors.

The situation is such, however, that all who attempt to influence the public opinion should take a conservative position in this matter, one that will be justified by future events.

There are some facts which are regarded as favorable to a successful production of beet sugar. The experience which has been gained in the season of 1897 certainly indicates that our soils and climate are favorable to the growth of beets which are satisfactory in quantity and quality. Of course figures in great variety have been reported from a large number of experimental plats, varying from very low yields to those which are suspiciously high. The experience on the Station farm this year in the culture of two acres of beets indicates that by proper methods the best farmers may possibly produce in favorable seasons from 15 to 18 tons of high grade beets. The average crop will doubtless be considerably below this. It must be confessed, however, that one season's experience is not enough upon which to base final conclusions.

It is unquestionably true that the cultivated lands of central and western New York are capable of a high rate of production of almost anything which is adapted to the conditions there prevailing. These lands, managed by intelligent farmers, may compete with any in the United States, and this is entirely favorable to success in growing sugar beets, after it is established that the conditions are suitable to this crop.

* A reprint, largely, from an article in the *Country Gentleman*, Dec. 30, 1897.

The capacity of the American farmer is cited as an evidence of his probable success in whatever he undertakes. This is, certainly, a strong argument. In intelligence, industry and capacity to master the details of new methods, even expert methods, he is not excelled by the farmers of any civilized country. We may expect, moreover, that the inventive genius of American manufacturers will meet the farmer half way in providing the implements necessary to cheap culture.

The enthusiastic advocate of this new enterprise claims the certainty of an unlimited market for the sugar. It is true that we now buy from eighty to a hundred million dollars' worth of beet sugar from France, Germany and other countries, and so long as a protective tariff places the foreign producer at a disadvantage, we may reasonably expect to be able to sell at fair prices all the sugar we can produce for some time to come. Regarded with reference to the immediate future, this argument appears to have weight. The doubt here lies with the continuation of existing conditions.

It will be an undoubted gain, too, if we can add another cash crop to those which we already regard as yielding fair returns for the labor expended and a moderate rental for the land. Crops which find a steady sale at living prices are needed by the American farmer. Every new, successful crop also tends to prevent overproduction along other lines.

There are many facts to be considered on the other side of this question, which, while not necessarily arguments against an attempt to produce and manufacture beet sugar in this State, nevertheless are worthy of the most careful attention.

In the first place, the sugar beet is a highly bred plant, sensitive, so far as content of sugar is concerned, to the conditions under which it is grown. The farmers who cultivate it successfully must be those who are willing to adhere faithfully to definite, careful methods. This does not mean that a minority of our farmers will not succeed, but that the average results are almost sure for a time to be disappointing, and it is average results which will determine the success of the business when broadly considered. Beet-sugar factories cannot be maintained unless the average experience of farmers in the growth of this crop is satisfactory.

We are greatly elated over the high percentages of sugar which have been found in New York beets this season, but we must bear in mind that high quality and a large production, as some regard production, are not consistent.

Some samples which have been sent to this Station for analysis have been accompanied by a statement that the crop of beets produced was at the rate of thirty tons per acre. It is probable, either that the method of estimating these crops was not a safe one, or that the beets were not properly grown. Erroneous and greatly excessive figures are very likely to result from computations based upon the theoretical possibility of growing a certain number of a certain size of beets per acre, or from the weight of a short section of a row of beets. Nothing short of the weighing of the entire actual product from a fairly extensive area will give safe figures.

The yield this year on the Station farm from a two-acre field was at the rate of sixteen and a quarter tons per acre, which quantity, after cutting off the top of the beet in the manner required at the factory, and making due allowance for dirt, was considerably reduced. This field of beets was on some of the best land the experiment station farm contains, and was given thorough cultivation and the best of care. The sugar content in this crop was very satisfactory.

It is significant that during the past five years the average production in Belgium, and also in Germany, has varied from about eleven to approximately thirteen and a half tons per acre. To be sure these are averages, and while averages are not measure of a what the best farmers may do, they are the standards by which, as before stated, the success of a business must be gauged. We should not expect the American farmer to do much better than the European farmer, where this industry has for a long time existed, especially at first. New York farmers, if they enter upon the production of sugar beets, will have occasion to congratulate themselves, if, for the first two or three years they reach an average of twelve tons of high grade product per acre. This is not necessarily a condemnation of the business.

We must remember still further that it is necessary for the farmer and the manufacturer to be mutually prosperous, and there

certainly are some facts which seem to warrant careful consideration, by the farmer, of the manufacturer's side of the business.

There is great danger that much of the capital which is likely to be invested in this new enterprise will be inefficiently directed. The manufacture of beet sugar is something with which eastern business men have had no experience, and no careful study of means and methods will take the place of the knowledge which comes from experience. Disasters to capital which may cause losses to farmers are to be feared. It behooves business men therefore, to proceed with the erection of beet-sugar factories with great caution and only after the most exhaustive study of the problems involved.

Doubtless farmers will be invited to invest in beet-sugar factory stock. They will be told not only that the stock will be profitable, but also that it is their duty to share in the risks. They should be very careful in this matter. If the professional boomer appears among them, they should give him a wide berth. He may be resourceful in plausible argument, and it may be hard to resist the fascination of his apparently sound reasoning; but unless the farmers resist his appeals, history will repeat itself, and shares of worthless stock will be very widely distributed among those who cannot afford to suffer the loss. This does not mean that under certain other conditions farmers may not wisely own a share of the factory. If local business men of unquestioned integrity and sound business judgment take the lead in the new enterprise—men who as the directors of banks and other financial organizations have won the confidence of the community by their successful and honorable methods—then perhaps the farmer may as safely entrust his money to them in this enterprise as in some others.

In discussing this matter we should ignore neither home nor foreign competition. The immense factory which Spreckels is erecting in the West to be sustained from cheap western fertility, is a significant beginning. Certainly if beet-sugar production and manufacture are at first unusually profitable we may expect to see this industry rapidly develop to a condition of the usual competition.

Prof. Brooks, of Massachusetts, has recently pointed out the fact that we can hardly compete with the lower wages paid in for-

eign countries, but he failed to note that the necessary fuel and limestone are much cheaper in the United States than in France and Germany. Probably European producers will have no advantage over us so long as we have a protective tariff, but we know how strong a sentiment there is in this country in favor of free sugar, and political revolutions are likely to make changes in the tariff conditions affecting this commodity. It seems probable, though, that the existence of a new industry in the early stages of successful development might modify or prevent legislation that would otherwise take place.

There is, however, a law of compensation operating in the world's industries to which we must give proper weight. We cannot safely leave out of account the rest of the world in estimating what may be done through a period of years along any line of production. It is a narrow view which only discovers that we are not producing our own sugar.

What conclusions, then, shall we draw from all these facts and conditions? It seems very probable that farmers will not realize unusual profits for any extended period of time from sugar-beet growing. The facts appear to justify the belief, however, that this crop may come to rank among those which for some time will be regarded as giving satisfactory returns. It will be a business of moderate profits and one that will not spring into uninterrupted success. If it is a success at all, it will become so by growth through education and experience. Above all, the manufacturer must guard the interests of the farmer, and the farmer must be able to have confidence in the manufacturer, and both must have a patient faith in the final triumph of intelligent means and reliable, conservative methods of management.

PART III.—THE STATION EXPERIMENTS WITH SUGAR BEETS.*

G. W. CHURCHILL.

The field selected for the experiment with sugar beets is a clay loam bordering on what is usually termed heavy, having a tendency to "puddle" when overcharged with moisture, and to cake or crust over when quickly dried by a hot sun and wind. If not disturbed in times of drought it will soon seam or crack open.

These features are characteristic of a large portion of the farm lands of this section and render the growing of small seed crops more difficult and expensive than on sandy or porous loams.

From a farmer's point of view, this soil would be considered to be in a good state of cultivation and fertility. The crops in the rotation that have been grown on it during the past ten years have yielded fully up to, if not above, the average of the farm lands in this section of the State.

The two acre plat which was selected had been used for fertilizer experiments with potatoes in 1896.

On May 7 and 8 the land was plowed and subsoiled to the depth of fourteen inches, and the surface was worked down with springtooth harrow followed by a Thomas smoothing harrow, and finished by rolling.

On May 11, after working down with the springtooth harrows, and before smoothing, 950 pounds per acre of the following mixture of commercial fertilizers was sown broadcast :

Sulphate of potash.....	250 lbs.	50 per cent	K ₂ O
Acid rock.....	300 "	14 "	P ₂ O ₅
Dried blood.....	200 "	10 "	N.
Nitrate of soda.....	200 "	15 "	N.
Total.....	950 "		

After the fertilizer had been sown and thoroughly worked in, the ground was smoothed and rolled. A marker to be drawn by one horse was then constructed from an old corn marker so that five rows could be lined out at one time, at a distance of twenty inches apart.

The teeth were fitted at the bottom with shoes about eighteen inches in length and three inches deep made from one and one-half inch plank. These were fastened by cutting a notch out of the bottom of the tooth one and one-half inches wide and about three inches deep. Holes were bored through the teeth at right angles to the shoes. Bolts passing through these holes and a corresponding hole in the shoe fastened the latter and the tooth together. The first plan for having the shoes work freely on the bolts as pivots was modified by nailing beveled blocks on the back of the teeth just above the shoes making them stationary. The difficulty encountered in the loose shoe was that when any resistance was met by the forward part, it would tip down and in digging into the soil raise the rear end out of the ground, thus throwing the whole marker out of line. After this change the marker, though crude, worked to our entire satisfaction, making a mark about one inch deep and two inches wide, which could be followed with ease by the seeder.

After seeding six rows an unexpected and very heavy shower of rain so saturated the ground that it was impossible to continue the work until May 17.

It was a mistake to completely fit the entire plat before commencing to sow the seed, for we were obliged to again harrow and roll the ground before seeding could be resumed. The only safe way is to prepare the ground as needed, thus avoiding the extra expense of re-working after every rainfall.

Another mistake was made which was a source of annoyance throughout the season. Because of haste to complete the seeding as soon as possible the small stones scattered over the plat were not picked. While these did not affect the growth of the beets they were a hindrance in seeding, and, later, in the cultivation of the crop. It would have been economy in the end if they had been removed. Any obstruction in the way of the seeder will give it a jerky motion which will bunch the seed. The motion should be smooth and continuous in order to allow an even distribution of seed. Later the stones interfered with hand and horse cultivation and more or less with hoeing and thinning the beets.

The seed was sown with an "Improved Model" Mathews hand

drill. It was found that by attaching the ends of a rope to the seeder, and fastening a short strap to this, making a device similar to a "breast collar" used in single harness, that two men, one to draw and the other to push and guide the seeder, could accomplish more than double the work of one man alone, and with greater ease and efficiency. Doubtless seeders will be used that will sow several rows at one time.

With the exception of six rows sown at an earlier date, two men sowed the two acre plat in eight hours. The only fault that could be found with the seeding was the bunching of the seed in places where small stones or clods were encountered by the drill, causing it to slacken motion or to stop altogether. When this happened several seeds were dropped within a very small compass and before the seed commenced flowing again the machine had moved along leaving a space without any seed.

Fifteen pounds of seed was sown to the acre. The ground was moist and in good condition for promoting quick germination, and vegetation commenced in about ten days from the time of seeding. About June 1 the plants were large enough for the rows to be easily distinguished and the hand cultivator was started, the machine used being a "Buckley" having several combinations of blades.

The arrangement that was found to work to the best advantage at this time was a broad V shaped blade set in the center of the frame in front and two smaller ones set on the right and left sides of the frame well to the rear of the machine. These latter are flat pieces of steel sharpened on the edges, and made to form a right-angle turned so that the points extend toward the center of the row, and as they are about eight inches in length they nearly meet in the middle forming what is commonly termed a "scarifier." One advantage of this form of blade is that the crust can be broken very near to the young plants without throwing the dirt over them. Soon after this cultivation, hoeing and the first or partial thinning were commenced. For the work of partial thinning the blades of ordinary hoes were cut down to four inches. By cutting across the row with such a hoe, bunches were left which could be thinned leaving plants from six to nine inches apart. At the same time the soil was loosened around the plants and all of the weeds removed.

On June 15 the beets were cultivated with a one-horse Syracuse harrow tooth cultivator, and the final thinning commenced.

It was intended to have the beets left eight inches apart in the rows. It was found necessary in some cases, however, to vary these distances on account of the spaces left by the seeder, and in order to preserve the strongest plants.

After the final thinning the beets received another cultivation to loosen the ground, as it had become more or less compacted by rain and the passing of the men while thinning. After this but one more cultivation with the horse cultivator was given, for the beet tops covered the ground to such an extent that a horse could not pass through without doing serious damage. The subsequent hand labor was small and would not have been considered necessary by many growers, but in order to adhere to strictly clean culture, men were sent through the field once to pull the weeds that had escaped previous cultivation. This consumed less than one day's time for two men, and at the time of harvesting the crop the field was entirely clear of weeds.

The harvesting of the beets began on September 22. Two methods were tried ; first plowing three furrows for each row, the third furrow turning out the beets, and plowing two furrows for each row, after which the beets were pulled by hand. The last named method seems preferable where the beets do not have too long tap roots, because in the first method the small beets are covered by the furrow and it is more work to uncover them by hand than it is to pull them out when they are standing upright and in plain sight.

As the beets were pulled out they were thrown in heaps, and men followed and cut off the tops. The harvesting, which includes pulling, topping and hauling, was found to be the most expensive operation connected with the growing of this crop.

It should be borne in mind that the very best of culture was given throughout the season and no expense spared in either hand or team labor, and that a liberal allowance has been made in all cases wherever estimates were necessary. Some mistakes were also made which were costly, and which can be avoided in the future. On the whole, therefore it is probable that these figures err on the side of too great cost, and that with the

experience gained in this season's work, we can cheapen the cost of growing an acre of beets quite materially.

In the table below we give the cost of growing one acre of sugar beets, based on hand labor at \$1.25 per day for hoeing and thinning, and team at \$3.50 per day ; and on hand labor at \$0.75 and team at \$3.00:

COST PER ACRE OF GROWING SUGAR BEETS.

	Expensive labor.	Cheap labor.
Fitting ground.....	\$7.00	\$6.00
Sowing fertilizer.....	1.12	1.12
Sowing seed.....	1.25	1.25
Hoeing, thinning and weeding.	23.43	13.88
Harvesting	24.25	14.80
Horse cultivation.....	2.00	2.00
Hand cultivation.....	3.75	2.25
Seed.....	3.00	3.00
Fertilizer.....	10.00	10.00
Total.....	\$75.80	\$54.30

Doubtless these figures will be criticised on the ground that they are too high, but it is probable that, if careful accounts were kept by one hundred farmers of the cost of everything connected with the growing and delivery to the factory of one acre of properly grown sugar beets, the average would not fall below \$50.00, with the present methods and machinery at the command of the grower.

The yield per acre, as harvested, was 32,548 lbs., or approximately $16\frac{1}{4}$ tons.

In order to determine the actual yield of perfectly clean beets, topped as they would be when sent to the factory, a lot weighing 1,000 lbs. was thoroughly washed and dried after which the crowns were removed.

Weight of beets taken.....	1,000 lbs.
Loss by washing	49 "
Weight of crowns	73 "

Weight of washed beets without crowns 878 lbs.

At this rate the yield of topped, washed beets was 14 tons 577 lbs.; of topped, unwashed beets 15 tons 200 lbs. At \$4 per ton the returns per acre would not be over \$60.

The shape of these beets was very satisfactory. With but few

exceptions, they were symmetrical and sent down a tap root to a good depth.

The average size was rather small, being not over three-fourths of a pound. This was the result of close planting, as the average distance between the beets was probably less than eight inches. The beets grew wholly in the ground, no special precautions being necessary to secure this result excepting the subsoiling. A careful chemical examination of these beets gave the following results:

Sugar in beets	15.2 per cent.
Sugar in juice	16 "
Coefficient of purity	81

According to these figures about 12 lbs. of sugar could actually be made from 100 lbs. of washed, topped beets. This shows that the yield of manufactured sugar from the Station farm would be 3,429 lbs. per acre.

An observation was made on the value of an application of commercial fertilizer in sugar beet growing. The plat from which the two acres of ground was measured for the experiment recorded contained an additional area of four-fifteenths of an acre. This ground was prepared with the two acre plot and received the same treatment, except that it was not fertilized in any way. The seed was sown at the same time and the crop recieved the same treatment, only that it was the last to be reached in thinning. From the start a marked difference was noticed in favor of the fertilized plants. The young plants did not vegetate so quickly on the unfertilized plat, and afterwards they were not so vigorous as on the fertilized area.

The yield of beets on the unfertilized portion of the field was between $7\frac{1}{2}$ and 8 tons per acre, which shows that the fertilizer caused an increase of at least 6 tons of beets. At four dollars per ton this increase would pay for at least twice the amount of fertilizer used.