REPORT

ON THE

PRODUCTION of BEET SUGAR

AS AN

AGRICULTURAL ENTERPRISE IN MASSACHUSETTS.

By Prof. CHARLES A. GOESSMANN, Ph. D.

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Among the various saccharine substances, which chemistry at present recognizes, are three of particular interest to the agriculturist, namely, milk sugar, grape sugar, and cane sugar. Milk sugar, which causes the sweetness of milk, is exclusively confined to this peculiar animal secretion, and constitutes in that of different animals from 3 to 9 per cent. Its application in an isolated form is quite limited, and its manufacture carried on mainly by the mountaineers of the Swiss Alps.

Grape sugar or glucose, which gives sweetness to the grape, is the most widely distributed of all saccharine substances. Most of our cultivated fruits derive from it, at least in part, their sweet taste.

It is the only one among the sugars previously enumerated, which we are able to produce by artificial means; its commercial importance, on account of its use for the production of alcohol and alcoholic liquors, as wine, beer, etc., and of sirups, is daily increasing. As our cheaper grains furnish the material, starch, from which grape sugar is mainly manufactured, its increasing production sensibly affects our home consumption of corn.

Cane sugar, which receives its name from its principal source, the sugar cane, is the kind which we commonly employ for household purposes, and is consumed in enormous quantities; while the number of plants which furnish it is quite limited. The sugar-cane, a few species of palm, the sugar-maple, the sorghum cane and the sugar-beet, are the plants which are turned to account for its manufacture. M. D. Dureau, in a report on the World's Exhibition of 1867, mentions that of the whole amount of sugar which has recently entered the various markets, 66.47 per cent is produced from the sugar-cane, 27.87 per cent from the sugar-beet, 4.29 per cent from the palms, and 1.24 per cent from the sugar-maple. The same authority

states that the whole amount of sugar sold in 1867 in the principal markets was 5,140 million pounds, besides eighteen million gallons of sorghum molasses.* The consumption of sugar is steadily increasing among civilized nations; in France it has more than doubled within the last thirty years; in England it has doubled within the last fifteen years, whilst in Germany, its consumption has increased threefold within the same period of time. Numerical statements like those of Dureau, respecting the total production, are therefore not surprising; in fact, if we should allow to the whole population of Europe the same liberal supply of sugar, required by the citizens of the United States (30 pounds per head), the total amount stated would scarcely suffice to meet one-half the demand. More than nine hundred million pounds of various grades of sugar, besides from fifty to sixty million gallons of sirup and molasses from sugar-cane and sorghum have been annually consumed of late, representing a value of nearly one hundred million dollars, of which about seven-tenths are first cost, and three-tenths government taxation.

Home Resources.

The sugar produced in the United States is far less than the amount consumed, leaving a heavy balance for importation. The production of sugar-cane in Louisiana and Texas, it appears from reports of Champonnois and others, never exceeded four hundred and fifty thousand hogsheads, besides twenty thousand gallons of molasses; the maple-sugar production may have reached in favorable years from twenty to twenty-five million pounds; the sorghum plant has thus far yielded, with but a few exceptions, only molasses,† whilst the cultivation of the sugar-beet for the manufacture of sugar, has just begun to attract attention as worthy a more thorough trial in various parts of the country.‡ In presenting the above figures concerning our home production, I have chosen as far as the sugar-cane cultivation is concerned, the results of 1861, the most favorable year on record. Glancing over the early history of the

* The home consumption, particularly in the East Indies, is apparently not estimated, for the home consumption of cane-sugar obtained from palms, is set down as 90,000 tons. (See Hunt's Commercial Review, Vol. 39, Nov., 1858, No. 5.)

† Mr. B. Moore, of Bloomington, Ill., and others, have produced a large quantity of crystallized sorghum-cane sugar.

‡ The first attempt to produce beet-sugar within the United States, is credited to David Lee Child, of Northampton, Mass., who made about 1,300 lbs. of sugar in 1838.

sugar-cane in Louisiana, we find that the large production of sugar, conceded to her above, proves to be based on an exceptionally large crop, and gives by no means a correct idea of her past contribution to our home product. The sugar-cane was first introduced into Louisiana in 1751; M. Dubreuil established the first plantation in 1758; from 1828 to 1843, its average produce per year has been about 82,000 hogsheads (90,000,000 pounds) of sugar, besides five to six million gallons of molasses; from 1844 to 1857, its annual produce averages two hundred and forty-one thousand and eight hundred hogsheads (each 1,100 lbs.), or 265 million pounds of sugar, with about sixteen million gallons of molasses; in 1854, there were one thousand four hundred and eighty-one plantations under cultivation, whilst in 1857, but one thousand two hundred and ninety-nine plantations are reported. The last report (1869) of the National Agricultural Department at Washington, D. C., states on the authority of M. Bouchereau, that one acre yielded during the past year 1,350 pounds of sugar, worth ten cents per pound, besides seventy gallons of molasses, worth sixty cents per gallon; and that improved lands fit for sugar-cane cultivation might be bought for from $25 to $40 per acre.

While the sugar-planters of Louisiana, a few years before the late war, thus apparently struggled to hold their slowly gained ground, we cannot help being struck by the prominent position which the sugar-cane cultivation acquired during the same period of time in the neighboring island of Cuba, which furnished for exportation from eleven to twelve hundred millions of pounds, about one-third of all the sugar that enters the markets of the United States and Europe. Unfavorable legislation with us is frequently cited as a cause of the results in Louisiana. Unsettled conditions regarding leading principles of political economy, no doubt, act most seriously on industrial enterprises, which require time for their healthy development; how much such influence may have interfered here, I do not propose to discuss, but shall confine myself to the exposition of a cause which has much to do with the past results of the Louisiana sugar-cane cultivation. A close examination of the statistics of the annual production of sugar in Louisiana, for over forty years past, leaves scarcely a doubt about the fact,

that unfavorable climatic influences—as early frosts, and the consequent serious limitation of the harvesting season, must have interfered with the most profitable cultivation of the crop.

The fluctuations in the annual produce of sugar during successive years are so large and of so frequent occurrence, that any other assumption can scarcely account for it. Thus we have—

In 1834,	100,000	hogsheads.	
1835,	30,000	"	
1838,	70,000	"	
1839,	115,000	"	
1843,	100,000	"	
1844,	200,000	"	
In 1846,	140,000	hogsheads.	
1851,	236,000	"	
1853,	439,976	"	
1856,	73,976	"	
1860,	228,758	"	
1861,	459,410	"	

To rely on the production of one crop exclusively without abundance of ready capital is hazardous, even in exceptional cases, where the special character of the soil and of the climate, or the peculiar condition of the markets, seem to secure a monopoly, for these conditions are at the present time in the majority of cases but temporary. Wherever large gains are to be secured, competition will sooner or later enter the field. The cane-sugar industry of Louisiana, judging from past experience, cannot stand in unrestricted competition with that of the islands of the West Indies; but a judicious rotation of crops, and the introduction of other sound principles of modern farming, may produce better results in the future.*

Our production of maple-sugar is of little consequence as far as available quantity is concerned, and still less reliable in regard to its annual yield; since an early spring with warm nights may reduce it to a mere trifle. An increase of maple-sugar production is scarcely to be expected, and its chances are daily diminishing. Many of our barren, rocky hillsides might furnish suitable grounds for maple-groves, yet before broad-leafed trees will flourish, it is probably necessary that the exhausted ele-

* The production of sugar from one acre of sugar-cane differs widely, and may be greatly increased, by the adoption of rational modes of cultivation. Upon Reunion 1,056 lbs. sugar are stated to be the annual results per acre, while upon Java, 4,045 lbs. are raised upon the same area. The great success upon Java is ascribed to the adherance to a judicious system of rotation, but one-fifth of the lands under cultivation being planted at one time with sugar-cane, the cane changing its place every two years, and the weeds upon the land being frequently burned, to destroy parasites, etc.

ments of fertility be restored by the growth of one or more generations of pines.

Our production of the sorghum plant, although spreading steadily in some portions of the country, has not yet received that attention in those localities, which, on account of a warm and long season, are particularly qualified to reap the full benefit of its cultivation. In a paper presented to the New York State Agricultural Society at their annual meeting in 1861, and printed in their annual report of that year, I stated the results of a chemical investigation carried out by me in 1857, concerning the fitness of the sorghum cane for the manufacture of sugar and of superior sirups. These statements have been confirmed, as far as its yield of a good quality of sirup is concerned; but the manufacture of sugar has not been tried to any extent, although there is no substantial reason why within some of the Southern States with their favorable climate, a part of its sugar might not be advantageously secured in crystals. A proper defecation of the sorghum juice before its concentration would doubtless accomplish that result. In making these statements here, I do not intend to assert that most of our Northern, and particularly our North-western States can profitably engage in the production of sorghum sugar. Localities liable to early frost and short seasons had better confine themselves, if at all engaged in sorghum cultivation, to the manufacture of sirups, for unripe cane is entirely unfit for the manufacture of crystallized sugar. The Middle and some of the Southern States have apparently not sufficiently appreciated the value of this crop. Associations between neighboring farmers for the purpose of supporting one cane-mill in common, no doubt, would reap handsome profits. Quick working of the ripe cane is essential to success, for there is no practical way as yet proposed, by which the sorghum cane may be preserved unchanged after it has attained its ripeness.

In view of these present conditions and future prospects of existing home resources of one of our most important articles for daily comfort, we must regard it as peculiarly proper that public attention is turning more and more seriously toward the question, whether with intelligent management the production of beet sugar as an industrial enterprise can be profitably undertaken in Massachusetts, as it has been in many countries of

Europe. Having witnessed personally the working of the sugar-cane upon the island of Cuba, and in Louisiana, and being also somewhat acquainted with the beet-sugar industry of Europe, and the treatment of sugar solutions for refining purposes, I do not hesitate to state, that the sugar-beet as a mere sugar producing plant is inferior to sugar-cane; in fact, if it were possible to cultivate advantageously the best sugar-beet alongside of the sugar-cane, bestowing at the same time equal care on the cultivation of both plants, and on the treatment of their juices, they could be scarcely considered rivals. Yet, to-day, the beet-sugar manufacture is looked upon in Europe by agriculturists and by sugar manufacturers as a decided success.* England, even with her great facilities for importation, and her favorable commercial relations with cane-sugar producing countries, is hastening of late to add the beet-sugar manufacture to its home industry. English agriculturists have had for years occasion to notice the highly prosperous condition of the farms in beet-sugar producing districts of Germany, France, and elsewhere; while English capitalists begin to believe in the sound foundation of the new business, when they notice the steady increase of beet-sugar importation into England, amounting in the year 1867 to a value of £1,600-000.

However different the views of the friends of the beet-sugar interest may have been at various times regarding its financial success as a mere industrial enterprise for a cheaper home manufacture of sugar, they all agree at the present day on one point, namely, that in connection with agriculture it has proved to be one of the most important, and at the same time, most successful attempts to stimulate the introduction of sound principles into agricultural pursuits, to develop, consequently, agriculture, and to promote a healthy feeling of a common interest between agriculture and manufactures, between capi-

* The beet-sugar manufacture in Europe amounted in 1859 to 812,113,000 pounds; in 1869 to 1,256,462,300 pounds, of which was produced—

By France,	32 per cent.
German Confederation,	28.5 per cent.
Austria,	11.8 per cent.
Russia,	14.83 per cent.
Belgium,	5.92 per cent.
Poland,	2.81 per cent.
Holland,	0.89 per cent.

tal and labor. Improved farm management and unusual progress in the modes of separating the sugar at a lower cost went hand in hand. European agriculturists have accomplished this thrifty union of mutual industrial and agricultural interests, only by devoting themselves with almost unrivaled perseverance to the task of producing a sugar-beet which contains the largest possible amount of sugar in the most favorable condition for extraction. The solution of the problem, whether beet-sugar manufacture can succeed with us, as a paying enterprise, will prove to depend here, as has been the case in Europe, on the interest which intelligent agriculturists and agricultural chemists will take in raising a suitable sugar-beet; for the quality of the root controls to a large degree the financial success of the industrial enterprise. A mere high percentage of sugar in the beet-root is not the sole requirement, although a most important one, but the production of a beet which contains the largest possible amount of sugar with the smallest possible percentage of foreign substances, whether saline, nitrogenous, or indifferent, non-nitrogenous organic compounds, for practice has established beyond doubt, that for every percentage of foreign admixture, about one and a half per cent of sugar in the juice will be rendered uncrystallizable, and thus converted into a less valuable molasses. It is of the utmost importance that the difficulties to be encountered be well understood, for a temporary check caused by want of proper precaution in producing a suitable beet, or providing the necessary apparatus, or oversight in the general management, would be deplorable, considering the benefits to be gained for agricultural development alone, in case the experiment should succeed. It is then to our intelligent farmers these few pages are addressed, for the purpose of aiding in the dissemination of facts, which have been instrumental in the development of the sugar-beet cultivation and the beet-sugar manufacture. Influenced by such views, I proposed a year ago to enter upon experiments concerning sugar-beet cultivation upon the college farm, and procured a variety of seeds from successful sugar-beet cultivators in Germany, believing that much was gained by having the best to begin with. The first year's crop has been gathered, and the percentage of sugar of each of the thirteen kinds ascertained. Beyond that point no experiments

have been made; for as it was too late to control a proper manuring of the land used, I left the determination of foreign admixtures, which, in quality and quantity are decidedly influenced by the kind of manure applied, to another season, when the soil can be properly prepared and planted with carefully selected seeds. The results of the past season, being for the reason just referred to of a mere introductory character, will follow as an Appendix to these pages.

The Cultivation of Sugar-Beets.

The rules, by which beets are successfully raised for feeding purposes, do not apply to a successful production of the beet for sugar. In the first case, quantity is the main aim; in the second, besides quantity, a good quality is essential. A good sugar-beet is expected to contain not less than twelve per cent of sugar, a small percentage of saline substances, and the least possible amount of nitrogenous and non-nitrogenous constituents. The more nitrogenous compounds are present, the less sugar will be noticed; for they exert a controlling influence on the formation of sugar in the growing beet-root. The saline substances, on the other hand, do not affect injuriously the formation of sugar; yet, they place it under very disadvantageous conditions, as far as its final separation in a crystallized state is concerned; they favor the production of molasses and thus increase the manufacturing expenses. The history of the beet-sugar industry of later years is not without many illustrations of these damaging influences. Some late experiments in this country, no doubt, owe their failure, in part at least, to the fact, that virgin soil, rich in vegetable mould and saline constituents, has been used for the cultivation of the sugar-beet. Judging from analogy, we cannot but consider the reported gigantic roots and unusually large crops per acre as unfavorable features of some recent attempts in beet-sugar manufacture. The common mangel is no substitute for the sugar-beet in the production of sugar, while the latter is highly valued for feeding purposes and becoming daily more popular.

Among the various kinds of sugar-beets at present cultivated in Germany, the Silesian white sugar-beet (Achard's beet) is almost exclusively employed. Two of its sub-varieties, the pear-shaped white Silesian beet, with somewhat drooping leaves,

(which is a cross-breed from the wedge-shaped Silesian white sugar beet and the Magdeburg chicory beet), and the Quedlinburg variety, with pinkish colored skin and red lines in the centre leaves, are particularly valued. The latter requires the richest soil. The French Vilmorin sugar-beets, on account of their superior saccharine property are also frequently raised ; yet as they are more liable to degenerate in the pits during the winter season, they are only cultivated to a limited extent, and are worked before frost during the latter part of September and October. The sugar-beet in its present state, a child of cultivation, is a variety of an unsightly biennial plant, *beta maritima*, which grows wild along the coast of the Mediterranean, in south-western Europe. A comparison of the following analyses of the ash constituents of the wild and the cultivated plant gives some idea to what extent a systematic cultivation for particular objects, aided by climate and soil, may affect the normal mineral constituents of a plant. The wild beet-root may be called a soda plant, while the cultivated sugar-beet is decidedly a potassa-plant.

Wild Beet-root. (WAY.)

Potassa,	30.1
Soda,	34.2
Lime,	3.1
Magnesia,	3.2
Chlorine,	18.5
Sulphuric acid,	3.8
Phosphoric acid,	3.5
Silicic acid,	3.6
	100.00

Cultivated Sugar-beet. (BOUSSINGAULT.)

Potassa,	48.9
Soda,	7.6
Lime,	8.8
Magnesia,	5.5
Chlorine,	6.5
Sulphuric acid,	2.0
Phosphoric acid,	7.6
Silicic acid,	13.1
	100.00

It is well known, that, as a general rule, the various mineral constituents of a plant are indispensable to its growth, so that, if any one is wanting, the rest are thereby rendered incapable of supporting it. Our whole system of manuring, and even of rotation, rests upon this premise, and practical experience manifestly confirms it.

The composition of the ash constituents of the highly cultivated sugar-beet, compared with that of the wild beet, furnishes us with a striking instance as to what extent elements of a similar chemical character, for instance, potassa and soda, may be substituted for each other. We may also notice, however gradually such substitution may have been accomplished, that it inevitably affects the normal physiological processes going on in those plants which are subjected to such treatment. Whatever favors abnormal growth in plants surely aids in hastening on their premature unfitness for propagation, and their final extinction. A comparative study of our garden plants regarding their ash and other constituents, in their wild and cultivated state, would furnish us most likely with numerous instances of differences similar to those noticed in the case of the sugar-beet, and investigations of that kind could not but point out to us very important facts concerning the most advantageous selection of special manures for the production of a desired abnormal growth of our cultivated plants. Louis Vilmorin, the celebrated French gardener and seedsman, states that he raised, by proper selection, sugar-beets which contained in their juice not less than 21 per cent. of sugar, thus surpassing in sweetness the juice of the sugar-cane.

Selection of Varieties of Beet.

The successful cultivation of the sugar-beet begins with the selection of seed beets. Vilmorin's views on this subject are considered of great weight; a detailed exposition of his rules may be found in the Journal d'Agriculture Pratique, No. 5, 1858. He advises the selection of healthy, well-shaped beet-roots of from $1\frac{1}{2}$ to 2 pounds weight, those, which with a large yield, show the most rings of leaf marks are preferred,—the specific gravity of their juice ought not to be less than 1.05; those which contain a juice of from 1.06 to 1.07 specific gravity are of superior character; seed-beets ought not to be taken from a

soil which for the first time is turned into use for the production of sugar-beets, and the seed-beet fields ought to be kept separated from the general sugar-beet fields.*

Soil for Sugar-Beet Cultivation.

The best soil for the cultivation of sugar-beets is a mellow, deep, sandy loam with a free and permeable subsoil,—a soil named by German agriculturists a rich, first-class barley soil. A sandy loam, if deep and rich in well decomposed organic matter, is preferable to a clayish soil, for the latter becomes too compact and hard in a dry season, particularly after heavy rain showers, and thus frequently interferes with the growth of the fleshy roots ; and in wet seasons it produces a watery beet of inferior saccharine properties. In case the subsoil is not perfectly free, under-drainage becomes indispensable. A stony soil, or a thin surface soil, with gravelly subsoil, or a deep virgin soil with large quantities of half-decayed vegetable matter, are very objectionable ; and stagnant waters cause the premature decay of the roots at their lower termination.

Favorable physical properties of the soil are of the first importance, for fitness of the soil, as far as a necessary amount of plant food is concerned, may be secured by a carefully selected system of rotation, supported by a proper selection of special manures. Inferior kinds of soil, may, to a certain degree in some exceptional cases, answer for beet-sugar cultivation, yet they ought not to be solely relied upon as a safe basis for beet-sugar manufacture. A moderately warm and moist climate seems to be best adapted to this crop ; the northern sections of Germany and France being considered more successful than the southern parts of those countries. This observation may find its confirmation in the United States. Whether a change from Wisconsin to California merely on account of a warm climate would be a judicious move, future experience may teach,—but past experience does not point in that direction. The sugar-beets raised in southern portions of Europe have been found to contain more saline constituents than those raised in northern sections, a circumstance which must counteract their superior richness on sugar. A careful change to deep plowing is for

* The amount of beet seed raised per acre, varies from 12,500 to 25,000 pounds.

obvious reasons highly recommended, provided the subsoil proves of a fit quality. In no case is the soil to be plowed to a less depth than eight inches; from ten to sixteen inches and deeper being desirable. Wherever deep plowing is undertaken for the first time, it is done during the fall, and the lands are immediately afterwards well manured. The rules for preparing the soil may be summed up as follows: Manure in the fall and plow the manure in deep; use only well rotted compost, if you are obliged to manure in the spring; begin the work in autumn at any rate, and turn the soil two or three times; do not work the soil when wet; pulverize it with the best implements, and as soon as possible; let not much time be lost between the last mechanical operation and the seeding.

Stable manure is the basis of the whole system of manuring; commercial or artificial manures are only relied on as an aid. For this reason sugar-beets are usually raised as second crop, giving a chance for a thorough disintegration of the stable manure; the effect of the latter is supported in the second year previous to the planting of the sugar-beet, by a special commercial manure. The condition and the composition of the soil, quite naturally, control the whole system of manuring. As the soil in both respects will differ more or less, practical experience does not point out any one manure, which will answer under all circumstances; yet sufficient is known to assert what kind of manure has a good effect, and what has a bad effect on the sugar-beet, as far as the percentage of sugar and its final successful separation are concerned. The production of sugar being the main object, and on account of its high price affecting most decidedly the balance sheet, it is but natural that the agriculturist has now and then to compromise in the interest of the sugar manufacturer. Large crops of watery sugar-beets are not economical, where, as for instance in Germany, the beet-root is taxed; in France, where the sugar resulting from the sugar-beet is taxed, spring manuring is more freely resorted to.

Plants differ less in regard to the various kinds of food they need, than in regard to the quantities of each kind. Stable manure and plant ash are for this reason the only universal manures we recognize; the former is preferable to the latter, on account of its decided effect on the physical condition of the soil. The beet partakes largely of atmospheric food, and as the

proper physical condition of the soil increases its disposition to absorb atmospheric plant food, we find that stable manure, and green crops turned under, are the best fertilizers; the only precaution recommended consisting in the advice to apply them in time to have them disintegrated before the beets are planted. The successful sugar-beet cultivator adheres to the rule to sell nothing without replacing it in some form or other, except what he has drawn from the atmosphere, the sugar,—considering almost everything else part of his real estate, which he cannot dispose of without injuring its value. Whatever he sells, besides sugar, is merely a matter of exchange; the mineral constituents, and to a certain extent the nitrogen, which the articles sold contain, whether in the form of milk, grain, or live stock, produced upon his farm, he brings carefully back, either by buying fertilizers, or better, by buying hay to manufacture the manure on his grounds.

We find no definite relation between the organic portion of plants and their mineral constituents; yet we know that an abundant supply of both nitrogenous and mineral substances controls the amount of oxygen, hydrogen, and carbon, absorbed for the formation of the organic constituents of plants, and that the available amount of these substances thus manifestly decides their final annual growth. It is thought best for this reason to calculate the amount of manure required for the production of a satisfactory crop from the quantity of nitrogen and mineral constituents, which a full crop contains. The form in which we apply the manures usually varies widely. They are rarely of a homogeneous nature, and require, therefore, more or less time for disintegration and final absorption; larger quantities of manure are consequently applied in starting a crop than it actually requires. It may be of interest to some to notice a few of those figures, which are commonly used as bases for the calculations of the time required to reap the full benefit of various kinds of manure.

	1 year.	2 years.	3 years.	4 years.
Stable manure, .	50 per cent.	25 per cent.	15 per cent.	10 per cent.
Flour of bone, .	30 "	30 "	25 "	15 "
Oil cake, . .	50 "	30 "	20 "	15 "
Peruvian guano, .	60 "	30 "	10 "	15 "

Pulverized commercial manures, as a general rule, are expected to work quickly, as slow action would seriously enhance their cost, adding interest of outlay to the capital; and most of them are designed to supply only special wants, and aid thereby in the production of large special crops. They therefore, if not proportionately supported by stable manure, green manuring, and a judicious rotation of crops, hasten on the exhaustion of the soil or general mineral plant-food. In some cases, as with guano, their effect depends, in an undesirable degree on the weather, whether dry or wet. Special manures occupy for these reasons a subordinate position. Potassa and phosphoric acid are, strictly speaking, the only plant constituents which have to be bought in consequence of the extensive stock-feeding usually connected with the farm management of sugar-beet cultivation for manufacturing purposes, particularly in cases where the molasses is sold, which contains a very large proportion of the soluble saline constituents of the beet-roots. Having attempted to enumerate some of the rules by which practice should be guided, it may be but proper to speak somewhat more in detail of the special effects of some of these manures. Fresh barnyard manure, particularly of horses and sheep, or liquid stable manure, or poudrette, and all manures containing uric acid are decidedly objectionable in the spring preceding the planting of the sugar-beet, for they induce an excessive growth of the leaves, shortening thereby the time for the ripening of the beet-roots, while favoring an increase of their nitrogenous constituents. They also cause a large absorption of saline constituents. In case barn manure has to be applied during the spring preceding the raising of the sugar-beet, cow manure is considered the least objectionable, but well-rotted compost is

preferred. Guano and oil-cake, without any admixture of superphosphate of lime, act similarly to the most objectionable fresh stable manures. Saline compounds, as saltpetre, salt, Stassfurth manure-salt, &c., increase the quantity of beets, yet render them, if applied freely, rich in saline constituents. A mixture of one hundred and thirty pounds of Peruvian guano, and three hundred to four hundred pounds of superphosphate of lime per acre, or Chili saltpetre with superphosphate of lime, or wood ashes, or flour of bone, or well-rotted bones with wood ashes, are considered the best special manures for the production of superior sugar-beet. Green manuring, if applied in time, is highly recommended on account of its effects on the physical properties of the soil. Judicious selection of crops for rotation is most carefully resorted to in the interest of economy of manure and an undiminished productiveness of the soil. To render an efficient system of rotation possible, but one-fourth of the entire area under cultivation is planted annually with sugar-beets. In case a rotation of five or six years is possible the results are still more satisfactory. In the absence of a large farm, a number of smaller ones may thus successfully support a beet-sugar factory; and the soundest basis for a sugar-beet establishment consists in making arrangements by which the farmer is to have an interest in the produce of sugar. To engage merely in the cultivation of the sugar-beet for supplying existing factories is, however, considered a paying business, particularly if the farmer secures to himself in part at least the vegeetable refuse, as press-cake, &c., for stock feeding.

Planting of the Seed and Treatment of the Sugar-Beet.

The seed are planted by hand or by machine; theoretically from two to three pounds would be necessary for one acre, but in practice from fifteen to seventeen pounds are used. The seeds, after being soaked in water, if planted by hand, are placed usually at a distance of fourteen inches apart; if sowed by machine (of Garret's patent) they are dropped about eight inches apart in rows about twenty inches apart, which allows one horse with implement to pass between. In the latter case from 28,500 to 30,000 plants could be raised upon one acre. A larger space around each plant favors an excessive enlargement of the roots, a result not at all desirable, for large beets are usually watery.

A beet-root from one to one and one-half pounds is preferable to those from two to three pounds. Every common beet seed, containing by its natural construction from two to three germs, will produce as many plants, of which the strongest is left, whilst the rest are pulled up or otherwise destroyed in due time. The process of thinning out the plants takes place as soon as the roots have reached a length of from three to four inches, and, if possible, shortly after a rain, to prevent the loosening of the soil around the specimen left. A transplanting of sugar-beet plants from a separate bed to the lands for final cultivation is rarely resorted to; it is only recommended to fill out the gaps produced by the failure of seeds. Whenever this failure acquires any considerable proportion in the beet fields, a re-seeding is preferred, provided the season has not too far advanced. The soil around the young plant should be frequently loosened by proper implements (every two or three weeks), and the roots kept carefully covered, until the leaves have acquired their proper development early in June. Such treatment destroys the weeds and increases the hygroscopic and general absorptive properties of the soil, and thus favors highly an undisturbed, early and rapid development of the leaves. The latter, it is asserted, exert a controlling influence on the formation of sugar. M. Vilmorin considers a large number of rows of leaf marks, as previously stated, an essential property of a good sugar-beet. The leaves absorb as a general rule atmospheric food in proportion to their number and size. The sooner they acquire a good size, and the more numerous they are, the better are the chances of a copious formation of sugar, for this apparently depends to a great degree on the supply of atmospheric food. There are three distinct periods in the growth of the beet, viz.: the development of the leaves, which closes usually within the first half of June; the formation of the roots which is accomplished by the middle of September or first part of October; and, finally, the production of the seeds which takes place in the second year. The ripeness of the roots is indicated by a change in the color of leaves from a deep green to a yellowish tint. Those varieties which show a particular inclination to grow out of the soil are considered inferior. As soon as the leaves have reached their size, which happens in ordinary years usually in the fore part of June, the loosening of the soil and the cover-

ing up of the beet-roots ceases, leaving them undisturbed in their growth. To convey some idea concerning the peculiar features in the growth of the sugar-beet plant, I insert here some of the results of an interesting investigation in this direction by Dr. P. Bretschneider. The weights are in grammes, one gramme being equal to 15.43 grains:—

DATE.	Weight of the Root.	Weight of the Leaves.	Proportion between Root and Leaves.	Percentage of Sugar.
June 12, . . .	0.2005	–	–	2.13
21, . . .	5.3000	–	–	4.17
July 9, . . .	78.3000	286.	1 to 3.65	4.99
16, . . .	109.600	226.	1 to 2.06	8.86
29, . . .	166.	224.	1 to 1.34	–
Aug. 8, . . .	124.	106.	1 to 0.56	11.27
26, . . .	228.	121.	1 to 0.53	11.52
Sept. 19, . . .	586.	346.	1 to 0.59	11.45
19, . . .	169.	38.	1 to 0.22	10.80
19, . . .	204.	50.	1 to 0.25	13.15

The harvesting of the sugar-beet root begins, when the outer leaves turn yellow and dry, which in different seasons and localities may vary from the fore part of September to the first of October; the past season being with us unusually dry and warm caused a somewhat premature dying out of the leaves upon our experimental field. The gathering of the leaves, even in part, at any preceding stage of the growth of the plants, is seriously objected to, for it affects most decidedly the final yield of sugar. Nature, in its wonderful economy of matter and force, always provides for the continuance of species under the most advantageous conditions, storing up in some of the organs of plants under the influence of a favorable summer temperature a maximum of such compounds as will enable them to develop their organs for propagation almost independent of outside assistance. The flowers and subsequently the seeds draw upon

the food accumulated in roots, stalks and leaves, and the seeds themselves again store up an amount to enable the embryonic germ to provide itself with such organs as will fit it to fulfill its mission in the production of a new plant. Sugar is undeniably one of those substances which are required to support the beet-root plant in this last stage of growth.

The amount of sugar in the sugar-beet is largest when the root has just attained its ripeness; subsequently, it diminishes gradually in consequence of advancing growth. To preserve undiminished the maximum percentage of sugar till the time of manufacture is somewhat difficult. There is no such thing in nature as absolute rest. If it were practicable to keep the beet-root frozen from the beginning to the close of the manufacturing season, it might prove to be the most efficient mode, so far as the preservation of sugar is concerned. The manufacture of the sugar begins usually in the latter part of September, and the beet-roots are daily carried in such quantities from the fields as the factory can dispose of. Those varieties, like the Vilmorin beets, which do not keep well in the pits over winter, are first gathered and worked up. As soon as frost becomes imminent, all the roots are gathered after the removal of the leaves, which operation is carried on upon the fields. They are then buried in suitable pits without loss of time. The beets are raised out of the soil by means of forks, and the leaves cut off with sword-like knives about one-half to one inch from the root. To cut off the top of the beet-roots from those which are to be kept over winter is disapproved of. The use of the plow in harvesting is also objectionable on account of frequent laceration of the roots.

The mature roots after being freed from the leaves in the manner just described, are with the adhering soil laid carefully into shallow pits about six feet long by three feet wide, and from four to five feet in depth. These are, finally, covered with soil to protect them against frost. Small pits of the size just described are preferred, for they allow a better control of the temperature than large pits, which frequently suffer from an undesirable increase of heat, causing the growth of leaves or degeneration by decay. The covering of soil is gradually increased in thickness with the advancing season, amounting usually to a final thickness of three feet, and this is sometimes

rendered more efficient by a thin outer layer of stable manure. To secure a uniform moderate temperature is the sole object of these proceedings, and pits beginning to heat, are worked up without delay. The pits must be located upon very dry land on or near the beet fields, and in such a position that no accumulation of water can injuriously affect them.

To give some idea about the changes which a good sugar-beet undergoes in the pits even under quite favorable circumstances, I insert the following statement of H. Rake. The same kind of beet-roots contained—

In October, 1862:	
Cellulose,	3.49
Water,	82.06
Cane sugar,	12.40
Grape sugar,	–
Mineral constituents,	0.75
Albuminous and extractive substances,	1.30
	100.00
In February, 1863:	
Cellulose,	2.52
Water,	84.36
Cane sugar,	10.60
Grape sugar,	0.65
Mineral constituents,	0.63
Albuminous and extractive substances,	1.20
	100.00

Whenever the roots begin to rot the sugar is lessened; the loss due to the sprouting of the leaves may amount to two per cent more than the preceding analysis states.

Yield of Sugar-Beets.

The numerous varieties of beets differ widely in regard to their annual yield, independent of the conditions of season, upon the same soil and under the same treatment. Whilst common mangels have been raised upon a suitable soil, in exceptional cases, at the rate of from ninety-four to one hundred

and ten tons per acre, the sugar-beet never yields at anything like such a rate. The following statement respecting the yield and amount of sugar obtained from three kinds of beets is quite interesting and suggestive regarding the important question, what kind of beet roots are the most desirable for cultivation for the manufacture of sugar.

NAMES.	Annual yield of Roots per acre.	Percentage of Sugar.	Amount of Sugar in the entire Root Crop.
Metz (fodder beet), . .	86,457 pounds.	4.5 per cent.	3,890 pounds.
Imperial (sugar-beet), .	59,613 "	10.51 "	6,265 "
Silesian White (sugar-beet),	52,787 "	13.64 "	7,200 "

These few numerical statements teach most decidedly, that mere quantity will not insure success for the beet-sugar interest. We find in practice as a general rule that the mean annual yield of sugar-beets is less than in the cases cited. In Silesia, the crop averages from 18,000 to 19,000 pounds per acre, and the beet juice itself is expected to contain throughout the entire sugar-making season from 11 to 13 per cent of sugar, which indicates that scarcely any roots with less than 12.5 per cent of sugar are worked in that district. In Saxony, from 23,500 to 24,000 pounds are obtained per acre, and, in exceptional cases, even as high as from 30,000 to 31,000 pounds are reported. In France, where the sugar resulting, and not the roots used for its manufacture, are taxed, the annual yield is larger than in Germany, one acre yielding there from 38,000 to 40,000 pounds of roots. Yet a larger final yield of sugar is claimed from one acre in Germany than in France.* The cost of production in Germany is set down at from 21 to 22 cents per hundred pounds of sugar-beet roots.

Those who sell their sugar-beets at the factory, receive from

* In Germany 100 pounds of sugar-beet roots are taxed (8 sgr.) 19.44 cents (1869). In France every (52 kilogrammes) 114.4 pounds of beet sugar are taxed (13 francs and 75 centimes) 2.66 dollars. Every 1,000 kilogrammes or 2,200 pounds of sugar-beet roots yield on an average (52 kilogrammes) 114.4 pounds of sugar in the form in which it is taxed. (Walkhoff.)

25 to 27 cents per hundred pounds, together with one-half of the vegetable refuse or press-cake.

Not unfrequently, separate contracts are made for furnishing small beets not exceeding two pounds in weight. The sugar-beet cultivation usually becomes a prominent feature of agricultural industry in the vicinity of beet-sugar factories, for although the manufacturer of sugar is, as a general rule, to some extent at least a producer of beets, he rarely limits himself to the amount of his own produce. He finds it profitable to purchase a certain quantity, if for no other reason, in order to be enabled to cultivate his own lands on a liberal system of rotation. He, also, frequently retains one-half of the press-cake and other refuse resulting from the working of an additional amount of beet-roots, for stock feeding and manuring purposes.

Yield of Juice.

The sugar-beet contains about 82 per cent of water, and 80 per cent of its juice may be obtained by subjecting the crushed beet to a powerful pressure. The relation of the power applied to the quantity of juice obtained may be inferred from the following statement of Walkhoff:—

By	50	pounds of	pressure	to the	square inch,	60 per cent.
	80	"	"	"	"	64 "
	400	"	"	"	"	75 "
	750	"	"	"	"	80 "

The press-plates are made 14 inches or more square, and 24 pounds of pulp for every 100 square inches of press surface is considered the best proportion. The roots are usually changed into a pulp by circular saws fastened upon two hollow iron rollers running in opposite directions. Water is added (from 15 to 30 per cent) while preparing the pulp to reduce the amount of sugar left in the press-cakes. By means of this and numerous other devices from 80 to 87 per cent of the actual juice in the beet-roots is secured. The profitable addition of water is limited by the expense arising from the evaporation of a diluted juice.*

* One hundred pounds of coal are required for the evaporation of 500 pounds of water, in the course of beet-sugar manufacture.

The extra expense necessary to procure more than 80 per cent of the juice diminishes largely its value, nevertheless improved methods are constantly sought and are doubtless attainable.

The press method and Roberts'* modification of warm and cold maceration of the fresh beets have apparently the warmest advocates. It would be a vain attempt on my part to treat here in a becoming manner on these questions. I propose to leave that task to some future occasion, when the manufacture of beet-sugar will be discussed. The supply of labor, fuel, and water, the condition of the sugar market, &c., control, as every manufacturer is aware, in such a degree the choice of apparatus and modes of operation, that very little information could be gleaned from a general discussion without some detailed explanation. To the farmer, the vegetable refuse, as press-cake and like substances, is of prime importance, and the various modes of abstracting the juice from the beet roots affect him only in so far as the value of the refuse for feeding purposes is concerned. A comparison of the composition of the juices obtained by means of a powerful hydraulic press and by Roberts' maceration, (or the dialytic mode), can aid in understanding this question of which I shall have to treat somewhat more in detail hereafter:—

I.

Beet juice procured by the aid of a hydraulic press contains:—

Sugar, ...	12.410	per cent.
Potassa and soda compounds, .	0.458	"
Lime and magnesia, . . .	0.187	"
Nitrogenous substance, . . .	1.418	"
Non-nitrogenous organic substances, ...	1.048	"

II.

Beet juice procured by Roberts' diffusion apparatus with an addition of 15 per cent of water, contains:—

* Roberts claims to secure 94 per cent of the juice by adding but 15 per cent of water, and carrying on the first osmotic maceration at 87 to 80 degrees centigrade, and the remainder at a common temperature.

Sugar, ...	11.580 per cent.
Potassa and soda compounds, .	0.441 "
Lime and magnesia, . . .	1.191 "
Nitrogenous substance, . . .	0.791 "
Non-nitrogenous organic substances, ...	0.983 "

Yield of Sugar.

According to the mode of operation pursued, more or less sugar will be left with the cellular refuse mass. The residue of the hydraulic press contains from 3.6 to 4.8 per cent of sugar, or 0.76 per cent of the amount in the original sugar-beet; while Roberts' mode leaves but 0.1 to 0.2 per cent of sugar. Between these figures lie the quantities of sugar left by the application of other modes of operation. With the removal of the juice begins consequently the loss of sugar, which amounts during the whole operation for its final separation to about 3.5 per cent under a good management of existing methods. To set down losses which occur in a branch of manufacture where peculiar skill so decidedly bears upon the final results, is no doubt quite arbitrary; but it is of interest to notice where they usually occur, and to what degree they affect the final results in many instances. The following statement is presented as a fair one and may serve the purpose just specified :—

One hundred parts of sugar-beet roots, under fair management, are liable to lose sugar as follows :

In the pits by degeneration, . .	2.00 per cent.
By change into grape sugar, . .	0.54 "
In process of filtration of the juice, .	0.14 "
In defecation and carbonization, .	0.21 "
In juice left in the press-cake, . .	0.76 "
Total loss, ...	3.65 "

One hundred parts of sugar existing in the beet roots were, in one case, accounted for in the following way at the close of manufacture :—

Crystallized sugar, ...	62.46 per cent.
Sugar left in the molasses, . .	14.75 "
Lost during manufacture, . .	22.79 "
Left in the press-cakes, . . .	11.48 "

Eight per cent of sugar from the beet is at present assumed to be the actual result of most factories with improved modes of operation and superior sets of apparatus; some factories claim even more. The importance of an increase in the yield of crystallized sugar may perhaps be best inferred from a case reported by W. Crookes, F. R. S., in his late publication on beet-sugar manufacture with reference to England. Mr. Baruchson, the beet-sugar manufacturer, is reported as stating that the factory cost £10,845; 150,000 pounds of sugar-beet root has been worked per day for five months; the expenses for labor amounted per year to £5,190; the total expenses per year had been £13,980; the total receipts per year were £20,470; the profits thus had amounted to £6,490, or 24.75 per cent on the first outlay; 6.5 per cent of crystallized sugar had been the result. He further states that one-half per cent of increase of the yield of crystallized sugar would be equal to 7.5 per cent additional profits; eight per cent of crystallized sugar from every 100 pounds of beet roots worked, would thus insure a profit of 48 per cent. Accepting this statement as correct, there is no doubt, but that the English beet-sugar manufacture ought to prosper under their present revenue law. In Germany, where eight per cent of crystallized sugar is obtained, the yield per acre varies from 1,520 to 2,270 pounds of sugar. In France, where but six per cent of sugar is obtained (Walkhoff), the yield is said to be from 1,706 to 2,650 pounds per acre. The same authority states that the average expenses in Germany for the production of sugar per acre, taking the average yield of beet roots as from 23,000 to 24,000 pounds, amount to from $132 to $133, of which the government takes in form of taxes from $45 to $46; while in France, assuming the average yield of beet roots per acre to be from 36,000 to 37,000 pounds, and separating 114.4 pounds of sugar from every 2,200 pounds of beet roots, the whole average expenses per acre for beet-sugar amounts to from $161 to $162, of which the government draws for taxes

on sugar $50.75. The expenses in the two countries are divided among the different operations in the following proportion :—

In Germany :*

Manure,	14.48 per cent.
Cultivation of beets,	11.20 "
Taxes on sugar,	34.82 "
Manufacturing expenses,	39.40 "

In France :

Manure and cultivation of beets,	24.40 per cent.
Taxes on sugar,	31.59 "
Manufacturing expenses,	44.01 "

Taking the produce of an American acre as equal to from 23,000 to 23,500 pounds, and presuming an average percentage of sugar in the beets of from 11 to 12 per cent, allowing at the same time 80 per cent of juice, which contains but 9.6 per cent of the sugar in the beets, and calculating, finally, but 6.5 per cent of crystallized sugar as obtainable from 100 pounds of beets, an American acre would yield 1,500 pounds, which at seven cents per pound† would amount to $105. The molasses obtained from the sugar-beet is not fit for household consumption on account of its unpleasant saline taste. It is fermented in most cases for the production of alcohol, and rarely fed to live stock, as its continued use, even in small quantities, is not considered safe, from its effect on the digestive organs. Its value as food is about one-half that of good hay, and its effect is similar to that of oil-cake. 1.8 pounds of molasses per day mixed with clover hay or even straw has increased the yield of milk. Sometimes the molasses is mixed with caustic lime or the carbonate, and composted for manure.

* Recent reliable private communications coming from different sections of Germany state the expenses for the production of sugar-beet roots, when in the pits, in one case at $46 and in another at $59.50 per acre. Land rent in both cases was equal and amounted to $12.50 per acre; manure in the first case amounted to nearly one-half, in the second case to but one-third of all expenses. The price of labor caused the difference.

† To assume a higher value is unsafe, considering the unsettled views concerning the degree of protection which our sugar industry may claim.

AVERAGE COMPOSITION OF BEET-SUGAR MOLASSES.

Albuminous substances,	9.2 per cent.
Sugar,	41.3 "
Other organic substances,	16.1 "
Saline compounds,	10.8 "
Water,	22.6 "
	100.0 "

The saline constituents of course differ somewhat in every case, particularly as far as the lime compounds are concerned. The following analytical results, (Trommer & Rode), may give some idea about their general character.

One hundred pounds of ash constituents of beet-sugar molasses contain of:—

Potassa,	30.46 per cent.
Soda,	10.12 "
Lime,	26.62 "
Sesqui-oxide of iron,	00.04 "
Carbonic acid,	19.07 "
Sulphuric acid,	1.92 "
Silicic acid,	0.06 "
Chlorine,	10.03 "
	100.00 "

The residual liquid left after the fermentation of the molasses is usually evaporated and the solid mass subsequently calcined. The beet-sugar manufacture furnishes in this form quite a large quantity of valuable saline compounds for general industrial purposes. One hundred pounds of these calcined saline substances contain from 45 to 48 per cent of soluble constituents of a composition more or less corresponding with the following figures:—

Carbonate of potassa,	27.60 per cent.
Carbonate of soda,	4.70 "
Chloride of potassium,	6.75 "
Sulphate of potassa,	6.75 "
	45.80 "

One single beet-sugar factory at Wagehäusel (Germany), sends every year 200,000 pounds of such potassa salts into market, which is mainly used for the manufacture of nitre. The molasses contains by far the largest portion of the soluble saline constituents of the sugar-beets, particularly the potassa compounds which must be returned to the soil directly or indirectly. The cheaper crude sulphate of potassa of Stassfurth is bought at present in exchange for the carbonate of potassa sold.* Distilleries are frequently connected with sugar beet manufactories.

The Cellular Residue of the Beet Root.

The juice is obtained in different ways, and, according to the mode adopted, the quality of the residue is affected. The press-cakes resulting from the application of the hydraulic press, which is the main apparatus employed, are compact in consequence of packing the pulp into bags or coarse linen cloths before subjecting it to the press. 100 pounds of beet roots furnish from 18 to 20 pounds of press-cakes, which consist, in case a very powerful press is used, of:—

Albumen,	1.336 per cent.
Potassa,	6.487 "
Sugar,	4.945 "
Cellulose,	11.922 "
Saline matters,	1.180 "
Water,	74.130 "
	100.000 "

These cakes are highly valued for feeding purposes; 100 pounds of press-cakes are valued at 29.6 cents, when hay is worth 20 dollars per ton; the cellular residue of beets left after the abstraction of the juice by other modes is as a general rule less valuable. For instance, the residue after the treatment with centrifugal apparatus and the subsequent displacement

* The producer of potatoes sells in an average crop of 7.41 acres (three hectares) the mineral constituents of four crops of wheat besides 600 pounds of potassa, and in an average crop of beet roots from the same area the mineral constituents of four wheat crops, besides 1,000 pounds of potassa.—*Leibig.*

process is considered worth but 16.9 cents per 100 pounds; that obtained by hot maceration of dried beet roots is held at from 24 to 25 cents per 100 pounds, while that obtained by a maceration of the fresh beet roots after Roberts' improved method, (free from an excess of lime), is valued at from 7.2 to 9.1 cents per 100 pounds. The last named residue contains but from 5.5 to 6.9 per cent of dry substance, while common press-cakes contain 25 per cent. Roberts' mode of operation leaves about 70 pounds of cellular residuum for every 100 pounds of beet, which contains, as stated previously, more nitrogenous matter in proportion to dry substance, but less sugar than common press-cakes. It is worth as fodder about one-quarter as much, according to the estimate of Grouven.

One and one-half tons of press cakes are assumed in practice as the produce from one Prussian morgen,* or 4,700 pounds per acre, so that allowing a value of 29 cents for every 100 pounds, the whole amount of press-cakes from one acre would be worth $13.60. Moreover, as 100 pounds of common press-cakes contain 25 per cent of dry substance, 4,700 pounds contain 1,175 pounds; and as the dry substance of any article of vegetable food is known to furnish 1.75 times its weight in common stable manure, 2,056 pounds of manure will result from the feeding of the press-cakes of one acre. Reckoning one ton of manure worth $1.75, 2,056 pounds will be worth about $1.80. The fodder value of press-cakes resulting from the operation with the hydraulic press without subsequent maceration is equal to the same weight of sugar-beet roots. They are even preferred to the latter, since they become more digestible and acquire, after being buried in pits in consequence of slow fermentation, a slightly acidulated taste. Cattle then eat them greedily and thrive upon them, particularly in case they are fed in connection with a proper quantity of oil-cake, bran, hay, or barley straw, &c., to replace the potassa compounds and the phosphates which the juice has carried off.

The preservation of the press-cakes is easily accomplished. They are packed closely into the empty beet-root pits or into

* In this report all calculations concerning reductions of German surface measures and of money value are based on the following proportions: one American acre is considered equal to 1.58 Prussian morgen, and one Prussian thaler equal to 0.73 dollars.

brick chambers, being frequently interlaid with a small quantity of chopped straw, and, finally, tightly covered with soil. The fermented mass resulting from this operation keeps in an excellent state of preservation for six to seven months.

Produce of Leaves.

The leaves amount at the time of the harvesting of the roots to about one-fourth of the weight of the latter; calculating as previously, 6,000 pounds of leaves would result from an acre. The leaves are separated upon the fields and subsequently in their green state plowed under deeply, or they are fed either fresh or in a preserved state. The manuring effect of the beet leaves is very great, since they contain in their fresh state more potassa, more phosphoric acid and more nitrogenous substances than an equal weight of roots. Their ash percentage is also larger than that of the beet roots, consisting mainly of alkalies and alkaline earths. Almost one-third of all the potassa, one-half of the phosphoric acid, and two-fifths of the whole amount of nitrogenous substances of the entire sugar-beet crop is contained in the leaves. As they can be fed in small quantity only, in their fresh state, they are salted down in pits. The pits used for this purpose ought to be in a dry locality and dug to a depth of from five to six feet. The bottom is covered from two to three inches thick with a layer of chopped straw of oats, rye or wheat; then a layer from four to five inches thick of fresh beet leaves, mixed with one-quarter of one per cent of common salt is put on and trodden down, and these alternations continued until the pit is not only filled, but raised from two to three feet above the ground, and then a layer of two feet of soil is added as covering. In the same proportion as the mass shrinks in consequence of fermentation new soil is added to keep the covering above the level of the surrounding ground as protection from the rain. The leaves in the pits begin soon to ferment and to discharge moisture, which the straw absorbs; they retain a strong smell until January, when they turn by degrees sweet and are on that account freely eaten by cattle. Sixty pounds of fresh green leaves produce forty pounds of preserved leaf-mass; one acre furnishing thus about 3,900 pounds of such food, which, taking 100 pounds of hay worth one dollar, is valued at 16.3

cents per 100 pounds One acre would thus produce in food derived from the leaves $6.35; fresh leaves have 11.99 per cent of dry substance, preserved leaves contain 15.0 per cent; the leaves of one acre of sugar-beet root contain therefore 585 pounds of dry substance; which multiplied by 1.75 gives about 1,000 pounds of manure from this source of food. The leaves are never fed by themselves. Grouven recommends the following composition of food for every 1,000 pounds of live weight per day: 40 to 50 pounds of preserved leaf-mass, 40 pounds press-cakes, 3 pounds of rape-cake with 6 pounds of hay. In proposing this composition of food, he presumes that 25 pounds of perfectly dry hay represent the normal quantity of food required to support 1,000 pounds of live weight per day. A comparison of the mineral constituents contained in 25 pounds of dry hay and 25 pounds of dried sugar-beet leaves explains the proposed practice.

Hay.

Potassa,	0.80 per cent.
Phosphoric acid,	0.20 "
Sulphuric acid,	0.07 "
Chloride of sodium,	0.12 "

Dry Preserved Leaves.

Potassa,	1.00 per cent.
Phosphoric acid,	0.14 "
Sulphuric acid,	0.28 "
Chloride of sodium,	0.52 "

The small quantity of phosphoric acid and the large percentage of sulphuric acid and chloride of sodium in the beet leaves renders their exclusive use objectionable. They are, therefore, fed in common with substances like oat-meal, oil-cake, bran, clover, hay, &c., on account of their richness in phosphates, &c. Preserved beet leaves, it appears from experiments of Tod, increase the production of milk in quality and quantity, whilst press-cakes, if exclusively used, reduce its quantity decidedly. A mixed food of 100 pounds of press-cakes with 75 pounds of preserved leaves produced for every 100 pounds of leaves fed, an increase of 24.5 pounds of milk per day, as compared with

a corresponding feeding of press-cakes alone. The value of press-cakes and preserved leaves for the support of live stock, particularly during a period when food as a general rule becomes scarce and thus expensive, must be quite apparent; especially when we consider further that every ton of sugar-beets raised furnishes 400 pounds of press-cakes and 400 pounds of fresh leaves, and that an ordinary factory consumes from 40 to 50 tons of beet roots per day during five months. In cases where stock feeding is no part of the enterprise, or where plenty of other kinds of food is at hand, the leaves while still green are plowed under. The part which the beet leaves perform in the absorption of mineral constituents from the soil may be seen from the following analytical statement:—

A fair average crop of sugar beets abstracts per acre,—

By Roots and Leaves.

Phosphoric acid,	35	pounds.
Potassa,	164	"
Lime and magnesia,	63.50	"
Silica,	15.09	"

By Roots Alone.

Phosphoric acid,	25	pounds.
Potassa,	126	"
Lime and magnesia,	32	"
Silica,	6.5	"

Returned in form of Leaves.

Phosphoric acid,	10	pounds.
Potassa,	38	"
Lime and magnesia,	31.5	"
Silica,	9.4	"

THE GENERAL INFLUENCE OF THE SUGAR-BEET CULTIVATION ON THE CONDITION OF THE SOIL.

The first question which will be forced upon us in this connection, is: Can the sugar-beet be raised upon the same lands continuously without reducing their value either for the production of sugar beets or for general farm management?

It is no doubt most convenient to refer for an answer to Germany and France, and notice the conditions of the lands engaged in the beet sugar cultivation for generations. We shall find that the yield of good sugar-beets is not diminishing, that the beet sugar industry in fact is continually growing—(has increased in Germany within the last fifteen years threefold)—and instead of reducing the general farm products, in consequence of engaging so large an area in the sugar-beet cultivation, we know from statistical reports that they exceed in value the farm products of previous periods. High farming based on rational principles has taken the lead; to increase the fertility of the soil has been the aim; advantageous systems of rotation have been introduced and the effects of special manures have been subjected to close study. Science has made itself familiar with common farm routine, and an enterprising farming community has listened to its advice. Two facts are quite evident to every intelligent farmer: first, that a certain chemical and physical condition of the soil is required to secure by the crops raised a satisfactory compensation for labor and expenses incurred in its cultivation; and, secondly, that the plants we cultivate differ in their requirements in both directions. The mineral constituents needed for the support of any one kind of plant will be sooner or later exhausted, for nature as a general rule does not change the mineral compounds required for the maintenance of a forced vegetation into a fit state for assimilation so rapidly as most of our farm crops, and the sugar-beet in particular, require. Fortunately for us the disintegrating surface of our globe has been for ages subjected to a leaching process, and its products are daily more and more opened to us in the form of saline deposits of every description; the accumulated results of animal and vegetable life of past generations are brought back to us in the form of guano and phosphates of varying character, while chemistry has taught us how to assist nature in its preparation of plant-food. The physical conditions of the soil, however favorable they may have been, will suffer, if year after year subjected to the same or a similar treatment for the cultivation of one and the same plant; diversity in its mechanical treatment and change of seasons for such treatment cannot otherwise but affect favorably its mechanical condition and its chemical disintegration, promoting thereby its

fitness for the absorption of atmospheric food. The roots of the same plants abstract their food year after year from the same layer of soil; while a change of crop frequently alters the depth from which the food is absorbed. To cultivate the same plant upon the same spot for any length of time is also objectionable on account of the particular chances offered for the growth of those parasites and insects which make that plant their home. These and other reasons demand imperatively a rotation of crops.

The sugar-beet sends its rootlets to a depth of several feet, and draws consequently largely from the subsoil; the latter is on that account, as stated before, of great importance. As the sugar-beet also depends in a high degree on atmospheric food, its leaf growth must be stimulated by a most careful pulverization of the soil, and as the fleshy root needs for its growth a loose, deep soil, deep plowing has been generally introduced. Thorough cultivation and a perfected system of under-drainage being absolutely indispensable to the highest success must necessarily improve the condition of lands devoted to beet culture. Green manuring and a liberal use of stable manure have also been employed to render the soil mellow and rich, and thus the farm lands have reached by degrees a high state of fertility. The use of special commercial fertilizers is resorted to not to the exclusion, but in aid of stable manure, and thus the chemical and physical requirements of the soil are met in the most efficient way. Rotation of crops in connection with a rotation of special manures has demonstrated the practicability of preserving unimpaired the fertility of soil engaged in sugar-beet cultivation.

Without entering here in detail upon this much studied question, I propose to state merely a few observations of a more general interest, in addition to what is said in previous pages. Well manured annual leaf crops for green feeding, are considered the best crop to precede the beet; next in order, follow well manured summer or winter grain crops; less recommended are perennial grasses and other fodder crops; directly objectionable are, if not specially manured, potatoes and root crops in general, of which the mangel is the worst. The sugar-beet, on the other hand, is a good crop to precede almost any other farm plant. The succession of crops adopted in the interest of

sugar-beet industry has reference to two important objects, namely, an adequate supply of food to each crop and the production of the largest possible amount of animal manure. A fair crop of beet roots is of course more exhausting to the soil, as far as phosphoric acid, and particularly potassa, is concerned, than most of our farm plants; a judicious system of rotation divides that effect over several years, and thus enables the farmer to draw more efficiently on the natural resources of the soil, and so avoid a direct outlay of money. The following succession of crops is considered very satisfactory, viz.: green fodder, wheat, sugar-beets, and, finally, a summer grain crop; or barley, sugar-beets, barley, green fodder, wheat, sugar-beets; and these are economical as far as manure is concerned. Two thousand three hundred pounds of hay, or its full equivalent in fodder value, are considered sufficient to replace the constituents which a fair beet sugar crop abstracts per acre in excess of what the refuse material resulting from such crop in the course of beet sugar manufacture will compensate for. The amount of refuse material fit for manuring purposes is counted per acre equal to 4,700 pounds. T. T. Fühling's figures on this question are of great interest as they come from a practical sugar-beet cultivator, whose opinion is regarded as of great importance. They refer to pounds per acre.

	I.*	II.†	III.‡	IV.§	V.‖
Nitrogen,	36.4	19.8	16.6	23.7	32.
Potassa,	96.4	19.	77.4	28.5	33.2
Soda,	39.5	6.3	33.2	9.5	3.2
Lime,	14.2	28.5	33.2	4.	28.5
Magnesia,	9.5	11.9	33.2	4.3	9.5
Chlorine,	28.5	2.4	26.1	4.3	9.5
Sulphuric acid,	7 9	6.4	1.5	11.5	9.5
Phosphoric acid,	15.8	9.5	6.3	2.	4.8
Silicic acid,	17.4	–	6.3	8.	47.4

* Substances abstracted by a full sugar-beet crop.

† Substances returned in the manure obtained from sugar-beets.

‡ Amount of substances not replaced by that manure.

§ Amount of substances abstracted per acre during a four years' rotation as detailed.

‖ Amount of substances restored to the soil by the manure resulting from the feeding of 2,300 pounds of hay.

Comparing these analytical results, we find that the manure obtained from the beet roots and from the hay replace what, in the course of a few years' rotation, as specified above, will be taken per year from one acre. Wherever a farmer deviates from the practice previously stated, potassa and phosphoric acid must be largely supplied in form of special manures, as superphosphate of lime, or flour of bones and wood-ash, or crude sulphate of potassa. One hundred acres of good meadow-land in twelve hundred acres under cultivation for beet-sugar manufacture are considered in Germany a suitable proportion to raise the amount of hay required.

Stock feeding then becomes a prominent feature in the farm industry. The farm produce is largely sold in the form of live weight, and the manure is more cheaply produced by fattening live stock than it can be bought. The farmer keeps only as many horses as are indispensable, and does his farmwork, as far as possible, with oxen. He looks upon cows, if not favorably located for the milk-market, as a mere manure-machine, and keeps only as many as required to make up the stock wanting. Sheep-fattening, if he has suitable pasture, he considers a profitable business. In feeding his stock he believes in the efficiency of feeding high, to reduce the expenses of keeping; and this produces also the cheapest manure. Every animal requires a certain amount of food for daily support independent of its increase in weight; the shorter the time for fattening the more food for mere keeping is saved. In calculating the quantity of food required for the various kinds of stock, the following figures are frequently adopted: for every one hundred pounds of live weight, 3.33 pounds of hay or its equivalent per day are considered necessary as the mere support of farm stock in cases of ordinary employment, and five pounds of hay or its equivalent for every hundred pounds of live weight for fattening purposes. In the case of young stock, eight times as much food is given for production of weight as for mere sustenance; from every hundred pounds of food for support, and fifty pounds of food for growth, from four to six pounds of increase in live weight are expected as return.

Summing up the value of the various products of one acre of sugar-beets, we find at a very low calculation the following result:—

Sugar, 1,500 pounds at seven cents, . . .	$105 00
Molasses, ...	2 90
Press-cakes, ...	13 60
Preserved leaf-mass, ...	6 30
Manure (about two tons), ...	3 50

(Profit, in converted produce, &c., &c.)

Every cent of increase in the price of the sugar would be equal to fifteen dollars additional profit per acre, and every one-half per cent increase in crystallized sugar from every hundred pounds of beet roots worked, would add about 115 pounds of sugar to yield, or $8.05 additional profit per acre. These additions in profit are by no means beyond reach, for the best management in Europe realizes them.

To enter, in concluding this Report, upon a detailed calculation of what our expenses for the production of the above articles per acre would be, could be at best but a mere approximation.

It may suffice to keep in mind that in Europe from forty-six to fifty dollars per acre has to be paid in taxes to the government; that our lands are cheaper, and that machinery is taking daily more and more the place of the hand in planting seeds, in cleaning the fields, and in securing the juice from the beet roots. Where the final pecuniary results may differ so widely, as must be quite apparent from previous statements, in consequence of a more or less favorable location of the factory and the skill engaged in its management, it is unsafe to state a definite sum of profit. It must here, as in every similar instance of an industrial enterprise, suffice to know that money can be made if the business be intelligently managed. As far as the farmer is concerned there is little risk. While the profits of the beet-sugar manufacturer may be lessened by changes in provisions of political economy, the farmer is not necessarily subjected to influences of that kind. In this case, he is aware that root crops are profitable, and that aside from this, his farm lands will receive a treatment which has everywhere been proved to enrich, rather than to exhaust the soil.

To restore his land to something like its original productive-

ness, and to do this mainly through capital furnished by outside parties, is worthy his serious consideration.

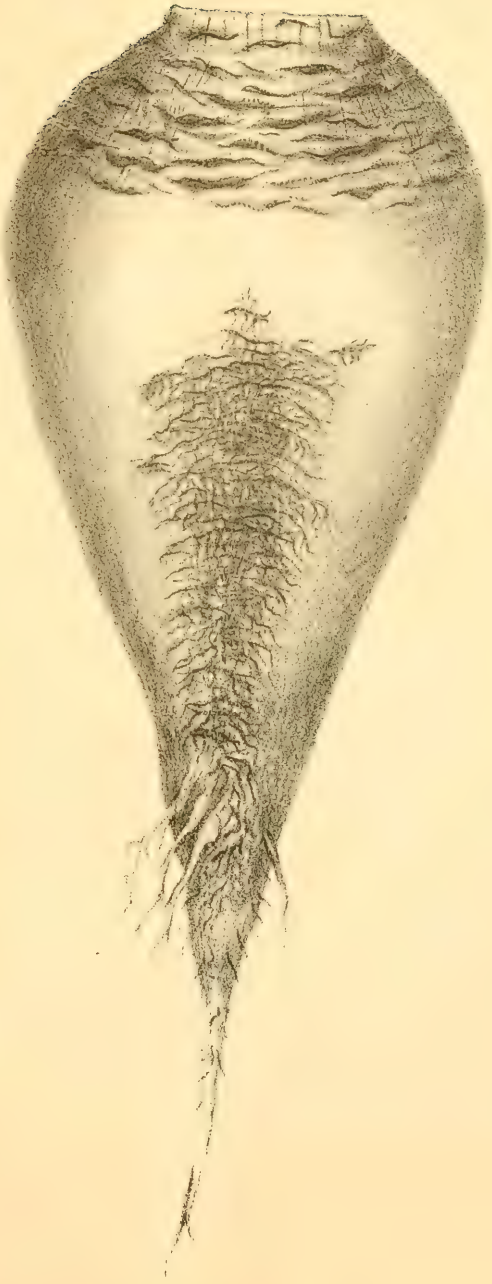
The real importance of this subject to the farming interest of the Commonwealth, as well as to the people at large, can never be satisfactorily determined, except by a series of wisely conducted experiments, which can no where be so appropriately undertaken as at the Massachusetts Agricultural College.

APPENDIX.

Results of the Examination of Sugar-beets raised on the College Farm during the past season.

NAME.	Source of Seed.	Weight, in pounds.	Percentage of Sugar in juice.
I.—Vilmorin beet,	Saxony,	$\frac{3}{4}$ to $\frac{7}{8}$	15.50
II.—Vilmorin beet,	"	$\frac{3}{4}$ to 1	15.61
I.—White Imperial,	"	$\frac{3}{4}$ to $1\frac{3}{4}$	14 20
New Imperial,	"	$1\frac{1}{4}$ to $1\frac{3}{4}$	13 80
I.—White Magdeburg,	"	$1\frac{1}{2}$ to 2	13.10
Quedlinburg,	"	$1\frac{1}{2}$ to $1\frac{3}{4}$	13 44
II.—White Imperial,	"	$1\frac{3}{4}$ to 2	10 27
II.—White Magdeburg,	Silesia,	$1\frac{1}{2}$ to $1\frac{3}{4}$	10.06
White Silesian,	"	$1\frac{1}{4}$ to $1\frac{1}{2}$	9.72
III.—Vilmorin beet,	"	$1\frac{1}{4}$ to 1	9.93
Long White beet,	"	$1\frac{1}{4}$ to $1\frac{3}{4}$	8 60
White Sugar beet,	"	$1\frac{3}{4}$ to 2	7.20
Vienna Red beet,	"	$1\frac{3}{4}$ to 2	8.10

The percentage of sugar was ascertained by means of a polarization apparatus, and the results obtained, in several instances, verified by Trommer's test. My thanks are due to Mr. J. E. Heyl, of Philadelphia, for kind assistance rendered in the laboratory work during his stay as special student in chemistry at the Agricultural College.



FRENCH VILMORIN SUGAR BEET

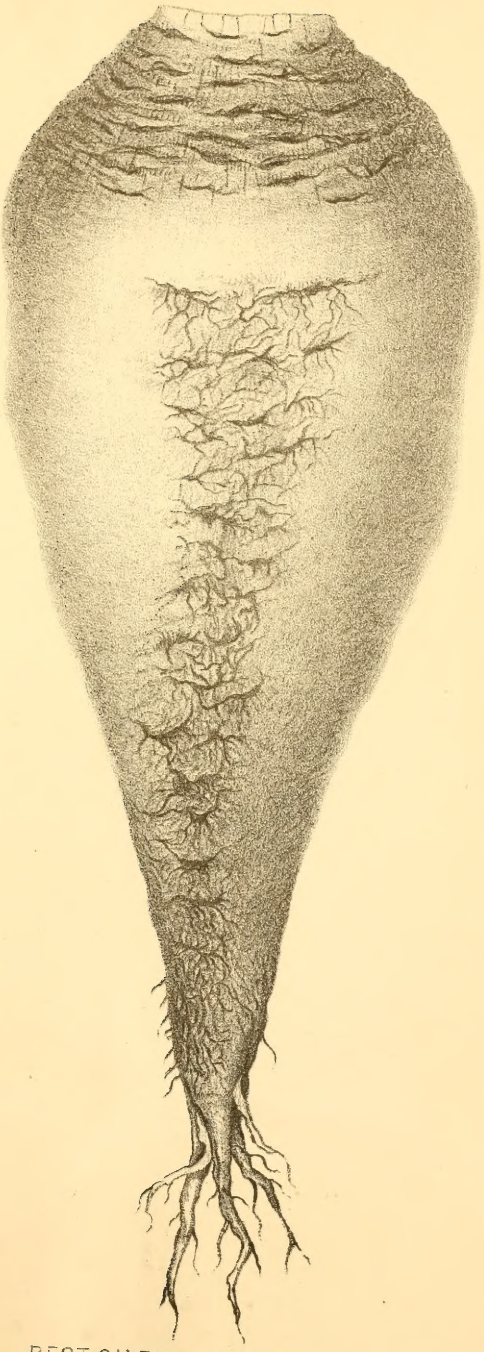
Weight 1 lb

FRENCH VILMORIN SUGAR BEET

Weight 1 lb. 4 oz.

WHITE IMPERIAL SUGAR BEET.

Weight 1 lb 1 oz



BEST SILESIAN SUGAR BEET.

Weight 1 lb 5 oz.