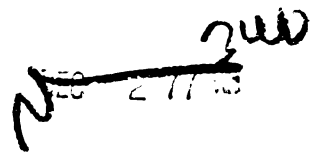

THESIS

THE SUGAR BEET AS A CROP FOR THE MICHIGAN FARMER

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THESIS

"THE SUGAR-BEET AS A CROP FOR THE MICHIGAN FARMER"

That science enters largely into the successful operation of many of our manufacturing and agricultural enterprises, is an undisputed fact; this is especially true of the sugar-beet industry. By scientific methods of selection and cultivation, the horticulturalist, with the aid of the chemist, has taken the weed-like plant of the Mediterranean shore and southern Europe, enlarged its root and stored it with sugar; the chemist has taken this plant and by scientific methods, has made it possible to separate its saccharine qualities, until today, its snow-white crystals furnish food for the millions.

However, as is the case with all new agricultural enterprises, the people have to be educated and instructed as to the best method for producing the raw material to be used. This was, and is still, the case in regard to the sugar-beet industry. Farmers are anxious to learn all they can about this industry and as a result, letter after letter is being received at the State Experiment Station from people who are desirous of information in regard to raising sugar-beets; the following will serve as an example:

Holt, Mich., Jan. 10, 1901.

Mr. J. D. Tower,
Agricultural College,
Michigan.

Dear Sir:

Will you kindly send me what information you can regarding sugar-beet culture and its effect upon the soil, best methods of cultivating, price received per ton, and the number of tons per acre, kinds of soil best suited for their culture and such other general information as would be of interest to farmers.

Many farmers here raise strong objections to the industry and attack the college for endorsing it, and claim that farmers in other parts of the state, who have engaged in the business, have quit, because it is not profitable to raise beets at the price the factory pays. I should like to know the facts in regard to the matter.

Yours,

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At the suggestion of Dr. R. C. Kedzie, and in view of the fact that so many were seeking information in regard to sugar-beet culture, it was thought that the sugar beet industry would prove a valuable field in which to do original and research work. Therefore, it is the object of this thesis to discuss, in some degree, sugar-beet production relative to seed, soil, climate, cultivation, production of the crop, and its effect upon the soil etc. but more particularly, to consider the value of the by-products of the factories of the state, their value for feeding and for fertilizers. In other words to discuss the question: "The Sugar-beet as a Crop for the Michigan Farmer"

It is not the purpose of the writer to enter into the history of the sugar-beet industry in Michigan, however, he feels that it would be an injustice not to mention the names of a few men who have labored unceasingly , in the promotion of the sugar industry of our state. First and foremost among these , Dr R. C. Kedzie, who for several years, labored with the hope that we might obtain our supply of sugar from the sister plant of the sugar cane, the sorghum plant. but after being convinced that it was useless to look for our supply of sugar from this source, he abandoned the work and with the same earnestness , took up the work of the sugar beet, until to-day, his name is proverbially connected with the industry.

Prof.C. D. Smithhas done much for the industry in our state. In almost every locality where beets are grown, you will hear Prof. Smiths name mentioned in connection with what he has told the farmers in regard to raising the crop." Prof. Smith told us so" are words that I often hear from the farmer.
Prof. F. S. Kedziehas always been much interested in the sugar industry in Michigan and in 1891, personally, obtained beet-seed from Schrieber in Germanyfor testing in this state.
The other members of our Experiment Station staffare deserving of much praise for their valuable services in the promotion of the industry, as is,also, Mr. S. G. Higgins of Saginaw.

The sugar-beet industry has made wonderful progress in Michigan . Three years ago the first factory was built at BayCity, today Michigan has more factories than any other state in the union, having ten factories in operation and two more in construction. The cause of this wonderful progress is due, largely, to three reasons; First, the launching of the industry was due , in a large degree, to the bounty offered by the state and the first factory was built at Bay City in 1898. This factory was successful in its first years run and this encouraged other capitalists to invest in like enterprises. Secondly, to the wide-awake and energetic men who saw the great possibilities of the industry and who spared no pains in forwarding its interests. Thirdly, to a good climate and soil and excellent manufacturing facilities.

CLIMATE

As will be seen by map(1) Michigan is located in what is known as the sugar belt of the U. S. This belt is about two hundred miles wide or one hundred miles on either side of the summer isotherm of 70 degrees Fah. The isotherm of 70 degrees begins near the city of New York , passes up the Hudson to Albany , then S. W. striking Lake Erie near Toledo, and then enters Michigan, reaching its highest point nearthis place(Lansing). It then passes S. W. after reaching Chicago, it passes N. W. through St. Paul,then westward to the Dakotas, then nearly south to the south boundry of New Mexico, then westward again through Arizona , and then touching the states of California, Idaho,and Utah. It is predicted that upon this area the beet-sugar industry of the U. S. will finally rest.

There may be smaller areas in different parts of the U. S. that will raise beets at a profit, but it will be due to some excellent

qualities of soil or climate and not directly to high or low temperatures . This is illustrated in Michigan by beets grown in the upper peninsula, where beets rich in sugar and high in purity were raised; not throughout the peninsula but in certain localities . Beets can be raised farther north than the isotherm of 70 degrees but the seasons are to short to produce sufficient tonnage and to give a sufficiently high per cent of sugar, except in certain localities , as has been mentioned. South of this line, we get the tonnage but have beets of low purity. North temperate latitudes seem to be the best suited to growing the sugar beet. Latitudes with a summer temperature of 70 degrees for the months of June, July, and August are the ideal locations forthe sugar-beet as far as temperature is concerned.

It must not be understood that all parts of this beet belt are equally suited to the growing of beets. This fact is due to variations in soil, temperature etc. Northern Nebraska and South Dakota, like Michigan, have long, cold winters and the beet crop has but a limited period for growth, while in southern California, they have scarcely any winter and can begin their planting in January and have a crop maturing from August until December, thus saving the trouble of siloing and, also, prolonging the campaign.

In this sugar beet belt there are three districts as relative to moisture. California and some of the land along the Platte and Arkansas rivers seem to have sufficient subterranean moisture and can grow a crop of beets without rainfall or irrigation. There is an advantage in irrigation in the fact, that, by with-holding the water supply, the crop can be matured at any time and there is no danger of a second growth from warm fall rains as is sometimes the case in Michigan. The third district is the one to which Michigan belongs, viz.; where there is no subterranean moisture and where irrigation is impracticable, but where there is sufficient rain in May and June to give the beets a good start and to develop a sufficient tap-root sothat they do not materially suffer from the drouth which frequently follows. July, August, and September should have plenty of sunshine and ripening weather to properly develop the crop. Dry Junes are very detrimetal to the crop, as they dry up the young plant. Warm fall rains are detrimetal. Beets will stand quite extremes of cold without being injured and can, therefore, be sown earlier in the spring than some other crops . Frosty nights in late autumn are often beneficial . I remember , while at Alma last year, that there were a few days of cool weather , with an occasional frost at night, and during this period analyses showed that the beets gained nearly one per cent, each day, in sugar content. A check in the growth seems to aid in the storing of sugar. [redacted]

In a personal letter from Dr. Wiley, he says " It is evident, that the culture of beets will finally be confined to those areas that are suitable for the growing of corn and wheat and located where the conditions of manufacturing are most favorable, that is, cheap fuel, good water, cheap labor, and good transportation. "

Michigan has all these conditions, see map (2) and I see nothing to prevent her from always holding the record she now has, unless it be that of area, as some other states having more area, can produce a larger tonnage .

SOIL

Any soil that will raise a good crop of corn or potatoes will be suitable for sugar beets. A deep sandy loam is an excellent soil; what is wanted is an open, porous soilwith a loose sub-soil. If the sub-soil is hard it must be loosened with a sub-soil plow before the crop is planted. Stiff clay is not good, for it is not only difficult to till, but it soon bakes and becomes hard , and does not retain the moisture, and,as a result,the small beet plant soon wilts and dies. Clay loam makes a good soil for beets. Muck that has been recently reclaimed, is not good for beets , for, although a large tonnage can be secured,the beets will contain too much of non-saccharine material to make them valuable for the manufacture of sugar. Lime will be found beneficial on both clay and muck, making the clay more open and friable and at the same time, assist in the liberation of other fertilizing elements , while upon the muck, it will neutralize the organic acids that may be presentand,also,assist in the decomposition of the organic substances in the soil.

Lands, intended for beets, should not be recently manured as this not only seversthe connection with the water supply below, but, also, causes the beets to become sprangly or branching towards the apex. The factories do not care for such beets as they are more difficult to work in both the tare-house and the factory. Beets should not be grown upon the same field for successive years. The following rotation is suggested by the Michigan Experiment Station as being well adapted to lower Michigan ; wheat, followed by beets, then clover, one crop cut for hay, the second plowed under, then potatoes or corn, then wheat, and finally beets again. Manure should be applied before planting the corn or potatoes, thus, giving it time to become decomposed before the planting of the beet crop. It is well to have beets follow wheat or some such crop so that the ground can be fall plowed. A sugar factory agriculturalist has given the following as a natural beet soil " Deep, rich,sandy loam and clay with plenty of vegetable earth and free from stones, containing a sufficient quantity of calcium, with a well drained, warm sub-soil similar to the top stratum, admitting of deep cultivation. The following may suggest a list of soils to be avoided in beet culture;

1, Hard clay.
2, Stony soils----these do not hold moisture and are difficult to work.
3, Gravelly soils-- cannot hold moisture.
4, Blowing sand.
5, Peaty or mucky soils as a rule-- they are too rich in organic matter (nitrogen).

The following table shows some of the more important elements found in the soil from fifteen counties located in the sugar belt of Michigan.

(Map 2) The analyses were made by Dr. R. C. Kedzie of the M. A. C. in 1893 .

Potassium	Calcium	Phos. acid	Nitrogen in organic matter
2.05 %	2.10 %	.41 %	9.39%
1.18 %	1.28 %	.40%	2.98 %
1.10 %	1.38 %	.33 %	7.50 %
1.97 %	1.46 %	.31 %	4.66 %
.83 %	.51 %	.13 %	3.41 %
.90 %	.62 %	.23 %	3.78 %
1.19 %	.80 %	.29 %	3.06 %
1.80 %	1.14 %	.33 %	3.18 %
.86 %	.87 %	.19 %	2.35 %
.54 %	.36 %	.15 %	1.34 %
1.85 %	1.64 %	.49%	5.30 %
1.90 %	.99 %	.36 %	5.90 %
.73 %	.35 %	.14 %	1.22 %
1.18 %	1.18 %	.38 %	5.57 %
.92 %	.68 %	.14 %	2.82 %
1.26 %	1.02 %	.28 %	4.16 % (average)

The above table shows in a general way, the manurial elements of the greatest importance that are on hand and at the disposal of the farmer; as to what extent he can keep these elements and at the same time raise a large crop of beets, will be discussed under the head of soil exhaustion.

SEED

The sugar-beet has been brought to its present high state of development only by careful methods of selection and cultivation. It is, therefore, under a sort of tension and it is only by the utmost care that we are able to keep the beet from deteriorating in sugar content. One has but to watch the beets as they come into the factory , to see , now and then, one of these beets that has the characteristics of some earlier and less sweet variety, therefore, we cannot use too much care in selecting our seed , if we wish to be successful in raising beets for factory use.

The production of seed is one of the most important operations connected with the sugar industry. As yet, but little has been done in this country along this line. Experiments show that home grown seed produce earlier plants. An experiment along this line gave the following results; Home grown seed gave thirteen and five-tenths tons per acre with fifteen and eight-tenths per cent sugar or 4,266 # of sugar , while the foreign grown seed gave thirteen and three-tenths tons per acre, with fifteen per cent sugar or 3,990# of sugar. Another experiment at Schuyler, Neb. showed that home-grown seed gave 21.1 tons of beets per acre and 5,891# of sugar, while the imported seed gave 17.9 tons of beets per acre and 5,185 # of sugar. This shows an increase of 12 % in quantity of sugar produced per acre in favor of domestic seed.

Imported seed is in danger of being injured in transportation as the moist air in the holds of the ship often causes the seedto become mouldy and the vitality is injured.
We are using about 800,000 # of beet seed , annually, in the U. S. thisseed sold for fifteen cents per pound amounts to $120,000 per year which we are paying to European countries for seed. I believe the time will soon come when all the seed used in the U. S. will be produced at home. The seed is produced somewhat as follows; the beets of the field are harvested with extraordinary care and the grower selects beets of good shape and weighing from sixteen to twenty five ounces, these are stored in silos and the next spring they are again sorted and the best are thrown into a salt solution of a certain density , those that float are thrown away, those that sink (the mother beets as they are called) are taken, and a portion of the beet is removed and tested for sugar ; if they contain a sufficient amount of sugar, they are saved and set , in rows and about thirty inches apart in the row. These are allowed to go to seed , this seed is harvested, cleaned, and stored in a dry place. The next year, this seed is planted and the beets siloed. The fourth year these beets are planted, usually without testing with a polariscope , and the seed from these beets are put upon the market. I made several tests to determine which part of the beetcontained the most sugar, and I found a variation of, from one to three per cent between the centres and the tops. This has to be taken into account in making the test of mother beets in order that the sample taken may be an average sample. The amount of sugar present in the beet varies , also,according to the time of the year. A German sugar manufacturer tells me that in raising beets for the production of seed, often , but two years are allowed for the production of seed. They merely test the beets and if they have a sufficient high per cent of sugar they set them out and thus get a crop of seed the second year.

TESTING SEED

Seed,as obtained upon the market, is frequently labeled" fresh , clean, good ." These are relative terms and do not signify much and give no idea as to the vitality of the seed or its purity. The seed used by the farmers is now largely furnished by the factories and they have the seed tested by their chemist or at some one of theExperiment Stations .In making the test, the following determinations are usually made;

I, Percentage of water.

Drying ten grams at 100 degrees C. in a hot air oven to constant weight.

2, Foreign matter.

This includes dust, earthy matter, foreign seed , vegetable matter, etc. The rough surface of the seed-ball makes it a good collector of dirt, seed etc. which add quite materially to its weight. The dirt is separated by means of a sieve. The seed is then spread out and the stems , leaves etc. removed. Gross weight less the last weight equals the foreign material.

3, Viability of seed

This means the number of plantlets that can be secured from I00 seed-balls in I4 days.

4, The number of seed balls per kilogram of seed.

5, The number of lifeless or unviable seed-balls per hundred .

A simple method for testing seed-balls, is to count out I00 seed-balls of average size and put them between blotting papers, which are placed in a dish and kept moistened with water. (A glass can be placed over the dish to conserve the moisture) These are allowed to grow for I4 days, each day, those that have sprouted are removed and the sprouts counted and recorded. The government standard is that I00 seed balls shall give I50 sprouts.

VARIETIES

The following tables show the results of four years work at this place (M. A. C.) , relative to varieties.

	Yield per acre	Per cent sugar	Purity
	I897		
Original Kleinwanzlebener	27,368 #	I8.27 %	94 %
Le Plus Riche	29,205 #	I8.78 %	92 %
Gov. Kleinwanziebener	25,648 #	I7.78 %	94 %
Improved Kleinwanzlebener	25,678 #	I6.40 %	9I %
	I898		
Kleinwanzlebener	20,840 #	I2.92 %	74.2 %
Vilmorin Improved	I8.493 #	I2.92 %	8I.8 %
Schreibers Elite	I6,556 #	I3.0 %	80.2 %
Vil. Blanche Ameliore	I8,06I #	I2.39 %	78.3 %
	I899		
Kleinwanzlebener	I0,6I9 #	I3.64 %	78.50 %
Vilmorin Improved	I2,020 #	I2.80 %	79.I0 %
Zehringen	I0,283 #	I4.00 %	80.60 %
Russian	II,390 #	I4.38 %	80.90 %
	I900		
Kleinwanzlebener	28.640 #	I3.44 %	83.I2 %
Zehringen	28,760 #	I4.48 %	82.4I %
Austrian Special	25,200 #	I2.98 %	8I.67 %

The average of 257 samples of Kleinwanzlebener , raised by farmers in different parts of the state, gave the following results; sugar I6.42 %, purity 83.3 % . Vilmorin Improved ; sugar I6.50 %, purity 84.4 %. These tests place the Vilmorin in the lead, however, it is generally agreed among sugar men that the Kleinwanzlebener will do better on heavy soils than the Vilmorin . The Vilmorin is better suited for a sandy soil.

PLANTING

The ground for the beet should be plowed in the fall and at the same time sub-soiled; in the spring it should be plowed again and and rolled. The rolling is beneficial in, that it establishes a capillary connection with the ground below and prevents the drying

out of the land. Some agriculturalists believe that shallow plowing in the fall and plowing and sub-soiling in the spring, to be the better plan, but it seems to me that the sub-soiling should be done in the fall as by the aid of the frost and action of the weather, considerable plant food is put into a more available form, and beside, the mechanical condition of the soil is improved . By fall plowing, the weeds that start in the fall can be cultivated out, thus, greatly reducing the number that might trouble in the spring .

Much discussionhas arisen in regard to sub-soiling. Why should we sub-soil for beets and not for potatoes ? We might sub-soil for potatoes but it is not as necessary as in the case of the beet. (Cut No. I)shows the rooting system of the potato, compare this with the beet (Cut No. II) and it will readily be seen that there is a great difference in the manner in which the two plants root. The beet sends its root very deep into the ground while the potato grows comparatively near the surface. We sub-soil, first, to enable the beet plant to send its roots deep into the ground and thus establish connection with the soil below which enables it to withstand the early summer drouths. Second , to get a better shaped beet. (Cut III)shows a beet that was grown on soil that was not subsoiled and it is an ill-shaped beet. By actual count, 71 % of the beets from a plot not sub-soiled were classed as ill-shaped and only 40 % were so classed from the sub-soiled plot. There seems to be no difference in sugar content.

No experiments have been tried at this college (M. A. C.) in regard to the effect of sub-soiling with beets; but in Colorado, an experiment on six plots showed the following results; average of the plowed plots 4,287 #, ; sub-soiled plots, 5,278 # , a gain of 23 % as the result of sub-soiling. A second trial with four plots, gave the plowed plots I905 #, ; sub-soiled plots, 2,I28 a difference of I2 % in favor of sub-soiling, or an average on the ten plots of I8 % in favor of sub-soiling.

Having established a good seed bed , the next operation is the putting of the seed into the ground. Where one has but a few acres, this can be done with a hand drill (Cut 5) but where there is more than an acre, it would be advisable to use a horse drill or a beet seeder as they are called. Those with a wheel behind the shoe are good seeders as the wheel enables the operator to regulate the depth of planting and beside, this wheel assists in packing the dirt about the beet seed.

Beets should be planted, as a rule, about the time we plant corn or potatoes in this state, possibly, a little earlier, as the beet seed will germinate at a lower temperature than corn and better withstand light frosts. Some advise sowing as early in the spring as possible but I think much must be left to the judgment of the farmer in this regard. As a rule, a better crop is secured by early sowing for reasons before mentioned e. g. the beet developes a sufficient tap-root to enable the plant to resist drouths that may follow. In regard to early planting, the Colorado station says; " It can be said , that taking into account all the factors of the problem, there is a decided advantage in early planting; it gives a better stand, produces a larger crop and this

crop is of good quality in sugar and purity.

About 12 or 15 lbs of seed should be sown per acre. This is a rather heavy seeding but a heavy stand is much better than a light one, as the extra beets can be pulled out but the vacant places cannot be filled.

In regard to the distance between rows and between the beets in the row, there seems to be considerabledifference of opinion. In this regard, there are at least, four factors to be taken into consideration; First, the matter of thinning, a difference of four inches between rows, makes a difference of a mile per acre, in travel, while thinning, and this is worthy of consideration, when one has to travel upon his hands and knees, as at present. Secondly, the matter of cultivation. It is much better to have the rows wide enough so that the cultivators used for corn may be used with the beets, andbeside, the horses are in less danger of stepping on the rows. The Michigan Station advises from 18 to 22 inches, preferably 18 inches. The rows should be made very straight. Thirdly, the question of tonnage. What distance should we plant in order to get the largest yield per acre ? Colorado has made some experiments along this line with the following results in 1899. ; rows 24 inches apart ; 23.7 tons per acre, rows 27 by 11 inches gave a yield of 28.1 tons per acre. Of course, the more crowed the beets are in the row, the smaller they will be. Medium sized beets, as a rule, are better than either large or small beets but the size is less determinative of the quality of the beets than the conditions under which they grew. Fourthly, the question of sugar content. Nebraska has spent several years in experimenting in regard to both tonnage and sugar content. I quote the following from Bul. No. 60 of that station; "the most satisfactory method of planting was in rows 18 inches apart and thinning out the beets to 8 inches in the row, as compared with rows 30 inches apart, and, also, as compared with hills 18 by 18 inches apart."

CULTIVATING

As soon as the rows can be seen plainly, cultivating should begin. Put on a shield to protect the plant and then cultivate close to the row. Experience has shown, at least, at Alma, Michigan, that cultivators with a blade-like tooth running parallel to the surface of the ground and serving as a weed cutter does not do the work that a cultivator should do; they leave the ground too hard and cultivators that have the ordinary tooth are being substituted in their place. I have obtained the above information from the agriculturalist of the Alma Sugar Co. . The ground should be kept clean and in a loose condition.

THINNING

This work, withdoubt, is the most monotonous and exausting work of any connected with the sugar beet crop. It is an objection most often raised by farmers for not raising sugar- beets and the

farmer certainly has good reasons for objecting . In thinning ten acres of beets, one has to travel, upon hands and knees, the distance of 55 miles, and beside this, the work has to be done at a certain time and it may be difficult to get help. I have heard many farmers say that they would raise beets were they sure of help during the time of thinning . In this regard, I can only give the expariences at Alma, and what I have heard from Bay City.At Alma, Mr. A. W. Wright, who grew several hundred acres last year said he had plenty of help and that he had to turn away some men, I have been told that there were men whom came to Alma from various parts of the state during the beet season in search of work. A gentleman, who was employed at Bay City, told me that they had no serious trouble there although there were a few days when they had to pay $I.25 per day beside having to drive those who were employed to and from the city.

There is a plan that has been tried and it seems to work fairly well. It is something like this: after the close of the city schools, those pupils who so desire are placed in charge of a gentleman who provides tent, cooking utensils, etc. in fact, a complete camping outfit and he, together with the children, go into the country and thin beets for the farmers for a certain compensation per acre. During this time, they live and eat in the tent and when one job is completed, they move to the next. Care is taken to give the boys some recreation along with their work so that it is not " All work and no play" . This plan accomplishes a threefold purpose: it gives the children in our large cities an outing, for which, at present, thousands of dollars ~~of dollars~~ are raised each year. It gives the children money to be used in attending school in the fall, and solves the question as to how the farmer is going to get his beets thinned.

Beets should be thinned at just the proper time and to accomplish this, the beets should not all be sown the same week. thinning should begin as soon as the fourth leaf appears and they should be thinned to about eight inches in the row , perhaps six inches on fertile soil. Great care should be used not to injure the leaf for this is of vital importance to the beet plant. Careless thinners may do a great amount of damage. Experiments, in regard to the effect of delaying the thinning are shown by the following;

Beets thinned at the proper time ----------I5 tons per acre
Beets thinned eight days later ---- ---------I3 tons per acre
Beets thinned fifteen days later ----------II tons per acre
Beets thinned twenty-two days later---------- 8 tons per acre

This shows that thinning is a very important factor in beet raising, Two beets should not be left to-gether as neither will make the development. Leaving too much space between beets should also be avoided as the beets will grow too large and the sugar content will thus be reduced.

HARVESTING

When the leaves of the beets nearly cover the space between the rows , cultivation should cease and the beets be allowed to

store up sugar. through the warm sunshiny days which follow. Cultivating too long causes a stimulation of the vegetable growth at the expense of the sugar, the same effect is produced by warm fall rains. When the leaves of the beet begin to turn yellow, harvesting should begin. There are several methods that can be used in harvesting; the beet-puller is quite extensively used at present. If there is no beet-puller at hand, one can plow along one side of the rowand then the beets can be pulled out very easily. After the beets are pulled, they should be topped and thrown into piles or on the wagon. Cut (4) shows how the beets should be topped, all the beet that grows above the ground has to be removed and here is where another large loss comes in by raising beets under improper treatment. That part of the beet above ground is rich in mineral salts and therefore, the manufacturer does not want the tops but for the reason that they are rich in mineral salts, the farmer does want them.

The beets after being topped, can be thrown into long piles, by placing four rows together, or they can be put into crates and taken directly to the factory. At Alma, those farmers, who had to leave their beets in the field for some time, made piles by continually throwing beets toward the centre and when the circle became so large that thay could not easily throw to the pile, they covered the pile with leaves and by putting a little dirt over these , the beetscould be kept for some time. Beets frozen once are not materially injured, but freezing and thawing is very effective in producing invert-sugar. Farmers should not be mistaken and think that they get payfor the dirt on their beetsnor for the crowns, these are all taken out in the tare.

Farmers at Alma, say that they raised the crop the second year at one third the cost of the first year. I can remember when ~~beans~~ beans were not raised in my part of the state, practically, for the same reason that many farmers refuse to raise beets to-day: they said it was too much work to harvest the bean crop as they must all be pulled by hand. To-day, these same farmers, who, but a few years ago, raised scarcely enough beans to supply their tables are now raising from 40 to 100 acres. Why? Because Yankee genius has come to their aid and now no one thinks of pulling beans by hand . Altho, it seems that the farmer is doomed to always be compelled to pull his beets by hand, still, I believe the time will soon come when this will be done by machinery. Europe preceded us in the sugar industry, nevertheless, many of her methods are too slow and cumbersome for use in this country. Recently, a gentleman, who was interested in the beet industry, made a visit to a farm where a modern German cultivator was in use. It required a heavy team and three men (labor is cheap in Europe) to manage it and it cultivated four rows. The same day, a visit was made to another field where an American cultivator was in use, it required but one man and a mule, was cultivating the same number of rows and doing as effectual work as the other. The same thing is true of factory machinery, it does not give the satisfaction that the American machinery does.

INSECTS

" It is not good for man to be alone " and upon the introduction

of a new crop, the farmer soon finds that he must begin war against some insect pest. Thus far, in Michigan, no great damage has resulted to the crop from insects, However, among the more troublesome might be mentioned the cut worm. These pests are more troublesome on sod lands. The cut worm works mostly at night. Bates made of cabbage or turnip leaves may be used by scattering these about the field and covering them with Paris green.

The Beet Aphis is an insect that formerly worked upon weeds such as the yarrow, door-mat etc. and sometimes found upon the potato, but upon the introduction of the beet, it has taken up its abode upon this plant. They remain in the ground during the winter and if the roots of the yarrow be examined there will be found insects in all stages of development. In April or May, the full grown insects give birth to 8 or I2 young which are wingless and these go on bearing young in their turn. In summer, we get a winged species which fly about, and lay eggs which are to tide them over the winter. These insects injure the beet crop by sucking the juices from both the roots and leaf, causing it to wilt. Fall plowing does not seem to be very effective in destroying the pest as they can endure much cold. Avoid planting beets on fields that were previously covered with weeds and do not plant thesame field several years in succession.

The Leaf Minerproduces a blister like mine between the upper and lower epidermis of the leaf. This insect is about one-half the size of a house fly and belongs to the same family as the onion fly, cabbage root maggot, and the bean maggot.

BACTERIA

There is a bacterium known as Violet Mold which is found on the roots of the beetand it has a violet color, it seems to spread and one plant that is effected will soon produce the disease upon a large area.

FUNGI

Beet Rust(Uromyces betae) attacks the leaves and stems of the beet. The acidium stage exists while the fungus is on the beet seed, possibly, the seed might be treated in some way?

White rust forms white pustules on both sides of the leaf.

Spot Disease (Cerospora Beticola) appears as round spots on both sides of the leaf,, being pale brown when the leaf is green and becoming darker, later.

Scab, this is the same as potato scab,therefore, do not follow potatoes with beets,in rotation.

Nematode is not a fungus but a disease caused by an eel-like worm which punctures the roots , causing the beet to wilt.

FERTILIZERS

Occasionally, there is received at the Experiment Station at this college(M. A. C.) a small box, containing a handful of soil and the sender wants to know what kind of fertilizer he shall use on such a soil. The botanist cannot tell what the particular species

of an apple tree is by one leaf, nor the chemist what particular kind of fertilizer should be used, merely, by the analysis of a small sample of soil, for the sample may be much different from the soil a foot from where the sample was taken and even if it should represent an average for the field , the chemical analysis would not show just what fertilizer would be best to use,as this depends upon the kind of a crop we intend to raise and is greatly influenced by methods of cultivation and rotation. The chemist can, only in a general way, tell what fertilizers are best for a certain crop. The best test is by the use of a certain kind of fertilizer upon a given soil and crop.

The question that is of interest at present is relative to what fertilizers we can best use with the beet crop. We will consider this from facts gained from chemical analyses and soil tests. In my analyses of the beet, I found that there was in one ton:

Moisture ----------	I,732 #
Dry matter ---------	267.6 #
Nitrogen ----------	4.98 #
Phosphoric acid ------	2.46 #
Potash ----------	I2.92 #

The U. S. Dep t of Agr'l.have made several hundred analyses and their results would more nearly represent an average sample than my results from the analysis of but a few samples. They obtain the following results; in one ton:

Moisture----------	I,730.0 #
Dry matter----------	270.0 #
Nitrogen----------	4.4 #
Phosphoric acid-----	2.0 #
Potash ----------	9.6 #

In order that we can make a comparison of the elements removed from the soil by the beet with the elements removed from the soil by some of the other leading farm crops , I give the following table which gives the results of the analyses made by the U. S. Dep't of Agr'l.

Elements removed by one ton of

	Nitrogen	Phosphoric acid	Potash
Corn ----------	33.06 #	II.80 #	7.40 #
Wheat ------	37. 53 #	I5.80 #	I0.60 #
Rye -------	35.20 #	I6.40 #	I0.80 #
Barley --------	39.65 #	I5.40 #	9.00 #
Oats ------	36.42 #	I2.40 #	8.80 #
Meadow Hay ----	20.42 #	8.20 #	26.40 #
Clover Hay ---	40.36 #	II.20 #	36.60 #
Timothy Hay---	25.20 #	I0.60 #	I8.00 #
Potatoes ------	6.40 #	2.40 #	9.60 #
BEETS ---------	4.40 #	2.00#	9.60 #

It requires no argument to show, that in raising the above crops, we would not use the same fertilizer as in raising a crop of beets. for example, a ton of clover hay removes 40.3# of nitrogen while a ton of beets removes but 4#, if 40# of nitrogen were applied to the beet on an area sufficient to raise a ton, it would without

doubt, ruin the crop, as far as its use for the factory is concerned. Rye removes I6 # of Phos. Acid, while beets remove but two lbs. therefore , we would not use the same fertilizer for rye as for sugar-beets. Clover hay removes 36# of potash per ton while beets remove 9# per ton. Thus, we see that the kind of a crop we are raising decides, in a large degree, the kind of a fertilizer we need to use. It is impossible to draw fast rules applicable to all circumstances and the farmer should ever be alertive to the need of studying the special requirements of his soils with the view of securing greater economy in the use of fertilizers.

In regard to fertilizing the beet, there is another matter to be taken into consideration and that is whether the beet tops are left on the ground or removed from the field. In raising beets for the factory use, it is the general custom to leave the tops upon the ground as they are used for covering piles and then are spoiled for feeding. When the leaves are fed, and the manure is returned, we get the fertilizing elements returned to the soil so that there is no great loss. The table below shows some of the more valuable elements that are to be found in a ton of the roots and leaves:

	Roots	Leaves
Ash ------	I4.I0 #	36.20 #
Of this ash there is		
Potash	6.60 #	I3.00 #
Phos. acid ---	I.60 #	2.60 #
Nitrogen -----	3.20 #	7.80 #
Magnesia -----	I.00 #	6.00 #

From the above it will be seen that the farmer, who removes the leaves from his field or does not use them for fertilizing purposes is making a serious mistake for there is twice as much of the fertilizing elements in the leaves as in the roots. The loss or in other words the cost to replace the material removed by the leaves would be as follows:

I3 # of potash at 5 cents per pound --------	$0.65
2.6 # of phos. acid at 4.5 cents per pound	$0.I2
7.8 # of nitrogen at I4 cents per pound -----	$I.09
Total ---------- ----	$I.86

The above shows that for every ton of leaves removedit will cost the farmer $I.86 to replace the fertilizing elements that have been lost should he buy them upon the open makketin the form of commercial fertilizers.

The amount and kind of fertilizer to use, depends also, upon the kind of soil upon which the beets are to be grown. We would not need to use a fertilizer as rich in potash upon a heavy clay as upon sand., provided the existing conditions in regard to the other elements were the same. I give below a part of the analyses of the clay, loam, and sand soils of Michigan as given by Dr. R. C. Kedzie in his bulletin on "Michigan Soils."

	Clay
Lime --- ------	I.28 %
Phos. acid ----	.4I %
Potash ------	2.I2 %
Nitrogen -----(Organic matter 4.I0 %--II% N)----	.45 %

Loam

Lime ----------I.46 %
Phos. acid ---- .3I %
Potash --------I.97 %
Nitrogen (Organic matter 4.66 %---.I2 % --- .56 %

Sand

Lime ---------- .32 %
Phos. acid ---- .0I %
Potash -------- .30 %
Nitrogen (Organic matter 2.25 %---.04 % N)-}}}}.09 % N

In the clay soil, we have 2.I2 % potash while in the sand we have but .30 % . In phos. acid , we have .4I % in the clay and .0I % in the sand : and in Nitrogen, the clay has .45 % while the sand has but .09 % . This would indicate that clay would be better for beets than sand as far as the chemical constituents are concerned, but owing to certain mechanical conditions, as well as chemical, the clay loam seems to give better results than either sand or clay. The table below shows the results from two years of experimenting in different parts of this state in regard to different kinds of soils for beets.

	I897			I899		
	No. of analyses	sugar in juice	Purity	No. of analysis	Sugar in juice	Purity
Clay loam	57	I6.84 %	8I.7 %	34	I4.90 %	86.6
Sand loam	I40	I6.37	84.0	58	I4.60	8I.I
Sand	62	I6.0I	83.5	29	I4.70	80.5
Clay	22	I5.90	8I.6	8	I4.30	79.2
Muck	4	I3.I4	78.00	I5	I3.II	78.3

For general farming in Michigan, I do not think it pays to use commercial fertilizersbut for the sugar beet, I think fertilizers can be used with profit. Potassium, it is believed, is useful in aiding in the formation of sugar, the more potash, up to a certain degree, the more sugar. Experiments show that the potash is in a certain ratio to the saccharine richness of the beet. Potash, as a rule, is not so much needed on heavy as on light soils. Kanite, appliedat the time of the first or second hoeing of the crop, proves very beneficial, more so, than when sown with the crop. Phos. acid aids in giving the beets a higher quotient of purity . Beets use nitrogen in the growing of the whole root , it determines, largely, the yield per acre, hence, potash for sugar, phos. acid for purity, and nitrogen for tonnage.

Experiments at the M. A. C. seem to indicate that nitrogen in the form of a nitrate makes a better fertilizer than nitrogen in the form of ammonia;

Complete fertilizer (Nitrate nitrogen) II,47I #per acre I5.22 % sugar and 8I.9 % purity.
Complete fertilizer (Ammonia nitrogen) 9,688 #per acre I2.69 % sugar and 67.0 purity.
In favor of nitrate nitrogen----I,783# --2.53 %----I4.9 %

Each plot in the above experiment was treated with phosphate rock and muriate of potash, the soil was a medium loam. Nitrogen is more soluable in the form of the nitrates and should not be applied

in excess or too long before the planting of the crop. Ammonium nitrate is more stable.

Some soils are deficient in lime, notably, in soils derived from granite, sandstone, etc. Lime is usefull in neutralizing the acids and in unlocking what would otherwise be unavailable potash, Phos.acid, and nitrogen. Lime, also, produces, on some soils, a beneficial physical effect. There are many conflicting statements as to the use of lime with sugar-beets. The station here (M.A.C.) states that there was an increase in yield on the highland but a decrease in yield upon the muck. there was 11% more beets, .2% more sugar, and 3.61 % higher purity from the unlimed muck. The Rhode Island station found an increase in yield of 12.5% from the use of 2.7 tons of air-slacked lime per acre while West Virginia station says that lime reduced the sugar content and the percentage of purity. Michigan station found an increase in leaf developement upon high land. No fixed rules can be given for the use of lime as the local conditions are so variable.

In concluding my remarks upon fertilizers, I will quote from experiments made in two of the leading sugar-beet states, Michigan and Nebraska. Michigan found that the best results were derived from the use of a complete home-mixed fertilizer costing $27.50 per ton and applied at the rate of 480lbs. per acre. The yield from this was higher than from stable manure; the percent of sugar .87% greater and the purity 1.84% higher. From single elements, potash gave the highest sugar and purity and nitrogen the lowest. This home-mixed fertilizer consisted of 300# of dissolvad phosphate rock, 50# nitrate of soda, and 50# sulphate of ammonia and 100# sulphate of potash.

Ashes can be used to an advantage. A gentleman living two miles east of Alma, told me that he applied ashes to two rows of beets and that the increase in growth of these two rows were plainly visible the whole length of the field.

THE CROP

Sugar-beets in Michigan are raised for one of two purposes; viz. for feeding or for factory use; the most of the beets are raised for the latter purpose.

I analyzed several samples of beets for the former purpose, that is, to determine the relative value of the leaves, crowns, and roots for feeding purposes with the following results:

	Leaves
Moisture	86.62 %
Dry matter	13.38 %
Crude fibre	1.31 %
Ash	1.77 %
Fat	0.008%
Proteids	2.82 %
Carbo-hydrates	5.53 %

	Crowns
Moisture	79.42 %
Dry matter	20.58 %
Crude fibre	.86 %
Ash	.45 %

Fat ----------.06 %

Proteids - -----.98 %

Carbo-hydrates-I0.23%

Roots

Moisture----------80.20 %

Dry Matter--------- I9.80 %

Crude Fibre ------- .64 %

Ash - ---------- .34 %

Fat ---------- .05 %

Proteid ---------- .70 %

Carbo-hydrates ----- I0.72 %

Nutritive Ratio

Leaves----I:2
Crowns----I:I0.5
Roots ----I:I5.5

It will be seen that the roots are much richer in carbo-hydrates than the leaves. There is not so much difference between the crowns and root In protein, the reverse is true, there being more protein in the leaves than in the roots.

Wolff-Lehmann feeding standards give the following ratios;

Ox at rest in stall, nutritive ratio--I:II.8

Fattening Cattle (first period)-- I:6.5

Milk cows(Yielding 22# daily)----- I:5.7

Horse-(medium work) - -------- I:6.2

In my analysis of the whole beet , I find the following food constituents.

Sugar- beets	water	protein	fat	carbo-hydrates	ash	crude fibre
----------	82.68%	I.5%	0.7%	8.86%	0.85%	0.93%

The U. S. Dep't of Agr'l publish the following as the food constituents of several feed stuffs;

Sugar-beets	86.5%	I.8%	0.I%	I0.7%	0.9%	0.9%
Turnips	90.5%	I.I%	0.2%	7.4%	0.8%	I.2%
Mangel-wurzels	90.9%	I.4%	0.2%	6.4%	I.I%	009%

Ruta bagas	88.6%	I.2%	0.2%	88%	I.2%	I.3%
Corn fodder	79.3%	I.8%	0.5%	I7.7%	I.2%	5.0%
Corn silage	79.I%	I.7%	0.8%	I7.0%	I.4%	6.0%
Timothy hay	I3.2%	5.9%	2.5%	74.0%	4.4%	29.0%

The above table shows that sugar-beets are somewhat richer , as far as chemical composition is concerned , than other root crops and it will be noticed, also, that beets are practically, completely digestible while only two-thirds of the corn silage is digestible. Experiments at the Wyoming station show that animals fed to the beets and hay gave better returns than those fed with grain and hay or hay alone. In the above experiment, the cattle were fed I4 # of sugar-beets per day and all the hay they would eat.

Most of the beets raised in Michigan are raised for the production of sugar and last year(I900) there were raised in this state, about 300,000 tons for factory use. These beets sold on an average , for about $5.35 per ton, which means that Michigan farmers received $I,605,000.00 last year for their beet crop, this makes a paying and ready cash crop for the farmer, beside, there is quite an amount of valuable material left in the by-products of the factory, of this I shall speak later. Wheat has been the great cash crop for the Michigan farmer but at the present time, in many parts of the state, wheat raising is being given up on account of insects and the condition of the soil, resulting from the raising of wheat without the proper rotation. Farms that once gave a yield of 30 bus. per acre now give but I0bus. with the same kind of cultivation. The introduction of the sugar-beet into the rotation will be much better than the sowing of wheat after wheat and will give cash returns, the same as the wheat crop.

BY-PRODUCTS

In the process of manufacturing beet-sugar, there are several products produced, which, at the present time, are largely going to waste. These

waste products are pulp, molasses, and lime-cake. I will speak of these in the order mentioned.

Pulp

Pulp is the residue left after the sugar has been extracted from the beet, with water at the temperature of about 70 deg's C. The Nebraska station give the following as the composition of the beet and pulp:

			Dry Matter	
	Sugar-beet	Pulp	Sugar-beet	Pulp
Moisture	8I.48%	88.53%		
Fat	00.23	00.08	I.25%	0.68%
Protein	I.36	I.08	7.37	9.45
Crude fibre	I.34	2.57	7.23	22.40
Ash	I.5I	.56	8.I6	4.85
Nitrogen-free Ext.	I4.07	7.I8	75.99	62.62

The amount of water in the pulp depends, largely, at what time and where the sample for analysis was taken, if taken directly after leaving the diffusion cells, it will contain a great excess of water.

We have already made comparisons of the beet with other farm crops, as relative to feeding values and it will be seen, in comparing the pulp with the beet, that the pulp has about 7% more water and I% more crude fibre and a decrease in other materials, especially carbo-hydrate, due in a large degree to the loss in sugar. By making the comparisons, it will be seen that the pulp is rather a better feed than turnips, having not so much water and more nitrogen-free extract. The protein is about the same in each, the crude fibre is a little higher in the pulp. Jenkins and Winton in their " American Feeding Stuffs" give the following ;

	Timothy hay	Pulp
Dry matter	86.80%	II.47%
Of dry matter		
Fat	2.86%	0.68%
Protein	6.79	9.45

Crude-fibre - - - -	33.41%	22.40%
Ash - - - - - - - -	5.07	4.85
Nitrogen-free extract - -	51.84	62.62

The pulp in the above analysis was taken from the cars at the factory of the Norfolk Beet Sugar Co. The hay contains seven times as much dry matter as the pulp but, if a comparison is made between the dry-matter of each, it will be seen that the pulp is more valuable ; here comes in the question of drying the pulp. The plant for drying the pulp costs about $20,000 and the cost of running it, about$I.00 per ton of dried pulp. The process is something like this: the pulp is cut into very fine pieces, water added and the mixture pumped to where it is wanted, here it is filtered, the pulp having now about 60%of water. The dryer is a long tubular affair, about six feet in diameter and forty feet long. It is revolved at the rate of about six revolutions per minute and the whole is heated by steam.It requires about thirty-five minutes for the pulp to travel the forty feet, the length of the dryer. After leaving the dryer, it has about 7% moisture, when molasses is added and the mixture dried, ground, and then put into sacks or pressed. Afactory using 500 tons of beets per day would make about 25 tons of dried pulp per day and use 2,400 # of molasses, or the total output would be 74,000 lbs. These dryers have not come into use very extensively, as yet, and I understand that they are not considered a very paying investment.However , I believe the time will come when pulp and molasses will be made use of much more extensively and be treated in a manner, somewhat like the above.

Pulp that has been siloed and allowed to ferment,somewhat, is more readily eaten by cattle and is said to be more digestible than fresh pulp. Pulp that has been frozen should not be siloed, for upon thawing it will soon decay and be fit for nothing but manure. At most factories at the present time, the pulp is piled up outside the factory and the farmers draw it away at their leisure, during the winter months.

The outside of the pile will be frozen while that within will be fresh, about the only difference between frozen and unfrozen pulp, as shown by analysis, is the fact that there is a slight loss in protein, a breaking down of fibre, and an increase in acidity in the frozen pulp. The farmer, who does not live too far from the factory, can well afford to draw the pulp home as he would otherwise, return home with an empty wagon and the pulp is surely worth the drawing--- we would not think of leaving a load of timothy hay, were it given to us, and we have shown that pulp is as valuable. As pulp contains such a high per cent of water it would not pay to draw the pulp toolong distances. A plan has been devised, and it seems to me to be a good one, by which it is made possible for the farmer to utilize his pulp even if the factory is some miles away. Diffusion batteries are built at some miles from the factory and for the sake of illustration, let us take Lansing for an example. Suppose a diffusion battery should be built at Grand Ledge and the juice piped to Lansing. At Grand Ledge, we have coal and plenty of water and the sugar company would save the freight on coal and the farmer the freight on his beets and beside, he would have his pulp near home, where he could utilize it. The first cost might be more than by the present system, but I believe, that in the end, it would be a paying investment.

It appears that the Michigan farmer is slow to make use of this by-product. I quote the following from a letter of Mr. R. M. Allen, gen. mgr. of the Standard Cattle Co. of Ames, Iowa" A number of cattle were fed beet- pulp, corn silage, and hay,for four months, making the cheapest ration we ever fed. Cattle eat the pulp with satisfaction and relish, will consume 100# per day and require little or no water while being fed on pulp. I feel satisfied, in my own mind, that the use of pulp effect a valuable saving of other food, both hay and grain, and in feeding cattle for beef, we can effect an economy of 20 to 30% of the total cost of food" .

It has been shown that aton of dry pulp is as valuable as a ton of timothy hay as far as its feeding value is concerned. In fact, it is more valuable, because it supplies a succulent feed for winter use.

Allowing for losses, a ton of beets will produce I,600# beet pulp, or .8 of a ton. Michigan, last year, produced 300,000 tons of beets which will be equal to 240,000 tons of pulp. I2% of a ton of pulp is dry matter ; a ton of timothy hay is quoted in Detroit, to-day, at $I2.50,this would make a ton of pulp worth $I.50 . 240,000 tons at $I.50 equals $360,000,. the value of the pulp produced by Michigan factories last year.

Notwithstanding the value of this pulp to the farmers, the Alma Sugar Co. last year, had to pay $0.I0 per cu. yd. to get the pulp drawn away. After experimenting somewhat, the farmers began to realize, in a degree, the value of this pulp, so much so, that the company's teams were stopped and by Mar. I the most of the pulp had been drawn away and used for feed by the farmers.

Molasses

Molasses is another by-product that is worth our consideration. I made the analysis of a sample of waste molasses from the Alma Sugar Co. and found its feeding value as follows:

Water ----------	I4.40%
Dry Matter------	85.60
In dry matter	
Carbo-hydrates	56.9%
Protein	6.3I
Fat	.00

Fertilizing value

Ash ----------	6.44%
Phos. acid(P_2O_5)--	.027
Potash(K_2O) -----	3.38
Nitrogen----------	I.0I

The U. S. Dep't of Agr'l from several analyses give the following figures for the above: Feeding value

Water	20.80 %
Dry Matter	79.20
Carbo-hydrates	59.50
Protein	9.10
Fat	0.00

Fertilizing value

Phos. acid	0.05%
Potash	3.63
Nitrogen	1.46

Molasses are very rich in both carbo-hydrates and protein but contains no fat. Let us compare molasses with corn and oats . Oats contain

Protein	9.30 %
Carbo-hydrates	47.30
Fat	4.20

Multiplying 4.2 by 2.4 gives 10.08 the equivalent of the fat in terms of carbo-hydrates. This makes the carbo-hydrates equal 57.38 % and makes the value of oats, as far as protein and carbo-hydrates are concerned, nearly identical with molasses. Corn contains:

Protein	7.90 %
Carbo-hydrates	66.70
Fat	4.30

$.30 multiplied by 2.4 equals 10.32, the fat in terms of carbo-hydrates making the total carbo-hydrates 77%, hence, corn is lower in protein and higher in carbo-hydrates than molasses.

At Alma,this year, the final molasses was 1.5 % of the weight of the beets used. Taking it forgranted that the results in the other factories of the state were the same, as a matter of fact, many of them must have had higher results as they had no osmose process. 300,000 tons of beets would give 4.500 tons of final molasses, allowing that the feeding val-

ue of molasses is equal to I00 # of oats, as far as C. H. and protein are concerned, we would have an equivalent of 9,000,000# . This divided by 32 gives an equivalent of 28I,250 bus. , at $.30 gives $84,375, the value of molasses for feeding. The value of molasses for a fertilizer, provided the elements were to be bought upon the market, would be as follows; allowing that nitrogen, potash, and phos. acid are worth respectively I3, I5, 4.5 cents.

9,000,000 lbs. of molasses would give

Nitrogen , I3I,400# at I3 cents equals	$ I7,082.00
Potash, 506,I00# at 5 cents	25,335.00
Phos. acid 4,500 # at 4.5 cents	202.50
Total manurial value equals	$42,5I9.50

LIME - CAKE

Lime cake is the refuse from the filter presses , which is mostly lime with some of the materials from the beet juice mixed with it. There is a great variation in the composition of lime-cake, depending upon its treatment in the factory. If the filter-press foreman sees to it that the cake is thoroughly washed, it will contain but a small amount of organic material, salts etc, but, if the press is dumped before being thoroughly washed, it will contain considerable organic matter and mineral salts. In my analysis of a sample of lime-cake, I found the following:

Organic matter	3. 80 %
Lime(CaO)	40.I0
Potash (K20)	.44
Phos. acid (P205)	.35
Nitrogen	.I3

How much is this lime-cake worth as a fertilizer? At Alma, about 70.6# of lime was used for every ton of beets, taking this as an average for all the factories of the state and allowing that 300,000 tons of beets were used last year, we have 300,000 times 70.6 # which equals 2I,I80,000 of lime(CaO). Lime in Lansing, to-day, is selling for 90 cents per

which would give $47,655.00, the value of the lime in the lime-cake, were the same amount of lime to be bought upon the open market. My anslysis was from a sample direct from the filter press and no allowance was made for water, and this would make the percentage composition a little low. The Norfolk factory, found in a dry sample of cake, the following:

Organic matter - - - - -	7.79 %
Lime (CaO) - - - - - -	-48.24
Potash(K20) - - - - -	.6I
Phos. acid(P205) - - - -	.87
Nitrogen - - - - - - -	.47

Hence, for every I00# of CaO we have practically, 200# of lime-cake and if every I00# of lime-cake contains 7.79# of organic matter, 200# will contain:

Organic matter - - - - - -	I5.58 #
Potash	I.22
Phos. acid	I.74
Nitrogen	.94

We have estimated that the Michigan factories used, last year, 2I,I80,00 of CaO or 2II,000 cwt. One cwt. of CaO has an equivalent of I5.58 # of organic matter, then, 2II,000 cwt. will have

Organic matter	3,299,844 #
Potash	258,396
Phos. acid	368,532
Nitrogen	I89,092

Estimating the value of these elements as before, we have

238,396 #ofK20 at 5 cents equals--	--$II,9I9.80
368,532 # P205 at 4.5 cents	I6,583.94
I89,092 # N at I3 cents	24,58I.96
52,950 bbls. CaO at 90 cents	47,655.00
Total value of lime-cake as a fertilizer	$I00,740.70

Let us consider the matter still farther. It will be seen that the mfg. wants the carbon, hydrogen, and oxygen(CI2H220II) but it will be noticed that there is still left in the final molasses about 60 % of carbohydrates which the mfg. cannot remove on account of the uncrystallizable matter and salts that are present. In feeding, all these fertilizing elements are found in the excrements that were originally in the feed, except the C. H. and these the farmer does not care about as they consist of nothing but air and water. Therefore, the manufacturer can make his sugar out of " wind and water" and when he is through, the farmer can fatten his cattle on the wind and water that remains and still have the manurial elements left to be used as a fertilizer. Therefore, we find in pulp, a feeding value of $ 360,000.00

Pulp, fertilizing value

940,800 # N. at I3 cents	$ I2,230.00
2I6,000 # P205 at4.5 cents	9,720.00
403,200 #K20 at 5 cents	20,I60.00
Total fertilizing value of pulp -------- --	$ I52,I84.00
Molasses, feeding value	$ 84,375.00
Molasses, fertilizing value	$ 42,5I9.50
Lime-cake -- --	$I00,740.00
Total value of by-products - - - -	-$739,8I9.20

I believe the time will come when the by-products of the sugar factories will approach or equal the value of the direct products. There has been a company organized for the purpose of manufacturing alcohol and potash from the molasses but with no great success thus far. I believe the land is more in need of the stimulating effects of these by-products than man.

The farmer, instead of letting all of this valuable material slip away down the river bank, should claim, for every ton of beets, a corrosponding amount of his share of the pulp, molasses, and lime-cake, which should be returnrd to his farm, then we should not hear so much about

the beet crop being " hard on the land".

SOIL EXHAUSTION

By the term, soil exhaustion, we do not mean that the land is tired; soil has no sense, nor do we mean that an exhausted soil is good for nothing for raising crops. A soil that will not produce is a barren soil. By soil exhaustion, we mean that the soil, owing to improper treatment in regard to cropping or cultivation, will no longer produce a crop at a profit. Of course, there are many other things influencing the profit and loss in a crop, other than the question of soil.

Before going farther, let us study, somewhat, the constituents of a plant. In order for a plant to make a complete growth and produce seed that will, in turn, produce other seed, it requires thirteen elements viz. carbon, hydrogen, oxygen, nitrogen, phosphorus, potash, calcium, sodium, chlorine, magnesium, lithium, iron, and sulfur. If the abogе thirteen elements are essential, the question is---where do they come from and how are they removed from the soil ? First, let us consider their origin:

Carbon
Hydrogen } From the air and water, forms sugar.
Oxygen
Nitrogen--- From the air and soil.
Potash
Phosphorus
Calcium
Sodium
Chlorine } From the soil.
Magnesium
Iron
Lithium
Sulfur

The above shows what elements must enter into every plant. What do we want to get out ? Sugar. (In this thesis, we are discussing the question, principally, of the raising of sugar-beets for the factory) What elements go to make up sugar ? They are carbon, hydrogen, and oxygen in the proportions of I2--22--II, respectively. As will be seen, these elements come entirely from the air and the water. Of the 65,000,000 # of sugar produced in Michigan last year, not one pound of anything valuable was removed from the soil. When the farmer draws a load of beets to the factory, is he merely drawing water and air ? Certainly not, he is drawing away, more or less, of these other ten elements, that are of the greatest value to the farmer. Does the manufacturer want these elements, other than the carbon, hydrogen and oxygen ? He does not, it costs him millions of dollars, each year, to get rid of these elements, and when he has separated them from the sugar, he throws them away, even paying money to get them removed. If the mfg. wants simply the C,H,O, and not the other ten elements, and the farmer vice versa, why not produce merely, the C,H,O,? If it costs the farmer thousands of dollars to produce these ten elements and the manufacturer thousands of dollars to get rid of them, why this waste ? Simply for this reason; to produce cloth, we must have a loom, so to produce C,H, and O in the proportion of I2:22:II, the beet plant is necessary. To produce the beet plant, it requires thirteen elements, eight elements would not do. To get sugar, we must have the plant and to get the plant we must have thirteen elements. Hence, the beet plant may be called the factory, sunshine the power, carbon, hydrogen, oxygen the raw material and sugar the finished product. The farmer should try to use as much of the carbon, hydrogen, and oxygen as possible and as little of the other elements as possible. Just what proportions of these vital elements may be used , or just how much should be applied to the soil in order to produce the greatest amount of sugar is a problem that the experiment stations are working on and one that has been discussed to

some extent in this thesis. It is evident that the farmer who raises beets upon raw muck or raises beets, that, for any reason, are low in sugar and rich in fibre and mineral matter, is taking much more of value from his soil than the farmer who raises beets with high sugar and purity. The latter also receives a much larger cash return for his beets.

Is the beet hard on the soil ? This is a question that is often asked and in answering it, let us make a comparison with three well known crops, viz. wheat, potato, and the beet. A fairly general average may be obtained by taking the analysis of the three crops as given in the U. S. Agr'l Dep's reports, they are as follows:

Wheat	Potatoes	Beets
N------ 2.36 %	N------ 0.32 %	N------0.22 %
P205--- .79	P205---- .I2	P205--- .I0
K20---- .50	K20----- .46	K20 ----.48

Using the same value per lb. for these elements as in the previous case, we have for I00 # of

wheat----------	36 cents
potatoes-------	6 --
beets ---------	4 --

In selling I00 # of wheat, the farmer returns nothing to the soil and to buy the materials which he sold with the bushel of wheat, in the form of a fertilizer, upon the open market, will cost him 36 cents . In selling I00 # of potatoes, he returns nothing to the soil, and it will cost him 6 cents to replace the elements removed. In selling I00 # of beets, he can replace nearly, if not all, of the lost elements to the soil, if he does not, it will cost him but 4 cents to replace the lost elements. It will be seen that beets are not as exhaustive to the soil as wheat or potatoes. An experiment last year, where beets were planted upon ground that had the year previous, been planted to both beets

and potatoes, showed that beets after beets gave better results than beets after potatoes.

As a recapitulation, let us consider some of the advantages and disadvantages of the industry.

DISADVANTAGES

I, Competition with the cheap labor of Europe. This cannot be prevented One thing in our favor, is the fact, that we do not have to transport our manufactured product.

2, Scarcity of help. I have had several tell me that they would raise beets were they certain of obtaining help. The Dakota wheat raiser has the same trouble, but he does not quit the business. After two years spent with the Alma Sugar Co. and, having more or less knowledge of the existing conditions at other factories in the state, I have yet to lear of any serious complaint from the farmers in regard to their not being able to get help. At Alma, there has always been plenty of help.

3, Hard work. It is hard work but it is paying work.

4, Cost of factory. The average cost of a sugar factory is about$500,000 hence, not every person has sufficient means to build a factory.

5, Beets are very bulky, therefore, one cannot afford to haul them very long distances.

6, Lack of harmony between the producer and the manufacturer. In order to secure the greatest success in this industry, there must be perfect harmony between the farmer and the manufacturer. The manufacturer must not take excessive mark or tare, or the farmer put to high a price on his beets.

ADVANTAGES

I, Excellent climate and soil.

2, Good transportation facilities.

3, Excellent manufacturing facilities. We have coal and abundence of lime stone, also ,plenty of good water.

4, Good market. The U. S. consumes annually, 4,000,000,000 pounds of sugar, while there are only 37 factories. It will require 530 to supply the U. S. alone under the present demand, and this demand is increasing at the rate of I2.5 % each year. It will require 80 to supply Michigan with sugar. At present, we have but I0 factories, therefore, we will not have to seek a market abroad, as yet.

5, Gives employment to the laboring classes. At present, we are paying $ 80,000,000 to foreign labor to produce our sugar.

6, Diversifies agriculture.

7, Creates a greater demand for other farm produce. Each factory employs about 250 men 2,500 in the whole state who are consumers of farm produce and are not engaged in producing it; perhaps many of them would be consumers, anyhow ,nevertheless, ready money generally means better living. It, also, makes a greater demand for grocery products. I understand that a grocerman in Lansing advertised that he did not sell beet sugar. I think, that those working upon the beet-sugar factory in that city should see to it, that he does not use beet-sugar money. I believe in patronizing home industry.

8, Creates other manufacturing enterprises. It calls for car mf'g Co's, makes a greater demand for farm and sugar factory machinery, which, in return, gives employment to more men and calls for more of the farmers produce. In order to formulate some idea of the equipment necessary to complete a sugar factory, I will name some of the things that are in stock at the Lehi factory in Utah; this is about an average sized factory.

28,800	tons of beets cost----------	$-I42,233.96
4,500	tons of coal at $3.00	I3,500.00
200	tons of coke at $I7.I0	3,420.00
I,600	tons of lime rock at $2.50	4,022.50

40,000 double sugar bags at I4.5 cents	$5,800.00
4,I50 yds. heavy duck at I5 cents	622.00
I,050 yds. German duck at 50 cents	525.00
6,000 lbs. of sal soda	I50.00
4,500 lbs. of tallow	270.00
30,000 lbs. of sulfur	600.00
I0,000 lbs. of HCl	350.00
Laboratory and other supplies	5,000.00
Paid for labor	52,923.80
Total - - - - - - - - - - -v- - - - -	$ 229,4I7.26

It is readily seen that it will require a variety of enterprises to produce the above named materials. The above are for but one factory; multiplying the above figures by ten, yes, by twenty, the number necessary to supply Michigan with sugar, or to go even farther, multiply by 30 or 530, the number of factories neccessary to supply the U.S. and one will be able to grasp, in a degree , the extent to which other industries must be developed in order to supply this want. The above merely includes the material for one campaign and beside this, there is the machinery for the factory, brick for the building, and cement for the floors etc., beside the furnishing of employment to a great number of men in building these buildings.

9, Brings capital into the state. Men of wealth are looking for good opportunities for making good investments and they find this opportunity in the manufacturing of beet sugar, even without the bounty. Plenty of money in circulation generally makes better times, financially.

I0, Raises the value and rental of lands. At Alma, the rental of lands has increased from three to five dollars per acre within the last year. This year (I90I) where the owner prepares the ground, it rents for ten dollars per acre. The value of the land has increased, accordingly.

II, The beet, being a deep feeder, is less effected by drouths than

are many other crops, less injured by frosts, and as yet, fairly free from the attacks of insects and fungi.

I2, Gives employment to the school-children in our large cities, who are out of employment fro- June until September. Beside, it serves as a means of filling their pockets with money and their blood with the beneficial influence to be derived from fresh country air.

I3, A stable price for the crop. The farmer does not have to take the risk of a drop in the market price; he knows beforehand just what the price of his crop will be.

I4, Make sugar cheaper. Taking the old rule, that the price of an article is regulated by the supply and demand of that article, it goes to reason, that in time, the price of sugar will be lower than at the present time. I do not see how it is going to be possible for monopolies and trusts to get full control of this industry as the lands are in the hands of the farmers and the factories cannot run unless the farmers furnish the acreage.

I5, Promotes the intensive system of agriculture. From the very nature of the crop, it is evident, that better forms of agriculture must be resorted to. The old time farmer, with his corn- field full of weeds will never make a success of raising sugar beets. The beet is a crop that requires the most careful and best methods known in agriculture.

I6, It is not exhaustive to the soil. We frequently hear it stated that the " beet crop is not an easy crop on the soil". By utilizing the by-products of the factories, which can be had for the asking and which, at present, are thrown into the river, I see no reason why the crop should be exhaustive to the soil.

I7, It is one of the most profitable crops raised. It is frquently asked " Does the raising of sugar beets pay"?" J. W. Cochrane of Midland at the round-up institute held at Lansing quoted results from several farms in that section and they were something like this: $I50

from two acres, $188 from two acres etc. At Alma, the average yield per acre was 10.5 tons, $56.17 per acre, some as high as $125 per acre. Farmers, on an average, made a profit of, from 20 to 100 per cent. I will quote from a Bay City paper" That farmers have at last found a crop that will pay them to raise is made evident by a visit to the register of deeds office in Bay Co.. The records show, that in the first two weeks of the new year(1901) , fifty-one morgages were discharged against eight last year. The farmers say the cause of the lifting is due directly to the beet crop. " There was paid to the farmers of this state last year $1,500,000 for their beet crop. The only two complaintsof which I have heard are, first, of a merchant and a drummer , who rented land and were going to increase their material wealth by raising beets; one lost money, the other made twenty cents. The second was from the sandy shores of Lake Michigan where beets cannot be raised at a profit. As before stated, beets cannot be raised at a profit on all kinds of soil.

18, Encourages the dairy interests of the state. It has been shown that pulp and molasses are both valuable feeds and instead of letting $444,375.00 worth of valuable feed go to waste each year in this state, I think the time will come when it will be used for feeding numerous dairy herds. Pulp is an excellent succulent feed for winter use and does not taint the milk if properly handled.

With all the above advantages, the Michigan farmer should certainly put the sugar beet in his rotation, provided he lives within a reasonable distance from the factory.

In conclusion, I believe the question of beet sugar production in Michigan is no longer an experiment but a well established industry however, it has, by no means, reached its fullest development. In spite of all the evidence given, showing the value, possibilities, and success of this industry, the editor of a certain paper which is quite largely

circulated among the farmers of this state, peers forth, with clouded visian, from his benighted state and makes these remarks" The Farm Journal has never been able to see a rosy prospect ahead for sugar beet growers and in our opinion, the outlook is less favorable than when the craze started. Farmers, who grow beets for stock feeding are likely to get more net cash out of it than those who grow them for sugar factories. It is evident that the editor of this paper has never been far beyond the confines of the coal smoke that enshrouds his rough and uneven state. He has, without doubt, gazed so long upon the dark and dirty products from the interior of the earth, that he can no longer see any beauty in the snow- white crystals that may be produced upon the surface of our fair state. In " our opinion " A man living in a coal country and where it is so rough that the use of farm machinery is impossible, can certainly give some good advice to the farmers of Michigan relative to the raising of sugar beets. " Less favorable" when ten factories have been built within three years and more being erected each year, when $ I,[illegible]00,000 are being payed to the farmers and $500,000 to the laboring classes,each year, when the farmers, as at Alma, sign their contracts very early in the season for fear they will not get an opportunity to take acreage, I say, do these things indicate that the " outlook is less favorable" I will admit that it is a "craze" and one that is going to revolutionize farming in the lower peninsula of Michigan. Factories will continue to be built and soon, the once heard whistle of the saw-mill will be superseded by the coarse and deep sounds of the sugar factory whistle, in the near-by meadows will be heard the tinkling of numerous cow-bells, giving evidence of the greatest dairy industry that this state has ever known. Then it can be truly said of the state which was at one time condemned as a worthless waste " It is a land that flows with milk and honey"

Alma College, Michigan. May, I90I.

P. S. This thesis was begun in Sep't, I899. One year was spent in work in the chemical laboratory at the Michigan Agricultural College, doing special work in chemistry and two years were spent as Ass't Chemist for the Alma Sugar Co.

MAP I

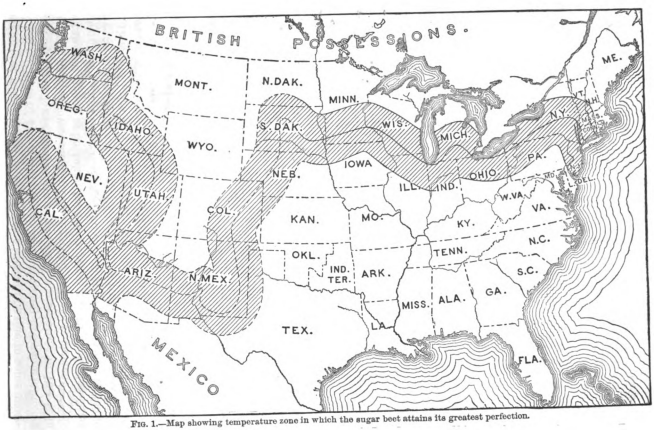
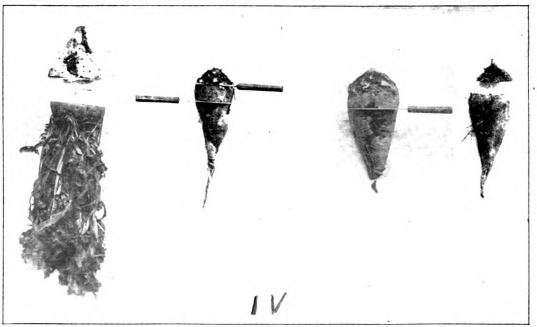


FIG. 1.—Map showing temperature zone in which the sugar beet attains its greatest perfection.



IV

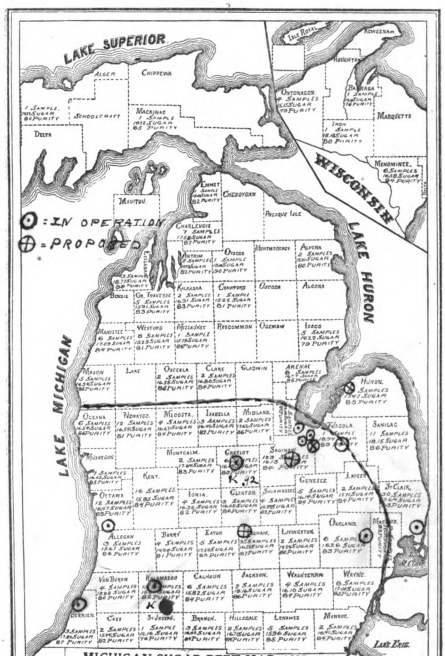
1.
Leaves.....36½ oz.
Head.....26 "
Trimmed beet.....28½ "

2.
Beets grown with too much room.

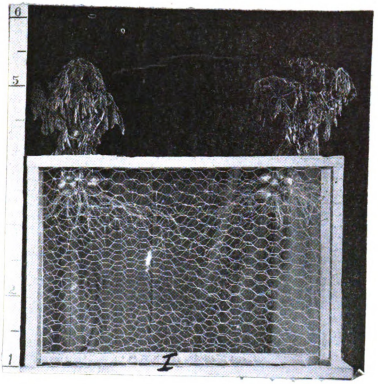
3.
Typical beet.
Head.....3½ oz.
Trimmed beet.32 "

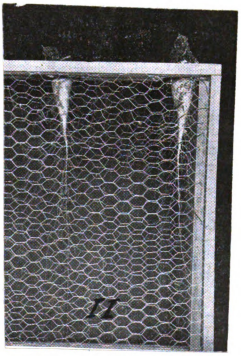
MAP II

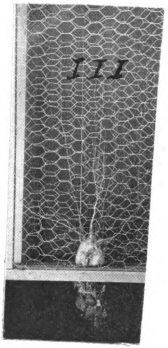
MICHIGAN SUGAR BEET MAP, 1897.



MICHIGAN SUGAR BEET MAP, 1897.


6
5
2
1
I


II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