MISSOURI

AGRICULTURAL COLLEGE EXPERIMENT STATION.

BULLETIN NO. 17.

SUGAR BEETS.

COLUMBIA, MISSOURI.

JAN. 1892.

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AGRICULTURAL COLLEGE EXPERIMENT STATION.

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INTRODUCTORY.

In carrying out the objects of the organization of an "Agricultural Experiment Station," we cordially invite the co-operation of all persons interested in its success. Suggestions as to lines of experimental work, problems to be solved, inquiries relating to agriculture, horticulture, stock, and the dairy, will be cheerfully received, and answered as far as possible; but no work will be undertaken unless of public value, and the results of which we are at liberty to use for the public good.

Specimens of grains and grasses; seeds of fruit and forest trees; vegetables, plants and flowers that are true to name; varieties of beneficial and injurious insects; samples of mineral waters and ores, and whatever may illustrate any department of agriculture, will be gladly received, and due acknowledgments made in annual reports. Directions for collecting, packing and shipping such specimens will be furnished on application.

Bulletins will be issued at least quarterly, giving the results of experimental work as fast as completed, together with such suggestions and information as may be thought valuable to the farmers of Missouri.

The bulletins and reports of this Station are sent free to every citizen of Missouri who applies for them. Copies are sent as soon as issued to every newspaper in the State, to every Grange, Farmers' Alliance, or other Agricultural organization whose address can be obtained. Bulletins and reports are also sent to the leading Agricultural papers of the country, and will be sent to *any* paper that may desire to exchange.

Letters relating to any special line of work should be directed to the officer in charge of that division, but all general correspondence relating to the work of the Station should be addressed to

EDWARD D. PORTER,
Director of Experiment Station.

Columbia, Boone Co., Mo.

SUGAR BEETS.

BY CHAS. P. FOX, ASS'T CHEMIST.

The aim of this Bulletin is to give information concerning the sugar beet, rather than any settled conclusion regarding Missouri as a sugar beet state. The experimental work with the sugar beet at this Station covers only a period of two years, and, in fact, only for one season has the experiment extended over a large territory. It is thought best to publish these meager results in connection with information of a general character, but carrying with it, however, the desire to instruct our farmers in the craft of beet growing in case of successful termination of future experiments.

HISTORICAL.—In 1747 Margraff detected sugar in the common garden beet and reported his discovery to the Berlin Academy of Science. It attracted but little attention and was quite forgotten by 1797, when Achard, a pupil of Margraff, again took up the investigation and transmitted his results to the Institute of France.

The first factory for the production of beet sugar was erected upon German soil in 1805.

The political condition of Europe at the beginning of the present century made the new source of sugar one of great value. The far-seeing Napoleon soon recognized its value and at once established schools and laboratories for teaching the methods of producing the new sugar. Aided by the government the new industry grew, prospered, and for many years has been a source of public revenue.

The rapid growth of the industry in Europe is best shown by the following statistics. The sugar production in France in 1826 was 1,500 tons, while in 1875 462,259 tons were produced. In 1890 60 per cent. of the sugar produced in the world came from the beet.

IMPROVEMENT OF THE BEET.—Margraff and Achard found only 6 per cent. of sugar in the beet. At present no beets are used in the manufacture of sugar containing less than 12 per cent. Beets have been grown in the United States containing as high as 26 per cent. The average per cent. of sucrose in beets used at the Oxnard sugar factory Grand Island, Neb., season of 1890, was 16. This great change has been wrought in less than one hundred years. It has been accomplished by careful study and experimentation. Probably no other industry has had such care bestowed upon it, and certainly no other agricultural pursuit.

PROPAGATION OF THE BEET.—The sugar beet is propagated by seed. This is obtained from carefully selected "mothers." The growing of beet seed forms a large industry in Germany and France. At present the seed used in the United States is imported chiefly from those countries. The differences between the revenue laws of Germany and France have led to the development of two races of beets. The members of one family are characterized by a comparatively low percentage of sugar, and a high tonnage per acre, while in the other the reverse is found. Among the best varieties may be mentioned the French Sugar, Vilmorin, Klein Wanzleben, White Silesian, Simon Le Grande, Florimond, Desprez and Imperial.

CULTIVATION OF THE SUGAR BEET.

The successful production of the sugar beet for the purpose of making sugar depends mainly upon three factors, namely, climate, soil and cultivation.

CLIMATE.—*a. Temperature.* The sugar beet succeeds best in the north temperate zone. The best results have been secured where the mean temperature for June, July and August is about 70° Fahr. An early, warm spring and a late, cool autumn, succeeded by a mild winter, are great advantages. *b. Rainfall.* The rainfall, where irrigation

is not practiced, should be uniformly distributed throughout the growing season. The minimum quantity is placed at 2 inches per month. There should be but little rain during the fall.

Soil. No particular kind of soil is demanded; soils that produce good crops of corn and potatoes give excellent results with beets. A heavy clay soil that is hard to cultivate and is inclined to "bake" is not suitable for beet raising. New ground should never be used. Large quantities of certain mineral salts, while they exert no bad influence upon the growth of the plant, their presence is detrimental to the manufacture of sugar.

The sugar beet is very exhaustive to the soil. One ton of beets removes from the soil 37.5 pounds of mineral matter. This is composed of 10.7 pounds of potash, 6.1 pounds of soda, 5.4 pounds of magnesia, 5 pounds of iron and alumina, 6.2 pounds of lime, 3.2 pounds of phosphoric acid, 2.2 pounds of sulphuric acid, 1.2 pounds of silica, and 1.7 pounds of chlorine.

A crop of 36 tons per acre (20 tons of beets and 16 tons of leaves) would remove 1,349.7 pounds of ash ingredients, valued, at current market rate, at $28.66;* 1,062.7 pounds of the ash are returned to the soil by the tops. This constitutes 60.8 per cent. of the potash, 89 per cent. of the soda, 93 per cent. of the lime, 88 per cent. of the magnesia, 82 per cent. of the iron and alumina, 69 per cent. of the phosphoric acid, 85 per cent. of the silica, and 80.4 per cent. of the chlorine. The deficiency (the amount taken away by the roots) must be replaced by some fertilizing material. In all probability good barnyard manure is the best material. It should be well rotted, applied and plowed under in autumn. The following table gives for comparison the quantities of potash and phosphoric acid removed from the soil by our common farm crops.

*Potash and phosphoric acid.

Table showing the amount of potash and phosphoric acid removed by an average crop of our common farm produce; also the value of the potash and phosphoric acid in each:

CROP.	Average yield per acre (pounds).	Amount of ash removed (pounds).	Amount of potash removed (pounds).	Value.	Amount of phosphoric acid removed (pounds).	Value.	Total value of potash and phosphoric acid.
Corn.....	1349.6	22.54	6.09	$ .31	10.08	$ .81	$ 1.12
Wheat.....	720	14.40	4.48	.22	6.65	.53	.75
Rye.....	666.4	13.33	4.12	.21	6.27	.50	.71
Oats.....	851.2	25.54	4.06	.20	5.29	.42	.62
Barley.....	1041.6	26.04	5.70	.29	8.54	·68	.97
Potatoes	4572	17.10	10.23	.51	3.27	·26	.77
Tobacco.....	727	175.06	47.97	2·40	6.30	.50	2.90
Timothy hay	2400	168	48.38	2.42	18.14	1.45	3.87
Sugar beets..	4000	287	152	7.60	36	2.88	10.48

CULTIVATION.—This factor is controlled mainly by the producer, and upon this element many times depends the success or failure of the crop. Too much can hardly be said in this connection. In the first place the ground should be well drained. The sugar beet requires a *deep, loose* soil in order that its long tap root may penetrate the lower strata of soil in time of drought in search of moisture and plant food. If the downward growth is obstructed the root becomes short, thick and irregular in shape. The development of sugar does not reach a high degree in such a root and its irregular shape increases the labor of cleaning.

The required condition of the soil is secured by subsoiling and deep plowing. After pulverizing the plowed land the seed is planted. It is drilled in rows 18 inches apart (for horse cultivation the rows should be wider) and using about 15 pounds of seed per acre. Cover the seed about one inch deep and then roll. The crop should be put in about corn-planting time, but not later than the middle of May.

When the young plants are well up commence cultivating; keep the weeds down and the soil loose. When the fourth leaf appears the plant must be trimmed. This can

be quickly done by cutting out the beets with a sharp garden hoe (blade six or seven inches wide) and leaving a clump of beets one and one-half inches long. After a few days thin the remaining plants to one in a place; the last trimming must be done by hand. If the work has been performed properly the plants will be about 8 inches apart and regular. The sugar content of the beet varies inversely with the weight or size of the root. A beet weighing one and one half pounds has a higher percentage of sugar, consequently a greater purity, than one weighing 7 or 8 pounds. The size of the roots can be regulated to a great extent by thick planting. Pagnoul's experiments, extending over a period of eight years, show that close planting gives a richer beet and a larger yield than wide planting. His averages are given in the following table:

DISTANCE APART (inches).	Per cent. Sucrose.	Yield per acre.	Mineral Matter Removed
Wide distances, 20x20	10.2	28.40. tons.	840 pounds.
Narrow distances, 17x8	12.2	36.05	520 "

Keep up the cultivation until the leaves cover the ground. Keep the top portion of the roots well covered with soil. The portion grown above the soil is unfit for sugar-making. At the last hoeing the hilling up must be carefully attended to.

Bulletin No. 57, Guelph Agricultural College, Ontario, calls attention to the difference between well covered and poorly covered roots.

		Per cent. Sugar.	Purity.
Well covered roots	Tops.	15.5	82.7
	Bottoms.	16.6	83.0
Poorly covered roots	Tops.	11.4	69.9
	Bottoms.	13.6	77.2

HARVESTING.—The crop should not be gathered until fully ripe. This stage has arrived when all the leaves assume a yellowish-green color, the outer ones fall and form a kind of wreath around the plant; center ones do not

fall. The crop should be gathered before heavy frosts occur. In case of sudden frosts the beets should be allowed to thaw in the ground. The roots are carefully withdrawn from the soil. If to be taken to the factory at once the leaves with the green portion of the necks are cut off. If, however, they are to be preserved for some length of time, only the leaves are removed.

The beets prepared as above described are preserved in cool cellars, silos or in trenches, the thickness of covering depending upon the severity of the winter. Hay or straw should not be used; dirt will be sufficient. Where beets are raised in large quantities special machinery is used to perform a large portion of the work of planting, cultivating and harvesting.

YIELD PER ACRE.—The yield per acre, of course, depends upon the variety of beets grown, the distance between the plants, soil, cultivation, season, etc. In many of the experiments reported from the various stations no yield is given. The average yield at Watsonville, Col. (Western Beet Sugar Co.), season 1889, was 21 tons (Sugar Beet, Feb. 1890). Prof. Harper, Bulletin No. 14, Minnesota Experiment Station, *estimates* the average yield for that state at 15 tons per acre. Dr. Wiley places the average at 24.5 tons.

The following yields, in tons per acre, have been obtained at other stations: Wyoming, 7.5; South Dakota, 8.14; Colorado, 26; Nevada, 20; Iowa, 20; New York, 19.5; Indiana, 30.

COST OF RAISING.—What does it cost to raise an acre of beets? is the practical question as far as the producer is concerned. The entire cost per ton or per acre will depend upon the rent, quality of land and the price of labor.

The Wisconsin Station (Bulletin, No. 26,) has done some very careful work along this line of inquiry.

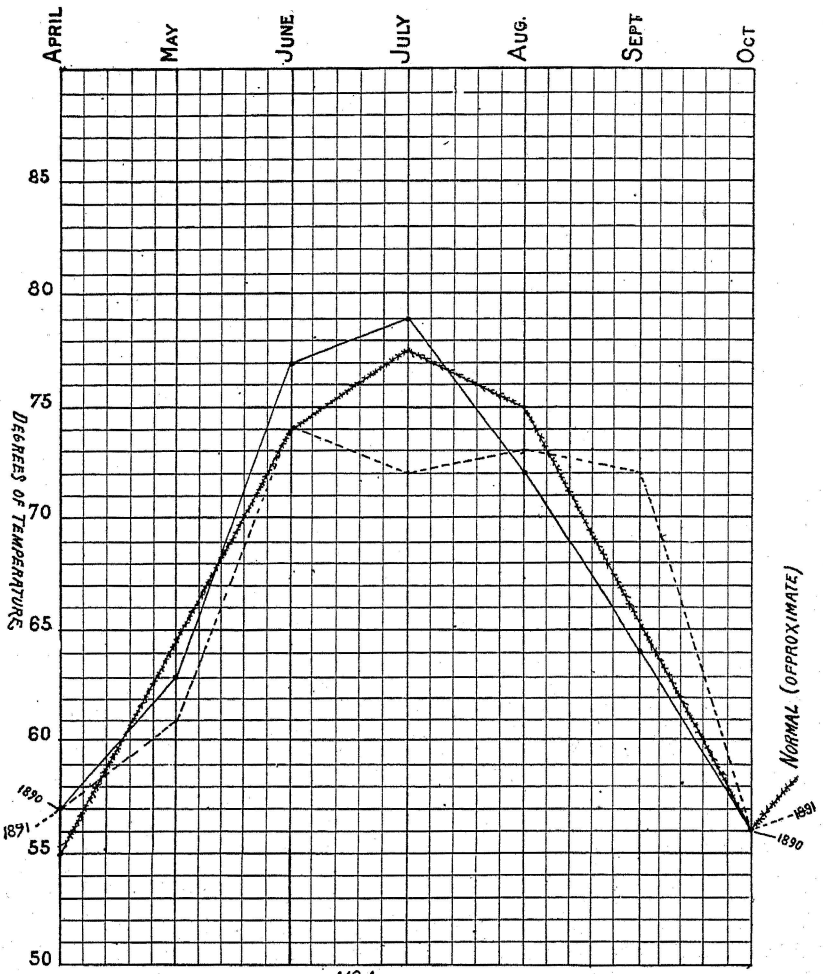
"Two plats were grown. In plat A the rows were twenty inches wide and the plants eight inches apart. The labor was done mostly by hand. Allowing ten cents

per hour for the labor of the men, twenty-five cents for man and team and fifteen cents for man and horse, the cost of production (not including delivery at factory or rent of land) was $1.38 per ton, or $31.81 per acre. In plat B the rows were thirty inches wide and the plats ten inches apart. Horse labor was used as much as possible. The cost in this case was eighty-four cents per ton, or $18.71 per acre. The cost of raising beets in Wyoming is placed at $40 per acre, (this includes delivery at factory). In Nevada the cost is estimated at $50 per acre.

VALUE OF THE CROP.—The value of the beets depends upon the percentage of sugar they contain. The prices paid for beets, delivered at factory, by the Grand Island Sugar Company during season of 1891, were as follows:

Per cent. of Sugar.	Price per ton.	Per cent. of Sugar.	Price per ton.	Per cent. of Sugar.	Price per ton.
12	$3.00	15	$3.75	18	$4.50
13	3.25	16	4.00	19	4.75
14	3.50	17	4.25	20	5.00

BEET SUGAR IN THE UNITED STATES.—The limited area in this country suited to the growth of the southern sugar-cane, the destruction of our maple forests, the yet feeble condition of the sorghum industry renders the sugar beet a valuable acquisition. The climatic conditions mentioned upon a previous page prevail over a large section of territory. Dr. McMurtie, chemist to the Department of Agriculture, some years ago mapped out the probable "sugar belt" of the United States. It consists of a strip of land one hundred miles wide on each side of the isotherm of 70 degrees Fahr. for the months of June, July and August. Many attempts have been made to develop the industry in this country, but all of the earlier adventures failed. The first successful factory began operations in 1879, at Alvarado, California. At present there are three additional ones at Watsonville, California, one at Grand Island, Nebraska, and the third in Utah.



No. 1
COMPARATIVE TEMPERATURE CHART
SHOWING TEMPEATURE AT COLUMBIA DURING MAY
JUNE, JULY, AUG, SEPT, AND OCT. 1890 & 1891.

The United States consumes annually 3,134,011,560 pounds (about fifty-one pounds per head) of sugar. The production amounts to about one-tenth of the consumption; the balance we import. Why not keep this money at home? It is to seek an answer to this question that these investigations with the sugar beet are being carried on. If our soil and climate are favorable for the production of good beets, then there is a new industry open to our farmers and capitalists.

It is estimated that seven hundred beet-sugar factories are needed to make the sugar we import.

These factories would consume 2,100,000 acres of beets, and require the labor of 2,000,000 men for six months of the year.

REQUISITES FOR THE MANUFACTURE OF SUGAR FROM BEETS.—*The Enterprise Requires a Large Capital.*—This is needed for the purchase of expensive machinery and to pay skilled labor to operate it. A plant having a capacity of 18,000 tons per season costs about $165,000. A guaranteed supply of beets suitable for sugar making. Beets having a lower percentage of sucrose than 12 and a coefficient of purity less than 70 cannot be used. This factor depends upon the farmer. To produce the necessary supply of beets for a factory of this size requires about 15000 acres.

AN ABUNDANT SUPPLY OF GOOD WATER.—A factory using 300 tons of beets per day uses about 1,000,000 gallons of water.

GOOD RAILROAD FACILITIES for transportation of beets and the manufactured products. *Fuel* must be obtained at reasonable cost. *A supply of suitable limestone* is also necessary.

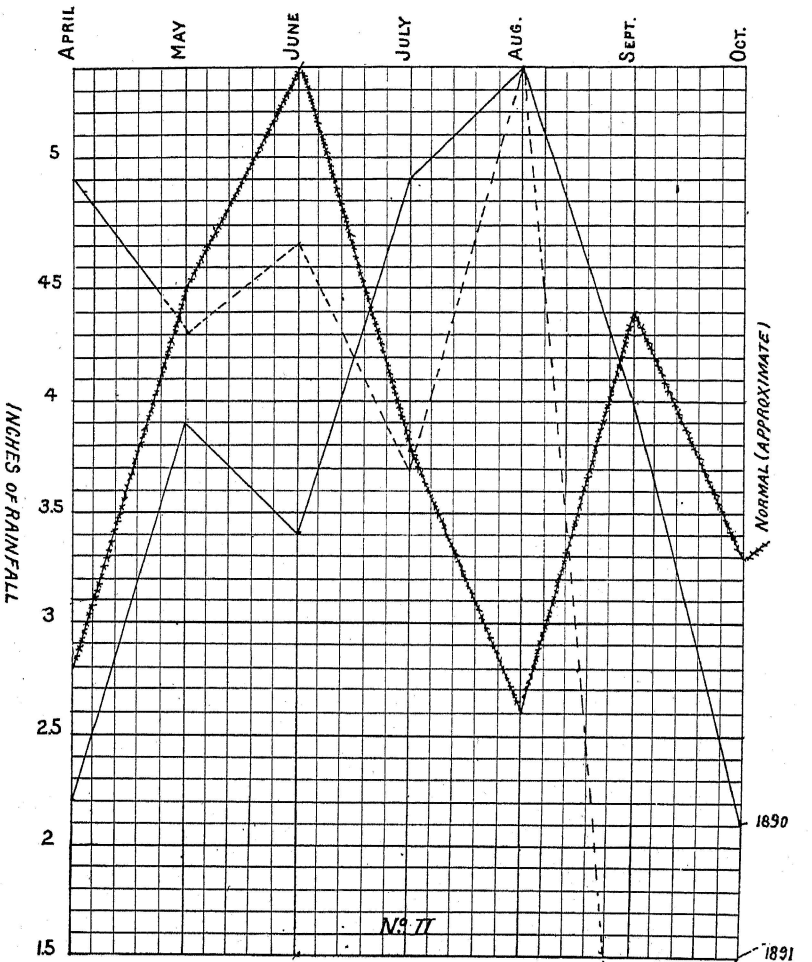
PROCESS OF MANUFACTURE.

A detailed description of a beet-sugar factory, its machinery and the processes employed in making sugar, although very interesting, is out of place in a publication

of this kind. A short resume will indicate the character of the apparatus and the great care necessary to produce a fine grade of sugar. As soon as the beets are delivered at the factory their value is determined by analysis of an average sample. They are thrown into canals, washed free from dirt, gravel, etc., by machinery. By means of slicing machines the clean roots are cut into small pieces (cossettes). These slices are macerated in water until the sugar is dissolved out. The sweet liquor or juice is now purified by means of lime, carbonic acid and filter presses. The purified juice is evaporated in a series of vacuum pans until it is reduced to "*masse cuite*" (a kind of sugar containing 6.10 per cent. of water). The sugar is separated from the adhering syrup by centrifugal force. By treatment with bone black the crude sugar is purified. The syrup is reboiled and again treated in the centrifugal. Syrups too poor for this treatment are utilized in the manufacture of alcohol. The exhausted chips are used for feeding cattle. Where they are properly cared for they form a very good food. To preserve them they are first freed from the large excess of water by pressing and drying. According to the *Sugar Beet* (February, 1890), one pound of the dried cossettes with 15 per cent. of water are equal to 8 pounds of the fresh. The press cakes, necks and other refuse are used for fertilizing purposes.

INSECT ENEMIES.—Bruner (Bulletin No. 16, Nebraska Experiment Station) describes at least a dozen insects injurious to the sugar beet. The garden webworm, flea beetles, blister beetles, leaf-hoppers, cutworms, wireworms, etc., are mentioned.

FUNGUS DISEASES.—The principal fungus diseases of the sugar beet are beet rust, white rust of beet, spot disease of beets, root rot and beet scab. Prof. Pammel (Bulletin No. 15, Iowa Experiment Station), reports that all of these diseases with the exception of rust occur in Iowa. For further information upon the above subject the reader is referred to the publications cited.



COMPARATIVE RAINFALL CHART.
SHOWING RAINFALL AT COLUMBIA MAY, JUNE, JULY, AUGUST, SEPTEMBER & OCT. 1890 & 1891.

EXPERIMENTS IN MISSOURI.

AT THE STATION, 1890.—Five varieties were grown upon the Station grounds during the season of 1890. The results are given in the following table:

NAME OF VARIETY.	Yield per acre (tons).	Av. wt. of beets (oz).	Sucrose in juice.
Dippes Vilmorin	14.		17.77
Dippes Kleinwanzleben	17.5	18.	16 25
Florimond Desprez	18.9	14.	10.42
Bulteau Desprez	15.4	18.6	11.65
Simon LeGrande	12.3	19.5	14.31
Average	15.2	.....	14.08

The yield was fair and the percentage of sugar good. The entire season was very favorable.

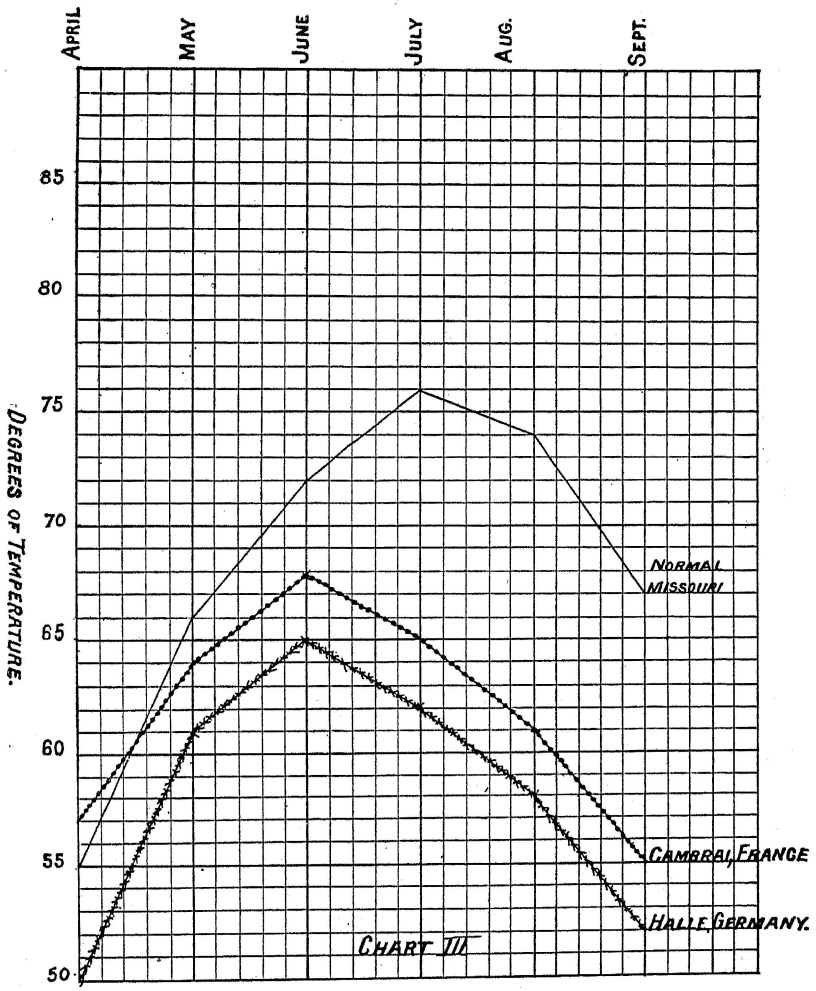
1891.—This year seven varieties of beets were grown at the Station. The results are expressed in tabular form as follows:

NAME OF VARIETY.	Yield per acre (tons).	Av. wt. of beets (oz.).	Sucrose in juice.
White Silesian	10.8	.....	7.32
Wohanko	12.2	.....	9.97
French Sugar	11.	.....	12.32
Simon LeGrande	10.5	.....	12.15
Dippes Vilmorin	8.3	.....	13.95
Kleinwanzleben	10.1	.....	11.17
Florimond Desprez	8.9	.....	13.30
Average	10.2	.....	11.45

The yield per acre and the percentage of sugar are much lower this season than last.

Four varieties grown in 1890 were again grown in 1891. For comparison the results for the two years are placed side by side.

Average of four varieties, 1890, yield 15.7 tons, sugar 14.49 per cent; average of four varieties, 1891, yield 9.5 tons, sugar 12.64 per cent. The beets were planted May 20th and harvested October 21st, 1891. The rows were



COMPARATIVE TEMPERATURE CHART FOR GERMANY (NORTH) FRANCE. AND MISSOURI.

18 inches apart and the distance between the plants 8.9 inches. The seed of the White Silesian did not germinate well, causing a poor stand. The season was not very favorable. The temperature (mean) from April to June was slightly lower than for the corresponding period of 1890. The mean temperature for July was 7° lower than that of July 1890. In 1890 the maximum mean temperature for the season was reached in July, succeeded by a gradual falling of temperature throughout the rest of the season. The mean temperature for September, 1890, was 64°, and for October, same year, it was 56°. The latter portion of the summer and the forepart of the autumn of 1891 was quite different from the same periods of the preceding year. The maximum mean temperature of the season was reached during August and was a degree or more higher than for August, 1890. The mean temperature for September was but slightly lower than that of August, and was 7° higher than for September, 1890. The mean temperature for October was the same as in 1890. The variation in rainfall for the two seasons is greater than the variation in temperature. The rainfall for April, May and June, 1891, was greater by one and one-half inches (average) per month than for the same period of 1890. For July the rainfall was less than in 1890. The rainfall reached its highest point in August and was exactly the same as in August, 1890. Then came a long and severe drought lasting throughout the rest of the season. The rainfall for September was only .46 inches and for October 1.5 inches. During September and October, 1890, the rainfall was 4 and 2.1 inches respectively. These differences are best shown on charts. [See charts I. and II.] This portion of the season of 1890 was unusually dry. The high temperature during August and September, in combination with the slight rainfall during the latter month, very likely, was the cause of our poor results. Assuming that the soil, seed, cultivation and other conditions (excepting the meteorological) exerting an influence upon the

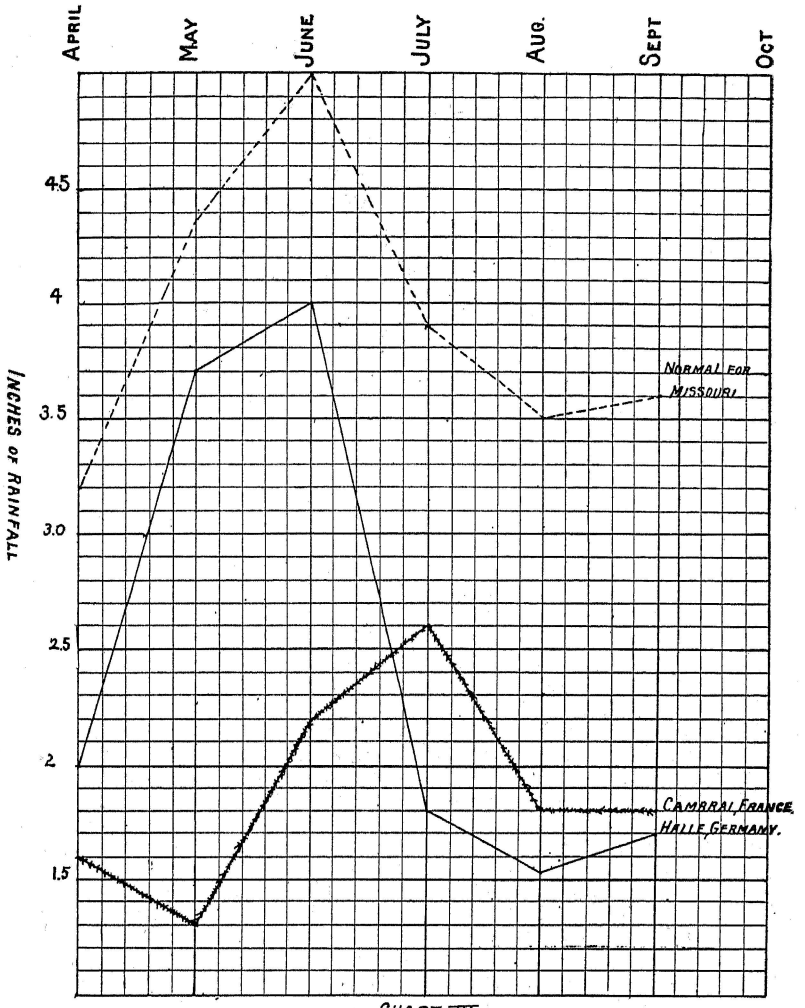


CHART IV.

COMPARATIVE RAINFALL CHART FOR NORTHERN, GERMANY, FRANCE, AND MISSOURI.

crop (hardly a fair assumption) were identical for the two seasons, then the failure must be due to the "weather." Of course, "off years" are to be expected in beet raising as in other similar industries. Upon the above mentioned charts the curves representing the normal (approximate) temperature and rainfall for Columbia have been traced also.

It will be seen that the temperature lines for 1890 and the normal run closely together during the entire season. As to the rainfall, the lines are too complicated to admit of a satisfactory comparison. It appears, however, that the rainfall for 1891, excepting August, is the mean of 1890 and the normal.

If our assumptions are correct (there is no data at hand to the contrary) these results plainly show the influence of the weather. The meteorological data was obtained through the kindness of the State Weather Service.

EXPERIMENTS IN MISSOURI.—The Director of the Station, desirous of testing thoroughly the adaptability of climate and soil of this State for the production of the sugar beet, issued the following circular:

COLUMBIA, MO., April 24, 1891.

The manufacture of sugar from beets has been a profitable industry in Europe for more than a half century. Beginning with a beet containing only 6 per cent. of sugar, and only one-half of which could be extracted owing to the imperfect methods and machinery employed, it was forced into competition with the product of the "sugar-cane" containing 18 per cent. of sugar, and with well-established methods of manufacture. Under the influenee of skilful seed-breeding (for as much care is bestowed upon the breeding of beet seed in Europe as is given to the breeding of any of our domestic animals) the per cent. of sugar has been raised from 6 per cent. to an average of 14, and in some special cases has reached 22 per cent.

In this time, also, the production of sugar from this plant had grown rapidly as shown by the fact that more

than three-fifths of all the sugar produced in the world is made from the beet. Both the French and German governments encouraged this industry in the early stages of its growth by granting to it bounties and special privileges. It has since become so remunerative as to be able to bear the burden of a special tax imposed by these countries upon the industry.

BEET SUGAR IN THE UNITED STATES.

Americans consume more sugar *per capita*, than any other people in the world. We produce but a small fraction of our annual consumption, making us heavy importers of this commodity ; for example we paid Germany, in 1889, the sum of $19,000,000 for beet sugar, and during that time her markets were closed against one of the most important products of the American farmer—the hog.

The area adapted to the production of the sugar beet in the United States is being thoroughly investigated. Already numerous attempts have been made to manufacture sugar from beets grown in this country, but so far, with two exceptions, they have proven financial failures. One at Spreckles, Cal., and one at Grand Island, Neb., have been thus far operated successfully. The reasons for the failure of other attempts need not be stated here, but they were not such as to destroy all hope for the future of this industry in our country. The climate required for the production of beets containing a high percentage of sugar has an average summer temperature of about 70 degrees, and an average monthly rainfall of at least two inches. The soil should be open, at least slightly sandy, with a porous subsoil. An excessively rich soil is not desirable for this crop.

The yield per acre on an ordinary soil is from fifteen to twenty-five tons, and the price per ton delivered at the factory during the past season in this country has been $3 for beets containing twelve per cent. of sugar, and twenty-five cents per ton extra for each additional per cent. of sugar.

The Experiment Station, desirous of making a thorough test of the adaptability of Missouri soil and climate for the production of the crop, has requested one or more representative farmers in each county to co-operate with it in this move by growing a small quantity for chemical analysis. The replies have been prompt, and so far uniformly favorable, showing an interest and spirit that is both commendable and encouraging. The soil and climate appear to be generally favorable, yet such a test as we are now entering upon alone can determine these points.

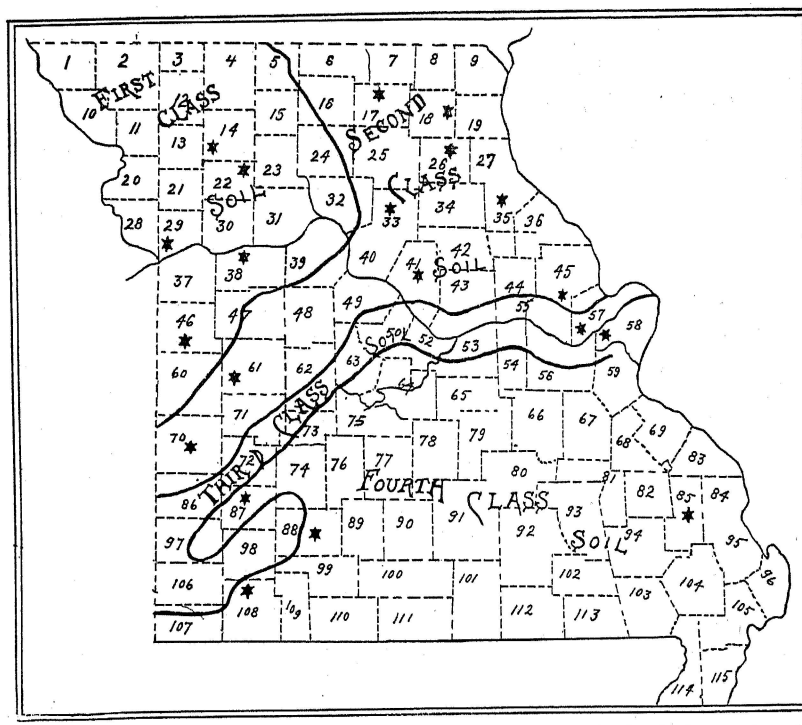
In the subjoined table is given a brief summary of the results with five different varieties of sugar beets grown on the Station grounds during the past season.

NAME OF VARIETY.	Yield of Topped Beets per acre. (tons)	Weight of individual Beets. (ounces)	Per cent. of Juice Extracted.	Per cent. of Sugar in Juice.
Dippe's Vilmorin	14.0	18	63.2	17.77
Dippe's Kleinwanzleben	17.5	14	61.5	16.25
Florimond Desprez	18.9	18.6	62.0	10.42
Bulteau Desprez	15.4	19.5	52.3	11.65
Simon LeGrand's White Imp.	12.3	.....	.....	14.31
Average	.....	.....	.....	13.08

From which it will be seen that for last season our soil produced a reasonable yield of beets containing a percentage of sugar above the standard required by the factories.

The attention of those who have kindly consented to grow the beets for this test, and for whom this circular is especially prepared, is directed to the following conditions affecting the value of the crop :

A beet having a high percentage of sugar with a minimum amount of the non-sugars (in growing beets for the factory these two points are kept constantly in mind). This condition is most often found in a small to medium-sized beet weighing from one and a half to two pounds, giving a moderate yield per acre. To a greater degree in this than in almost any other crop does the soil, season



The above map of Missouri shows the four classes of soils in the State, as given by Dr. Broadhead, state geologist, in report of 1874. The marks (*) indicate the localities from which the foregoing samples of beets were taken for analysis. The numbers refer to the different counties, as below:

1. Atchison.
2. Nodaway.
3. Worth.
4. Harrison.
5. Mercer.
6. Putnam.
7. Schuyler.
8. Scotland.
9. Clark.
10. Holt.
11. Andrew.
12. Gentry.
13. DeKalb.
14. Daviess.
15. Grundy.
16. Sullivan.
17. Adair.
18 Knox.
19. Lewis.
20. Buchanan.
21. Clinton.
22. Caldwell.
23. Livingston.
24. Linn.
25. Macon.
26. Shelby.
27. Marion.
28. Platte.
29. Clay.
30. Ray.
31. Carroll.
32. Chariton.
33. Randolph.
34. Monroe.
35. Ralls.
36. Pike.
37. Jackson.
38. LaFayette.
39. Saline.
40. Howard.
41. Boone.
42. Audrain.
43. Callaway.
44. Montgomery.
45. Lincoln.
46. Cass.
47. Johnson.
48. Pettis.
49. Cooper.
50. Moniteau.
52. Cole.
53. Osage.
54. Gasconade.
55. Warren.
56. Franklin.
57. St. Charles.
58. St. Louis.
59. Jefferson.
60. Bates.
61. Henry.
62. Benton.
63. Morgan.
64. Miller.
65. Maries.
66. Crawford.
67. Washington.
68. St. Francois.
69. Ste. Genevieve.
70. Vernon.
71. St. Clair.
72. Cedar.
73. Hickory.
74. Polk.
75. Camden.
76. Dallas.
77. Laclede.
78. Pulaski.
79. Phelps.
80. Dent.
81. Iron.
82. Madison.
83. Perry.
84. Cape Girardeau.
85. Bollinger.
86. Barton.
87. Dade.
88. Greene.
89. Webster.
90. Wright.
91. Texas.
92. Shannon.
93. Reynolds.
94. Wayne.
95. Scott.
96. Mississippi.
97. Jasper.
98. Lawrence.
99. Christian.
100. Douglass.
101. Howell.
102. Carter.
103. Butler.
104. Stoddard.
105. New Madrid.
106. Newton.
107. McDonald.
108. Barry.
109. Stone.
110. Taney.
111. Ozark.
112. Oregon.
113. Ripley.
114. Dunklin.
115. Pemiscot.

and cultivation, influence the character of the crop. Any ordinary soil, in an average season with almost any method of cultivation that keeps the soil stirred and free from weeds, will produce a fair crop measured in tons per acre; yet the crop may be utterly worthless for the manufacture of sugar. The following directions are based upon the practical experience of beet growers, both in this country and in Europe, and it is earnestly hoped that each farmer will follow them in every respect as far as his circumstances will permit. Methods better suited to our conditions may be discovered should this become an industry in our state; yet, for the purpose of this test and for the sake of uniformity, we hope they will be closely followed. It is hoped, also, that a careful record of all the points noted in the accompanying blank be kept, and after harvest mailed to the director of the Station, Edward D. Porter. Without this, the work will have been largely in vain.

DIRECTIONS.

SOIL.—A porous soil of good depth with good drainage, either natural or artificial, having a porous or open subsoil, a good exposure to light, and of average fertility, should be selected. Avoid excessively rich or heavily manured soils, or new land. A clover sod is unfit for this crop. Use no manure unless well rotted, and that in most cases is unnecessary in this preliminary test.

PREPARATION.—Plow deep, ten or twelve inches, in soils of good depth and seven to ten inches in thin soils. Pulverize thoroughly and reduce to a fine condition before seeding.

PLANTING.—Plant about the time you do corn, in rows eighteen inches apart, with the seed not over an inch deep and two inches apart in the row. Firm the soil over the seed to insure prompt and uniform germination. When the plants begin to show four leaves, thin out to one plant every six to nine inches, leaving one every six inches in rich soil, and thinning to nine inches on poor soil.

This may be quickly done with an ordinary sharp garden hoe, the blade of which is usually from six to seven inches wide, by passing down the row and by a single stroke (across the row) cutting out the beets, leaving a clump one, two or three inches long, according to the distance you desire to thin. After a few days when the plants yet standing have recovered, pass over and thin by hand to one plant. It is very essential that this matter be attended to at the proper time, as a failure to thin, or thinning too much, may materially reduce the per cent. of sugar in the crop.

CULTIVATION.—Keep the soil well stirred and free from weeds until the leaves begin to cover the ground. At the last cultivation carefully hill around all beets that are not already covered with soil to the base of the leaves or crown. This is necessary, as that portion growing above ground is of no value for sugar.

"The Gem" or "Planet, Jr.," cultivator is a most excellent implement for cultivating this crop, but if the farmer is not already in possession of one of these implements, the garden hoe will answer for the few rows necessary to be grown in these experiments.

Directions for harvesting, preserving and selecting samples for chemical analysis will be forwarded to you later. Very respectfully,

H. J. WATERS,
Assistant Agriculturist.

A number of farmers responded to the circular and undertook the work. Fifty-seven samples of beets were received from twenty farmers, representing as many counties. No attempt was made to arrive at the cost of production. Only one or two reported upon the yield. The methods of planting and cultivation were various. While the majority succeeded in getting the proper distance between the plants, but few of them used the same distance between the rows; these distances ranged from 14

to 40 inches. Many different kinds of soil were tested in this experiment. Fertilizer (barnyard manure) was used only in one. A large number of our correspondents complained of the season; the early summer was too wet, preventing the necessary cultivation and the latter portion of the season was very dry. Several experimenters report that the beet tops were eaten off by the "striped potato bug." Damage done by rabbits was reported, also. The hot, sulphurous smoke from a brickyard injured the plants in another case. Some of the samples were frozen when received. This may have something to do with the low percentage of sugar found in many of the samples. The average time to grow the crop was 162 days; the shortest period was 126 days and the longest, 180 days. Mr. Jos. Kirchgarber, Springfield, Mo., thinks that it would be cheaper to sow the seeds in beds and then transplant. This is a good suggestion and it should be investigated. Comparative experiments with the methods in practice concerning cost, character of roots, etc, would be of value.

The following table gives the name and address of the grower, dates of planting and harvesting, kind of soil, average weight of beets, per cent. of sucrose and the purity. This table includes the samples grown at the Station.

Station number		Date of planting	Date of harvesting	Kind of soil	Av. wt. of beets (ounces)	Per cent. of sucrose, single polarization	Purity
	Experiment Station Columbia, Boone Co.						
572	White Silesian	May 20	Oct. 21	Clay	28.7	7.32	65.2
573	Wohanka	May 20	Oct. 21	Clay	18.7	9.97	68.9
574	French Sugar	May 20	Oct. 21	Clay	17.4	12.32	72.6
575	Simon Le Grande	May 20	Oct. 21	Clay	20.7	12.15	71.6
576	Vilmorin	May 20	Oct. 21	Clay	16.4	13.95	74.8
577	Kleinwanzleben	May 20	Oct. 21	Clay	20.1	11.17	66.3
578	Florimond	May 20	Oct. 21	Clay	14	13.30	70.6
	J. C. Evans, Harlem, Clay Co.						
579	.....	May 17	Oct. 25	Loess	57	11.77	74.3
580	.....	May 17	Oct. 25	Loess	32	11.62	73.4
581	.....	May 17	Oct. 25	Loess	42	12.78	75.9
582	.....	May 17	Oct. 25	Loess	72	5.87	48.5
	John Patterson, Kirksville Adair Co.						
583	Wohanka	June 13	Oct. 19	Clay	25	10.33	67.8
584	Vilmorin	June 13	Oct. 19	Clay	27.6	9.12	62.2
585	White Silesian	June 13	Oct. 19	Clay	34.6	10.70	66.2
	Geo. Wilson, Greenfield, Dade Co.						
586	White Silesian	May 11	Oct. 26	New ground, black and sandy.	23.3	7.31	62
587	French Sugar	May 11	Oct. 26		26.3	7.07	55.3
588	Vilmorin	May 11	Oct. 26		30	7.79	58.8
589	Wohanka	May 11	Oct. 26		26.3	5.10	47.5
	F. W. Arms, Nettleton, Caldwell Co.						
590	White Silesian	May 19	Oct. 26	Sandy loam.	25.6	16.33	78.6
591	French Sugar	May 19	Oct. 26		21	13.51	73.8
592	Vilmorin	May 19	Oct. 26		17	16.85	79.3
593	Wohanka	May 19	Oct. 26		23	15.10	76.4
	R. W. Muller, Augusta, St. Charles Co.						
594	French Sugar	May 1	Nov. 1	Loam	65	8.15	66
	W. H. Hickman, Winston, Daviess Co.						
595	French Sugar	May 14	Oct. 28	Black loam	46.1	9.49	61.8
596	Vilmorin	May 14	Oct. 28		40	10.98	66.8
597	White Silesian	May 14	Oct. 28		66.3	6.53	52.9
598	Wohanka	May 14	Oct. 28		45	6.87	55.8
	Jas. Shouse, Knox City, Knox Co.						
599	French Sugar	May 25	Oct. 27	Light, thin and sandy.	13	7.95	59.7
600	Wohanka	May 25	Oct. 27		12.5	9.86	66.4
601	White Silesian	May 25	Oct. 27		14.6	11.34	72.1
602	Vilmorin	May 25	Oct. 27		19.3	10.79	70.3
	Timbner and Aull, LaFayette Co.						
603	French Sugar	.....	.....	.....	19	12.54	70.4
	Jos. Kirchgarber, Springfield, Greene Co.						
604	Vilmorin	May 7	Oct. 26	Gravelly clay.	22.8	11.07	70
605	French Sugar	May 7	Oct. 26		21.8	9.99	67.3
606	Wohanka	May 7	Oct. 26		35.6	8.63	62.2

* Concentration. These figures are for per cent. of sugar in juice; to obtain the per cent. of sugar in beet, multiply by 9.

Station number		Date of planting	Date of harvesting	Kind of soil	Av. wt. of beets (ounces)	Per cent. of sucrose, single polarization	Purity
	Fred. L. Jabin, Wright City, Warren Co.						
607	French Sugar	May 29	Nov. 4	Rich loam.	20.9	10.94	67.6
608	White Silesian	May 29	Nov. 4		21	7.64	58
609	Vilmorin	May 29	Nov. 4		18.4	9.36	63.1
610	Wohanka	May 29	Nov. 4		17.4	8.30	60
	J. C. Evans, Harlem, Clay Co.						
611	Duplicates	.....		Loess	43	9.86	67.1
612	Duplicates	.....		Loess	52	11.76	72.2
613	Duplicates	.....		Loess	64	12.78	76.5
614	Duplicates	.....		.....	63	10.39	68.5
	Wm. Muir, Fox Creek, St. Louis Co						
615	French Sugar	May 12	Nov. 6	.....	17	4.59	49.1
616	Wohanka	May 12	Nov. 6	.....	11	7.92	64.3
617	Vilmorin	May 12	Nov. 6	.....	14.4	8.80	66.1
618	White Silesian	May 12	Nov. 6	.....	4.3	7.10	60.1
	D. H. Webster, Austin, Cass Co.						
619	Vilmorin	May 16	Oct. 29	Limestone soil.	26	9.14	61
620	French Sugar	May 16	Oct. 29		15.8	10.24	56
	G. W. Waters, Center, Ralls Co.						
621	White Silesian	May 11	Oct. 31	Clay	27	5.88	39.8
622	French Sugar	May 11	Oct. 31	Loam	23.2	8.08	47.9
623	T. P. Withers, Monett, Barry Co.						
	Unknown variety	May 16	Nov. 11	Gravelly	31.5	8.79	52.2
	J. G. Buckhardt, Bethel, Shelby Co.						
624	White Silesian	May 10	Nov. 1	Loam	30.2	9.85	63.2
	Sender unknown.						
625	French Sugar	.....	.....	.....	55	12.44	65.5
626	Vilmorin	.....	.....	.....	24.9	9.62	52.1
	F. A. Scott, Huntsville, Randolph Co.						
627	French Sugar	May 17	Oct. 21	Light Sandy	43	9.90	63.4
636	Imperial	May 17	Oct. 21		42.6	8.62	58.3
	J. J. Conrad, Marble Hill, Bollinger Co.						
628	Wohanka	May 12	Nov. 4	Clay two feet with a gravelly subsoil.	6.5	12.76	64.2
629	White Silesian	May 12	Nov. 4		2.5	15.14*	.....
630	Vilmorin	May 12	Nov. 4		2.6	16.95*	.....
631	French Sugar	May 12	Nov. 4		9.6	14.58	68.2
	J. H. Logan, Nevada, Vernon Co.						
632	Wohanka	May 16	Nov. 1	Lig't sandy loam	28	6.90	48.4
633	Unknown	May 16	Nov. 1		17.4	11.77	60.8
	C. H. Hartsook, Deep Water, Henry Co						
634	Lost	Lost	Lost	Lost	Lost	Lost	Lost
635	French Sugar	May 12	Oct. 24	Lig't sandy.	16.1	9.76	62.1

DISTRIBUTION OF SAMPLES.—By examining a map of Missouri (V) it will be seen that the samples are not very evenly distributed.

The representation is as follows:

Northwest: Five counties, fifteen samples.
Northeast: Nine counties, twenty-eight samples.
Southwest: Five counties, twelve samples.
Southeast: One county, four samples.

Dr. Broadhead (Missouri Geological Survey, Vol. 1 1874), has divided the soil of this State into four classes. (See map 1.)

According to this classification we have fifteen samples grown upon the best land; twenty-seven samples grown upon land of the second class; five samples upon the third class and twelve samples upon land of the fourth class.

The highest percentage of sucrose found was 18.85 and the lowest 4.59. The average for the State was 9.81 per cent. of sucrose and a purity of 67.3.

By map No. 2 it will be seen that Missouri lies south of the "Sugar Belt." The mean temperature for the State is about six degrees higher than that of the belt. The two great centers of the Sugar Industry in Europe are Halle, Germany, and Cambria, France. The temperature and rainfall of these localities are compared with Missouri in the annexed diagrams. (See charts III. and IV.) It will be seen that the temperature is much higher during the entire season. The above statement is also true for the rainfall. We are liable to have too much rain in early summer and again during the harvest season. Besides these drawbacks, much of our soil is not fit for beet culture. The present outlook for this crop in Missouri is not very encouraging, yet the past results are not conclusive.

The Station desires to repeat the work. We want the aid of one or more reliable farmers in each county of the State in this work. Those situated near the Stations of the State Weather Service are preferred, but do not let this preference keep anyone from sending in his application.

The beets will make excellent food for cattle and for this purpose alone they will more than repay the labor expended. Before entering upon the work give the question careful thought. Remember that to do the work rightly and to obtain results of any value whatever requires time and labor. Keep in mind that the object is not to prove that beets can or can not be grown in this State, but whether beets sufficiently rich in sugar and large enough yield per acre to induce capitalists to erect factories and to pay the farmers for raising the beets. These are the questions to be answered. Until they are, we are at sea. Fourteen samples contained over 12 per cent.