U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF CHEMISTRY—BULLETIN NO. 74.

H. W. WILEY, Chief.

THE INFLUENCE OF SOIL AND CLIMATE

UPON THE

COMPOSITION OF THE SUGAR BEET, 1901.

BY

HARVEY W. WILEY,

CHIEF OF BUREAU.

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL EXPERIMENT STATIONS OF INDIANA, IOWA, KENTUCKY, MICHIGAN, NEW YORK, UTAH, VIRGINIA, AND WISCONSIN.

WASHINGTON:

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., December 31, 1902.

Sir: I have the honor to transmit for your approval manuscript and graphic charts embodying the results of the cooperative work conducted by this Bureau in the study of the effect of environment upon the composition of the sugar beet during the year 1901. To the work as conducted in 1900, the results of which were published in Bulletin 64, Bureau of Chemistry, has been added the consideration of the influence of the soil. I recommend that this manuscript be published as Bulletin No. 74, Bureau of Chemistry.

I wish again to express my appreciation of the work done by the various stations taking part in the experiment, the continued cordial cooperation of the Weather Bureau, which is of vital importance, and the information received from the Coast and Geodetic Survey and the Naval Observatory in response to the request made for geodetic data. The analytical work done in this Bureau was performed, under the direction of Mr. G. L. Spencer, by the assistants in the sugar laboratory, namely, H. W. Houghton, A. W. Bache, and Arthur Given.

Respectfully,

H. W. Wiley,
Chief of Bureau.

Hon. James Wilson,
Secretary.

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THE INFLUENCE OF SOIL AND CLIMATE UPON THE COMPOSITION OF THE SUGAR BEET, 1901.

ORGANIZATION OF COLLABORATIVE WORK.

In continuation of the cooperative experimental work with sugar beets carried on in 1900[a] by this Bureau in collaboration with certain experiment stations and the Weather Bureau, the following letters were addressed to the experiment stations of North Carolina, Iowa, Michigan, Utah, Indiana, Wisconsin, Kentucky, and to the two New York stations in the spring of 1901:

MARCH 18, 1901.

DEAR SIR: For the collaborative work in the study of the influence of environment on the composition of the sugar beet for the present year, I have decided to use seed No. 5772, Dippe's Kleinwanzlebener Elite, and 20 pounds of this seed marked "special" have been sent to you for such collaborative work.

The area planted need not exceed an eighth of an acre, unless you desire a larger area or a number of plots. This matter is left entirely to your own judgment, and the residue of the seed you can dispose of as you like. I suggest, however, that the special plot be seeded very heavily, so as to be sure of a good stand, and that enough of the seed be reserved for replanting in case the first planting should not germinate.

I will send you in a few days a blank giving some special points in regard to the study of the environment which I should be glad to have you observe during the season.

H. W. WILEY, *Chemist.*

MARCH 18, 1901.

DEAR SIR: In connection with the collaborative study of the influence of environment on the composition of the sugar beet, I desire to make a careful chemical and physical analysis of the soils of the plots used for the growing of the beets.

I therefore ask that you take a representative sample of the soil and subsoil of the plot on which you grow the No. 5772 "special" seed during the present year. After getting such a sample, reduce it in size by quartering or otherwise, so as to secure a representative subsample weighing about 4 pounds, and send under the inclosed frank by mail to my address.

H. W. WILEY, *Chemist.*

On March 20, 1901, the seed was mailed to the stations named by the Section of Seed and Plant Introduction, and on March 23 the following letter was addressed to the cooperating stations:

MARCH 23, 1901.

DEAR SIR: In order that I may be put into direct communication with the official of your station who will be in personal charge of the collaborative work on the study

[a] Results published in Bulletin No. 64, Bureau of Chemistry, U. S. Department of Agriculture, 1901.

of the influence of environment on the sugar beet, I write to ask that in case you delegate this work to one of your assistants you inform me of that fact. In case you take personal charge of it please let me know also, in order that I may have an official record of the person immediately in charge.

H. W. WILEY, *Chemist.*

These letters were also later addressed to the Virginia station at Blacksburg. The responses showed that the following stations and officials would take part in the work:

Washington, D. C., G. L. Spencer; Lafayette, Ind., H. A. Huston; Agricultural College, Michigan, J. D. Towar; Ames, Iowa, James Atkinson; Lexington, Ky., M. A. Scovell; Geneva, N. Y., G. W. Churchill; Ithaca, N. Y., L. A. Clinton; Logan, Utah, John A. Widtsoe; Blacksburg, Va., W. B. Alwood; Madison, Wis., R. H. Shaw.

The work at the North Carolina station was temporarily abandoned, owing to a change in the personnel of the station.

On April 8, 1901, a final letter of instructions was sent out to the stations above-named, which read as follows:

APRIL 8, 1901.

DEAR SIR: I feel that it is scarcely necessary to make any suggestions in regard to the methods of planting and cultivating the beets which you undertake to grow in collaboration with this division. The seed, No. 5772 "special," you have probably already received. If not, please let me know at once.

Some time before sowing, preferably the previous autumn, the soil should be plowed to the usual depth of 8 or 9 inches, and subsoiled 6 inches deeper, making a seed bed at least 15 inches in depth. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, and a subsoiling of 6 inches additional will be advisable.

The surface of the soil should be reduced to a fine tilth, and be well harrowed and stirred immediately before planting, so as to stop all growth of weeds which may have been started.

The rows should be 18 inches apart, and the seed be planted at the rate of about 25 pounds per acre, so as to be sure of a good stand. If the soil be moist, the seed should be covered to a depth of from one-half to 1 inch. If the weather be dry, slightly deeper planting may be advisable.

So soon as the plants are growing vigorously they should be separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each hill. When the beets have a vigorous growth and begin to form the fourth leaf, they should be thinned to about one plant in each 9 inches. Where vacancies occur in a row, transplant carefully so as to have the number of plants indicated above.

Ordinary surface cultivation is all that is required, taking care not to cover up the beets at the first cultivation.

In sending the samples of soil, in accordance with previous instructions, do not forget to send a history of the plot, so far as known. Complete cultural and meteorological data in collaboration with the Weather Bureau should be kept and forwarded with the samples. Franks for forwarding samples and full instructions for harvesting and sampling will be sent later. It is earnestly requested that frequent analyses be made also at the station, so that the results of those analyses can be compared with those which are made of beets sent here.

Any questions in regard to further details will be cheerfully answered.

Respectfully,

H. W. WILEY, *Chemist.*

The following letter in regard to harvesting was forwarded to the cooperating stations under date of September 15:

DEAR SIR: Relative to the sugar beets grown by you from seed marked "No. 5772 special:"

When the beets appear to be approaching maturity and before any second growth can take place, please harvest a sufficient quantity to enable you to make a fair estimate of the yield per acre. Select 30 average beets from those harvested, have the tops removed, leaving about an inch of stems, and wash and wipe the roots.

Pack the carefully dried beets in a box, inclose full data relative to the sample on the slip "A," and forward the package to me by express, charges collect.

I will forward you the necessary slips "A" and envelopes. Please repeat this sampling and the estimate of yield at intervals of a week until end of season, timing the shipments, if practicable, so that packages will not reach here Saturday or Sunday.

Keep accurate data of all field work, which please transmit at end of season.

Respectfully,

H. W. WILEY, *Chief.*

Slip "A," referred to in the above letter, calls for the following data: Variety; when planted; when thinned; when harvested; date of shipment of sample; character of the soil; width between rows, inches; character of the growing season, favorable or unfavorable; estimated yield per acre, tons; remarks.

EXPERIMENTS CONDUCTED AT WASHINGTON, D. C.

Fourteen rows of the Dippe Kleinwanzlebener Elite beet seed (S. P. I. No. 5772) were sown on the experiment farm at the Potomac Flats on May 18. They showed above the ground on May 25, and were cultivated once a week and oftener when there were frequent rains. Between June 11 and 14 the beets were thinned, one-half being allowed to remain 8 inches apart and the other 12 inches apart. The distance between the rows was 18 inches. Hand hoes and rakes were used for the first cultivation, after which wheel hoes were employed. In the following tabulated data the thick stand and the thin stand of beets have been separately considered for purposes of comparison.

Agricultural and analytical data on beets grown on the experiment farm, Potomac Flats.

THICK STAND (PLANTS 8 INCHES APART).

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	33.4	6.6	8.3	7.4	.....	66.7
October 3	31.6	6.2	7.6	7.3	7.1	65.8
October 10	34.1	6.7	7.9	7.8	7.5	68.4
October 17	33.5	5.9	8.1	8.0	7.8	67.2
October 24	33.0	6.7	8.1	8.6	8.4	65.6
October 31	22.5	8.6	11.8	9.4	9.1	69.1
November 7	34.0	6.7	5.1	8.8	8.5	67.7
November 21	34.2	5.1	7.0	10.6	10.3	68.8
Averages	32.0	6.6	8.0	8.5	8.4	67.4

Agricultural and analytical data on beets grown on the experiment farm, Potomac Flats—Continued.

THIN STAND (PLANTS 12 INCHES APART).

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	35.1	10.4	7.0	7.3	.....	65.2
October 3	39.0	9.9	10.1	7.4	7.2	65.5
October 10	30.6	8.5	9.9	7.8	7.5	66.6
October 17	34.3	8.5	7.8	8.2	8.0	66.6
October 24	39.9	7.2	7.5	9.0	8.7	66.6
October 31	24.6	10.7	8.6	10.2	9.9	70.8
November 7	39.2	8.0	6.6	9.6	9.3	67.6
November 21	35.6	10.1	8.2	10.0	9.7	68.5
Averages	34.8	9.2	8.2	8.7	8.6	67.2
General averages	33.4	7.9	8.1	8.6	8.5	67.3

A comparison of the two plats represented by the tables under "thick stand" and "thin stand" shows that the crowding of the beets produced a marked effect upon the average weight, which in the "thick" plat was 6.6 ounces and in the "thin" plat 9.2 ounces, after topping. The term "topping" means the removal of the top of the beet at the neck, as in preparation for the factory. The beets were undersized on both plats, which is a matter of remark, inasmuch as the soil is composed of the deposit from the Potomac River bottom and is considered quite fertile, producing abundantly other crops grown in the same field. The yield per acre on the two plats was almost identical, the thin stand having a slight advantage. In regard to the yield of sugar the two plats are very close together, but contrary to expectation the small beets in the "thick stand" plat had slightly less sugar than the beets of larger growth. The purity in both plats was extremely low, but was slightly higher in the "thick stand" plat.

The meteorological conditions under which these beets were grown are shown in the following table:

Meteorological data for Washington, D. C., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	62.5	2.81	197.1	443.8	44	10	16
June	72.4	4.66	329.8	445.9	74	18	6
July	79.8	5.17	273.6	453.0	60	12	7
Averages and totals	71.6	12.64	.....	.....	59.3	40	29
August	76.0	4.12	267.3	423.2	63	11	9
September	67.4	1.61	245.4	373.4	66	11	5
October	55.6	0.97	268.0	346.0	77	19	6
Averages and totals	66.3	6.70	.....	.....	68.7	41	20
General averages and totals	69.0	19.34	.....	.....	64.0	81	49

The meteorological conditions were quite favorable to the growth of beets, especially in respect of the distribution of the rainfall. In the three months most important to growth, namely, June, July, and August, the rainfall was abundant, while in September, the month most favorable to ripening, and in October, the month of harvest, the rainfall was deficient. In respect of distribution of rainfall, therefore, the season was ideal for the growth of a sugar beet. The temperature of the three principal growing months, as was to be expected, was very much in excess of the maximum which is found to be best suited to the production of beets of high sugar content. The excess above the maximum of 70° F. for June was 2.4°, for July 9.8°, and for August 6°. The distribution of the clear and cloudy days was also favorable to the growth of the beets. Aside from the temperature, therefore, it may be said that the meteorological conditions under which these beets grew were extremely favorable. It would appear from the consideration of this single plat that the temperature is the most important factor in the production of a high-grade beet.

EXPERIMENTS CONDUCTED BY THE INDIANA STATION

Prof. H. A. Huston makes the following report as to the cultivation of the beets grown from the Dippe Kleinwanzlebener Elite seed at Lafayette:

The special sugar-beet seed, No. 5772, furnished us by the Department in 1901, was planted on April 30, 1901. The land was plowed and subsoiled and was in fair condition at the time of planting. As two quite hot days preceded the planting, the soil temperature was sufficiently high. The seeds were planted in plats of six rows each, there being four plats. The rows were about 20 rods long, but the sampling was done upon the north end of the field because the conditions were more uniform there. The spaces between the four plats were filled out by three plats of 6 rows each from the other seed furnished by the Department. Samples of the soil and subsoil were drawn on May 1, 1901, and forwarded to the Department. The beets came up on May 9. The stand was not very good nor uniform, although double the usual amount of seed was used. As the season progressed the stand became still more uneven and was little improved by transplanting, although at two periods when conditions seemed to be favorable beets were transplanted to fill the vacancies. The beets were thinned to 8 inches in the row, and the rows were 22 inches apart. The cultivation was kept up into July. The season was decidedly unfavorable on account of the lack of moisture, and this fact combined with the rather uneven stand gave a low yield, although the beets were of very good quality. On November 1, the average yield from the four plats of No. 5772 was 5.4 tons of washed capped beets per acre. The weighings upon the other plats showed that the yields were not materially different from this. The last samples were drawn on November 1. On November 4, the ground froze and remained frozen for several days, and no further work was done upon the field, since the beets were badly frozen to a depth of 3 inches. Previous to the heavy freeze the bulk of the field had been harvested, a small portion only being left to study the question of ripening.

Agricultural and analytical data on beets grown at the Indiana experiment station, Lafayette.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Per cent.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 20	.....	6.3	.....	12.1	.....	85.2
October 5	.....	6.2	.....	15.5	.....	93.3
October 26	.....	7.7	.....	15.5	.....	91.7
October 28[a]	14	8.2	.....	15.1	14.6	82.5
November 1	.....	6.4	5.4	16.7	.....	90.7
Average	14	7	5.4	15	14.6	88.7

[a] These analyses were made at Lafayette, with the exception of the one dated October 28, which was made at Washington from a sample corresponding to that analyzed on October 26 at the Indiana station.

The data for Lafayette show the growth of a beet very much undersized, the average size of the topped beet as prepared for the factory being only 7 ounces. The average yield per acre was also only about one-half the normal average—namely, 5.4 tons—though this figure is open to suspicion, only one estimate having been made. The percentage of sugar in the beets was quite high, and the purities were phenomenally high, as has been the case in previous reports. In the sample analyzed in the Bureau of Chemistry the purity was found to be 82.5, which leads us to believe that some modification of the ordinary method of ascertaining purity is used at the Lafayette station, which is the cause of the phenomenally high figures. In the platting of the curves in the charts which follow, the data used are those obtained in the Bureau of Chemistry on October 28.

The meteorological data for Lafayette and Indianapolis as given in the following tables illustrate clearly the conditions of drought and excessive sunshine that prevailed, although the actual average temperature was 1.2° lower than in 1900.

Meteorological data for Lafayette, Ind., 1901.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	59.5	2.89	2	14
June	72.9	4.46	8	11
July	81.1	.44	18	2
Average and total	71.2	7.79	28	27
August	75.5	2.50	10	12
September	66.8	1.34	15	6
October	56.1	4.78	21	7
Average and total	66.1	8.62	46	25
General average and total	68.6	16.41	74	52

The sunshine record for Indianapolis, the nearest station at which sunshine records were kept, is shown in the following table:

Meteorological data for Indianapolis,[a] Ind., 1901.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	60.2	2.45	228.5	446.7	51	8	12
June	73.6	3.52	297.6	449.0	66	7	5
July	82.0	.83	396.3	455.2	87	19	0
Average and total	71.9	6.80	.....	.....	68	34	17
August	75.2	3.57	286.7	425.2	67	7	6
September	67.4	.66	284.1	373.6	76	14	2
October	56.7	3.52	247.8	344.9	72	17	7
Average and total	66.4	7.75	.....	.....	71.7	38	15
General average and total	69.2	14.55	.....	.....	69.85	72	32

[a] Fifty-nine miles southeast of Lafayette, Ind.

As will be seen from the preceding page the rainfall at Lafayette was very small, being only 16.41 inches as compared with 30.52 inches in 1900, and, moreover, the distribution was very unfavorable. In July, which is the principal growing month, there was scarcely any rain at all, while the supply for August was very moderate, and that for September still less. On the other hand, during October, the harvesting season, the rainfall was excessive. Thus it is seen that the distribution of the rainfall was not at all favorable to the production of the crop.

The temperatures for the growing season were above the maximum for the production of beets of the highest quality, being 2.9 degrees above 70° F. for June, 11.1 degrees above 70° F. for July, and 5.5 degrees above 70° F. for August. There is a remarkable contrast between the character of the beets grown at Lafayette and those at Washington, D. C., where it appears that the high temperature interfered very seriously with the production of sugar in the beet. In the case of Lafayette this effect does not appear, and the conclusion to be drawn from these data would be contrary to that reached at the Washington station. In this case it seems to be the latitude which is the predominating factor. The distribution of clear and cloudy days was very irregular, October having the largest number of clear days, although it was a month of heavy precipitation, July coming next and September third. The total number of clear days was 10 greater than in 1900, and the percentage of sunshine, as observed for Indianapolis, was 5.1 per cent higher.

The meteorological data for Indianapolis, about 59 miles southeast of Lafayette, are interesting for comparison. It is seen that the temperature and precipitation average about the same for the two points, but the distribution of the rainfall is slightly different, being heavier during August at Indianapolis and lighter during September. The

total precipitation for the six months, however, was slightly greater at Lafayette, while the average temperature, as might be expected, was a little higher at Indianapolis.

Under date of October 28, Professor Huston, in commenting on the prevailing meteorological conditions during the beet season of 1901, says:

As you are doubtless aware, the summer season has been quite unusual in this section, the drought being so severe that the corn crop will be reduced fully one-half; on our own farm we have practically no corn.

Your circular of September 15, was received, but since the beets had not appeared to approach maturity, but were simply standing still from lack of water, I did not deem it wise to send samples at that time. On September 20, I sampled a field, and the results you will find on inclosed card; on October 5, I sampled again, and you will see that between these dates the beets had made a very substantial gain in both sugar content and purity. No rain fell between these dates. On October 11, a general rain set in, and in four days we had 4.35 inches of rain. The beets started to grow, but you will see from the results of the analyses on October 26, that the sugar content was not reduced. This is an unusual result, and from now on we shall sample the field every few days to see what takes place. The drought reduced the stand of beets fully one-half, but those remaining are of marketable size and very good quality.

I regret very much that the beets are not so situated that we could have tried irrigation on them, for it would have been a banner year for the purpose.

EXPERIMENTS CONDUCTED BY THE IOWA STATION.

The beets were planted at the Iowa station on May 22, thinned on June 20, and harvested for the first time on October 7. Mr. James Atkinson, assistant in agriculture at Ames, writes as follows concerning the beet crop on September 23, 1901:

I may say that, while our beet crop has run the gauntlet of many foes this year, still it looks exceedingly well at the present time. You are, no doubt, aware that our crop suffered considerably from the hot winds and drought during the summer. I found that the beet crop stood it about as well as any other crop, although it was not by any means exempt from injury. The blister beetles also gave us considerable trouble, and we were compelled to fight four broods of them with Paris green and London purple. However, it appears at the present time that we have come out on top and that we shall have beets of good quality to harvest. * * * Sugar making has scarcely commenced yet, the beets being only slightly sweet to the taste. I think the first harvesting will be ready about October 1.

The results of the analyses made at Washington of the three samples of beets forwarded are found in the following table:

Agricultural and analytical data on beets grown at the Iowa Experiment Station, Ames.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 10	18.7	13.4	12.1	13.7	13.3	80.6
October 21	20.1	12.6	12.8	14.4	13.9	79.6
November 5	14	16.7	13.8	15.7	15.1	80.5
Average	17.6	14.2	12.9	14.6	14.1	80.2

The agricultural and analytical data for Iowa show beets of fine character, very favorable yield per acre, and satisfactory purity. The average weight of the beets, prepared for the factory, was 14.2 ounces and the estimated yield per acre 12.9 tons. The percentage of sugar in the beet was 14.1 and the purity 80.2. These data must be regarded as exceedingly favorable, especially in view of the climatic conditions under which the beets were grown.

The following detailed statement of the meteorological conditions shows the extent of the drought referred to by Mr. Atkinson, the rainfall for the six months being only 16.15 inches, as compared with 36.29 inches the preceding year. The temperature was practically the same, the record for 1900 showing an average of 68.2°.

Meteorological data for Ames, Iowa, 1901.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
1901.	°F.	*Inches.*		
May	61.4	3.69	17	5
June	74.4	2.36	21	1
July	83.3	2.26	27	1
Average and total	73.0	8.31	65	7
August	72.8	1.21	25	1
September	61.6	3.65	16	7
October	53.9	2.98	21	4
Average and total	62.8	7.84	62	12
General average and total	67.9	16.15	127	19

The sunshine record is taken from a table of meteorological data for Des Moines, Iowa, about 30 miles south of Ames, that being the nearest station at which sunshine records were kept:

Meteorological data for Des Moines, Iowa, 1901.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
1901.	°F.	*Inches.*					
May	61.6	1.40	312.7	451.9	69	12	6
June	73.4	2.41	329.1	456.2	72	11	3
July	84	1.72	390.1	461.8	84	15	1
Average and total	73	5.53	.....	.....	75	38	10
August	75	0.67	318.9	429.4	74	13	3
September	64.8	2.60	199.9	374.5	53	9	9
October	56.2	2.14	230	342.5	67	13	9
Average and total	65.3	5.41	.....	.....	64.7	35	21
General average and total	69.2	10.94	.....	.....	69.85	73	31

These data show that the months of June, July, and August were considerably above the desired temperature, the month of July especially having been excessively hot both at Ames and at Des Moines. The heat coupled with a very insufficient rainfall, July and

August showing a very small precipitation, made the season unusually dry. The data for Des Moines show a much smaller precipitation and at the same time a much smaller number of clear days than the data for Ames. These data show that the beet crop, properly planted and cultivated, is independent of variations in precipitation to a surprising extent. The total precipitation during the growing season at Ames for 1901 was considerably less than one-half that of the previous year and yet no deleterious effect was produced thereby on the size of the beets. In this respect and in quality the beet crop was markedly superior to that of 1900. These data are valuable as showing that, in regions where deficient rainfall may occur during the summer time, the sugar beet may produce a satisfactory crop if the proper attention is paid to the preparation of the soil and the cultivation.

EXPERIMENTS CONDUCTED BY THE KENTUCKY STATION.

The special beet seed was planted at Lexington, Ky., on April 29, 1901, 18 inches between the rows, thinned on May 23 and June 10, and harvested on October 17. The soil was plowed 8 inches deep and subsoiled 5 inches.

The analysis made at Washington of a sample of these beets gave the following data:

Agricultural and analytical data on beets grown at the Kentucky Experiment Station, Lexington.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 21	25.2	10.4	8	9.3	9	71

The analytical and agricultural data obtained at Lexington during the season are as follows:

Agricultural and analytical data determined at the Kentucky station.

Date of sampling.	Number of beets.	Average weight topped.	Sugar in juice.	Purity coefficient.
1901.		*Ounces.*	*Per cent.*	
July 11	1	.....	8.1	63.7
July 27	4	8	9.4	70.3
August 1	4	9.7	12.1	75.4
August 19	4	10.9	9.7	77.2
August 23	3	10.7	9.9	77.2
October 16	10	12.5	10.1	75.7
Average	.....	10.4	9.9	73.3

The data for the Kentucky station show that the beets produced there were slightly under the normal size, and neither the content of sugar nor the purity was high enough to enable these beets to compete

in sugar making with beets grown in more northern localities. The analysis of the single sample of beets made at Washington gave almost the same data as the average of the analyses made at the Kentucky station from July 11, to October 16, inclusive. From the analyses made at the Kentucky station it appears that the beets reached their highest content of sugar early in August, but too much stress must not be laid upon a single analysis. From the middle of August to the middle of October there was not a very large variation in the content of sugar in the beets.

Mr. Scovell states that the early season was favorable, but that July and August were unfavorable. The climatic conditions, as shown in the following table, do not differ greatly from those of the preceding season, even as to total rainfall:

Meteorological data for Lexington, Ky., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	*Inches.*	*Hours.*	*Hours.*			
May	62.8	2.67	273.4	441.7	62	14	7
June	73.9	3.70	322.3	443.1	73	13	2
July	80.3	2.61	385	450.1	86	23	0
Average and total	72.3	8.98	.....	.....	73.7	50	9
August	74	3.71	305.5	422.1	72	10	5
September	67	2.18	276	373	74	13	2
October	57.9	1.33	288.4	347.3	83	22	2
Average and total	66.3	7.25	.....	.....	76.3	45	9
General average and total	69.3	16.23	.....	.....	75	95	18

The meteorological data show that the temperature of June and July was lower than at Ames, Iowa, although Lexington is about 275 miles south of Ames. The distribution of the rainfall at Lexington was fairly favorable, although the supply was not sufficient. There is, however, a remarkable uniformity of precipitation during the months from May to September, inclusive. The precipitation for October was small, which is distinctly favorable for beet culture.

Mr. Scovell further calls attention to the existing drought by a statement of the accumulated deficiency of precipitation from January 1, 1901, which in May amounted to 8.12 inches; in June to 8.67 inches; in July to 10.24 inches; in August to 10.59 inches; in September to 11 inches, and in October to 11.78 inches.

A slight improvement took place in the quality of the beets, the average of sugar in the beet having been 7.8 per cent and the purity coefficient 69.6 in 1900, as compared with 9 and 71 for 1901. The beets are, however, still considerably below the commercial standard, both as to sugar content and purity.

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EXPERIMENTS CONDUCTED BY THE MICHIGAN STATION.

As will be seen by reference to the following table, two sets of experiments were conducted at the Michigan station, field No. 3 having been planted May 16, with rows 18 inches apart, and thinned June 15, while field No. 6 was not planted until June 8, and was thinned July 8 and 9, the rows being 21 inches apart. The soil of field No. 3 is described as a sandy loam and that of field No. 6 as a gravelly loam. The constituents of the soil will be discussed in detail under that heading. While leaf spot checked the growth somewhat, the season was in general very favorable, cool, and with a great deal of sunshine. The data for both fields are as follows:

Agricultural and analytical data on beets grown at the Michigan Experiment Station, Agricultural College.

FIELD NO. 3, EARLY PLANTING, MAY 16, 1901.

When received.	Removed in topping.	Average weight after topping.	Yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 26	21.9	8.8	13.6	12.5	.....	79.1
October 10	16	8.8	14.5	14.4	13.8	79.6
October 15	10.2	10.9	14.5	15.4	14.9	81.5
October 18[a]	14.2	8.2	16.9	14.1	13.7	80.1
November 2[a]	19.1	9.4	16.1	15.3	14.8	80.1
November 8	25.5	10.1	14.5	16.5	16	82.9
November 14	22.4	13.7	15.4	15.2	14.7	80.4
Average	18.5	10	15.1	14.8	14.7	80.5

FIELD NO. 6, LATE PLANTING, JUNE 8–9, 1901.

September 26	15.1	5.4	5.3	12	11.7	79.5
October 10	12.5	6.4	5.4	14	13.4	89.9
October 15	11.8	4.1	5.4	14.8	14.3	82
October 18[a]	14.2	8.2	4.7	14.1	13.7	80.1
November 2[a]	19.1	9.4	5.1	15.3	14.8	80.1
November 8	24.2	6.4	4.6	17.4	16.6	83.7
November 14	23.7	7	6.6	16.8	16	82.4
Average	17.2	6.7	5.3	14.9	14.4	82.5
General average	17.9	8.3	10.2	14.9	14.6	81.5

[a] In the two packages arriving on these dates the beets harvested from the two fields could not be separated.

The analytical data furnished by the station showed an average weight of beets in the field of 13 ounces, 12.7 per cent of sugar in the beets, a coefficient of purity of 79.2, and a yield per acre of 11.6 tons.

In case of the early planting, while the average weight of the beets was slightly below the normal, the estimated yield per acre was far above the average, namely, 15.1 tons. The data for the late planting, June 8 and 9, field No. 6, show practically the same quality of beets as regards sugar content and an even higher purity, but, in so far as yield per acre is concerned, the crop was only about one-third that of the early planting.

The beets grown during 1901 were of a better quality than those of the preceding year, the percentage of sugar in the beet and the

coefficient of purity being each 1.5 higher. The beets were smaller, however, and the average yield per acre was lower. The data for the late planting are responsible for the decrease to a great extent, the figures for the early planting being but little lower than those for 1900.

The climatic conditions existing at Agricultural College and at Detroit during this season are shown in the following tables:

Meteorological data for Agricultural College, Mich., 1901.

Month.	Temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	55.2	2.42	10	14
June	68.0	3.57	13	2
July	74.2	5.08	22	3
Average and total	65.8	11.07	45	19
August	68.4	2.49	15	7
September	61.7	1.67	18	7
October	49.6	4.61	18	4
Average and total	59.9	8.77	51	18
General average and total	62.8	19.84	96	37

In the following table is given the sunshine record for Detroit, Mich., 76 miles southeast of Agricultural College, the nearest point at which sunshine records were kept.

Meteorological data for Detroit, Mich., 1901.

Month.	Temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*			
May	56.6	2.76	222.2	451.9	49	5	10
June	68.8	2.08	286.5	456.2	63	9	8
July	76.8	5.50	333.4	461.8	72	18	3
Average and total	67.4	10.34	.....	.....	61.3	32	21
August	71.9	3.20	238.3	429.4	55	10	6
September	64.8	1.65	244.5	374.5	65	13	4
October	52.8	1.90	231	342.5	67	16	3
Average and total	63.2	6.75	.....	.....	62.3	39	13
General average and total	65.3	17.09	.....	.....	61.8	71	34

These data show an abundant rainfall during the three principal growing months, especially in July, when the amount appears to be excessive. September was a dry month, favorable to the ripening of the beet, while, on the other hand, October was a wet month and unfavorable to the harvesting. The figures for Detroit show practically the same conditions as those prevailing at Agricultural College. A comparison of the meteorological data with that for 1900 shows that there was a fall in the average temperature of 1.7 degrees and an increase in the precipitation of 2.3 inches, while the percentage of sunshine increased 2.6 per cent.

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT GENEVA.

The experimental beet plots at the Geneva station were planted on June 10, with 20 inches between the rows, and were thinned from July 10 to 20. Special fertilizer experiments were conducted at this station, which will be further discussed under soil. The season was reported as being favorable, and the following analytical data, as determined at Washington, bear out this report, the beets from Geneva outranking any others grown as to sugar content and purity, standing second in size and yield.

Agricultural and analytical data on beets grown at the New York experiment station, Geneva.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
November 2	16.8	19.7	.....	16.5	16.0	82.1
Do	15.9	18.4	.....	17.9	17.3	89.1
November 11	17.8	21.4	.....	14.9	14.4	79.7
Do	17.8	19.7	.....	15.8	15.3	83.2
December 24	38.3	10.8	.....	15.45	.....	82.6
Do	15.5	13.1	.....	17.2	.....	86.9
Averages	20.4	17.2	[a]13.8	16.3	15.8	83.9

[a] Averaged from N. Y. Exp. Sta. Bul. No. 205, 1901.

As the conditions existing at Geneva seem to approach the ideal for sugar-beet culture, it is regretted that only the temperature and rainfall data are obtainable for that place. The sunshine data is not available for any nearer point than Ithaca. It is shown, however, that the decreased temperature in 1901, as compared with the previous year—i. e., 1.6°—and the increased rainfall of 3.4 inches had practically no effect on the quality of the beets, while their size was slightly increased. The meteorological data available are as follows:

Meteorological data for Geneva, N. Y., 1901.

Month.	Temperature.	Precipitation.
1901.	° *F.*	*Inches.*
May	56.9	3.80
June	68.9	2.07
July	76.6	3.97
Average and total	67.5	9.84
August	71	5.52
September	64	2.46
October	51.4	1.35
Average and total	62.1	9.33
General average and total	64.8	19.17

These data show a most favorable distribution of the rainfall during the growing season. There was not too much precipitation during May and June, the period of preparation. There was abundant precipitation during July and August, the period of rapid growth; a diminished precipitation during September, the period of ripening, and a very slight rainfall during October, the time of harvesting. No more ideal distribution of the rainfall could be desired.

EXPERIMENTS CONDUCTED BY THE CORNELL STATION AT ITHACA, N. Y.

The season at Ithaca is reported as having been favorable, and a comparison of the analytical data with that of the previous year shows that the beets were of practically the same high sugar content, although the purity was 2 points lower. While these beets are of excellent character, it is to be noted that the purity is not as high as would be expected in beets of their sugar content, being very slightly below the desired standard. The analyses made at the station give higher figures for both sugar content and purity than those obtained in our own work.

Agricultural and analytical data on beets grown at the Cornell experiment station, Ithaca.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 17	17.9	12.2	10.1	14.5	14.1	80
October 24	17.3	11.2	13	14.5	14.1	81.9
October 31	15.8	13.7	13	14.5	14.1	77.5
November 7	21.6	13.3	13.5	16.3	15.8	81.1
November 21	26.7	11	13	14.6	14.2	79.3
November 25	15.8	17.3	13	15.8	15.3	79.4
Average	19.2	13.1	12.6	15	14.6	79.9

Agricultural and analytical data prepared at the Cornell Station.

When harvested.	Average weight of beets.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Ounces.*	*Per cent.*	*Per cent.*	
October 15	12.5	15.85	15.06	82.6
October 22	10.0	16.05	15.25	82.3
October 29	8.0	16.65	15.85	80.5
November 5	13.5	19.40	18.43	84.0
November 19	10.0	16.60	15.77	81.0
November 21	16.5	18.75	17.80	83.0
Average	11.75	17.22	16.35	82.2

The climatic conditions under which these beets were grown are shown in the following table:

Meteorological data for Ithaca, N. Y., 1902.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	°F.	Inches.	Hours.	Hours.			
May	55.8	4.20	219.6	451.9	49	6	16
June	67.8	3.06	344.7	456.2	76	10	8
July	74.3	3.60	369.4	461.8	80	5	8
Average and total	66.0	10.86	.....	.....	68.3	21	32
August	69.5	3.85	277.6	429.4	65	8	9
September	61.8	1.66	261.8	374.5	70	13	7
October	51.2	1.07	190.6	342.5	56	7	6
Average and total	60.8	6.58	.....	.....	63.7	28	22
General average and total	63.4	17.44	.....	.....	66	49	54

The meteorological data show an even distribution of rainfall, indicating, however, a larger precipitation in May and a smaller one in August than at the Geneva station. The dry weather of September and October was extremely favorable to the ripening and harvesting of the beets.

EXPERIMENTS CONDUCTED BY THE UTAH STATION.

The plat selected for the cooperative sugar-beet work was plowed and subsoiled on April 24, and seeded with a drill on April 27, 1901. The beets were thinned on June 1, and as late as June 19, were not suffering for water, at which time they stood 6½ inches. The dates of irrigation were July 1, 16, and 31; August 15; and September 3 and 16. The beets were cultivated on May 23, June 13, and July 3, the harvest taking place on November 4, 1901. The growth was uneven, there being vacant places in the rows. To the above report Director Widtsoe adds the following data, which differ somewhat from those obtained at the Washington office:

	Tons.
Yield per acre	23.91
Per cent sucrose in juice	17.05
Purity coefficient	81.0

The analytical and agricultural data obtained on the samples forwarded to Washington are as follows:

Agricultural and analytical data on beets grown at the Utah Experiment Station, Logan.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	Per cent.	Ounces.	Tons.	Per cent.	Per cent.	
October 3	14.7	26.1	24.7	12.4	11.9	75.0
October 10	13.7	23.1	22.0	14.6	14.1	79.8
October 14	9.9	24.2	.....	14.3	13.9	79.4
October 22	10.2	23.2	.....	17.2	16.7	82.3
Average	12.1	24.2	23.4	14.6	14.2	79.1

The data for the Utah station are given for reference and comparison, but of course are not platted with the other stations in the graphic charts. It is the intention during another year to include a series of comparative tests at irrigation stations when the data obtained for Utah will serve as an introduction. The most marked characteristic of the Utah beets is their large size, being fully one-third above the ideal average for sugar beets of high quality. The yield per acre is also far above that obtained at the other stations where irrigation is not practiced. The sugar content of the beets is entirely satisfactory, although the purity, as might be expected from the character of the soil and the method of culture, is somewhat low.

The meteorological conditions prevailing at Logan and the vicinity during the period of growth were as follows:

Meteorological data for Logan, Utah, 1901.

Month.	Mean temperature.	Total precipitation.	Clear days.[a]	Cloudy days.[a]
	Degrees.	*Inches.*		
May	60.6	2.43	21	7
June	61.4	0.41	20	2
July	76.7	.07	28	2
Average and total	66.2	2.91	69	11
August	72.8	1.60	21	8
September	59.2	1.03	22	8
October	53.6	1.83	18	10
Average and total	61.9	4.46	61	26
General average and total	64.0	7.37	130	37

[a] Record made at Corinne, 19 miles southwest of Logan.

In the following table is given the sunshine record for Salt Lake City, Utah, the nearest point at which sunshine records were kept, 66 miles south of Logan.

Meteorological data for Salt Lake City, Utah, 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	°*F.*	*Inches.*	*Hours.*	*Hours.*			
May	63.0	4.27	352.6	449.1	79	20	2
June	65.0	0.49	351.4	451.9	78	23	3
July	80.2	.31	386.0	458.6	84	19	2
Average and total	69.4	5.07	.....	.....	80.3	62	7
August	76.0	1.22	282.0	427.4	66	18	6
September	63.0	.66	302.9	374.0	81	21	3
October	55.6	.98	239.4	343.9	70	22	5
Average and total	64.9	2.86	.....	.....	72.3	61	14
General average and total	67.2	7.93	.....	.....	76.3	123	21

The meteorological conditions at Logan are interesting in showing the distribution of the precipitation and the variations in temperature. During July it is seen that only a trace of rain fell, while in August and October the precipitation compares favorably with that of some of the nonirrigated stations. The temperature at Logan during the growing season is decidedly lower than at the nonirrigated stations. July shows a high temperature, but June especially is low, and the August temperature is not much above 70°.

The data for Salt Lake City show practically the same distribution of precipitation as at Logan during the months of June, July, and August. The temperature, however, at Salt Lake was decidedly higher, especially during July, and the precipitation during the month of May was nearly twice as great as at Logan.

EXPERIMENTS CONDUCTED BY THE VIRGINIA STATION.

For the first time the experimental beet work was carried on at Blacksburg, in 1901, thus supplying a Southern station to take the place of North Carolina, where the work was temporarily discontinued.

The beets were planted on June 1, with 18 inches between the rows, thinned on July 5, and the first sample forwarded was harvested on October 12. The determinations of the percentage of sugar in the juice, as made at the experiment station, were as follows:

	Per cent.
September 20, 1901	6.65
September 30, 1901	8.95
October 12, 1901	12.62
October 22, 1901	12.69
October 31, 1901	12.77
Average	10.74

The analytical data obtained at Washington on the samples forwarded from Blacksburg and the climatic conditions prevailing during the period of growth are shown in the following tables:

Agricultural and analytical data on beets grown at the Virginia experiment station, Blacksburg.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 15	8.7	5.6	10+	11.6	11.2	75.5
October 24	20.6	4	.....	13.5	12.9	76.7
November 2	16	4	.....	15.8	15.3	80.2
Average	15.1	4.5	10	13.6	13.1	77.6

Meteorological data for Blacksburg, Va., 1901.

Month.	Mean temperature.	Total precipitation.	Sunshine.[a]	Clear days.	Cloudy days.
	° *F.*	*Inches.*	*Per cent.*		
May	58.7	6.71	.....	12	10
June	67.8	6.78	46.8	10	12
July	74	4.51	54.6	14	7
Average and total	66.8	18	50.7	36	29
August	68.6	10.53	40.8	7	12
September	61.6	2.59	61.3	15	9
October	52	.96	[b] 68	21	3
Average and total	60.7	14.08	56.7	43	24
General average and total	63.8	32.08	53.7	79	53

[a] These data were averaged from weekly means furnished by Mr. Alwood.
[b] To October 19 only.

In commenting on the season at Blacksburg, Mr. Alwood, under date of October 12, says:

> The weather conditions have been decidedly bad here this year, so that the crop is not extra heavy, but it can be considered a fair average. I think that at this time the beets are practically mature, but I fear that the wet season and consequent lack of sunshine will cause them to analyze very low in sugar. To the present time no second growth has begun; in fact, only a few of the bottom leaves have died. It is hardly probable that conditions as to sunlight will be such as to increase the sugar content very materially from this on.

It will be noticed that the general characteristics of the season at Blacksburg are in striking contrast to those at the other stations, unusual rains having prevailed at the former and drought at the latter. In forwarding the samples, Mr. Alwood said: "A more unfavorable year could not occur, but in this garden soil the result is fair."

A study of the agricultural and analytical data for Blacksburg shows a beet of phenomenally small size but of a fair average yield per acre. The sugar content of the samples was fair, but the purity was unsatisfactory. The high sugar content of this low latitude must be ascribed principally to the altitude of the station, which is about 2,100 feet. One of the principal objects in extending the collaborative work to Blacksburg was to determine the effect of altitude and its accompanying meteorological influences upon the sugar content of the beet. This object has been attained in a most striking manner in the preceding data.

The rainfall during the preparatory planting period was excessive. For the month of June it was abundant and for August far in excess of the quantity required for favorable growth. The precipitation for September and October, however, was favorable to the ripening and harvesting of the crop.

EXPERIMENTS CONDUCTED BY THE WISCONSIN STATION.

While the beets grown at the Wisconsin station were of very fair quality, they were far inferior to those of the previous season, showing a decrease of sugar in the beet of 2.5 per cent and a decrease in purity of 8.8. The beets grown in 1900 ranked next to the highest among the cooperating stations, and undoubtedly the falling off in quality in 1901 was due not solely to the drought (the total precipitation for the growing season being 7.7 inches less than in the previous year), but also in part to the unfortunate distribution of such rain as fell. The drought was most extreme in the first months of growth and the rainfall greatest in September and October, thus probably inducing a second growth and lowering the quality of the beets. The average temperature and the number of clear and cloudy days remained practically the same as in 1900, the rainfall being thus the only important variant.

The tables given below show the analytical data obtained at Washington on these samples and also the meteorological conditions under which the beets were grown:

Agricultural and analytical data on beets grown at the Wisconsin Experiment Station, Madison.

When received.	Removed in topping.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beets.	Purity coefficient.
1901.	*Per cent.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
October 1	10	8.2	11.375	13.5	12.9	80.3
October 9	15.1	8.3	9.3	14.1	13.5	82
October 16	9.4	11.4	12.8	11.1	10.8	71.2
October 24	14.9	15.8	10.5	13.8	13.4	76.2
Average	12.4	10.9	11	13.1	12.7	77.4

Meteorological data for Madison, Wis., 1901.

Month.	Mean temperature.	Total precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	57.8	2.41	4	15
June	70.4	2.40	5	12
July	79.6	1.54	12	9
Average and total	69.3	6.35	21	36
August	71.6	1.33	10	11
September	61.4	4.16	7	10
October	52.4	2.49	10	9
Average and total	61.8	7.98	27	30
General average and total	65.6	14.33	48	66

The following comment on the climatic conditions as shown in the above table is made by Mr. Shaw:

The season of 1901 was, as a whole, very unfavorable to most crops in Wisconsin. The extremely hot and dry weather during July and August did great damage to

crops all over the State, the southern part of the State suffering most from the drought. The average temperature of July was 4.8° F. above normal, and in the region along the western border of the State the average for this month rose 10° F. above the normal temperature. The rainfall during the season was very uneven, the average for the northern and central counties being nearly 23 inches for the seven months, March to September, and only about 14 inches for the southern counties. The total rainfall for the seven months was, on the average for the whole State, 20.41 inches, which is two-thirds of an inch below normal.

The following detailed report of the cultural data and other interesting items as to the season's work was forwarded by Messrs. Woll and Shaw, in charge of the cooperative work at the Wisconsin station:

The land was plowed early in the spring of 1901 and a few weeks later prepared in the usual manner for the planting of the beet seed by disking and pulverizing. The planting was done by means of a hand seeder on May 17, in rows running north and south, 18 inches apart. The experience of last year was duplicated this spring; a hard crust was formed on the land through heavy rains a few days before the young plants began showing themselves above ground; as most of the young plants probably would have been unable to break the crust formed, it was decided to reharrow and replant the entire plat, and this was accordingly done on June 7.

The plants began appearing above the ground about June 14. A terrific thunderstorm appearing on June 16 did great damage to the beets, as to all crops in this vicinity, and the soil of the eastern part of the field was washed badly, in places to a depth of 2 or 3 inches; in other places the young beet plants were covered to a similar depth. The field was thoroughly hoed, and although the crop at first seemed entirely ruined, the beet plants gradually recovered. In the eastern part they seemed struggling for existence against heavy odds for a week or more.

The plants were thinned from June 27 to July 1, a strong plant being left every 9 inches in the row. Owing to the severe drought, no transplanting was attempted. For over a month after this date no rain fell and the beets grew but little, the best stand being in the southwest corner and the poorest in the southeast corner of the field. The drought in this vicinity completely ruined some crops, and the prospects were at this time that there would not be a yield of 50 per cent of the usual average of any crop.

The sampling of the beets for analysis took place for the first time September 25, and from that time up to harvest the variety No. 5772 was sampled every week. The results of the analysis are given in the following table:

Agricultural and analytical data determined at Madison, Wis., on beets grown at that station.

Date of sampling.	Weight of trimmed beets.	Sugar in juice.	Sugar in beets.	Purity coefficient.
1901.	*Ounces.*	*Per cent.*	*Per cent.*	
September 25	9.6	12.6	12.0	77.2
October 4	8.0	13.7	13.0	78.4
October 11	10.7	10.8	10.2	71.6
Average	9.4	12.4	11.7	75.7

The sampling of No. 5772 was done by digging all beets in 60 feet of a row of average luxuriance and selecting three beets from the lot. Samples were forwarded to the Bureau of Chemistry, United States Department of Agriculture. The low results of analyses were due to the immature condition of the beets. A rainy period set in on October 7, which lasted for five days; over 2 inches of rain fell during this time.

The weather was raw and cold during the following days, and the harvesting was postponed as long as practicable, so as to give the beets a chance to mature. Other farm work and the uncertainty of the advanced season rendered it necessary, however, to begin the harvest on October 18. At that time the beets looked as if they were still growing; but few dead leaves were observed, and the general appearance of the beets was green and thrifty. The beets on the western half of the plat looked much better than those on the eastern half.

A bushel basket of beets was taken from each load hauled off the field (1 to 2 bushels of each variety). The samples thus secured were washed to determine shrinkage from adhering dirt. This amounted to 8.8 per cent for some of the different varieties, and on the average to 5 per cent. The results obtained at harvest were as follows:

Estimated yield per acre	tons	9.9
Sugar in the beets	per cent	10.9

The low results obtained during the past season with the university farm beets were somewhat of a surprise to us, although we did not expect much this year from the adverse conditions under which the beets grew throughout the season, the most important of which was the late date of planting. The peculiar climatic conditions, together with the short growing period which the beets had, fully explain the results, and also show that soils which in ordinary seasons will produce rich beets, higher in sugar than the common factory standard by at least several per cent, as has been generally the case on our university farm soil, may with the same kind of careful culture under exceptionally unfavorable circumstances produce beets that would not be accepted at a sugar factory.

The results of the analyses of beets grown by Wisconsin farmers during this season show that similar conditions did not prevail in all portions of the State. From three to four weeks after the beets were harvested the weather was most favorable to the maturing of beets, being sunshiny and quite warm, and, if the harvesting could have been postponed to this period, there can be no doubt that the results would have been nearly up to the standard set by earlier work in this line done at our experiment station. This would, however, have brought the harvest nearly a month and a half later than usual, which under ordinary fall conditions would be impracticable or at least quite inconvenient. The possible improvement of beets during the weeks following the harvest is suggested both by comparison with analyses of beets received from outside points before and after the time of our beet harvest and from what we know of the relations of weather conditions to the quality of the beets grown.

THE SOILS.

For the first time in the study of the effect of environment on the composition of the beet we have collected and examined a number of the soils on which the experiments were conducted. Unfortunately data on some soils are wanting, owing to the failure of the collaborating station to forward samples. The following data are therefore given tentatively, and in so far as possible the influence of the soil on the composition of the beets and the magnitude of the crop has been studied. The notes descriptive of the soils received from the stations follow on the next page.

DESCRIPTIVE NOTES ON SOILS.

Lafayette, Ind.

(Nos. 22383 and 22384.)

The samples of soil received from the Indiana station were accompanied by the following description:

I send you to-day a sample of the soil and a sample of the subsoil from the land on which the work on sugar beets will be conducted. This land has not been used for experimental plats, but has been in bulk crops, following the general rotation of corn, oats, wheat, and clover. Before the last corn crop I think there was millet on it. Last year the land was in clover with a poor stand, so that the beets are planted upon a clover sod which consists largely of weeds. The land is in the northwest corner of the field immediately west of the station building and is opposite the old greenhouse.

Agricultural College, Mich.

Field No. 3, Nos. 23581 and 23582.
Field No. 6, Nos. 23583 and 23584.

Under date of November 11, 1901, Mr. J. D. Towar, agriculturist of the station, made the following report on the soil on which the beets were grown:

In this mail I am sending you samples of the soil and subsoil on which the sugar beets which we have been sending you from seed No. 5772 were grown. The sample marked field No. 3 was a clover sod of two years' standing which was covered during the winter uniformly with a coat of stable manure. As soon as we could work the ground in the spring it was plowed to a depth of 8 inches and subsoiled 7 inches deeper. This operation was immediately followed by the roller, and the ground was harrowed at frequent intervals until May 9, when it was in fine condition, and an application of 200 pounds of home-mixed fertilizer per acre was made. This fertilizer consisted of one part nitrate of soda, one part muriate of potash, and two parts dissolved phosphate rock, the latter giving an analysis of about 17 per cent total phosphoric acid. The nitrate of soda was 96 per cent pure, and the muriate of potash contained 49.85 per cent K_2O.

The soil samples were taken August 28. In field No. 3 four samples of the soil were taken in the following manner, where the depths were respectively 9 inches, 8½ inches, 6½ inches, and 11½ inches. In each case a hole was dug about 1 foot square, leaving one perpendicular side from which a vertical slice about 3 inches in thickness was taken. The several samples were thoroughly mixed, and the sample sent is a portion of this mixture. The samples of subsoil, taken immediately below the soil samples, were from a depth of 1 foot, and were procured in a similar manner.

The samples from field No. 6 were taken in a similar manner to those from field No. 3, though the soil, a heavier loam, was from a plot which has grown sugar beets three years in succession, receiving absolutely no fertiliz r. The depth of soil in the three places sampled was 8½, 8, and 9¼ inches. This plot was adjacent to others which have received each year applications of fertilizers, but the remarkably low yield of the No. 6 plot is due more to the lateness of the season at which the seed was planted than to exhaustion of the soil fertility. I wrote you some time ago that we had sown this seed on a piece of muck land, some of which was quite thoroughly mixed with alluvial soil.

Logan, Utah.

(No. 23586.)

The history of the plot used for the special beet work at the Utah station was reported as follows:

Plot No. 379 is located on the upper level of the Logan delta. The soil is gravelly and not more than 2 feet in depth. It is underlaid by a stratum of coarse porous gravel perhaps 25 feet or more in thickness. The virgin ground was broken in 1889. Corn was grown on it in 1890 and 1891, oats in 1892, clover in 1893, wheat in 1894, timothy in 1895 and 1896, wheat in 1897, peas in 1898, wheat in 1899 and 1900, and sugar beets, United States Department of Agriculture No. 5772 "special," in 1901. The plat was manured in the winter of 1900–1901.

Blacksburg, Va.

(No. 23818.)

The soil in which the beets were raised is described as a brownish-black loam. The following description of the taking of the sample forwarded to Washington for analysis and its general characteristics was furnished by the director of the station:

Three positions, fairly representing the entire plot, were chosen, and the notes made as follows:

Opening No. 1.—The soil down to the subsoil measured 7¼ inches, dark brown color, mellow loam in character. Color changed sharply at this point. Subsoil ocherous gray, quite friable, with considerable sand, yet firm.

Opening No. 2.—Same general character of soil; 9 inches down to the line of change of color.

Opening No. 3.—Soil 8½ inches to the line of change of color. The loam is a lighter brown in color. The subsoil is the same.

This land is a part of the experimental garden which was heavily manured until the last three years, during which time it had received no barnyard manure and no chemical fertilizers. It would be considered a very good type of garden soil, but in its present state is not very rich, as it has been cropped heavily each year. Last year on this area we grew a collection of Chinese vegetables, chiefly root crops, but no beets or crops belonging to this family.

Madison, Wis.

(Nos. 25051 and 25052.)

The history of the soil on which the sugar beets of 1901 were grown is as follows:

The plat set apart for the sugar beets at the university farm was a piece of land one-half acre in area (155 by 141 feet) in the northwestern portion of the Randall field. The field has been used as a pasture ever since this region was settled, and was in corn last year. During late years, prior to 1900, it served as a pasture for sheep or cows, but has never been otherwise manured. The soil is a clay loam, and, like most of the land on the university farm, has a tendency to bake after rains. The land produced a very good corn crop last year, and, as regards its state of fertility, should have been well adapted to the production of sugar beets. The lower part of the field slopes toward the northeast, and the unevenness in the soil in different parts of the field thus introduced rendered it somewhat unsatisfactory for variety tests.

Ithaca, N. Y.

(No. 25099.)

Unfortunately the sample of soil was not taken at Ithaca until 1902, and in the meanwhile a crop of oats and a crop of hay from clover and timothy had been harvested. The analysis of the sample of soil from the plat on which the beets were grown in 1901 is, however, submitted with the above explanation.

Ames, Iowa.

(No. 25114.)

The sample of soil from the plat on which the beets were grown in 1901 was not taken until 1902, and Mr. Atkinson, writing under date of October 28, 1902, in regard to this soil, says:

I may say that there was a crop of soy beans grown on this plat during 1902, but I have had samples of the soil of the first 6 inches, the second 6 inches, and the third 6 inches taken, and will forward them to you if you desire to have them now. Of course I understand that the soy beans will have produced a very marked effect on the soil, particularly on the amount of nitrogen present. However, I shall dry the samples and forward them to you, and hope that they may be of some use in compiling results.

The samples sent were so small that the three were mixed and one analysis made.

Potomac Flats, Washington, D. C.

(No. 25125.)

This soil is an alluvial silt pumped from the Washington harbor side of the Potomac River. It was first plowed in 1898, and has never been fertilized. In 1899 the plat lay fallow, and in 1900 it was in corn.

Lexington, Ky.

No sample was forwarded from this station, but the soil in which the experiments were conducted is described as the clay loam of the station farm known as bluegrass soil.

Geneva, N. Y.

No sample of soil was received from Geneva, but the following descriptive data were furnished, relating to the fertilizer experiments:

The general character of the soil was that of a clay loam. Comparative experiments were carried on with farm manure and commercial fertilizer, and for the first time in four years the beets raised on the plats to which the commercial fertilizer had been applied were superior to those on which stable manure had been applied.[a] This is

[a] For a full discussion of the work from this point of view see Bul. No. 205, N. Y. Exp. Sta., Influence of Manure on Sugar Beets, December, 1901.

attributed to the fact that an excessive amount of the latter was used. The analytical data obtained at Geneva bearing on this point is shown in the following table:

Agricultural and analytical data prepared at the New York Experiment Station, Geneva.

Fertilizer.	Quantity of fertilizer per acre.	Beets grown.				
		Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beets.	Purity coefficient.
	Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
Stable manure	80,000	13.1	14.9	18.6	13.4	80.0
Commercial fertilizer	1,000	12.0	12.6	20.7	15.6	87.7
Average	.....	12.7	13.8	19.7	14.5	83.4

ANALYSES OF SOILS.

In the comparative table of analyses given below, including such stations as sent samples of soil, two methods of examination were employed, namely, the method of the Association of Official Agricultural Chemists,[a] and the method of ascertaining the quantity of mineral matter soluble in N/200 hydrochloric acid, as proposed by C. C. Moore, of the Bureau of Chemistry.[b] The first method gives practically all of the mineral matter in the soil that may become available in many years. The second method represents an attempt to determine the quantity of mineral matter (in this case potash and phosphoric acid only) which is available for the immediate uses of a crop. The method has been developed, however, with special reference to the oat plant. A glance at the analytical data obtained shows a wide difference in the character of these soils, both in respect of the total amount of plant food eventually available and the amount immediately available.

Chemical analyses of sugar-beet soils, 1901.

Station.	Soil sample.		Insoluble matter.	Water (H_2O).	Volatile.	Nitrogen (N).	Soluble in N/200 hydrochloric acid.	
	Serial number.	Description.					Potash (K_2O).	Phosphoric acid (P_2O_5).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind.	22383	Soil	79.40	1.60	8.83	0.295	.0074	.00017
	22384	Subsoil	78.74	1.92	8.00	.239	.0051	.00014
Agricultural College, Mich.	23581	Soil (field No. 3)	91.87	.28	3.62	.154	.0036	.000062
	23582	Subsoil (field No. 3)	92.03	.24	2.44	.091	.0102	.00017
	23583	Soil (field No. 6)	91.87	.46	4.30	.161	.0052	.00009
	23584	Subsoil (field No. 6)	93.59	.26	2.08	.070	.0039	.00015
Logan, Utah	23586	Soil	71.54	1.26	10.75	.201	.0333	.00143
Blacksburg, Va.	23818	.....	89.00	.42	4.46	.154	.0198	.00003
Madison, Wis.	25051	Soil	82.77	6.50	4.45	.165	.0040	.00040
	25052	Subsoil	79.81	5.20	4.40	.105	.0027	.000025
Ithaca, N. Y.	25099	Soil	78.86	8.24	5.50	.201	.0077	.00003
Ames, Iowa	25114	.....do	78.49	2.82	8.45	.267	.0079	.00020
Washington, D. C.	25125	.....do	83.47	1.75	5.35	.183	.0062	.00020

[a] Methods of Analysis, Bul. 46, Revised, Bureau of Chemistry, U. S. Dept. Agr.

[b] Journal American Chemical Society, *24*, 79.

Chemical analyses of sugar-beet soils, 1901—Continued.

Station.	Soil sample.		Soluble in 1.115 sp. gr. hydrochloric acid.					
	Serial number.	Description.	Sulphuric acid (SO_3).	Potash (K_2O).	Lime (C_aO).	Magnesia (MgO).	Fe_2O_3 Al_2O_3 Mn_3O_4.	Phosphoric acid (P_2O_5).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind	22383	Soil	0.09	0.85	0.60	0.60	8.49	0.12
	22884	Subsoil	.06	.36	.72	.62	9.83	.10
Agricultural College, Mich.	23581	Soil (field No. 3)	.07	.12	.46	.32	3.33	.06
	23582	Subsoil (field No. 3)	.09	.18	.43	.45	4.60	.03
	23583	Soil (field No. 6)	.06	.06	.34	.22	3.30	.06
	23584	Subsoil (field No. 6)	.03	.13	.32	.35	3.61	.04
Logan, Utah	23586	Soil	.07	.76	5.00	3.42	7.49	.24
Blacksburg, Va	23818		.07	.80	.14	.29	5.57	.10
Madison, Wis	25051	Soil		.35	.87	.59	4.42	.04
	25052	Subsoil		.38	.52	.75	9.82	.06
Ithaca, N. Y	25099	Soil	.09	.22	.16	.56	6.55	.13
Ames, Iowa	25114	do		.35	.85	.65	8.22	.06
Washington, D. C	25125	do		.39	.47	.51	8.27	.03

Mechanical analyses of sugar-beet soils, 1901.[a]

Station.	Soil sample.		Fine earth.							
	Serial number.	Description.	Organic matter.[b]	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Lafayette, Ind	22383	Soil	3.52	1.94	4.00	2.22	2.00	5.76	62.08	22.00
	22384	Subsoil	3.00	1.37	3.12	2.06	1.72	5.35	58.23	18.15
Agricultural College, Mich.	23581	Soil (field No. 3)	1.62	2.84	6.76	12.20	34.54	15.84	18.22	8.86
	23582	Subsoil (field No. 3)	.54	2.78	5.32	11.60	37.60	14.96	13.26	13.86
	23583	Soil (field No. 6)	1.73	5.18	7.58	14.86	41.76	9.64	13.70	7.24
	23584	Subsoil (field No. 6)	.80	4.84	6.80	14.58	44.06	10.66	11.04	7.12
Logan, Utah	23586	Soil	3.24	.62	1.90	1.84	15.48	27.62	25.26	26.62
Blacksburg, Va	23818	do	2.07	2.68	3.84	4.68	9.62	12.66	48.10	18.00
Madison, Wis	25051	do	2.41	.48	1.46	2.26	6.36	11.82	64.12	13.36
	25052	Subsoil	.68	.....	.46	.94	3.68	10.52	69.46	14.76
Ithaca, N. Y	25099	Soil	2.09	6.10	4.78	3.74	10.30	16.26	38.88	19.98
Washington, D.C.	25125	Soil (from flats)	1.63	.34	1.52	2.94	16.78	24.00	33.02	21.40

[a] Made in the Bureau of Soils, U. S. Department of Agriculture.
[b] Organic matter determinations were made by the wet combustion method.

COMMENT ON ANALYSES.

The study of the analytical data in the above tables is interesting from a scientific point of view, and is also conclusive, in so far as one series of observations can be, in regard to the very small effect which the composition of the soil has upon the sugar content of the beet. While it is doubtless true that the character of the soil influences to a greater or less degree the quality of some crops, it is certain that its principal influence in the case of the sugar beet is exerted almost exclusively upon the magnitude of the crop. In this connection the writer would like to recall from personal experience two instances

showing how widely different kinds of soil may produce beets which have practically the same content of sugar. A few years ago samples of beets were received from Chautauqua County, N. Y., which were grown in a reclaimed swamp where the drainage had been so perfected as to permit the cultivation of the soil. The beets grown in this soil, extremely rich in vegetable mold, had a very high content of sugar. On the other hand, samples of beets taken from almost a pure sand near the Kankakee River in Indiana, where there was scarcely any organic matter in the soil, had almost the same content of sugar. These two types of soil were as entirely different as can well be imagined.

RELATION OF CROP TO THE PHYSICAL PROPERTIES OF THE SOIL.

Among the physical properties of the soils in question, determined for us by the Bureau of Soils of this Department, the first to be considered is the content of clay. The soil having the lowest amount of clay was that from field No. 6, Agricultural College, Mich., 7.24 per cent. Low clay content is usually associated with a high percentage of sand, and such is the case in this instance, the total sand of all dimensions being nearly 75 per cent. The highest clay content is found in the sample from Utah, namely, 26.62 per cent. This, of course, would indicate a low percentage of sand, which, in point of fact, is only about 45 per cent. The percentages of clay in the three soils producing the beets with the highest content of sugar (about 14.6 per cent in each case) were as follows: In the sample from Agricultural College, Mich. (field 3), 8.86 per cent; in that from Ithaca, N. Y., 19.98 per cent, and in that from Lafayette, Ind., 22 per cent, while the soil producing the poorest beets, namely, Washington, D. C., had 21.4 per cent of clay. It is evident from a study of the figures grouped in the following table that, while the texture of the soil, as shown by the mechanical analysis, undoubtedly has a direct bearing on the yield per acre, it has practically no effect on the content of sugar in the beet:

Mechanical analyses of soils and data regarding the crops of sugar beets grown thereon.

Serial number.	Station.	Sugar-beet crop.		Mechanical analyses of soils.		
		Sugar content.	Yield per acre.	Clay.	Silt.	Total sand.
		Per cent.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*
25125	Washington	8.5	8.1	21.40	33.02	45.24
25051	Madison, Wis	12.7	11	13.36	64.12	21.90
23818	Blacksburg, Va	13.1	10	18	48.10	30.80
22783	Lafayette, Ind	14.6	[a]5.4	22	62.08	13.98
25099	Ithaca, N. Y	14.6	12.6	19.98	38.88	35.08
23581	Agricultural College, Mich.[b]	14.7	15.1	8.86	18.22	69.34

[a] Only one estimate.

[b] Field No. 3.

In considering the effect of the chemical composition of the soil upon the character and magnitude of the crop we have a problem of intricate difficulties. If we regard the soil in the light of the total plant food contained therein as indicated by treatment with hot concentrated hydrochloric acid for a considerable period of time we introduce figures which must be foreign to the problem in question. In point of fact, in order to have any accurate conception of this problem it is necessary to differentiate the amount of any given plant food consumed by a given crop from the total supply which is present. This might be illustrated by an attempt to determine how much nourishment would be given a man of average size during a day by analyzing the total nourishment in a barrel of flour from which his day's supply of bread has been made. The actual effect produced upon the man would not be represented by the total amount of flour in the barrel, but only by the total amount of flour he consumed. Therefore, as before stated, in considering the influence of the composition of the soil upon that of the beet and the magnitude of the crop it is important to know first the total quantity of plant food present, and next to ascertain if possible what portions are immediately available for the use of the crop. The following table has been arranged in order that the interrelations of these factors may be more conveniently observed:

Chemical analyses of soils and data regarding the crops of sugar beets grown thereon.

Serial number.	Station.	Sugar-beet crop.		Chemical analyses of soils.				
		Sugar content.	Yield per acre.	Nitrogen.	Potash.		Phosphoric acid.	
					Total.	Available.	Total.	Available.
		Per cent.	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25125...	Washington	8.5	8.1	0.183	0.39	0.0062	0.03	0.00020
25051...	Madison, Wis	12.7	11.0	.165	.35	.0040	.04	.00040
23818...	Blacksburg, Va	13.1	10.0	.154	.80	.0198	.10	.00003
22383...	Lafayette, Ind	14.6	[a] 5.4	.295	.35	.0074	.12	.00017
25099...	Ithaca, N. Y.	14.6	12.6	.201	.22	.0077	.13	.00003
23581...	Agricultural College, Mich.[b]	14.7	15.1	.154	.12	.0036	.06	.00062

[a] One estimate only.

[b] Field No. 3.

Our studies of this problem are too restricted to justify any conclusion at present further than to call attention again to the patent fact that the quality of this crop is affected only in a minor degree by the chemical and physical properties of the soil. The case is quite different in respect to the kind of crop best suited to a given soil and the magnitude of the harvest. These two items are intimately associated both with the texture of the soil and the quantity of plant food therein.

SUMMARY OF DATA.

Summary of agricultural and analytical data, 1901.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C	7.9	8.1	8.5	67.3
Lexington, Ky.[a]	10.4	8	9	71
Madison, Wis	10.9	11	12.7	77.4
Blacksburg, Va	4.5	10	13.1	77.6
Ames, Iowa	14.2	12.9	14.1	80.2
Logan, Utah	24.2	23.4	14.2	79.1
Agricultural College, Mich	[b] 8.3	[b] 10.2	14.6	81.5
Lafayette, Ind.[a]	8.2	[c] 5.4	14.6	82.5
Ithaca, N. Y	13.1	12.6	14.6	79.9
Geneva, N. Y	17.2	13.8	15.8	83.9

[a] One sample analyzed at Washington.
[b] Average of late and early planting; data for early planting gives average weight 10 ounces, and average yield 15.1 tons.
[c] One estimate, for November 1, 1901.

Summary of meteorological data, May to October, 1901.

Station.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	°*F.*	*Inches.*			*Per cent.*
Washington, D. C	69	19.34	81	49	64
Lexington, Ky	69.3	16.23	95	18	75
Madison, Wis	65.6	14.33	48	66	.....
Blacksburg, Va	63.8	32.08	79	53	[a] 53.7
Ames, Iowa	67.9	16.15	127	19	[b] 69.85
Logan, Utah	64	7.37	130	37	[c] 76.3
Agricultural College, Mich	62.8	19.84	96	37	[d] 61.8
Lafayette, Ind	68.6	16.41	74	52	[e] 69.85
Ithaca, N. Y	63.4	17.44	49	54	66
Geneva, N. Y	65.5	18.03	See Ithaca.		

[a] Average of weekly data furnished by Blacksburg station.
[b] Observed at Des Moines.
[c] Observed at Salt Lake.
[d] Sunshine record for Detroit.
[e] Observed at Indianapolis.

Summary of geodetic data for experiment stations.

Station.	Average length of day.[a]	Latitude.[b]	Altitude.[b]
	h. m.	° ′ ″	*Feet.*
Washington, D. C	14 23	38 53 23	37.5
Lexington, Ky	14 18	38 02 25	979
Madison, Wis	14 44	43 04 36	955
Blacksburg, Va	14 14	37 14 00	2,100
Ames, Iowa	14 38	42 02 00	917
Logan, Utah	14 37	41 44 00	4,506
Agricultural College, Mich.[c]	14 42	42 45 00	847
Lafayette, Ind	14 30	40 23 00	542
Ithaca, N. Y	14 41	42 27 00	810
Geneva, N. Y	14 44	42 53 00	453

[a] These figures are for May to August, inclusive, and are from the records of the U. S. Naval Observatory.
[b] Data furnished by the U. S. Coast and Geodetic Survey.
[c] Determinations for Lansing, Mich.

CONCLUSIONS.

As in the previous report on this subject, the data obtained in the studies described in the previous pages are for convenience platted graphically in three charts, figs. 1, 2, and 3.

Chart No. 1 shows the percentage of sugar in the beet, the latitude of the station, and the sunshine record, including the total percentage and its distribution. The plat is based upon the percentage of sugar in the beets, beginning with the station having the lowest record and ending with that having the highest. Since North Carolina has dropped out of the list of stations cooperating, Washington enjoys the distinction of having produced beets with the lowest content of sugar. In order of sugar content, the other stations are arranged in an ascending scale, as follows: Lexington, Madison, Blacksburg, Ames, Agricultural College, Lafayette, Ithaca, and Geneva.

In general it may be seen that the latitude, as in the first year's experiments, follows the sugar content. A notable exception to this is found in the case of Blacksburg. The reason of this exception has been stated, namely, the great altitude of the Blacksburg station. This fact, for the illustration of which the Blacksburg station was especially selected, indicates that, in platting the latitude curve, some method of reducing it to sea level should be introduced. Just what method is best suited for this purpose can not be stated or even suggested. It is evident, however, that this is a problem which must receive due consideration, and that this calculation must be a special one for each case. For instance, the effect of altitude on temperature on a mountain plateau like that of Blacksburg would be very different from the effect of the same altitude upon the temperature on a vast plain like that extending around Ames, Iowa, or even Lexington, Ky. These problems are of the utmost meteorological and scientific import, and the depression in the curve of latitude, as illustrated in this chart by the Blacksburg station, is of the greatest interest. Eliminating this one point, it will be seen that the content of sugar varies practically with the latitude, the only other exception to this being the data from the Lafayette station, which from the first of the collaborative studies have been found to be very erratic.

The curve showing the percentage of sunshine is broken, because no data for the Madison station is procurable. Kentucky, as will be seen, had the maximum percentage of sunshine platted, namely, 75 per cent. The lowest percentage of sunshine was that of the Blacksburg station, namely, 53.7 per cent. The next highest was that of the stations at Ames and Lafayette, they having the same percentage, namely, 69.9 per cent. The percentage of sunshine seems to have but little effect upon the sugar content, and it appears to be well established that the chemical activities of the sun's light, in promoting the condensation

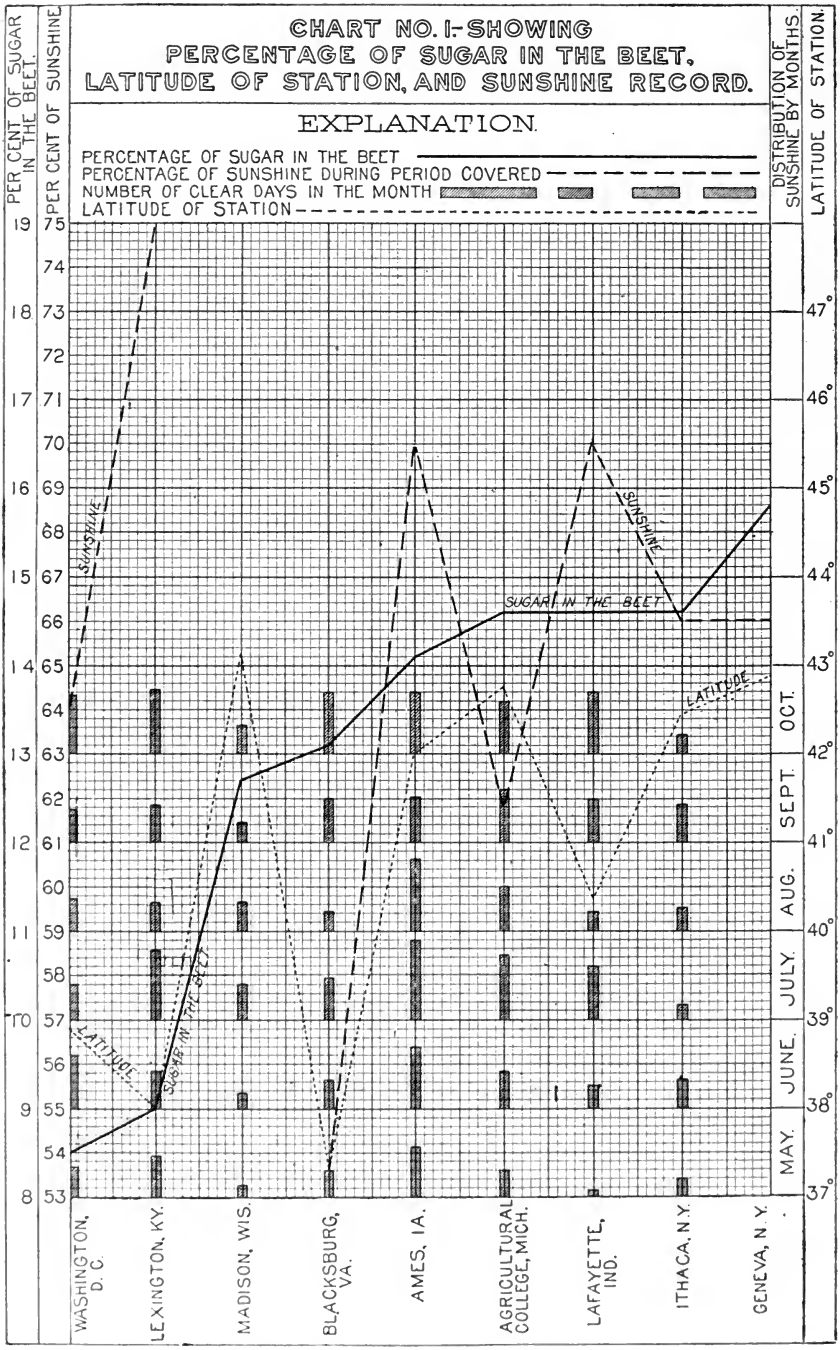

FIG. 1.—Showing percentage of sugar in the beet, latitude of station, and sunshine record.

of carbohydrate molecules in the chlorophyll cells, are not notably diminished by filtration through aqueous vapor.

The distribution of the sunshine as indicated by the number of clear days in each month is also an interesting part of the problem. From the chart, Washington and Ames appear to have had the most uniform distribution of clear days—that is, the number was quite uniform for each month. The smallest number of clear days was experienced at Madison; especially is this true of May, June, and September. The largest number of clear days was experienced at Ames, July and August being conspicuous in this particular. Ithaca stands next to Madison in regard to the small number of clear days, having almost the same record. As in the case of sunshine, it must be said that the actual predominance of clear days is not to be reckoned as an important factor, except in so far as it may indicate drought, and thus interfere with the magnitude of the crop. Thus the large number of clear days at Ames was accomplished by excessively dry weather in 1901.

Chart No. 2 shows the percentage of sugar in the beet, the purity of the juice, the temperature, and the average length of day at the station. The most interesting feature of this chart is the relation between the average length of day and the sugar in the beet. Eliminating, as in the case of latitude, the Blacksburg station, where the days, on account of the southern latitude, were short, and ignoring the slight variation at Lafayette, we find that there is a general agreement in the direction of the two curves, representing the percentage of sugar in the beet and the length of the day. In other words, it may be generally stated, as the result of an inspection of this chart, that the percentage of sugar in the beet increases with the length of the day. This is in harmony with the commonly accepted theory of the correlation of the functional activity of the chlorophyll cells and the light of the sun. Under the same general conditions it is evident that the longer the hours of activity the greater the amount of work accomplished; hence, with longer hours of sunlight the quantity of carbohydrates formed will be greater.

The temperature curve, as in chart 2 of Bulletin 64, crosses the curve of sugar content, but not symmetrically, as in the chart just mentioned. One reason of this lack of symmetry is the low temperature of the Blacksburg station. On the other hand, a phenomenally high temperature is recorded for the Lafayette station. While showing more irregularities than the curves representing latitude and length of day, it is yet evident that the tendency of the sugar is to diminish as the temperature increases. The purity curve, as was to be expected, follows in general the percentage of sugar in the beet.

Chart No. 3 shows the percentage of sugar in the beet, the altitude of the station, and the rainfall record, both the totals and the distribution by months.

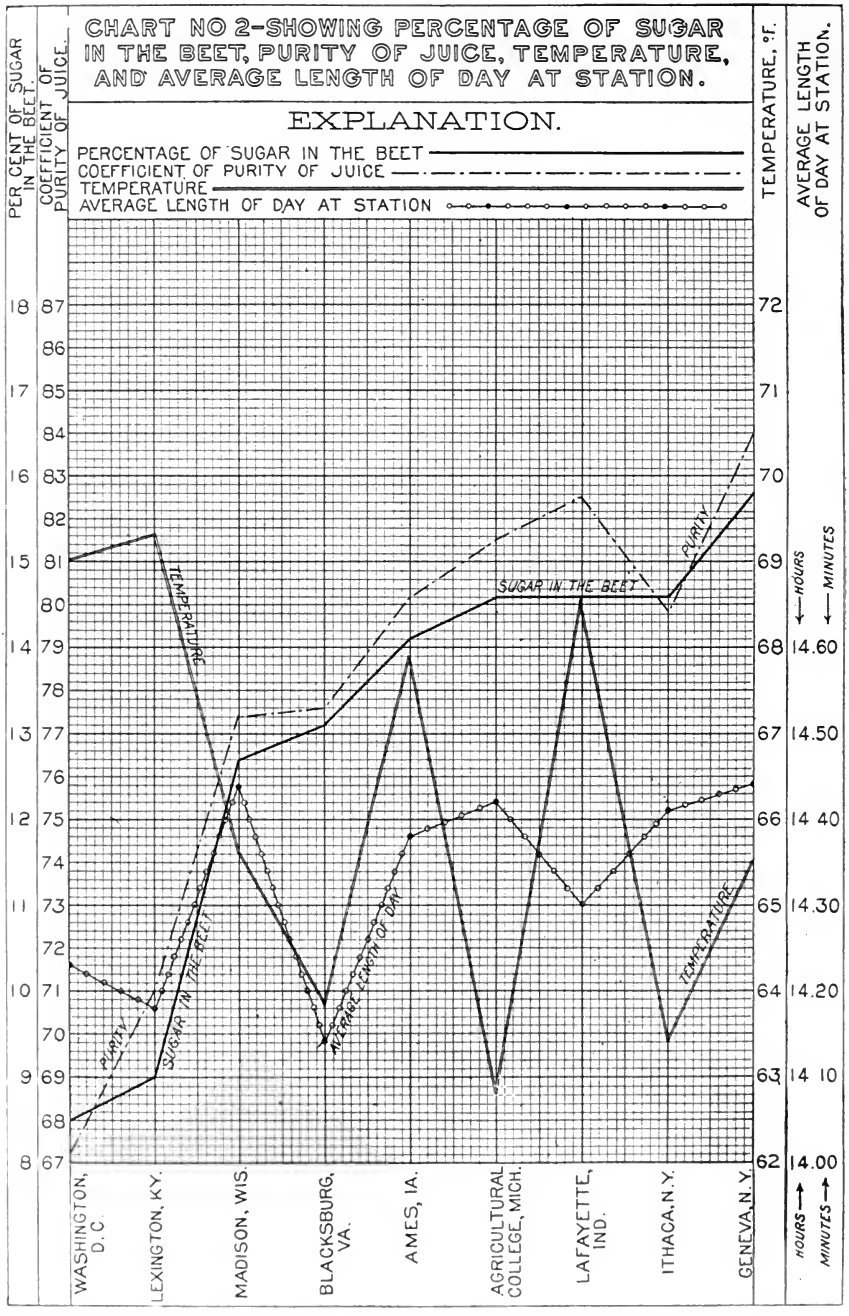

FIG. 2.—Showing percentage of sugar in the beet, purity of juice, temperature, and average length of day at station.

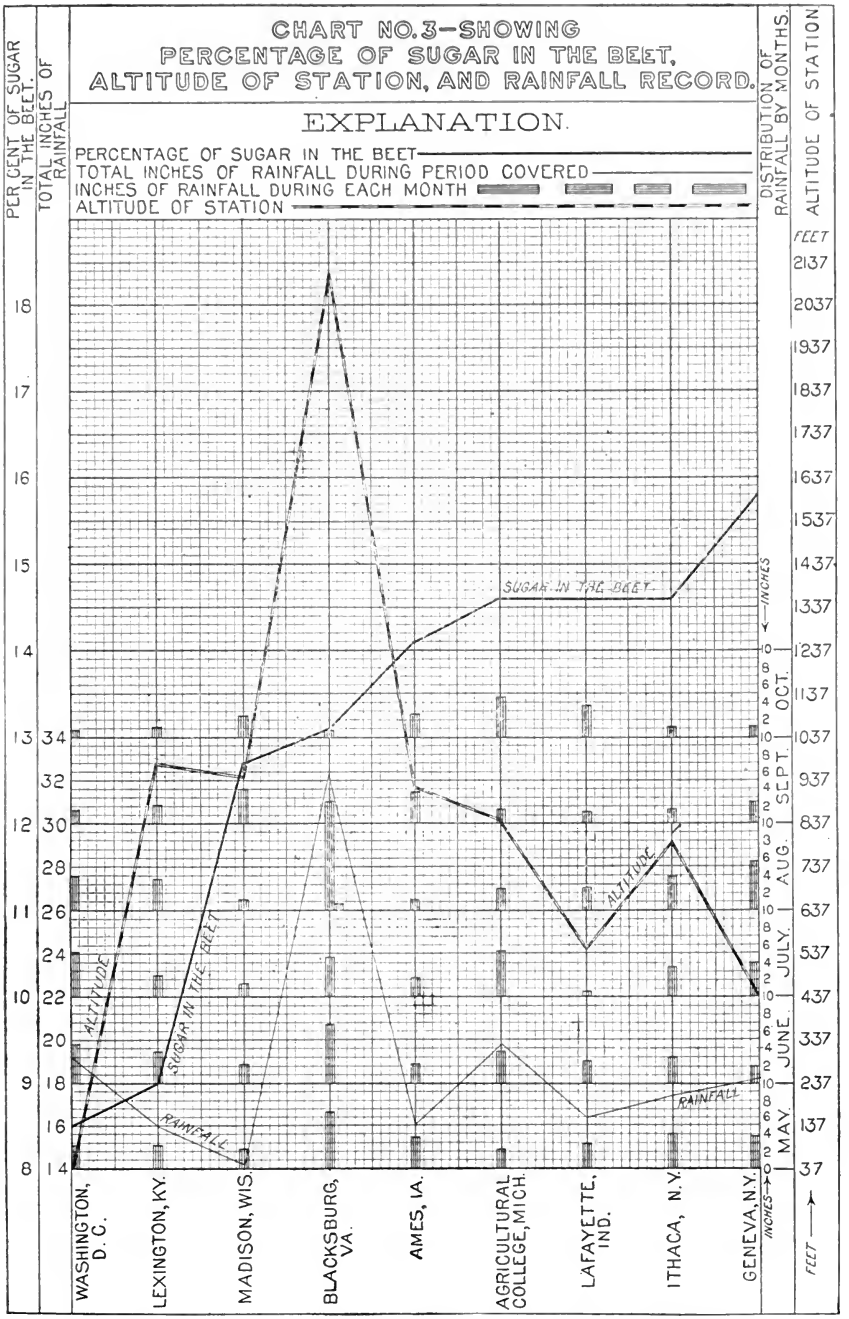

FIG. 3.—Showing percentage of sugar in the beet, altitude of station, and rainfall record.

The remarkable curve showing the altitude of the Blacksburg station is first to be noted. No more striking effect of environment on the composition of the beet could be given than that shown here. It is the altitude in this case which has secured so high a content of sugar in the beet. This station, which has the lowest latitude, shows almost the mean percentage of sugar found at the other stations. Another important effect of altitude is shown at the Washington station, which is practically at sea level, where the lowest altitude coincides with the lowest percentage of sugar. The only proper way to study the effect of altitude, as has already been intimated, is in connection with other physical features of the environment, such as mountain ranges, broad and extensive plateaus, etc. Altitude evidently does not in every case tend to increase the content of sugar. This is illustrated in the case of Ithaca and Geneva. Ithaca is almost 400 feet higher than Geneva and yet the sugar content of the beets grown at Geneva in the two seasons covered by this experiment has been higher than at Ithaca.

The rainfall, as is shown by the curve, was smallest at Madison. Other areas receiving a small rainfall were Ames, Lafayette, and Lexington. The greatest amount of rainfall was at Blacksburg, and the next greatest at Agricultural College, Mich., and at Washington. The actual amount of rainfall does not have so great an influence on the composition of the beet as does its distribution. It has been shown that excellent beets can be produced with a rather deficient supply of rain, as was the case at Madison, at Ames, and at Lafayette. On the other hand, an excessive amount of rain is not necessarily destructive of sugar content, as is illustrated by the plat at the Blacksburg station. In other words, it may be stated that, given a sufficient quantity of water to secure normal growth, the beet is not very sensitive either to a slightly diminished or a slightly increased supply. It is important, however, that the rainfall be not too great in September, which is the period of ripening, nor in October, the season of harvesting.

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