MISSOURI

AGRICULTURAL COLLEGE

EXPERIMENT STATION,

BULLETIN, NO. 5.

SOIL, WEATHER, FIELD TRIALS WITH CORN.

BY
P. SCHWEITZER,
Chemist.

COLUMBIA, MISSOURI, FEBRUARY, 1889.

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COLUMBIA:
STATESMAN JOB OFFICE PRINT.
1889.

To the Executive Committee, Hon. Board of Curators, Missouri State University,

GENTLEMEN:

In conformity with your rules, I submit for your approval the following bulletin, detailing a part of the work done by me while Director of the Missouri Agricultural Experiment Station. In doing so I beg to remind you that my appointment as Director of the Station lasted from February 20th, to July 5th, and that the ground for field experiments, assigned to me on March 6th, was to be turned over to Prof. J. W. Sanborn, my successor in office, by October 15th, 1888; as a result of the change and the difficulties, incident to organizing and starting a Station such as I conceived it to be, some of the work outlined in Bulletin No. 1, had to be abandoned.

P. SCHWEITZER,
Chemist of Station.

P. Schweitzer, Ph. D., Chemist of Missouri Agricultural Experiment Station,

DEAR SIR:

The enclosed Manuscript bulletin has been examined and approved for publication. It is especially commended for the thoroughness of the treatment of the subject in hand.

Yours Respectfully,

W. POPE YEAMAN, Chr. Ex. Com.
W. S. PRATT.

BULLETIN No. 5.

The main idea of the work outlined in Bulletin No. 1, was the study of the corn plant, and embraced a study of the soil, the climatic conditions prevalent during the growth of the crop, the plant itself; this latter rested again upon three factors: The growth of the plant as influenced by tillage and cultivation and the employment of fertilizers, measured at the end of the season by the crop that was harvested; the composition of the plant and its different parts during successive periods of growth in quantity and quality of ash; the structure and contents of the cells of different organs of the plant at different stages of developement.

The present Bulletin contains the result of work in the study of soil, climatic conditions and the growth of the plant by field trial, the remainder being left for a subsequent Bulletin, soon to follow.

I. THE SOIL.

The ground set apart on March 6th for the use of the Agricultural Experiment Station, was selected with reference to two considerations, first: its detachment from the College Farm should not cripple the latter as an independent and self-supporting institution, and second: it should be convenient to the Laboratory of the University, in which all of the indoor work during the summer had to be carried on; in addition to this, of course, it should in a measure be adapted to the purposes of the work, and choice was made of a strip of land, which though not fulfilling to perfection the conditions named, yet came up to them to a reasonable degree; it embraced some forty acres, more or less, and was divided and laid out as is indicated in the diagram, the portion west of the avenue A B, being designed to test the effect of subsoiling, stable manuring and mineral fertilizers, while that east of it was reserved for various minor experiments; the plats were made large to avoid the disturbing influence of any possible unevenness in the composition of the soil and the lateral spreading of fertilizers from one plat to another, and it is believed both ends sought were completely attained; the soil itself had been under cultivation and in grass for years, and was from eight to ten inches in depth, with a clayey subsoil, looking black in fall and spring while wet, and gray in summer, when sun and wind had dried it. It represented a typical Missouri soil, made of what Prof. Swallow has called the Bluff formation, and extends over a large portion of our State; composition and properties, as described in this Bulletin, apply to all such soils wherever they may be found, modified only to some extent by artificial alteration or special local conditions.

For the purpose of studying the properties of this soil, an imaginary line was drawn from A to C, dividing the whole ground into three nearly equal sections: that enclosed by the triangle A C D, that by the triangle A C B, and that by the quadrangle east of A B; samples of soil were taken from each of these three sections in about twelve different spots, the top soils to a depth of about ten inches, and the subsoils to a depth of eight inches below this; the different portions of each of these samples were then thoroughly mixed and furnished the six samples tested, 1 a and 1 b from A C D, 2 a and 2 b from A C B, and 3 a and 3 b from the square field, a, being in every case the surface and b, the sub-soil; in addition to these a sample marked 4 was used, obtained from a depth of about three feet, and representing an exceedingly stiff and plastic clay, such as is occasionally found in this formation in pockets or layers anywhere and at any depth. I may add that the soil, though resting on a limestone foundation, is deep, extending downwards at least twelve and may be 100 feet to solid rock.

a. CHEMICAL COMPOSITION.

The well mixed and air dried soil is fine and contains but little gravel; very few pieces indeed are larger than a rape seed; they were removed by sifting and the remainder of the air dried material analyzed with the following result:

AIR DRIED SOILS.

	1.a.	1.b.	2.a.	2.b	3.a.	3.b.	4.
Water at 100° C.	1.82	2.92	2.44	2.83	2.31	2.32	4.60
Nitrogen—total	0.14	0.06	0.13	0.06	0.13	0.07	0.02
Carbon—total	1.63	0.80	1.57	0.81	1.67	0.68	0.44
Loss by ignition	6.97	7.47	6.92	6.78	7.18	6.86	6.56
Silica	77.82	74.09	77.20	74.04	77.76	75.36	70.21
Alumina	8.93	10.62	8.02	10.74	8.47	10.10	12.91
Oxide of Iron	3.05	4.19	2.73	3.44	3.24	4.72	6.24
Lime	0.63	0.55	0.63	0.59	0.47	0.42	0.62
Magnesia	0.44	0.38	0.40	0.45	0.29	0.21	0.34
Potassa	1.32	1.23	2.54	2.57	1.17	1.13	1.38
Soda	1.59	1.51	2.05	1.99	1.45	1.45	1.72
Phosphoric Acid	0.08	0.09	0.07	0.07	0.06	0.06	0.06
Total	100.29	100.13	100.56	100.67	100.09	100.31	100.04

For the sake of comparison with other soils a second table is calculated for perfectly dry material, and in addition some data given, which are derived from treating the ignited soils with muriatic acid and partially analyzing the solution.

IGNITED SOILS.

	1.a.	1.b.	2.a.	2.b.	3.a.	3.b.	4.
Silica	83.06	80.06	82.91	79.39	83.77	80.89	75.13
Alumina	9.60	11.48	8.61	11.51	9.13	10.84	13.81
Oxide of Iron	3.28	4 53	2.93	3.69	3.49	5.07	6.68
Lime	0.68	0.59	0.67	0.63	0.51	0.45	0.66
Magnesia	0.48	0.41	0.43	0.48	0.31	0.23	0.37
Potassa	1.42	1.33	2.73	2.75	1.26	1.21	1.48
Soda	1.71	1.63	2.21	2.13	1.56	1.56	1.84
Phosphoric Acid	0.09	0.10	0.07	0.08	0.07	0.06	0.07
	100.32	100 13	100.56	100.66	100.10	100.31	100.04
Insoluble in Acid	94.73	92.41	95.72	96.10	95.69	96.61	94.34

PORTION SOLUBLE IN MURIATIC ACID.

Alumina	2.44	3.57	1.74	1.55	0.80	0.57	2.53
Oxide of Iron	1.95	3.04	1.90	2.00	2.61	2.23	2.59
Lime	0.13	0.13	0.39	0.18	0.13	0.15	0.11
Magnesia	0.25	0.24	0.24	0.19	0.19	0.15	0.02
	99.50	99.39	99.99	99.97	99.42	99.71	99.59
Alkalies dissolved	0.82	0.74	0.57	0.69	0.68	0.60	0.45

The composition of these soils is so nearly uniform as to warrant the conclusion, that the results of field experiments made upon them cannot be influenced by any supposed difference in their make up.

On a comparison of the surface with the subsoils, the former are seen to concentrate silica, lime, magnesia and potash, and the latter alumina and oxide of iron; this is important and doubtless the result both of cultivation and of the processes constantly going on in the soil; the roots of the plants in search of ash constituents take a portion of them from the subsoil, and as they are left after harvest for the most part behind, the surface soil gets enriched by what they have lifted from the depth of the subsoil, markedly so by silica and the other substances mentioned; cultivation therefore ameliorates and improves the soil, provided only the subsoil is sufficiently rich in decomposable mineral matter, aided by the effects of evaporation which in like manner lifts from the lower levels whatever is soluble; as the plants take up this dissolved portion, new supplies rise and keep up a uniform concentration. This is probably also true of phosphoric acid, though more difficult to trace on account of its small percentage in the soil; certain it is that as we descend phosphoric acid diminishes, in proof of which I append an analysis of a soil obtained from a depth of twelve feet, calculated also for dry material.

SOIL FROM DEPTH OF 12 FEET.*

Silica	8.412
Alumina	10.86
Oxide of Iron	3.26
Oxide of Manganese	0.24
Lime	0.40
Magnesia	0.29
Potassa	0.61
Soda	1.62
Phosphoric Acid	0.02
Carbonic Acid	0.68
	100.39

It bears out the statement just made, and permits a judgment on the fertility of Missouri soils of this origin claimed to be inexhaustible, as least in so far as it depends on the mineral or ash constituents necessary to the growth of plants. Prof.

*Published in Catalogue of Missouri State University for 1875.

Swallow in a paper published in 1881 in the report of the Board of Agriculture of Missouri gives the results of a calculation of the number of pounds of these constituents on an acre of soil for various depths, his data having been all the known analyses of soils in the State from widely separated localities and of greatly differing kinds; here are his results:

POUNDS TO ACRE IN

	First foot.	Second foot.	Third foot.	Twelfth foot.
Organic Matter	269636	253381	142310	46787
Lime	19166	16117	29494	26484
Magnesia	13329	30927	18184	18818
Potassa	13310	32234	17413	40423
Phosphoric Acid	12868	11157	13996	1491

If these figures and the deductions made from them are correct, and I see no reason to doubt them, then we must look for the decreased fertility of our lands elsewhere than in the direction of a deficient supply of ash constituents including carbon and perhaps also nitrogen. I am inclined to the belief, indicated already in the first Bulletin of the Station, that *superior tillage with the chemical and physical processes induced by it in the soil*, is the key to the situation and one remedy for existing distress in agricultural pursuits.

Looking for a moment at the carbon and nitrogen in these soils, we find them as we did the other valuable constituents more concentrated in the surface than in the subsoils, and doubtless for the same reason as given above; the absolute quantities also, calculated for an acre of land are large. If we take the weight of a cubic foot of dry soil as 100 pounds, 10 inches in depth over an area of an acre represent 36300 cubic feet or 3630000 pounds, and eight inches additional 29040 cubic feet or 2904000 pounds.

The percentages given above represent then the following:

POUNDS PER ACRE FOR 10 RESP. 8 INCHES IN DEPTH.

	1.a.	1.b.	2.a.	2.b.	3.a.	3.b.	4.
Carbon	59160	29040	56991	29403	60621	24684	15972
Nitrogen	5082	2178	4719	2178	4719	2541	726

These quantities are certainly large enough to supply the demands of plants for a season's growth, provided the roots are sufficiently extended to find their way to the material stored up, it would seem, in abundance. *To encourage root development is therefore to lay the foundation for a good crop*, and the success of early planting and seeding with its abundant and vigorous root development receives a simple and plain explanation. The earlier the planting the better, as the seemingly stationary period before hot weather supervenes is the very one in which root growth is made, an impairment of which at this time can never be supplemented afterwards, no matter how favorable the season or how superior the tillage; a crop deficient in quality or quantity or both must be the inevitable result.

A question offers itself here as to the cause of the black color in soils; when moist it is so pronounced that we incline to ascribe it to finely divided carbonaceous organic matter, which is known to possess in that form a high tinctorial power and is even used for paint; but on drying, this color disappears to reappear again with a falling rain, and it is easy to prove, that a purely mineral soil mixed with one and one-half per cent. of carbon, such as these soils possess, yield by no means a mass, either dry or moist, which approaches even approximately to the color of soil; the cause of the black color I take to be a compound of iron, such as ink, the constituents of which are constantly present in soil. Oxide of iron and tannic and gallic acids or bodies like it unite in the presence of moisture, separating and decomposing on the escape of it, through a process of oxydation; this process of oxydation and de-oxydation is of great moment since it converts large qantities of atmospheric oxygen into carbonic acid at a time when sufficient moisture renders it most available for plants. Every shower descending after a dry spell has a part of the carbonaceous matter of the soil burned up at the expense of the oxygen of the iron, which on the escape of the moisture by evaporation or otherwise readily takes it up again from the air, and serves as a vehicle of transmission of a most important element in nature and as a means to the maintainance of the vital functions of the plant.

b. PHYSICAL PROPERTIES.

The physical properties of a soil important for purposes of agriculture come under four headings: porosity, water-holding power, water-lifting power, absorptive power.

1. POROSITY.

The porosity or air holding capacity of a soil depends upon the spaces between adjacent particles and is measured by the volume of water which a given volume of soil absorbs; since vegetation thrives only in a soil sufficiently porous to admit air both for its oxygen and moisture, and yet not so porous as to expose the roots to injury from drought by being bare of earth under but near the surface, its importance becomes apparent; experience easily determines the extent of salutory and detrimental porosity, which lies fortunately between wide limits; the porosity of our soils is about fifty per cent. of their volume, so that a cubic foot of dry soil contains about one-half a cubic foot of air space.

2. WATER-HOLDING POWER.

This depends not only on the porosity of a soil, but also on the attraction which the particles of soil have for the particles of water, for it is evident, that on filling a vessel with dry soil and compressing it to a reasonable extent, water poured over it will fill the air spaces or pores and measure the porosity; but on placing now the contents of the vessel on a funnel loosely stoppered by a tuft of cotton, a portion of the water will run off, while the rest is retained against the force of gravity and measures the water-holding power. This water can only escape from the soil by evaporation from its surface or from the leaves of the plants after absorption, and since it takes an enormous amount of heat compared with air and even dry soil, to increase its temperature, it is plain that while porosity within the limits mentioned is advantageous to plants, a large water-holding power is always detrimental. Direct experiment gave the water-holding power of the air dried soils in per cent. of their weight as follows:

1.a.	1.b.	2.a.	2.b.	3.a.	3.b.	4.
42.53	44 91	35.55	37.29	38.32	41.62	51.30

The water-holding power of the subsoils and of the clay is, as might have been expected, greater than that of the surface soils ; it is greater even than desirable and climatic conditions bring home to us at times its disadvantages; yet cold and wet springs of long duration are rare, and what is lost then is made up by corresponding advantages at other times ; for these same soils, when placed under conditions the most favorable for loosing water by evaporation* required nine days to dry completely and demonstrated their ability to stand well a long and continued drought.

3. WATER-LIFTING POWER.

This power depends on the closeness of the particles of soil, so as to leave comparitively few large air spaces while yet not so compacted as to form a uniform solid mass, and the attraction between soil and water particles ; it differs from the water-holding power by the nature of this attraction. On wetting a dry soil at any particular place, the water is seen to spread rapidly in all directions ; if the wetting is effected at the bottom, the water rises and often with surprising rapidity and to a considerable height ; for the purpose of measurement glass tubes of about three-quarter inches in bore and three feet in length had pieces of muslin tied over one of their open ends ; they were placed upright in a frame and the air-dried soils poured into the open ends, gently tapped to firm the soils, placed with the muslin tied ends in a shallow pan of water, and the rise read off from time to time. The height to which the water is lifted in inches is as follows :

	½hr,	1½hrs,	2½hrs,	3½hrs,	4½hrs,	6hrs,	22hrs,	25hrs,	30½hrs,	44½hrs,
1.a..	2¾	5	6⅝	7⅞	8⅝	9¾	15⅝	18½	19½	21½
1.b..	2¼	4¾	6⅝	8⅛	9	10⅛	17⅛	20	20⅛	22¾
2.a..	3½	6	8⅛	9½	10½	11⅞	18⅞	21½	21⅝	—
2.b..	3½	5⅞	8	9⅜	10¼	11½	17⅞	20½	21⅜	23½
3.a..	3	5½	7⅜	8⅝	9½	10¾	17¼	20	20⅝	23½
3.b..	2¾	5¼	7⅛	8⅜	9¼	10¼	17	20	20½	23½

*They were placed under a bell jar over oil of vitriol, the thermometer indicating 20-22° C. and the barometer 29.3 to 29.5 inches.

The rise of water is seen to be quite rapid and for our soils under the conditions stated complete in about 48 hours, though soil 3.a continued to lift the water up to the end of the sixth day to thirty-one inches. During the early summer months this power comes into play with great advantage to the growing crops, not only furnishing water to their roots, but also the more or less soluble ash constituents of the subsoils; these are lifted from a depth of two and three feet, and are either taken up by the plants or accumulate near the surface as the water evaporates.

A fine, not gravelly subsoil, is best adapted to the exercise of this power, and accounts for the satisfactory crops that can be raised from it, even with an insufficient rainfall during the growing season. Our own State is blessed over a large portion of her domain with subsoil of this kind, working an advantage rather than otherwise when not too closely compacted; underdrainage is called for only in few places and under special conditions. Experiments made to overcome in a measure the excessive closeness of structure of some subsoils, proved that by mixing the latter with quicklime in the proportion of even twenty to one, moistening and drying gave a perfectly loose and friable material; *might not this serve as a cheap and efficient means for draining, and at the same time improving our land?* If the plow is followed every fourth or sixth furrow by a subsoil plow with hopper attachment, a continuous thread of lime, say of a square inch in section, could be drilled into the land sufficiently deep and stable to answer for several years the purposes of a drain, while it would alter and benefit the soil in virtue of its presence at a merely nominal cost. I recommend it to intelligent and enterprising farmers in view of the fact that Missouri soils are rather deficient in lime than otherwise, as is seen by an examination of the analyses of soils published. Prof. Swallow in his previously mentioned paper, gives the analyses of twenty-three soils from different sections of the State, and with the exception of three, none contain as high as 0.6 per cent. of lime; the three exceptions being 0.62, 1.39 and 8.07 per cent.

4. ABSORPTIVE POWER.

The absorptive power of a soil for moisture is measured by the amount of it, which it can under given conditions remove from the atmospheric air; this is determined by many factors such as the temperature and degree of saturation both of air and soil, and since varying conditions affect air and soil differently, an equilibrium is only reached when both are either perfectly dry or perfectly saturated; the former condition never does and in fact never can prevail, and the latter is speedily disturbed by winds and sunshine, when the warfare between air and soil for the possession of water begins. How important this absorption of water by soil becomes for the well-being of plants may be judged by the fact, that in our latitude the rainfall during the summer months is insufficient to fully supply the needs of a crop of cultivated plants, and that the deficiency must be made good by either bringing down to the roots the water from the air, or lifting it up to them from the depth of the subsoil; both factors, no doubt, are of moment, though we are unable at present to measure their relative value*. To determine the absorption finely broken up air dried soil was completely dried at the temperature of boiling water and the loss ascertained; it was then exposed under a belljar, covering also a dish of water, and the gain it experienced noted. The figures for the six soils express per cent. by weight as follows:

	Per cent. of water lost.	Per cent. of water gained after				
	at 100°C	14 hours ‡	24 hours	2 days	3 days	12 days
1.a.	1,82	3.07	3.15	3.97	4.14	4.47
1.b.	2.92	4.03	4.30	5.77	5.98	6.43
2.a.	2.44	2.61	2.68	3.50	3.57	3.80
2.b.	2.83	3.58	3.78	4.94	5.21	5.30
3.a.	2,31	2.67	2.77	3.49	3.78	3.86
3.b.	2.32	3,33	3.93	5.54	6.15	6.37

*The mean quantity of rain falling during the year in the moderate zone of Germany on a Prussian morgen, which is a little more than half-an acre, is two and one-half million pounds of water, of which thirty-three to fifty-seven per cent. is lost by artificial and natural drainage; different cultivated plants evaporate during the season from four and one-half to nine million pounds of water, leaving a deficiency which becomes greater even by the water falling during winter and fall being lost.

‡ The weighings were always made in the morning and at the time barometer and thermometer noted, which stood as follows: 29.7 inches 59°F; 29.7 and 67°F; 29.5 and 78°F; 28.9 and 80°F; 29.3 and 70°F.

The subsoil, containing a greater proportion of clay, absorbs more moisture than the surface soil, and the percentages, though appearing small, make in the concrete very large amounts; it is also seen that under like circumstances the greatest amount of water is taken up a few hours after exposure, and as this absorption takes place only where the soil comes in direct contact with air; *a rough surface, loose soil and skilful cultivation aids it;* it is plain therefore that plants resting in a soil well-nigh baked by an eight to ten hours exposure to a fervid sun must profit from such absorption during the night; their limp and wilted leaves at sundown, changed to a vigorous turgid appearance in the morning is a phenomenon that may be often seen for weeks at a time, and holds out the prospects of a satisfactory crop if not continued too long.

2. THE CLIMATIC CONDITIONS.

To study the climatic conditions of the locality of the Station, a complete set of meteorological instruments was obtained of Henry J. Green, of New York; a standard barometer (No. 3124, internal diameter of tube 0.62 inches), and a normal thermometer made part of the outfit; circumstances as well as lack of facilities prevented our making all the observations contemplated, and we confined our attention to readings of the barometer, the maximum and minimum thermometer, the dry and wet bulb thermometer and the soil thermometers, of which there were five, placed in suitable positions in the ground at depths of three inches, six inches, one foot, two feet and three feet. All thermometers had previously been tested by comparison with the normal thermometer and found to agree perfectly; this and the testing of the other instruments occupied some time, so that the record begins only on March 5th, and is continued to September 5th, a period of just four months. All observations were taken daily at 7 A. M., 2 P. M. and 6 P. M., supplemented by the continuous automatic record of the Thermograph; I regret that the work had to be given up at the time mentioned, but though divided, the recording of the soil thermometers falling to my share, and that of the other instruments to Mr. Gehring's, the time for it could no longer be spared from other duties.

It was conceived that instead of the ordinary figure record, a mapping out of the temperature might be suggestive and of interest, and is carried out on a number of plates, showing at a glance the temperature of the air and of the soil at different depths; the curve of the former is self-made,* while those of the latter are constructed from the three daily observations; since however there is rarely within the soil a sudden thermometric disturbance between sundown and sunrise, it is surmised no error has been committed and the curves mapped out represent actual conditions.

A noticeable feature of the tables is the evenness of the temperature of the soil at depth of one to three feet; constantly though slowly ascending, the three curves seem to be affected by no atmospheric changes, be they ever so violent and sudden; from respectively 54, 56 and 57°F. on May 5th, they rise in a nearly straight line to 66½, 67½ and 66°F. at the end of four months; the soil six and three inches below the surface is affected, however, readily, following closely the changes of the temperature of the air; a curious feature in this connection is the rise of the temperature of the surface soil over that of the air on May 14th, 20th and other dates, for which I offer at present no explanation. The equal rise and fall of the air temperature over and below the mean of the curve of the soil temperature, tends to turn the latter into a straight line, as though acted upon by interfering waves; sudden changes of atmospheric condition were numerous during the season; the humidity at all times was considerable; the barometer rose regularly from 28.747 inches, corrected reading on May 3d, 2 P.M., to 29.397 inches on September 2d, 7 A.M. Altogether it is to be hoped that a more complete record, mapped out as here begun, and containing additional data will be made part of the work of the Station; for the rest I refer to the nine plates, which explain themselves.

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*The Thermograph does not respond to changes of temperature as quickly as the thermometer, and its record has therefore been corrected by the readings of the air thermometer.

3. FIELD TRIALS. (Corn–Zea Mays).

The ground set apart for experimental purposes embraced some forty acres, more or less, and was divided into two sections by an avenue extending from A to B (see diagram); the western portion was laid out into forty eight half-acre plats, arranged in such a manner as to present four sets of tiers of twelve plats each in one way, and twelve sets of tiers of four plats each in another. Plats one to twelve and thirty-seven to forty-eight were ploughed in the usual way, about eight inches deep, while plats thirteen to thirty-six were subsoiled, the subsoil plow being set to go eight inches below and immediately following the surface plow; the fertilizers applied consisted for the two southern tiers or plats twenty-five to forty-eight of stable manure, spread before ploughing at the rate of ten two-horse wagon loads to the half-acre, and ploughing and subsequently harrowing with much care and precision; this work was begun on April 11th, and finished on April 26th, when the chemical fertilizers, as indicated on the diagram, were drilled in and the crops planted on May 2d to 4th; length of the rows and distance between them and the hills is likewise given on the diagram, and with three to six grains to each hill, four and one-half bushels of seed corn was required for the forty-eight plats; the seed selected was "St. Charles White," obtained from the St. Louis Plant Seed Company, and was perfect in every respect. Soon after planting showers moistened the land, and the whole season was favorable to the growth of corn, as may be seen from the entries in the diary of the Agriculturist, Mr. D. D. Moss, who conducted the work with much knowledge and zeal:

June 15th: last night and to-day heavy rain.

June 19th: about 11 o'clock a.m. heavy rain and wind.

June 20th: considerable rain this evening about 7 o'clock.

June 21st: about 10 o'clock a.m. it rained very hard, and blew down some of the corn.

June 22nd: it rained hard again last night and broke down some of the corn and bent it all over.

June 25th: it rained hard yesterday; corn blown down; rain again this evening.

July 5th: rained very hard last night and this morning; corn blown down some.

July 9th: several showers during the day. The tassels have appeared in nearly all of the fields; plants have twelve to fourteen leaves.

July 16th: it rained some to-day.

July 25th: it rained a little this evening.

July 27th: it rained hard this morning.

August 4th and 5th: hard rain and wind blew down a great deal of corn, broke some off and tangled it up generally. Varieties suffered most.

August 7th: grain hardly in milk state.

August 13th: grain in milk state.

August 20th: grain not out of milk state yet.

The corn was up by the 11th of May and as it suffered in spots from cutworms and late frosts empty hills were replanted on May 18th and 19th with the result of having at the end of the season a nearly perfect stand, injured only by the rain storms of June 21st and 22nd and August 4th and 5th. The crop was thrice cultivated between May 11th and June 12th, running the plow each time shallower than before, and beginning at that time to hoe and thin out the hills to two plants each, excepting on plats 1, 24, 25 and 48, where three plants each were left; subsequently the ground was cultivated once more, and as a portion was very weedy, it was kept clean by hoeing, receiving up to July 18th another and the last cultivation.

The cultivator used in this work was the "Golden Eagle," run alternately lengthwise and across the plats, with a one-horse tool for the two last cultivation; we expected at first to give a thorough trial to different cultivators, but the ground being weedy and heavy on account of the numerous rains, prevented our carrying out the original purpose. In cultivating, the inner diamonds were set to run shallow and to throw the dirt over the roots, and the outside tongues to run deep enough to lift and partially cover the weeds. I am of opinion, that *any single tool will answer the purpose, if handled with judgment*, which is as indispensable to the successful pursuit of farming as to other vocations in life. A "hand" without a directing brain is a machine that may benefit others but can never be of much benefit to its owner.

On July 6th the chinch bugs appeared on the ground, coming from the field just north of it, from which a crop of wheat had been harvested; they spread but as no facilities for destroying them were at hand at this time, and I expected no great damage from their attacks, no warfare was waged against them. The crop grew and developed well, no particular or striking difference becoming apparent on any of the plats that might have been ascribed to the use of fertilizer; subsoiling likewise seemed to have no special effect, all of which is doubtless due to the special fitness of this season for growing corn. The plants were cut and shocked on and after September 10th, and though in my judgment not fully matured, I assented to the cutting, partly to preserve the stalks in as good a condition as possible for feeding pusposes, and partly to test the question whether a heavy crop of corn and a valuable feed in stalks and leaves can be obtained at one and the same time. The weather being favorable the ripening process proceeded quickly and the corn was husked and weighed between October 1st and 15th; the weight of the stalks was not ascertained, and if not sufficient difference in the crop itself appears, it is more than likely that a difference both in weight and value of the stalks makes up for it. The experiment certainly proves, though perhaps not for the first time, that under favorable conditions, corn will yield a heavy crop of ears and a heavy and in case of need quite serviceable crop of stalks and leaves. The plants grew about ten and one-half feet in height with a stem of one and one-half to two inches in diameter, and developed but one ear each. The shelled corn was tested for water, two carefully taken samples from the whole crop, of four ears from each plat, giving an average of 13.92 per cent.; taking the moisture in corn as delivered by the farmers of the Mississippi valley to commission houses and elevators at twelve per cent, two per cent. or one fiftieth must be substracted from the figures of the tables to represent commercial values. It is also perhaps proper to say, that the figures given are actual figures obtained by direct weighing and in no instance calculated for perfect stand or other imaginary standard. The arrangement of the tables will be easily understood; each gives the number of the plat as on the diagram, and the knowledge to be derived from it in the heading; conclusions can be drawn from them by mere inspection, and the intelligent and successful farmer, who farms with brain rather than with brawn, will prefer to read the lesson himself to have it read to him; some short statements and reflections, however, on the tables may not be amiss.

a. EFFECT OF SUBSOILING.

Taking the first table we find the values at the bottom of the four columns to offer a measure for the advantage of subsoiling; the difference between the two outer and the two inner figures is 254 pounds in favor of subsoiling on twelve acres of land or virtually nothing; the first and second column alone speak in fact against subsoiling at all; but this must not be supposed to be the case in reality, as a less favorable season with fewer and less abundant rains would have shown to a certainty; our State is blessed every four or five years with an extraordinary season for growing corn, and in fact all crops; sunshine and warmth, with numerous and timely rains, prevent the ground from baking to the hardness of stone and cracking in every direction; the development of semi-tropical leaves shades the soil and fits it, porous and moist as it is, to become the seat of active chemical and physical processes; insect pests and blights do little damage; during such a season when all factors are favorable to the productive development and maturity of healthy, vigorous plants, subsoiling is of no benefit; but under adverse conditions, especially during the prevalence of a drought, subsoiled land will grow and mature a crop, that on other non-subsoiled land would prove a certain and disastrous failure.

b. EFFECT OF STABLE MANURE.

The difference in weight between the crop of the two last over that of the two first columns is due to stable manure; it amounts to 1428 pounds on twelve acres, or 119 pounds to the acre, and is not sufficient to pay for cost; a more unfavorable season, as in the case of subsoiling, would have proved, however, its value, and both may in this instance even have returned their cash equivalent in increased weight and quality of stalks and leaves; a definite answer on this point will be given in a subsequent Bulletin.

C. EFFECT OF MINERAL FERTILIZER.

The effect of the various mineral fertilizers employed is read off in the last right hand column, and by taking as standard the figure for the second cross tier of four plats, on which no fertilizer was aplpied, we obtain in a simple manner the per cent. of increase. Charcoal and lime produced none or only a deleterious effect, the values falling to 93.99 and 99 03 per cent. ; the super-phosphate, potassium chloride, sodium nitrate, ammonium sulphate and the mixed fertilizers in the remaining two tiers produce the greatest increase, reaching in the last case 17.86 per cent. over and above that of the non-fertilized plat. These increased amounts, though substantial, are yet insufficient to warrant the buying of either of these fertilizers, but as in the previous cases, quality and weight of crop and fodder may make up for it. The first tier shows a slight gain by having three plants left to a hill, but table III gives the measured bushel of this corn, when shelled, to be lighter than the others, being in fact the lightest of all, and the advantage is neutralized; indeed, when we consider the plant, as it is in reality, a machine for producing organic matter under certain conditions, one of which is sunshine, and remember that this is a fixed quantity beyond our power to increase or to diminish, we readily see that increased leaf surface through closer planting, over the limit fixed by nature and known by experience must be useless even in favorable seasons, and a downright detriment in unfavorable ones.

To show the difference of opinion in regard to the non response of the corn crop to any fertilizer employed I take the liberty of reproducing the following three statements ; the first is to the effect that there was no response because the season was too favorable, which is in substance my explanation; the second, embodying in reality two statements, that there was no response because the season was too unfavorable (cold and wet); the third that there was no response because there were too few plants to the acre.

Annual Report, Connecticut Agricultural Experiment Station, 1887, S. W. Johnson, Director, page 116.

FERTILIZING CORN WITH PHOSPHATIC MATERIAL.

The difference in total crop is not striking, though there is a decided gain over the no-phosphate plots. Where phosphates were used the largest gain was in the weight of the sound ears. * * * The season was particularly good for corn raising, and this fact probably was to the advantage of [the phosphate plots, as the plants on the non-manured plot] grew fastest and matured soonest, and in event of a cold August or an early frost, would probably have yielded much better than the others.

(P.S.—The brackets merely indicate that the wording is changed to explain the meaning without giving the tables.)

Bulletin No. IV., Agricultural Experiment Station, Cornell University, J. P. Roberts, Director.

Upon the dryest and most gravelly portion of the field in which the fodder corn was grown, several one-tenth acre plots were measured off and treated with several forms of concentrated fertitilizers. The corn, Sibley's Pride of the North, was planted on May 7th, the fertilizers were applied broadcast on June 4th, 400 pounds per acre being applied in every instance.

As will be seen by the table, no results in the crop can be traced to the use of the fertilizer. This is undoubtedly due to the fact that there was not enough water at hand to enable the plant to use the fertility that was in the soil before the fertilizers were added. There are many things that go to show that lack of success with concentrated fertilizers may be entirely due to the peculiarity of the climate of the particular season in which the fertilizers are used. This has been noticed by other investigators. Dr. B.L. Sturtevant in Bulletin No 14 of the New York Agricultural Experiment Station, under date of October 20th, 1882, says "The season has been marked by the coolness of the spring weather, the dearth of hot days during the summer, and the warm and dry weather of the autumn. With this unusual season we are willing to lay to the season's account various circumstances of vegetation which are outside of our common experience. Our corn field has shown but little reaction of the crop to the fertilizer used. This observation taken in connection with another fact, viz., that in no case have we obtained a large or a maximum yield, would seem to indicate the necessity of a heated soil in order that the corn plant may avail itself of the fertility distributed within the soil.

Bulletin No. VI., Louisiana Sugar Experiment Station, Wm. C. Stubbs, Director.

It is clear from the above that none of the manures used *paid*. The reason may be found in the fact that there was not corn enough on the ground to make a very heavy yield. The rows were 4½ feet apart and hills 3 feet, and only one stalk left to the hill. The natural fertility of the soil under the very favorable season readily developed and matured such a stand, hence small increase, wherever manures of every kind were used.

The truth is the land is much better than it seemed to be and it must hereafter be treated more heroically. Larger stands with the same manures may hereafter show more decisive results.

d. ADDITIONAL FACTS AND CONSIDERATIONS.

Table XI gives a bi-daily record of the growth in inches of five corn plants; no observations being made on Sundays, three values had to be dropped, viz.: Saturday night to Sunday morning, Sunday morning to night, and Sunday night to Monday morning; the ages of the plants differed by a successive two weeks later planting, which makes number five eight weeks younger than number one, and the others in proportion. A stake was firmly driven into the ground near each plant, the leaves gathered together by both hands, and the highest point marked with pencil; measuring then was easy; a summary of these measurements is given in table XII, from which two facts speak out in unmistakable language, the first: *That plants make the heaviest growth after having passed, as it were, the stage of infantile existence, or rather after having made during it ample provision for subsequent development by abundant root growth, for which early planting and a cool spring are the natural conditions*, and the second: *That the rate of growth during day and night increases in younger and less vigorous plants, which evidently means, that the material produced during the day cannot be transported and utilized by them as readily as by older plants;* the result of both facts taken together is a smaller, less-stocky, shorter-lived and more uncertain plant, with the probability of failure as a crop, unless unusual and favorable conditions prevail to remedy congenital defects.

The leaves of corn in vigorous plants are large and doubtless the chief seat of production of organic matter; their number reaches in our climate to sixteen and even eighteen, though under usual conditions the lower one's die off and activity is confined to perhaps twelve only. An examination was made on July 9th, of the leaf surface of a vigorous plant, and represents in my judgment the average development of corn; under favorable circumstances the results may be exceeded, as was the case with the general crop grown here, whose leaf surface three or four weeks later had measurably increased. To make the measurement the leaves were removed from the plant at the knots, and after wilting spread out on sheets of paper, on which the outline was marked by a bag of colored chalk; the area was then measured by a Plani-meter, obtained from Buff & Berger, of Province Court, Boston, whose accuracy had been tested by measurements of irregular surfaces of known extent; this had to be done in sections, as the instrument was not sufficient to cover more than about forty square inches. The total surface of the twelve living leaves on one side was 1633.73 square inches, which doubled for both sides, and adding the area of the outside of the sheaths, makes the total external leaf surface of this plant 3480 square inches or twenty-four square feet, a larger value than had been anticipated by me, but one certainly that accounts for the wonderful productiveness of the plant, which bearing a thousand fold and more, is easily the peer of all the cereals.

e. VARIETIES OF CORN.

On plat sixty-six and sixty-seven nineteen varieties of corn were planted during the first week in May; each covered a space of one-twentieth of an acre, excepting Shield's Stooling Flour Corn which occupied twice this space, or eight rows arranged as in the other plats, with two plants to the hill; cultivation was the same as in the general trials, the results being given in Table XIII and XIV, with the statement that Murdock's Improved, Riley's Favorite, Leaming and Canada early yellow Flint, had suffered by storms and depredations, which make comparison by weight of crop unfair to them; they are tabulated with the others on account of the heavy weight of the measured bushel of shelled corn and the low percentage of cob. All of those given in the table are valuable, Giant White Normandy, Piasa King and Wabash even appearing superior to St. Charles White, though I do not mean to be understood as giving this as my deliberate and certain opinion. All the varieties and especially the four mentioned here, are worthy of attention and trial by the farmers of the State, and are so recommended to them.

A number of additional facts in the life history of corn, brought forth by special experiments, are deferred to a subsequent Bulletin, which is nearly ready, and will finish the work undertaken by me in this direction during the past season.

P. SCHWEITZER,
Chemist of Station.

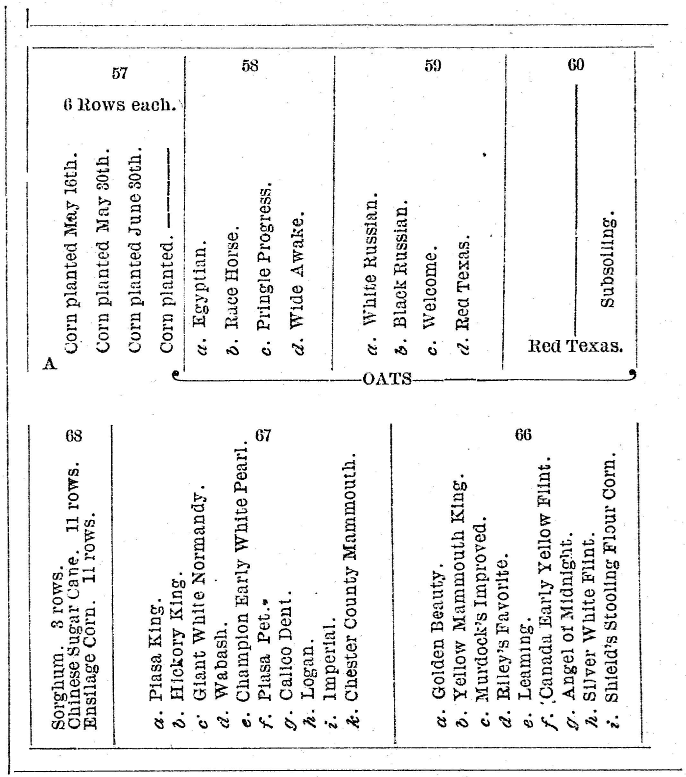


Diagram of Northern Plats Enlarged.

A. Beginning East.

a. Pearl Millet.
b. Bird's Foot Clover.
c. Sulla.
d. Serradilla.
f. Giant Spurry.
g. Hairy Vetches.
Small Pea.
Lupines.
Millet.

NOTE:—Plats not drawn to scale.

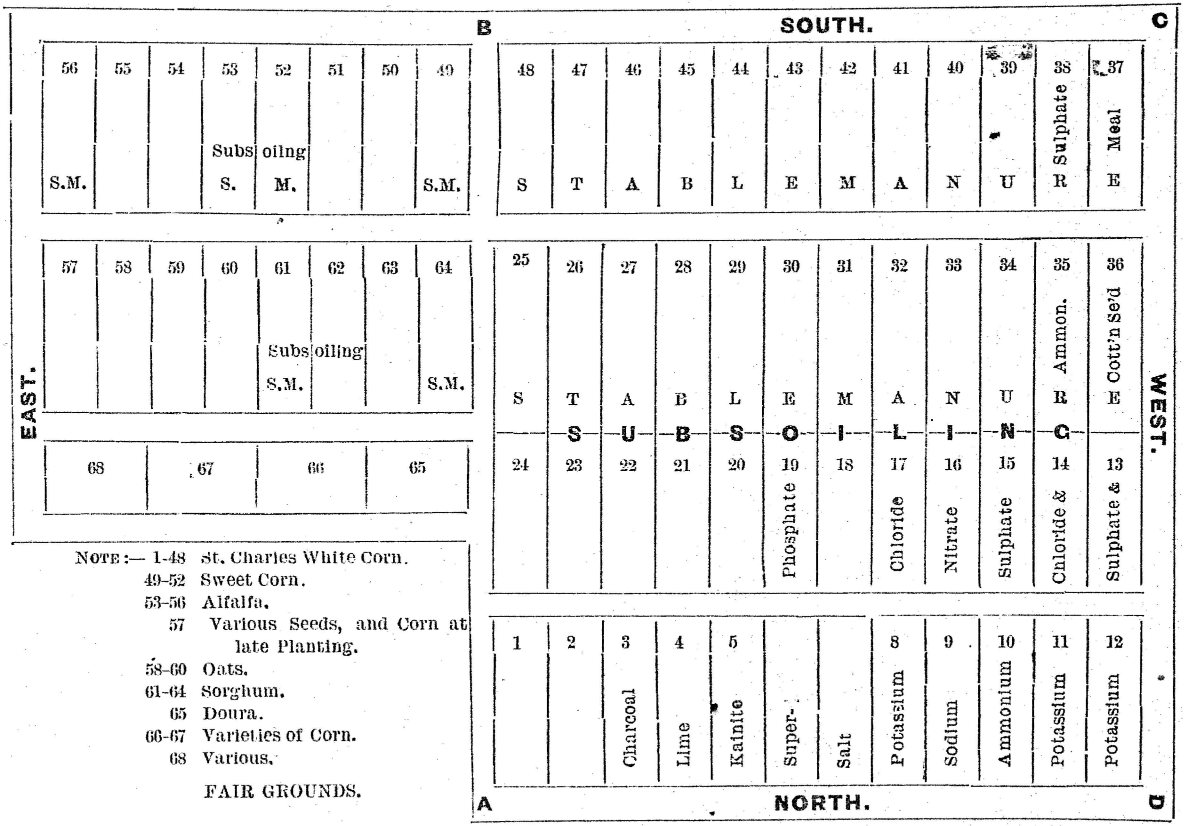
1-67 One-half acre each.
68 About one-quarter acre.

1-48 116.90 feet wide.
186.32 feet deep.
Rows 3 feet 8 inches apart.
Plants 3 feet 8 inches apart.
32 rows east to west.
51 rows north to south.
1632 hills to one-half acre.
Crop planted May 2d to May 4th.
3 plants to each hill in plat 1, 24, 25, 48.
2 plants to each hill in other plats.

Mineral fertilizers over the four plats north to south, using for each plat as follows:

Charcoal, 100 pounds.
Lime, 25 pounds.
Kainite, 100 pounds.
Superphosphate, 100 pounds.
Salt, 80 pounds (1 bushel.)
Potassium Chloride, 100 pounds.
Sodium Nitrate, 100 pounds.
Ammon. Sulphate, 75 pounds.
{Ammon. Sulphate, 75 pounds.
{Potassium Sulphate, 100 pounds.
{Potassium Sulphate, 200 pounds.
{Cotton Seed Meal, 100 pounds.

Experimental Plats.



NOTE:— 1-48 St. Charles White Corn.
49-52 Sweet Corn.
53-56 Alfalfa.
57 Various Seeds, and Corn at late Planting.
58-60 Oats.
61-64 Sorghum.
65 Doura.
66-67 Varieties of Corn.
68 Various.

FAIR GROUNDS.

TABLE I.

POUNDS OF HUSKED CORN PER PLAT OF ONE-HALF ACRE.

No.	Pounds.	No.	Pounds.	No.	Pounds.	No.	Pounds.	Totals.
1	1998	24	2675	25	3036	48	2960	106 69
2	2460	23	2445	26	2575	47	2520	100 00
3	2455	22	2314	27	2310	46	2320	93 99
4	2590	21	2433	28	2450	45	2430	99 03
5	2895	20	2522	29	2585	44	2310	103 12
6	2735	19	2823	30	2750	43	2900	112 08
7	2355	18	2615	31	2691	42	2920	105 81
8	2955	17	2715	32	2702	41	2780	111 52
9	2750	16	2790	33	2881	40	2850	112 71
10	2770	15	2561	34	2745	39	2810	108 86
11	2885	14	2885	35	2835	38	2850	114 55
12	3056	13	2910	36	3190	37	2630	117 86
Tot'l	31904		31688		32750		32280	128622

Weight in pounds of the whole: 128622.

Number of bushels at 70 pounds: 1837.4.

Number of bushels per acre: 76½.

A large straw stack was standing on Plat No. 7, taking up about one-sixth of its space and reducing the yield in that proportion; 400 pounds of corn were lost by it.

Plat No. 1 was next to the Fair Grounds and suffered from depredations during fair week.

TABLE II.

BUSHELS OF HUSKED CORN PER ACRE. (70 LBS. PER BUSHEL)

These are the number of bushels a farmer would be credited with and receive pay for, if selling by weight his crop as based on the yield of Table I; the number of bushels which he actualy sells, are given in Table III.

No.	Bus.	No.	Bus.	No.	Bus.	No.	Bus.		Bus.
1	57.1	24	76.4	25	86.7	48	84,6	Avg.	76,2
2	70.3	23	69.9	26	73.6	47	72,0	"	71.4
3	70.1	22	66.1	27	66.0	46	66.3	"	67.1
4	74.0	21	69.5	28	70,0	45	69.4	"	70.7
5	82.7	20	72.1	29	73.9	44	66,0	"	73.7
6	78.1	19	80.7	30	78.6	43	82.9	"	80,1
7(*)	78.7	18	74.7	31	76.9	42	83.4	"	78.4
8	84.4	17	77.6	32	77.2	41	79.4	"	79.6
9	78.6	16	79.7	33	82.3	40	81.4	"	80.5
10	79.6	15	73.2	34	78,4	39	80.3	"	77.9
11	82.4	14	82.4	35	81,0	38	81.4	"	81.8
12	87.3	13	83.1	36	91.1	37	75.1	"	84.1
Avg.	76.9		75.5		78.0		76.9	"	76.6

(*) Corrected as indicated in Table I.

TABLE III.

BUSHELS OF SHELLED CORN PER ACRE (56 pounds per bushel)

ACTUAL VALUES DERIVED FROM TABLE I. AND TABLE VI.

The percentage is calculated to find whether subsoiling or any of the fertilizers used had influenced the weight of kernels, a fact which would appear by comparison with the respective figures in Table I; no influence of this character is however recognizable.

No.	Bus.	No.	Bus.	No.	Bus.	No.	Bus.		Bus.	Per Cent.	
1	62.4	24	79.4	25	87 4	48	89.7	Avg.	79.7	106.6	p.c
2	72.1	23	73.6	26	76.9	47	76.6	"	74.8	100.0	"
3	73.6	22	70.1	27	68 6	46	70.1	"	70 6	94.4	"
4	78.4	21	73.5	28	74 0	45	73.2	"	74.8	100.0	"
5	87.4	20	74.2	29	77.9	44	72.0	"	77.9	104.1	"
6	82.0	19	83.1	30	81.5	43	86.0	"	83.1	111.1	"
7*	81.5	18	78.6	31	82.2	42	86.3	"	82.1	109.7	"
8	89.0	17	79.9	32	80 6	41	84.2	"	83.4	111.5	"
9	84.8	16	84 6	33	86.9	40	82 4	"	84.7	113.2	"
10	81.0	15	75.2	34	82.3	39	83.5	"	80.5	107.6	"
11	86.3	14	87.4	35	85.0	38	85.7	"	86.1	115.1	"
12	91.2	13	87 8	36	97.6	37	78 8	"	88.8	118.7	"
Avg.	80.8		78.9		81.7		80.7				

TABLE IV.

WEIGHT IN LBS. PER MEASURED BUSHEL OF SHELLED CORN.

No.	Pounds.	No.	Pounds.	No.	Pounds.	No.	Pounds.		Pounds.
1	53,46	24	55,76	25	55.60	48	54.78	Avg.	54.90
2	53,71	23	56.01	26	58.30	47	58.55	"	56.64
3	52,97	22	56.54	27	54.94	46	58.34	"	55.70
4	55,35	21	57.77	28	54.61	45	56.42	"	56.04
5	55.60	20	56,58	29	57.24	44	56.58	"	56.50
6	57,24	19	57.85	30	55.84	43	56.91	"	56.96
7	55.84	18	55.84	31	54.49	42	56.25	"	55.60
8	55,19	17	59.00	32	57.89	41	56.42	"	57.12
9	55,35	16	55,19	33	54.04	40	56.66	"	55.31
10	58.38	15	56,58	34	53,71	39	56.17	"	56,21
11	56.42	14	54,45	35	55.43	38	56.17	"	55,62
12	56.09	13	54.04	36	57.73	37	54.69	"	55.64
Avg.	55.47		56.30		55.82		56.50		

Average of whole equal to 56.02 pounds [the legal weight in the State is 56 pounds].

* Corrected as indicated in Table I.

TABLE V.

WEIGHT IN OUNCES AND TENTHS OF OUNCES OF ONE EAR, GRAIN AND COB.

	Ear	Gr.	Cob		Ear	Gr.	Cob		Ear	Gr.	Cob		Ear	Gr.	Cob	Ear Gr. Cob
1	13.4	11.4	2.0	24	13.1	10.9	2.2	25	13.5	10.9	2.6	48	13.7	11.6	2.1	13.4–11.2–2.2
2	14.2	11.6	2.6	23	13.5	11.4	2.1	26	13.6	11.4	2.2	47	14.4	12.2	2.2	13.9–11.6–2.3
3	14.0	11.7	2.3	22	14.4	12.2	2.2	27	15.5	12.9	2.6	46	13.4	11.3	2.1	14.3–12.0–2.3
4	13.5	11.5	2.0	21	13.7	11.6	2.1	28	14.8	12.5	2.3	45	15.0	12.6	2.4	14.2–12.0–2.2
5	14.3	12.0	2.3	20	14.2	11.7	2.5	29	14.8	12.5	2.3	44	13.9	12.1	1.8	14.3–14.1–2.2
6	14.4	12.8	1.6	19	14.4	12.3	2.1	30	14.7	12.2	2.5	43	14.2	11.8	2.4	14.4–12.3–2.1
7	14.3	11.9	2.4	18	15.1	12.4	2.7	31	13.9	11.9	2.0	42	16.4	13.5	2.9	14.9–12.4–2.5
8	14.1	11.9	2.2	17	14.9	12.2	2.7	32	13.2	11.0	2.2	41	15.0	12.8	2.2	14.3–12.0–2.3
9	13.6	11.7	1.9	16	13.7	11.6	2.1	33	15.1	12.7	3.4	40	14.7	11.9	2.8	14.3–12.0–2.3
10	13.7	12.0	2.7	15	13.5	11.1	2.4	34	14.4	12.1	2.3	39	13.8	11.5	2.3	14.1–11.7–2.4
11	14.5	12.1	2.4	14	15.2	12.9	2.3	35	15.5	12.9	2.6	38	14.5	12.2	2.3	14.9–12.5–2.4
12	15.8	13.3	2.5	13	15.5	13.1	2.4	36	14.9	12.5	2.4	37	14.7	12.3	2.4	15.2–12.8–2.4
Av	14.2	12.0	2.2		14.3	12.1	2.2		14.5	12.1	2.4		14.5	12.2	2.3	

TABLE VI.

PER CENT OF COB ON EAR.

No.	P. c.	No.	P. c.	No.	P. c.	No.	P. c.		P. c.
1	15.1	24	16.9	25	19.4	48	15.1	Avg.	16.6
2	18.0	23	15.7	26	16.4	47	14.9	"	16.2
3	16.0	12	15.2	27	16.8	46	15.4	"	15.9
4	15.2	21	15.4	28	15.4	45	15.7	"	15.4
5	15.8	20	17.6	29	15.6	44	12.7	"	15.4
6	16.0	19	17.6	30	17.0	43	17.0	"	16.9
7	17.2	18	15.8	31	14.5	42	17.2	"	16.2
8	15.7	17	17.6	32	16.5	41	15.2	"	16.2
9	13.7	16	15.1	33	15.5	40	19.0	"	15.8
10	18.1	15	17.8	34	16.1	39	16.8	"	17.2
11	16.2	14	15.2	35	16.0	38	15.8	"	15.8
12	16.4	13	15.5	36	15.9	37	16.1	"	16.0
Avg.	16.1		16.3		16.3		15.9		

Average of whole 16.15 per cent.

The legal weight of one bushel of corn is 70 pounds on cob and 56 pounds of shelled corn; the law assumes therefore the cob to be 20 per cent. of the ear, and as the average of these determinations is only 16, it follows that the buyer of corn makes the farmer at start to hand over 4 per cent. of the weight, which is equal to 4 per cent. of the price.

TABLE VII.

NUMBER OF GRAINS ON ONE EAR.

No	Grains	No.	Grains	No.	Grains	No.	Grains		Grains.
1	968	24	929	25	929	48	988	Avg.	953
2	988	23	967	26	967	47	1041	"	991
3	1000	22	1039	27	1099	46	965	"	1026
4	975	21	985	28	1066	45	1074	"	1025
5	1022	20	995	29	1061	44	1031	"	1027
6	1028	19	1044	30	1039	43	999	"	1027
7	1008	18	1082	31	1014	42	1153	"	1064
8	1011	17	1044	32	940	41	1084	"	1020
9	998	16	987	33	1083	40	1014	"	1020
10	1020	15	942	34	1030	39	977	"	992
11	1032	14	1096	35	1097	38	1036	"	1065
12	1123	13	1117	36	1064	37	1045	"	1087
Avg.	1014		1019		1032		.1034		

Average of all: 1025 kernels to the ear.

This table was calculated by multiplying the weight in grammes of the kernels of one ear [Table IX] by 3, the weight of one kernel being found by numerous tests to be about 0.33 grammes; large numbers of the ears have up to 22 rows of kernels, and 52 to 54 kernels in a row.

TABLE VIII.

WEIGHT OF ONE QUART OF SHELLED CORN IN GRAMMES.

No.	Grammes	No.	Grammes	No.	Grammes	No.	Grammes		Grammes.
1	652	24	680	25	678	48	668	Avg.	669,5
2	655	23	683	26	711	47	714	"	690,7
3	646	22	689.5	27	670	46	711.5	"	679,2
4	675	21	704.5	28	666	45	688	"	683,4
5	678	20	690	29	698	44	690	"	689,0
6	698	19	705.5	30	681	43	694	"	694,6
7	681	18	681	31	664	42	686	"	678,0
8	673	17	719.5	32	706	41	688	"	699,1
9	675	16	673	33	659	40	691	"	674,5
10	712	15	690	34	655	39	685	"	685,5
11	688	14	664	35	676	38	685	"	678,2
12	684	13	659	36	704	37	667	"	678,5
Avg.	676.4		686.6		680 7		689		

Average of whole: 683.2 grammes.

From this table was calculated Table IV in the following manner: The quart, being fluid measure—231 cubic inches to the gallon—has a capacity of 57¾ cubic inches; the bushel, dry measure, has a capacity of 2150.42 cubic inches; the factor therefore, with which the weight of the quart must be multiplied to give the weight of the bushel is 37¼ [37 237]; if the weight of the quart is taken in grammes, the factor with which to multiply to obtain pounds per bushel is 0.0821. (37.237 divided by 453.59)

TABLE IX.

WEIGHT IN GRAMMES OF ONE EAR, GRAIN AND COB.

	Ear	Grain	Cob		Ear	Grain	Cob		Ear	Grain	Cob		Ear	Grain	Cob
1	379.9	322.6	57.2	24	372.2	309.6	62.6	25	384.1	309.7	74.4	48	388.2	329.3	58.9
2	401.8	329.4	72.4	23	382.1	322.2	59.9	26	385.6	322.2	63.4	47	408.0	347.1	69.9
3	396.9	333.5	63.4	22	408.6	346.5	62.1	27	440.4	366.4	74.0	46	389.0	321.6	58.4
4	382.9	324.9	58.0	21	387.9	328.2	59.7	28	420.1	355.2	64.9	45	425.0	358.1	66.9
5	404.9	340.7	64.2	20	402.6	331.7	70.9	29	419.2	353.8	65.4	44	393.7	343.7	50.0
6	408.0	342.6	65.4	19	407.1	348.0	59.1	30	417.4	346.3	71.1	43	401.4	333.0	68.4
7	405.9	336.0	69.9	18	428.4	360.6	67.8	31	395.5	338.1	57.4	42	464.4	384.4	80.0
8	399.9	337.0	62.9	17	422.4	347.9	74.5	32	375.0	313.2	61.8	41	426.1	361.5	64.6
9	385.6	332.7	52.9	16	387.2	328.9	58.3	33	427.1	361.0	66.1	40	417.4	338.0	79.4
10	415.0	339.9	75.1	15	381.7	313.8	67.9	34	409.5	343.4	66.1	39	391.4	325.7	65.7
11	410.6	344.0	66.6	14	431.4	365.5	65.9	35	435.5	365.6	69.9	38	410.1	345.4	64.7
12	447.9	374.2	73.7	13	440.9	372.5	68.4	36	422.0	354.6	67.4	37	415.4	348.4	67.0
Avg	403.3	338.1	65.2		404.4	339.6	64.8		410.9	344.1	66.8		410.1	344.7	65.4

TABLE X.

MEASUREMENT OF LEAVES OF CORN PLANT, JULY 9th 1888.

Leaf		Leaf	Leaf	Sheath	Leaf	Sheath	Leaf
Counting from roots		Square In. one side	Square In. both sides	Square In. one side	Length of in inches	Length of in inches	Greatest width in In.
No.	1	dry and dead					
"	2	dry and dead					
"	3	98.66	197.32	29.14	40.00	10.00	3.12
"	4	142.46	284.92	33.70	49.88	9.88	3.88
"	5	153.63	307.26	33.50	50.63	9.38	3.88
"	6	164.80	329.60	33.29	51.38	8.88	3.88
"	7	177.83	355.66	27.80	54.00	8.75	4.00
"	8	184.08	368.16	26.45	53.00	8.38	4.25
"	9	172.49	344.98	15.68	48.38	5.00	4.50
"	10	156.85	313.70	9.62	46.12	3.88	4.38
"	11	143.06	286.12	4.02	41.75	1.98	4.50
"	12	112.96	225.92	——	36.00	——	4.38
"	13	80.45	160.90	——	32.12	——	3.75
"	14	46.46	92.92	——	25.38	——	2.62
Total		1633.73	3267.46	213.20		66.03	

Total leaf surface including one side of sheath is 3480.66 square inches, or a little more than 24 square feet.

TABLE XI.

DAILY GROWTH OF 5 CORN PLANTS IN INCHES.

	June 23.		June 24.		June 25.		June 26.		June 27.		June 28.		June 29.		June 30.		July 1.		July 2.	
	ngt	day.	ngt	day.	ngt	day.	ngt.	day.	ngt.	day.	ngt.	day.	ngt.	day.	ngt.	day	ngt.	day.	ngt.	day
	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 p m	7 a m	6 pm
No. 1................	2	2		3½		1	1	2	1	1½	1	½	1½	1½	1½	1½		4½		1¾
No. 2................	1	½		3		½	1	1	½	½	1	½	—	1½	½	1		3¼		1¾
No. 3................	—	1		3		1	1	1½	½	½	½	½	—	1¼	1	1		2¼		½
No. 4................	1	1		1½		½	½	½	—	—	—	½	½	1	½	½		1		—
No. 5................																				

	July 3.		July 4.		July 5.		July 6.		July 7.		July 8.		July 9.		July 10.		July 11.		July 12.	
No. 1................	1¼	2	2½	2	1	1½	2	2½	2	1½		5		1½	1	1½	—	2½	1½	2
No. 2................	2	¾	1¾	1	1	1½	1½	1½	2½	1		4¼		1¼	1	1	1½	1	1½	1½
No. 3................	½	¾	½	1¼	½	½	½	1	½	1½		4		½	1	½	1	1	1¾	¾
No 4................	¼	¾	1	½	¾	¾	½	1½	1½	1½		2¼		1¾	1	1½	1	1½	½	1
No. 5................		1	2	1	1	1	½	¾	1¼	1½		2		¾	¾	½	½	1	½	½

	July 13.		July 14.		July 15.		July 16.		July 17.		July 18.		July 19.		July 20.		July 21.		July 22.	
No. 1................	2½	1	1½	1		3½		1	2	½	1½	½	½	½	½	¼	¾	—		2½
No. 2................	2	1	1	2		5		2	2	¾	¾	½	1	1	1	—	—	2		3½
No. 3................	3½	1	1½	1		4½		1	½	1½	¾	¾	1	1	¾	¾	¾	1¼		3½
No 4................	1	1¾	1¼	1½		3½		1¼	1¾	1½	1½	¾	¼	¼	¾	½	¼	¼		3¾
No. 5................	½	½	1½	1½		8		½	1	1½	1	1	¾	½	½	—	—	¾		4

	July 23.		July 24.		July 25.		July 26.	
No. 1................		—	½	½	½	½	finished	growing.
No. 2................		½	½	½	½	¾	½	2
No 3................		1	1	½	1½	1¼	1¼	¾
No. 4................		½	1¼	—	2½	1	1	1½
No. 5................		1	½	1	¼	½	¾	1½

TABLE XII.

SUMMARY OF GROWTH OF 5 CORN PLANTS IN INCHES.

No. 1	at beginning of Expt.	51 days after planting	3′10″	at end 10′2½″.
No. 2	" " "	37 " "	2′9″	" 10′6½″.
No. 3	" " "	23 " "	1′8″	" 9′10½″.
No. 4	" " "	9 " "	0′6″	" 7′7½″.

No. 5 planted June 27th; came up July 2nd; observations begun July 3rd.
Plants No. 4 and 5 were not fully grown at the end of trial.

Plant No. 1	exclus. Sundays,	23	observ's for night growth,	28	for day growth
Plant No. 2	"	24	" " "	29	"
Plant No. 3	"	24	" " "	29	"
Plant No. 4	"	24	" " "	29	"
Plant No. 5	"	17	" " "	21	"

Plant No. 1, 23/ 29.5/ 1.28″ during night—1-13= 1.18 during night.
28/ 34.5/ 1.23″ during day+1-13= 1.33 during day.

Plant No. 2, 24/ 26 / 1.08″ during night—1-13= 1.00 during night.
29/ 30.75/ 1.06″ during day+1-13= 1.14 during day.

Plant No. 3, 24/ 21.75/ 0.91″ during night—1-13= 0.84 during night.
29/ 26.75/ 0.92″ during day+1-13= 0.99 during day.

Plant No. 4, 24/ 20.5/ 0.85″ during night—1-13= 0.79 during night.
29/ 25.5/ 0.88″ during day+1-13= 0.94 during day.

Plant No. 5, 17/ 13.25/ 0.78″ during night—1-13= 0.72 during night.
21/ 18.25/ 0.87″ during day+1-13= 0.93 during day.

PROPORTIONATE GROWTH OF PLANTS DURING NIGHT AND DAY.

No. 1.	1 : 1.13
No. 2.	1 : 1.14
No. 3.	1 : 1.18
No. 4.	1 : 1.20
No. 5.	1 : 1.30

ABSOLUTE GROWTH OF PLANTS DURING 24 HOURS IN INCHES.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
2.51 inch.	2.14 inch.	1.83 inch.	1.73 inch.	1.65 inch.

TABLE XIII.

POUNDS OF HUSKED CORN.

	Pounds per 8 rows—1-20 acre.	Bu. per acre.	Pounds per measured bushel.	Per cent. of cob.	Kernels on one ear	Actual bushels shelled corn.
Piasa King	310	87.1	56.2	13.5	1071	95.8
Hickory King	218	62.3	56.8	10.3	636	69.8
Giant White Normandy	312	87.7	55.9	12.1	993	97.9
Wabash	299	85.4	52.8	16.6	972	89.1
Champion Early White Pearl	238	68.0	56.3	14.5	912	72.5
Calico Dent	249	71.1	55.8	15.5	981	75.1
Logan	260	74.3	58.8	14.2	915	79.7
Imperial	255	72.8	55.3	16.2	972	76.5
Golden Beauty	244	69.7	58.2	15.5	891	73.3
Yellow Mammouth King	250	71.4	59.2	15.5	903	75.4
Murdocks Improved	180	——	59.4	13.9	864	
Riley's Favorite	153	——	60.4	14.1	885	
Leaming	182	——	60.3	14.2	858	
Canada Early Yellow Flint	96	——	63.9	13.6	——	
Piasa Pet	267	76.3	——	——	——	
Chester County Mammouth	260	74.3	——	——	——	

In the case of these varieties the same injustice to the farmer is noticeable as was mentioned in Table VI; he would receive f. e. pay for 87.1 bushels of corn but actually deliver 95.8. The encomium bestowed in the text upon *Giant White Normandy, Piasa King and Wabash* becomes more apparent in the last column of figures here, though 2 per cent. or 1-50 for excess of water, should be subtracted, to get ordinary commercial values.

TABLE XIV.

WEIGHT IN GRAMMES AND OUNCES OF:

	One Ear—grammes			1 quart	One Ear—ounces		
	Ear	Grain	Cob	grs.	Ear	Grain	Cob
Piasa King	413	357	56	685	14,6	12.6	2.0
Hickory King	236	212	24	693	8.3	7.5	0.8
Giant White Normandy	391	331	60	682	13.8	11.7	2.1
Wabash	388	324	64	644	13.7	11.4	2.3
Champion Early White Pearl	355	304	51	687	12.5	10.7	1.8
Calico Dent	387	327	60	680	13.6	11.5	2.1
Logan	355	305	50	717	12 5	10 8	1.7
Imperial	387	324	63	674	13.7	11.4	2.3
Golden Beauty	352	297	55	710	12.4	10.5	1.9
Yellow Mammouth King	357	301	56	722	12.6	10.6	2.0
Murdock's Improved	335	288	47	725	11.8	10.2	1.6
Riley's Favorite	343	295	48	737	12.1	10.4	1.7
Leaming	333	286	47	736	11.7	10.1	1.6
Canada Early Yellow Flint	200	173	27	780	7.1	6.1	1.0

EXPLANATION OF PLATES.

- - - - - Air Thermometer.
——— Three inches below surface.
. . . . Six inches below surface.
- - - - - 1, 2, 3 feet below surface according to position.

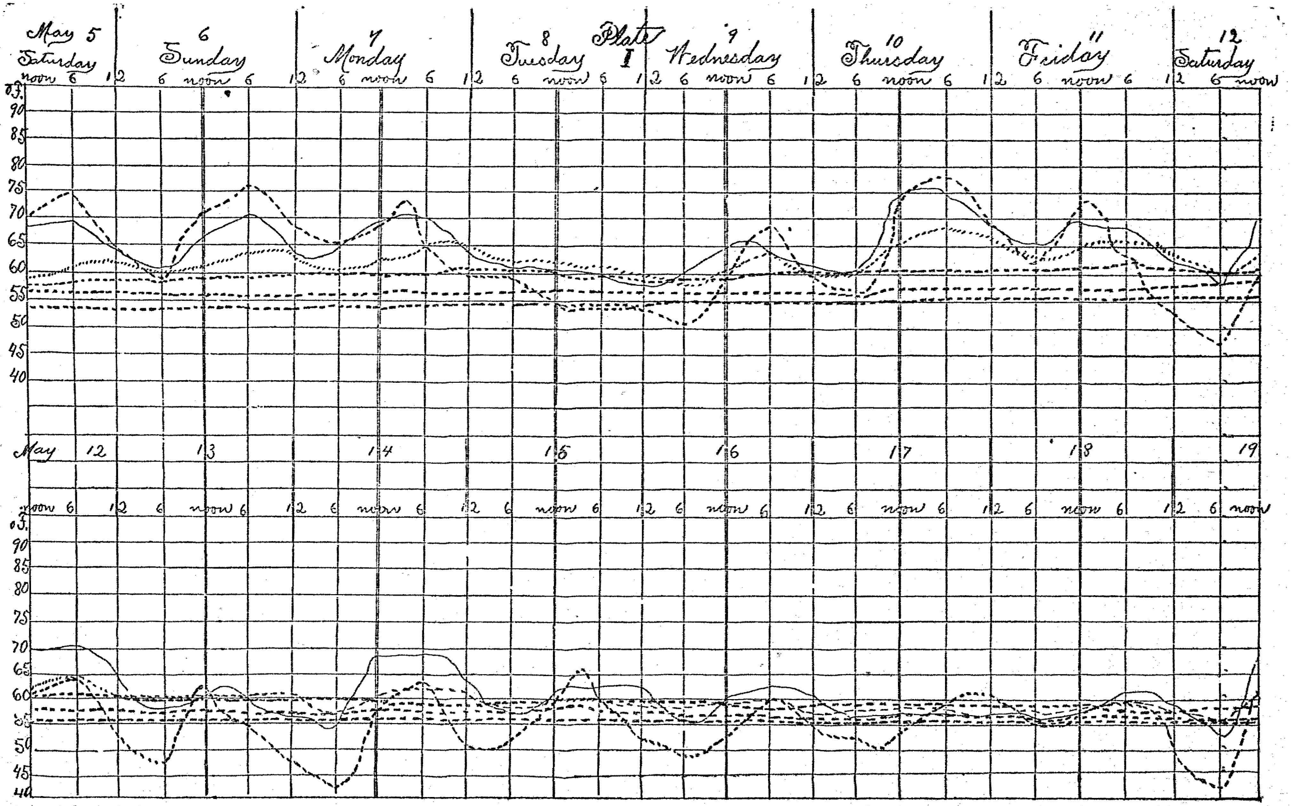


Plate I
May 5 Saturday
6 Sunday
7 Monday
8 Tuesday
9 Wednesday
10 Thursday
11 Friday
12 Saturday
noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon
F. 90 85 80 75 70 65 60 55 50 45 40
May 12 13 14 15 16 17 18 19
noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon 6 12 6 noon
F. 90 85 80 75 70 65 60 55 50 45 40

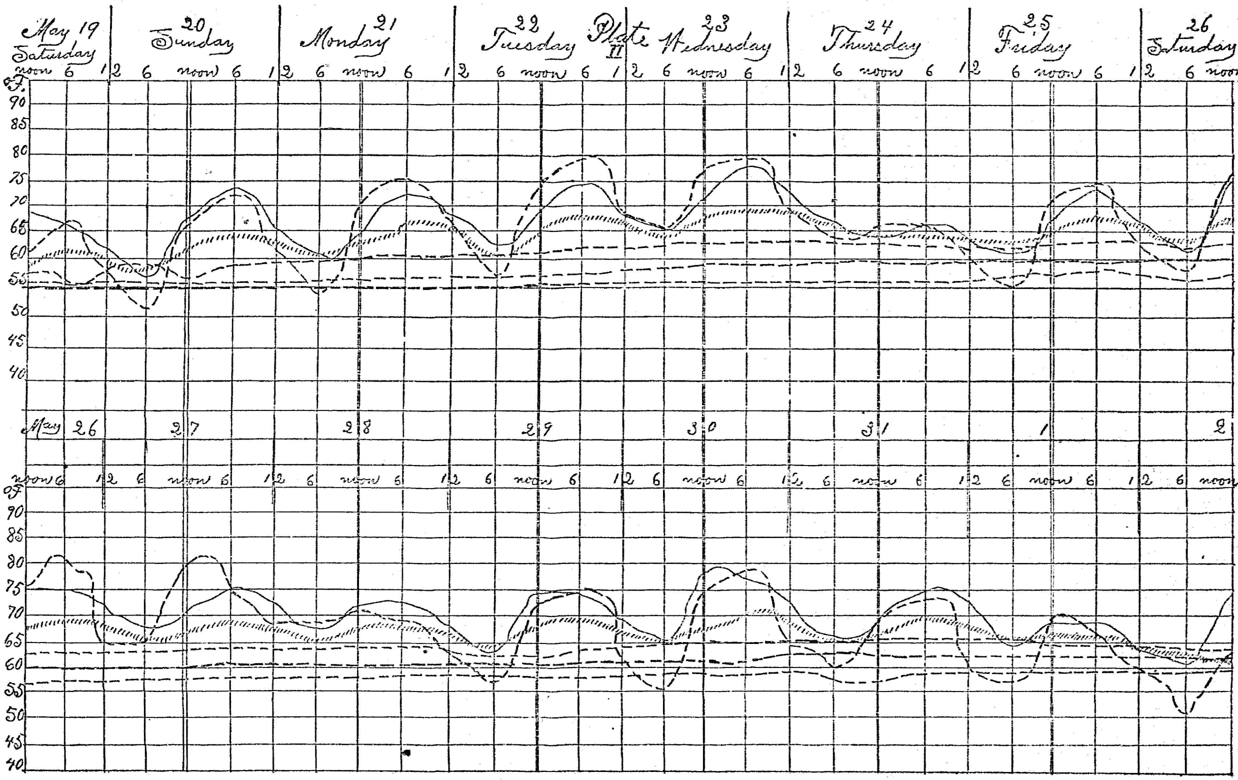


Plate II
May 19 Saturday
20 Sunday
21 Monday
22 Tuesday
23 Wednesday
24 Thursday
25 Friday
26 Saturday
noon 6 12 6 noon 6 12 6 noon
°F.
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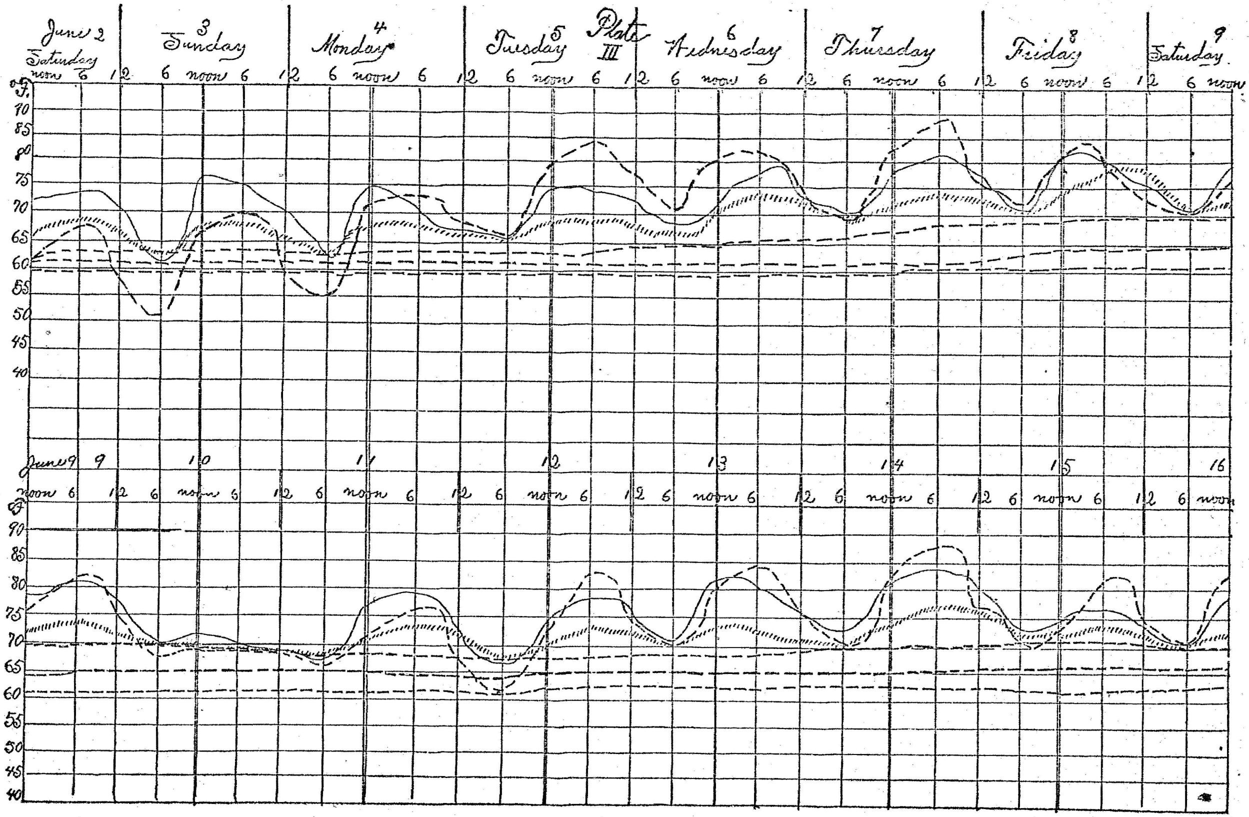
Plate III
June 2 Saturday
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4 Monday
5 Tuesday
6 Wednesday
7 Thursday
8 Friday
9 Saturday
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°F.
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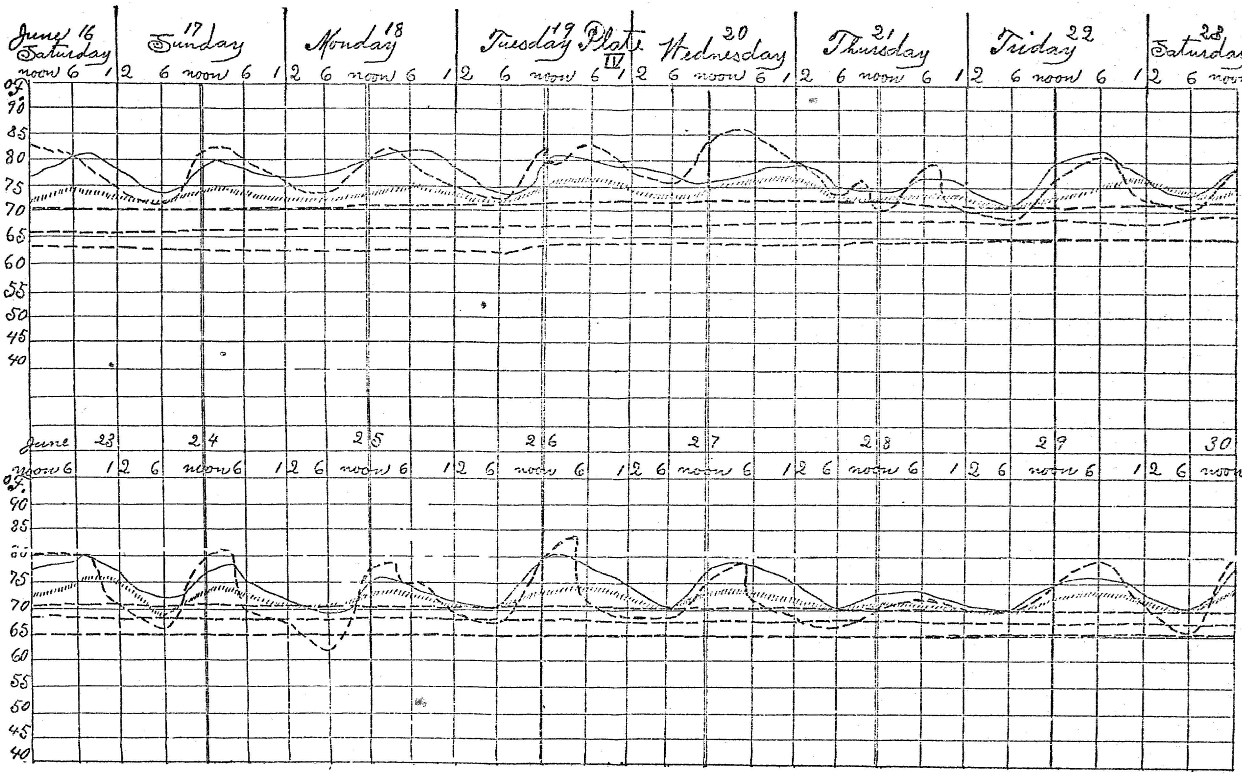
Plate IV
June 16 Saturday
17 Sunday
18 Monday
19 Tuesday
20 Wednesday
21 Thursday
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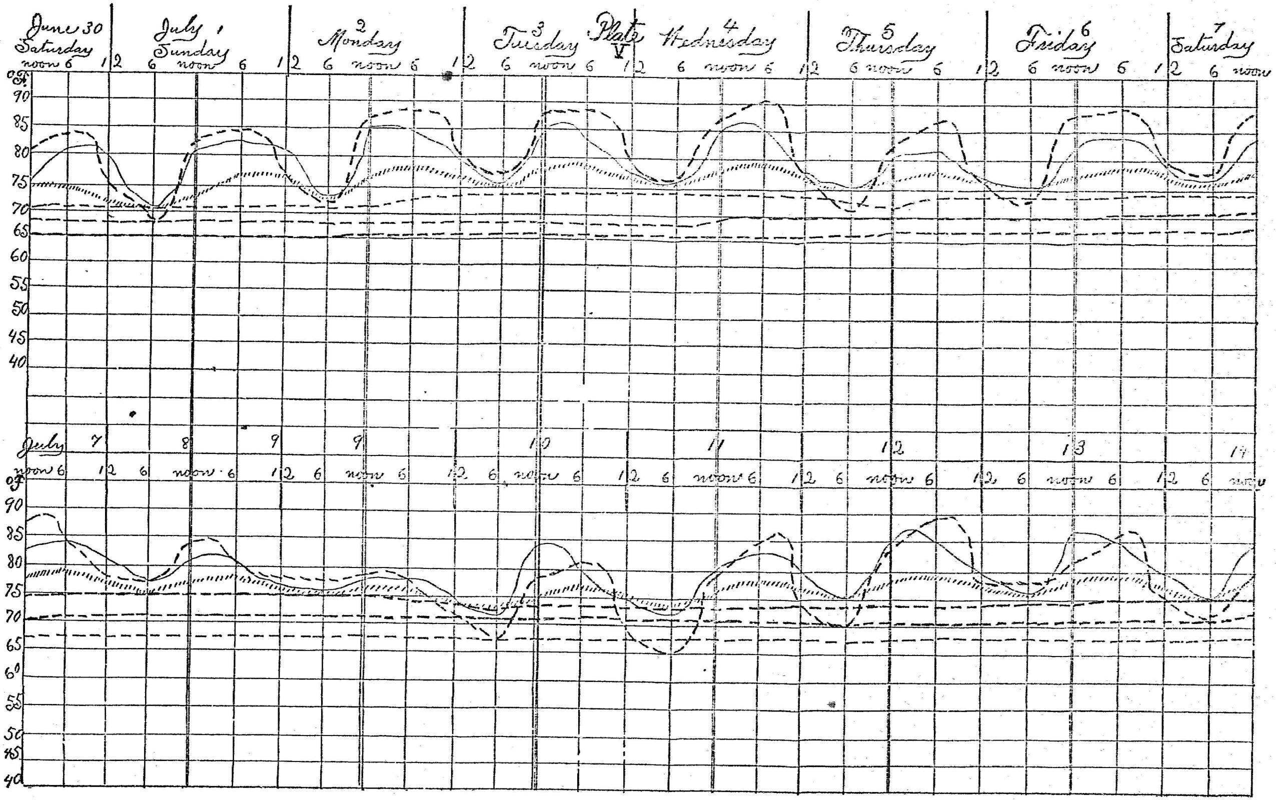
Plate V
June 30 Saturday
July 1 Sunday
2 Monday
3 Tuesday
4 Wednesday
5 Thursday
6 Friday
7 Saturday
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July 7
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July 14 Saturday
15 Sunday
16 Monday
17 Tuesday
Plate VI
18 Wednesday
19 Thursday
20 Friday
21 Saturday
noon 6 12 6 noon 6
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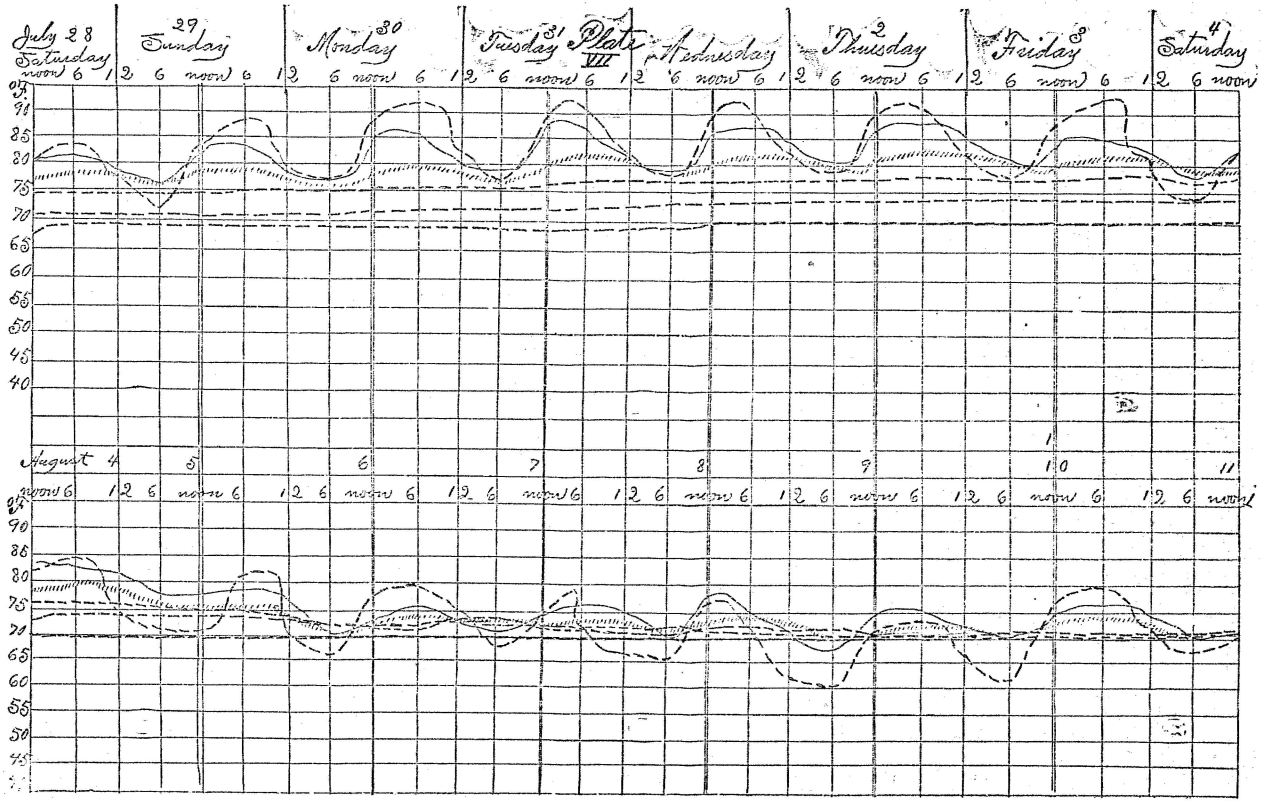

Plate VIII
July 28 Saturday
29 Sunday
30 Monday
31 Tuesday
Wednesday
2 Thursday
3 Friday
4 Saturday
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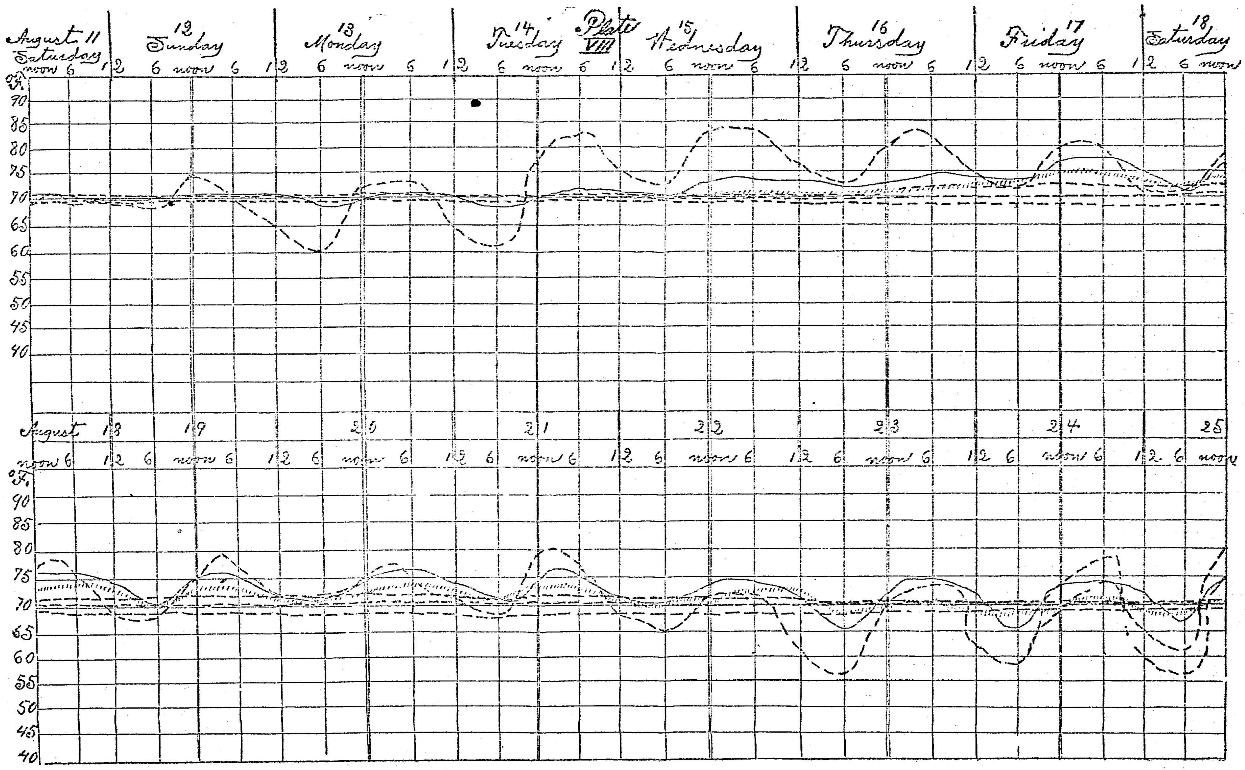
Plate VIII
August 11 Saturday
12 Sunday
13 Monday
14 Tuesday
15 Wednesday
16 Thursday
17 Friday
18 Saturday
noon 6 12 6 noon 6
°F.
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August 18
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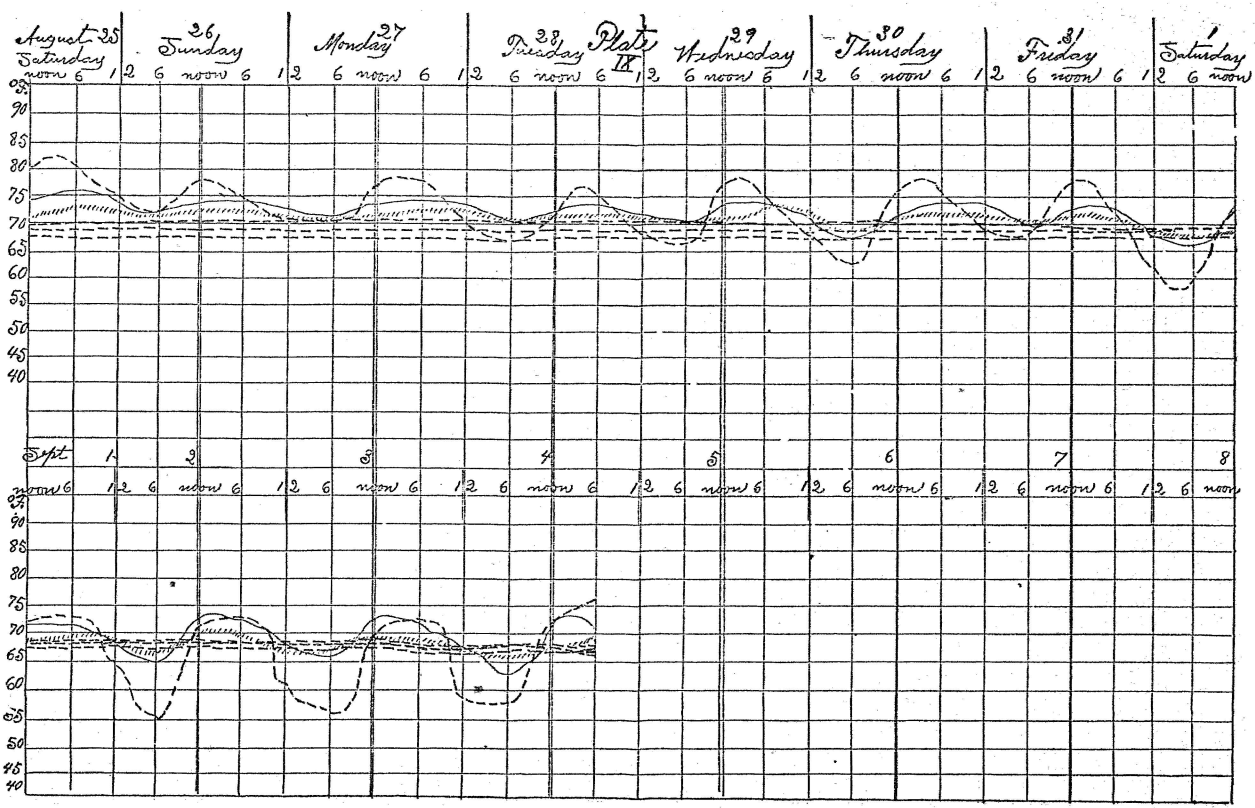
Plate IX
August 25 Saturday
26 Sunday
27 Monday
28 Tuesday
29 Wednesday
30 Thursday
31 Friday
1 Saturday
noon 6 12 6 noon 6 12
90 85 80 75 70 65 60 55 50 45 40
Sept 1 2 3 4 5 6 7 8