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OKLAHOMA SOIL STUDIES

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STUDIES OF OKLAHOMA SOILS.

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SUMMARY.

1. Soils resemble the rocks from which they were formed. Rocks vary in structure and hence many kinds of soils are found. There are also many ways by which soils have been formed. Each gives a certain character to the soil. Farmers should be careful students of their own fields.

2. The soils examined at the Oklahoma Agricultural Experiment Station prove to be loose textured with some of the properties of finer soils. They are easily handled. The specific gravity ranges from 2.60 to 2.66. Under field conditions, without water, the weight of the first twelve inches of cultivated soil was 67.5 pounds per cubic foot, uncultivated 82, alkali 95.1 pounds.

3. The water supply is very important in plant production. Our rainfall is often poorly distributed and much water is lost by poor methods of soil culture. The water content of the soil at the Experiment Station during the growing season of 1896 ranged from 5 to 26 per cent.

4. Water percolates best into freshly plowed or cultivated soil. Compacting the soil hinders percolation. The plow is the best implement for putting the soil in condition to receive the rainfall. Subsoiled ground receives more moisture during a heavy rain than unsubsoiled ground.

5. Cultivation conserves much soil moisture. Soil mulches prevent evaporation. Cultivation sufficient to keep the weeds from growing is very essential, but we should cultivate to conserve moisture. Very frequent cultivation is not so effective as less frequent.

6. Rolled ground, when dry, showed an increase in soil moisture for the first few days. It also showed a larger decrease in the second foot during 32 days.

7. Other things equal the rapidity of the growth of plants depends upon the moisture content of the soil. The highest per cent. of soil moisture found in the first foot of soil at the Experiment Station is about 26, the lowest about 5. Alkali soils do not contain as much moisture as ordinary prairie.

8. Monthly averages of soil moisture and soil temperature are given in tables 10 and 11. Attention is called to Bulletin 22 of this Station for the climatic conditions of 1896.

Soils are essentially composed of fragments of rock. Their formation is the result of the weathering processes. These processes of nature are going on about us continually, and have been sufficient, through the lapse of ages, to grind or dissolve the solid rock and leave our soils. When a soil lies immediately over the rock from which it has been formed it much resembles the parent rock in chemical composition. Some rocks are much harder than others and leave a more stony or gravelly soil. Rocks of uniform texture will naturally form an even textured soil. Rocks of fine uniform texture give our finely divided soils. The character of a rock determines the texture and largely the natural fertility of a soil formed from it.

Sometimes soils are so finely divided that there is scarcely any grit in them. In this case we have a heavy soil. Other soils may be gravelly or sandy and we call them light. These terms are applied to the working of the soils and not to their actual weights. A heavy soil sticks together and a slight puddling by working when too wet will cause it to be cloddy and impervious to water. Reservoirs are sometimes made to hold water by puddling the bottoms, and no doubt our ponds will hold water better if the bottoms are puddled. Nothing but freezing or dissolving will pulverize a puddled soil, and hence great care should be taken in cultivation of soils liable to this action. Sandy soils have but little tendency to become cloddy. They can be worked much sooner after rains without injury. Between the coarse and fine soils there are many classes. No two farms are exactly alike. Each farmer must study his own soil; learn its needs and adopt a method of handling to suit it.

The chemical analysis of the soil of the Station farm was made by Prof. Geo. L. Holter, from samples of the virgin soil and the results are given below. We copy from Bulletin No. 5:

	Virgin Upper Soil. Station Farm.	Virgin Alkali Soil, Station Farm.
Water and Volatile Matter	4.10	2.06
Soluble Silica	7.76	4.47
Insoluble Silica	79.99	87.91
Lime	.95	.76
Magnesia	.21	.18
Soda	.31	.36
Potash	.44	.32
Manganese	.07	.06
Iron Oxide	3.40	2.80
Clay	2.78	1.05
Sulphuric Acid	.15	.16
Phosphoric Acid	.06	.06
Humus	.51	.51

In the virgin upper soil there was found no chlorine and a trace of effervescence with acid. The alkali soil efferveses with acid and gives a trace of chlorine. This virgin upper soil, though not the same sample, is comparable with that given in table 1.

The soils examined at the Oklahoma Agricultural Experiment Station have been of the following types: Upland light colored, upland red, river bottom, black jack, and alkali. Analyses of these soils show them to be finely divided. There is practically no coarse material, while the amount of clay is small. The finest material, or clay, ranges from about 3 per cent. in black jack soil to nearly 20 per cent. in alkali soil. The second foot of soil shows a remarkable increase in clay, which ranges from about 6 per cent. in black jack soil to nearly 40 per cent. in upland light soil.

The following table shows the analyses of the first foot of soil on the Experiment Station farm. This soil belongs to the type of upland light soils and is of very fair fertility:

Table 1. — Texture of Soil on Oklahoma Experiment Station Farm.

Conventional Names.	Diameter of Grains in Millimeters.	Per Cent.
Gravel	2-1	0.01
Coarse sand	1-0.5	0.93
Medium sand	0 5-0.25	0.10
Fine sand	0.25-0.1	3.63
Very fine sand	0.1-0.05	25.17
Silt	0.05-0.01	43.89
Fine silt	0.01-0.005	9.71
Clay	0.005-0.0001	12.37
Total mineral matter		94.91
Moisture in air dry sample		2 12
Organic matter		3.90

One millimeter is one twenty-fifth of an inch, so that the largest particle would be between one-twelfth and one-twenty-fifth of an inch in diameter. There are very few particles more than one-hundreth of an inch in diameter in this soil. It has about 70 per cent. of very fine sand and silt and enough clay to allow it to settle closely together and become quite compact, as illustrated in our hard roads. The finer particles lie between the coarser ones and, while it is naturally a loose textured soil, this gives it some of the properties of a finely divided soil. Where this soil is cultivated the rain is readily absorbed and well retained. The rapid increase of the finer particles in the second foot of soil aids it in holding the moisture.

The weight of soil varies with its specific gravity and compactness. The specific gravity of the soils studied is as follows:

Upland light colored	2.60
Creek bottom	2.60
Black jack	2.65
Alkali	2.65
Upland red	2.66

These figures do not have reference to the soil as it lies in the field, but to perfectly dry soil without air space. With the soil in this condition they simply tell us then how many times heavier the soil is than the same bulk of water. A sandy soil always has a higher specific gravity than a clayey soil. A bucket full of sand will weigh more than the same bucket full of clay.

The weight of soil was determined under field conditions by sampling the soil with a tube of known dimensions and weighing the sample when dried at 110 degrees centigrade, or at or above the temperature of boiling water. The weight of a cubic foot of soil given below is the same as it is in the field if there were no moisture.

Table 2—Weight and Porosity of Soil.

	Weight of Cubic Foot.			Per Cent. of Air Space or Porosity.		
	1st foot.	2nd foot.	3rd foot.	1st foot.	2nd foot.	3rd foot.
Upland, light, cultivated	67.5	91.6	116.3	58.5	43.7	28.5
Upland, light, uncultivated	82.0	91.8	116 3	49.6	43.5	28.5
Alkali	95.1	117.4	120.3	42.6	30.0	27.4

It will be noted that cultivation has caused an increase of about 9 per cent. in its porosity in the first foot of the upland soil, while practically no increase is shown in the second and third.

The soil needs air to hasten decomposition. Our upland light colored soils have become darker because cultivation has admitted the air and decomposition of organic matter has taken place. The porosity of a soil greatly influences the amount of water it will receive during a dashing rain.

We cannot well over estimate the importance of water to the plant. All are acquainted with the fact that green plants, if cut and dried in the sun, lose much of their weight. They are largely composed of water. Thus 100 pounds of meadow hay contains from sixty to eighty pounds of water: 100 pounds of red clover about eighty-six pounds of water, while our garden plants, such as lettuce, cucumbers and cabbage contain from ninety-five to ninety-eight pounds of water to the hundred. The seeds of plants do not contain so much water as the leaves and stems. When well dried, wheat, oats and rye contain about 14 per cent. each, while Indian corn contains about 11 per cent. of water. In the fall of '96 we found at the Experiment Station 65 per cent. of water in corn stover, stalks and leaves of the plant, cut when the corn was well glazed. In teosinte cut green August 5 there was 80 per cent.

While plants contain large amounts of water this is small as compared with the amount given up by the soil through evaporation from the plant and soil. It is stated that a grass plant on a dry hot day will lose an amount of water equal to its weight. Of the water passing into the plant a large amount does not remain there. It has other purposes. The food a plant gets from the soil is taken from the water passing through its tissues. A plant needs a great deal more water than we find in it at any one time. Professor Whitney says: "A plant needs thirty to forty times as much water as we find in it when harvested."

Water falls from the clouds through the air at a certain velocity. It strikes the soil and its velocity is retarded, but it tends to fall till it reaches the ocean level or is returned to the sky by evaporation. It is our business as agriculturists to use this water while it is falling through the soil. The one who does this to the best advantage will receive larger crops for his care.

After a heavy rain we may see the water standing on the soil, but in a few hours we must dig in the soil to find it. We have not lost all this water supply, for around each particle of soil there is a thin film. In a few days after the rain fell we notice the surface appears dry. The film of water is much reduced, yet, an examination will show that there is some water left that the plant can use. The larger part of the water has evaporated. As we watch carefully from day to day we will notice that the soil becomes dryer to a greater depth, and yet not nearly so rapidly as if it were exposed in a pan and cut off from the soil below. We have all noticed how brightly our lamp burns when it is full of oil. We have noticed how dull it became when the oil was low or the wick could not reach it. The lifting of the oil through the wick is by capillary action. The same force is ever present in the soil. The capillary power of the soil is dependent upon the arrangement and size of the soil particles. The stronger this power in the soil, the less readily will it give up the water to the plant. In some soils, plants will flourish with a certain amount of water, while in other soils plants will die with the same amount of water. Thus it was found that grass land in Kentucky seemed dry with 15 per cent. of moisture while the plants growing along the Atlantic seaboard in a sandy soil did well with 7 per cent. of moisture. Loose, open textured soils give up water to plants more freely than close textured ones. On the Oklahoma Agricultural Experiment Station farm the average per cent. of soil moisture while the crop was growing most vigorously during May, June and July was 16.1 per cent. When the crop of Kaffir was harvested on August 14 there was about 7 per cent. of moisture.

Soils lose water in three ways—percolation and drainage, consumption by the plant, evaporation from the surface. A German authority finds that for every pound of dry matter produced by the plant there are 310 pounds of water lost or taken from the soil. Professor King found that in Wisconsin dent corn required 309 tons of water per ton of dry matter produced; red clover, 452 tons; oats 522 tons. An inch of rainfall on an acre is equal to about 113.4 tons of water. It would seem then that less than three inches of rainfall would be necessary to produce a ton of dent corn to the acre. At our Experinent Station last summer there were produced over nine tons of corn fodder per acre, or over three tons of dry matter per acre, as this fodder contained 65 per cent. of water. We cannot say that this would require only nine inches of rainfall. The actual rainfall during the growth of the crop from April to July was twenty inches. It was very unequally distributed and much of it ran off the surface because the showers were so heavy.

Since plants require so much water, how can it be supplied to them to the best advantage? A large number of Oklahoma farmers cannot look to irrigation to benefit them. Their work will be in putting the soil in the best possible condition to take in the water that falls and give it up to the plants with the least loss by evaporation. Soils ought to be so cultivated that the rains falling on them will be quickly absorbed.

The following experiment was conducted to show the variation in the rate of percolation of water into the soil under different conditions. It was carried on about two months after the ground had been rolled. The soil under cultivation contained between 16 and 17 per cent of moisture in its first foot The prairie sod had 25.8 and the alkali 18.8 per cent. This was near the total water capacity of the last two soils. A galvanized sheet iron cylinder, eight inches in diameter and sixteen inches deep, with a fine wire sieve at the top to prevent puddling of the soil, was forced into the ground eight inches. About four inches of water was poured in, after which a measured quantity was allowed to percolate into the soil and the time required noted. This was repeated several times in each case and found to be quite uniform between certain limits.

Table 3.—Rate of Percolation of Water.

CONDITION OF SOIL	Minutes per Inch. Average
Recently plowed ground	7.8
Rolled ground, subsoiled	28.3
Same as above, unrolled	15.7
Ordinary plowing	8.7
Ordinary plowing, subsoiled	18.9
Prairie sod	37.1
Alkali sod	48 hours

The recently plowed ground had not been harrowed. The other cultivated ground had been plowed early in August and sown to wheat. In addition to the same treatment the rolled ground was rolled twice. The cultivated plats, except the first, were adjoining.

In order to get the rain water into the soil and prevent its running off the surface, we plow and subsoil, cultivate, apply mulches and grow crops. Compacting the surface prevents percolation as may be noted in the experiment with rolled ground. The moisture content of the soil depends much upon percolation.

The following experiment will show how the plow assists percolation: On a plat plowed about August 6, that had been in oats, samples were taken on October 24 to the depth of three feet. Just across the road lay a plat that had been in wheat but had not been plowed. It was also sampled.

Table 4—Influence of the Plow on Percolation.

DEPTH.	Per Cent. of Soil Moisture.		
	Plowed.	Unplowed.	Difference.
First foot	19.1	13.8	5.3
Second foot	16.1	11.7	4.4
Third foot	16.0	11.7	4.3

These samples were taken the day after a rain of 2.48 inches. The average for the three feet is 4.7 per cent. more in the plowed than in the unplowed land. This equals over 2.5 inches of rainfall, or more than 283.5 tons of water per acre for the first three feet of soil. The latter plat was plowed four days later or on October 28. These plats were again sampled on December 5. Between October 24 and December 5, 1.76 inches of rain had fallen.

Table 5—Per Cent. of Moisture in Plowed Ground December 5.

DEPTH.	Date of Plowing.		Increase Since October 28. Date of Plowing.	
	August 6.	October 28.	August 6	October 28.
First foot	20.7	17.7	1.6	3.9
Second foot	15.8	18.1	0.3	6.4
Third foot	16.9	15.0	0.9	3.3
Average	17.5	16.9	0.7	4.5

On December 5 soil plowed in August and October was compared with prairie and alkali sod as to soil moisture. The average of the first three feet gives the following results:

Ground plowed in August showed 17.5 per cent. of soil moisture; plowed in October 16.9 per cent.; prairie sod 14.2 per cent.; alkali sod 11.9 per cent.

Laboratory methods supplement field work. A compact or fine soil retards percolation. From the mechanical analysis of a soil one can understand the relation a soil will sustain to water. In a cubic foot of soil on the Station farm there is about an acre of space on the soil grains. In a cubic foot of black jack soil analyzed there is about one-sixth as much space. Water will run through these soils in about the same ratio.

Thus we see that percolation is hastened by plowing and subsoiling. After cultivation is an important factor in the same process. Even shallow cultivation will notably influence the amount of percolation. Cultivated plats during the summer of 1896 on the Experiment Station farm increased 5 per cent. more in moisture in the first foot of soil than uncultivated plats during a rainfall of nearly two inches. Mulching is one of the most effective helps to percolation. The mulch of leaves in a forest holds the water till the soil can have time to absorb it. Growing crops assist percolation by the penetration of the soil by their roots and by keeping the surface more moist.

The plow is the best implement by which we may put the soil in condition to absorb the rainfall to the best advantage and retain it near the roots of the plants. This is a wedge shaped tool which is drawn through the ground, tending to separate the soil particles to a certain depth. It is imperfect in that it is a poor pulverizer and tends to cement the soil over which it slides, and in some cases makes it impervious to water. Subsoiling loosens the ground to a greater depth and thus water is admitted more freely. By subsoiling we mean the stirring of the subsoil, and not the turning of it or raising it as is done in plowing. In our Territory we should allow as little as possible of the rainfall to go to waste by running off the surface. The following experiments with the plow were carried on at the Experiment Station: Three plats were plowed from August 6 to 10. 1. Plowed with the Secretary or disc plow 14 to 15 inches deep. 2. Plowed with Casaday riding plow 6 to 8 inches deep and followed in each furrow by the Perrine subsoil plow 15 to 16 inches deep. 3. Plowed with Casaday riding plow 6 to 8 inches deep. Weekly determinations of soil moisture were made to a depth of two or three feet. These plats lie side by side, running east and west about 80 rods long and over 5 rods wide. The ground slopes gently from the north to the south. The plats are numbered from south to north.

The samples for moisture were taken on a portion sown to wheat. The soil was treated alike in each case. The plats were harrowed twice and drilled across the plats with a press drill. There was a quite rapid increase in moisure till September 26. The next two weeks show a loss of over 4 per cent. of moisture. The heavy rainfall of the next week increased the soil moisture, after which it was somewhat constant till March 20, 1897. The moisture in the different plats seems to have about the same relation through the experiment as in the first determination. For the second foot of soil it was different. Plats one and two, which were subsoiled, kept drying out until September 19. Plat three, not subsoiled, shows an increase in moisture of 2 per cent on September 19.

The first and second foot of soil do not correspond in the rise and fall of soil moisture. In some cases the samples were taken soon after a rain which had not as yet affected the second foot of soil. October 22 and 23 a rain of 2.48 inches fell. On October 24 the first foot of soil showed an increase of 6 per cent., while the second foot showed a decrease of about 2 per cent. since the previous week. During the next two weeks the first foot decreased, while the second increased in moisture, although the rainfall was two-tenths of an inch.

The following table gives the monthly average of soil moisture in the plats under different methods of plowing. From two

Table 6--Soil Moisture in Per Cent. of Fresh Sample.

MONTH.	SURFACE FOOT.			SECOND FOOT.			THIRD FOOT.		
	Plat No.			Plat No.			Plat No.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
August, 1896	8.0	6.1	6.6	17.2	18.0	16.3	....	....	......
September, 1896	13.3	12.1	12.5	16.6	12.6	13.5	....	....	....
October. 1896	15.5	14.8	14.6	19.4	17.6	15 0	16.0	13.7	12.5
November, 1896	19.4	15.8	17.0	18.8	16 6	18.6	15.1	12.6	15.3
December, 1896	18.6	17.5	15.7	18.1	17.8	16.3	16.9	15.1	17.2
January, 1897	16.7	16.2	16.1	18.3	17.1	15.7	....	....	....
February, 1897	18.9	18.0	17.0	19.3	17.6	18.0	....	....	....
March, 1897	17.8	18.0	17.7	18.7	17.3	17.4	16.8	16.4	13.5
Average	16.0	14.8	14.6	18.2	16.8	16.3	16.2	14.4	14.6

to six determinations were made each month except for August The figures for that month show the per cent. of moisture in the soil at the time of plowing, (August).

Water enters the soil by percolation and we call it soil moisture. It exists in three forms: capillary, hygroscopic, and combined water. The latter is in small quantity and is unimportant in plant growth. Plants use free and combined water to some extent but their large supply is from capillary water. When this becomes low they wilt and ripen, or die. Only few plants can live when the soil is full of free water. Capillary water has peculiar laws, many of which have not been determined. We know it has a tendency to pass from one portion of the soil to another. There seems to be an attraction of the different particles of soil for it. The finer the soil particles the more closely it is held and the less available is it for plants. We know that it can be influenced by cultivation. We can cultivate so that the greater part of it is lost from the soil. In some cases it is necessary to cultivate so as to get rid of soil moisture. In our Territory we should cultivate so as to conserve it. The plant demands all the water it can get—in most seasons more. Water is far more largely used by plants than is any other constituent. They not only use it to build up tissue but all of the ash must be carried to the plant by the water passing into its roots. If the plant could convey the water back again to the soil it would need but a small amount. No doubt the amount of water passing through the plant can be controlled but there is a more practicable plan.

The top soil soon becomes dry after a rain. The moisture has evaporated. It keeps on drying to a greater depth, but at a slower rate. The air has not so close a contact with the deeper soil. There is a large amount of air space in all soils. A current of air tends to flow from the air above to the soil below. It is either up or down, according to the differences in temperature or barometric pressure.

After we have put the soil in condition to receive the water how can we best retain it for the use of the plant? In other words how can we prevent evaporation? While the particles of soil lie closely together, there is, owing to their irregular shape, much space between them. The contact with the air causes rapid evaporation. Stirring the soil checks capillary flow because evaporation is checked. Capillary moisture will not rise so readily into dry soil.

Soil mulches are very useful in the conservation of moisture. They also effect its location, tending to dry out the lower layers and keeping the surface soil more moist. As has been suggested, mulches retain the moisture. Forests, by their mulches of leaves, prevent floods. Dry earth is the most practical mulch that farmers can use. Experiments prove that shallow and not too frequent cultivation prevents loss of much more moisture than no cultivation, and also more than daily cultivation. Growing crops prevent much evaporation by shading the ground and lessening the effect of the wind. Frozen ground is a good mulch for the time being, but it leaves the moisture so near the surface that on thawing, it soon evaporates and is lost. We have all noticed how wet the ground was on thawing. The following experiment shows the increase in soil moisture while the ground was frozen: November 27, 1896, the thermometer dropped down below freezing point and on the next day the soil was frozen four or five inches deep, and remained frozen till December 4, beginning to thaw on top December 2 and 3.

Table 7—Influence of Frozen Ground on Soil Moisture.

DATE.	Per Cent. of Moisture.		Temperature of the Soil.	
	Depth in Inches.		Depth in Inches.	
	0-3	3-12	4	36
November 26	22.7	21.7	56	56.5
November 27	22.1	21.8	36	56.5
November 28	28.0	20.6	30	56.5
November 30	26.6	20.5	29	55
December 1	32.8	20.8	27.5	53.5
December 4	24.1	20.4	29.5	51.5
December 5	22.8	19.4	42	50.5

This table shows a rapid increase in moisture in the first three inches of soil. It will be noticed that there was a difference of 20 degrees or more in temperature between the soil at four inches deep and that at thirty-six inches deep. When there was a less difference in temperature the increase in soil moisture, though noticeable, was not so great.

The harrow and shallow cultivator are similar in their influence upon the soil. They pulverize and break up the hard crust, or compact the loose freshly plowed soil. The soil that they disturb dries out quickly and forms a layer or soil mulch which prevents rapid evaporation.

Uncultivated ground shows moist soil to the surface, or very near it. At the Experiment Station cultivated and uncultivated plats were compared during the period of cultivation from May 12 to July 16 by daily determinations of soil moisture. The uncultivated plats gave an average of 15.2 per cent., while the plat cultivated weekly gave an average of 17.1 per cent. of soil moisture. A plat cultivated shallow and quite frequently gave an average of 16.3 per cent. moisture. A plat with manure spread on top averaged 17.3 per cent., while an adjoining one with no manure averaged 16.4 per cent. of moisture. At the beginning the uncultivated plat showed the highest per cent. of moisture but usually the lowest throughout the experiment. The manured plats average the highest. Kafir corn grew on all the plats.

The roller is an implement that ought to be studied carefully in regard to its influence on soil moisture. It compacts the soil and hinders percolation and hastens evaporation. When practicable it should be followed immediately by the harrow. On some wheat plats that were plowed and subsoiled to the depth of 14 to 15 inches, the influence of the roller on soil moisture was studied. It was found that ground rolled September 15 had, September 19, about 3 per cent. more moisture than ground on the same plat not rolled. This was about one-third more moisture and to the crop it meant a day or two of difference in appearance above the ground. This was not the case when the ground had more moisture. The same plat sampled September 22 shows 1.5 per cent. more moisture, and on September 26, 2 per cent. less moisture; October 3 there was about 1 per cent. less moisture than in unrolled ground. There was an increase in the first foot of soil during a few days after the rolling, then the soil lost moisture rapidly.

Table 9—Influence of the Roller on Soil Moisture.

PER CENT. OF MOISTURE IN ROLLED GROUND.					UNROLLED GROUND
Rolled September 15		Sept. 25	Oct. 5	Oct. 15	
First foot	12.0	12.3	12.7	12.3	12.6
Second foot	12 9	14.4	15.2	16.2	16.7
Per cent. loss second foot	3.8	2.3	1.5	0.5	

The samples giving the above per cents. were taken on October 17. In every case but one the first foot of soil was dryer on the rolled than on the unrolled ground. There was a decided difference in the second foot. The difference increased as the length of time increased. While there was one-half per cent. in two days, there was nearly 4 per cent. difference in thirty-two days. The moisture being brought to the surface was readily evaporated and lost to the soil. This loss of 4 per cent. means about eighty-three tons of water per acre for the second foot of soil.

The rapidity of the growth of plants depends largely on the amount of moisture in the soil. Daily measurements of Kafir corn from June 8 to 22 shows an average growth of 0.75 of an inch, while the soil moisture averaged 13.3 per cent. From June 22 to July 6, the Kafir grew at the rate of 1.8 inches per day, while the soil moisture averaged 19.8 per cent. An increase of 4.5 per cent. of soil moisture was accompanied by an equal increase in growth.

Indian corn grew most rapidly when the soil moisture averaged from 16 to 20 per cent. In no case was the soil moisture below 15 per cent., and only in one case was it below 16 per cent. when the corn grew two inches per day or more. In individual cases it grew four inches in a day. During the growing period the average per cent. of moisture in a cultivated plat, without crop, was 17.1; with crop, 16.1.

Under ordinary field conditions soils vary in the amount of water they will retain. After our heaviest rains when the water was standing on the surface the soil contained about 25 or 26 per cent. of moisture. About 20 per cent. is the highest moisture content found in alkali soils. The lowest per cents. of moisture were found in August and September. On September 7 ordinary prairie contained 5.3 per cent. in the first foot. On August 22 the first foot had 5.6 per cent., while the first six inches of alkali contained 3 and ordinary uncultivated upland without crop 10.1 per cent. On August 14 a plat in Kafir corn had 6.4 per cent. while an uncultivated plat without crop had 10.7 per cent. moisture.

The following table gives the average monthly per cent. of moisture of soil under different conditions. The uncultivated plat was plowed in the early spring of 1896 and again October 20, 1896. It had been previously cultivated and was in fair tilth. The depth of samples taken was twelve inches in all cases not stated except that of the alkali sod. This was sampled to a depth of six inches in August, September and October, except a few days in the early part of August and the latter part of October, when the samples were taken to the depth of nine inches. They were taken to the latter depth also during November and December. Beginning with July the uncultivated plat was sampled to the depth of three inches, and also from three to twelve inches. The averages are given for those depths:

Table 10—Monthly Averages of Soil Moisture in Per Cent.

MONTH.	Prairie Sod.		Plowed Land.	
	Ordinary.	Alkali.	Uncultivated.	
April	13.5	15.4	14.3	
May	17.0	13.7	16.1	
June	15.4	14.6	15.9	
			3—12 inches	3 inches
July	18.0	14.2	20.3	17.0
August	7.9	7.3	13.8	7.8
September	9.6	9.8	14.5	9.6
October	15.0	12.8	15.6	13.2
November	21.2	17.3	19.7	18.0
December	22.8	18.9	18.8	19.7

Table 11—Monthly Averages of Soil Temperature. Taken Daily at 7 A. M. and 2 P. M.—1896.

	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Air at surface	....	78.4	78.1	88.6	88.2	78.3	61.3	49.7	43.8
Depth of soil—									
4 inches	68.6	73.3	75.3	80.5	86.3	73.6	58.4	46.3	38.9
6 inches	68.1	72.2	76.2	81.6	84.5	77.8	60.0	49.4	40.6
12 inches	65.6	70.8	73.7	78.0	83.4	75.3	62.4	53.6	43.9
36 inches	58.5	65.3	70.5	74.0	76.3	72.7	65.5	58.5	50.7
MINIMUM TEMPERATURE.									
Air at surface	42	52	60	62.5	60	42	38	13	20
Depth of soil—									
4 inches	53	56	60	68	70	47	45	28	26
6 inches	61	61.5	65	71	71	55.5	51.5	35	34
12 inches	58.5	67	68.5	74	76	63	58	43	40
36 inches	54.5	62.5	68	72.5	75.5	69	62.5	54.5	47.5
MAXIMUM TEMPERATURE.									
Air at surface	91	100	100	100	113	110	99	83	75
Depth of soil—									
4 inches	86	83	92	99	103	92	76	64	52
6 inches	78	81	83.5	90-5	94.5	86	78.5	62.5	50.5
12 inches	71.5	75	79	81.5	87.5	81.5	68	59.5	48
36 inches	62.5	68	73	75.5	80.5	77	69	62.5	53.5