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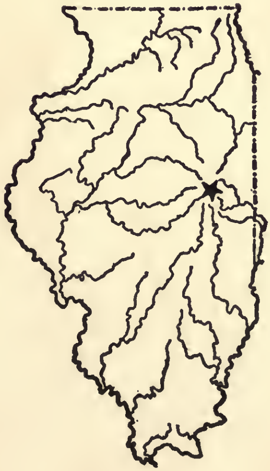
SOIL MOISTURE AND TILLAGE FOR CORN

By J. G. MOSIER and A. F. GUSTAFSON



URBANA, ILLINOIS, APRIL, 1915

Summary of Bulletin No. 181

1. A deep, well-prepared seed bed is essential for aeration, proper root development, and conservation of moisture. It gave a gain of 14.5 bushels ($7.25 at 50 cents) per acre over no seed bed. (Table 6.)

2. Killing weeds is the most important factor in cultivating corn on brown silt loam. No weeds gave an increase over weeds of 38.6 bushels of corn, a gain of $19.30 per acre. (Table 6.)

3. Weeds reduce the yield of corn more by robbing it of plant food and light than by depriving it of moisture. Irrigation on a weed plot gave an increase of only 3.8 bushels. (Table 6.)

4. As an average of sixteen tests in eight years, killing weeds without cultivation produced a gain of 17.1 percent, or 6.7 bushels per acre, over ordinary cultivation. (Table 6.)

5. Three-fourths of the corn roots are in the plowed soil, and as plants develop no unnecessary roots, any injury to them results in a lower yield. Four-inch pruning six inches from the hill reduced the yield 16.9 bushels. (Table 4.)

6. The cultivated soil, especially in periods of drouth, is too loose and dry for proper root development, consequently the plant is deprived of the food which it contains.

7. After the roots are well distributed thru the soil, little moisture can escape, even from uncultivated land. (Table 9.)

8. On gray silt loam on tight clay in southern Illinois, as a three-year average, preparation of seed bed gave an increase of 21.5 bushels; killing weeds by scraping with a hoe gave a gain of 21 bushels over allowing them to grow; and fertilization gave an increase of 14.2 bushels. Ordinary shallow cultivation gave a yield of 31.2 bushels per acre, while killing weeds without stirring the surface gave 31.5 bushels. (Table 12.)

9. The proper type of cultivation is deep enough to kill the weeds but shallow enough to reduce root injury to the minimum. On Illinois soils a good seed bed, killing weeds, and soil enrichment are the important factors in growing corn.

10. Cultivation is beneficial for aeration of heavy soils, clays and clay loams. (Table 14.)

11. Cultivation raises soil temperature early in the season and lowers it later. (Table 11.)

12. Subsoiling on gray silt loam on tight clay at Odin caused a decrease of 2.7 bushels per acre. (Table 15.)

13. Results of deep-tilling tests so far conducted by this experiment station do not warrant recommending the purchase and use of deep-tilling machines in this state.

SOIL MOISTURE AND TILLAGE FOR CORN

By J. G. MOSIER, Chief in Soil Physics, and
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The common impression among farmers and most agricultural writers is that cultivation of corn is necessary as a means for conserving moisture. While this may be true to a large extent in sub-humid and semiarid regions, yet in humid sections this purpose in the cultivation of corn is a very secondary object.

The reader is asked to note and to keep in mind that it is not the purpose of the authors of this bulletin to recommend specific methods or implements to be used in the cultivation of corn, but to develop principles that should be observed in order to secure the best results. The investigations reported were conducted to discover why corn is cultivated, and no one should assume that we advocate for practical farming the substitution of hand labor for horse power, but only that principles should guide practice toward the greatest profits.

KILLING OF WEEDS

The most important factor in the growth of a crop of corn on fertile soil with a well-prepared seed bed in humid regions is the killing of weeds. With the same preparation of seed bed, corn produced, as an eight-year average, 7.3 bushels per acre where the weeds were allowed to grow, and 45.9 bushels where the weeds were kept down without any cultivation. This gives an increase of 38.6 bushels, or say $19.30 per acre, for keeping weeds down. Weeds deprive the plant of moisture, light, and food, all of which are absolutely necessary for the production of crops. Of these factors, however, the one that has made the greatest difference is that of plant food. Corn has been grown together with weeds, but irrigated so that it was not deprived of moisture, yet the increase from irrigation, as a four-year average, was only 3.8 bushels per acre. Weeds are much better foragers than are most cultivated crops; and it would be just as reasonable to expect a lamb to thrive with a bunch of hogs as to expect corn to compete with weeds.

MOISTURE AND FOOD

If a soil is in good tilth and there are no weeds, little or no cultivation is necessary. If it is in poor tilth with no weeds present, some cultivation may be necessary for aeration. This is especially true of heavy soils or those containing a large amount of clay. In humid climates cultivation of corn is rarely necessary for the conservation of moisture if a good seed bed has been prepared. After the corn has become twelve inches or more in height, the roots are so completely distributed between the rows that it is difficult for moisture to escape from the soil, for it is captured by the roots in its upward progress. As an average of eight years' investigations, the soil was found to contain no more moisture where the corn was cultivated than where the weeds were destroyed without cultivation. (See Table 9.)

Cultivation should be as shallow as possible at all times, altho deeper stirring is permissible the first time than later. For the highest yield, cultivation should never be deep enough to injure the roots. The purpose of the roots is to get plant food and moisture, and as a general rule plants develop no more than are necessary for this purpose. The injury of a few roots, therefore, may stunt the corn. It must be remembered, too, that the plowed stratum is the richest part of the soil, and that the roots will naturally develop where there is the largest supply of plant food. Three-fourths of the roots of the corn plant are developed in the plowed soil. For this reason deep plowing in both fall and spring should be done to give a large feeding area.

CULTIVATION EXPERIMENTS IN OHIO

Experiments have been carried on at several stations to determine how often and how deep corn should be cultivated. A few stations have determined the effect of weeds on a crop of corn. The first

TABLE 1.—RESULTS OF CORN CULTIVATION AT OHIO EXPERIMENT STATION, COLUMBUS, OHIO[1]

(Yields in bushels per acre)

Kind of cultivation	1883	1884	1885	1886	1887	3-yr. av.	Av. %[2] of No. 3
1. None, weeds allowed to grow	21.7	14.5	6.4	13.5	.35	6.7	23.8
2. Surface	....	28.4	91.3	53.5	13.40	52.7	99.4
3. Ordinary, 4 or 5 times	49.8	29.4	82.4	56.0	20.00	52.8	100.0
4. Ordinary, excessive number	....	....	88.3	55.2	21.30	54.9	104.0
5. Ordinary, three times, 2 days apart	....	....	89.5	44.7	18.90	51.0	96.5
6. Ordinary, three times, 4 days apart	....	....	78.1	47.0	20.40	48.5	91.8
7. Ordinary, three times, 8 days apart	....	....	81.0	56.4	16.10	51.2	97.0
8. Ordinary, three times, 12 days apart	....	....	94.0	53.0	18.80	55.3	104.7

[1]Annual Reports 2 to 6.

[2]The yield from shallow cultivation is taken as the standard and represented as 100 percent; the relative yields from the other methods of cultivation are then expressed in percentage of this, based upon all comparable yields.

to carry on experiments along this line was Ohio, at Columbus, before the station was removed to Wooster. Table 1 gives the results.

Little was gained by a large number of cultivations. Comparing the average yields of 1885-1887, we find 54.9 bushels for excessive cultivation as against 52.8 bushels for four ordinary cultivations, or an increase of 2.1 bushels. The effect of weeds on the crop as shown in these results was very striking. Where the weeds were allowed to grow, 8.7 bushels of corn per acre were produced, as a four-year average, but where the weeds were kept down by surface cultivation the yield was 46.6 bushels, or 37.9 bushels increase.

MISSOURI EXPERIMENTS

Table 2 gives the results from some experiments on tillage at the Missouri Station.

TABLE 2.—RESULTS OF CORN CULTIVATION AT MISSOURI EXPERIMENT STATION[1]
(Yields in bushels per acre)

Kind of cultivation	1889	1890	Av.	Av. % of No. 2
1. None, scraped with hoe	82.0	45.7	63.8	95.3
2. Shallow, 4 times	80.1	53.8	66.9	100.0
3. Deep, 4 times	65.8	41.2	53.5	80.0

[1]Bulletin 14.

Without cultivation, but with the weeds kept down by scraping with a hoe, the average yield for the two years was 63.8 bushels per acre, while for shallow cultivation the yield was 66.9 bushels, or 3.1 bushels increase. Deep cultivation, compared with shallow, shows a loss of 13.4 bushels per acre.

INDIANA EXPERIMENTS

Table 3 gives the results from experiments at the Indiana Station in which cultivations at different depths were compared.

TABLE 3.—RESULTS OF CORN CULTIVATION AT INDIANA EXPERIMENT STATION[1]
(Yields in bushels per acre)

Depth of cultivation	1888	1889	1890	1891	2-yr. av.	4-yr. av.
One inch deep	60.7	....	....	56.6	58.7	....
Two inches deep	64.3	45.5	46.7	57.6	61.0	53.5
Three inches deep	64.6	41.8	46.4	50.2	57.4	50.8

[1]Bulletin 39.

EARLY EXPERIMENTS IN ILLINOIS

Professor G. E. Morrow, of the University of Illinois, began some experiments in 1888 to determine the value of cultivation and its best

TABLE 4.—RESULTS OF CULTIVATION OF CORN AND ROOT PRUNING, ILLINOIS EXPERIMENT STATION

(Yields in bushels per acre)

Kind of cultivation	1888	1889	1890	1891	1892	1893	1896	3-yr. av.	4-yr. av.	5-yr. av.	Av. %[1] of No. 2
1. None, weeds kept down by scraping with hoe	90.0	77.1	69.1	55.3	76.8	28.7	87.0	78.7	72.9	68.3	97.6
2. Shallow, 4 or 5 times	93.8	84.6	66.8	58.4	70.1	36.3	85.5	81.7	75.9	70.3	100.0
3. Deep, 4 or 5 times	84.9	74.2	60.8	63.4	80.1	33.6	83.4	73.3	70.8	66.7	96.9
4. Shallow, 12 to 14 times	94.6	80.9	71.1	....	81.5	35.9	....	82.2	....	72.8	103.6
5. Deep, 12 to 14 times	84.5	68.8	69.4	....	69.2	30.6	....	74.2	....	64.5	91.7
6. Roots unpruned, shallow, ordinary	97.0	90.9	78.7	70.0	78.9	33.4	....	88.8	84.1	75.8	109.5
7. Roots pruned, shallow, ordinary	91.0	78.3	55.0	48.7	70.7	26.2	....	74.7	68.0	64.2	90.2
8. Roots unpruned, weeds scraped off with hoe	94.0	85.8	76.7	66.3	....	....	....	85.5	80.7	....	106.3
9. Roots pruned with knife, weeds scraped off with hoe	85.5	68.4	61.5	39.7	....	....	....	71.8	63.8	....	84.1

[1]Based on all comparable yields.

TABLE 5.—RAINFALL AT UNIVERSITY OF ILLINOIS, 1889 TO 1896

(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1889	1.48	2.08	1.61	.61	5.52	6.81	5.81	.60	2.74	1.42	4.38	1.82	34.88
1890	5.26	1.87	2.70	4.11	3.56	3.80	2.83	1.93	1.19	2.35	1.63	.05	31.28
1891	.99	2.60	3.55	3.54	.89	2.08	1.41	2.86	.41	1.29	5.58	1.53	26.73
1892	.79	2.64	2.59	6.45	7.86	5.36	2.50	2.45	.93	.93	4.95	1.62	39.05
1893	1.05	4.48	3.20	7.68	4.83	1.55	.59	.06	3.62	1.14	2.98	1.09	32.37
1894	1.95	1.32	2.41	1.86	3.32	1.78	1.08	2.06	4.21	.51	2.77	1.44	24.72
1895	1.36	.52	.70	2.42	2.20	2.24	3.61	1.81	5.27	.21	3.07	5.71	29.12
1896	1.12	1.95	1.22	1.89	5.62	2.98	7.87	3.74	5.84	.42	2.87	.39	35.91
Aver.	1.75	2.18	2.24	3.57	4.22	3.32	3.21	1.94	3.02	1.03	3.53	1.70	31.75

depth and frequency; also the effect of root pruning. Table 4 gives his results, while Table 5 gives the rainfall by months during the time the experiments were in progress, with the exception of the year 1888, for which the record was not complete.

Where the weeds were kept down by scraping with a hoe without producing a mulch, the yield, as a seven-year average, was 97.6 percent of that for ordinary, shallow cultivation, or a difference of 1.7 bushels per acre in favor of cultivation. Deep cultivation, four or five times, gave 96.9 percent, or 2.2 bushels less than shallow cultivation. Shallow cultivation twelve to fourteen times during the season gave 103.6 percent, or an increase of 2.5 bushels per acre, while deep cultivation the same number of times gave 91.7 percent, or a decrease of 5.8 bushels per acre. Compared with twelve to fourteen shallow cultivations, deep cultivation twelve to fourteen times gave 8.3 bushels decrease per acre.

Another experiment carried on at the same time was the pruning of the roots of corn at a distance of about six inches from the hill. This was accomplished by placing a frame twelve inches square over the hill and running a knife around the outside to a depth of four inches, thus cutting the roots to that depth. Where shallow cultivation was practiced, this pruning resulted in a decrease of 12.5 bushels per acre, but where the weeds were removed by scraping with a hoe instead of by shallow cultivation, the yield was diminished 16.9 bushels per acre.

LATER EXPERIMENTS AT URBANA, ILLINOIS

The results obtained by Professor Morrow seemed so remarkable that in 1906 and 1907 a series of experiments was begun to demonstrate them, and at the same time to obtain data on some other features; namely, the damage by weeds, the value of a seed bed, the effect of cultivation on moisture and temperature, and the value of irrigation and the addition of plant food in abundance. The results of these experiments are given in Table 6. Table 7 gives the rainfall during the time covered by the experiments.

The soil on which these experiments have been conducted is a brown silt loam, the ordinary corn-belt soil. The field had been under cultivation for fifty years or more, but during this time no fertilizer had been applied, with the possible exception of farmyard manure.

A four-year rotation of corn, corn, oats, and clover has been practiced. The corn stalks and both crops of clover have been removed. In 1912 and 1914 soybeans were grown because of the failure of clover. The cultivating was done with the three-shovel cultivator till 1912; and since then the surface cultivator has been used.

While the total rainfall of 1911 and 1913 appears to be approximately normal, yet in both these years there were dry periods during

TABLE 6.—RESULTS OF TILLAGE OF CORN AT URBANA ON BROWN SILT LOAM

(Bushels per acre as an average of two plots)

Treatment	1906	1907	1908	1909	1910	1911	1912	1913	1914	6-yr. av.	8-yr. av.	Av. %[1] of No. 4
1. Not plowed or cultivated, weeds kept down by scraping with hoe		38.3	25.0	28.6	33.1	25.5	46.1	16.5	38.5	33.0	31.4	80.1
2. Plowed, seed bed prepared, no cultivation, weeds kept down by scraping with hoe		44.0	33.0	50.7	40.5	39.8	75.5	34.0	50.0	47.3	45.9	117.1
3S. Plowed, seed bed prepared, weeds allowed to grow		0.0	16.0	10.2	.4	.9	7.9	10.4	12.3	5.3	7.3	18.6
3N. Plowed, seed bed prepared, weeds allowed to grow, irrigated		....	....	....	....	2.6	11.5	12.3	20.4	....	....	28.8
4. Plowed, seed bed prepared, cultivated shallow 3 times	44.7	49.6	25.0	31.4	45.7	34.5	65.2	21.9	40.5	42.9	39.2	100.0
5. Plowed, seed bed prepared, cultivated shallow 3 times, irrigated	46.2	49.8	28.2	40.0	50.3	55.0	61.2	41.2	56.2	52.3	47.7	119.6
6. Plowed, seed bed prepared, cultivated shallow 3 times, irrigated, fertilized	69.7	102.2	....	....	78.3	77.3	93.0	50.6	56.1	76.2	....	174.5

[1]Based on all comparable yields.

TABLE 7.—RAINFALL AT UNIVERSITY OF ILLINOIS, 1906-1914

(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1906	1.65	1.11	4.61	2.23	3.39	3.08	2.16	4.57	2.45	1.36	4.59	3.13	34.25
1907	6.12	.24	3.34	2.34	5.00	5.56	5.41	4.42	.94	1.51	1.99	3.32	40.19
1908	1.11	3.79	3.20	5.00	7.83	1.99	2.31	2.05	1.95	.21	1.99	1.44	32.87
1909	2.17	5.80	1.76	7.44	5.56	3.75	7.57	2.37	2.36	2.25	3.45	2.55	47.03
1910	2.23	1.79	.38	1.57	5.35	2.99	2.76	2.62	4.14	1.34	1.20	1.59	28.06
1911	2.27	1.19	1.82	3.59	2.44	.82	.62	3.35	8.90	3.10	2.83	1.35	33.28
1912	1.36	2.28	3.42	5.60	4.16	1.89	3.68	2.06	1.76	2.95	1.77	.57	31.50
1913	5.38	1.10	5.99	2.19	.56	1.67	1.52	1.44	2.50	4.03	4.49	.77	31.64
1914	1.97	2.50	.89	2.87	1.94	2.40	1.44	2.66	2.11	2.85	.80	2.25	24.68
Aver.	2.67	2.20	2.82	3.65	4.02	2.68	3.05	2.84	3.01	2.18	2.47	1.89	33.72

TABLE 8.—AMOUNT OF RAINFALL AND WATER APPLIED, APRIL 1 TO AUGUST 31, 1906-1914

(Inches)

	1906	1907	1908	1909	1910	1911	1912	1913	1914
Rainfall April 1 to August 31..........	15.52	22.73	19.18	26.69	15.29	10.82	17.39	7.38	11.31
Acre-inches of water applied...........	3.11	None	5.75	3.83	3.67	16.91	5.28	12.85	9.60

the time when corn should have been making its greatest growth and needed a large supply of moisture. It will be noted that in 1911 during June .82 inch of rain fell, and during July .62 inch, while in 1913 in May .56 inch fell, in June 1.67, in July 1.52, and in August 1.44 inches. The year 1913 was the driest during the growing time for corn since the rainfall record has been kept at the University.

Table 8 gives the amount of water applied to the irrigated plots for each year of the experiment, and also the rainfall from April 1 to August 31.

It will be seen that the largest amount of water, 16.91 inches, was applied during 1911, and the next largest, 12.85 inches, in 1913. The water was applied in amounts equal to about an inch of rainfall, by the furrow method of irrigation. After it was absorbed and the soil had become sufficiently dry, the furrows were partly filled with loose soil to prevent any excessive loss by evaporation. The yields for 1913 were diminished by the extreme heat during the time when pollination was taking place. A storm on July 16, 1914, damaged the corn on all plots to some extent, but especially where the growth was rank, as on the fertilized and irrigated plots.

FIG. 1.—PLOT 1: GROUND NOT PLOWED, NO SEED BED PREPARED, WEEDS KEPT DOWN BY SCRAPING WITH A HOE. YIELD, 25.5 BUSHELS (1911)

TREATMENT OF PLOTS

Plot 1 was plowed but once during a rotation, and that for oats. The vegetation, such as clover or old corn stubs, was removed and the corn planted with a hoe. The weeds were kept down by scraping with a sharp hoe so as to produce practically no mulch, and this was done only as often as necessary to kill the young weeds.

Plot 2 was plowed in the spring about 6 inches deep for corn; a good seed bed was prepared before planting the corn, but no cultivation was given. The weeds were kept down in the same way as on Plot 1.

Plot 3S (Plot 3 until 1910) was plowed in the spring and a good seed bed prepared, but after planting time the weeds were allowed to grow.

Plot 3N was plowed and a seed bed prepared; weeds were allowed to grow as in 3S, but the plot was irrigated as often as necessary to keep the soil in a moist condition.

Plot 4 was treated like Plot 2, except that the corn was cultivated shallow three times with the three-shovel cultiva-

FIG. 2.—PLOT 2: GROUND PLOWED, SEED BED PREPARED, WEEDS KEPT DOWN BY SCRAPING WITH A HOE. YIELD, 39.8 BUSHELS (1911)

tor previous to 1912, and with the surface cultivator since then. Any weeds that escaped the cultivator were pulled or cut out with a hoe.

Plot 5 was treated the same as Plot 4, except that the crop was irrigated whenever it was deemed necessary.

Plot 6 was treated similarly to Plot 5, except that 2 tons of rock phosphate and 80 tons of manure per acre were applied once in each rotation before the second crop of corn.

In Table 6, the yield of the cultivated plot, No. 4, is taken as the standard for computing the relative yields shown in the last column. On Plot 1, without plowing or the preparation of a seed bed in any way, the average yield for eight years was 31.4 bushels per acre, or 80.1 percent of that of the standard cultivated plot, No. 4. In comparison with this, on Plot 2, where a good seed bed had been prepared and the weeds kept down, the percentage of yield was 117.1, while the average actual yield for the eight years was 45.9 bushels, or an increase of 14.5 bushels per acre over Plot 1. This represents the value of the seed bed. The lowest yield of Plot 2 was 33 bushels in 1908 and the highest, 75.5 bushels in 1912. It would seem scarcely possible that such a yield as this could be produced without cultiva-

FIG. 3.—PLOT 3: GROUND PLOWED, SEED BED PREPARED, WEEDS ALLOWED TO GROW. YIELD, .8 BUSHEL (1911)

tion; yet this yield was the highest obtained from any plot except the fertilized one, and was 10.3 bushels larger than that produced by cultivation. It will be noticed that Plot 2, uncultivated, gave larger yields three out of the eight years than Plot 5, the cultivated and irrigated plot, and that the average was 6.7 bushels larger than for the standard cultivated plot, No. 4.

On Plot 3, it was the intention to see what would be the effect of weeds on the corn crop. It will be noticed that the average yield here is only 18.6 percent of that of the cultivated plot, but the actual yields varied from 0 to 16 bushels. The results of Plot 3S certainly make it very evident that corn cannot thrive with weeds.

In order to determine whether it was a lack of moisture that produced the low yields where weeds and corn were grown together, Plot 3 was divided in 1911, and the north half was irrigated often enough to keep the soil abundantly supplied with moisture. The effect was quite noticeable both on the corn and the weeds, but as an average of four years the yield was increased only 3.8 bushels per acre. It must therefore appear that the injury done by weeds is not largely due to the moisture that they take out of the soil, but to some other cause or causes.

FIG. 4.—PLOT 4: GROUND PLOWED, SEED BED PREPARED, CULTIVATED THREE TIMES. YIELD, 34.5 BUSHELS (1911)

It would be well to compare very carefully Plot 4 with Plots 2 and 5. Plot 2, uncultivated, produced 6.7 bushels more corn per acre than Plot 4 with standard cultivation; but the fact should be emphasized that to obtain such a result requires that the weeds be kept down. Plot 5, cultivated and supplied with all the moisture that was necessary, produced, as an average of eight years, only 1.8 bushels more than the uncultivated, unirrigated plot where weeds were kept down. Irrigation gave an increase every year but one. This exception was in 1912, when only a small amount of water was used. There is no doubt that one irrigation, which was followed within a few hours by a heavy rain, did no good and even may have damaged the crop to some extent.

The fertilized plot, No. 6, gave a large increase, the average yield being 74.5 percent above that from standard cultivation. For two years, 1908 and 1909, this plot was not fertilized; hence the yields for these years have been omitted in the table. In 1914, because of the heavy growth, the crop was badly damaged by a storm. The average yield for the seven years was 75.3 bushels per acre, or 174.5 percent of the yield from the standard cultivated plot for the same years.

FIG. 5.—PLOT 5: GROUND PLOWED AND SEED BED PREPARED, CULTIVATED THREE TIMES, IRRIGATED (16.91 INCHES APPLIED). YIELD, 55 BUSHELS (1911)

The fact that the uncultivated corn produced so well in comparison with the cultivated and with the cultivated and irrigated, shows that cultivation for conservation of moisture is a very secondary consideration in this climate on brown silt loam, the common prairie soil of the corn belt. On Plot 2 the crop was enabled to use all the plowed soil as a feeding ground, while on Plots 4, 5, and 6 almost half the plowed soil was disturbed by cultivation, so that the roots of the corn were either injured or could not develop in that stratum because of its dry, loose character. This was especially true on Plot 4 during dry seasons. As a result, the plant food in the stirred soil was of little benefit to the crop; and the conclusion that must be drawn is that the cultivated soil is of much greater value for the plant food that it contains than for the conservation of moisture. In semiarid or subhumid regions this probably would not be true.

A study of the moisture content of the plots at Urbana was made from samples taken to a depth of 40 inches from four different plots. The samples were taken in the spring immediately after the plowing was done and once each week until the corn was mature. Table 9 gives the results in percentage of total moisture.

FIG. 6.—PLOT 6: GROUND PLOWED, SEED BED PREPARED, CULTIVATED THREE TIMES, IRRIGATED (16.91 INCHES APPLIED), HEAVILY FERTILIZED. YIELD, 77.3 BUSHELS (1911)

TABLE 9.—AVERAGE MOISTURE CONTENT OF SOIL UNDER DIFFERENT METHODS OF CULTIVATION, 1907-1914

(Percentage of total moisture)

Cultivation	Depth, *inches*	1907	1908	1909	1910	1911	1912	1913	1914	Av.
1. Not plowed or cultivated, weeds kept down by scraping with hoe	0–6⅔	20.1	24.2	23.2	24.1	20.3	22.1	17.5	17.6	21.1
	6⅔–20	21.5	25.9	24.5	25.7	24.1	25.8	22.1	21.4	23.8
	20–30	21.0	26.0	25.1	27.0	23.2	26.3	22.8	21.9	24.2
	30–40	20.4	24.8	24.3	26.5	22.7	25.9	21.7	19.6	23.3
2. Plowed, seed bed prepared, no cultivation, weeds kept down by scraping with hoe	0–6⅔	21.7	24.5	25.5	24.2	21.1	24.1	17.6	18.1	22.1
	6⅔–20	21.4	25.5	25.3	24.8	22.5	24.2	19.7	19.6	21.9
	20–30	19.6	25.6	24.9	25.2	21.8	24.3	21.1	20.3	22.8
	30–40	19.4	24.7	25.1	23.9	21.4	23.9	19.9	20.6	22.3
3S. Plowed, seed prepared, weeds allowed to grow	0–6⅔	22.8	24.1	23.8	23.5	17.9	25.9	16.8	18.1	21.6
	6⅔–20	24.3	23.8	23.0	23.5	18.6	23.7	19.2	18.9	21.9
	20–30	22.4	24.4	25.0	23.3	19.3	23.9	19.6	19.9	22.1
	30–40	21.4	23.7	24.0	23.5	20.3	23.1	19.8	19.0	21.9
4. Plowed, seed bed prepared, cultivated shallow 3 times	0–6⅔	23.1	19.5	23.6	26.5	20.6	24.0	18.4	17.5	21.8
	6⅔–20	23.1	20.5	23.9	24.7	20.5	25.0	20.3	20.5	22.3
	20–30	20.3	21.7	24.8	23.6	20.3	24.4	22.5	22.0	22.4
	30–40	19.3	22.1	24.6	23.5	21.1	23.7	22.8	20.2	21.0

From the averages given in the table, it will be seen that the surface stratum of the unplowed plot, No. 1, had the lowest moisture content, but the difference among the plots was slight, the average being only 1.0 percent higher in the plowed, uncultivated plot, No. 2, .5 percent higher in the weed plot, No. 3S, and .7 percent higher in No. 4, cultivated. The weed plot, both in 1911 and in 1913, showed a lower moisture content than the other plots—less even than the unplowed one.

Probably a better idea of the moisture content of the soil can be obtained from Table 10, which gives the lowest moisture content found in the surface soil during the season.

The moisture content as given includes both hygroscopic and capillary moisture. The wilting coefficient of this type of soil, i.e., the point at which the plant wilts permanently, or where the plant has used all of the available water, is about 9.3 percent. The amount of available water in the soil at any time is the difference between the actual amount present and the wilting coefficient. From the above it will be seen that but little available moisture was in the soil at certain times in 1911, 1913, and 1914.

The temperatures at a depth of 2 and 4 inches have been determined once each week during the last five years on Plot 1, unplowed, and on Plot 4, plowed and cultivated. The temperatures were taken three times a day, at 9 a. m. and at 1:45 and 4:45 p. m., from plowing time till the corn was mature. Table 11 gives the averages of these determinations.

The general effect of tillage, as an average for the season, was to lower the temperature from .3 to 12.4 degrees. A single exception was the average temperature taken at 9 a.m. for the two-inch depth in 1909, which was the same for both the plowed and the unplowed soil. The average differences in temperature between the plowed and the unplowed plots for the two-inch depth were 1.7 degrees at 9 a.m., 4.7 at 1:45 p.m., and 3.9 at 4:45 p.m. The average differences for the four-inch depth were 1.3 degrees at 9 a.m., 2.2 at 1:45 p.m., and 1.8 at 4:45 p.m.

Early in the spring the effect of plowing is to raise the temperature of the soil by decreasing the amount of evaporation, which is a cooling process, and by concentrating the heat near the surface. Evaporation takes place very rapidly from unplowed soil because of its compactness and its rather high moisture content. Later in the season, however, after the unplowed soil loses some of its moisture, the tendency is for it to become warmer than the plowed and cultivated soil, and the result is that during June, July, August, and September the relative temperature of the unplowed, uncultivated soil is higher from one to twelve degrees.

TABLE 10.—LOWEST MOISTURE CONTENT OF SURFACE SOIL DURING THE SEASON, WITH DATE OF OCCURRENCE, 1907-1914

Plot	1907		1908		1909		1910		1911		1912		1913		1914	
	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day	Per-cent	Month and day
1	17.1	7–22	14.8	8–11	13.7	8–24	18.1	8–2	15.8	8–22	16.7	7–23	11.5	7–29	11.1	7–29
2	17.8	7–22	15.6	8–11	14.0	8–24	14.9	8–17	10.0	8–22	15.1	8–28	10.0	8–5	11.5	7–15
3S	17.9	7–3	14.2	8–11	13.1	8–24	16.1	8–31	7.7	8–22	19.5	7–16	11.7	8–12	10.2	7–15
4	20.7	8–28	15.6	8–25	13.8	8–17	16.8	8–9	12.3	7–25	14.8	8–28	12.8	8–12	10.7	7–29

TABLE 11.—MEAN TEMPERATURE OF SOIL AT A DEPTH OF 2 AND 4 INCHES: UNPLOWED VS. PLOWED AND CULTIVATED SOIL
(Degrees Fahrenheit)

Tillage	Time of observation	1909	1910	1911	1912	1913	1914	Av.	Excess over plowed soil
Depth 2 Inches									
1. Not plowed, weeds kept down by scraping with a hoe....	9:00 a. m.	70.2	72.0	75.7	72.6	81.3	74.1	74.3	1.7
	1:45 p. m.	81.3	82.6	89.1	85.0	98.2	91.3	88.0	4.7
	4:45 p. m.	81.5	83.5	85.2	82.3	95.9	89.0	86.1	3.9
4. Plowed, cultivated shallow 3 times....................	9:00 a. m.	70.2	70.9	73.8	70.3	78.9	71.7	72.6	
	1:45 p. m.	79.2	81.2	83.9	81.3	85.8	88.2	83.3	
	4:45 p. m.	79.6	81.1	76.0	77.9	92.7	86.1	82.2	
Depth 4 Inches									
1. Not plowed, weeds kept down by scraping with a hoe....	9:00 a. m.	67.4	69.7	73.7	70.2	77.0	71.9	71.7	1.3
	1:45 p. m.	76.1	77.3	83.6	79.5	92.6	84.7	82.3	2.2
	4:45 p. m.	77.5	79.5	84.5	79.2	91.8	84.9	82.9	1.8
4. Plowed, cultivated shallow 3 times....................	9:00 a. m.	67.1	68.3	72.4	68.8	75.9	70.1	70.4	
	1:45 p. m.	74.7	76.2	80.9	76.7	89.8	82.2	80.1	
	4:45 p. m.	76.8	77.5	81.2	76.5	91.5	83.2	81.1	

TABLE 12.—RESULTS OF TILLAGE OF CORN ON GRAY SILT LOAM ON TIGHT CLAY AT FAIRFIELD, WAYNE COUNTY

(Yields in bushels per acre)

Treatment	1908	1911	1912	1913	1914	3-yr. av.	5-yr. av.	Av. %[1] of No. 4
1. Not plowed, not cultivated, weeds kept down by scraping with hoe....	4.0	3.2	22.8	0.0	0	10.0	6.0	31.4
2. Plowed, seed bed prepared, weeds kept down by scraping with hoe....	16.7	22.1	55.6	0.0	0	31.5	18.9	98.9
3. Plowed, seed bed prepared, weeds allowed to grow..................	8.1	8.7	14.6	0.0	0	10.5	6.3	33.0
4. Plowed, seed bed prepared, cultivated shallow 3 times............	23.8	24.0	45.8	2.1	0	31.2	19.1	100.0
5. Plowed, seed bed prepared, cultivated shallow 3 times, manure, rock phosphate, limestone....................................	41.5	32.6	62.1	14.6	0	45.4	30.2	158.1

[1]Computed from 5-year average.

TABLE 13.—RAINFALL AT FAIRFIELD, WAYNE COUNTY, 1908-1914

(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1908	2.56[1]	6.55[1]	4.99[1]	5.30	8.02	1.21	2.59	2.61	.35	.00	3.21	1.02	38.41
1909	3.02	6.83	3.91	6.18	3.17	3.95	5.35	1.05	4.10	1.86	3.60	2.34	45.36
1910	2.40	3.87	.08	3.20	3.77	1.14	5.20	1.54	6.35	7.45	.96	1.91	37.87
1911	1.40	2.19	2.00	6.21	1.20	3.89	.84	2.53	6.80	2.01	2.64	2.91	34.62
1912	1.85	3.09	4.45	5.42	3.20	8.05	7.41	4.87	3.53	.54	2.87	1.58	46.86
1913	10.18	1.05	12.43	3.70	2.30	1.48	1.41	3.46	4.65	4.08	4.40	1.84	50.98
1914	2.30	3.82	3.36	3.36	.12	1.14	1.46	7.15	3.58	3.86	.89	3.27	34.31

[1]For Albion, 16 miles distant.

EXPERIMENTS IN SOUTHERN ILLINOIS

A series of experiments was conducted at the Fairfield field in Wayne county, on the gray silt loam on tight clay, the common prairie soil of southern Illinois, to determine the relative value of cultivation on that type of soil. The results are given in Table 12, while Table 13 shows the monthly rainfall during the time of the experiments.

Comparing Plots 1 and 2, we find that a good seed bed, as prepared on Plot 2, increased the yield by 215 percent on this type of soil, while on the brown silt loam treated similarly at the University, it gave an increase of 46.2 percent. Expressed in actual yield, the increase at Fairfield was 12.9 bushels, and at Urbana 14.5. The yields as given in the table show a benefit of only .2 bushel from cultivation after the seed bed was prepared. Taking the average of the first three years, it will be seen that the uncultivated plot gave an actual increase of .3 bushel over the cultivated. The fertilized gave an increase of 58.1 percent over the standard cultivated.

EXPERIMENTS IN MANY STATES

Bulletin 257 of the United States Bureau of Plant Industry gives data recently obtained on many different soils in twenty-eight states. It seems unfortunate that the types of soil were not described more fully in the bulletin, as some important distinctions in regard to soils might be deduced. In six years' experiments with corn, from 1905 to 1911, representing 112 tests, the average yield from uncultivated plots of various types of soil expressed in percentage of similar cultivated plots was 99.8 percent. This figure indicates that cultivation has but little value in growing a crop of corn, provided the weeds are kept down in some other way. It shows that the principal value of cultivation lies in the killing of weeds and not in the aeration of the soil or the conservation of moisture. We find that in subhumid or semiarid sections the average yield from the uncultivated land was

TABLE 14.—CORN YIELDS OF UNCULTIVATED PLOTS EXPRESSED IN PERCENTAGE OF THE YIELDS OF CULTIVATED PLOTS FOR DIFFERENT GROUPS OF SOIL TYPES[1]

(Average of six years' experiments, 1905-1911)[2]

Groups of soil types	Average percent
Clays	92.6
Clay loams	94.5
Silt loams	102.4
Sandy loams	105.7
Average of groups	98.8

[1]Data taken from U. S. Bur. Plant Indus. Bul. 257.
[2]This includes only the data from soils which could be classified.

85.9 percent of that from the cultivated. This shows a greater necessity for cultivation in such regions than in humid ones. The results obtained from some of the different types of soil experimented with are reported in Table 14.

It will be noticed that the value of cultivation diminishes as the coarseness of the soil increases. This is what would be expected, considered theoretically. The fine-grained soils, such as clays and clay loams, are naturally somewhat poorly aerated, and for these cultivation would be of value for aeration. In the coarser soils, the silt loams and sandy loams, aeration is naturally better and hence cultivation is not so beneficial.

SUBSOILING

Investigations to determine the value of subsoiling in preparation for corn on gray silt loam on tight clay, the common prairie soil of the lower Illinois glaciation, have been carried on for eight years at the Odin field, in southern Illinois. Table 15 gives the results of these experiments. The form of plow used, shown by Fig. 7, consists of a shoe that runs in the bottom of the furrow made by the ordinary mold-board plow, loosening the soil but not throwing it upon the surface.

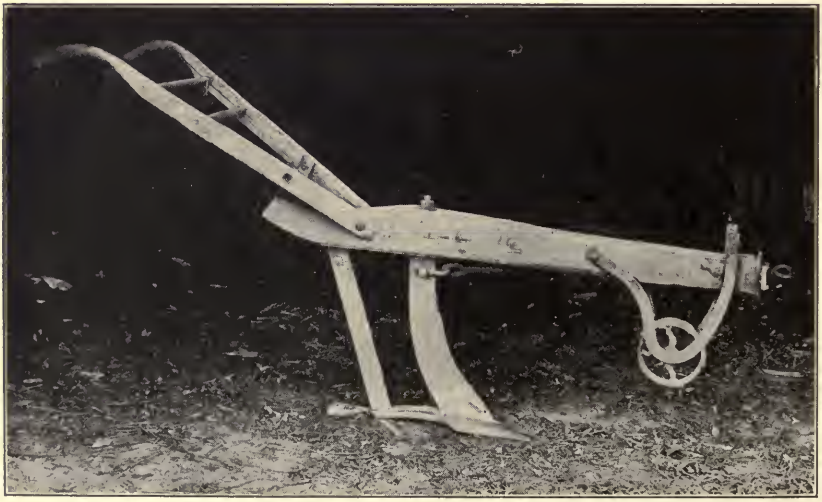

FIG. 7.—SUBSOIL PLOW. FOLLOWS ORDINARY PLOW AND LOOSENS THE SOIL IN THE BOTTOM OF THE FURROW

It will be seen that with every soil treatment there was an almost uniform decrease in yield for subsoiling. The general average for eight years shows a decrease of 2.7 bushels per acre. The alleged benefit of subsoiling is the increasing of the water capacity of soils and of their ability to retain water during dry seasons. Yet in 1913 and 1914, both of which were very dry seasons, this method, as a general average, gave only the very slight increases of .5 and .7 bushel respectively. The subsoil was loosened by the plow, but ran together as soon as it was wet and became approximately as it was before. The experiments as a whole show that subsoiling on this type of soil not only does not pay, but is a losing operation, for in order to pay for the extra work involved in subsoiling, at least a three-bushel increase would be necessary.

NOTE.—Until recently the amounts of limestone and crop residues on the Odin field were too small to provide for the adequate liberation of potassium; but where larger supplies of limestone and organic matter are provided the addition of potassium salts produces but little effect, as will be seen from the results of the Fairfield experiments reported in Bulletin 123, and in the Appendix of county soil reports.

TABLE 15.—CORN YIELDS IN TILLAGE EXPERIMENTS ON GRAY SILT LOAM ON TIGHT CLAY, ODIN FIELD[1]

(Bushels per acre as an average of two plots)

Soil treatment	1907	1908	1909	1910	1911	1912	1913	1914	8-yr. av.
Not Subsoiled									
None	44.4	35.5	29.3	28.8	16.8	26.1	2.5	4.3	23.5
Residues	50.1	33.2	30.4	32.8	19.0	39.6[2]	3.9	3.3	26.5
Residues, lime	47.3	35.5	29.2	40.3	24.7	48.6	4.1	2.1	28.9
Residues, lime, phosphorus	47.0	39.9	38.9	38.7	22.8	49.4	6.1	2.0	30.6
Residues, lime, phosphorus, potas.	70.1	76.1	64.0	79.8	35.7	65.4[2]	10.1	3.1	50.5
Average	51.8	44.0	38.3	44.1	23.8	45.8	5.3	2.9	32.0
Subsoiled									
None	37.6	32.5	24.1	22.5	13.3	31.7	3.2	4.0	21.1
Residues	43.2	26.4	27.2	35.1	19.9	24.0[2]	3.6	4.3	22.9
Residues, lime	47.3	34.9	28.5	37.5	22.7	47.5	4.1	2.4	28.1
Residues, lime, phosphorus	44.4	45.9	37.6	39.8	19.9	28.1	7.9	2.5	28.3
Residues, lime, phosphorus, potas.	59.4	60.3	60.4	85.6	40.4	48.5[2]	10.1	5.0	46.2
Average	46.3	40.0	35.5	44.1	23.2	35.9	5.8	3.6	29.3

[1]The east half of each plot of each series was subsoiled as follows: Series 400 in 1907, Series 300 in 1908, Series 200 in 1909, Series 100 in 1910, and so on in regular succession.

[2]Yields from single plots, as the corn in two plots in 1912 was badly damaged by water.

DEEP TILLING

Farmers are frequently urged to purchase a machine for plowing to a depth of 12 to 15 inches. There is little doubt that under certain conditions of soil and climate such plowing would be beneficial; but the results obtained by the Experiment Station in this state with the deep-tilling machine on the common prairie soil of the corn belt do not warrant recommending its purchase. Experiments have been started also on gray silt loam on tight clay, in southern Illinois, to determine the comparative value of ordinary plowing, subsoiling, deep tilling (plowing 12 to 15 inches deep), and dynamiting the subsoil. Only one year's results have been secured, and no conclusions are as yet justified.