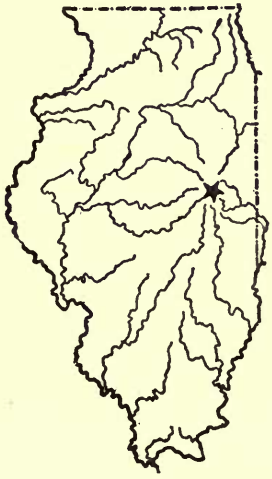
UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

BULLETIN No. 259

THE CULTIVATION OF CORN

Weed Control vs. Moisture Conservation

By D. C. Wimer and M. B. Harland



URBANA, ILLINOIS, MARCH, 1925

SUMMARY

The principal object and greatest value of corn cultivation on Brown Silt Loam is the destruction of weeds. Weedy corn probably suffers more from a lack of nutrients than from a moisture deficiency in this climate. Since cultivation is the only practical method of controlling weeds, the depth and frequency of corn cultivation should be determined by their growth. The growth of weeds should be prevented in so far as possible by shallow rather than by deep cultivation.

Deep cultivation of corn may result in root injury and decreased yields in comparison with shallow cultivation. The effect of excessive and deep cultivation seems comparable to that of actual root pruning. Proper cultivation should kill the weeds with minimum injury to the corn roots; obviously, this is more easily accomplished when the weeds are small.

The need for cultivation seems to be no greater in dry than in wet years; it may, in fact, be less. However, on heavy soils which check badly, cultivation may be necessary in order to fill the large cracks and thus stop the direct loss of moisture from the deeper strata.

The data and brief discussions presented in this bulletin are intended to be of assistance in developing the principles underlying the successful cultivation of corn and are not intended as recommendations of specific methods or particular implements.

(This Bulletin is a revision of No. 181, Soil Moisture and Tillage for Corn, issued in 1915. See note, page 196.)

THE CULTIVATION OF CORN

Weed Control vs. Moisture Conservation

By D. C. Wimer, Assistant Chief in Soil Physics, and M. B. Harland, First Assistant in Soil Physics

The cultivation of corn is clearly for the purpose of making a more satisfactory crop yield possible. The specific reasons why cultivation helps to achieve this result are not so obvious. Several explanations have been offered; one, a common assumption, has been that the mulch formed by cultivating the soil results in the conservation of moisture. There seems to be no evidence to justify this conclusion; instead, it is now generally recognized that the drier the season, the less need for cultivation. Even in arid and semiarid regions where the evaporation rate is high, cultivation apparently results in little or no conservation of moisture. The killing of weeds, however, appears to have been proved the most important object of cultivation; except on very heavy soils which check badly, it seems that cultivation ordinarily is necessary only for the control of weed growth.

A dry crust is probably just as effective in checking the movement of water vapor from the deeper layers of moist soil to the open air as is a dry, granular mulch. If the conditions are such that this dry top layer forms promptly, then it is clear that cultivation is not needed as an aid to its formation. If it does not form promptly, then cultivation will assist in its formation by increasing temporarily the rate of evaporation. Fig. 1 perhaps gives a clearer idea of the way in which a dry top layer of soil affects evaporation than can be given by discussion.

Under field conditions, the upward movement of capillary water is very slow as soon as the saturated condition of the soil in early spring is past. A dry top layer then forms readily because the amount of water evaporated from the surface exceeds the amount brought up by capillary rise, and loss by evaporation is thus decreased.

From the above it would seem that conservation of moisture is not a reason for cultivating corn except possibly in case of soils which crack badly. This conclusion is strengthened by the fact that early in the growth period the corn roots become so completely distributed between the rows that they intercept any moisture which may be brought up by capillary action. Thus there is little chance of the moisture reaching the surface and evaporating.

SHALLOW CULTIVATION PREFERABLE

Cultivation should always be as shallow as possible, altho deeper stirring is less harmful at the first cultivation than later. For the highest yields, cultivation should never be deep enough to injure the roots, for such injury is likely to retard the development of the corn plant.

It must be remembered too, that the plowed stratum is the richest in available plant nutrients, and that it is far more valuable as a feeding ground for the corn roots than it is as a dry layer of soil functioning as a mulch.

That good yields of corn cannot be produced in fields where weeds are allowed to grow unmolested is clearly shown by results of experi-

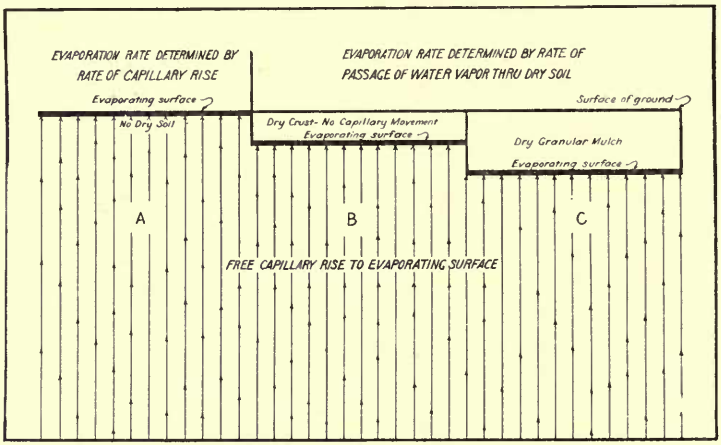


FIG. 1.—SHOWING HOW THE CONDITION OF THE TOP SOIL AFFECTS THE EVAPORATION OF SOIL MOISTURE

So long as the soil is moist entirely to the surface (A), evaporation is free to go on; but just as soon as a dry layer forms (B and C), the evaporating surface is lowered to the bottom of the dry soil and any further loss must take place by movement of the water in the form of vapor thru the dry soil. Since the movement of water in this way is exceedingly slow, the loss of soil moisture is greatly lessened.

ments at this Station and by the experience of farmers. For instance, with the same preparation of seed bed, only 7.4 bushels of corn per acre were produced as a nine-year average where weeds were allowed to grow, while 48.9 bushels were obtained where the weeds were kept down without any cultivation. Keeping the weeds down was apparently responsible for an increase of 41.5 bushels yearly. This is easy to understand when we realize that weeds deprive the corn plant of moisture, light, and nutrients, all of which are necessary for the growth of the plant and seed. Of these factors, however, the lack of plant nutrients probably makes the greatest difference.

On another plot weeds were allowed to grow, but the plot was irrigated so that the corn was not deprived of moisture, yet the increase from irrigation as a five-year average was only 2.5 bushels an acre.

Weeds are much better foragers than are most cultivated crops; as has well been said, "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."

EARLY EXPERIMENTS AT URBANA

Morrow and Hunt began some experiments in 1888 to determine the value of cultivation and its best depth and frequency; also the effect of root pruning. These experiments were continued up to and including 1893 by Gardner, who concluded that "there seems to be no advantage in cultivating more frequently than is necessary to destroy weeds and keep the ground moderately porous; that shallow cultivation has never failed to produce an increase in yield over that of deep cultivation"; and that "root pruning has never failed to reduce the yield in a marked degree." Table 1, reprinted from Bulletin 181 of this Station, gives a partial summary of the results obtained in these early cultivation experiments, and Table 2 shows the rainfall by months during the time the experiments were in progress, with the exception of the year 1888, for which the record is not complete.

Where the weeds were kept down by scraping with a hoe without producing a mulch, the yield as a six-year average was 96.9 percent of that for ordinary, shallow cultivation—a difference of 2.1 bushels an acre in favor of cultivation. Deep cultivation practiced four or five times also gave a 96.9-percent yield, or 2.1 bushels less than shallow cultivation. As a five-year average, shallow cultivation practiced twelve to fourteen times during the season gave a 103.6-percent yield, or an increase of 2.5 bushels an acre over ordinary shallow cultivation, while deep cultivation the same number of times gave a 91.7-percent yield, or a decrease of 5.8 bushels an acre. Compared with twelve to fourteen shallow cultivations, deep cultivation practiced twelve to fourteen times resulted in a decrease of 8.3 bushels an acre.

These decreased yields from deep cultivation seem comparable to the results secured from actual root pruning in another portion of the same experiment. A frame twelve inches square was placed over the hill and a knife run 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 13.2 bushels an acre as an average of six years, but where the weeds were removed by scraping with a hoe instead of by shallow cultivation, the yield was diminished 16.9 bushels an acre as an average of four years.

TABLE 1.—RESULTS OF CULTIVATION OF CORN AND ROOT PRUNING AT URBANA, 1888–1893
(Bushels per acre)

Plot No.	Kind of cultivation	1888	1889	1890	1891	1892	1893	3-yr. av.	4-yr. av.	5-yr. av.	6-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	78.7	72.9	68.3	66.2	96.9
2	Shallow, 4 or 5 times	93.8	84.6	66.8	58.4	70.1	36.3	81.7	75.9	70.3	68.3	100.0
3	Deep, 4 or 5 times	84.9	74.2	60.8	63.4	80.1	33.6	73.3	70.8	66.7	66.2	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	74.8	109.5
7	Roots pruned, shallow, ordinary	91.0	78.3	55.0	48.7	70.7	26.2	74.7	68.2	64.2	61.6	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

The above table is reprinted, except for six-year average and corresponding percentages, from Bulletin 181 of this Station. These results have been reported in detail and progressively in Bulletins 4, 8, 13, 20, 25, 31, and 37.

[1]Based on all comparable yields.

TABLE 2.—RAINFALL AT UNIVERSITY OF ILLINOIS, 1889 TO 1893
(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1889	1.48	2.08	1.61	.61	5.52	8.00	5.81	.60	2.74	1.42	4.28	1.82	35.97
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	2.43	.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	32.27
Aver.	1.91	2.73	2.73	4.48	4.53	4.16	2.63	1.58	1.78	1.43	3.88	1.22	33.06

The record for 1888 is incomplete; hence not reported.

LATER EXPERIMENTS AT URBANA

The results obtained by Morrow and Hunt were contrary to popular belief and seemed so remarkable that in 1906 and 1907 a series of experiments was begun to test them and at the same time to obtain information on some other features such as the damage resulting from allowing weeds to grow and the value of seed-bed preparation, irrigation, and fertilizer treatment.

The results of these experiments, as given in Table 3, represent the averages of first and second-year corn; the individual yields are reported in Table 4 for the convenience of those who may care to make a more thoro study of the data. Table 5 gives the rainfall during the time covered by the experiments.

The soil on which these experiments were conducted is Brown Silt Loam, an upland prairie soil formed from loess overlying the drift of the early Wisconsin glaciation. This soil is fairly representative of the gently undulating areas of the corn belt in Illinois. The field had been under cultivation for fifty years or more, but during that time no fertilizer had been applied, with the possible exception of barnyard manure.

A four-year rotation of corn, corn, oats, and clover was practiced. The cornstalks and both crops of clover were 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 after that the surface cultivator was used.

While the total rainfall of 1911 and 1913 appears to be approximately normal, yet in both these years there were dry periods during 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 only .82 inch of rain fell, and during July .62 inch; while in 1913 in May only .56 inch fell; in June, 1.67 inches; 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 6 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 by the furrow method of irrigation, individual applications being approximately equal to one inch of rainfall. After it was absorbed and the soil had become sufficiently dry, the furrows were partly filled with loose soil to prevent an 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 particularly where the growth was rank, as on the fertilized and irrigated plots.

TABLE 3.—RESULTS OF TILLAGE EXPERIMENTS WITH CORN AT URBANA ON BROWN SILT LOAM,[1] 1907–1915
(Bushels per acre as an average of two plots)

Plot No.	Treatment	1907	1908	1909	1910	1911	1912	1913	1914	1915	9-yr. av.	8-yr. av. ('09 out)	5-yr. av. (1911-15)	Av. % of Plot 4		
														9-yr. av.	8-yr. av.	5-yr. av.
1	Not plowed or cultivated, weeds kept down by scraping with hoe	38.2	25.0	28.6	33.1	25.5	46.2	16.4	38.5	64.9	35.2	36.0	38.3	81.3	80.4	80.5
2	Plowed, seed bed prepared, no cultivation, weeds kept down by scraping with hoe	44.0	33.0	50.7	40.6	39.8	75.5	33.9	49.9	72.9	48.9	48.7	54.4	112.9	108.7	114.3
3S	Plowed, seed bed prepared, weeds allowed to grow	0.0	16.0	10.7	.4	.9	7.4	10.3	12.3	8.6	7.4	7.0	7.9	17.1	15.6	16.6
3N	Plowed, seed bed prepared, weeds allowed to grow, irrigated	....	....	....	....	1.7	11.5	12.3	20.4	5.9	....	....	10.4	....	....	21.8
4	Plowed, seed bed prepared, shallow cultivation 3 times	49.6	25.0	31.4	45.7	34.5	65.2	21.9	40.2	76.0	43.3	44.8	47.6	100.0	100.0	100.0
5	Plowed, seed bed prepared, shallow cultivation 3 times, irrigated	49.8	28.2	40.0	50.2	55.0	61.2	41.2	56.2	70.3	50.2	51.5	56.8	115.9	115.0	119.3
6	Plowed, seed bed prepared, shallow cultivation 3 times, irrigated, fertilized	102.2	28.8	42.9[2]	78.3	77.3	93.0	50.5	56.1	71.9	....	69.8	69.8	....	155.8	146.6

The 1906 results, as given in Bulletin 181, are incomplete, and since the experiment for that year was conducted on a different plot of ground, it seems advisable to omit entirely the 1906 yields from this publication.

[1]This soil would probably be classified as Tama silt loam by the Bureau of Soils, U. S. Department of Agriculture.

[2]Yield of one plot only. Thru a mistake fertilizer was not applied to the 2d-year corn plot in 1909.

TABLE 4.—RESULTS OF TILLAGE OF FIRST- AND SECOND-YEAR CORN AT URBANA ON BROWN SILT LOAM, 1907–1915
(Bushels per acre)

Plot No.	Treatment	Year	1907	1908	1909	1910	1911	1912	1913	1914	1915	9-yr. av.	8-yr. av. ('09 out)	5-yr. av. (1911-15)	Aver. % of Plot 4		
															9-yr. av.	8-yr. av.	5-yr. av.
1	Not plowed or cultivated, weeds kept down by scraping with hoe	1st yr.	44.8	23.4	14.3	33.1	27.0	38.3	16.4	47.9	69.6	35.0	37.6	39.8	78.3	80.0	82.9
		2d yr.	31.7	26.6	42.9	33.1	24.1	54.1	16.5	29.2	60.3	35.4	34.5	36.8	84.5	81.2	78.1
2	Plowed, seed bed prepared, no cultivation, weeds kept down by scraping with hoe	1st yr.	52.8	37.3	62.9	36.6	49.0	69.1	38.5	54.5	73.1	52.6	51.4	56.8	117.7	109.4	118.3
		2d yr.	35.2	28.8	38.6	44.6	30.7	82.0	29.4	45.4	72.8	45.3	46.1	52.1	108.1	108.5	110.6
3S	Plowed, seed bed prepared, weeds allowed to grow	1st yr.	0.0	28.8	4.3	0.0	.5	5.6	15.8	18.9	5.5	8.8	9.4	9.3	19.7	20.0	19.4
		2d yr.	0.0	3.3	17.1	.8	1.3	9.3	4.9	5.7	11.7	6.0	4.6	6.6	14.3	10.8	14.0
3N	Plowed, seed bed prepared, weeds allowed to grow, irrigated	1st yr.	....	....	....	....	2.6	16.1	16.3	36.7	3.0	....	....	14.9	.....	.....	31.0
		2d yr.	....	....	....	....	.9	7.0	8.3	4.1	8.9	....	....	5.8	.....	.....	12.3
4	Plowed, seed bed prepared, shallow cultivation 3 times	1st yr.	56.0	28.8	25.7	51.4	38.6	63.7	23.1	41.0	73.6	44.7	47.0	48.0	100.0	100.0	100.0
		2d yr.	43.2	21.3	37.1	40.0	30.5	66.7	20.7	39.4	78.4	41.9	42.5	47.1	100.0	100.0	100.0
5	Plowed, seed bed prepared, shallow cultivation 3 times, irrigated	1st yr.	65.6	32.0	44.3	57.1	61.8	57.6	45.6	61.2	74.6	55.5	56.9	60.2	124.2	121.1	125.4
		2d yr.	34.0	24.5	35.7	43.4	48.2	64.9	36.8	51.3	66.1	45.0	46.2	53.5	107.4	108.7	113.6
6	Plowed, seed bed prepared, shallow cultivation 3 times, irrigated, fertilized	1st yr.	117.7	19.2	42.9	76.6	76.4	95.4	57.7	59.8	78.9	69.4	72.7	73.6	155.3	154.7	153.3
		2d yr.	86.7	38.4	(1)	80.0	78.2	90.7	43.4	52.4	65.0	....	66.9	65.9	.....	157.4	139.9

[1]Thru a mistake, fertilizer was not applied to Plot 6 in 1909.

TABLE 5.—RAINFALL AT UNIVERSITY OF ILLINOIS, 1907–1915
(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1907	6.12	.24	3.34	2.34	4.96	5.56	5.01	4.42	.94	1.51	1.99	3.32	39.75
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	27.96
1911	2.27	1.19	1.85	3.59	2.44	.82	.62	3.35	8.90	3.10	2.83	1.35	32.31
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	2.65	2.11	2.85	.80	2.25	24.67
1915	1.81	2.33	1.12	1.59	5.11	2.98	7.30	4.90	2.58	.64	1.02	2.85	34.23
Average	2.71	2.34	2.44	3.58	4.21	2.67	3.58	2.87	3.03	2.10	2.17	1.85	33.55

TABLE 6.—AMOUNT OF RAINFALL AND WATER APPLIED, APRIL 1 TO AUGUST 31, 1907–1915
(Inches)

	1907	1908	1909	1910	1911	1912	1913	1914	1915
Rainfall April 1 to August 31	22.29	19.18	26.69	15.29	10.82	17.39	7.38	11.30	21.88
Acre-inches of water applied	None	5.76	3.83	3.67	16.91[1]	5.28	12.85[2]	9.52	1.07

[1]Amount added to Plot 3N in 1911, 14.80 inches.
[2]Amount added to Plot 3N in 1913, 12.68 inches.

CULTIVATION NEEDS NO GREATER IN DRY YEARS

The statement has frequently been made that the drier the season, the greater the need of cultivation. However, this has never been proved by experimental results where the yield of the crop produced has been taken as the standard of measurement. There is, on the other hand,

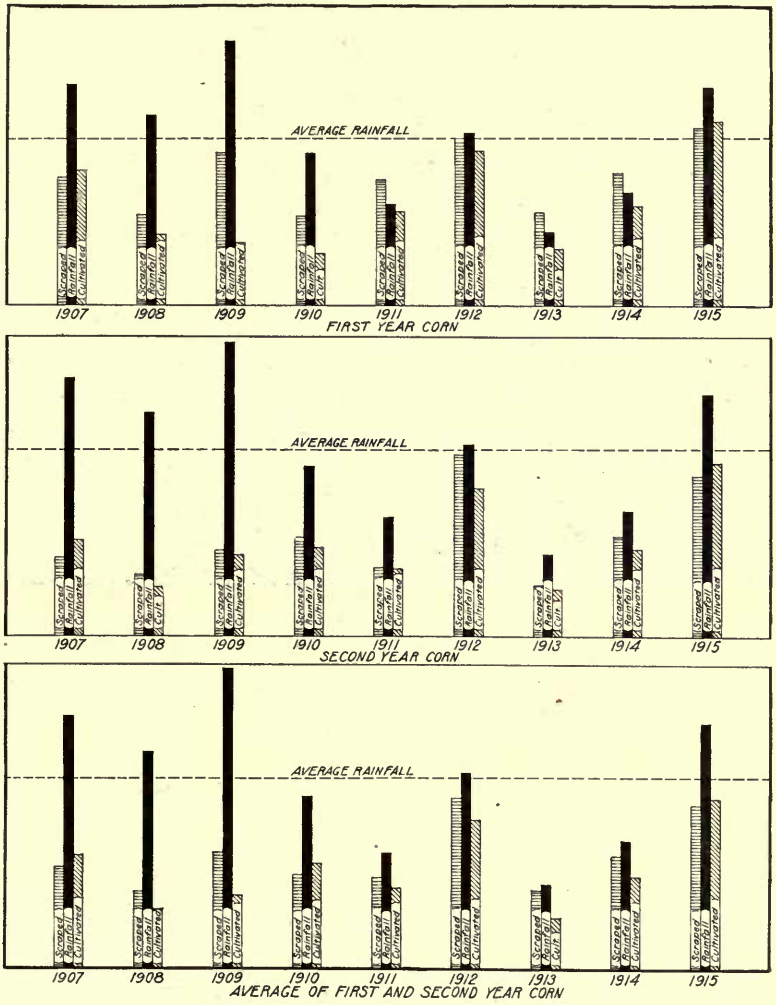


FIG. 2.—THE NECESSITY OF CULTIVATION AS INFLUENCED BY RAINFALL

This diagram constructed from the data given in Tables 3, 4, and 6, shows the comparative yields on the "scraped" and "cultivated" plots in relation to the total rainfall from April 1 to August 31. There seems to be little or no evidence of greater cultivation need in seasons of limited rainfall.

some evidence which tends to discredit, if not to disprove, this teaching.

It may be noted from the accompanying diagram (Fig. 2) that during the four years when the rainfall was below the nine-year average, cultivation gave an increased yield but once. This increase—14.8

FIG. 3.—DECREASED GROWTH RESULTED WHERE PLOWING AND PREPARATION OF SEED BED WERE OMITTED

On this plot (No. 1, photographed in 1911) the weeds were kept down by scraping with a hoe, but the ground had not been plowed nor a seed bed prepared. Compare with Fig. 4.

bushels an acre in the first-year corn in 1910—is insignificant when compared with the total decrease in the first- and second-year corn in 1910, 11 and 1913, 14, which amounted to 58.8 bushels. The net decrease as a result of cultivation on the two plots during the four years when the rainfall was deficient in the growing period, was 44 bushels an acre. An average decrease of 5.5 bushels of corn to an acre would hardly warrant any recommendations for more cultivation in dry seasons.

TREATMENT OF PLOTS

Plot 1 (Fig. 3) was plowed for the oats crop only; that is, but once in each rotation. The vegetation, such as clover or 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 (Fig. 4) was plowed in the spring about 6 inches deep for corn; a good seed bed was prepared before planting the corn, but no

FIG. 4.—BETTER GROWTH RESULTED FROM PLOWING AND PREPARATION OF SEED BED

On this plot (No. 2, photographed in 1911) the ground was plowed, a seed bed prepared, and the weeds kept down by scraping with a hoe.

cultivation was given after planting. The weeds were kept down in the same way as on Plot 1.

Plot 3S (Plot 3 until 1911) (Fig. 5) was plowed in the spring and a good seed bed prepared, but after planting the corn, 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 (Fig. 6) was treated the same as Plot 2 except that the corn was given three shallow cultivations with the three-shovel cultivator previous to 1912 and with the surface cultivator after that time. Any weeds that escaped the cultivator were pulled or cut out with a hoe.

Plot 5 (Fig. 7) was treated the same as Plot 4 except that the crop was irrigated whenever it seemed necessary.

Plot 6 (Fig. 8) 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.

DISCUSSION OF RESULTS

In Table 3, the yield of the cultivated plot, No. 4, is taken as the standard for computing the relative yields shown in the last three columns. On Plot 1, without plowing or the preparation of a seed bed in any way the average yield for nine years was 35.2 bushels an acre, or 81.3 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 yield was 112.9; while the average actual yield for the nine years was 48.9 bushels, or an increase of 13.7 bushels an acre over Plot 1. This increase presumably represents the value of seed-bed preparation. The lowest yield on Plot 2 was 33 bushels in 1908 and the highest, 75.5 bushels in 1912. At the time these results were secured it seemed scarcely possible that so high

FIG. 5.—UNMOLESTED WEED GROWTH BADLY STUNTED THE GROWTH OF CORN

This plot (No. 3S, photographed in 1911) was undisturbed after planting. In spite of previous plowing and seed-bed preparation, the resultant growth of corn was very poor and the yields appreciably lower than might be expected from the growth shown.

a yield could be produced without cultivation. It will be noticed that Plot 2, uncultivated, gave larger yields four out of the nine years than Plot 5, the cultivated and irrigated plot, and that the average for Plot 2 was 5.6 bushels larger than for the standard cultivated plot, No. 4.

The treatment on Plot 3 was for the purpose of determining the effect of weeds on the corn crop. It will be noticed that the average yield of Plot 3S was only 17.1 percent of that of the cultivated plot; however, the actual yields varied from 0 to 16 bushels. The results on this plot 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 five years the yield of corn was increased only 2.5 bushels an acre. It must therefore appear that the injury done by weeds is not due so much to the moisture they take out of the soil as to some other cause or causes.

FIG. 6.—WEED CONTROL BY MEANS OF MODERATE CULTIVATION INSURED A MORE SATISFACTORY GROWTH

This plot (No. 4, photographed in 1911) was plowed, a seed bed prepared, and the corn cultivated three times. Compare with Figs. 4 and 5.

It would be well to compare very carefully Plot 4 with Plots 2 and 5. Plot 2, uncultivated, produced 5.6 bushels more corn per acre than Plot 4 with standard cultivation; but the fact should be empha-

FIG. 7.—IRRIGATION GAVE A SOMEWHAT INCREASED GROWTH

Irrigation on this plot (No. 5, photographed in 1911) in addition to plowing, seed-bed preparation, and cultivation, gave better growth but not an economic increase in yield.

sized that to obtain such a result the weeds must be kept down. Plot 5, cultivated and supplied with all the moisture that was necessary, produced as an average of nine years only 1.3 bushels more than the uncultivated, unirrigated plot where weeds were kept down. Irrigation gave an increase every year but two. These exceptions were in 1912 and 1915, when only a small amount of water was used. There is no doubt that the one irrigation in 1912, 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 fertilizer treatment for Plot 6 was accidentally omitted for the 1909 crop of second-year corn; for this reason, the yield for that year, as given in Table 3, is for first-year corn only, and is not included in the averages. In 1914 a storm damaged the crop badly, especially on the fertilized plot, where the growth was particularly heavy. The increase

for fertilization as an average of eight years was 18.3 bushels an acre, as shown by comparing the yields on Plots 5 and 6 (Table 3). It should be noted that the fertilized plot received an excessive amount of manure

FIG. 8.—FERTILIZATION PRODUCED GREATER GROWTH OF CORN

This plot (No. 6, photographed in 1911) was plowed, prepared, cultivated, and irrigated in a way similar to Plot 7, but in addition received liberal applications of rock phosphate and manure. The fertilizer treatment, however, was so excessive that the increased yield does not represent an economic gain.

and rock phosphate, and that the increased yield on this plot is no indication of the value of rational fertilizer treatment on this soil.

The fact that the uncultivated corn produced so well in comparison with the cultivated, also with the cultivated and irrigated, shows that cultivation for conservation of moisture is decidedly a secondary consideration in this climate on Brown Silt Loam. On Plot 2 the crop could use all the plowed soil as a feeding ground, while on Plots 4, 5, and 6 probably half the plowed soil was so disturbed by cultivation that the roots of the corn were either injured or could not develop in the stirred portion because of its dry, loose character. This was especially true on Plot 4 during dry seasons. As a result, the nutrients in the stirred soil were of little benefit to the crop; *the logical conclusion is that the cultivated soil is of much greater value for the plant nutrients it contains than for the moisture it may conserve.*

TABLE 7.—TILLAGE EXPERIMENTS WITH CORN ON GRAY SILT LOAM ON TIGHT CLAY AT FAIRFIELD, WAYNE COUNTY, 1911–1914
(Bushels per acre)

Plot No.	Treatment	1911	1912	1913	1914	2-yr. av.	4-yr. av.	Av. %[1] of Plot 4
1	Not plowed, or cultivated, weeds kept down by scraping with hoe....	3.2	22.8	0.0	0	13.0	6.5	38.7
2	Plowed, seed bed prepared, no cultivation, weeds kept down by scraping with hoe.....	22.1	55.6	0.0	0	38.8	19.4	115.5
3	Plowed, seed bed prepared, weeds allowed to grow	8.7	14.6	0.0	0	11.6	5.8	34.5
4	Plowed, seed bed prepared, "ordinary" cultivation.....	25.9 14.5	50.4 41.3	2.1 0.0	0 0	33.0	16.8	100.0
5	Plowed, seed bed prepared, "ordinary" cultivation, fertilized[2]	32.6	62.1	14.6	0	47.3	27.6	164.3

[1]Computed from four-year average.
[2]Manure 80 tons, rock phosphate 2 tons, limestone 5 tons per acre for each rotation.

TABLE 8.—RAINFALL AT FAIRFIELD, WAYNE COUNTY, 1911–1914
(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
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
Average.....	3.93	2.54	5.56	4.67	1.70	3.64	2.78	4.50	4.64	2.62	2.70	2.40	41.69

EXPERIMENTS IN SOUTHERN ILLINOIS

A series of experiments was conducted at the Fairfield experiment field in Wayne county, on Gray Silt Loam On Tight Clay, the common prairie soil of southern Illinois, to ascertain the relative value of cultivation and thoro seed-bed preparation on that type of soil.

This experiment in general was similar to the one begun at Urbana in 1907 except that irrigation was not practiced. The plots, twelve in number and one-tenth of an acre in size, were arranged in two series, one of which was cropped to corn in 1908 when the experiment was started. According to the records, the 1908 corn yields are unreliable, due to damage by livestock, and are therefore omitted. No corn was grown on either series in the years 1909 and 1910. The original four-year rotation of corn, cowpeas, wheat, and clover was changed in 1912 to a two-year rotation of corn and soybeans. The tillage and fertilizer treatments of the individual plots are explained in Table 7. Table 8 shows the monthly rainfall during the years for which the corn yields are reported.

The value of seed-bed preparation is shown by comparing the corn yields on Plot 1, which received no preparation, with those on Plot 2, which was thoroly prepared prior to planting. This comparison shows that on Gray Silt Loam On Tight Clay, seed-bed preparation trebled the yield. On Brown Silt Loam at Urbana it resulted in an increase of almost 40 percent. Expressed in actual yield, the increase at Fairfield was 12.9 bushels an acre, and at Urbana, 13.7 bushels.

Where the seed bed had been prepared, cultivation resulted in an apparent decrease of 2.6 bushels an acre, as a four-year average (compare Plots 2 and 4). For the first two years the decrease was 5.8 bushels an acre a year.

The fertilized plot, No. 5, yielded 64.3 percent more than the standard cultivated plot, No. 4, an increase of 10.8 bushels an acre yearly. This, however, does not represent a profitable gain because of the cost of the excessive fertilizer treatment.

The Fairfield results, while failing to indicate the relative merits of scraping compared with ordinary cultivation, show rather clearly the necessity of seed-bed preparation on this type of soil. However, the limited amount of data furnished by the present experiment does not warrant the drawing of any definite conclusions.

RECENT EXPERIMENTS AT URBANA

The most recent experiments on corn cultivation at this Station were conducted from 1916 to 1921 inclusive, on the Roland farm, Urbana, which is now a part of the Stadium field. The purpose of this series of experiments was to study the effect upon corn yield of weeds growing unmolested; of surface scraping to eradicate weeds without the formation of a mulch; and of shallow cultivation with blade or

shovel cultivator. These studies were made on both fertilized and unfertilized plots, arranged in four series of six plots each. The size of the individual plots was $\frac{1}{36.36}$ of an acre.

The soil on which these experiments were conducted is the morainal Brown Silt Loam, the same type of soil used for the series of cultivation experiments in progress from 1907 to 1915. A four-year rotation of corn, corn, oats, and sweet clover was practiced, with soybeans as a substitute crop when the clover failed in 1916, 1917, and 1919. All cornstalks and residues were removed from those plots which received no treatments of manure, rock phosphate, or limestone. All corn plots were disked, plowed, prepared, and planted in the same manner.

TREATMENT OF PLOTS

On Plots 1 and 2 the weeds were allowed to grow. On Plots 3 and 4 the weeds were kept down by scraping with a sharp hoe without forming a mulch. On Plots 5 and 6 the corn was given three or four shallow cultivations, a blade cultivator being used on the north half and a 3-shovel cultivator on the south half of the plots. The average depth of the cultivations was about 1 to 1½ inches for "blades" and 2 to 3 inches for "shovels."

With reference to the fertility treatments, Plots 1, 3, and 5 served as checks in that they received no residues, manure, phosphate, or limestone. Plots 2, 4, and 6 received manure in proportion to the crops produced, also 1 ton of rock phosphate and 2 tons of limestone per acre once in a rotation. Manure, equal in weight to all corn (grain), oats (grain and straw), and clover (hay and seed) removed from each plot, was returned to that plot in the spring preceding second-year corn. Applications of phosphate and limestone were made in the fall or early winter previous to the 1916 and 1920 crops.

DISCUSSION OF RESULTS

A careful study of the data in Tables 9, 10, and 11, reporting yields and rainfall, fails to show any definite relation, similar to that illustrated in Fig. 2, between the total rainfall during the growing period and the cultivation needs of corn in seasons of deficient rainfall.

In Table 9 the yield of the shovel-cultivated plot is taken as 100 percent, or the standard for computing the relative yields of the other plots. It should be noted that since the actual yields of the standard plots (the cultivated plots Nos. 5S and 6S), are widely different, the percentage values for the yield of corn on the unfertilized plots are not directly comparable with those of the fertilized plots.

The corn yields, as shown by the six-year averages, were always higher on the fertilized than on the corresponding unfertilized plots. The fertility treatment gave an apparent increase of 4.6 bushels of

TABLE 9.—CULTIVATION EXPERIMENTS WITH CORN ON FERTILIZED AND UNFERTILIZED BROWN SILT LOAM AT URBANA, 1916–1921
(Bushels per acre as an average of two plots)

Plot No.	Treatment		1916	1917	1918	1919	1920	1921	6-yr. av.	Aver. % of shovel-cultivated plots	
										Unfert.	Fert.
1	Weeds allowed to grow.....	Unfertilized	.05	13.1	1.9	2.9	9.6	14.5	7.0	13.7	....
2	Weeds allowed to grow.....	Fertilized	.15	25.3	4.8	4.0	13.7	21.8	11.6	....	19.5
3	Scraped with hoe.....	Unfertilized	28.6	66.1	59.7	56.0	56.4	53.1	53.3	104.3	....
4	Scraped with hoe.....	Fertilized	29.8	65.3	62.4	61.6	61.3	53.5	55.6	....	93.4
5N	Cultivated—blades	Unfertilized	32.0	60.7	56.2	61.2	51.4	56.4	53.0	103.7	....
5S	Cultivated—shovels	Unfertilized	32.6	59.6	55.1	55.5	50.2	53.4	51.1	100.0	....
6N	Cultivated—blades	Fertilized	33.4	64.1	64.7	61.4	60.0	64.9	58.1	....	97.6
6S	Cultivated—shovels	Fertilized	36.5	67.5	62.1	57.0	67.9	65.8	59.5	....	100.0

TABLE 10.—RESULTS OF CULTIVATION OF FIRST- AND SECOND-YEAR CORN ON FERTILIZED AND UNFERTILIZED BROWN SILT LOAM AT URBANA, 1916–1921

(Bushels per acre)

Plot No.	Treatment			1916	1917	1918	1919	1920	1921	Averages	
1	Weeds allowed to grow.....	Unfertilized	1st-yr. corn	.1	13.2	3.1	4.1	9.1	10.7	6.7	7.0
			2d-yr. corn	.0	12.9	.6	1.6	10.1	18.2	7.2	
2	Weeds allowed to grow.....	Fertilized...	1st-yr. corn	.3	26.4	8.6	4.3	17.4	23.2	13.4	11.6
			2d-yr. corn	.0	24.2	.9	3.6	10.0	20.4	9.7	
3	Scraped with hoe.....	Unfertilized	1st-yr. corn	35.7	65.3	61.8	60.9	56.4	60.3	56.7	53.3
			2d-yr. corn	21.4	66.9	57.6	51.1	56.4	45.8	49.9	
4	Scraped with hoe.....	Fertilized...	1st-yr. corn	31.4	65.7	65.0	69.6	59.6	53.8	57.5	55.6
			2d-yr. corn	28.2	64.9	59.8	53.5	62.9	53.2	53.7	
5N	Cultivated—blades	Unfertilized	1st-yr. corn	36.4	64.3	65.8	68.6	51.9	65.7	58.8	53.0
			2d-yr. corn	27.6	57.0	46.6	53.7	50.8	47.1	47.1	
5S	Cultivated—shovels	Unfertilized	1st-yr. corn	42.9	66.2	56.4	63.3	49.2	65.7	57.3	51.1
			2d-yr. corn	22.3	52.9	53.7	47.6	51.2	41.0	44.8	
6N	Cultivated—blades	Fertilized...	1st-yr. corn	40.6	68.1	66.1	67.2	70.4	73.4	64.3	58.1
			2d-yr. corn	26.1	60.1	63.3	55.6	49.6	56.4	51.8	
6S	Cultivated—shovels	Fertilized...	1st-yr. corn	45.3	68.1	61.5	61.4	71.4	72.1	63.3	59.5
			2d-yr. corn	27.7	66.8	62.6	52.6	64.4	59.5	55.6	

TABLE 11.—RAINFALL AT UNIVERSITY OF ILLINOIS, 1916–1921
(Inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1916	6.02	.63	1.14	1.28	5.70	3.88	.73	1.46	2.69	2.26	1.93	1.99	29.71
1917	1.07	.45	4.43	3.62	4.55	6.45	2.73	3.80	2.01	2.34	.18	.60	32.23
1918	1.74	1.86	1.57	6.84	4.64	5.69	2.25	5.15	4.97	2.82	1.73	3.99	43.25
1919	.21	1.92	4.12	.75	3.29	6.90	2.66	3.85	2.47	5.59	3.37	.12	35.25
1920	.83	.45	3.40	5.71	3.78	.94	3.19	3.08	1.79	2.02	1.29	2.81	29.29
1921	1.60	.49	5.82	5.25	5.26	1.68	2.54	4.36	5.54	2.23	4.91	1.98	41.66
Average	1.91	.97	3.41	3.91	4.54	4.26	2.35	3.62	3.24	2.88	2.23	1.91	35.23

corn per acre on the weed plot, No. 2; 2.3 bushels on the scraped plot, No. 4; 5.1 bushels on the "blade" cultivated plot, No. 6N; and 8.4 bushels on the "shovel" cultivated plot, No. 6S. These increases are probably too small to show an economic gain for the fertilization used.

The removal of weeds by scraping with a hoe instead of by cultivation increased the yield 46.3 bushels an acre on the unfertilized plot, No. 3, and 44 bushels on the fertilized plot, No. 4. The average yields of the unfertilized plots that were scraped and cultivated (Plots 3 and 5) show no significant differences, thus indicating that the greatest value of cultivation with either blades or shovels was to eradicate weeds.

When fertilized, the cultivated plots produced an average of 2.5 to 3.9 bushels an acre more than the scraped plots. While no great importance can be attached to these small differences, they might suggest the possibility that the corn plant, when grown on a heavily fertilized soil, is less dependent upon the natural fertility of the surface soil or perhaps has greater power of recovery from root injury caused by cultivation.

NOTE

This bulletin includes material published in Bulletin 181 of this Station (1915) entitled "Soil Moisture and Tillage for Corn," by J. G. Mosier and A. F. Gustafson. Its purpose is to bring the discussion on corn cultivation up to date and to include the final results, the work on this problem now having been discontinued.

The experimental work on corn cultivation at the Illinois Station, as herein reported, falls into three periods: first, early experiments at Urbana begun in 1888 by Morrow and Hunt and terminated in 1893; second, later experiments begun at Urbana in 1906 and at Fairfield in 1908 by Mosier and terminated in 1915; third, experiments begun in 1915 on the Roland farm, Urbana, by Mosier and Gustafson, and terminated in 1922 because of the location of the Memorial Stadium on this field.

The data secured during the first period of experimentation are reprinted from Bulletin 181; the data obtained in the second period have been corrected, completed, and rearranged in part; while the data secured since Bulletin 181 was published, or for the third period, are presented for the first time. It should be explained that the soil temperature and moisture data found in Bulletin 181 are omitted because subsequent work has shown them to be of questionable value; the number of determinations of temperature and moisture in the individual plots was insufficient to give reliable averages.

This material represents the contributions of a number of present and former members of the Agronomy Department. Special recognition should be given the late Professor J. G. Mosier and Professor A. F. Gustafson, mentioned above, Mr. F. A. Fisher, now Farm Adviser of Wabash county, and Dr. R. S. Smith, Associate Chief in Soil Physics.