Effects of BASIC TILLAGE METHODS AND SOIL COMPACTION ON CORN PRODUCTION

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This moldboard plow, when used with the clodbuster, produced a satisfactory seedbed for corn in one operation.

CONTENTS

Page

PART I — EFFECTS OF NEW TILLAGE TREATMENTS 3

REVIEW OF LITERATURE ON TILLAGE 4

PLAN AND CONDITIONS OF TILLAGE STUDY 4

PERFORMANCE OF MACHINES 11

Seedbed Preparation 11

Cultivation 16

Physical Conditions in Seedbeds and Rootbeds 17

Crop Growth Response 18

Harvestability 20

Yield Response 22

PART II — EFFECTS OF COMPACTION AND EXTRA DISKINGS 27

REVIEW OF LITERATURE ON COMPACTION 27

PLAN AND CONDITIONS OF COMPACTION STUDY 28

PHYSICAL CONDITIONS IN SEEDBEDS AND ROOTBEDS 29

SUMMARY 33

LITERATURE CITED 34

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Effects of Basic Tillage Methods and Soil Compaction on Corn Production

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SOIL TILLAGE requires a major amount of the cost of labor, power, and machinery for producing a corn crop. The cost of these items per acre of corn in Illinois for the six years 1948-1954 averaged $14.25, or a fourth of the total cost of $57, according to estimates of the Department of Agricultural Economics.[18]* If the costs of tilling the 9.2 million acres planted to corn in Illinois can be reduced, farmers will be able to make enormous savings in the production of a crop that in both 1954 and 1955 was estimated to be worth $670 million.[11]

Studies of new methods of tillage are needed to develop specifications for new machines and to improve methods of using existing machines so that profits for present farmers can be increased without the profits of those of the future becoming endangered.

Evaluation of the tolerance of soils and plants to compaction from tillage and from the heavy tractors used on farms is important in the design and operation of farm machines. For this reason, a study was made of the effects of applying high pressures on the soil before plowing and of the effects of extra diskings afterwards.

The results of these two studies are reported here as Parts I and II.

Part I—Effects of New Tillage Treatments

These new systems of tillage were designed to: (1) reduce the number of hours required to put in and cultivate the crop; (2) find out what type of operation lessens weed hazards; (3) lower soil compaction from tractors and machinery; (4) hold more rainfall in the soil for crop growth; and (5) reduce erosion by retarding water runoff.

* Superior figures refer to literature cited.

REVIEW OF LITERATURE ON TILLAGE

Although many new systems of corn tillage have been studied,[1] most attention has been focused on minimum tillage methods in which conventional machines were used but fewer operations performed. These methods provide a seedbed much less compact than that provided by following former recommendations for a "firm" or "well settled" seedbed. A less compact seedbed has often produced yields equal to those produced on a firm seedbed, as studies at Michigan and Ohio have shown.[6, 7, 19]

Schaller and Evans,[17] reviewing the literature on mulch tillage, indicated that the mulch improved the soil structure near the surface, reduced water loss, and thus tended to keep the moisture content of the soil at a higher level. But it also lowered the temperature of the soil and often decreased the availability of nitrogen and potassium.[2, 3, 4] Studies have shown, however, that corn yields with this mulching system can often be maintained near those of conventional systems if enough fertilizers, especially nitrogen and potassium, are applied. The limitations of conventional machines to operate satisfactorily under this system have been demonstrated by earlier studies.[16] McAllister[13] reported that "mulch farming" is being accepted in the Southeast where the agronomic and economic advantages appeal to farmers, but that better planting machines are still needed. Machinery adaptations for a mulch and ridge system have been developed at Iowa by Buchele, Collins, and Lovely.[5]

Rotary tillage methods permit preparing a seedbed in a once-over-the-field operation with crop residues mixed through the soil. These methods, however, have normally produced the same or lower yields than methods using present machines that require fewer horsepower hours per acre, as studies at Michigan and Ohio have shown.[6, 7, 19]

A number of studies have shown that growing forages in the corn either with or without modified row-spacings gave soil conservation advantages, but yields could be maintained only when adequate fertility and water were available for both crops.[12, 14]

PLAN AND CONDITIONS OF TILLAGE STUDY

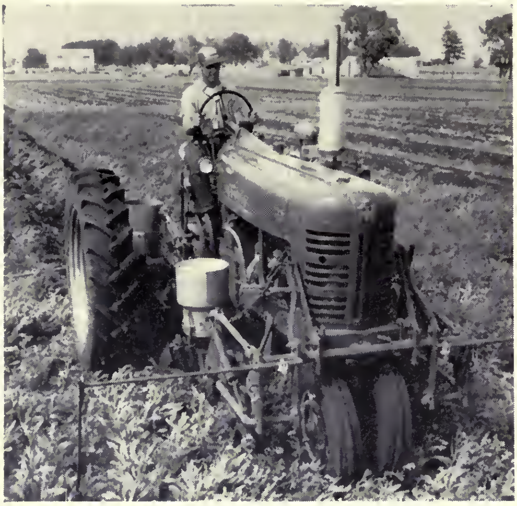
The tillage treatments studied during the 4-year period 1953-1956 were basically determined by the methods of handling crop residues. Three methods were used: (1) Turning residues under; (2) leaving them on the ground as a mulch; and (3) mixing them throughout the tilled layer. In addition, various amounts of tillage were applied to residue disposition. Treatments were studied for two methods of spacing the rows at two levels of nitrogen and for the effects of the weather conditions prevailing in the four years.

Description of machines

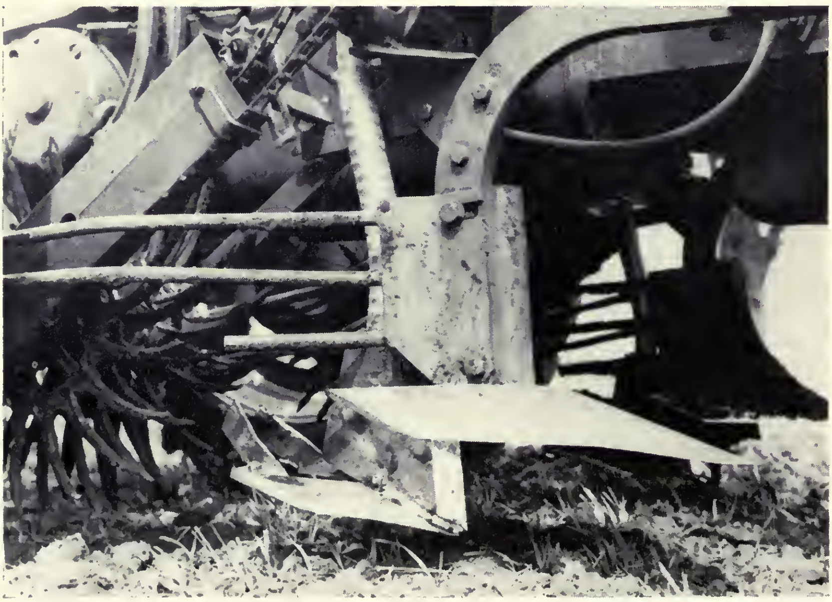
When the residues were turned under, a moldboard plow was used for the primary tillage with the clodbuster (made by Valley Tiller) pulled behind the plow (Fig. 1). Machines for secondary tillage included a tandem disk and spike tooth harrow.

Residues were left on the ground as a mulch between rows with a new type of planter called a till-planter. This machine prepared a

Appearance of seedbed prepared in a once-over-the-field operation, using a plow and clodbuster. Crop residues were turned under. (Fig. 1)



(Top) the till-planter used to prepare the seedbed, place fertilizer, and plant the corn in one operation. Crop residues were left on the surface as a mulch between rows. Planter unit is shown in Fig. 5. *(Bottom)* the sweeps and rotary hoe wheels used to prepare the seedbed.
(Fig. 2)



seedbed, band-placed the fertilizer, and drilled the corn in one operation (Fig. 2). Poynor[15] first described this machine in 1950. This till-planter was equipped with two large sweeps for each corn row to prepare a seedbed about 18 inches wide. The lower 18-inch sweep operated 7 to 8 inches deep, and the upper 30- or 36-inch sweep operated just under the surface to remove the residues and move them to the space between the rows where the residues acted as a water-absorbing mulch. Removing the mulch cleared a path for the planter shoe. Behind the sweeps a section of 4 rotary-hoe wheels broke up the soil. A 2-row planter was mounted on the rear of the tractor. Fertilizer from the front fertilizer hoppers was band-placed 2 or 3 inches under the seed. A second type of fertilizer was metered from the rear hoppers mounted on the planter and band-placed about 3 inches to the side and at seed level.

In the third general method of treatment, mixing the residues throughout the tilled layer, a sweep-rotary machine was used. This machine, like the till-planter, was a mulch type. The mulch was left between the 20-inch strips prepared for the rows. With this machine, the soil was cut loose at the 7- or 8-inch depth with a 14-inch sweep. Residues and soil were then mixed by power-driven blades (Fig. 3). A planter was pulled behind the tractor to complete planting and fertilizing in one operation.

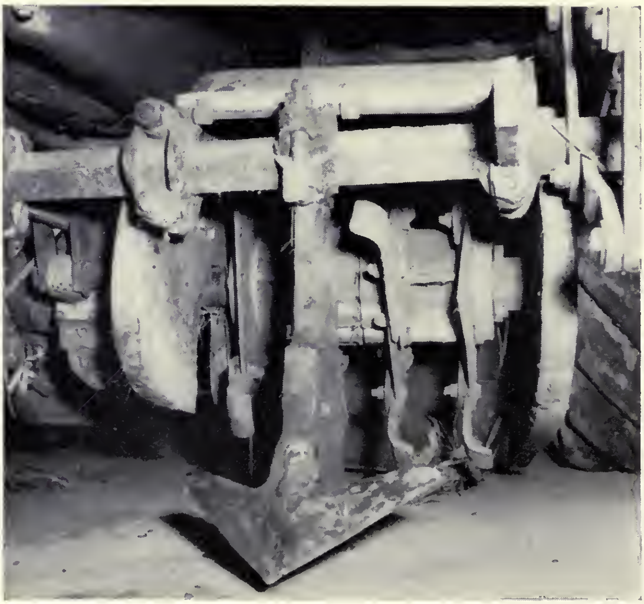
A second kind of rotary machine, a rotary tiller 7 feet wide, was used to mix the residues throughout the tilled layer. This machine used power-driven rotary blades to cut the soil loose and mix the residues with the pulverized soil. This tiller was operated with a separate engine of about 100 horsepower and pulled by a tractor (Fig. 4).

Row spacings

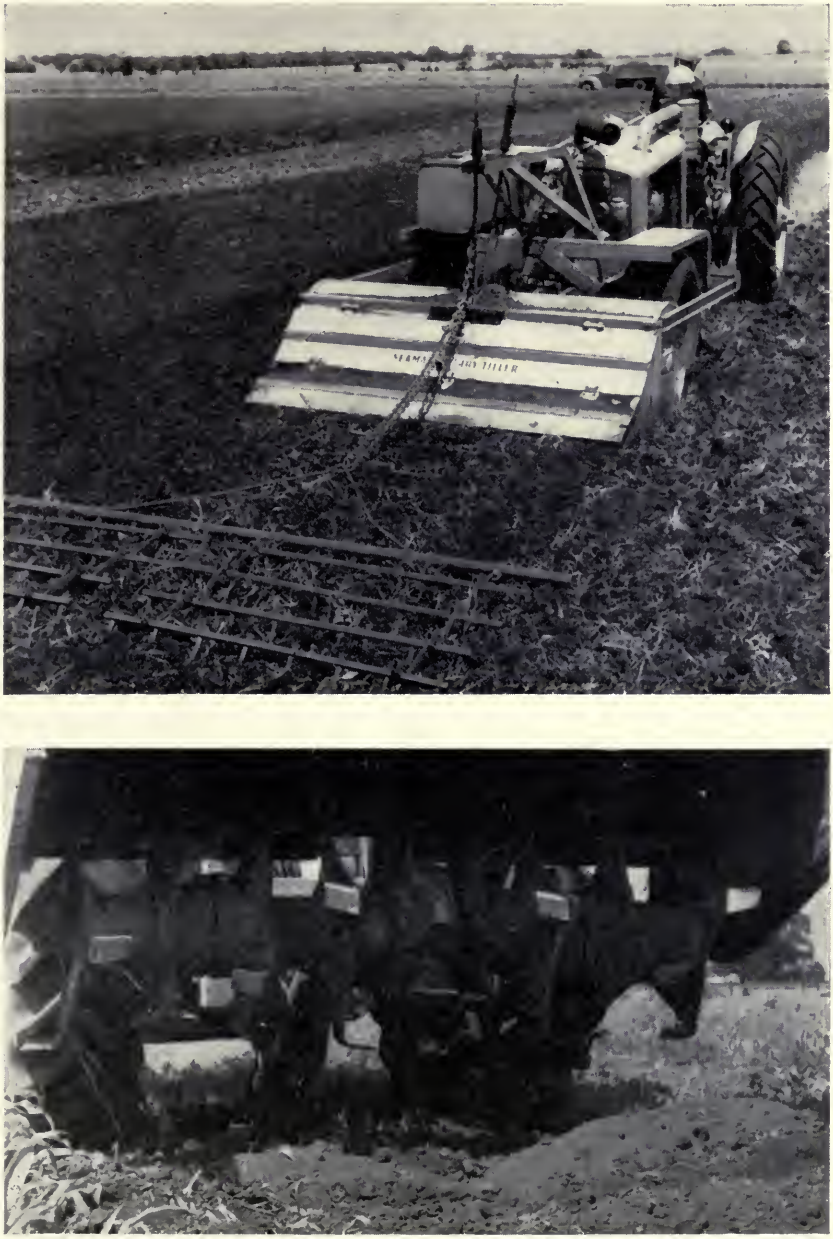
Tillage treatments were compared on plots planted in the normal 40-inch rows and on two methods of managing a 40-and-90-inch spacing. An alfalfa strip 50 inches wide was grown in the 90-inch space between pairs of corn rows. On one series of plots in these 40-and-90-inch-spacing studies, the corn rows were located in the same place each year, while on another series the rows were rotated to the alfalfa strip each year.

Soil description

The soil types were Brenton, Proctor, and Flanagan silt loams and Drummer silty clay loam. These medium- to fine-textured soils are dark and developed under moderately good to poor natural drainage.



(Top) this sweep-rotary machine performed the same operations as the till-planter in one trip over the field. The crop residues were mixed throughout the tilled layer in half the width of the row and left on the surface on the other half. *(Bottom)* the sweep that was used to shear and lift the soil, and the power-driven blades that broke up the soil and mixed the residues in it. (Fig. 3)



(Top) rotary tiller that mixed the residues throughout the tilled layer in one trip over the field. *(Bottom)* power-driven blades used to prepare the seedbed. (Fig. 4)

Soil tests indicated that the pH was 5.7 to 6.0, and that the soil contained 170 to 220 pounds of phosphorus (P_2O_5) and 230 to 280 pounds of potassium (K_2O) to the acre.

Fertilizer program

To avoid any possibility that yields might be limited by lack of fertility, enough fertilizers were applied to provide an adequate amount of fertility for maximum yields in a continuous corn system. The object of applying fertilizers was to make it more nearly possible to attribute differences in yield to variations in tillage treatments. Enough starter fertilizer was applied to provide 35 to 40 pounds of phosphorus and potassium to the acre. This fertilizer was applied in a band to the side of the seed. When the corn was planted, granular nitrogen was band-applied below seed level the full length of the plot at the rate of 75 pounds of elemental nitrogen to the acre. At the time the corn was first cultivated, enough more nitrogen to bring the level up to 150 pounds an acre was applied to half the length of each plot.

Plot location and design

The studies were conducted on the Agricultural Engineering Experiment Field and were located on the same plots in each of the four seasons. The plots were 300 feet long, making it possible to operate machines at normal speeds. On the plots where the rows were 40 inches apart, the plots were 6 rows wide and on the skip-row plots (40-and-90-inch rows) they were 4 rows wide. The plot design was a complete block with split plots. Treatments were repeated 4 times to give a total of 176 plots in the 10 acres used in the study. Since the 4 main plots for each treatment were split as to nitrogen levels, the final averages for yields and for other determinations were derived from 8 readings.

Weather conditions

Rainfall was below the average of 14.1 inches for May through August in each year of the study, but was especially low in 1953. For 1953, 1954, 1955, and 1956 rainfall totalled 8.7, 13.3, 13.0, and 13.1 inches respectively. In the 123-day growing season, maximum temperatures of 90° F. were recorded on 45, 46, 36, and 21 days respectively.

Operations, labor, and power used

Only the number of operations and the amount of tillage used in preparing the seedbed varied. To prepare a seedbed, plant, and cultivate the corn, 4 to 6 operations were used instead of the 8 to 10 that Illinois farmers commonly use. In all treatments, cornstalks were tandem disked. Other machines and operations used to prepare a seedbed and plant the corn and the disposition of the residues in the various methods are given in Table 1.

After it was planted, the corn was cultivated twice for each treatment. In the 40-and-90-inch rows, additional operations were used to clip the alfalfa strips.

For the six treatments studied, labor used to grow corn in 40-inch rows under farm conditions ranged from 18 to 25 hours per 10 acres (Table 1). (Labor used on farms in a typical series of operations averages 38 hours. For these time comparisons, the corn planter and cultivator were 2-rows wide since some of the experimental machines were of this width.) For the 40-and-90-inch skip-row-planting pattern, the labor required was only about two-thirds that required for the crop grown in 40-inch rows, or 12 to 16 hours, but the time required to clip the alfalfa brought the total number of hours to about that required on the 40-inch rows (Table 1).

PERFORMANCE OF MACHINES

Under the soil conditions of the study, a number of observations were made on the performance of the machines, their proper adjustment, and on their effects on soil and weed conditions.

Seedbed Preparation

Residues turned under, 40-inch rows

No serious difficulty was encountered in the operation of the planter when planting was done on freshly plowed, undisked soil. The soil was leveled and the air pockets removed by the clodbuster pulled behind the plow. In 1956, after this treatment had been used for 3 years, the plow pulverized the soil enough to make using the clodbuster unnecessary. The tractor wheels made deeper-than-normal tracks in this loose soil, so the rows were planted on small, flat ridges. When cultivating, it was harder to move soil into these ridged rows than it was to move it into rows planted in a level seedbed or in a shallow furrow. The use of furrow openers on the planter helped to reduce the ridging effect.

Residues left on surface as a mulch, 40-inch rows

The till-planter, equipped with its normal 18- and 30-inch sweeps, required relatively high amounts of power. Therefore, the machine was equipped with 10- and 20-inch sweeps and results of treatments made with sweeps of these widths were compared with those made with sweeps of 18- and 30-inch widths. The power required to oper-

Table 1. — Disposition of Residues, Machines Used, Operations Performed, and Labor and Power Required on 10 Acres; Various Tillage Treatments

(Rows 40 inches apart compared to rows 40 and 90 inches apart)

Disposition of residues	Machines used to prepare seedbed and plant	Number and name of operations used to produce crop[a]	Labor and power required for 10 acres			
			Labor		Power	
			40-inch rows	40-and-90-inch rows[a]	40-inch rows	40-and-90-inch rows
Conventional methods			hr.	hr.	hp.-hr.	hp.-hr.
1. Turned under, typical farm conditions	Plow, disk, harrow, and planter[b]	(1) Stalks tandem disked; (2) ground plowed and harrowed; (3 and 4) ground tandem disked; (5) ground tandem disked and harrowed; (6) corn planted; (7) corn rotary hoed; (8, 9, and 10) corn cultivated	38	..	370	...
2. Turned under (check used to compare with experimental methods)	Plow, clodbuster, disk, harrow, and planter	(1) Stalks tandem disked; (2) ground plowed and broken up with plow and Valley Tiller; (3) ground tandem disked and harrowed; (4) corn planted; (5 and 6) corn cultivated	25	26	250	200
Experimental methods						
1. Turned under	Plow, clodbuster (Fig. 1), and planter	(1) Stalks tandem disked; (2) seedbed prepared with plow and Valley Tiller; (3) corn planted; (4 and 5) corn cultivated	22	..	210	...
2. Left on surface	Till-planter (Fig. 2) with 18- and 30-inch sweeps, planter mounted on machine	(1) Stalks tandem disked; (2) seedbed prepared and planted; (3 and 4) corn cultivated	18	19	210	180
Left on surface	Till-planter with 10- and 20-inch sweeps, planter mounted on machine	(1) Stalks tandem disked; (2) seedbed prepared and planted; (3 and 4) corn cultivated	18	19	170	150
3. Mixed in tilled layer in half width of row, left on surface in other half	Sweep-rotary machine (Fig. 3), planter pulled by tractor	(1) Stalks tandem disked; (2) seedbed prepared and planted; (3 and 4) corn cultivated	18	19	230	200
4. Mixed in tilled layer	Rotary tiller (Fig. 4), and planter	(1) Stalks tandem disked; (2) seedbed prepared; (3) corn planted; (4 and 5) corn cultivated	24	23	490	360

[a] In the 40- and 90-inch row-spacings, the alfalfa was clipped twice in 1953 and 1954, 4 times in 1955, and 5 times in 1956.
[b] Size of machines used for comparisons: plow, three 14-inch bottoms; disk, 10 foot; rotary tiller, 7 foot; planters and cultivators, 2 row.

ate this machine with the narrow sweeps would be reduced 15 to 20 percent, according to estimates made from vacuum gage readings on the tractor engine. However, the 20-inch top sweeps did not move enough soil to cover weeds and forage, nor cut enough of them to delay their growth until first corn cultivation. Consequently, use of the narrow top sweeps often created a serious weed problem.

The sweeps on the till-planter moved the soil aside and the till-planter planted the corn, usually in a furrow. The depth of this furrow could be regulated most easily when planting was made in soils that were easy to break up and that were not held together by sod roots (Fig. 5). This furrow made it possible to move soil into the row to smother the weeds without making too high a ridge during cultivations. This machine often left a rough surface in the row so that there was less soil crusting. Weeds started to grow later in this soil than in a well-pulverized seedbed and fewer weed seeds germinated.

The operation of the rotary-hoe wheels on the till-planter was improved by removing every other tooth. The teeth were then able to penetrate the soil more deeply than before and break it up more completely. This deeper penetration gave more constant turning, which provided a more positive drive for the fertilizer hoppers.

The disks used on the till-planter to band-place the starter fertilizer put the band well away from the seed and deeper in the soil than the original split-boot applicators supplied with the machine. When they were operated in moist soil, the split boots tended to clog the seed tubes. A wheel 10 inches in diameter with a 0-pressure tire operated immediately behind the furrow opener to press the seed into the soil before it was covered (Fig. 6). This small press wheel operated satisfactorily except when excessively wet soil stopped the wheel and soil packed in the seed tubes. Some seeds also passed by the round tire. For this reason, a flat or concave cross-section might be an improvement.

Residues mixed, 40-inch rows

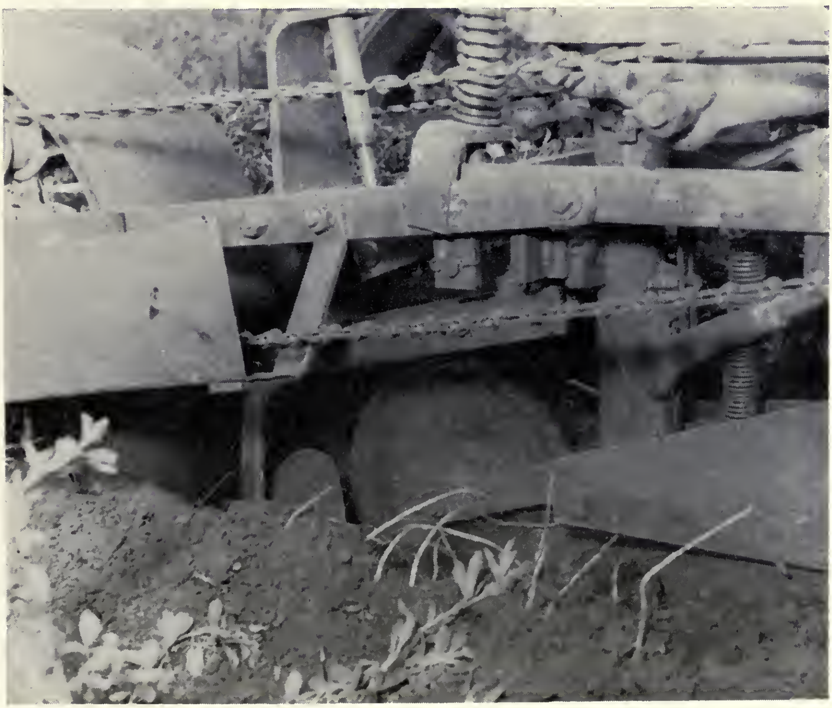
The sweep-rotary machine mixed residues and cover crops throughout the top 4 to 5 inches of soil in a strip 20 inches wide for each row. This dry residue often caused lower-than-average germination. The machine would be improved with sweeps that would remove some of the residues and cover crops before the soil is tilled. The sweep-rotary machine did a better job of pulverizing the soil than the till-planter and could be operated at the same ground speed with a tractor of the same size.

For the best use of both the till-planter and the sweep-rotary

(Top) appearance of seedbed and depth of furrows when corn was planted with till-planter in sod and *(bottom)* appearance of soil and corn at time of first cultivation. Note absence of weeds in the rows. *(Top, next page)* appearance of seedbed and depth of furrows when corn was planted in cornstalks with the same machine. (Fig. 5)

(Left, Fig. 5 continued)

A press wheel 10 inches in diameter with a 0-pressure rubber tire located behind the seed tube. This wheel was used to press the seed into the soil before the seed was covered. (Fig. 6)



machine, disking the cornstalks should be delayed until a short time before planting, because later disking retards the beginning growth of weeds in the nontilled area between the rows.

To prepare the seedbed with the rotary tiller in one operation over the field, a low rotor speed and a faster-than-normal travel speed were used to keep the seedbed from being too finely pulverized and to distribute a few small clods over the surface. But even with this coarse tilling, the travel speed of the rotary tiller was slower than that of any of the other machines.

Machinery operations in skip-row (alternate 40-and-90-inch) spacings

When the plow-and-disk method of tillage was used, open furrows were left along the alfalfa strips that were not reseeded each year in the nonrotated-row system. A narrower disk than the usual one was needed to prepare the seedbed in the strips that were 2 rows wide. The other machines were better adapted to this method of spacing the rows than the plow and disk because with them a seedbed 2 rows wide could be prepared without damaging the alfalfa strip.

The 90-inch rows had to be accurately spaced so that the tractor axles would not break off the corn when the alfalfa was clipped. To reduce the competition for moisture, the alfalfa was clipped 4 times in 1955 and 5 times in 1956. The 90-inch strip not only gave each row more sunlight, but made it possible to go through the field with a tractor of normal size to spray late in the season or make an early fall seeding. Corn lodging during the clipping season did not prevent travel through the field. One advantage of not rotating the rows is that the alfalfa need not be seeded each year.

Cultivation

Methods

The usual cultivator sweeps could be used in all treatments except the mulch treatments planted in sod. When clover sod was left on the surface, it was necessary to use disk hillers. For the first cultivation, the front hillers on each side of the row were angled to move the soil away from the row and to act as fenders. Behind the front hillers, a second set of hillers was placed farther from the row and angled to move soil into the row. The use of a sweep to remove weeds in the space between the two hillers on each side of the row was found desirable. The sweep could be located back of either the front or rear hillers. For the second cultivation, both front and rear hillers were adjusted to move soil into the row.

Effectiveness

In the 40-inch rows, cultivations were equally effective for each of the tillage methods. Cultivations were less effective, however, in the alternate 40-and-90-inch rows, especially where mulch methods were used in sod. The spacing no doubt allowed more sunlight to get between the rows and permitted more weeds to mature seed in the alfalfa strips.

Treatments that left a rough soil surface at planting time delayed and reduced the amount of weed growth. More volunteer corn was found in the plots prepared by both types of rotary machines than in the other plots because the rotary machines shelled the ears lost by the picker the previous fall and the other machines did not. The shelled corn was distributed in the newly planted rows and could not be cultivated out.

Physical Conditions in Seedbeds and Rootbeds

Condition of soil at planting time

Continuous use of each of these treatments over a 4-year period brought about no observable deterioration in the physical condition of the soil. It was noticeable that after minimum tillage treatments had been used for 1 or 2 years the soil broke up more completely. A combination of factors, including applications of adequate amounts of fertilizers, tillage when soil moisture was at a level to prevent excessive compaction, and less tillage no doubt account for this improvement. In 1956, corn had been grown 4 to 6 years continuously in the different replicates.

At planting time, the amount of soil moisture at seed level varied little for the various treatments. However, during seasons of limited rainfall, the content was lowered when a forage crop was allowed to grow until planting time. The moisture at seed level also changed very little during the 6- to 7-day germination period.

For most of the treatments, there was a sufficient amount of soil moisture as shown by uniform seed germination. In some plots and in some years, however, germination was lower in plots prepared by the sweep-rotary machine than in the other plots. Mixing dry residues and cover crops in a 4- to 5-inch layer of soil no doubt prevented some kernels from making good contact with the soil, a fact which accounts at least in part for some of this lower germination.

Condition of soil following cultivation

Bulk density, soil moisture, and penetrometer readings of soil resistance in August, 1956, indicated the influence of tillage treatments on soil conditions. Three determinations were obtained from the same soil sample by driving a tube into the soil to collect cores 1 inch in diameter. The tube was forced into the soil by dropping a 10-pound weight a distance of 18 inches, giving 15 foot-pounds of energy per blow.

In the tilled layer, the resistance and bulk density of the soil in the corn row was significantly lower in the plots prepared with the plow and clodbuster than in those prepared by the rotary tiller (Table 2). In the conventionally prepared plots (check plots plowed and disked) and in those prepared with the till-planter, resistance and bulk density fell in between results for the first comparison. For all practices, only the penetrometer showed a layer of greatest resistance at the 10- to 13-inch depth. Resistance at this depth under the rotary-tilled soil was significantly greater than resistance in a similar layer in the plots prepared with the plow and clodbuster and the plots conventionally prepared.

Resistance readings for different soil-moisture contents indicated that the range in moisture did not have enough effect to change the relative significance of the treatments. The trend was toward lower soil-moisture content at lower depths. For various treatments and depths, moisture varied from 23 to 28 percent.

The soil between the rows was compacted by the tractor wheels during planting and cultivating. A comparison of soil resistance in the row and between the rows indicated the change in soil compaction resulting from 6 passes of the rear tractor wheel during planting and cultivating. The results showed that the rear wheels caused greater changes in the tilled layer than in the soil at lower depths. As would be expected, this increase in soil resistance or compaction was greatest in the seedbeds that gave the lowest soil resistance in the row. The highest resistance at the 4-inch level was in the soil prepared with the till-planter that did not disturb the soil in the wheel tracks when the seedbed was prepared. At other depths, soil resistance in the tracks for the various treatments did not differ (Table 2). Bulk density due to wheel compaction increased for some treatments, but there was no difference between treatments at various depths.

Crop Growth Response

Measurements of the rate of growth made in 1955 and 1956 indicated that differences due to tillage occurred during the early stages and until the corn was 14 to 18 inches tall. After the corn reached this height, the rate of growth was more nearly the same for the

Table 2. — Effect of Tillage Treatments on Physical Condition of Soil after Tillage and Cultivations, 1956

Depth, inches	Machines used for preparing seedbed								Least significant difference, 5-percent level
	Conventional, plow and disk		Experimental methods						
			Plow and clodbuster		Till planter, sweeps 10″ and 20″		Rotary tiller		
	In corn row	In wheel track	In corn row	In wheel track	In corn row	In wheel track	In corn row	In wheel track	
Soil moisture, percent									
0–4	**27**	28	**27**	27	**23**	26	**25**	27	1.0
4–8	**26**	27	**26**	26	**23**	24	**24**	24	3.8
8–12	**26**	26	**24**	25	**25**	25	**25**	25	3.0
12–16	**24**	24	**24**	26	**24**	24	**24**	24	2.6
Bulk density, grams per cubic centimeter									
0–4	**.96**	1.05	**.83**	1.08	**.91**	1.10	**.96**	1.05	.13
4–8	**1.11**	1.16	**.91**	1.13	**1.05**	1.14	**1.11**	1.19	.18
8–12	**1.15**	1.14	**1.09**	1.14	**1.11**	1.15	**1.14**	1.18	.14
12–16	**1.19**	1.23	**1.10**	1.31	**1.20**	1.29	**1.20**	1.31	.15
Soil resistance, foot-pounds per inch[a]									
4	**28**	48	**16**	49	**27**	64	**30**	55	12
8	**60**	78	**48**	69	**69**	76	**81**	78	17
At maximum	**72 (11″)[b]**	90 (10″)[b]	**72 (13″)[b]**	85 (11″)[b]	**78 (11″)[b]**	91 (10″)[b]	**90 (10″)[b]**	90 (10″)[b]	18
15	**65**	75	**63**	72	**66**	74	**65**	69	17

[a] Work required to drive a tube into the soil to obtain a soil sample 1 inch in diameter.
[b] Maximum depth in inches.

various tillage treatments. The early growth rate in 1956 for plantings in cornstalks was slowest in the plots prepared by the plow and clod-buster in 40-inch rows. A still slower rate was recorded for planting with the till-planter and sweep-rotary machine in the alfalfa strips. The alfalfa had lowered the moisture content of the soil at planting time, a fact which contributed to the slower rate of growth.

During the 4 weeks after planting, the rate averaged ½ inch per day and during the next 7 weeks averaged slightly over 2 inches per day.

Plant loss

The number of plants that emerged compared with the number of stalks at harvest that produced ears showed the losses that could be attributed to cultivation, insects, and disease. This loss averaged 5 percent in 1954 and 12 percent in 1955. The largest growing loss for a single treatment, 25 percent, occurred in 1955 in the sweep-rotary-prepared plots, largely because when the corn was first cultivated, the weeds between the rows were very tall and in removing them many corn plants were covered up.

Barren stalks

Neither the tillage treatments nor the row-spacing methods gave any significant trend on the number of barren stalks at harvest. The barren stalks averaged 5 percent in 1953, 7 percent in 1954, 8 percent in 1955, and 3 percent in 1956.

Harvestability

Yields can be reduced by the number of ears that become detached before harvest and by the corn lost by the machine. Yield determinations for 1953 and 1954 were made by hand harvesting, and in 1955 and 1956 with a combine. Harvestability for the various treatments was evaluated by counting the detached ears, gleaning ears left by the combine, and sampling the shelled corn left on the ground.

Stalk lodging

Tillage treatments had very little effect on lodging. Major differences were caused by seasonal variations. More than half the stalks lodged in 1955, largely because of a general stalk-rot infestation in Illinois. While results were not always significant, stalks in the alternate 40-and-90-inch rows did not lodge as much as those in the 40-inch rows in any year (Table 3).

Corn loss

Treatments showed no differences in total amounts of corn lost. The excessive lodging that occurred in 1955 points up the importance

Table 3. — Influence of Row Spacings and Lodging on Corn Losses

Item	1955	1955	1956	1956
Harvesting conditions				
Row spacings, inches	40	40–90	40	40–90
Number of tests	64	80	64	80
Travel speed, miles per hour	1.7	1.7	3.1	3.1
Average yield, bushels per acre	82.2	69.6*	123.6	96.7*
Total number of stalks, thousands per acre	16.3	12.2	15.5	11.0
Average number of lodged stalks, thousands per acre	8.5	6.2	1.2	.6*
Percent of moisture in kernels	17.8	17.4	20.2	21.0
Corn losses, bushels per acre				
Ears detached	1.7	1.1	1.1	.6
Ears lost by machine	12.7	5.8*	1.5	.8
Shelled loss from rolls and separation loss	2.9	1.8*	3.8	2.5*
Unshelled on cobs	.5	.3	.8	.5
Total	17.8	9.0*	7.2	4.4*
Total losses, percent	21.7	12.9*	5.8	4.5

Note: On the rows spaced 40 and 90 inches apart, an asterisk indicates the difference in the same year between these rows and the 40-inch rows was significant at the 5-percent level.

of standing corn at harvest. In that year, 52-percent lodging reduced yields 22 percent in the 40-inch rows, while in 1956 when less than 8 percent of the stalks lodged, losses were only 6 percent. In the alternate 40-and-90-inch rows, losses were less than these each year. Severe lodging did not cause as much loss in these 40-and-90-inch rows as it did in the 40-inch rows (Table 3). The gathering shields could pick up the lodged stalks in the 40-and-90-inch rows without so many breaking off because the lodged stalks were not woven into the next 2 rows.

Two planting rates, 12,000 and 16,000 stalks to the acre, were compared. In 1955, total loss was greater at the higher rate. Using the 16,000 rate in 1955 caused higher losses in the 40-inch than in the 40-and-90-inch rows since stalk lodging was higher in the 40-inch rows. In 1956, the two planting rates had no influence on the corn lost, largely because there was little lodging.

Under differing lodging conditions, the number of ears the combine lost varied more than the number of detached ears and more than the shelled corn loss. In the 40-inch rows in 1955, the machine lost 16 percent of the ears, but under the better harvesting conditions of 1956, it lost only 1 percent.

The shelled corn loss per acre in the 40-and-90-inch rows was lower than that in the 40-inch rows, a fact which gave this new method of spacing a yield advantage. As between the two methods of spacing, the shelled corn loss for a given distance in the rows did not differ. However, the shelled corn loss per acre was less for corn planted in 40-and-90-inch rows because in this spacing two rows make up 62 percent more area than two 40-inch rows.

When it is realized that on the 40-and-90-inch rows the combine had to operate in higher-yielding corn than it had to do in the 40-inch rows, the lower harvest loss in the 40-and-90-inch rows becomes even more striking. Since in the 40-and-90-inch spacings, the stalks for 3 rows were crowded into 2 rows, a field yield of 100 bushels an acre gave a yield in the row of 162 bushels an acre.

Applying nitrogen at the rate of 150 and 75 pounds an acre had no effect on either total loss or on the individual loss-components.

Yield Response

In the evalution of these tillage treatments, yield was the important measure. Before any given treatment can be fully evaluated for farm conditions, however, other factors need to be considered, such as time required for labor, possible peak labor periods, extra fertilizers required, and machinery costs.

Yields on rows 40-inches apart

Corn yields were influenced more by seasonal conditions than by tillage treatments. The lowest yields in the four seasons occurred in 1953 when rainfall was only about 60 percent of normal. The highest yields and the smallest variations between treatments were recorded in 1956 when the rainfall was about normal, but not very different from that in 1954 and 1955. The same hybrid, Illinois 1332, was used each year to evaluate yields.

Planting corn on freshly plowed ground with a minimum of tillage gave significantly higher yields in 1 year (Table 4). In the remaining 3 years, yields did not differ significantly from those produced by the conventional method of plowing early and tandem disking at planting time.

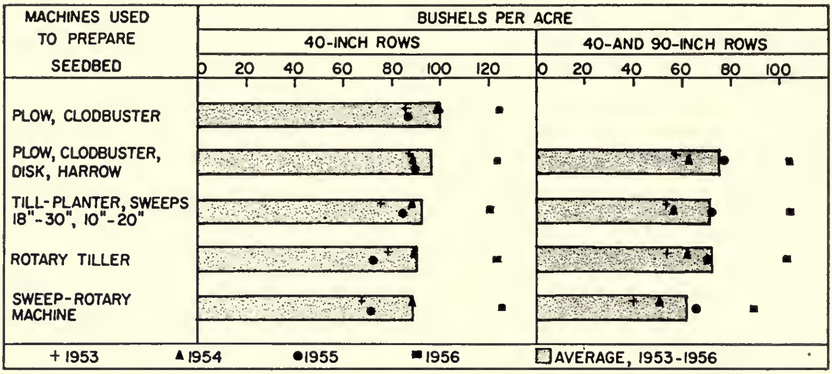
In 2 of the 4 years, plowing gave significantly higher yields than the average of those methods in which the residues were mixed in the soil or left on the surface. In 1 season, leaving the mulch on the surface with the till-planter gave significantly higher yields than did mixing the residue in the soil with the rotary-type machines. In 1 year, yields were higher where the whole area was rotary-tilled than where half the area was sweep-rotary tilled (Table 4 and Fig. 7).

Table 4. — Comparisons of Corn Yields: Various Tillage Treatments; Rows 40 Inches Apart

(Corn grown on same plots each year; averages of 8 plots for each treatment)

Disposition of residues	Machines used to prepare seedbed	Ears, thousands per acre					Yield per acre, bushels				
		1953	1954	1955	1956	**Average**	1953	1954	1955	1956	**Average**
		Averages of combinations of treatments									
Turned under	Conventional plow, disk, and harrow, and plow and clodbuster	11.5	14.3	17.3	15.5	**14.6**	87.6	94.4	88.7	124.8	**98.9**
Left on surface as mulch, mixed in half width of row, and mixed in entire row	All experimental	10.3	14.3	15.8	15.5	**13.9**	74.8	89.7	78.9	123.0	**91.6**
Difference		−1.2*	0	−1.5*	0	**−.7**	−12.8*	−4.7	−9.8*	−1.8	**−7.3***
Mixed in half width of row, and mixed in entire row	Rotary tiller and sweep rotary	9.9	14.2	16.2	15.8	**14.0**	73.4	90.1	73.1	124.9	**90.4**
Left on surface as mulch	Till-planter, sweeps 18″ and 30″ and 10″ and 20″	10.6	14.3	15.3	15.3	**13.8**	76.3	89.3	84.8	121.2	**92.9**
Difference		+.7	+.1	−.9	−.5	**−.2**	+2.9	−.8	+11.7*	−3.7	**+2.5**
		Average of each treatment									
Turned under	Conventional plow, disk, and harrow	11.8	13.9	17.4	15.6	**14.7**	88.0	89.0	90.2	124.3	**97.9**
Turned under	Plow and clodbuster	11.2	14.6	17.2	15.4	**14.6**	87.0	99.8	87.1	125.5	**99.9**
Difference		−.6	+.7	−.2	−.2	**−.1**	−1.0	+10.8*	−3.1	+1.2	**+2.0**
Mixed in half width of row	Sweep rotary	9.5	13.5	16.2	15.6	**13.7**	68.2	89.6	72.7	126.4	**89.2**
Mixed in entire row	Rotary tiller	10.3	15.0	16.3	15.9	**14.4**	78.6	90.6	73.4	123.6	**91.3**
Difference		+.8	+1.5*	+.1	+.3	**+.7**	+10.4*	+1.0	+.7	−2.8	**+2.1**
Left on surface as mulch	Till-planter, sweeps 18″ and 30″	10.8	14.3	15.6	14.7	**13.9**	72.8	82.4	82.4	117.9	**88.9**
Left on surface as mulch	Till-planter, sweeps 10″ and 20″	10.5	14.3	15.0	16.0	**14.0**	79.7	96.2	87.3	124.4	**96.9**
Difference		−.3	0	−.6*	+1.3*	**+.1**	+6.9	13.8*	+4.9	+6.5	**+8.0***

Note: An asterisk indicates the difference is significant at the 5-percent level.



Tillage methods had less effect on corn yields than seasonal conditions or the two methods of spacing the rows. (Fig. 7)

Yields on plots prepared with 10- and 20-inch sweeps on the till-planter were significantly higher in 1 year than the yields on plots prepared by the same machine equipped with 18- and 30-inch sweeps, and the yield trend was higher in the other 3 years. In another study in 1955, however, yields on plots prepared with the normal 18- and 30-inch sweeps had the advantage. In 1956, the yields differed little for plots prepared with the lower sweeps in widths of 18 inches, 10 inches, and with no sweep on the center shank. For this separate study, a 30-inch top sweep was used for all treatments.

The ear population at harvest showed some differences, but showed no general trend for a given treatment (Table 4).

Tandem disking

On the check or conventionally prepared plots, the ground was tandem disked only once. In the compaction study made in 1955 and 1956 on ground in good physical condition, yields were as high on ground disked only once as they were on that disked 4 times (Table 6).

Rotation as against continuous corn

The rotation consisted of corn, corn, oats (alfalfa). Plots were prepared by plowing and disking. In 1 year, average yields were higher on the plots where this rotation was used than they were on the plots planted continuously to corn. In other years, there was no difference. Plots in the rotation received the same amount of commercial fertilizer as those in continuous corn.

Yields on rows 40 and 90 inches apart

On these plots where the rows were spaced 40 and 90 inches apart, only two-thirds of the area was in corn. In the first 2 years, this spacing lowered average yields for all tillage treatments 35 percent and in the last 2 years 15 percent (Table 5). Part of the reason yields were relatively higher in the last 2 years is that the alfalfa strips between the rows were clipped earlier and oftener during the season to reduce the competition between crops for moisture.

Comparisons of tillage treatments showed that plowing the soil gave higher yields in all years than mixing the residues in the soil or leaving them on the surface. In these comparisons, average yields of plots where rows were rotated and not rotated were considered. The till-planter treatment increased yields over the average of the rotary-type treatments in all years. Further comparisons, however, showed that in 3 of the 4 years yields were lower on the plots prepared by the sweep-rotary machine than they were on the plots prepared by the rotary tiller. Yields were higher on plots prepared by the till-planter than they were on those prepared by the rotary tiller in only 1 year. In this row-spacing method, varying the width of the sweeps had no effect on yield (Table 5 and Fig. 7).

In 2 of the 3 years, planting the corn in the same row each year gave significantly higher yields than planting it in rows rotated with the alfalfa strips. Individual treatments, however, did not always follow the trend of the average yields of rotated and nonrotated rows (Table 5).

The corn population was lower in 40-and-90-inch-row plots than in the 40-inch-row plots because less corn was planted per acre, but the spacing of the kernels in the rows was about the same on both sets of plots. Increasing the planting rate beyond that used on the 40-and-90-inch rows did not increase yield, as another study showed.

Even though the yield was reduced 15 percent in the 40-and-90-inch planting system, over 25 percent more corn was produced on a given land area than was produced in a rotation of corn, corn, oats (alfalfa). While two-thirds of the land area was used for corn in each system, the extra corn in the new planting system would normally have a greater value than the oats produced in the rotation system. The new method also provided alfalfa strips to help hold the soil and lowered harvesting losses. The system did, however, present machinery problems.

Nitrogen fertilizers

Adding nitrogen at the rate of 150 pounds per acre as compared with a rate of 75 pounds increased yields very little. In the 4-year period, 64 nitrogen-rate comparisons were made for both row-spacing methods. Applying nitrogen at the rate of 150 pounds per acre increased yields significantly only 4 times.

Table 5. — Comparisons of Corn Yields: Various Tillage Treatments; Rows 40 and 90 Inches Apart; Rows Rotated and Not Rotated

(Corn grown on same plots each year; averages of 8 plots for each treatment)

Disposition of residues	Machines used to prepare seedbed	Ears, thousands per acre					Yield per acre, bushels				
		1953	1954	1955	1956	**Average**	1953	1954	1955	1956	**Average**
	Average of combinations of treatments; rows rotated and not rotated										
Turned under	Conventional plow, disk, and harrow	8.0	10.2	13.2	12.0	**10.9**	57.6	60.7	74.3	104.3	**74.2**
Left on surface as mulch, mixed in half width of row, and mixed in entire row	All experimental	7.4	10.3	12.0	10.9	**10.2**	50.8	56.2	68.4	94.8	**67.5**
Difference		−.6	+.1	−1.2*	−1.1*	**−.7**	−6.8*	−4.5*	−5.9*	−9.4*	**−6.7***
Mixed in half width of row, and mixed in entire row	Rotary tiller and sweep rotary	7.1	10.1	12.8	10.7	**10.2**	47.4	54.2	65.4	91.4	**64.6**
Left on surface as mulch	Till-planter, sweeps 18″ and 30″ and 10″ and 20″	7.7	10.5	11.3	11.1	**10.2**	54.1	58.3	71.4	98.3	**70.5**
Difference		+.6	+.4*	−1.5*	+.4	**0**	+6.7*	+4.1*	+6.0*	+6.9*	**+5.9***
	Average of each treatment; rows rotated and not rotated										
Mixed in half width of row	Sweep rotary	6.2	9.9	13.0	9.9	**9.8**	40.4	50.7	65.1	83.6	**59.9**
Mixed in entire row	Rotary tiller	8.0	10.3	12.5	11.4	**10.6**	54.4	57.6	65.6	89.1	**66.7**
Difference		+1.8*	+.4*	−.5	+1.5*	**+.8**	+14.0*	+6.9*	+.5	+5.5*	**+6.8***
Left on surface as mulch	Till-planter, sweeps 18″ and 30″	7.8	10.2	10.7	11.1	**9.9**	53.8	57.7	71.9	99.5	**70.7**
Left on surface as mulch	Till-planter, sweeps 10″ and 20″	7.6	10.9	11.9	11.0	**10.3**	54.5	58.9	70.9	97.0	**70.3**
Difference		−.2	+.7*	+1.2*	−.1	**+.4**	+.7	+1.2	−1.0	−2.5	**−.4**
	Effect of rotation of rows; average of all treatments										
All methods of disposition	All machines										
Rows rotated		....	10.1	12.1	10.8	**11.0**	....	55.9	67.4	92.1	**71.8**
Rows not rotated		....	10.4	12.4	11.3	**11.4**	....	58.3	71.7	101.3	**77.1**
Difference		....	+.3*	+.3*	+.5*	**+.4***	....	+2.4	+4.3*	+9.2*	**+5.3***
	Effect of rotation of rows; average of each treatment										
Turned under	Conventional plow, disk, and harrow										
Rows rotated		....	9.8	13.1	12.1	**11.7**	....	58.6	70.7	104.0	**77.8**
Rows not rotated		....	10.6	13.2	10.9	**11.9**	....	62.8	77.9	104.6	**81.8**
Difference		....	+.8*	+.1	−.2	**+.2**	....	+4.2	+7.2*	+.6	**+4.0***
Mixed in half width of row	Sweep rotary										
Rows rotated		....	9.8	13.0	9.9	**10.9**	....	50.2	63.9	77.7	**63.9**
Rows not rotated		....	10.1	13.0	10.0	**11.0**	....	51.2	66.3	89.5	**69.0**
Difference		....	+.3	0	+.1	**+.1**	....	+1.0	+2.4	+11.8*	**+5.1**
Mixed in entire row	Rotary tiller										
Rows rotated		....	10.2	12.4	11.0	**11.2**	....	52.2	61.1	95.2	**69.5**
Rows not rotated		....	10.4	12.7	11.8	**11.6**	....	63.0	70.1	103.0	**78.7**
Difference		....	+.2	+.3	+.8*	**+.4**	....	+10.8*	+9.0*	+7.8*	**+9.2***
Left on surface as mulch	Till-planter, sweeps 18″ and 30″ and 10″ and 20″										
Rows rotated		....	10.5	11.0	10.6	**10.7**	....	59.4	70.7	91.9	**77.3**
Rows not rotated		....	10.6	11.6	11.5	**11.1**	....	57.1	72.2	104.6	**77.6**
Difference		....	+.1	+.6	+.9*	**+.4**	....	−2.3	+1.5	+12.7*	**+.3**

Note: An asterisk indicates the difference is significant at the 5-percent level.

Nitrogen was required to prevent large yield reductions when corn was planted in a sod with the till-planter. This fertilizer was not needed for seedbeds prepared with a plow and disk, as shown by the first-year corn comparisons given below. For second-year corn, using starter fertilizer maintained yields for both methods in a limited number of comparisons.

Machines used and type of fertilizer applied[a]	Relative yields	
	First-year corn	Second-year corn
	perct.	*perct.*
Plow and disk		
No fertilizer	103	80*
Starter	93	102
Starter and nitrogen	100	100
Till-planter		
No fertilizer	60*	66*
Starter	65*	95
Starter and nitrogen	100	100

[a] Starter fertilizer was applied at the rate of 30 pounds per acre of phosphorus and potassium and nitrogen fertilizer at a rate to give 80 pounds of elemental nitrogen per acre.
Note: An asterisk indicates a significant difference at the 5-percent level.

Part II—Effects of Compaction and Extra Diskings

This study was made on a group of plots in 1955 and 1956. Its purpose was to determine the effects of compacting the soil by applying high pressure to it before it was plowed and the effects of compacting by extra diskings and wheel traffic after it was plowed.

REVIEW OF LITERATURE ON COMPACTION

Studies on the effects of soil compaction as related to crop yields have been limited, but those on the physical changes in the soil have been more extensive. Doneen and Henderson[9] found that the infiltration of irrigation water was reduced by tractor wheel traffic and that the reduction was greater when the compaction was made when the moisture content of the soil was high. Free[10] found that compaction from tractor wheels between potato rows reduced infiltration and that at the 8- to 12-inch depth there was a resistant layer. These tractor wheel tracks could be detected by a soil penetrometer even after winter weathering.

While the pressure inside the rear tractor tires is normally about

15 pounds per square inch, the tires can produce much higher pressure on the soil when only the tire lugs are in contact with the soil. Cooper and others[8] determined that one tractor of large size operating on a dense soil so that only the lugs were in contact with the soil developed a pressure of 54 pounds per square inch at the surface and 12 pounds per square inch at the 10-inch depth.

PLAN AND CONDITIONS OF COMPACTION STUDY

This study was made in Drummer silty clay loam, which is considered one of the most difficult soils to prepare for a seedbed. The plots were located on the Agricultural Engineering Experiment Field in a low depressional area that maintained a higher percentage of soil moisture than did the surrounding areas. A randomized block design with split plots was used. Individual subplots were 4 rows wide and 40 feet long so arranged that machines could operate at normal speeds. Treatments were replicated 6 times in 1955 and the compacted plots were replicated 3 times in 1956.

Soil tests indicated that pH was 6.0, the phosphorus (P_2O_5) 270 pounds, and the potassium (K_2O) 220 pounds to the acre. Starter fertilizer was band applied at the same rate and in the same location as it was in the tillage studies. Nitrogen fertilizer was applied at the rate of 125 pounds to the acre.

The soil was compacted before it was plowed by the rubber tires of a truck that was loaded to apply 75- to 85-pounds of pressure per square inch, or greater pressures than most tractor tires would apply. This pressure was applied 4 times to all the soil in the plot just before it was plowed. Some of the effects of compaction were thus removed by the pulverizing action of the plow. This compaction was applied to the 6 replications in 1955 and to 3 in 1956. The plots not recompacted in the 3 replications in 1956 indicated the carry-over effects of the 1955 compaction.

While this compaction was excessive, it gave an indication of the effects of excessive packing by livestock or machinery at a time after which there would be no winter freezing or thawing.

Comparisons of 1 and 4 tandem diskings were made on soil that had been and had not been packed before it was plowed. The 1 and 4 diskings indicated the amount of secondary tillage required on the compacted and uncompacted soils, and produced different amounts of soil packing after plowing.

PHYSICAL CONDITIONS IN SEEDBEDS AND ROOTBEDS

The large clods and slabs (Fig. 8) turned up by the plow was the most striking soil condition that resulted from compaction before plowing. This condition made planting and cultivating difficult, especially on the plots that were disked only once.

Plow draft

Data on draft were obtained by measuring the draft of a 1-bottom moldboard plow that had been mounted on a tractor for soil testing purposes. Data are for pulling only the colter and 12-inch bottom through the soil.

Compaction greatly influenced draft, as the draft in the packed and unpacked soil shows.

Comparisons	Soil moisture, percent		Plow draft, pounds per square inch	
	1955	1956	1955	1956
Effect of packing before plowing				
Soil unpacked	29.8	27.8	8.9	8.2
Soil packed 1955, 1956	29.1	25.7	16.8	16.4
Difference	−.7	−2.1	+7.9*	+8.2*
Effect of packing and carry-over to next spring				
Soil unpacked	25.2	30.6	9.5	8.0
Soil packed, 1955	29.5	30.2	16.8	8.6
Difference	+4.3	−.4	+7.3*	+.6
Carry-over effect of disking unpacked soil				
1 tandem disking, 1955	....	29.2	....	7.5
4 tandem diskings, 1955	....	29.4	....	7.9
Difference	....	+.2	....	+.4
Carry-over effect of disking soil packed in 1955				
1 tandem disking, 1955	....	31.2	....	7.9
4 tandem diskings, 1955	....	28.9	....	8.3
Difference	....	−2.3	....	+.4

Note: An asterisk indicates the difference is significant at the 5-percent level.

In packed soil, the draft increased an average of 92 percent. Neither packing nor extra diskings had a carry-over effect to the next spring, indicating that freezing and thawing had removed the compaction effects in one season. These results were obtained on a soil in a high state of fertility. Lower fertility or a different soil type may give different results.

Soil moisture at planting time

When the soil was disked once, soil moisture at seed level at planting time was lowered each year because of compaction. Four diskings

The soil in the foreground was compacted before it was plowed and that in the background was undisturbed. (Fig. 8)

as compared to 1 conserved moisture on the packed soil in 1 of the 2 seasons and showed no effect on the unpacked soil. During the 6-day germination period that was free of rain in 1956, soil moisture did not change for any of the treatments.

Soil resistance and bulk density

Measurements of soil resistance and bulk density were made in August, 1956, after all tillage operations had been completed. They did not reveal that packing the soil before plowing or changing the number of diskings made any significant differences. The changes in the readings from near the surface to below the plow layer were similar in this study to the readings for the conventionally prepared (check plots) in the tillage study (Table 2). In this study also a layer of maximum resistance was encountered at the 11- to 12-inch depth, but the resistance of this layer was not increased by either the packing or the extra diskings. The packing by the rear tractor wheels increased the soil resistance only in the tilled layer.

Crop growth

Compaction before plowing delayed plant emergence and reduced the rate of growth until the plants were about 12 inches tall (Fig. 9). After the plants reached this height, the corn in the compacted soil

Plant emergence in the compacted soil in the foreground was later than emergence in the uncompacted soil in the background. This is the appearance of the compacted soil after it was broken up by diskings before the corn was planted and following a rain a few days after planting. (Fig. 9)

grew faster than that in the uncompacted until it reached its mature height. Even with this faster growing rate, corn in the compacted soil was always shorter than corn in the noncompacted soil. The number of days required to reach a given height in 1956 and the growing rates (see page 32) also indicate that the extra diskings increased the growing rate during the early stages of growth only in the compacted soil.

Treatment before plowing	Disking after plowing	Time required to reach height, inches[a]				Rate of growth in given ranges, inches[b]			
		12	24	48	108	0-12	12-24	24-48	48-108
		days				*inches per day*			
None	1	16	27	37	66	.7	1.1	2.4	2.1
None	4	16	27	37	66	.7	1.1	2.4	2.1
Packed	1	27	34	45	70	.4	1.7	2.2	2.4
Packed	4	23	31	42	67	.5	1.5	2.2	2.4

[a] Time based on planting date of corn.
[b] Trends in 1955 were the same.

Plant population

Each year fewer kernels germinated in the compacted soil than germinated in the uncompacted, but a larger percent germinated in 1956 than in 1955. Disking the compacted soil 4 times increased the number of plants on that soil, but did not affect the number on the noncompacted soil (Table 6).

Table 6. — Effects on Ear Populations and Corn Yields From Compaction Before Plowing and Disking After Plowing, 1955-1956
(Compaction of 75 pounds per square inch)

	Number of diskings	Ear population per acre			Yield per acre		
		No compaction	Compaction	Difference	No compaction	Compaction	Difference
					bu.	*bu.*	*bu.*
1955	1	14,800	7,100	−7,700*	93.1	59.8	−33.3*
1955	4	14,200	11,600	−2,600*	87.6	82.3	−5.3
Difference	..	−600	+4,500*	....	−6.5	+22.5*	......
1956	1	14,600	11,500	−3,100*	122.9	107.2	−15.7*
1956	4	14,600	13,000	−1,600*	128.4	117.8	−10.6*
Difference	..	0	+1,500*	....	5.5	+10.6*	......

Note: An asterisk indicates the difference is significant at the 5-percent level.

Corn yield

When the soil was tandem disked once, compaction before plowing limited yield 37 percent in 1955 and 13 percent in 1956. When the compacted soil was disked 4 times, however, yield was not reduced in 1955 but was reduced 8 percent in 1956. After winter freezing and thawing, 1955 compaction before plowing had no effect on 1956 yield. Yield in neither year was affected by disking noncompacted soil an extra 3 times (Table 6).

These results were obtained on a soil of high fertility, where fertilizer was band-placed at planting time and when the water table was higher than usual during the growing season. It would be desirable to learn the effects of these and other compaction variables under other growing conditions and under milder winter weather than Illinois normally has.

Summary

Three basic tillage treatments — turning residues under, mixing them throughout the tilled layer, and leaving a mulch on the surface were studied. Two methods of spacing the rows at 2 levels of nitrogen — 75 and 150 pounds to the acre — under weather conditions in 4 seasons were also studied. These tillage treatments required fewer operations and fewer hours of labor than have normally been used to grow a corn crop in Illinois.

The till-planter prepared the seedbed and planted the corn successfully in soil where the crop residues were dead, but where growing forage was heavy, it presented problems in both planting and cultivating.

The sweep-rotary machine more completely pulverized compacted soil and sod growth than did the sweeps on the till-planter. Mixing the forage in the soil, however, appeared to cause some reduction in germination. The rotary machine pulverized the soil most thoroughly, but such thorough pulverization did not prove necessary on the soils used in the tests.

When a sod mulch was left at planting time, disk hillers were used successfully to cultivate the corn. Standard cultivator sweeps were used for all other treatments. Leaving the soil rough at planting time reduced the weed problem.

When the corn was planted, various amounts of tillage produced little difference in soil moisture at seed level, and soil moisture changed little during the germination period.

Soil resistance to penetration by a metal probe was least in the seedbed prepared by the plow and greatest in that prepared by the rotary-tiller. The penetrometer detected a layer of maximum density at the 10- to 13-inch depth. This layer was not revealed by bulk density determinations. Soil resistance was increased by the compaction of the rear tractor wheels. After this compaction, resistance was about the same for the various treatments.

Loss of plant population due to cultivation or barren stalks was not affected by variation in tillage treatments. Tillage treatments also had little influence on the amount of corn lost in machine harvesting. Less

corn was lost, however, in the rows spaced 40 and 90 inches apart than in those spaced 40 inches apart, and less was lost in standing corn than was lost in lodged corn.

Corn yields produced by using minimum tillage treatments were equal to or greater than those produced by more intensive tillage. Plowing normally produced higher yields than other methods. Yields on plots prepared by the till-planter more often equalled or approached yields on the plowed plots than did yields on plots prepared by the two types of rotary-tillage machines. Least tillage was used on those plots prepared by the till-planter, which left a mulch on the surface. Using narrower sweeps on the till-planter gave yields equal to those produced with sweeps of normal width. Rotary tillage of all the soil produced more corn than rotary tillage of half the soil.

Yields on the plots where rows were spaced 40 and 90 inches apart were below those on plots where rows were spaced 40 inches apart, but not below them in proportion to the one-third reduction in the area planted to corn. Yields were higher where the rows were not rotated each year to the alfalfa strips than where they were.

Using 150 pounds of nitrogen to the acre rather than 75 had little effect on yield or harvest loss.

Compacting the soil before plowing, using pressures of 75 to 85 pounds per square inch, increased the plow draft 92 percent. The effect of compaction, however, did not carry over to the next season.

When the soil was disked 4 times after it had been compacted, there was less loss of both plant population and yield than there was when the ground was disked only once. The 1956 yield was not influenced by the compaction made in 1955. Disking noncompacted ground 4 times after it was plowed rather than only once did not change either yield or ear population.

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6M—6-59—68257