planning a minimum tillage system for corn

BY H. P. BATEMAN AND WENDELL BOWERS
Some Illinois farmers are maintaining maximum corn yields even though they have reduced their growing and harvesting operations to no more than four trips over the field. Others follow more conventional tillage systems but have eliminated two or more operations.

Both groups are using the minimum amount of tillage that will give quick germination, a high percent of germination, and maximum yields on their particular farm. Thus, minimum tillage, rather than being any one given method, is really a principle, which can be applied in many different ways.

The method you choose for your farm should be based on a combination of factors including soil type, climate, crop rotation, labor supply, and available machinery.

Value of Reduced Tillage

Lower costs

Because circumstances on different farms can vary widely, it is difficult to say exactly how much can be saved by eliminating a disk, harrowing, or cultivation. Even at a saving of a dollar an acre for each operation, $600 a year could be saved by eliminating three operations on 200 acres of corn. While this is an assumed example, many farmers have reported substantial reductions in machinery and labor costs after a few years of minimum tillage planting.

Reduced soil losses

Improved soil conservation is another advantage of minimum tillage. The soil is looser, permitting more water intake and less erosion (Figs. 1 and 2). According to conservative estimates, only about half as much soil is lost with minimum tillage as with conventional tillage. Some studies show even more advantage for minimum tillage on steep slopes. The conservation benefits alone may justify the adoption of a minimum tillage system on soils where erosion is a serious problem.

Yields the same

Corn yields on the Agricultural Engineering Experiment Field have averaged the same for minimum tillage as for conventional tillage over the

Minimum tillage on the right half of this field has kept the soil loose and porous, so that it can quickly absorb rain water. Conventional tillage on the left half has caused so much compaction that water cannot easily soak into the ground. (Fig. 2)
Table 1. — Corn Yield Comparisons for Minimum and Conventional Tillage Systems on Agricultural Engineering Experimental Field (1952-1960) and on Demonstration Fields on Private Farms (1956 and 1958)

<table>
<thead>
<tr>
<th>Comparison made</th>
<th>No. of comparisons</th>
<th>Harvest population per A.</th>
<th>Yield, bushels per A.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conventional tillage</td>
<td>Minimum tillage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14,500</td>
<td>14,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13,800</td>
<td>14,800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13,900</td>
<td>12,300</td>
</tr>
</tbody>
</table>

RESEARCH RESULTS ON AGRICULTURAL ENGINEERING FIELD

| Comparisons in which minimum tillage gave higher yields than conventional tillage | 12 | 13,800 | 14,800 | 97    | 110* |
| Comparisons in which minimum tillage gave lower yields than conventional tillage | 13 | 13,900 | 12,300 | 90    | 77*  |

RESULTS ON DEMONSTRATION FIELDS

| Total comparisons                          | 16 | 11,800 | 11,200 | 100   | 103  |

* Each comparison was based on averages of three to six replicates for each treatment.
* Soil was plowed and disked one to three times before planting.
* Soil was plowed and planted with no major tillage operation between these operations. Methods included plow-planting; plowing, with or without clod-buster, then planting; and plowing then planting in the tractor wheel tracks.
* The difference between minimum-tillage yield and conventional-tillage yield is significant.

The comparisons reported in Table 1 include three types of minimum tillage practices: (1) plow-planting; (2) plowing, either with or without a light tillage machine attached, then planting; (3) plowing then planting in tractor wheel tracks.

Minimum tillage gave higher yields than conventional tillage in 12 of the 70 comparisons, and lower yields in 13 of the comparisons. Both the decreases and the increases averaged 13 bushels an acre. And both occurred mainly on the same soil types — dark clay loams, which are hard to pulverize. When the soils were flooded for part of the season, minimum tillage often showed an advantage. When they were dry at planting time and for an extended period afterwards, conventional tillage often gave better yields. However, if a drouth occurred after the corn germinated and became established, no yield difference was noted.

Further comparisons were made of the methods on soils that are easy to pulverize, such as Brenton and Flanagan silt loams, and soils that are difficult to pulverize, such as Drummer silty clay loam. In 25 comparisons on the easy-to-pulverize soils, minimum tillage resulted in only one yield increase and one decrease (Table 2). In 32 comparisons on the hard-to-pulverize soils, however, there were seven increases and nine decreases for minimum tillage. Both the increases and the decreases averaged 14 bushels an acre. Average corn yields were about the same for the two methods on both types of soil.

A successful minimum tillage seedbed was more difficult to establish on the hard-to-pulverize soils. These soils, because of their high clay content, stay wet a comparatively long time in the spring, and are therefore likely to compact, especially if they are tilled when too wet. With excessive tillage, the surface may become dry and cloddy, making it difficult to obtain a good seedbed in the row. Both compaction and the dry topsoil were blamed when yields from conventional tillage were below those from minimum tillage. On the other hand, minimum tillage reduced yields when we intentionally used too little tillage in the row or when soil moisture was too low for good germination. Usually the minimum tillage plantings were deliberately made under adverse conditions to learn the effect of these conditions.

When a seedbed is not well pulverized, seed-to-soil contact is poor. Tillage devices to help overcome this difficulty are suggested on pages 10 and 11.
Seven Guides to a Successful Minimum Tillage Operation

Research has helped develop seven principles to serve as guides in the use of minimum tillage. They need to be combined with other good management practices, such as maintaining adequate fertility, using the proper plant population, planting at the right time, and controlling weeds and insects.

Highly pulverized and heavily compacted soil reduces yields. An optimum amount of tillage is required for a given soil type and previous crop situation. Tillage beyond this optimum point can compact the soil and lower the amount of soil moisture available for germination. Excessive diskings after plowing reduced average yields by 7 bushels an acre (Table 3). A minimum tillage system can be selected to produce a given degree of pulverization in the tilled layer so that the maximum yield is obtained.

Soil needs to be well pulverized in seed zone. For best results in any tillage system, the soil needs to be pulverized enough to make good contact with the seed (Fig. 3). A few clods on the surface are good. Below the surface finer soil should be compacted around the clods to keep air spaces small and maintain capillary movement of moisture from the subsoil to the seed area. The well-pulverized zone or seedbed should be 12 to 15 inches wide and extend down to the unplowed subsoil.

<table>
<thead>
<tr>
<th>Tillage system</th>
<th>No. of comparisons</th>
<th>Harvest population per acre</th>
<th>Yield, bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional tillage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 3 diskings after plowing (check treatment)</td>
<td>9</td>
<td>14,200</td>
<td>95</td>
</tr>
<tr>
<td>4 to 6 diskings after plowing</td>
<td>7</td>
<td>13,400</td>
<td>88*</td>
</tr>
<tr>
<td>Minimum tillage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plowed soil tilled once with corn cultivator sweeps at planting (System I, page 5)</td>
<td>2</td>
<td>14,600</td>
<td>95</td>
</tr>
<tr>
<td>Plowed with light tillage machine attached to plow, then planted (System IIA, page 7)</td>
<td>9</td>
<td>13,900</td>
<td>92</td>
</tr>
<tr>
<td>Soil plowed then planted in tractor wheel tracks (System III, page 8)</td>
<td>8</td>
<td>14,000</td>
<td>94</td>
</tr>
<tr>
<td>Plow-plant or plow then plant (System III, page 8)</td>
<td>9</td>
<td>13,200</td>
<td>91</td>
</tr>
<tr>
<td>Other tillage machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil tilled with diskers and sweeps on a field cultivator</td>
<td>4</td>
<td>14,300</td>
<td>92</td>
</tr>
<tr>
<td>Soil tilled with powered rotary tiller</td>
<td>5</td>
<td>13,900</td>
<td>88*</td>
</tr>
</tbody>
</table>

*The difference between this yield and that from the conventional check treatment is significant.

Less pulverization is needed between rows. The area between the rows is called a rootbed and does not need to be as completely pulverized as the seedbed. With minimum tillage methods, two degrees of pulverization are possible in the plowed layer, with the rootbed looser than the seedbed. Both rootbed and seedbed are less compact than with conventional tillage, so that more rain enters the soil for plant use and less soil is lost through erosion. The loose rootbed allows water to drain away from the seedbed zone.

Adequate moisture is needed to germinate seed. Any tillage system needs to be planned so that it will not reduce soil moisture before or after planting. Dry soil is difficult to pulverize for good seed-to-soil contact, and germination will be poor unless it rains soon after planting.

If freshly plowed soil is allowed to remain...
with large air pockets, it will dry out too much. Excessive drying can be prevented by pulling a light tillage tool behind the plow to level the soil. This is particularly important in spring plowing. Too many diskings will remove valuable soil moisture at the seed level.

In the minimum tillage seedbed the soil in the row must be pulverized enough that soil moisture doesn’t escape too fast. Tillage between the rows should be sufficient to remove the large air pockets that permit rapid loss of soil moisture. Tests during the germination and early growth periods have shown that as much moisture is available in a minimum tillage seedbed, if it has been properly prepared, as in a conventional one.

Allowing a forage crop or weeds to grow until late in the planting season may reduce soil moisture so much that germination is delayed. It is thus desirable to complete minimum tillage planting by the middle of the planting season, especially if rainfall is limited.

Minimum tillage requires deeper planting. Normally seed is planted $\frac{1}{2}$ to 1 inch deeper in a minimum tillage seedbed than in a conventional one (Fig. 4). In either type of seedbed, seed planted early in the season should not be placed as deep as those planted later. Early in the season there is more chance for rain to restore soil moisture. And, since soil temperatures at that time are normally low, the shallow planting gives the seed extra warmth to encourage germination.

Good plowing is essential. For a successful minimum tillage system, the plow must be adjusted and operated so that it covers the trash and pulverizes the soil adequately. Plow 6 to 8 inches deep and use plow accessories such as disk coulters, jointers, or cover boards to help bury the trash. When there is a limited amount of power for the soil conditions and size of plow, it is best to sacrifice a little depth of plowing to maintain enough speed for adequate pulverization.

Soil is easier to pulverize after the first year of minimum tillage. When minimum tillage is used for the first time, the soil may be difficult to pulverize. To reduce this difficulty, it is desirable to plant after soybeans, clover, or alfalfa. During the second and succeeding years of minimum tillage, the soil will normally be less compact than at first. It should therefore pulverize easier and require less tillage.

Basic Tillage Systems

With the foregoing principles in mind, you can select a minimum tillage system that will suit your farm. Or, at least, you can survey your soil conditions, available equipment, and labor supply, and perhaps simplify some of your previous methods. Whatever plan you adopt, it’s a good idea to try only a few acres the first year and study the new system carefully for its strong and weak points.

There are three basic minimum tillage systems to choose from. All give corn yields about equal to those from conventional tillage (Table 3).

System I — Plow at regular time then plant with minimum of intermediate tillage

This system presents the least risk and is the easiest to adopt when switching from a conventional tillage system. It reduces the labor needed during planting, so there is a better chance of finishing on schedule.

Operations. Plow the soil at the regular time in fall or spring. In the spring, pull a light tillage machine such as a clodbuster, rotary hoe section,
Combining a row crop cultivator with the corn planter saves tillage trips on either fall- or spring-plowed land. The spring-plowed field at left required only one disking.  
(Fig. 5)

In the picture below, fall-plowed ground is being planted after one disking.  
(Fig. 6)

This fall-plowed ground is ready for planting with only one tillage operation in the spring. The field cultivator-spike tooth harrow combination works well. (Fig. 7)
With a special hitch, diskling and planting may be combined into one operation. (Fig. 8)

...or heavy harrow to fill in the large air pockets and pulverize large, moist clods.

*Till the soil once with sweeps on a mounted corn cultivator and pull the planter in the same trip over the field* (Fig. 5). Mount an extra sweep in the row to remove the weeds in the strip to be planted. The sweeps will push residue and old roots aside so that the planter runner has a clear path. If the sweep for the row is mounted near the back of the shank support bars or pipes it will have more clearance than if it is mounted on the front.

**Remarks.** One man can prepare the seedbed and plant the corn with one tractor. Compaction from the tractor wheels is confined to the soil between the rows, and covers a smaller total area than when diskling and planting are separate operations. Unusually rough or weedy fields may need to be disked a week or two before planting.

**Alternate machines.** With fall or spring plowing as the first operation, till the soil with a field cultivator or tandem disk at planting time (Figs. 6 and 7). Rows may be crooked if the planter is hitched to these machines, since they don’t always follow straight behind the tractor. However, special hitches are available to pull the planter from the tractor drawbar (Fig. 8).

On soil that has been fall-plowed, weeds can be controlled by spraying when they are quite small. A spraying operation takes only a small amount of labor, and loss of soil moisture will be less than for several diskling operations.

**System II — Prepare the seedbed and plant in two operations**

Corn can be successfully planted on freshly plowed soil without further trips to till the soil before planting. Planter runners and special tillage attachments (pages 10 and 11) will give extra tillage in the row.

Plowing should be delayed until just before planting. This gives the corn a chance to start germinating at the same time as the weed seed. Also, planting on freshly plowed soil pulverizes the soil so that less moisture is lost.

Meadow fields should be plowed and planted early, before the forage crop removes too much moisture. When corn stalks have to be disked, it is desirable to leave this operation until about 2 weeks before plowing and planting, to kill the early spring weeds.

Two general methods are suggested for this system of planting.

**System IIA — Operations.** Plow the soil and pull a light tillage machine. Use an aggressive light tillage machine on soils difficult to pulverize (Figs. 9 and 16). Less aggressive machines can be used on soils that are easy to pulverize (Figs. 10 and 17).

Plant the corn with the normal size planter as a separate operation. Accessories can be used to give added tillage, fill in the deep tractor wheel tracks, and leave the row level or in a shallow furrow as desired (pages 10 and 11).

**Remarks.** If cultivating problems seem likely to arise, remember that rains may reduce the size
A mulcher attachment on the plow (right) levels and tills the surface so planting can be done with a minimum number of operations. (Fig. 9)

A spiral roller (below) may be used behind a plow to give added tillage. (Fig. 10)

of some clods, or the clods can be pulverized with a rotary hoe operation. Also, rows can be hand-sprayed to delay the first cultivation.

**System IIb — Operations.** *Plow the soil.* On some soils a light-tillage machine may not be needed behind the plow, especially after the first year of System II practices. Increasing the tractor speed will give more soil tillage from plowing.

*Plant in tilled strips.* Prepare the tilled strips with attachments on the planter; or plant in the tractor wheel tracks if you can get the desired spacing.

**Remarks.** The tractor wheels will break up the soil to prepare a strip for planting in the wheel tracks. However, clay soils tend to become too compacted, so that the planter runner does not penetrate them easily. In general, wheel-track planting is best suited to sandy or light-textured soils, low in clay content.

It is difficult and sometimes expensive to get four tractor wheels located on 40-inch spacing. One company has a special four-row wheel-track planter (Fig. 11) that makes it easier to obtain the desired wheel spacing for packing the soil ahead of the planter runner. Two rows are packed with weighted wheels on the planter and the other two rows are packed with the rear tractor wheels.

**System III — Prepare the seedbed and plant in one operation**

In the plow-plant operation the seedbed is prepared and the corn planted in one trip over the field. This method eliminates any soil packing from
the tractor wheels after plowing and leaves the soil level. Soil moisture content can be a little higher at planting than when the tractor is driven over freshly plowed soil.

Large tractors or tandem tractor units will pull plows big enough to prepare a two-row strip (Fig. 12). At speeds of 4 to 6 miles an hour, a sizable acreage can be planted in a long day.

**Operations.** **Plow-plant the field.** Some farmers mount one or two one-row planters on the proper size plow. Others pull a two-row planter behind the plow with a special hitch. When a two-row planter is hitched behind a three-bottom plow, a second tractor and plow can be used to provide a strip wide enough for the two rows. Special tillage machines have been mounted on the plow or drawn between the plow and trailed planter.

**Remarks.** Plow-planting is best done around and around the field, as is common when soybeans are planted. It is desirable to disk the dead furrows before planting. Farmers who drive carefully while plow-planting find the rows are uniform enough in spacing that a four-row corn cultivator can be used.

## Tillage Accessories and Other Machines

### Tillage accessories

After a good job of plowing, the planter runner will often give enough tillage in the row to provide a good seedbed. For difficult soil conditions or for more complete soil pulverization, a number of attachments can be used on the planter or plow (Figs. 14 through 20). These devices are quite effective because they are operated in fresh-plowed soil that has the correct moisture for easy pulverizing. They till the soil in the row beyond the seed depth, and some act as leveling devices to bring about more uniform planting depth.

### Other tillage machines

Research has demonstrated that normally the moldboard plow is the most efficient machine for pulverizing the soil and covering the trash to provide a satisfactory seedbed. Extra tillage can be obtained during the plowing and planting operations so that no additional trips over the field are necessary. Other tillage machines have been studied, however, and deserve mention.

On soils that are easy to pulverize, a seedbed can be prepared with a field cultivator without using a plow. Narrow chisels on the machine make it possible to till deeper with less power. These chisels tend to leave the soil open, which is an advantage in the fall because rain and snow can enter the open soil easily. If chisels are used in the spring, however, moisture may be lost from the open soil, so it is desirable to pull a harrow behind the cultivator to level the soil.

For the operations just before planting, use narrow sweeps to leave the soil level. More sweeps on the cultivator will require more power, but if the field is weedy, the extra sweeps are needed to remove the soil from the roots.

Select a cultivator on which the shanks can be placed far enough apart to prevent clogging from the corn stalks or trash. Heavy corn stalks may need to be tandem-disked or broken up with a stalk
beater ahead of the cultivator. Trials over a 2-year period have given yields about equal to those from conventional tillage (Table 3).

**Powered rotary tiller** machines can be used to prepare a seedbed in one or two trips over the field. The rotating blades cut the soil loose, pulverize it, and mix the residue throughout the tilled layer. These actions result in what appears to be a satisfactory seedbed. However, more of the row width is tilled to a finer clod size than is necessary. This finely pulverized soil tends to be quite loose under normal conditions, but after a heavy rain it becomes very compacted and crusted, sometimes to the point of retarding germination.

Corn yields on this type of seedbed averaged 7 bushels an acre less than for conventional tillage over a 5-year period (Table 3). Since the machine has a high power requirement, travel speed is slow even with a large tractor and labor per acre is greater than for most of the other methods.

Pictured on these two pages are light tillage machines that can be attached to the planter or plow, if necessary, for better pulverization of the soil.
A plowpacker is the least aggressive attachment and the lightest in draft. (Fig. 17)

Five steel tines are used to till the soil in the row. Adjustments are provided for depth and angle of the fingers. (Fig. 19)

A rotary hoe section is between the clodbuster and plowpacker in aggressiveness. It should be pulled backward so that it won't collect cornstalks. (Fig. 18)

Fins mounted on each side of the runner roll the clods out of the row, till the soil, help to fill in deep tractor tracks, and level the surface to provide a uniform planting depth. (Fig. 20)
Cultivating and Spraying for Weed Control

The normal type of cultivator sweeps can be used in minimum tillage. Where clods are quite large, disk hillers will speed up cultivation. A set can be placed next to the row in front of or in place of the normal sweeps. These front hillers should be adjusted to move the soil and large clods away from the row. A second set of hillers may sometimes be needed to move the soil back to the row. Some of the new types of sweeps with “built-in fenders” can be used to advantage next to the row.

Cultivation will be easier if certain measures are taken at planting time. The furrow openers or leveling fins should be adjusted so the row is fairly level. Because of greater compaction, the soil in the row will naturally be somewhat lower than the soil between the rows, but it shouldn’t be much lower. If long leveling fins are used, the large clods are moved away from the row or are pulverized so that they do not cause trouble during cultivation.

Chemicals are now available to help control weeds with less tillage and compaction of the soil. Both grasses and broad leaf weeds can be controlled with a band application at planting. Illinois Circulards 771 and 839 give directions on the use of application equipment.

Chemical weed control makes it possible to delay the first cultivation until the corn is quite high, so the cultivator can travel at higher speeds. Many fields will need only one cultivation.

This circular was prepared by H. P. Bateman, Assistant Professor, and Wendell Bowers, Associate Professor of Agricultural Engineering.