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Save Money, Water, Soil with Minimum Tillage

Michigan State University Extension Service

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Save Money - Water - Soil with

# **MINIMUM TILLAGE**

**MICHIGAN STATE UNIVERSITY**

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# Save Money—Water—Soil With Minimum Tillage

By R. L. Cook<sup>1</sup>, H. F. McColly<sup>2</sup>, L. S. Robertson<sup>3</sup>, and C. M. Hansen<sup>4</sup>

## MINIMUM TILLAGE DEFINED

Minimum tillage can be defined as the least amount of tillage needed for quick germination and a good stand. In Michigan this can be done with a moldboard plow alone, or with a moldboard plow with a light smoothing implement attached. Moldboard plowing greatly increases total pore space and quickly buries crop residues and trash. This makes it possible to do an accurate job of planting right after plowing.

## SOIL COMPACTION

Soil compaction results from three forces — gravity, rainfall, and traffic. The first two vary with time and how often and hard it rains. Frequent, heavy rains or irrigation by sprinkling will pack soil in a fairly short time. Irrigation by flooding also causes compaction, especially where water stands at the soil surface for a considerable period.

All soil compaction forces become more severe as soil organic matter is depleted. This is because humus (decomposing organic matter) acts as a cement to give stability to soil aggregates. A clay soil low in organic matter may be quite friable and easy to work when first plowed in the spring. After a few rainstorms, though, the plowed layer may settle into a compact, poorly aerated mass. Every gardener of that kind of soil has seen this.

Is soil compaction desirable? Generally, no! Only for quick germination does soil need to be packed.

Seeds should be planted in a firm, well-packed seedbed — this is old but still good advice. In firm soil, water moves quickly into the seed. If the soil below the seed is firm, water will move up to supply the new seedling until roots move down into moist soil. Capillary water movement, however, is effective only for short distances. Water a few inches to the side of the seed has no effect on germination.

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You can pack the seedbed by pressing the soil on the seed in the row. Under certain conditions and for some crops you should firm the soil under the seed. Press wheels ahead of and behind the seeding mechanism, as in wheel-track planting of corn, do this well.

### ADVANTAGES OF LOOSE SOIL

Root beds should be loose. Evaporation losses are much lower from loose than from packed soil. Loose soils are well supplied with oxygen which plants must have for nutrient intake. Carbon dioxide escapes easily from loose soil. Roots permeate the loose furrow slice much more completely than through one which is too firmly packed. Plants can use soil nutrients more efficiently in loose soil.

Iowa corn experiments showed that a reduction of the total soil pore space occupied by air resulted in stunted growth and nutrient deficiency. Potassium uptake was especially lessened as total soil pore space decreased.

Water penetrates loose soils readily, reducing run-off and erosion. A workshop on slope practice was held July 19 and 20, 1956, at Purdue University. Representatives of the Soil Conservation Service, the Agricultural Research Service, the Extension Service, and State Experiment Stations agreed that plow-planting (the least amount of cultivation and packing) reduces soil loss by 40 percent. This was explained at the conference as being due to the fact that such tillage "leaves soil in condition to absorb rainfall".

On second-year corn land, where first-year corn residues are left on the surface during the winter, and where plow-planting is practiced, erosion losses will be slightly less than where corn is planted after meadow which was fitted with a field cultivator (all residues left on the surface). This was brought out at the slope practice workshop mentioned above. With minimum tillage you can grow corn on steeper slopes than is advisable where the older methods are used.

Loose soil is a better medium for organism activity. Organic matter decomposes and general soil formation processes occur faster in well-aerated soil. Of course, you need to provide more raw organic matter. The larger crops will furnish more residues, and green manures can supply what is lacking. Think of the soil as a factory. A greater output of finished product requires more input of raw material.

Weeds start slowly in loose soil. This is because the soil surface soon dries out, due to broken capillary films, and weed seeds below that zone are buried too deep for germination.

Minimum tillage saves you money. Packing soil with tractors and tillage implements before planting costs money. Basing figures on conservative custom rates, farmers would save about \$3.00 to \$6.00 an acre — this for doing less work. Considering only oats and corn, and assuming an average saving of \$4.00 an acre, the total saving in Michigan from using minimum tillage would amount to \$14 million a year.

### **TRACTORS PACK TOO MUCH**

All tillage should be a once-over operation. Some farmers have said, "I disked it lightly once," or, "I springtoothed it only once" when asked if they used minimum tillage methods. This is much less than the average amount of tillage, but it is not ideal. Tractors drawing fitting implements should not pass over plowed soil.

The first pass with a tractor packs the plowed soil almost as much as do several passes in the same tracks. Another scientist found that this first pass of a tractor on plowed soil will pack the soil 10 times as much as a second or later pass. This points out that the tractor should be driven in the tracks made by previous passes whenever possible. More damage is done by making new tracks than by driving in old ones. A study on clay loam soil showed that three passes with a cultivating tractor packed the furrow slice as firmly as the soil below the plowed layer. In other words, try to avoid using tractors on plowed land, except for the planting operation.

Large rubber tires cause less soil deformation and surface compaction than small tires. Depth of compaction, only slightly reduced by increasing the tire diameter, depends on the total load on the tire. Deep compaction is not affected by slippage of a driving tire, but is increased by liquid in the tire and wheel weights. Remove wheel weights when you don't need them for traction.

### **Do a Good Job of Plowing**

Minimum tillage, as defined here, must include a good job of mold-board plowing. Set the plow deep enough to cover trash and roots with enough soil to allow planting (7 to 10 inches). The 10-inch depth is especially good for sugar beets. Turn the furrows over evenly. Adjust coulters, jointers, and covering boards to do a good job of covering all trash, especially corn stalks. In some cases, you will need stubble rods, chains, or wires to direct trash and growing plants under the furrow. Good coverage of corn stalks also helps in corn borer control.



Fig. 1. The plow packer does as little tillage as any of the once-over implements. Experiments, however, have shown that it is sufficient as long as adequate crop stands are obtained.

Soil should not be too wet. This is always good advice but is doubly important in a minimum tillage program. Remember, there will be no chance to break lumps with disk or cultipacker.

If a good furrow can be turned, the soil is not too dry for minimum tillage, as long as you use the right planting equipment. For corn, this means *press wheels ahead* of the planter as well as *behind*, or *wheel-track planting*. Wheel-track planting is especially good when soils are on the dry side.

#### Are Smoothing Implements Needed?

Perhaps smoothing implements are not needed. A good job of plowing may be all that is needed. Many farmers plant right on the furrow. It is most likely best on sandy and sandy loam soils, and on heavier soils which are well supplied with organic matter — in other words, on those which do not present a structure problem. On soils, which turn over lumpy, whatever the cause, planting will be made easier by attaching a smoothing implement to the plow. The first cultivation of row crops will also be easier if lumps are broken with a trailing tillage tool.

The following pages suggest ways in which minimum tillage has been accomplished, and show implements which farmers and research-

ers have used successfully. A chart also shows some of the results obtained from minimum tillage.

### MINIMUM TILLAGE EQUIPMENT

Some farmers are planting directly on the furrow and are well satisfied with the results. Most farmers, however, prefer to use a light smoothing implement attached to the plow.

#### Plow Packer

The plow packer (Fig. 1) is not a new tool. Several companies have manufactured it for many years. It was one of the first implements used in a series of Michigan State University tillage experiments started in 1946. Draft requirement on a level clay loam soil was only 100 pounds. As shown by the picture, the plow packer did only a small amount of tillage. Yields, however, from plots where the plow packer was used have been just as high as where any other implement was used.

The plow packer works best on loam and lighter soils having some cover other than a heavy sod. It does very little smoothing, but it crushes soft lumps quite well.

#### Plow Packer with Press Drill

The equipment shown in Fig. 2 has worked very well for planting oats. It would do just as well for spring barley. On experimental plots, oats planted this way emerged 48 hours earlier than those planted with



Fig. 2. The plow packer and press drill combination has been a very good method for planting oats and legumes. Note the good soil condition following the drill. Seeding is through five straight disk openers. A packer wheel follows each opener. Soil is pressed on the seed to aid in quick germination.



a conventional drill. This was due to the effect of the press wheels. The drill shown in the picture was adapted for band seeding of legumes. Seedings were satisfactory.

This equipment is not recommended for seeding wheat in Michigan because it is not safe to delay plowing until planting time, simply because at that time the soil may be too dry. Field experiments, conducted over a period of several years, showed that wheat yields were just as high on plots planted with minimum tillage as they were on plots planted in the usual way, *when* all plots were plowed on the day of planting. However, land plowed a month prior to planting gave higher yields.

Such experiments have not been run with winter barley, but the writers believe the results would be similar to those obtained with wheat.

### Mulcher

The mulcher shown in Fig. 3 does a much better job of fitting than does the plow packer. It smooths the soil and is especially good where an ideal job of plowing is impossible. Do not set the spring teeth deep enough to pull up sod or trash. On a level clay-loam soil, the



Fig. 3. The mulcher smooths the soil better than the plow packer. It makes possible a more even job of planting. Yields, however, have not proved that it is better.

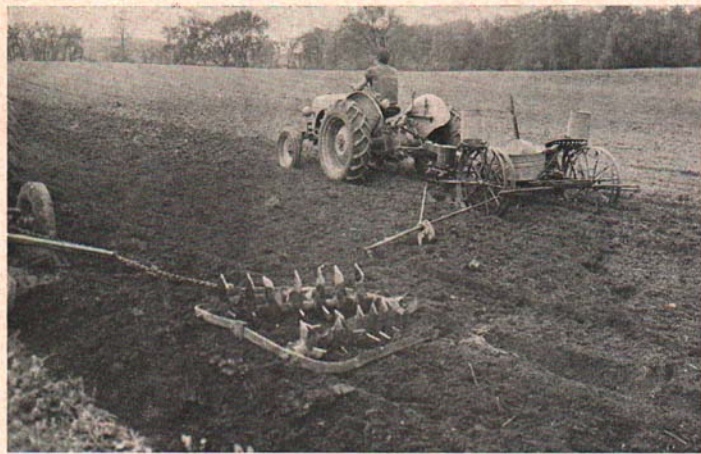


Fig. 4. Many farmers like the revolving bladed tiller. Note the desirable condition of the soil after its use. Note also that the farmer is wheel-track planting corn as fast as he plows. Even with rain that night, he did not need to refit his soil. Furthermore, the corn germinated ahead of the weeds.

draft was 250 pounds. This can be varied with the setting of the spring teeth.

Yields where this implement was used on experimental plots were not greater than where the plow packer was used. In many cases, however, first cultivation of row crops was easier on plots which had been worked with a mulcher.

#### **Revolving Bladed Tiller**

This tiller (Fig. 4) has been especially good for very heavy soils, for soils of poor structure, and for very heavy sods on any soil. The blades press the furrows down and exert some packing below the surface. At the same time the frame, hinged in the middle, does some smoothing. This action does more to correct plowing defects than does the plow packer. Thousands of these tillers are now in use on Michigan farms. Draft is about twice that needed for the plow packer.

#### **Spike Harrow**

Under most soil conditions, one section of a spike harrow is very satisfactory as a minimum tillage tool. Its good performance is shown



Fig. 5. The spike harrow is known by all farmers, and most of them have one — probably discarded. One section makes a good light-draft minimum tillage implement. Set the teeth slanting, so the frame drags on the soil. This may be hard on the frame but there are probably two more sections behind the barn.

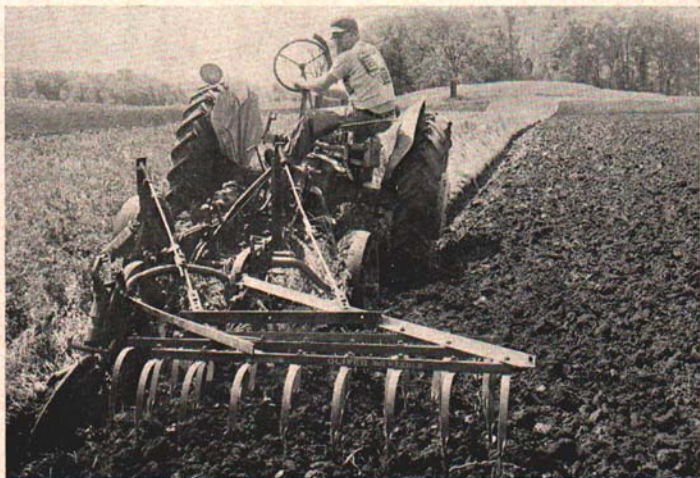


Fig. 6. The long-tined weeder, designed for weeding row crops, is a good minimum tillage tool, especially on sandy soils.

by Fig. 5. Used with a two-bottom 14-inch plow, it covers the soil twice. A rather poor job of plowing can look quite presentable when a spike harrow is attached. Set the teeth slanting so the frame drags and levels the soil better.

Spike harrows collect trash. This usually happens on the ends of the field but won't be as much of a problem if you arrange a boom to lift the harrow when the plow is lifted. This setup also automatically cleans the harrow at each end of the field. Draft was not measured but it is relatively light.

### Weeder

The weeder shown in Fig. 6 has very little draft. It seldom clogs with trash and does a very good job of breaking up soft clods. It does very little, however, in smoothing out defects caused by poorly adjusted plows. It is especially well adapted for use on loam and sandy soils. The tines are too flexible for clay or clay-loam soils except for those very high in organic matter.

Weeders like the one shown in Fig. 6 are on the market, and are available for several makes of plows. The farmer shown adapted his own from a discarded one-horse weeder for row crops.

### Rotary Hoe

The rotary hoe, run backward, serves very well as a minimum tillage tool (Fig. 7). It crumbles lumps and presses down partly turned

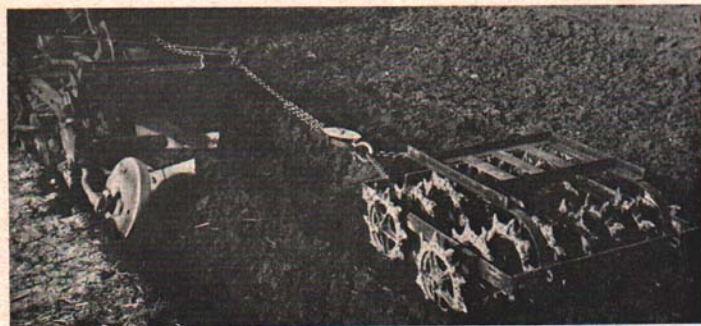


Fig. 7. The rotary hoe, run backward, does a little pressing of furrows and breaks soft lumps. Note the badly worn condition of this hoe. It still did a good job as a minimum tillage tool. There are many others in Michigan fence corners that could be used this way.

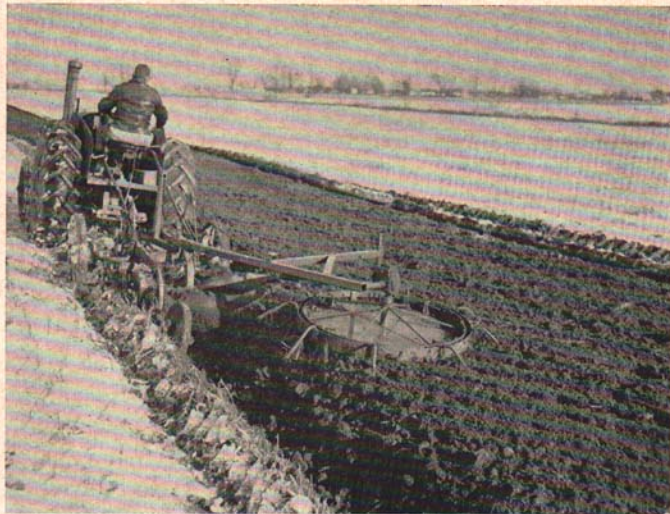


Fig. 8. This circular tiller revolves as it is pulled behind the plow. You can add weight to the wheel for more firming.

furrows. In amount of tillage performed and in draft, it compares favorably with the plow packer. Many badly-worn machines might be used to good advantage in this manner.

### **Circular Tiller**

The circular tiller shown in Fig. 8, recently put into production, tills and firms the soil by the turning action of the wheel which lies almost flat on the ground. The slight pitch of the wheel causes it to turn, and a small gage wheel holds it in adjustment. The tines are adjustable to a wide range of soil conditions. It will not clog with trash and will give any degree of soil firming with added weight. It can be easily attached to any plow and lifts with the plow for turning. It is a light draft tillage tool.

### **Other Possibilities**

The writers have used, heard of, and seen used, several other implements and adaptations. One of the earliest was a single section of spring tooth harrow. It was not too satisfactory because it pulled up trash and grass.

Cultipackers have long been used. A farmer near Mesick, Michigan uses one about 30 inches wide. Another farmer attached a full width packer directly behind his plow so that part of the packer rolled on the unplowed ground. He liked it because there was no side draft. With a 6- or 7-foot single packer, this arrangement should be satisfactory. With plenty of power, it might be possible to attach one section of spike harrow to the plowed-land end of the packer. The combination should do a thorough job.

A farmer in Clinton County dragged a log chain, held in the shape of a half loop by a short piece of 2 by 4. It was attached behind a plow packer similar to the one shown in Fig. 1 except that it had smooth rather than crow-foot packers.

### Grain Drills Adapted to Minimum Tillage

The press-drill shown in Fig. 2 is not yet used to any extent in Michigan, although it is commercially available. Accordingly, the writers have considered the use of regular grain drills in freshly-plowed, loose soil.

A tractor pulling a grain drill on loose soil makes deep tracks. These make it hard to cover the grain evenly.

A spike harrow was fitted with adjustable covering blades and was attached in front of a grain drill. (See Fig. 9.) The covering blades were adjusted to fill the tractor-wheel marks, and the spikes and har-

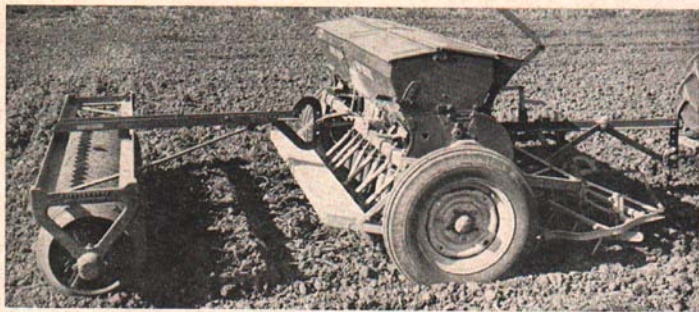


Fig. 9. This combination lets you do a good job of planting oats and legumes on the furrow. The spike harrow raises and lowers with the disks. It is up in the picture to show the leveling blades used to throw soil into the tractor wheel tracks, thus making level soil for uniform planting. You can use press wheels instead of a cultipacker.

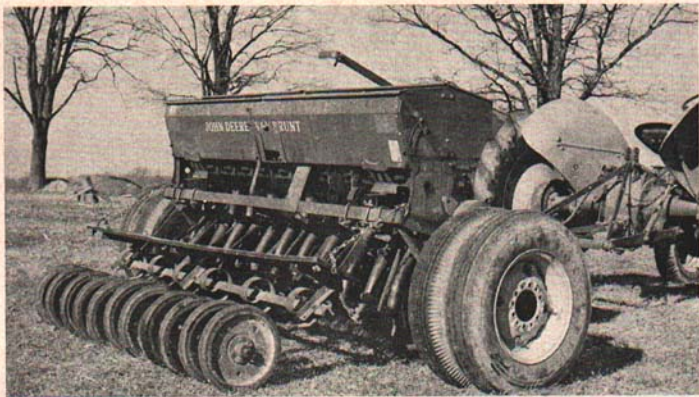


Fig. 10. Press wheels firm the otherwise loose soil around the seed to help hasten germination.

row frame smooth the plow furrows. The whole arrangement lifts with the drill disks. You can get blueprints of the plans from the Agricultural Engineering Department of Michigan State University.

Press wheels are available for most drills. Using small wheels to firm the soil around the seed hastens germination, especially in sandy soils. Seedings in small grains are often better where press wheels are used. Press wheels have also helped on medium- to heavy-textured soils that were plowed too dry. (See Fig. 10.)

Using dual wheels on the drill adds supporting surface to the drill. They are especially desirable on loose sandy soils that rut easily. You can adapt most rubber-tired grain drills to dual wheels by using an extra set of rims and four bolts. High-wheel drills with metal rims are harder to adapt. Welding a 4-inch iron strip to the edge of the metal rim has done a satisfactory job.

A farmer in southern Michigan attached a regular grain drill behind his plow (Fig. 11). With a second plow ahead, he planted his oats in record time.

A Chesaning farmer is strongly in favor of minimum tillage. He not only saves a lot of time and expense in planting oats, but finds that he cashes in again when he plows the same land for wheat. The soil is never too hard to plow, even though it is dry, and he saves a lot in fuel and plow points.

## MINIMUM TILLAGE POINTERS

### Power

Minimum tillage calls for extra tractor power. This may be in terms of a larger tractor or using a lower gear. This may not always be true, as some tractors already have more power than is required for the plow being used. This is likely to be true of the newer models.

Roughly, the mulcher and revolving bladed tiller require one-half as much draft as one 14-inch plow bottom. The plow packer and press-drill combination has about that same requirement. The other implements pictured require less draft.

### Horsepower Hours

There are several ways to figure costs of preparing a seedbed. One is to compare the horsepower hours needed by the several systems.

A horsepower hour is the unit of power used, at the rate of 1 horsepower for 1 hour. The load on the tractor can be obtained in terms of pounds pull. Draft in pounds, times the speed in feet per minute, divided by 33,000, will give horsepower. Thus, a tractor supplying 24 horsepower to pull a machine over 1 acre for a period of 1 hour equals 24 horsepower hours per acre. It will take a 12-horsepower tractor 2 hours to cover the acre, but the horsepower hours for 1 acre is still 24.



Fig. 11. Don Pace, Calhoun County, Michigan, has figured how to plow and plant oats in one operation. The rear plow has three 14-inch bottoms and a tandem packer, with the eleven-hole (7-inch spacing) grain drill attached to the outer end of the packer frame. Ahead is a two-bottom 16-inch plow with packer. Oats are fertilized and legume is seeded in one operation, leaving no tractor wheel marks.



Fig. 12 gives the horsepower hours per acre for several tillage tools. These data are averages of horsepower and time requirements for the tools working in several soil types and conditions. Heavier soils such as Brookston will require more horsepower hours per acre to prepare a seedbed.

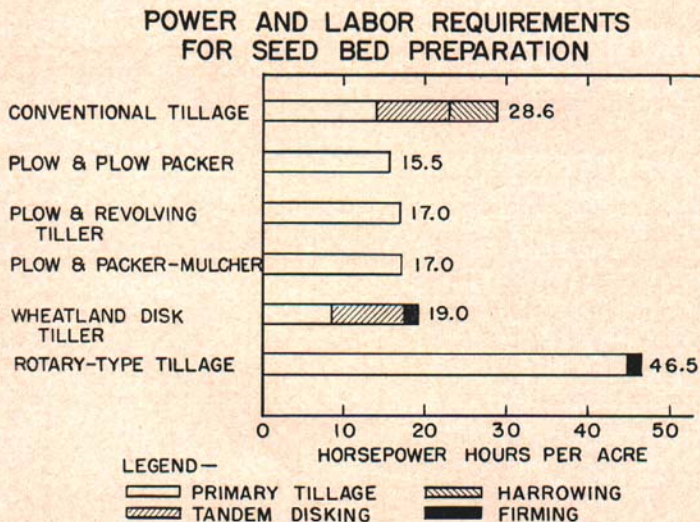


Fig. 12. This chart compares the power and work needed per acre to prepare seedbeds by different methods. For example, conventional tillage shows 14 horsepower hours for plowing, 9 for tandem disking twice, and 5.6 for harrowing twice — a total of 28.6. The minimum tillage methods, using a soil-fitting tool with the plow, use only 60 percent as many horsepower hours — a saving of 40 percent.

#### Soil Moisture

Never disturb soils when they are wet. At that time, structure is easily destroyed. Even sandy loams may be injured. You should be even more careful about soil moisture in a minimum tillage program. You won't have a chance later that year to undo the damage from plowing when too wet.

Examine the soil at *plow depth*. A handful, pressed firmly, should crumble readily. Otherwise, wait until the soil dries.

### **Plow Carefully**

Adjust the plow so it cuts deeply and lays the furrows over smoothly. Bury all residues and green plants deeply enough so they will not interfere with planting. Deeply buried residues will decompose because the soil will be left loose. You don't need to leave trash on the surface to block the flow of water and help control erosion; the loose soil will trap the water so it will not run off.

Use a short moldboard to get maximum shearing and crumbling effect. This gives the soil better aeration. Move fairly fast to better crumble the furrows.

### **Plant Immediately**

Plow and plant the same day. In Michigan, one cannot assume that tomorrow will be a fair day. A rain during the night may delay planting for several days. Extra fitting will then be necessary, and the delay in planting may reduce yields.

On the other hand, when soil moisture is low at the time of plowing, a delay of a day or so may result in enough moisture loss to slow up germination and reduce stand.

One of the big advantages of immediate planting is reduction in hazard from weed competition. Weed seeds, especially the annual grasses, start slowly. Most crop seeds germinate much faster than weed seeds. Given an even start, with plenty of fertilizer, the crops compete favorably with the weeds.

Weed seeds do not germinate until they are exposed to air. When land is plowed, the weed seeds near the surface start to germinate. Harrowing after plowing may disturb and delay them, but does not kill them. Crop seeds planted at that time do not have a chance in competition with weeds which are about to emerge. The farmer may have a hard time controlling weeds with such a head start.

### **Less Row Crop Cultivation**

Many farmers who have always cultivated their corn three or four times are now getting just as good weed control with minimum tillage and starter fertilizer with one or two cultivations. This is largely because they can wait 4 or 5 weeks after planting before they need to start cultivation. The corn shown in Fig. 13 was planted on May 14 right after the land was plowed. It was cultivated first on June 18, and again on June 25. Weeds never had a chance.

Minimum tillage, a pre-emergence spray, and one good cultivation about 5 weeks after planting is "sure-fire" weed control on any soil,



Fig. 13. This corn was wheel-track planted on May 14, the day the land was plowed. A spike harrow attached to the plow did all the tillage. The first cultivation was on June 18; the second on June 25. The row width is 56 inches. The picture was taken on July 9. (Note the absence of weeds.) This corn yielded 85 bushels of dry, shelled corn.

unless quack grass is bad. In that case, it is better to omit the spray and plan on two cultivations, the first one about 3 weeks after planting.

### RESULTS OF MINIMUM TILLAGE

Minimum tillage really does work! Experiments that we have conducted since 1946, on sandy soils, loams, and clay loams, prove that crop plants thrive best on loose soil.

Many methods of tillage were tried. None were better than those which involved the use of the moldboard plow. Disking and harrowing after plowing were harmful rather than helpful. Smoothing the furrows with a trailing implement helped make planting and cultivation

*easier*, and resulted in a better stand. But it did not increase yields where stands were not a factor.

On the Soil Science Department experimental fields, minimum tillage has become conventional. On the University farm, where the soil is sandy loam, the weeder shown in Fig. 6 is left on the plow at all times.

At the Ferden farm where the soil is clay loam, a revolving bladed tiller (Fig. 4) or a spike harrow is standard equipment. Oats, barley, sugar beets, corn, and soybeans are planted immediately after such soil preparation.



Fig. 14. Soybeans are being wheel-track planted, June 4, on land which has just been plowed with a revolving bladed tiller attached to the plow. The row width is 36 inches with 28-inch "guess" rows. Note the nice condition of the soil. Soil moisture was good, germination was fast and uniform. This method of planting has worked very well for corn, giving quick germination and good stands.



Fig. 15. This equipment applies fertilizer to be plowed under (left hopper), fits the soil with a revolving bladed tiller, applies fertilizer beside the row, and plants soybeans, all in one operation. The 30-inch rows were well enough spaced to allow the use of a two-row cultivator. For planting corn, a three-bottom plow was used and a pre-emergence weed sprayer was added. This machine is still in the experimental stage, but it has operated quite satisfactorily.

Results are better than in the days when disk, spring tooth, and cultipacker were used, especially with corn. In fact, plowed-under fertilizer has been more effective during the minimum tillage era than before.

Soybeans have done well under minimum tillage for several years at the Ferden farm and now for 2 years on a farm in Clinton County. Planting in 1957 at the Clinton location, and results for the 2 years, are shown in Figs. 14, 15, and 16.

An outstanding Huron County farmer plows sugar beet soil 11 inches deep, trails a spike harrow (Fig. 17) and plants right away. He has averaged 23 tons of beets over a 5-year period. On the same farm, prior to 1934, his father was not satisfied until he had worked sugar beet land at least 10 times. His 6-ton yields were not profitable, so he quit growing the crop.



Fig. 16. These soybeans were planted with the one-row planter shown in Fig. 15, and cultivated two rows at a time as shown here.



Fig. 17. Harold Gremel, Sebawaing, uses this method of soil preparation for all crops. He raises 23 tons of sugar beets on land where his father raised 6 tons after working the land 10 times.

The corn shown in Fig. 13 yielded 85 bushels an acre. Experimental plots on the same farm that year yielded as high as 111 bushels an acre. The crop shown in Fig. 18 was planted on June 6, 1956. Frosted before it was fully mature, the yield was 90 bushels dry shelled corn.



Fig. 18. This corn was planted on June 6, on the same day the land was plowed. A long-tine weeder was attached to the plow. This picture was taken June 30, at the time of the first cultivation. Note freedom from weeds in the uncultivated row at the left. Yield was 90 bushels an acre despite an early frost.

### SUMMARY

More than a decade of research and observations show that loose soils are more productive than packed soils, and that under Michigan conditions, the moldboard plow is the best implement to loosen them.

Many farmers agree that the only tillage necessary for top production is a good job of moldboard plowing. Others prefer to smooth the plow furrows by trailing a light tillage implement. The smoothing makes planting and the first cultivation of row crops easier, especially on very heavy soils and on those having poor structure. Several smoothing implements have been used in experimental work. There is little difference in their performances.

Yields have been as high or higher where minimum tillage was practiced as where more tillage was performed. Production costs are, of course, reduced as less tillage is used.



*On all soils . . .*

## **MINIMUM TILLAGE**

Lets rainwater soak in.

Helps prevent washing of soil.

Saves fuel and machinery.

Saves time for the farmer.

Gets crops in earlier.

Makes weed control easier.

Brings satisfactory yields.