Tillage Systems for Michigan Soils and Crops
Part II: Secondary Tillage and Cultivation
Michigan State University
Cooperative Extension Service
L.S. Robertson
C.M. Hansen
A.E. Erickson
Extension Specialists in Crop and Soil Sciences and Agricultural Engineering
February 1979
8 pages

COOPERATIVE EXTENSION SERVICE · MSU AG FACTS

Tillage Systems for Michigan Soils and Crops

PART II: Secondary Tillage and Cultivation

No. 122 Extension Bulletin E-1042 Reprinted February 1979

L. S. ROBERTSON, C. M. HANSEN and A. E. ERICKSON
Extension Specialists in Crop and Soil Sciences and Agricultural Engineering

TILLAGE CONCEPTS, implements and terminology are changing. While most farmers still believe that some tillage is necessary, others question its essentiality. A few are successfully combining limited tillage, pesticide application and planting into one or possibly two operations, thus greatly reducing both time and cost of crop production without sacrificing yields.

SECONDARY TILLAGE

Secondary tillage is the process of seedbed preparation after a field has been plowed. The desirability of secondary tillage is dependent upon soil characteristics after plowing. If there are no weeds, large clods or crusts, and if the surface of the field is relatively smooth, there is little justification for secondary tillage. In fact, under such circumstances, secondary tillage may be harmful, especially when a very fine seedbed is produced and where heavy tractors pulling tillage tools excessively pack the soil.

The depth of compaction produced by tractors pulling secondary tillage tools is not well understood. The information in Figure 1 shows that depth of compaction increases with moisture content of the soil. If the subsurface soil is wet, compaction will be excessive and deep.

In Figure 2, tire size and tractor weights are variables, but the pressure remains a constant, 12 psi. Notice the greater depth of compaction by larger and heavier tractors. Such compaction is not readily visible when using secondary tillage tools because the compact zones are covered with freshly tilled soil.

The effect of the deeply compacted soil can be minimized where width of a secondary tillage tool is matched to the power of the tractor and where, in successive trips across the field, the same wheel tracks or "roadbed" is used.

The basis for suggesting that the same roadbed be used is shown in Figure 3. Seventy to 90% of the total compaction occurs on the first trip across the field. By using the same roadbed, ruts in the field will be slightly deeper but the soil between the ruts will not be compacted. Dual wheels obviously reduce the depth of ruts, but spread the compacted zone over wider areas. If compaction with dual wheels is excessive, such as sometimes occurs in the spring when farmers use dual wheels to keep from getting stuck in a wet field, soil structure problems are more evident than where only single wheels are used on drier soil.

Secondary tillage may be desirable where, after plowing, large amounts of trash and crop residues are left on the soil surface. Under such circumstances, conventional planters do not place seed and fertilizer in a precision manner. Also good contact between seed and soil is not estab-

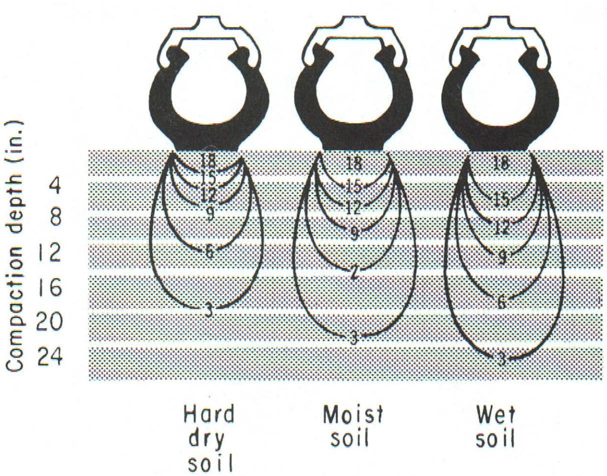

Figure 1—How soil moisture affects soil compaction. The lines in the soil under the tire represent curves of equal pressure. In all three situations the tire size was 11 x 28, the load was 1,650 pounds and the pressure 12 psi. On wet soil, pressures were transmitted to depths of more than 24 inches. (Source—Soehne, Jour. of Agr. Eng., May 1958.)

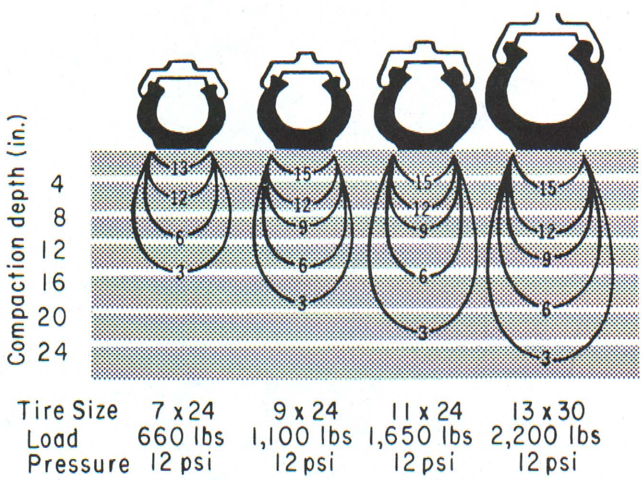

Figure 2—How tractor loads affect soil compaction. The lines in the soil under the tire represent curves of equal pressure. In this diagram pressure per unit area is a constant 12 psi. The size and total weight increase with tractor size as does depth and width of transmitted pressure. (Source—Soehne, Jour. of Agr. Eng., May 1958.)

lished. Secondary tillage may also be necessary when the surface inch or two of soil is dry. Planting seed in moist soil is essential for rapid germination.

On fine-textured soil hard clods may be a problem. Secondary tillage breaks, cuts or buries the clods so that they do not affect planting.

Herbicide use becomes a real problem on some farms because its effective use requires finely granulated soil. To produce such a condition more tillage than otherwise necessary is frequently required for rapid seed germination and a good stand. Unfortunately, after application, some herbicides need to be worked into the soil. This herbicide requirement is one of the major reasons why soil compaction problems are more common than in the past.

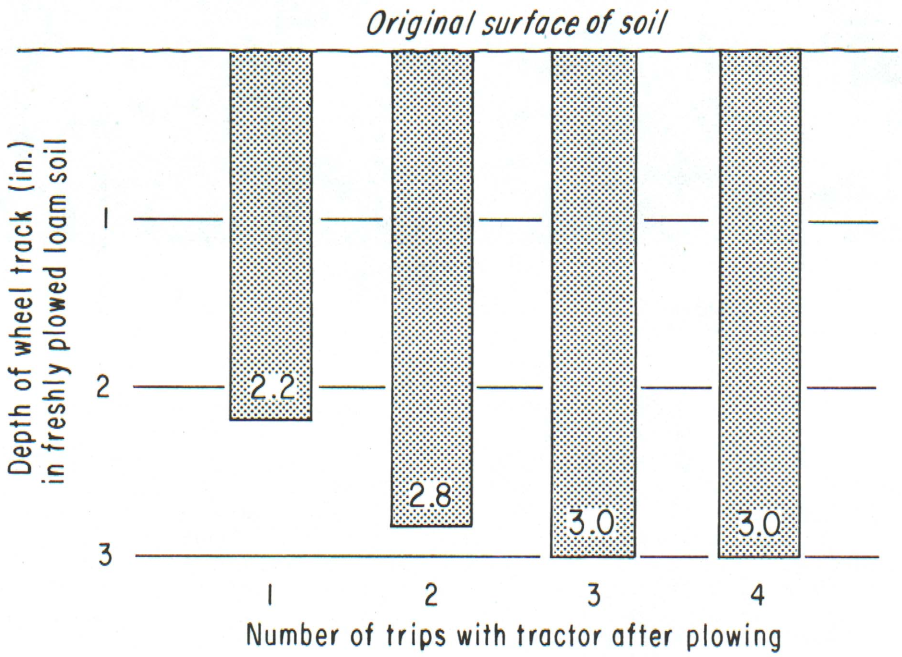

Figure 3—In a freshly plowed soil, most compaction caused by tractor tires occurs in the first pass over the field. If compaction is excessive, root growth and crop yields will be affected.

Objectives of Secondary Tillage

1. To smooth the surface of the soil to facilitate precision planting.
2. To break down large clods to facilitate precision planting.
3. To incorporate herbicides.
4. To provide stable traction for tractors and implements.
5. To mix dry soil materials with moist to insure rapid seed germination.
6. To kill weeds.
7. To improve surface drainage.

Disc

The disc is the most common secondary tillage tool in Michigan (Figure 4). It cuts through trash and clods because it puts up to 300 pounds of weight on each foot of soil tilled. It does an excellent job of mixing together dry and moist soil materials, incorporating crop residues and in repacking freshly plowed soil. Considering the amount of soil moved by the disc, power requirements are low. As with all secondary tillage tools, multiple treatments are possible. This tool is especially well adapted to the conditions created with chisel plows.

The major drawback to the disc is that it is a compacting tool because all of the weight rests on the discs which are relatively narrow. The vibration of the turning disc as it skids through the soil tends to orient soil particles so that soil porosity immediately below discing depth is significantly reduced. Increased frequency of discing accentuates this problem and, in some instances, the soil porosity directly below the discing depth is reduced sufficiently to in-

Figure 4—The disc loosens the surface soil to a depth of several inches but compacts the soil immediately below tillage depth. Opportunities for excessive compactness increase with soil moisture levels. It is seldom that the disc loosens the soil to the depth of compaction caused by the tractor pulling the disc.

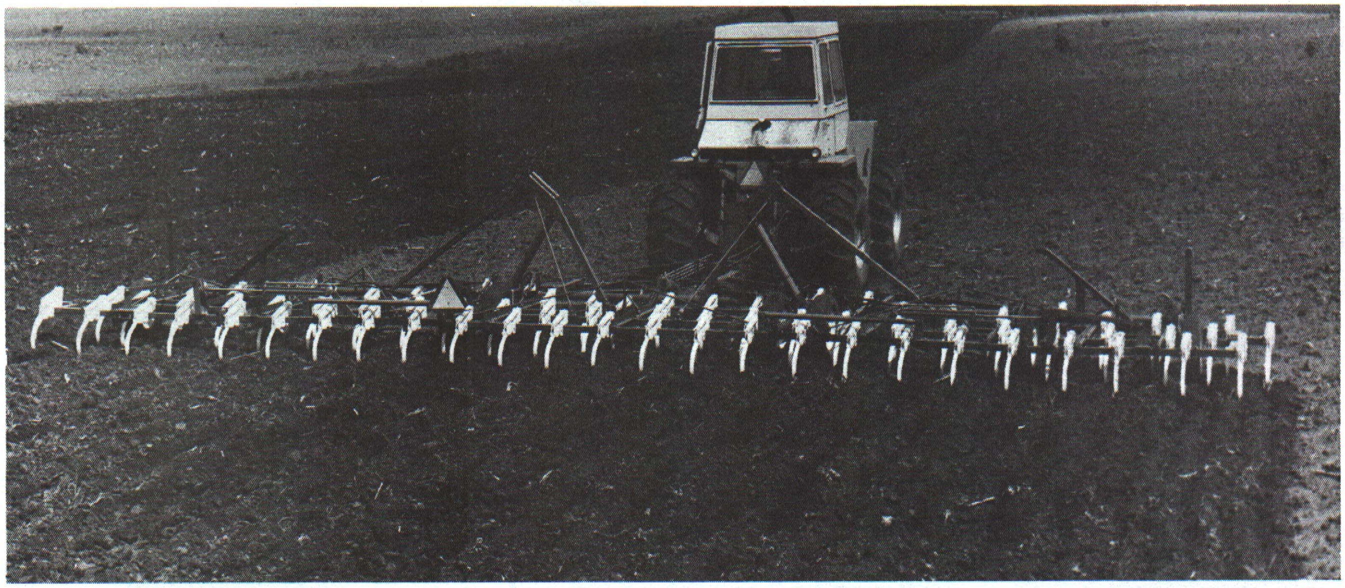

Figure 5—This field cultivator tills a strip of soil 42 feet wide. In this instance, it is used for two purposes: (1) to destroy a thin crust that developed before the field could be planted and (2) to kill very small weeds that started to grow after the first secondary tillage treatment. Because the field cultivator does not loosen the deeply compacted soil in the tractor wheel marks, the same "road bed" should be used for each tillage treatment.

hibit root growth and water movement.

Field Cultivator

The use of the field cultivator is increasing in Michigan (Figure 5). This implement is designed primarily as a secondary tillage tool, although on occasions, especially on sandy soils, it is used as a primary tillage tool. It differs from the chisel plow in that frames and shanks are lighter weight. The shanks are generally more flexible and have closer spacings—frequently at 6 or 7 inches.

The field cultivator is best used for seedbed preparation after moldboard plowing. It is effective in killing small weeds and in loosening fall-plowed soil for better erosion control. It may be less effective on spring chisel-plowed soil, especially those that have large amounts of crop residues on the surface. This tool is more effective than the disc on fall chisel-plowed soils where weeds are dead.

Some field cultivators have relatively small tines of spring steel spaced somewhat closer than on the conventional field cultivator. These are referred to as Danish tooth or flexible-tine field cultivators. The teeth frequently do not penetrate as deeply into the soil as the standard field cultivator. The flexible-tine field cultivator is designed to be used at high speeds, five to seven miles per hour. Under such conditions, the rapidly flexing tines shatter clods, break crusts and tear up small weeds.

Draft requirements are similar to a disc ranging between 250 and 300 pounds of force for each foot tilled. More crop residues are left on the surface, and the surface soil is not as smooth, thus resulting in better wind and water erosion control. It should be realized, however, that occasionally residues on the surface may harbor insects and diseases. Also there is less soil compaction because the digging action is different from the cutting and pressing action of discs. In very cloddy fields, many crop pro-

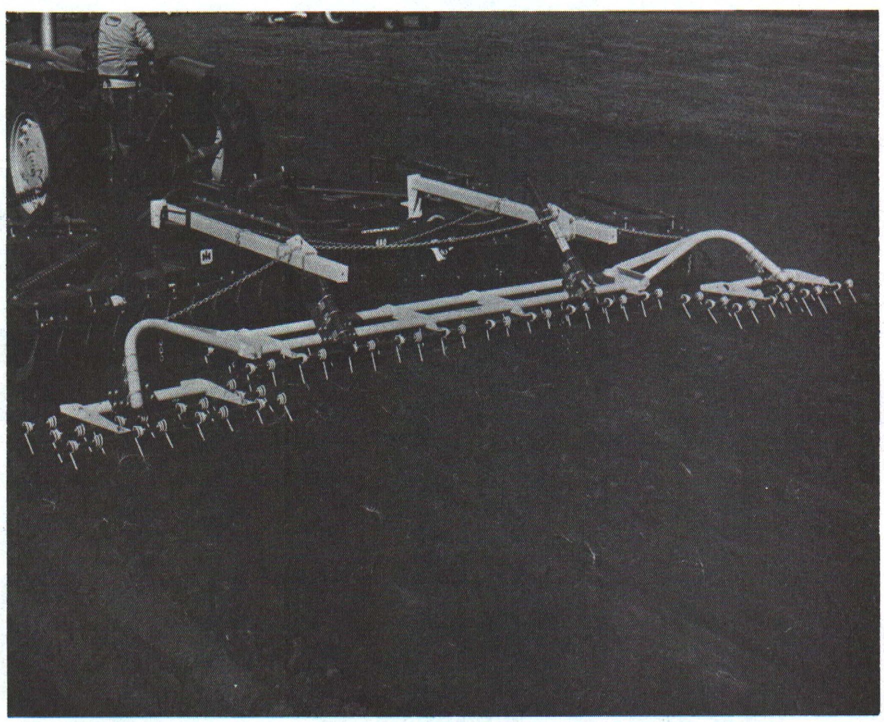

Figure 6—A flexible-tined harrow attached to disc. This special harrow smooths the surface of the soil, thus making it easier to place both fertilizer and seed in a precision manner into the soil.

ducers prefer a disc because hard clods tend to slip between the shanks of a field cultivator.

Harrows

While discs are sometimes considered as harrows, most consider harrows as a light-weight tillage tool used primarily for smoothing the surface of the soil, destroying crusts and controlling weeds. Tillage depth usually is not as great as with a disc or other secondary tillage tools.

Harrows, such as the spike-tooth or spring-tooth, were once used independently of other tillage tools. Today they may be an attachment to or in tandem with another tillage implement (Figure 6). As such, their primary function is to smooth the surface soil to expedite precision seed placement.

Mulchers

Mulchers are relatively heavy equipment designed for conditions where there is little trash on the soil surface and where the soil is relatively cloddy or where a sandy soil needs to be gently firmed to reduce evaporation (Figure 7). Contrary to the thinking of many, this tool, in comparison with the disc, does relatively little packing, as its weight is supported by the two sets of rollers. Mulchers are finding their place on many farms where secondary tillage is necessary after moldboard plowing. Farmers who have relatively level fields of fine-textured soil that was fall plowed like this tool as a once-over preplanting spring treatment.

Tips on Secondary Tillage

1. Provide for rapid water drainage, both surface and internal, before any tillage treatments are made.
2. Test subsoil moisture levels before tillage so tractor wheels won't excessively compact the soil.
3. Till no deeper than necessary.
4. Till no more frequently than necessary.
5. Combine tillage, fertilizer and pesticide applications into one or two operatons.
6. Use the same tractor wheel marks where possible for extra secondary tillage, planting and fertilizer and pesticide application.
7. Don't use secondary tillage in the fall or winter except on clay and clay loam soils.

TILLAGE SYSTEMS

Crop producers too frequently have a formula for tillage. Regardless of season, crop or soil conditions, select procedures are rigidly followed. This results not only in a waste of time and money, but increases opportunities for erosion in many situations.

Basically five major tillage systems are available to Michigan farmers (Table 1). Variations within a given system have been coded A through D. In all instances the least erosive system is Code A and the most erosive is Code D.

In **system 1**, where tillage is necessary, all is accomplished in the spring. Historically, this system has been as productive as the best and has the advantage of holding erosion opportunities to a minimum. It has one disadvantage (except in Code A): due to time limitations it is not well adapted to very large farms where, for timely planting, some fall plowing is necessary.

System 2 is similar to system 1 except it recognizes that some soils have deep-lying zones of compact soil material. Therefore, subsoiling, which should never be done in Michigan in the spring, is necessary. As in system 1, this is better suited to smaller farms. On large farms, the no-till concept has its place (Code A).

Primary tillage is done in the spring to loosen the surface soil, control weeds, insects and diseases, and to incorporate large amounts of fertilizer or lime. If a good job of plowing is done, no secondary tillage should be necessary.

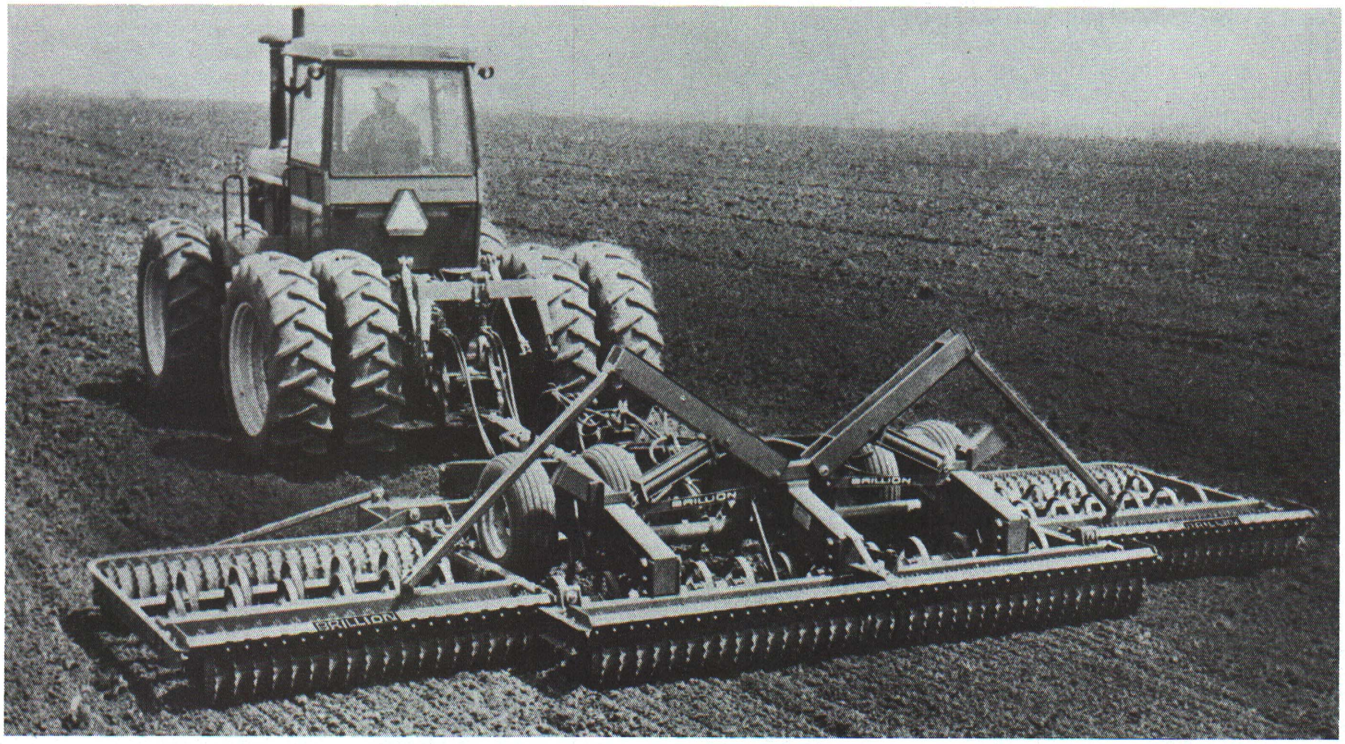

Figure 7—The mulcher represents a special combination of cultipacker rollers and spring tooth harrow. It has been especially effective as a once-over tool on fall-plowed, fine-textured soil because it easily breaks down or buries large clods. Producers with sandy soil like this implement because they believe that moisture loss from the seed zone is less than where other implements are used.

System 3 is well suited to large farms where the fields are relatively level and there is little danger of serious erosion. Code D should be used only where the soil has a clay loam or clay texture and where very early planted crops such as sugarbeets, oats or barley are grown.

Secondary tillage in the fall should be done only if it eliminates some secondary tillage in the spring. It should be recognized that fall secondary tillage treatments increase opportunities for both wind and water erosion.

Systems 4 and 5 are not necessary or desirable on most farms. They are designed for problem soils, especially those with deeply compacted zones. The same concepts as previously discussed in regard to erosion potentials and time of secondary tillage apply to these systems.

Table 1. Tillage Systems for Michigan

System number	Tillage code	Time of tillage system: Fall	Spring
	A	....	No-till
1	B	....	Primary-plant
	C	....	Primary-secondary-plant
	A	Subsoil.................	No-till
2	B	Subsoil.................	Primary-plant
	C	Subsoil.................	Primary-secondary-plant
	A	Primary.................	Plant
	B	Primary.................	Secondary-plant
3	C	Primary-secondary........	Plant
	D	Primary-secondary........	Secondary-plant
	A	Subsoil-primary	Plant
	B	Subsoil-primary	Secondary-plant
4	C	Subsoil-primary-secondary .	Plant
	D	Subsoil-primary-secondary .	Secondary plant
	A	G.P.*	Plant
	B	G.P.....................	Secondary-plant
5	C	G.P.-secondary	Plant
	D	G.P.-secondary	Secondary-plant

**Giant plow*

CULTIVATION

Cultivation is a tillage operation after seed is planted or after young plants have emerged. The reason for cultivation includes breaking crusts, controlling weeds, increasing rainwater infiltration rates, controlling erosion and facilitating harvests.

With herbicides, less cultivation is practiced than in the past. However, with some crops, especially those of high value, cultivation remains a significant input in crop production costs. In many instances, fields are cultivated hoping that the soil will capture more of the water from summer rains. With no-till methods used as recommended, cultivation is not possible or desirable because organic matter on the surface of the soil prevents the formation of soil crusts. Water infiltration is usually rapid.

Rotary Hoe

The rotary hoe is used less frequently than in the past. Its greatest benefit was in weed control and breaking crusts. Used at high speeds, its tines penetrate the soil to a shallow depth tearing out small weeds and destroying thin crusts. Many bean farmers like this implement because it ranges up to 30 feet wide, and many acres can be treated in a relatively short time. Its most effective use is obtained at speeds ranging between 5 and 7 miles per hour.

Some farmers believe that the rotary hoe is less effective now than in earlier years. If this thought is valid, the explanation is probably related to the firm or packed soil conditions and the thick crusts found on many farms, especially those with fine-textured soil. Such a condition is usually the result of excessive tillage.

Row Cultivators

Many designs of row cultivators are available. Some involve a modification of the rotary hoe concept, while others use the vibrating tine principle. Still others use rigid shanks to which several designs of shovels can be attached. No one design is best because soil conditions vary as much as do the reasons for cultivation. The most important considerations involve good depth control and stability as the cultivator moves down the row at a reasonable speed.

Many potato and dry bean producers like to move some soil into the row at the last cultivation. This practice aids in controlling weeds growing in the row and with potatoes, fewer

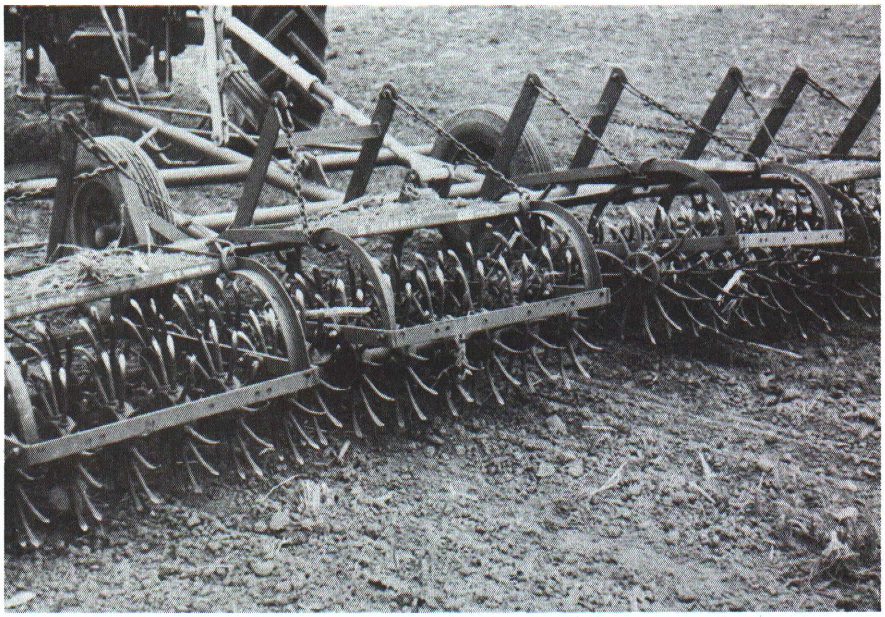

Figure 8—The rotary hoe is effective only when used at high speeds on relatively dry soil. Both dry bean and soybean producers have liked this implement because it tears out small weeds and destroys thin crusts. Some feel that this tool is not as effective as in the past. The successful use of herbicides reduced the need for this tillage tool.

green tubers are produced. Most farmers feel that the crop is easier to harvest. Bean pullers and potato diggers need not penetrate the soil so deeply at harvest time. Great care needs to be exercised in this process because numerous observations show that roots are frequently destroyed, especially in compacted soil.

In general, cultivation should be shallow. Penetration of teeth or shovels should be no more than necessary to destroy a crust or to kill weeds. Also, in general, a Michigan grown crop should be cultivated no more frequently than necessary. Many producers now grow corn with no row cultivation.

Tips on Row Cultivation

1. Check subsoil moisture levels before cultivation, and do not cultivate where tractor wheels will compact the soil.
2. Be certain that vegetation is dry so that disease is not spread.
3. Cultivate no deeper than necessary.
4. Adjust the cultivator to prevent root pruning.
5. Use recommended speed so that soil moves without damaging the crop.
6. Check cultivator twice a day to be certain that it remains in adjustment.
7. Replace worn shovels.
8. Cultivate no more frequently than necessary.

POWER REQUIREMENTS

Power requirements for tillage are variable, depending upon many considerations. Fuel consumption is but one evaluation, but realistically reflects energy consumption. The information in Table 2 should not be considered as representative of fuel use on a specific farm or soil but as relative to the fuel used with different implements. In other words, more fuel will be consumed when plowing with a moldboard than with a chisel plow, assuming same tillage depth. The data show clearly why minimum tillage methods conserve more fuel than conventional tillage and why no-till methods require the least amount of fuel.

Table 2. Estimated fuel requirements for field operations that have a tillage effect.*

Operation	Fuel needed
Primary tillage	**Gal/A**
Moldboard plow	1.8
Chisel plow	1.2
Rotary plow	2.1
Plow-plant in one operation	2.0
Secondary tillage	
Disc—corn stalks	0.4
Disc—plowed soil	0.5
Field cultivator	0.4
Cultivation	
Row cultivation	**0.3**
Rotary hoe	**0.2**
Miscellaneous	
Applying anhydrous ammonia	0.4
Planting—plowed soil	0.3
Planting—no-till	0.3
Spraying herbicide	0.3

**Diesel fuel consumption calculated from several sources. For gasoline, multiply by 1.4; for L.P. gas, multiply by 1.7.*

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2P-10M-2:79-UP, Price 25 cents.

Michigan State University Printing

O-11146