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Tillage Systems for Michigan Soils and Crops

PART I: Deep, Primary, Supplemental and No-Till

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TILLAGE MAY BE necessary for several reasons, including:

1. Loosening a compact soil
2. Destroying weeds
3. Incorporating fertilizer and lime
4. Using livestock manure effectively
5. Reducing soil erosion
6. Incorporating pesticides
7. Preparing for the harvest of such crops as navy beans.

Many kinds of tillage tools are available. All are most effective on optimally moist (relatively dry) soil, while some are better adapted to fine-textured soil such as clay loam and clay. The best tool to use is based on the reason for tillage. If a reason is not obvious, tillage probably is unnecessary.

DEEP TILLAGE

Deep tillage involves any implement that penetrates the soil to a greater depth than possible or usual with a moldboard plow. Thus, deep tillage is likely to improve crop yields only on problem soils and under average conditions will have little effect.

Deep tillage has improved crop yields in Michigan under two situations. One involved compact soil zones immediately below the plow layer. Such conditions may be natural but are more likely to be the product of poor management or unfortunate circumstances such as having to harvest a crop on wet soil. Working soil at high moisture levels is a common cause of soil compaction. Also plowing with tractor wheels in the furrow of a wet soil creates similar conditions, except that the compacted zone is deeper.

Soils that have been compacted by such treatments will be improved by deep tillage only if the soil is relatively dry at tillage time. Tillage of wet soil causes puddling and decreases yields.

Yield responses to deep tillage have been greater on soils with artificially produced compact zones than on soils that are naturally compact. An explanation is not evident unless the naturally compacted zone is too thick for deep tillage tools to penetrate.

The other situation where deep tillage increased crop yields represents an uncommon condition in Michigan. In the lake plain areas of the state there may be a sand lens several inches thick between horizons of fine-textured soil material. Under such circumstances it is frequently possible to see the location of tile lines (Figure 1). When the lens is less than two feet deep, it can be destroyed by plowing through the lens, thus improving water movement patterns, root distribution and depth, and crop yields.

There are two classes of deep tillage tools, subsoilers and giant plows. Subsoilers are available which will penetrate the soil to a depth of 3 feet. Giant plows have been used only experimentally in Michigan. Both moldboard and disc types are available.

Subsoilers

Subsoilers are chisel-like tools designed to penetrate the subsoil to break up hard or dense layers. Most are designed to have minimal effect on trash or crop residues left on the surface. Subsoilers (Figures 2 and 3) have increased crop yields but the effect was inconsistent from year to year. No explanation of this situation was made but apparently was related to soil moisture levels at subsoiling time and to the kind of weather that prevailed after treatment during the growing season.

In general, subsoiling in Michigan should be done in the fall when soil moisture levels are normally low. Un-

Figure 1—An alfalfa field showing location of tile lines in soil with a sand lens approximately 24 inches deep. Soil above the lens is compacted because tile did not function as expected. On occasions, it was necessary to be in the field when the soil was wet. Deep plowing is the only known solution to this problem.

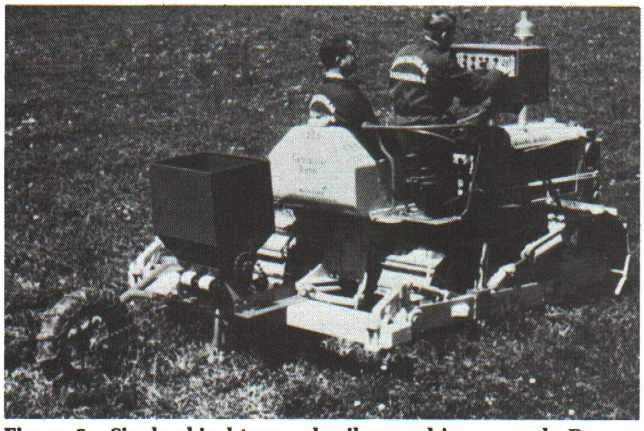

Figure 2—Single-chisel type subsoiler used in research. Deeper penetration is possible with single-chisel tools than multiple chisels. Strain gauges have been added to this equipment to measure power requirements and to test design. It also includes a special device for placing fertilizer, lime or other soil amendments into the subsoil at variable rates and depths.

Figure 2-B—This single tooth chisel subsoiler is designed for deep penetration. The "foot" has a lifting action which is effective only when used on dry soil. Deep subsoiling should not be attempted on wet soil.

fortunately, on occasions, the fall season is wet. Under these circumstances, deep subsoiling should be postponed until the subsoil is dry. Working wet soil decreases porosity, thus making it more compact. Surface as well as tile drainage on lake plain clay loam and clay soils removes excessive water, thus improving the effect of subsoilers.

An actively growing deep-rooted crop such as corn, sugarbeets, or alfalfa tends to decrease subsoil moisture levels, thus making treatments more effective, although power requirements are increased.

Subsoilers should be used only on well-drained soil, otherwise water may collect in the subsoil, thus delaying subsequent tillage treatments and planting.

In tiled fields, especially those with shallow tile, care must be exercised so that tile are not broken. On research plots with tile located 34 to 38 inches deep, tile were broken while subsoiling to depth of 26 to 28 inches. It is good insurance to have a minimum of 12 inches between the tip of the subsoiler and the tile.

From a theoretical viewpoint, subsoiling should be most effective when treatment is across the tile. With shallow tile, make treatments parallel with and between tile.

In the past, questions have been raised on the value of fertilizer and lime placed in the subsoil with deep tillage equipment. Extensive research on Michigan soils failed to demonstrate any benefit from this practice, provided the surface soil was not low in plant nutrients. Most crops are able to extract ample nutrients from the surface soil.

Giant Plows

Giant plows are available as both moldboard and disk types. The moldboard type is better suited to inverting the plow layer, while the disk type can be adjusted for mixing surface with subsurface soil materials. Giant plows (Figure 4) have been used experimentally in Michigan to till soil to

Figure 3—Modern multiple-shanked subsoiler. The tillage effect is more complete than with single-shank shown in Figure 2. Depth of penetration frequently is limited with multiple-shank tools. Such implements are especially well suited for destroying tillage pans or for loosening relatively shallow compact horizons.

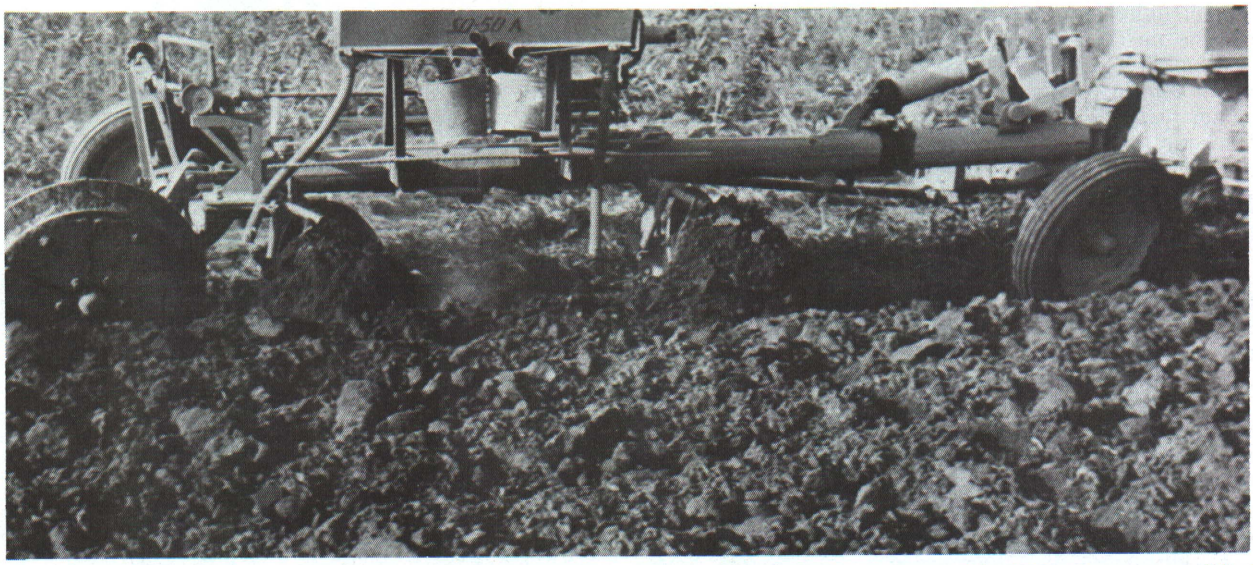

Figure 4—Giant disc plow used in Michigan research program. Penetration to 30 inches was possible. This plow was modified for application of fertilizer and lime as plow down treatments. While this plow was designed with four discs, only two were used because of inadequate power. Deep plowing is the only known way of improving the soil conditions described in Figure 1.

depth of 30 inches. The only known method of permanently improving the physical condition of soil with a sand lens is with a giant plow.

Giant plows have also been used to bury diseased crop residues. Research with Verticillium wilt of peppermint showed that the disease could be controlled for a short time but that the effects were only temporary. Similar precautions to those described for subsoilers is strongly urged.

PRIMARY TILLAGE

Primary tillage involves complete treatment of the surface horizons. It is the first and most intensive, as well as the deepest, tillage treatment, unless the field has been subsoiled.

Four types of primary tillage tools are common in Michigan: the moldboard, disc, chisel and rotary type plows. Each has its place and should be used to achieve previously suggested specific goals.

Moldboard Plow

The most universally used primary tillage implement in Michigan is the moldboard plow (Figure 5). When properly adjusted and used at medium soil moisture levels, it surpasses all other implements in loosening the soil, while incorporating crop residues, manure, fertilizer or lime and in reducing opportunities for weed, insect and disease problems. In addition, it can be adapted for the application of anhydrous ammonia, thus saving one field operation and an-

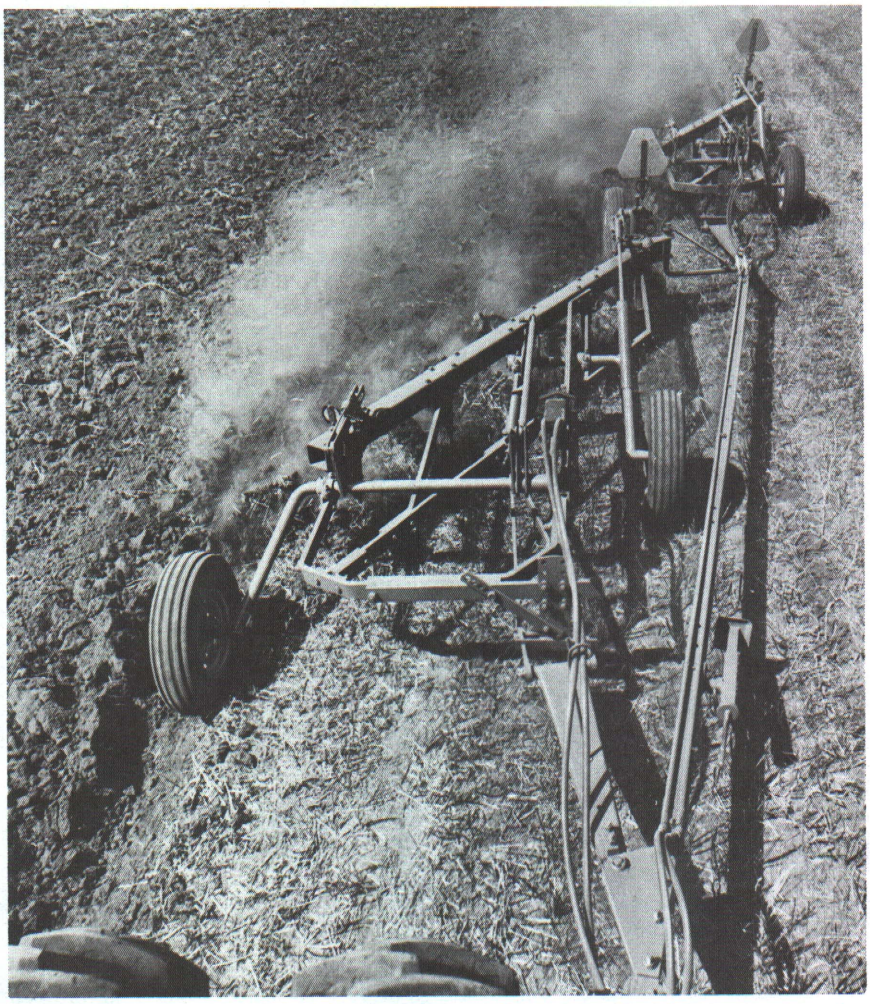

Figure 5—Modern, tandem moldboard plow used on dry soil to increase rain water infiltration rates and to loosen a compacted soil. Dual wheels of tractor are on-land rather than in-furrow, which is desirable when working soil with more moisture. With the modern, high-clearance moldboard plow, there is little need to disc or chop crop residues before plowing.

other opportunity for soil compaction.

How the moldboard plow loosens the soil and increases air space is shown in Figure 6. Before plowing, this loam soil had 23% air space, which represented 1.5 inches or slightly more space than that occupied by water. With minimum tillage, which in this case represented only moldboard plowing, the air space was increased to 4.5 inches which is equal to 47% of the total soil volume. In this situation, the soil could absorb in excess of 4 inches of rain and have no erosion. Therefore, loosening a soil with a plow has the immediate effect of resisting erosion.

The dotted line in Figure 6 representing minimum tillage shows the extent to which air space decreased during the growing season. Thus, plowing has only a temporary effect on total soil porosity and erosion resistance.

While plowing and planting in one operation is no longer practiced on commercial farms, the practice has significant advantages as can be seen in Figure 7. With the soil between the rows containing 45% air space, it dries rapidly, preventing many weed seeds from germinating. With large-sized pores, water infiltration is rapid. This soil can absorb more than 4 inches of rain.

The moldboard plow has some disadvantages. The power requirements

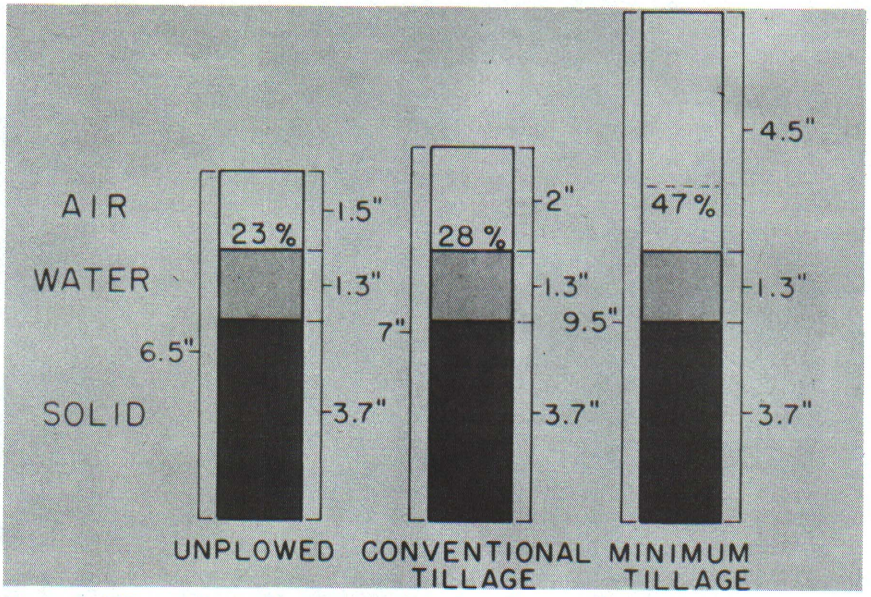

Figure 6—Tillage affects air space in soil. Before plowing, this soil contained 23% air space, which is typical in central Michigan. With conventional tillage methods, including 2 discings, space for air increased only 5% to 28. However, with minimum tillage, which in this instance involved only plowing and no secondary tillage, air space was increased to 47%. This is a desirable situation because there is ample space in the soil to store large volumes of rainwater without having any significant erosion or creating conditions leading to an oxygen deficiency.

are relatively high because it moves large volumes of soil a distance of 14 or more inches. Soil movement is forward, lateral and upward, all in one action. Large plows involving 6 to 12 bottoms are clumsy because they extend so far back of the tractor.

Figure 7—Moldboard plowing and planting in one operation with research implements. The soil between the rows contains in excess of 40% air space, which retards weed seed germination. It is in good condition to receive and store water from a heavy rain. The ideal moisture level for plowing is also the ideal level for rapid seed germination. Press wheels on the planter firms moist soil around the seed, insuring rapid germination. A well-adjusted plow on this well-drained medium-textured soil is loosening the soil and greatly improving its porosity.

Most moldboard plows are designed to be used at a given speed. Slow speeds result in incomplete fracturing of the soil, while excessive speed throws the soil material a greater distance than necessary, thus increasing power requirements.

Precision adjustment, especially as related to coulters and jointers, may be difficult without reference to a manual. Improper adjustment results in excessive wear, increased power requirements, incomplete shattering of the soil and failure to completely cover trash and crop residues.

The major problem with the moldboard plow is that after plowing, the soil is completely exposed to the weather. There is nothing to protect the soil from the devastating forces of a driving rain or strong wind until a good crop cover is established. Soil moisture losses, especially after secondary tillage, may be excessive.

Chisel Plow

The chisel plow is increasing in popularity in the corn belt including southern Michigan as well as in the northern section of the state (Figure 8). It is best adapted to fine-textured soils and to cash crop farms where soil fertility levels are high and where no manure needs to be plowed down.

The chisel plow is effective in loosening a soil that has been compacted by excessive or untimely till-

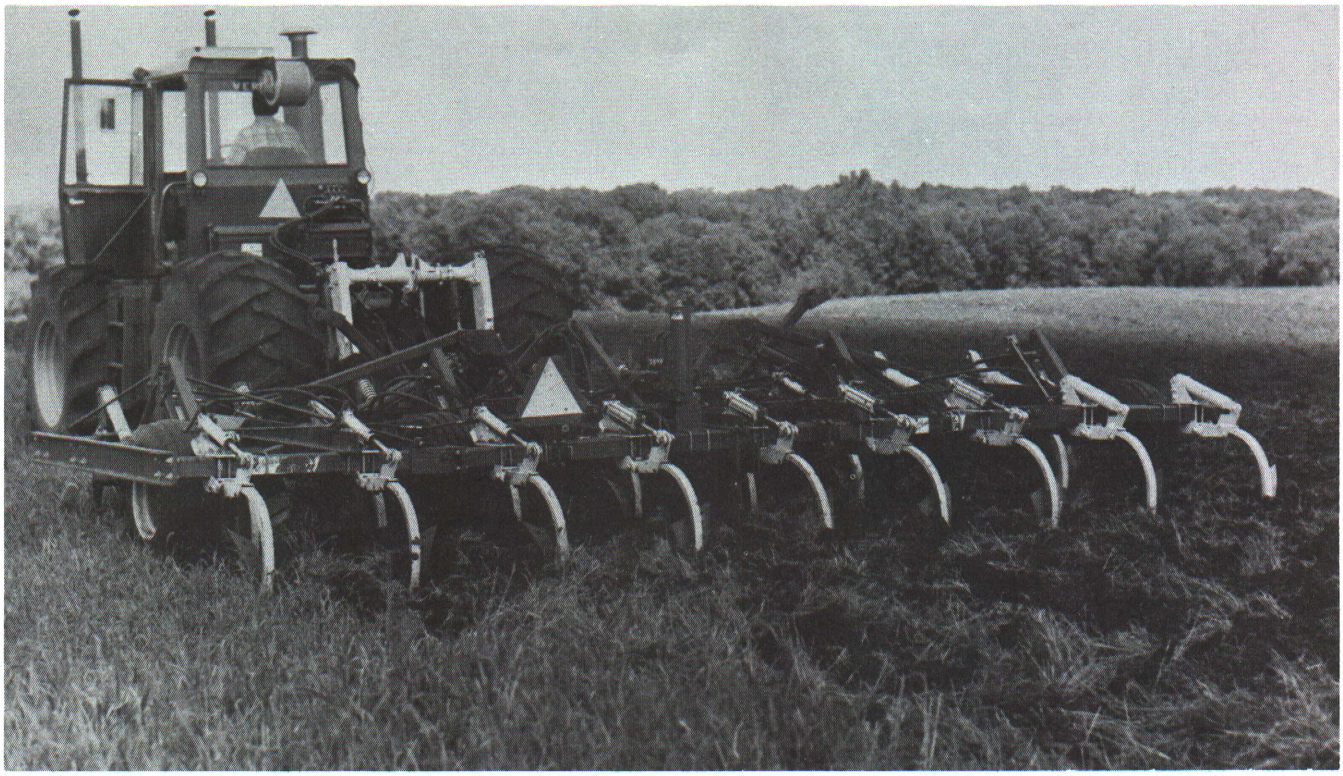

Figure 8—Some modern pull-type chisel plows can penetrate the soil to 10 inches and are available in widths ranging up to 30 feet. The wider the treatment, the shallower the penetration when pulled with a given size tractor. The exposed crop residues aid greatly in conserving the soil but, under some circumstances, contribute to a buildup of certain pests. Chisel plows can be easily adapted to the application of anhydrous ammonia.

age or in the harvest process. It works reasonably well in stony fields. It can be adapted for the application of anhydrous ammonia.

The chisel plow is superior to the moldboard plow in erosion control because it leaves some crop residues on the soil's surface. This aids in decreasing both wind and water erosion and in reducing water evaporation losses early in the season. This implement, therefore, is more effective on slopes than is the moldboard plow.

Other advantages to the chisel plow include variable tillage depths with power requirements somewhat less than the moldboard plow. With lower power requirements, greater tillage widths are possible which result in some saving of time and less traffic with fewer opportunities for excessive soil compaction. Also, where desirable, two or three treatments are feasible.

The disadvantages of a chisel plow are closely related to the fact that the soil is not turned. Broadcast fertilizer and lime are restricted to the surface few inches. Theoretically, weed, insect and disease problems can develop more easily because significant amounts of crop residues which protect such pests remain on the soil surface.

Disc Plow

Only a few Michigan farmers use disc plows, sometimes called rolling plows, but most are pleased with the effect they have upon the soil (Figure 9). Disc plows are best adapted to the sandier agricultural soils in the state, to those with some stones, to those fields which are erosion prone due to slope and to some cash crop farms where coverage of livestock manure is not a problem.

This implement has medium power

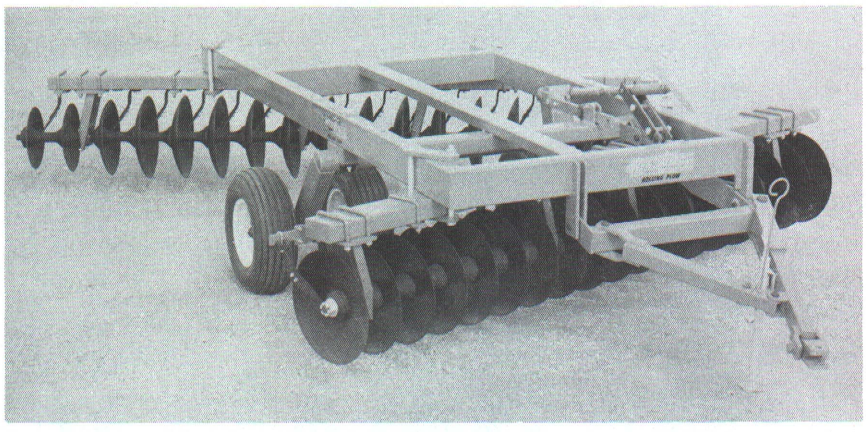

Figure 9—Disc plows, sometimes called rolling plows, are primarily larger and stronger designs of the disc. The action on the soil is similar. Assuming similar tillage depths and widths of cut, they have slightly lower power requirements than moldboard or chisel plows. Crop residue coverage is less complete than with a moldboard plow. Attachments for smoothing, leveling or ridging and the application of anhydrous ammonia are generally available. Such accessories tend to reduce the need for secondary tillage.

Figure 10—Rotary-type plows are used most extensively on specialty farms, although there is increased interest on others because it can produce clod-free soils. It is especially well adapted for the incorporation of manure and compost materials. Tillage depth is limited, and power requirements are generally higher than with other implements. Where rotary type plows are used as a once-over tool, power requirements will be lower than in those systems that involve secondary or supplemental treatments.

requirements similar to the chisel plow. Therefore, with a given tractor, tillage width is wider than with the moldboard plow.

Like the chisel plow, there are few or no adjustments to make, and multiple treatments are possible. Also, as with the chisel plow, crop residues are not completely incorporated into the soil; thus some protection against wind and rain is provided.

The diadvantages are similar to those of the chisel plow. With the disc plows used in Michigan, tillage depth is restricted more than with the chisel or moldboard plow.

Rotary Type Plow

Rotary type tillage tools represent the last group of primary tillage implements to be considered (Figure 10). They are well adapted to small farms because .of their maneuverability. They do an excellent job of incorporating crop residues and compost material into the soil.

The advantages of such implements involve creating a soil that contains no clods. Crop residues are completely pulverized and decompose very rapidly. Multiple treatments are possible.

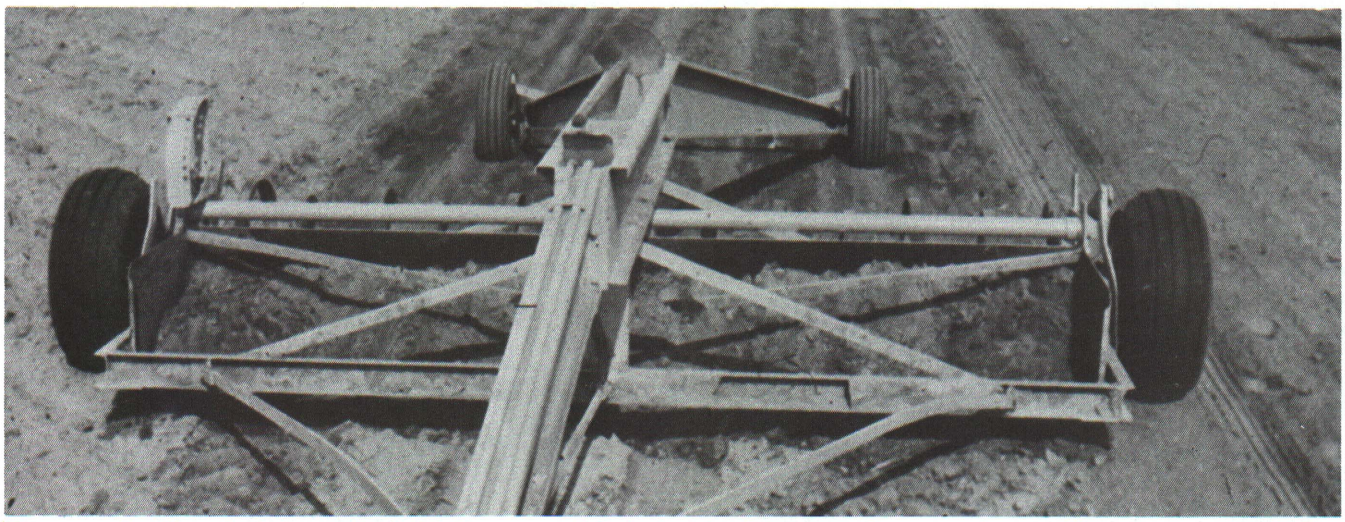

Figure 11—Land leveling is increasing in Michigan, especially in the lake plain areas where sugar beets and beans are produced. They reduce the number and depth of low-lying areas in a field. This improves timeliness of field operations and size of harvest areas within a field.

Figure 12—Trailing minimum-tillage tool. This was once a popular soil treatment in Michigan but is now used less extensively because many feel that it is difficult to transport from one field to another. Used behind a plow, it firms the surface soil and easily breaks down clods, thus reducing the need for secondary tillage. Where secondary tillage can be eliminated, earlier planting is possible.

All rotary tillage tools have relatively high power requirements and limited depth potentials. While the kill of annual weeds is excellent, the pulverized soil after a heavy rain represents an ideal seed bed for weeds. Such plows have not been used extensively on large farms and in fields with many stones. In addition, the use of anhydrous ammonia requires a separate operation.

SUPPLEMENTAL TILLAGE

Land leveling, sometimes called land forming or field smoothing, is increasing in the lake plain areas of the state because it permits better surface drainage. In this process most vegetation should be completely buried and the soil loosened before leveling is possible (Figure 11). This operation, with well-designed and sodded outlets to ditches, has increased bean yields many hundredweight per field because areas where water collects are reduced or even eliminated.

With high yields of crop residues, some feel that preplowing supplemental tillage is necessary in order to do a good job of moldboard or chisel plowing. Stalk shredders are not common in the state; therefore, some use a disc to break up cornstalks or to initiate decomposition by mixing the crop residues with small amounts of surface soil. Such a procedure is not necessary on most farms but may be desirable where super high yields were produced and where older type low-clearance moldboard or chisel plows are used.

Another form of supplemental tillage involves pulling a special tillage tool behind a moldboard plow (Figure 12). At one time this was a common practice but became less popular as the number of plows on the frame increased. It became increasingly difficult to transport such implements from one field to another. Trailing a tool behind a plow is not as difficult or inconvenient as it may appear. It has the advantage of saving one secondary tillage operation because it not only smooths the soil surface but also has a firming action.

Similar effects can be obtained on larger plows with special tools that lift automatically when the plow is raised to transport position (Figure 13). The successful use of such supplemental tillage tools is dependent upon a good job of plowing which involves complete coverage of crop residues. This is difficult when the plow is in poor adjustment or when soil moisture levels are unreasonably high.

Supplemental tillage tools, either trailing or fastened directly to the plow frame, frequently are more effective and require significantly less power than secondary tillage tools because they are used while the soil is moist and when fragmentation is easiest. Most secondary tillage occurs after some drying of the soil when more energy is required to break down large clods.

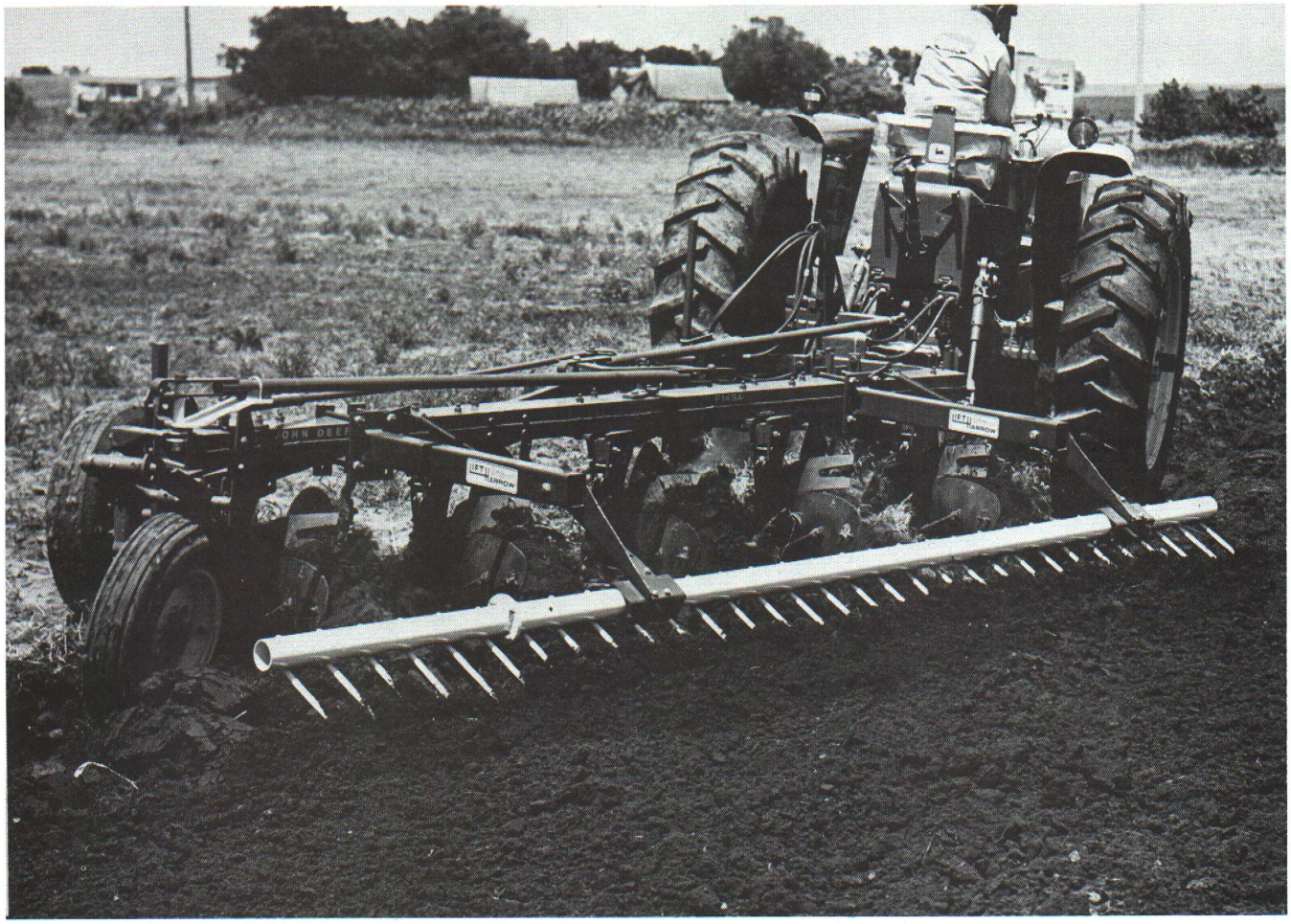

Figure 13—Mounted minimum-tillage tool causes no problems at end of fields or in transportation. The tines easily destroy clods, thus reducing the necessity for a secondary tillage treatment. With spring plowing, many farmers with such tools prefer to plant the same day as plowing, thus taking advantage of the ideal soil-moisture levels that frequently prevail.

NO-TILL

The term, "no-till," is a misnomer because some tillage is achieved with the special planters used. This minimum tillage method involves special planters and herbicides. In no-till, a narrow slot is made in untilled soil so that seed can be planted where moisture levels are adequate for rapid germination. The fluted coulter device on the planter is the most common in Michigan today. This method of crop production is increasing. It should be used by more farmers because many acres of land in Michigan are well suited to this method. No-till is the most significant recent soil conservation development. As previously stated, if there is no obvious reason for tillage it should not be done.

For details on no-till crop production methods, refer to Extension Bulletin E-904, No-Till Corn 1, *Guidelines;* Extension Bulletin E-905, No-Till Corn 2, *Fertilizer and Liming Practices;* Extension Bulletin E-906, No-Till Corn 3, *Soils;* Extension Bulletin E-907, No-Till Corn 4, *Weed Control;* Extension Bulletin E-956, *Sod Seeding of Birdsfoot Trefoil and Alfalfa.* Extension Bulletin E-791, *Problem Perennial Weeds,* is an excellent supplemental publication to the series on No-Till and Sod Seeding.

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