Conservative Tillage
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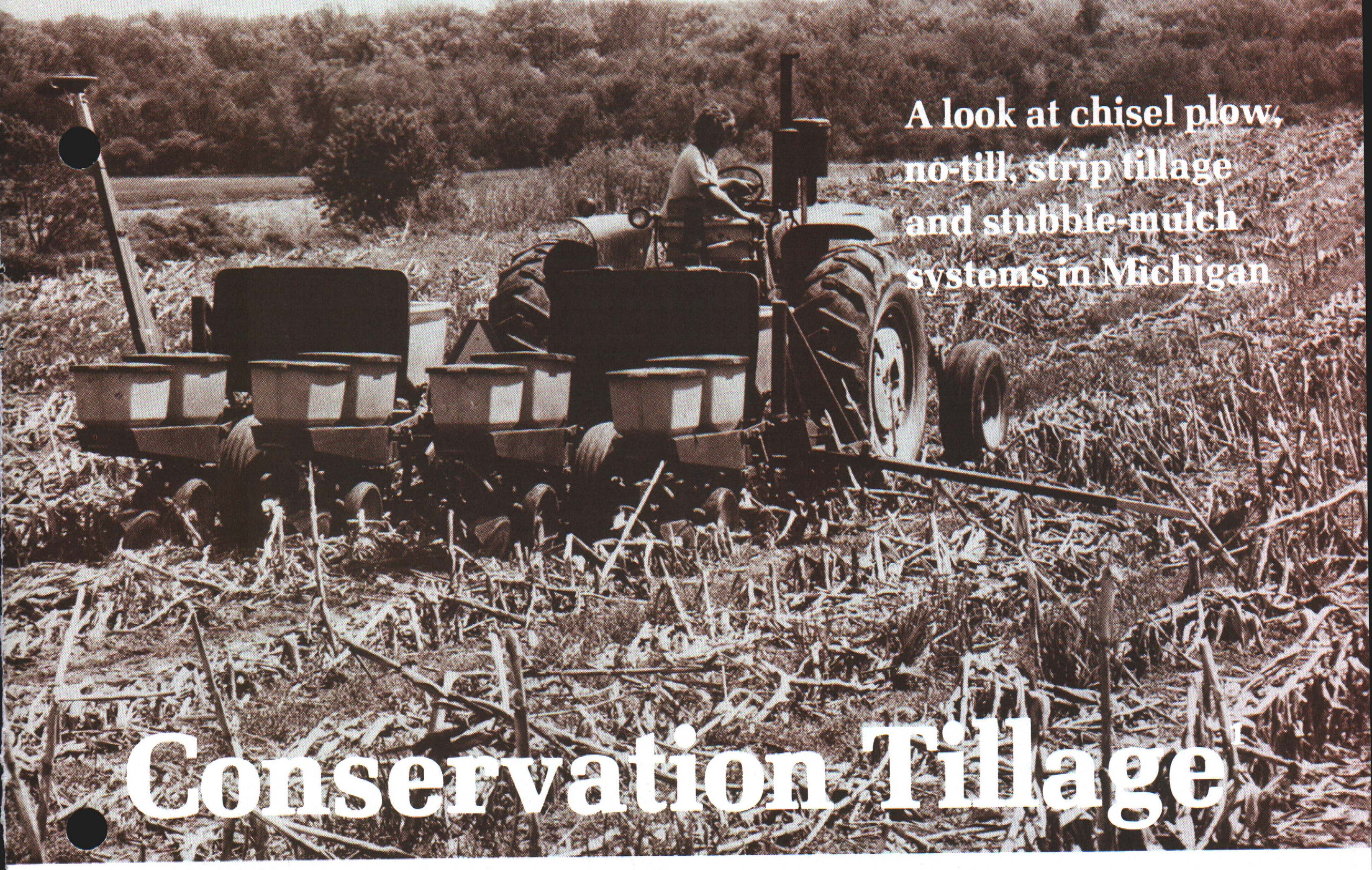

A look at chisel plow, no-till, strip tillage and stubble-mulch systems in Michigan

Conservation Tillage[1]

By W. J. Cook and L. S. Robertson[2]

Fact: Runoff water loss during the summer is a major problem in Michigan.

Fact: Michigan averages less precipitation during the growing season than any state east of the Mississippi River.

Fact: Invariably, there is a period when crops suffer from a water deficiency.

Fact: Any practice that allows more water to enter the soil during the growing season is likely to result in increased crop yields.

Fact: Conservation tillage, the most significant recent development in soil and water conservation, has its place in Michigan.

What is conservation tillage? The Soil Science Society of America considers it as "any tillage sequence which reduces loss of soil or water relative to conventional tillage" (9). The Soil Conservation Service of the USDA defines it as "a form of non-inversion tillage that retains protective amounts of residue mulch on the surface throughout the year" (12).

Conventional tillage is "the combined primary and secondary tillage operations normally performed in preparing a seedbed for a given crop grown in a given geographical area." (9) These definitions are practical, but the implications are not well understood, especially by those who think in terms of specific tillage implements, planters or herbicides.

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Figure 1. Excessive soil erosion by water is an unsolved problem in Michigan. Here, erosion occurred on fall moldboard-plowed land with slopes varying between 2 and 6 percent.

Tillage methods, timing and soil erosion are closely related (Figure 1). The erosion problem in Michigan is as deceptive as widespread. Even in these modern times, erosion continues *quietly* depleting our soil, *silently* contributing to non-point source pollution, and *subtly* remaining in the background away from the spotlight of creative concerns.

Loss of soil due to water erosion is an unsolved problem in Michigan. Research on watersheds in East Lansing showed that soil loss for a four-year period on a Hillsdale loam soil (Soil Management Group 3a) with a four and six percent slope totaled 39,433 pounds or 19.7 tons per acre (1). This took place despite there being no loss during one of the four years. Such losses occurred with "conventional tillage"—moldboard plowing in the spring, discing and harrowing twice and then planting corn across the slope (Figure 2). These data illustrate what likely occurs when similar methods are used on other sloping soils in other parts of the state.

Water loss also was great. Erosion reduces the water-holding capacity of soil as well as its ability to absorb water. Summer rain water is frequently lost when raindrops fall on hard or compacted soil material and collect in ponds or run down slopes, causing even more erosion (Figure 3).

Figure 2. Water erosion on watershed research project in East Lansing. Much of the water from the June 22 rain was lost from this conventionally-tilled soil. Erosion was excessive as determined by soil material collected in "silt box" (lower right).

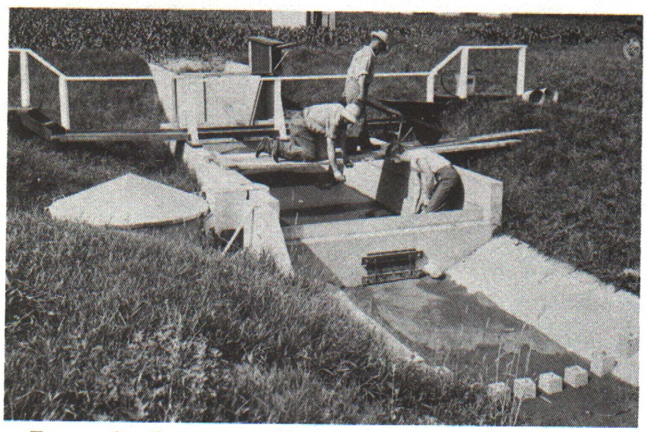

Figure 3. Emptying silt box which was full following only 1.49 inches of rain on conventionally tilled corn soil. This soil was compacted and crusted, resulting in increased runoff and erosion.

Conservation Tillage Systems

Conservation tillage represents a principle as much as a specific method, implement or herbicide. Several systems are used in the state and the success of each depends upon the managerial skills of the crop producer. Good managment is the key. Conservation tillage is not a salvage operation, but a practice that should be used in the most successful of farm operations.

Chisel plow systems are the most extensively used conservation tillage systems in Michigan, even though other systems might be more effective for soil and water conservation. Farmers are discovering that the crop yields produced with chisel plows are equal to those obtained with the moldboard plow and that soil and water losses, especially from sloping land, are greatly reduced.

The chisel plow is effective in loosening a compact soil. It works reasonably well on stoney fields. Some have adapted it for the application of anhydrous ammonia. This saves both time and fuel, and a trip that could excessively compact the soil.

The chisel plow is superior to the moldboard plow in reducing soil erosion and water losses because it leaves part of the crop residues on the soil's surface, which aids in reducing soil and water losses during the entire season. It also increases the surface roughness which may be beneficial in wind erosion control.

The value of chisel plow systems in conserving soil and water is closely related to the amount of crop residues left on the soil's surface and to the number and kind of field treatments after plowing. The amount of residues left on the soil surface varies greatly, usually ranging between 20 and 70 percent of the total residues (Figure 4). The amount left depends primarily upon the number of tillage treatments, tillage depth, type of chisel shovel (twisted or straight), and the amount and kind of secondary tillage.

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 compaction in the field.

For more details on tillage implements and their effects upon soil, refer to MSU Extension Bulletins on tillage systems (5, 6).

No-till systems are not as common as chisel plow systems in Michigan, but the number of farmers using no-till methods is slowly increasing. No-till is a method of growing crops on unplowed soil with the use of herbicides. No-till is used in Michigan most frequently with corn planted through the residues of previous crops, including those used for cover. Very few producers have adapted the system to other crops, even though they are aware of promising research that has been done in Michigan on vegetables (15), asparagus (4), and alfalfa and birdsfoot trefoil (10).

No-till methods have been recommended for corn for several years by the Cooperative Extension Service, especially on level, sandy or organic soils where wind erosion is a problem. It has been strongly recommended on mineral soils that have a water erosion problem. This includes soils with a slope, those that are naturally low in organic matter and soils with a course textured surface. On fine textured soils, no-till methods are also recommended in some instances, but it is recognized that a very high level of managerial skill is required to

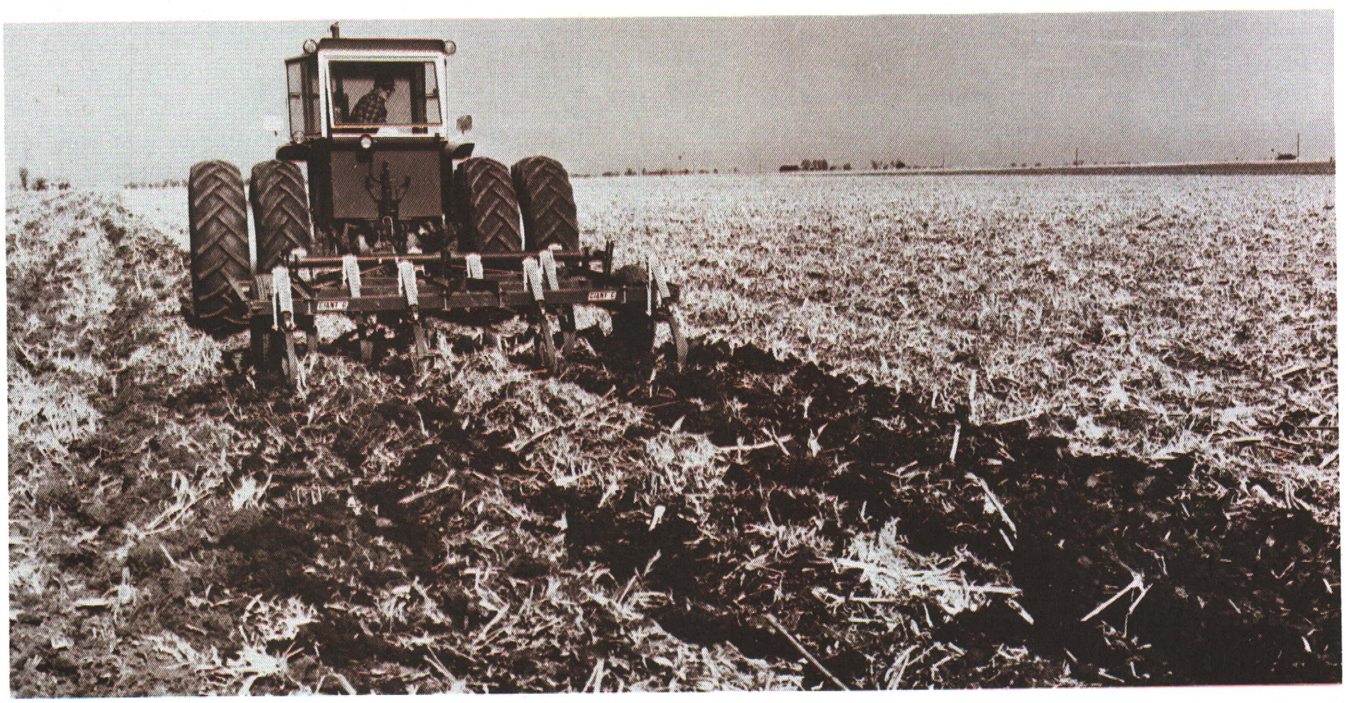

Figure 4. Chisel plows should be large enough and strong enough to penetrate compacted soil. The curved chisel shovels generally leave less crop residues on the surface than do the narrower standard straight shovels. A coulter in front of each chisel would help to prevent plugging with corn stalks.

Figure 5. Forage field renovation as with this special planter involves the use of quality seed, suitable herbicides, and adequate fertilizer and lime.

be successful on such soil. *No-till is not a substitute for good management.*

Both sandy and fine-textured soils respond to extra water infiltrating into the profile and to sound soil conservation practices. Recommended practices for no-till corn are summarized in a special series of four extension bulletins: Guidelines (3); Fertilizer and Liming practices (14); Soils (7), and, Weed Control (8).

The current situation on no-till corn in Michigan is illustrated in a 1978 survey of 18 farmers in Huron County (13). The producers had a total of 1,138 acres of no-till corn and averaged 63 acres per grower. Yields ranged between 33 and 190 bushels per acre, with an average of only 79 bushels. Planting dates ranged between May 1 and June 10, with an average date of May 24 which is much too late for optimum yields. When asked if they would plant no-till corn in the future, ten responded yes, three no, and five were undecided.

While some had disappointing results, the survey showed that high corn yields can be produced with no-till procedures. The high yields were similar to those reported from research on the MSU campus, where average yields in excess of 170 bushels per acre are reported for no-till, moldboard plow and chisel plow systems (2).

The survey also emphasized the importance of new managerial skills and how failures due to stand and weed problems may occur if no-till management techniques are not used. This undoubtedly explains why no-till systems are not now more common. Two major changes on the part of the producer need to occur for success with no-till corn: one, a change in attitude as to what is possible with no-till and, two, a change in planting technique.

No-till forage field renovation is a real possibility on many fields with sloping soils (Figure 5). Michigan has over two million acres of permanent grass pastures and hay fields. Current research on interseeding birdsfoot trefoil in the wetter sites and alfalfa in the drier is promising. Again the basic concept involves using suitable herbicides on closely grazed or cut fields and planting disease-resistant seed with a special or adapted drill into the suppressed sod. For more information on no-till forage production (sod seeding), refer to MSU Extension Bulletin E-956, "Sod Seeding Birdsfoot Trefoil and Alfalfa."

Strip tillage systems have not been evaluated in Michigan since modern and reliable herbicides became available, but in theory, represent effective production methods. Special planters prepare a narrow strip as a seedbed (Figure 6). With the planters now used in the Midwest, no more than one-third of the residue is disturbed. The Soil Conservation Service reports that, "This system is highly effective in reducing (water) erosion if the rows are on the contour or across the slope. If they are up and down the slope, runoff may flow in the tilled strips and cause increased localized erosion problems." This explains why strip tillage is not now widely used in Michigan, since many fields have variable slopes as related to length, direction and steepness. The system, however, should be effective on level outwash and lake plain soils where wind erosion is a problem.

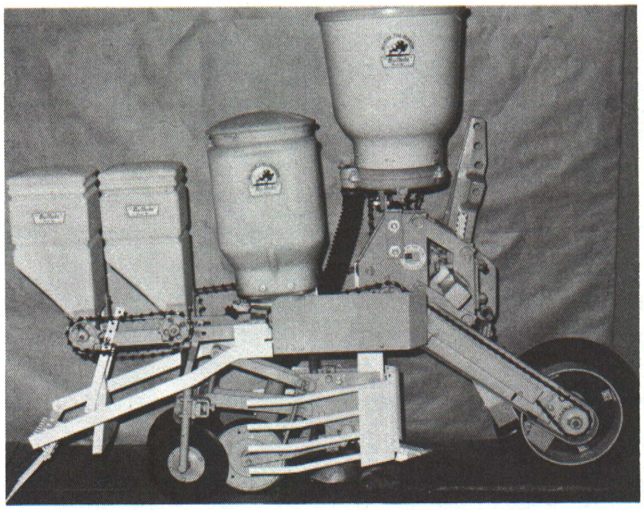

Figure 6. One unit of a modern till planter used for strip-tillage planting.

Stubble-mulch systems are common in the small grain regions of the Midwest but not used in Michigan at the present time. Stubble-mulch systems use equipment that cuts below the surface of the soil. Sub-surface sweeps or blades 30 inches or more wide till the soil while leaving the residues on the soil's surface. Seed is planted in the loose soil and stubble.

Stubble-mulching reduces both wind and water erosion and is especially practical in low rainfall areas where wind erosion is a problem. Crop residues left on the surface reduce wind speed at the soil's surface. This reduces movement of soil material. The residues also reduce the impact of raindrops which stabilize water infiltration rates and slow runoff.

Early research showed that stubble-mulch tillage practices have potential value in Michigan (11). However, there were plant nutrient availability problems introduced by stubble-mulch practices. At the time of the research, much less was known about the use of chemical herbicides and commercial fertilizers. Considering the soil fertility research that has been done since this report, such problems should not occur now. Thus, this conservation tillage system has unrecognized potential.

Conservation Tillage Systems and Compact Soil

Compact soil is a major hazard on many Michigan farms. Yields produced with conservation tillage methods on compact soil are reduced as much or more than with conventional tillage methods. Excessive compaction during primary tillage operations is common. Most compaction, however, occurs after plowing when tractors pull heavy implements such as secondary tillage tools, herbicide applicators and fertilizer, lime, an manure spreaders across the field.

Cultivation and harvesting are also soil compacting processes. Excessive compaction is likely to be great if soils are wet. Thus, improved surface and tile drainage helps to reduce the compact soil problem on many farms.

Visual symptoms of excessively compact soil are well known. They can be seen when studying both the soil and the growing crop. Crusts, zones of soil that contain few if any roots, areas of standing water, excessive erosion by water, and high power requirements for tillage are symptoms of excessively compact soil. In plants, look for slow emergence from the soil, variable plant size, off-colored leaves, shallow root systems and malformed roots (Figure 7). For more details on visual symptoms of excessively compact soil, refer to MSU Research Report 294.

To be successful with conservation tillage methods, excessively compact soil should be loosened. This can best be done in conservation tillage systems with a chisel plow when the soil is relatively dry. Fall chisel plowing with little or no soil erosion is a great possibility on large farms that have water or wind erosion problems which are closely associated with fall moldboard plowing.

The best chisel plows for conservation tillage are those that are large enough and strong enough to penetrate the compact zones (Figure 4). Standard shovels (not curved) leave more crop residues exposed on the soil's surface, and large notched coulters help to prevent crop residues from bunching and plugging the implement.

Suggestions for Successful Conservation Tillage

Wind and water erosion occurs on most Michigan farms. Conservation tillage can have both short-term and long-term advantages. However, certain changes must be made in planting implements, techniques and materials. The following is an outline for successful conservation tillage. Use the outline and adapt it to your conditions to conserve your soil while reducing time, energy, and labor requirements for crop production.

FIELD SELECTION

Proper selection of fields for conservation tillage can be a key. Select fields that:

1. Are erosion prone.
2. Are well drained.
3. Have a pH of 6.0 or above (6.7 or above for alfalfa).
4. Have sufficient plant nutrients to produce the level of yields required.
5. Have green or dry crop residue to convert into a protective mulch.

Figure 7. No-till corn grown on soil with a plow pan which interferes with both water movement and root penetration. Such zones of compacted soil need to be destroyed with tillage for efficient crop production.

6. Contain relatively sandy surface soil such as loam, sandy loam and loamy sands. (Finer-textured soil requires a higher level of managerial skills, especially as related to timeliness of operations.)

FERTILIZER

Follow these fertilizer recommendations with conservation tillage crop production:

1. Soil test to know exactly how much "plant food" or lime to apply.
2. Apply lime if soil tests indicate a need.
3. Use fertilizer on the basis of soil test results. If high rates are required, broadcast most of *what is required*.
4. Use starter fertilizer with conservation tillage planting the same as with conventional planting. Fertilizer should be placed so as to avoid contact with seed. Below the seed level is best.

PESTICIDE APPLICATION

Herbicides and insecticides are the most widely used pesticides in conservation tillage. Proper pesticide application can have as much effect on conservation tillage success as any other factor.

Herbicides

To be successful, weed control programs must do four things: a) control existing vegetation, b) control germinating weeds and those regrowing from roots, c) avoid injury to the present crop, d) not injure the succeeding crop. Several basic steps will help achieve these goals:

1. Select the *proper* herbicide or combination to control the specific vegetation present in a field.
2. Properly calibrate application equipment periodically throughout the planting season.
3. Select proper nozzles for uniform herbicide distribution. Flat-fan nozzles generally give the most uniform herbicide coverage. However, if liquid fertilizer is used as a carrier, flood nozzles should be used to allow large volume applications. The spray from the flood nozzles should be overlapped 100% to obtain uniform coverage.
4. Check nozzles regularly and replace worn nozzles.
5. Check compatibility of herbicides that are tank mixed by carefully reading labels and running small scale compatibility tests (see Extension Bulletin E-1296). Be sure to use a non-ionic surfactant with paraquat.

6. Constantly agitate herbicide mixtures to keep all materials in suspension or solution.

7. Do not store herbicide mixtures in a sprayer overnight without constant agitation.

8. Use 20 to 50 gallons per acre of water (or carrier) to insure complete coverage of vegetation and the soil surface. The lower volumes may be used when vegetation is sparse.

9. Use a minimum of 30 psi to achieve necessary coverage. Higher pressure (40 to 50 psi) is needed for adequate coverage on fields with dense vegetation.

10. Keep sprayer booms high enough to get complete coverage of existing vegetation. Spray patterns should properly overlap at the top of the vegetation.

11. If hiring a custom applicator, select one experienced with conservation tillage.

12. *Read* and *follow* herbicide label information regarding rates, surfactants, and other use precautions.

13. Apply contact herbicides to growing vegetation 5 to 10 days before planting if existing vegetation reduces possibilities of preemergence herbicides reaching the soil surface. Applying the contact herbicide 5-10 days before planting also eliminates competitive vegetation which can deplete soil moisture.

Insecticides

Insect control may or may not present a major obstacle to conservation tillage farming; however, it demands very careful planning and attention. Be sure you:

1. Know the major insect problems encountered by conservation tillage in your area and what to do if you encounter them.
2. Prevent as many insect problems as you can by using treated seed and by applying a recommended soil insecticide at planting time. Use a planterbox seed treater for insect and disease control.
3. Use an approved corn rootworm insecticide where rootworms are likely to be a problem.
4. Apply, according to the label, a product registered for cutworm and armyworm control. These are frequent problems with conservation tillage.
5. Use adequate seed and have good coverage to minimize mouse damage. Consult local agricultural extension authorities for slug control.
6. Check fields frequently throughout the season. Be prepared to quickly spray for insect or disease if necessary.

PLANTING

Here are some helpful hints to make your job of conservation tillage easier:

1. Plant in moist soil. Seed germination will be rapid if soil temperatures are above 50°F, but planting at lower temperatures is not considered to be a limiting factor if high-quality, treated seed is used.
2. Plant slowly—3 to 3.5 mph is best. Watch the coulters to see if they throw soil out of the row. If they do, reduce planting speed.
3. Add a press-wheel *in front* of the planter's packer wheel where seed coverage is a problem.
4. Match planter plates to the seed you are using.
5. Stop regularly to check seed depth. Make a check in low, hilly or eroded spots, and on level ground. Be sure to place the seed in the ground—not on the ground.
6. Plant 10 to 20% more seed to insure a good stand of corn.
7. Be certain that seed and fertilizer do not drop in the same path.
8. Planter must be level, fore and aft, when in planting position. Proper adjustment is important.
9. Depth gauge wheels are necessary where variable depth of planting is a problem.
10. Coulters (fluted) should be adjusted to penetrate no more than twice the depth of desired seed placement (Figure 8).

Trouble-Shooting Planting Problems

As with conventional tillage methods, planting problems can arise with conservation tillage methods, but they can be avoided. Following are some of the common conservation tillage planting problems and what to do to correct them.

1. **Inadequate stands.** Add more weight on the planter. Getting the fluted coulters to proper depth (2 to 2½ inches) in the soil often requires 400 to 600 pounds extra weight per row.
2. **Trash accumulation.** Use a double-disc opener instead of a chisel-boot or shoe-type furrow opener.
3. **Obstructions in the field.** Use double-disc furrow openers that roll over rocks with little or no damage.
4. **Depth control.** Use depth control gauges mounted on either side of the opener and set coulters only ½ to 1

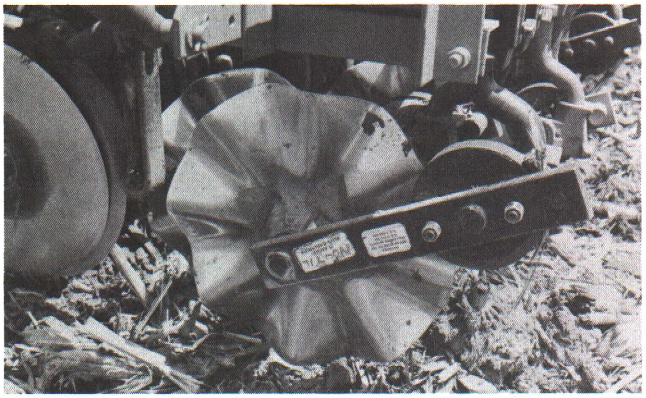

Figure 8. Fluted coulter on modern no-till corn planter cuts through trash and crop residues and prepares a "bed" for the seed.

inch deeper than you intend to plant.

5. **Seed placement.** You may need a seed firming wheel when rear press wheels do not properly cover the seed. Corn should be covered with 1 to 1½ inches of soil.

6. **Seed won't cover.** Besides the above, a typical cause is planting when the soil is too wet. If it is too wet to plow, it's too wet to plant. Use the "ball" or "snake" method to evaluate soil moisture levels.

7. **Non-uniform stands.** You may be running fluted coulters too deep. Good seed-to-soil contact is necessary. Check press wheels for soil firming action.

8. **Where poor surface soil structure or other undesirable conditions exist,** use two overlapping fluted coulters per planting unit.

Summary

Conservation tillage is any tillage sequence that reduces soil or water loss relative to conventional tillage. A reduction in soil and water loss should result in increased crop yields as well as improved water quality in lakes, ponds and streams.

Four systems of conservation tillage have received research attention in Michigan: 1) chisel plow, 2) no-till, 3) strip tillage and 4) stubble mulch. A combination of the chisel plow and no-till planter appear to be the most practical where soil erosion is a problem and where soils are excessively compact. Where compact soil is not a problem, all of the systems will reduce erosion and water pollution problems.

All conservation tillage systems require a higher level of managerial skills than conventional tillage. This point should be recognized when making changes in tillage systems. In starting to use conservation tillage systems, experiment in only one or two fields and preferably those with the least problems. Fields that have not been farmed recently are usually problem fields and should not be used for conservation tillage by the inexperienced. After some experience is gained, expand operations into other fields. Have a positive attitude. Make the system work for you so that you can maintain, if not improve, current yield levels while reducing soil erosion and improving pond, lake and river water quality.

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