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Conservation Tillage-Planting Systems

Edward J. Constien, Department of Agricultural Engineering; Laurel Anderson, William J. Murphy, and C. M. Woodruff, Department of Agronomy; Einar Palm, Department of Plant Pathology; George Thomas, Department of Entomology; and Herman Workman, Department of Agricultural Economics, College of Agriculture

Conservation tillage, or minimum tillage, involves practices that conserve energy and soil while maintaining high yields. The terms are used to describe a wide range of tillage-planting systems of reduced tillage where all or part of the crop residues are left on or near the surface.

Reducing tillage operation lowers production costs, saves energy, and allows more time for other operations. Although specialized machinery may be needed, there can be long-term savings because of lower power and fuel needs.

Various conservation practices--mulch tillage or no-tillage planting systems--probably have the most promise of widespread effectiveness and acceptance for erosion control.

Pests--weeds, insects, and diseases--become more of a problem in conservation tillage. Care must be taken in controlling pests by selecting the tillage-planting system that provides opportunities for this control.

Tillage-Planting Systems

Conventional System - Conventional tillage normally is done with a moldboard plow, disk, harrow, cultivator, or similar tool. Advantages are:

- Uniformly fine seedbed for easy planting.
- Effective pest control.
- Flexibility and adaptability to wide range of soil, crop, and weather conditions.
- The equipment is readily available on most farms.
- Yields are as high as or higher than with other systems over a wide range of soil and climatic conditions.
- Fertilizer can be placed for maximum effect.

Limitations are:

- Several operations increase fuel consumption and production costs.
- Fine seedbed usually has a reduced rate of water intake.
- Bare, fine, or compact soils are subject to wind and water erosion especially on greatly sloping land.

Reduced Tillage - Medium Surface Residue Systems - Primary tillage is usually done by chisel plow or large disk plus one or more additional operations. Advantages are:

- Fuel use and machinery and labor time are reduced by eliminating some operations.
- Rough, open soil surfaces plus crop residues help to reduce crust formation, and provide more rapid water infiltration and absorption before runoff begins.
- Soil erosion can be reduced.
- Soil compaction is reduced.
- Pesticides (insecticides, herbicides, fungicides, etc.) can be incorporated into soil or applied on a relatively residue-free surface.
- Yields comparable to conventional tillage.

Assistance in preparing this Guide also given by Fred D. Whitaker and Douglas R. Lowe, Soil Conservation Service.

Limitations are:

- Rough, porous surface may make planting more difficult.
- High rates of chemicals may be needed for adequate weed control.
- The soil is only partially inverted with much of the fertilizer and lime remaining in the top 2 or 3 inches.
- Crop residues on the surface may harbor insect and disease pests.

No-Tillage Systems - Planting in undisturbed soil by using a fluted or ripple coulter or slot-type planter shoe. Fertilizer and pesticides must be applied on the surface or in the narrow, tilled area. Advantages are:

- Low power, labor, and fuel needs.
- Planter can be used in sod, in previous crop residue, or conventionally prepared seedbed.
- Soil erosion is reduced.
- Compaction is reduced.
- Soil moisture is conserved.
- Yields comparable to conventional tillage under optimum conditions.

Limitations are:

- Special planting equipment required.
- Low soil temperatures result which may delay planting and slow early plant growth.
- Fertilizer, lime, and pesticides can't be adequately incorporated.
- High rate of chemicals may be needed for adequate pest control.
- Careful management needed to obtain desired stands.

Ridge Farming and Strip Tillage - Ridge farming, no-tillage on beds, has most of the advantages and limitations of no-tillage. Planting ridges may be formed when cultivating the previous crop or especially for the intended crop.

The ridge warms up fast in spring and will dry quicker than the area between the rows. Crop residue remains on or near the surface, but the seed is planted in a tilled strip.

Usually the strip-till planter tills a strip 3 or 4 inches deep and one-third to one-half the row width. This mixes crop residue throughout the depth of the tilled area. Planter attachments can be removed and the machine used as a cultivator. Rotary tillers can effectively mix chemicals in the tilled area. For soils that tend to crust badly, this system may not be desired.

Considerations for Conservation Tillage - Planting Systems

Soil Temperatures Are Lower - Seedbed temperatures vary among different tillage systems. As surface mulch is increased soil temperatures become lower. Spring temperatures under sod are commonly as much as 5° to 6° F lower compared to clean tilled soil.

Corn planting should be delayed until soil temperature reaches 50° F. Corn begins to germinate near 40° F, but plants will not grow until soil reaches 50°. An extended period between the start of germination and plant establishment gives opportunity for seed deterioration.

Crop Residues Conserve Moisture - Surface mulch conserves moisture, an advantage in dry summer periods, but a disadvantage at planting time and during early growth, especially on soils with poor internal drainage.

The effect of added moisture on planting doesn't apply to a green growing mulch because the plants are removing moisture from the soil.

Germination Affected - Stand establishment is affected by soil temperature and the amount of surface residue. Good contact between the seed and soil is needed for germination and root establishment. Research in Indiana demonstrates that there is little difference in percent stand between conventional and conservation tillage systems in lighter soils. However the conventional system seems to be superior in heavier soils.

PERCENT STAND (CORN) 1968-1969

TILLAGE SYSTEM	SANDY LOAM	SILT LOAM	SILTY CLAY LOAM
Conventional	91	86	82
Chisel Plant	87	76	62
Strip Rotary	93	86	69
Till Plant	96	87	64
Strip Coulter	89	79	73

A common practice with minimum tillage systems is to increase the seeding rates by 10 percent. There is danger that too high final populations will cause plant food deficiency and moisture stresses. The results may be lower yields, smaller ears, barren stalks and excessive lodging.

Adjustments in planting rates should be based on experience and judgment of farmers. Minimum tillage systems may produce inconsistent stands until producers gain considerable experience with different soils.

Fertilizer and Lime Placement - When soils are not plowed, phosphorus and potassium fertilizer and lime may remain mostly in the top 2 inches because they move downward very slowly. This movement into deeper soil layers may not be rapid enough to help in low fertility soils. Basic fertility needs can be met by plowing down fertilizer-lime before no-plow tillage practices begin.

Periodic plowing, possibly once every four or five years, may be needed to move these fertilizers down for best possible long-time yields.

Controlling Plant Disease

Plant disease-causing organisms survive in crop residues left on the soil surface or in volunteer plants. The question of increased disease incidence must be considered.

For a disease to occur, three factors are involved: a susceptible host, aggressive parasite or causal agent, and a favorable environment for initiation and spread of the infection. If one factor is missing, a disease will not develop. A disease can develop if a pathogen is present in the crop residues, a susceptible crop is planted, and the weather conditions are favorable to disease establishment.

The survival of disease causing organisms in crop residues is a critical factor to the extent and severity of disease. When a crop is grown continuously certain fungi and bacteria overwinter in crop residues and tend to intensify. For example, bacterial blight, anthracnose, brown spot, characoal rot, downy mildew, pod and stem blight, purple seed strain, and others affecting soybeans become more serious in continuous soybeans.

Growing one crop continuously should be avoided in all tillage systems. However, minimum tillage systems may be somewhat more vulnerable to disease because crop residues remain on the surface. Periodic plowing will cover disease-bearing residues and speed up decay. Many organisms present in the decay process often work against pathogens. Crop rotations can also help to reduce disease build-ups.

Improvement in fertility balances and pH levels associated with using fertilizers and lime according to soil tests, can also help reduce effects of disease. For example, low potassium levels as related to other nutrients - particularly nitrogen levels - can accentuate stalk rot disease in corn, weakened stalks, and lodging.

Cultivating or using herbicides may reduce diseases, or destroy alternate hosts of certain diseases.

Shallow planting of soybeans will often result in less damage from root rot diseases. Turning under green manure crops and other methods of incorporating organic material into the soil may have beneficial effects in reducing root rot diseases.

Each specific disease has unique characteristics and environmental requirements. Difficulties and ultimate control of diseases depend on the crop grown and the particular sequence of crops used. Also the geographical location, native fertility, rainfall, soil and air temperatures, and many other factors affect the presence or intensity of plant diseases.

Controlling Insects

Tillage-planting systems that leave residues up or near the surface favor overwintering and development of some soil pests. Also, in many cases these systems don't provide for adequate placement, incorporation and/or coverage of soil insecticides.

Cutworms, wireworms, seed corn maggots, and seed corn beetles are the most frequent soil insect problems with reduced tillage. No-till sod plantings may be severely damaged by seed infesting pests, rodents, and cutworms; and by army worms when corn is 6-9 inches or more in height. General increase in European corn borers may occur where stalk residues remain on the soil surface for several consecutive seasons.

There is no "one best" insecticide for all situations for all corn soil insects. Anticipating where insects might be a problem is important. The value of seed treatment insecticides increases as the number of tillage operations decreases. The greatest need would be if no soil insecticides were used during tillage or planting.

Broadcast - Where cutworms or wireworms are known to give problems, sprays, granules, or fertilizer-insecticide combinations of aldrin or heptachlor are effective. They should be applied broadcast on the surface of plowed or cultivated soil prior to planting and immediately incorporated in the top 3-5 inches of soil with disk or field cultivator.

Row Band - Apply rootworm granular insecticides with planter-mounted applicators in a 5-7 inch band behind the planter shoe but in front of the covering devices and packer wheels. All insecticides perform better when lightly covered with 1/2 to 1 inch of soil and compacted by packer wheel.

Rootworm insecticides are used primarily when corn is grown continuously, but may also give adequate control of several minor soil insects. However, rootworm dosage rates will not control cutworms or wireworms. Avoid direct contact between the seed and these granules because several rootworm insecticides may affect germination.

Seed Furrow - With no-tillage equipment, placing granules directly in the seed furrow is about the only choice. Only a limited number of insecticides are registered for such use. The granules must be lightly covered with soil and the seed furrow sealed for this method to be environmentally acceptable.

Basal Application - Where no rootworm insecticide was used at planting, apply these granules at the base of small plants and follow with light cultivation.

Baits - Pelleted baits may be banded on both sides of the row or broadcast when cutworms are feeding near the soil surface.

The key to controlling cutworms with sprays or baits is early detection of infestation. Sprays containing some insecticides for controlling small cutworms may be applied to the soil at the base of plants and covered with 2-3 inches of soil by light cultivation.

The best advice for proper and safe use of insecticides is to follow directions and precautions on the labels.

According to a 1971 survey of entomologists in the North Central States, corn insect problems were worse when reduced tillage or no-tillage sod planting practices were used. These practices made control more difficult or impossible.

Controlling Weeds

Profitable production of any crop requires that competition from weeds be minimized. In a conventional system or reduced tillage system, weed growth is destroyed before planting and the soil is in a favorable condition for weed control following planting. When tillage is reduced, alternate weed control practices must be used.

Sod Planting - A combination of paraquat and atrazine appears to work effectively.

Tilled Surfaces - Surface pre-emergents such as atrazine, Lasso or Amiben will not perform effectively under conservation tillage conditions.

Incorporated pre-emergents require a relatively well prepared seedbed if the herbicide is to be incorporated uniformly at a given depth. A trashy, cloddy surface will inhibit uniform incorporation and subsequent performance. Neither surface applied nor incorporated pre-emergents will function at the optimum under some conservation tillage conditions.

Post emergence herbicides offer more effective weed control in combination with minimum tillage than pre-emergents. To minimize competition early season weed control is highly desirable. This would involve using an early-post application. This limits selection of a herbicide because such post-emergents as Lorox and Banvel-D cannot be used until the crop is well along.

Late post emergent applications don't eliminate early season competition and consequently are less desirable. A crop-weed height differential is also essential where a directed spray is used, and frequently weeds grow right along with the crop.

Weed control by mechanical cultivation is difficult in heavy crop residue when tools such as the sweep cultivator, rotary hoe, spring-tined weeder, etc. are used. Rotary tillers and disk cultivators will work in heavy residue but bury much of the residue thus reducing the conservation and water infiltration benefits of the system. The rolling cultivator is an effective weed control tool which works well in crop residue and will bury only a small portion of the residue.

Conservation Tillage for Soil Erosion Control

Conservation tillage is well adapted to large scale farming with modern equipment. Conservation tillage practices provide the desired level of erosion control on gentle slopes when high amounts of residue are left on the surface. When low quantities of residue are left on the surface, other conservation practices are also necessary to effectively control erosion. Where conservation tillage is used, terraces may be needed but spacing can be increased.

Raindrop impact breaks down soil aggregates, reduces surface roughness, and causes surface sealing and crusting, thereby increasing runoff. A growing vegetative canopy or surface residue reduces raindrop-caused erosion. A year-around cover will greatly reduce soil erosion caused by raindrop impact, but is difficult to maintain in a row crop system.

Crop residue allowed to remain on the surface or incorporated in the soil will aid in reducing soil erosion. On long slopes, steep slopes, or large watersheds, additional conservation methods are usually needed, however. Fields of continuous corn have greater soil erosion if the corn is cut for silage than if it is harvested for grain. Residues mixed in the surface by operations such as chiseling or disking reduce erosion more than if the residue is more completely inverted with a moldboard plow.

Tillage-induced roughness and cloddiness increase infiltration and reduce runoff velocity. The soil loss reductions from planting in loose, open soil are due primarily to these effects. However, when there is little or no protection from residues, high-intensity rains early in the crop growing season may rapidly diminish this

RUNOFF AND SOIL LOSSES FROM CLAYPAN SOILS

		RUNOFF (INCHES)			SOIL LOSS (TON/ACRE)		
YEAR	PRECIPITATION	NO-TILL	FIELD CULTIVATION	CONVENTIONAL	NO-TILL	FIELD CULTIVATION	CONVENTIONAL
1970	47.55	18.74	15.66	17.13	1.60	4.64	15.61
1971	27.34	4.24	2.43	2.43	.24	.44	.54
1972	30.60	5.58	3.07	3.10	.09	.10	.09
1873	46.33	12.00	11.77	13.11	.34	.82	1.14
		10.34	8.20	8.94	.57	1.50	4.35

F.D. Whitaker, Water Research Unit, ARS-USDA Columbia.

Test results at the ARS-USDA Research Station at Kingdom City, Missouri show crop residue on the soil surface consistently reduced soil erosion.

open, rough effect and cause surface sealing. When this happens, a cultivation, even though it may not be necessary for weed control will increase infiltration and reduce soil erosion.

In any conservation-tillage system, row direction is important. Chiseling up and down a slope, for example, may result in severe erosion Row direction, either on the contour or across the slope aids in water infiltration and in reducing runoff velocity.

Reduced tillage should not be expected to completely control erosion. It can be an important part of a more complete erosion control system.

Economics

Will a switch from conventional tillage to minimum tillage system be profitable? The answer depends on weighing the added benefits against the added costs of the changeover. Added benefits include: less fuel used, better control of soil and water losses, reduced machinery overhead costs. Added costs include: increase cost of crop material, possibly increased machinery overhead costs, and risk of reduced yields.

Machinery overhead costs per crop acre (depreciation, repairs, taxes, etc.) can either decrease or increase by switching to a minimum tillage system. If the total power requirements are reduced and a complete change to minimum tillage equipment is made, then a reduction in machinery overhead costs per acre can be expected. If the same tractors are used and some of the conventional tillage equipment is kept, purchasing minimum tillage equipment will likely increase the machinery overhead costs.

Total operating costs per acre (excluding labor) may increase with minimum tillage systems. Additional crop materials (pest chemicals, seed, and fertilizer) can increase operating costs $8 to $15 per acre of corn for a no-tillage system. On the other hand, fuel costs will likely be reduced by the minimum tillage systems. A no-tillage system could save up to four gallons of fuel per acre over contentional tillage. Fuel or energy conservation can be an important benefit of minimum tillage. However, at present fuel prices the savings in fuel costs per acre would not likely offset the additional cost of crop materials.

Reduced man and machine hours may be one of the most important benefits of minimum tillage systems. Up to one hour of labor per acre of corn could be saved by a no-tillage operation over conventional tillage. Thus, the net increase expected in operating costs per acre (excluding labor) could be offset by the value of labor saved with minimum tillage systems. Value of labor saved depends on the individual's cost of labor and the productive use made from labor saved.

Other than weighing the changes in machinery overhead and total operating costs per acre, questions regarding the added benefits of minimum tillage systems are: What is the value of better soil and water control? What is the value of lower fuel requirements? What are the opportunities for double cropping and more intensive land use? What is the value of man and machine time saved? If yields can be maintained and weed and insects controlled without excessive costs, individual farms may find the added benefits will make the minimum tillage system pay.

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