

1992

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Siemens, J. C.; Dickey, Elbert C.; and Threadgill, E. D., "Definitions of Tillage Systems for Corn" (1992). *Biological Systems Engineering: Papers and Publications*. 246.

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Definitions of Tillage Systems for Corn

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If "tillage" is defined as the mechanical manipulation of soil, it follows, then, that a "tillage system" would be the sequence of soil-manipulation operations performed in producing a crop. Today, however, such a definition is recognized as inadequate. We know, for instance, that the management of nonharvested plant tissue (i.e., residue) affects both crop production and soil erosion, and that field operations in which the soil is not tilled have a marked influence on soil condition.

Therefore, in this publication, a tillage system is the sequence of *all* operations involved in producing the crop, including soil manipulation, harvesting, chopping or shredding of residue, application of pesticides and fertilizers, etc. But before describing and comparing the various tillage systems for corn, some terminologies and possible points of confusion need to be addressed. These have to do with primary vs. secondary tillage and the different ways in which similar tillage systems could be defined.

PRIMARY AND SECONDARY TILLAGE

For many tillage systems, the specific operations can be separated into "primary" and "secondary." Primary tillage loosens and fractures the soil to reduce soil strength and to bring or mix residues and fertilizers into the tilled layer. The implements ("tools") used for primary tillage include moldboard, chisel and disk plows; heavy tandem, offset and one-way disks; subsoilers; and heavy-duty, powered rotary tillers. These tools usually operate deeper and produce a rougher soil surface than do secondary tillage tools; however, they differ from each other as to amount of soil manipulation and amount of residue left on or near the surface.

Secondary tillage is used to kill weeds, cut and cover crop residue, incorporate herbicides and prepare a seedbed. The tools include light- and medium-weight disks, field cultivators, rotary hoes, drags, powered and unpowered harrows and rotary tillers, rollers, ridge- or bed-forming implements, and numerous variations or combinations of these. They operate at a shallower depth than primary tillage tools and provide additional soil pulverization.

Equipment that permits primary and/or secondary tillage *plus* planting in a single operation is also available.

TILLAGE SYSTEMS FOR CORN

Throughout the United States, many different tillage systems are used in producing corn. Most provide for planting the crop into a flat seedbed, but some prepare a raised seedbed or ridges. Frequently, the tillage system dictates the design of the corn planter and its attachments. These attachments can range from a complete secondary tillage implement operating ahead of the entire planter to coulters or flexible harrow teeth that just till in front of each row of a planter.

Because of the number and diversity of corn tillage systems, it is difficult to give each one a meaningful name or even a precise definition. For instance, a system may be identified according to its ultimate objective (e.g., conventional, clean, reduced, minimum or conservation tillage); or according to the primary tillage tool used (e.g., moldboard plow, chisel plow, disk or rotary-till system); or according to its basic function (e.g., subsoil-plant, slot-plant, no-till, zero-till, strip-till or ridge-plant system).

The name problem is further compounded by the fact that definitions differ between regions of the country and even within regions. Different names may be used to identify the same tillage system, or the same name may refer to different tillage systems, all depending on where you live.

Thus, to accurately define or describe a given tillage system, all the operations that make up the system must be listed, including tillage, chopping or shredding residue, and application of pesticides and fertilizers. The American Society of Agricultural Engineers has compiled definitions and illustrations for most agricultural implements in *ASAE Standard S414*. This standard, revised periodically to include major new tillage implements, is available from ASAE, 2950 Niles Road, St. Joseph, MI 49085.

Recognizing that a confusion in terminology does exist, here are general definitions for the major tillage systems grouped according to ultimate objective, primary tillage implement and basic function. (Some of these systems are discussed in detail in other NCH fact sheets.)

Tillage Systems as Defined by Objective

Conventional tillage. This refers to that set of tillage operations most commonly used in a given geographic area to produce a given crop. Since operations vary considerably under different climatic, agronomic and other conditions, the definition of "conventional tillage" likewise varies from one region to another—and even within a region.

For instance, on the prairie soils of central Illinois, conventional tillage for corn means: (1) in the fall, phosphorus, potassium and lime are applied and the ground moldboard plowed; (2) in the spring, the ground is disked, nitrogen and herbicides applied before field cultivating twice and then the crop planted; and (3) the crop is rotary hoed if necessary and cultivated once. On the sandy Coastal Plain soils of south Georgia, on the other hand, conventional tillage usually involves the following sequence of operations, all done in the spring: disking, moldboard plowing, application of fertilizer and herbicides, and field cultivating or disking before planting, with the crop subsequently cultivated two or more times.

Conventional tillage is often used as the "standard" or "check" in experiments to assess the potential of other tillage systems in a given area. Factors usually compared in such studies include: soil conditions, plant emergence, growth and yield costs, erosion control, energy use and labor requirements.

Clean tillage. Another defined-by-objective system is clean (or residue-free) tillage. It involves a set of operations that prepares a seedbed having essentially no plant residue on the surface. Many conventional tillage systems are also clean-till, particularly those based on use of the moldboard plow. However, a clean soil surface can be achieved with

other tools, depending on the previous crop, amount of surface residue, and number and timing of tillage operations.

Reduced tillage. This refers to any system that is less intensive than conventional tillage. Either the number of operations is decreased or a tillage tool that requires less energy per unit area is used in place of a tool used in the conventional tillage system.

Minimum tillage. The definition of minimum tillage has varied over the years and from region to region; thus, the term is today little used and not very meaningful. Perhaps the best definition has been: "The minimum soil manipulation necessary for crop production or for meeting tillage requirements under existing conditions." The way most people use the term minimum tillage, they mean reduced tillage as defined above.

Conservation tillage. Although specific operations or sequence of operations might differ, most would agree that the objective of conservation tillage is to provide a means of profitable crop production while minimizing soil erosion due to wind and water. The emphasis is on soil conservation; but moisture, energy, labor and even equipment conservation are sometimes additional benefits.

To be considered conservation tillage, a system must produce, on or in the soil, conditions that resist the erosive effects of wind, rain and flowing water. Such resistance is achieved either by protecting the soil surface with crop residue or growing plants, or by increasing the surface roughness or soil permeability.

How effectively these conditions control erosion depends on certain related factors, including soil type, degree and length of slope, rainfall pattern and intensity, and cropping sequence. The Universal Soil Loss Equation (USLE), which takes all these factors into consideration, may be used to estimate the extent to which a particular conservation tillage system will control erosion. Local Soil Conservation Service personnel can provide assistance in using the USLE.

Tillage Systems as Defined by Major Implement

Moldboard plow system. The moldboard plow is used in the fall or spring for primary tillage, with various secondary tillage operations performed ahead of planting. Often before plowing, the previous crop residue is chopped or disked, and fertilizers and lime (if necessary) are applied.

Secondary tillage varies widely in type and number. *If herbicides are incorporated*, the plowed soil is often leveled, then herbicides applied and incorporated with one or two passes of a tillage tool that also prepares the seedbed. Fertilizers may be applied after the leveling operation or after planting (especially nitrogen in the form of anhydrous ammonia for corn). A portion of the fertilizers may

be applied during the planting operation. A rotary hoe or row-crop cultivator is also frequently used for additional weed control and soil loosening after crop emergence.

If herbicides are not incorporated, one or more secondary tillage operations are used to level the soil and prepare a seedbed, with the herbicides usually applied after planting. Fertilizing may be done before, during or after planting.

Chisel plow system. Except, of course, for the primary tillage tool, the chisel plow system is essentially the same as the moldboard plow system. The chisel plow generally leaves a rougher soil surface and considerably higher percentage of residue on or near the surface than does the moldboard plow.

Chisel plows come with a variety of chisel point shapes and sizes—from straight to twisted and from 2.5-inch to 4-inch widths. Chisel plows are also available with coulters or a disk gang mounted in front to cut through residue, thereby eliminating the need to disk or chop the residue beforehand.

Disk system. Tillage is usually not as deep with the disk system as with the moldboard plow or the chisel plow system. The number and type of operations in the disk system may vary considerably. An offset disk or tandem disk is usually used for primary tillage in the fall or spring, whereas secondary tillage may include tandem disking, field cultivating, harvesting and/or other operations. Fertilizers and herbicides are applied the same as with the moldboard plow system.

Rotary-till system. The rotary tiller may be used for primary tillage, secondary tillage or both. Sometimes the tool is mounted ahead of the planter to prepare the seedbed and incorporate herbicides in a one-pass tillage-planting operation. There are also rotary tillers available that only till narrow strips into which the corn is planted.

Tillage Systems as Defined by Function

Subsoil-plant system. This is a type of reduced tillage system that has become popular in areas having severe compaction problems. The system uses a combination tillage tool. In a single operation, the area beneath each row is subsoiled and tilled by coulters or other devices, and the crop then planted in the tilled strip.

Till-plant (or ridge) system. With this system, the corn is grown on pre-formed ridges or beds. The ridged seedbeds are made initially either (1) when cultivating the previous crop, using a cultivator equipped with sweeps and/or disk hillers, or (2) after harvesting the previous crop, using a moldboard lister bottom or short disk gangs.

In the spring, the residue is chopped, if necessary. Till or ridge planters usually have a sweep or double disk mounted in front of each planting unit. These sweeps or disks, set to operate 1-2 inches deep, transfer the disturbed soil and residue to the area between the rows. This leaves a clean strip into which the crop is planted.

With the till-plant system, preemergence herbicides are often banded or broadcast after planting. Several alternatives are available for applying fertilizers.

No-till (zero-till or slot-plant) system. This is a system whereby seed is planted in previously undisturbed soil. A no-till planter is designed and equipped to plant through residue and into firm soil. The only "tillage" done is the making of a narrow strip or slot into which the seed is dropped.

Generally, fertilizer has been broadcast on the soil surface before planting; however, equipment is available to apply fertilizer below the surface in otherwise no-tillage situations. Preemergence herbicides are usually applied after planting, with contact herbicides applied, if necessary, before the crop emerges to kill growing weeds.

A publication of the National Corn Handbook Project

NEW 1/85 (5M)

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