AGRONOMIC Spotlight
Technology Development & Agronomy by MONSANTO

Tillage Systems

- Tilling the soil can help prepare a seedbed, kill weeds, incorporate nutrients, and manage crop residues.
- There are many potential economic advantages for reducing the number of tillage operations.
- Each system has advantages and disadvantages that need to be assessed for each field situation.
- Selecting the best tillage system for specific situations requires consideration of several factors.

Tillage Classifications

Primary tillage is deep tillage (> 6 inches) that loosens and fractures soil for weed control and incorporation of residue, fertilizer, lime, and manure. Shallow tillage (<6 inches) kills weeds, cuts and covers crop residue, incorporates herbicides, and prepares a seedbed. In-crop tillage for weed control or injecting fertilizer or manure is considered tertiary tillage.2

- Conventional-till - A multiple tillage pass system that disturbs 100% of the soil surface (full width), including moldboard plowing, that leaves less than 15% residue on the soil surface after planting.
- Reduced-till - A full width tillage system that leaves 15 to 30% residue cover after one to three tillage passes.
- Mulch-till - A one to three pass full width tillage system using a chisel, disk, field cultivator, and combination tillage tools that leave more than 30% residue cover after planting.
- Ridge-till - Soil is left undisturbed from harvest to planting except for 4 to 6 inch high ridges built during row cultivation. One to two inches of the ridge are scraped off during planting.
- Strip-Till - Soil is left undisturbed except for strips where the soil is tilled and residue removed to facilitate planting. Typically a mole knife is used to till a zone about 10 inches wide and 4 to 5 inches high in the fall and fertilizer is applied in the zone.
- Vertical tillage - Full width, shallow tillage (2-3 inches) leaving 30% or more surface residue. Used to cut, mix, and anchor residue in the upper few inches of soil and break up surface compaction and crusting.
- No-till - A system with minimal soil disturbance (> 70% residue cover) with a row cleaner, coulter, seed opener, or other planter attachment to help establish a good crop stand.

Table 1. Yield Comparisons for No-till and other Tillage Systems.

		% Yield Advantage for No-till	
		Corn	Soybean
Region	Northern	-5.5%	-3.9%
	Central	-1.8%	-0.6%
	Southern/Western	12.2%	5.0%
Soil Drainage	Moderate/well drained	2.0%	2.0%
	Poorly drained	-4.5%	-1.4%
Crop Rotation	Corn x Soybean	1.9%	0.7%
	Continuous Corn	-1.5%	1.1%

Source: DeFelice, M.S. et al. 2006.[1]

The Purpose of Tillage

Tilling the soil can help prepare a seedbed, kill weeds, incorporate nutrients, and manage crop residues. The goal of the tillage system is to provide a proper environment for seed germination and root growth for crop production.

There are many potential economic advantages for reducing the number of tillage operations including: 1) lower fuel costs, 2) reducing the amount of tillage equipment needed, 3) lower labor requirements, 4) reducing soil loss from water and wind erosion, and 5) conserving soil moisture.[5]

Farmers and agronomists have debated the pros and cons of no-till versus other tillage systems. A recent report extensively reviewed the research comparing corn and soybean yields between no-till and other tillage systems (687 site-years of data) and found that the national average difference in yield between no-till and other tillage systems was small for corn and soybean.[1] No-till corn and soybean performed better in southern and western regions by about 12% or 5%, respectively (Table 1). The yield disadvantage in the north-central states and Canada was 5.5% for no-till corn and about 4% for soybean. Soil drainage had a negative effect on corn and soybean performance in no-till. Crop rotation had a small effect on performance. The authors found that many of the tillage studies were conducted without having a stable no-till system in place prior to initiating an experiment. Despite these differences no-till systems provided grain yields nearly equivalent to tillage systems.

Tillage Systems

The intensity of soil disturbance and number of operations can be used to define a tillage system (Table 2). Each system has advantages and disadvantage that need to be assessed for each field situation (Table 3).

Tillage Systems

Making Tillage Decisions

Selecting the best tillage system for specific situations requires consideration of several factors.[4]

- Crop rotation. The amount and durability of residue is crop specific. Corn generates more residue that degrades more slowly than soybean residue. It may be difficult to maintain adequate residue cover in crops following soybean.
- Erosion potential. The length and steepness of the slope, top soil depth, and soil texture determine erosion potential. Highly erodible soils may require large reductions in tillage operations to maintain residue and crop productivity. Tillage intensity and residue cover can help manage sediment loss on flat soils.
- Internal drainage. Poorly drained soils usually require more tillage to help soil warm-up and drying. High levels of residue can keep soils cool and wet too long for sensitive crops. Tile drainage may be needed to improve crop productivity.
- Surface compaction. Primary tillage may be needed to alleviate compaction caused by field activities on wet soils.

Table 3. Tillage Systems Comparison.

System	Advantages	Disadvantages
Plow	Suited for poorly drained soils. Excellent incorporation. Provides a well-tilled seedbed.	Major soil erosion. High soil moisture loss. Highest fuel and labor costs.
Chisel	Less winter wind erosion from roughened soil surface. Well adapted to poorly drained soils. Good incorporation.	Little erosion control. High soil moisture loss. Shredding may be needed for residue flow. Medium fuel and labor requirements.
Disk	Less erosion with more residue. Well adapted for well-drained soils. Good incorporation.	Little erosion control with more operations. High soil moisture loss. Destroys soil structure. Compacts wet soil.
Ridge-till	Excellent for furrow irrigation or poorly drained soils. Ridges warm up and dry out quickly.	No incorporation. Wheel spacing and other machinery modifications may be needed. Creating and maintaining ridges.
Strip-till	Tilled, residue-free strips warm up quickly. Injection of nutrients into row area. Well suited for poorly drained soils.	Cost of preplant operation. Strips may dry too much, crust, or erode without residue. Not suited for drilled crops. Timeliness in fall. Possible RTK guidance costs.
No-till	Excellent erosion control. Soil moisture conservation. Minimum fuel and labor costs. Builds soil structure and health.	No incorporation. Increased dependence on herbicides. Slow soil warming on poorly drained soils.

Source: University of Nebraska CropWatch Tillage website - http://cropwatch.unl.edu.[3]

Table 2. Typical Field Operations for Several Tillage Systems.

System	Typical Field Operations
Plow	Fall or spring plow, two spring diskings or field cultivations, plant, cultivate.
Chisel	Fall chisel, one/two spring diskings or field cultivations, plant, cultivate.
Disk	Fall or spring disk, spring disk and/or field cultivate, plant, cultivate or post-emergence spray.
Stubble Mulch	Blade plow in summer, one or more shallower operations with wide sweeps or a field cultivator, one or more rod weedings, drill, post-emergence spray.
Ridge-till	Shred corn stalks, plant on ridges, cultivate for weed control, rebuild ridges.
Strip-till	Fall strip-till, spray, plant, post-emergence spray as needed.
No-till	Spray, plant, post-emergence spray as needed.

Source: University of Nebraska CropWatch Tillage website - http://cropwatch.unl.edu.[3]

- Nutrient management. Moderate to low fertility fields should be fertilized to higher levels before conservation tillage is initiated. Surface applied nitrogen needs incorporation to minimize volatilization and runoff losses. Broadcast applications of phosphorus and potassium should be made following corn to use tillage to incorporate the fertilizer. Injecting or disking liquid manure is preferred over broadcast application to soybean residue. Try to avoid applying manure on sloping soybean ground.
- Pest management. Reduced tillage systems may have more weed, insect, and disease problems than conventional systems. More residue cover can increase overwintering survival of some insects and diseases or delay crop development (cool, wet soils), increasing the risk of crop infestation. Tillage can bury weed seed, disrupt weed, disease, and insect lifecycles, and bury residue that harbors pests. Seed treatments, foliar pesticides, and pest protected corn products can help manage pest problems.
- Planting equipment. Planter modifications (coulters, row cleaners, starter fertilizer attachments) may be required to handle higher crop residue levels. Planting equipment specific to a strip-till, ridge-till, or no-till systems may be required to match tillage and planting operations in each system.

Sources: [1] DeFelice, M.S. et al. 2006. Influence of tillage on corn and soybean yield in the United States and Canada. Plant management Network. [2] Tillage management. Agronomy Guide. Pennsylvania State University. [3] CropWatch Tillage/No-Till Systems (http://cropwatch.unl.edu, *verified 10/17/2013*). University of Nebraska. [4] Randall, G. & J. Vetsch. 2005. Factors to consider when making tillage decisions WW-08315. University of Minnesota Extension. [5] Harper, J.K. Economics of conservation tillage. Agronomy Guide. Pennsylvania State University.