SDSU Extension

iGrow Soybean

BEST MANAGEMENT PRACTICES

Chapter 15:
Developing a Tillage System that Increases Soybean Long-term Sustainability

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When South Dakota was homesteaded, tillage and cultivation were the primary means to manage residue, diseases, insects, weeds, and soil compaction. The consequence of 100 years of tillage was a 50 to 60% loss of our soils organic matter. Over the last 25 years, tillage intensity has been decreasing as indicated by a survey of in South Dakota (Fig. 15.1). Decreases in organic matter are attributed to: 1) improved equipment; 2) research investments made by the State of South Dakota, South Dakota producers, and USDA; and 3) improved weed control resulting from the release of herbicide resistant crops.

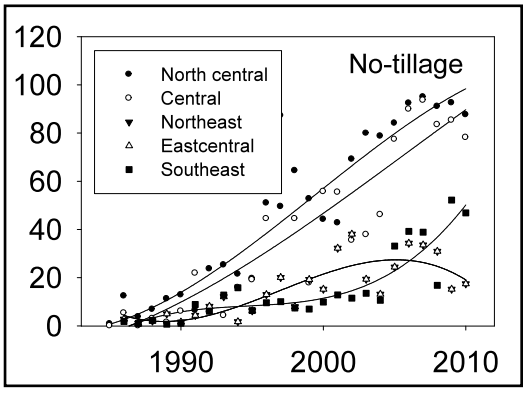

Figure 15.1. No-tillage adoption in different regions of South Dakota. (Modified from Clay et al., 2012b)

In many areas, no-tillage adoption has reduced erosion, increased carbon sequestration, increased the soils yield potential, improved soil water management, and increased wealth production. This chapter reviews tillage options for corn and soybeans grown in eastern South Dakota.

Rapid conservation tillage adoption

Across the Great Plains, tillage and cultivation were the primary means to prepare a seedbed and control pests. A consequence of over 100 years of intensive tillage was the loss of 50 to 60% of the soils organic matter (Clay et al., 2012), along with the loss of surface soil through wind and water erosion. Intensive tillage, reduced surface residue, and declining soil organic matter contributed to the Dust Bowl of the 1930s. The result was reduced yield potential of millions of acres of farmland.

Improved equipment, transgenics (Roundup Ready® crops), and close collaborations between USDA, SDSU, and South Dakota farmers provided opportunities for fully integrating conservation tillage systems (Fig. 15.1). No-tillage provided the ability to trade water lost through evaporation for yield and allowed row crop production to expand into drier regions.

Table 15.1. Advantages and disadvantages of various tillage systems.

Clean Tillage *(Moldboard Plow)*

Advantages	Disadvantages
Suited to most soils	Erosion potential
Well-tilled seedbed	Compation
Pest control	Fuel & labor cost
Quick soil warm up	Soil moisture loss
Mixes nutrients	Reduced infiltration
	Reduced soil carbon

Conservation Tillage *(Chilsel Plow & Rippers)*

Advantages	Disadvantages
Reduced erosion	Stalk chopping may be necessary
Reduced cost	Compaction (if disked in wet conditions)
Mixed Nutrients	Delayed planting (if too wet)
Reduced water loss	
Improved infiltration	
Increased snow catch	

Ridge Tillage

Advantages	Disadvantages
Reduced erosion	Not well suited to all rotations (alfalfa or small grains)
Saves water	Must have both equal wheel spacing on all equipment
Lower fuel costs	and narrower tires
Increased snow catch	

Strip Tillage

Advantages	Disadvantages
Reduces soil erosion and runoff	Specialized equipment needed
Saves moisture	Greater reliances on herbicides
Reduced compaction	Potential for disease and insect outbreaks
Increased snow catch	
Reduced crop residue interference	

No-Till

Advantages	Disadvantages
Greatly reduces soil erosion and run-off	Specialized equipment needed
Saves moisture	Greater reliance on herbicides
Lower fuel costs	Slower spring soil warm-up and drying
Reduced compaction	Nutrient stratification
Increased snow catch	Potential for disease and insect outbreaks

Associated with the rapid adoption of conservation tillage across the state were wheat, soybean, and corn yields that increased 56, 33, and 102% from 1980-1984 to 2006-2010, respectively. In the central portion of the state, 60 to 90% of cropland acres are in no-tillage systems. Comparatively, no-tillage adoptions in the eastern regions are between 20 to 40% of cropland acres. Recent statewide declines of no-tillage adoption have been observed and are likely due above average rainfall totals since 2009.

A review of no-tillage adoption in central and southern regions of the United States is available in DeFelice et al. (2006).

Creating a tillage system that fits your needs

There is no one tillage system that fits all cropping systems (Table 15.1). A tillage system used in one field may not be the best system in another field. Factors to consider when designing a tillage system include erosion potential, crop rotation, soil characteristics, nutrient management, pest problems, and available planting equipment. Tillage tends to reduce surface residue cover and increase erosion. Reducing surface residues can interrupt lifecycles of insects and diseases that can reduce yields.

Plant diseases are generally caused by a fungus, virus, or bacteria. Some can only live on one plant species, others may infect another species but may not harm it. Most disease pathogens overwinter on crop residue. Tillage buries residue reducing the chance of pathogen survival and infection of the upcoming crops. The exception is soybean cyst nematodes (SCN), which live in the soil. Some insects overwinter on crop residue. Burying those insects exposes them to soil microflora that may feed on them. Tillage can also expose insect larvae in the spring, leaving them vulnerable to predators and intolerable conditions.

Tilled fields tend to dry and warm quicker than no-tilled fields. Surface residues reduce evaporation as well as wind and water erosion, while improving soil structure, and enhancing water infiltration. http://clean-water.uwex.edu/pubs/pdf/residue.pdf

Figure 15.2. Compaction created by a tandem disk.
(Photo courtesy of T.E. Schumacher, SDSU)

However, while surface residue helps increase moisture, it also deflects radiant heat energy from the sun, slowing spring soil warming, and may interfere with planting and seed-soil contact. Tillage is conducted to reduce compaction rather than cause it. However, it is not uncommon to find a plow pan (area of compacted soil) 4 to 8 inches (10 to 20 cm) below the surface. Disking can create layers of compaction at much shallower depths (See Fig. 15.2).

Silty clay loam to clay soils have the greatest compaction potential and even soils with higher sand and silt content can compact if field operations are conducted under wet conditions. Soil fertility and pest control strategies are directly influenced by tillage system. Nutrient loss is reduced and effectiveness of fertilizers and manure is increased when incorporated. In addition, selected herbicides and insecticides must be incorporated to be effective.

No-till systems leave little choice but to surface apply fertilizer, manure, herbicides, and insecticides. In this system, fall-applied P and K fertilizers, manure, and lime left on the surface can be carried off the field during spring snow melt-and early spring rainfall runoff events. Since P and K move very slowly through the soil profile, surface applied P and K can also be lost to erosion. In addition, surface-applied lime may take several years for it to move far enough into the profile to become beneficial.

One alternative to no-tillage is strip tillage, where soil in the crop row is mixed and fertilizers and pesticides are incorporated into that band. Strip tillage, like any other tillage system has positive and negative aspects. The following provides a discussion of selected tillage systems.

Clean-till

Clean tillage involves inverting the soil so that most of the residue is buried. Moldboard plowing followed by pre-plant disking is a common clean-till procedure (Fig. 15.3). For most situations, clean tillage is not a best management practice (BMP). Clean tillage often leads to depletion of soil organic carbon, and ultimately, loss of soil moisture. Because crop residue is buried, surface soil can be lost through wind and water erosion. In addition, clean tillage can result in soil compaction and a loss of productivity.

Figure 15.3. Clean till, typically moldboard plowing.
(Photo courtesy of H.J. Woodard, SDSU)

Clean tillage can result in a loss of organic matter and reduced soil health. When used, clean-tillage should be used judiciously and is most often used in bottomland (toeslope positions) or poorly drained soils. However, clean tillage generally only provides temporary relief. The best solution to minimize compaction is to minimize field traffic and avoid fieldwork when soil is too wet, regardless of tillage system selected.

Conservation till

Conservation tillage systems leave at least 30% of the soil covered with crop residue (Fig. 15.4). Conservation tillage tools include chisel plows, disks, mulch rippers, disk rippers, and minimum till rippers. These implements can be customized with various coulters, standards, ripper points, sweeps, and shovels. This flexibility allows producers to select tillage tools that are best suited to local soil conditions. Increasing the residue on the soil surface decreases the potential for erosion and soil water loss.

Figure 15.4. Example of conservation tillage.
(Photo courtesy of USDA-NRCS Photo Gallery)

The amount of residue on the soil surface is directly related to evaporative water loss, available water, and the length of time needed for the soil to warm. Residue cover is indirectly related to the soil erosion potential. The amount of residue remaining on the soil surface can be increased by:

- Including a high-residue-producing crop in the rotation.
- Conducting tillage operations in the spring.
- Reducing the number of tillage passes.
- Using cover crops.
- Driving slower during tillage.
- Setting chisels and disks to work soil to a shallower depth.
- Using straight shanks and sweeps.

Ridge-tillage

Ridge-tillage is a conservation tillage system where crops are grown on permanent beds (or "ridges") (Fig. 15.5). Ridge tillage consists of:

1. planting the crop,
2. cultivating to build the ridges,
3. harvesting the crop, while attempting to stay off the ridges,
4. spreading residue evenly, *and*
5. shaving off the top of ridge, during planting, to plant your crop into a residue-free zone.

Ridge-tillage is used to help reduce heavy residue problems. If the ridge cleaners are working correctly, the seedbed will be relatively residue clean. If the ridge is not clean of residue, then the planter must be able to cut residue, penetrate the soil to the desired depth, and plant the seed. Following planting, cultivators are used to control weeds between rows and rebuild and shape the ridges. Ridge-tillage is well suited to relatively flat landscapes and is often furrow irrigated in arid climates.

Figure 15.5. Planting soybeans in a ridge-tillage system. (Photo courtesy of K. Alverson)

In ridge-tillage, crop residue and organic matter tends to accumulate between the ridges. If mechanical cultivation and ridge building take place during the growing season, these materials are mixed into the surface soil. Relative to clean-tillage, ridge-tillage increases water infiltration and reduces run-off. Nitrogen leaching can be reduced by banding the fertilizer into the ridge. Herbicides may be applied to the ridge, with cultivation used for between-row weed control. Two disadvantages of ridge-tillage are: 1) specially designed equipment is needed, and 2) it is labor intensive.

In ridge-tillage, it is recommended that the soil samples for nutrient analysis be collected halfway between the center of the row and the crop row. When applying fertilizers into the ridge, care should be taken to minimize direct contact with the seed.

Strip-till

Strip-till is a conservation tillage system where the seedbed (8 to 10" wide) (20 to 24 cm wide) is tilled and cleared of residue (Fig. 15.6). Strip-till systems prepare a seedbed that is relatively free of residue, even in corn-following-corn situations. Strip-tillage may be conducted in the fall or spring. Spring strip-till uses a tillage tool that tills strips ahead of planter seed openers. If strips are tilled in a separate operation, prior to planting, it can be challenging to consistently follow the strip with the planter, although guidance systems are alleviating this problem. It is recommended to track the direction of travel of the tillage implement. Strip-tilled fields tend to warm faster than in no-till fields.

Figure 15.6. Erosion in a strip-till system. (Photo courtesy of D. Beck, SDSU)

Strip-tillage does not eliminate erosion, and following rainfall, erosion can occur down the strip. Contour strip-tillage should be considered in high-slope situations. In some strip-till systems, when strips are tilled in the fall or spring, fertilizer is applied into the strip. Failing to follow the strips with the planter can affect fertilizer placement with respect to the seed. As with any tillage system, N fertilizer should not be fall-applied until soil temperatures are below 50°F. Starter fertilizer can be used. Many producers have problems when attempting to plant into fall-created strips in rolling terrain. If the seed row is either too close or too far away from the fertilizer band, plant vigor during early growth can be compromised.

No-till

Of the tillage systems discussed, properly managed no-till systems leave the most residue on the soil surface (Fig. 15.7). Compared to other systems, the soil retains the most moisture, has the highest infiltration rates, and least erosion potential. The effects of no-tillage on erosion are attributed to increased water infiltration and reduced run-off. No-tillage can lead to higher soil organic carbon levels and improved soil health. Considering the benefits, no-tillage should be strongly considered by most South Dakota producers.

In South Dakota, no-till systems are largely responsible for expansion of row crop production into the mid and western regions of the state. This expansion has resulted in reduced soil water loss, reduced runoff, increased soil organic matter levels, and higher water infiltration rates.

No-till systems require optimization of planting and residue management systems. Residue management begins by leaving as much residue in place as possible. For example, use stripper headers for harvesting. In corn, this is accomplished by adjusting the strippers and rolls to keep the stalk intact and upright. Cutting corn plants 12 to 24 inches above the soil surface (http://www.ipm.iastate.edu/ipm/icm/2006/5-15/notill.html) may also reduced damage to equipment ties. In addition, standing residue is relatively easy to manage planting; and upright residue provides more protection from wind and water erosion.

Figure 15.7. Planting soybeans in a no-till system.
(Photo courtesy of H.J. Woodard, SDSU)

During planting a residue manager can help prepare a good seedbed. However, a residue manager can compensate for non-uniform residue distribution. Residue managers work best in situations where residue is uniform. When residue is not uniform, it is almost impossible to properly adjust residue managers. Moving residue is easier if it is cut before moving it. Single-disc fertilizer openers placed at the same depth and two to three inches to the side of the seed opener path can cut surface residue and provide an opening for band-applied fertilizer. When compared to conservation tillage, no-till soils generally remain cooler in the spring. Cooler soil temperatures can slow nitrogen (N) and sulfur (S) mineralization. Placing nutrients like N and S as a side-band improves early season plant vigor.

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