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Best Management Practices for Conservation/Reduced TILLAGE

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Farming today requires producers to employ best management practices (BMPs) to be successful. Because of increased crop production costs, most farmers have to re-evaluate how they till and consider adopting reduced or conservation tillage practices.

Conservation tillage does not mean never till. Some tillage is not bad if it is necessary, but unnecessary trips across the field are costly — often in more ways than one. Maintaining residue on the soil surface increases water infiltration, reduces erosion, increases organic matter, reduces weed pressure, saves time and reduces costs.

There is no specific formula for success, and the BMP that works best in one area or on one farm may not necessarily work somewhere else. In 1995 we began evaluating different tillage systems in south central Texas at the Luling Foundation Farm (LFF). Crop failures and poor crop performance have demonstrated since then what practices are inappropriate for the region, while other BMPs have proven to be profitable. In addition, cooperation with innovative producers in the region has been invaluable in reducing the time needed to determine appropriate practices.

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Tillage Systems

To explain the results of our LLF trials and the differences among tillage practices, we use the following terms:

- **Conventional tillage** leaves less than 15 percent residue cover after planting through intensive tillage.
- **Conservation tillage (con-till)** covers 30 percent or more of the soil surface with crop residue after planting.
- **Reduced-till** leaves 15 to 30 percent residue cover after planting.
- **No-till** leaves the soil undisturbed from harvesting to planting except for nutrient injection. Planting and fertilization are done with row cleaners and slits in the soil for placing seed and nutrients. Weeds are controlled with herbicides except when doing emergency weed control.
- **Ridge-till (stale seed bed)** leaves the soil undisturbed from harvesting to planting except for nutrient injection, but rows are rebuilt during cultivations for next year's crop. Permanent rows and traffic patterns are important to the success of this system.
- **Mulch-till** disturbs the soil before planting with chisels, field cultivators, disks or sweeps. Weeds are controlled by cultivation/and or herbicides.

- **Strip-till and zone-till** are not separate systems, but are variations of systems. A fertilizer knife or mole knife is typically run in the row in the fall, early winter or late spring to loosen the soil and inject fertilizer. The soil usually is tilled with sweeps or disks over the row only, leaving the soil in between the rows untilled. The width of the tilled area can vary, and a bed may or may not be formed.

Performing strip-till or zone-till occasionally is the best compromise between conventional tillage and no-till. Yield with these systems is comparable to that of conventional tillage — without the cost.

Fundamental BMPs for Successful Con-till

In our experiments, we have not documented increased yields from con-till compared to conventional tillage, but there are economic advantages. These come from having less labor, less fuel, fewer repairs and less maintenance, better field accessibility, lower capital investment and lower horsepower equipment. The way we have dealt with specific challenges to crop production have led to a BMP system that fits the LLF operation and may help producers elsewhere in implementing their own practices.

Soil compaction

This is one of the reasons soil is tilled. While most producers worry about soil compaction, their concern is often unwarranted because compaction does not exist in most fields. *The primary cause of compaction comes from heavy equipment traffic crushing air spaces out of moist soil.* (See "Recommended Reading" on page 6.)

Top soils typically contain approximately 50 percent of pore space by volume. Pore space may be filled with water or air; so, when weight is applied to a moist soil, the soil aggregates are crushed, and the pore space is destroyed. Traffic patterns must be controlled, and proper tire pressure on equipment must be maintained. Generally, the potential for compaction increases as the percent of clay in the soil increases and as the organic matter content decreases.

Organic matter absorbs water like a sponge, provides nutrients as it decomposes and reduces the bulk density (or weight per volume) of soil. Tillage mixes, oxygenates and buries crop residue, resulting in maximum decomposition under warm, moist conditions. Reduced tillage, however, leaves residue on the soil surface, which decreases the rate of decomposition and increases organic matter in the surface horizon.

A second type of compaction occurs slowly over time in clay soils that receive more than 30 inches of annual rainfall. Because of their small size, clay particles begin to fill the pore space, which increases bulk density. Soils at the LFF site are 50 percent or more clay, and we had to deal with naturally occurring soil compaction in the seed drill zone because no tillage had been done in 3 years. Organic matter appeared to decompose rapidly in the planting zone, which resulted in very dense, firm soil in the top 4 inches.

Rotational tillage, where the soils are tilled every second or third season, or strip or zone tillage will eliminate this problem. In areas with less clay and lower rainfall, compaction does not seem to be a problem, and the topsoil horizon actually becomes more mellow with time.

Fertilizer placement and application

These practices are more difficult to accomplish in con-till than in conventional tillage, which is another justification for rotational tillage. Surface applications of fertilizer can result in nitrogen loss from volatilization and cause phosphorus and other immobile nutrients to accumulate near the soil surface. Nutrient deficiencies are likely to occur in no-till or stale seed beds, where crops are planted into the same row each year. Rotational tillage with a chisel plow will break up soil firmness in the top 6 inches and may replace a herbicide application.

Because *placement and timing of phosphorus applications are important,* we recommend the following practices:

- Phosphorus should be applied *before or at* planting to ensure that it is available early in the season. Most producers prefer a smooth coulter with fertilizer sprayed into the coulter slit or a strip-till unit.

- In corn and sorghum, it is important to apply a starter fertilizer or place all phosphorus fertilizer close to the developing seedling to prevent nutrient deficiencies. However, you must *keep excessive nitrogen away from developing seedlings to prevent possible salt injury.* (Nitrogen can be side-dressed easily with a coulter/knife or coulter/spray.)
- Where a starter or a well-placed high-phosphate fertilizer is used, grain crops grow better and mature faster although yields may not be higher. If all the fertilizer is banded 2 or 3 inches from the seed at planting, there should be no delays in crop development.
- This is also true if you use a *pop-up,* or seed-placed fertilizer, that is applied directly to the seed. Pop-up fertilizer applications of 10-34-0 or 11-37-0 in the seed drill at rates of about 5 to 7 gallons per acre or less are an option.
- While pop-ups have not helped cotton, they are more likely to increase yield and to establish stands quickly in grain crops. The amount of phosphorus in the pop-up should be subtracted from the total amount that is needed for the crop to prevent over-fertilization. This is because the nutrients are *not in addition to* the normal fertility amounts and because they minimize total fertilizer costs. *Do not use fertilizer on the seed in sandy soils because injury is likely.*
- Phosphorus, potassium and many micronutrients (such as zinc and copper) are immobile in the soil and tend to remain very near the point of placement. In reduced-till and no-till systems, repeated surface applications of these nutrients with little or no incorporation can lead to *stratification.* This process involves the build-up of nutrients in the upper 2 to 3 inches of soil, where they may have very limited availability to plant roots — especially under dry land conditions. This is particularly a problem in heavy-textured soils that contain clay.
- To slow stratification, phosphorus and other immobile nutrients should be banded 5 to 6 inches below the surface where possible. Placing the nutrient close to the planted row will also increase fertilizer efficiency. Using rotational tillage also may be necessary to incorporate surface-bound nutrients from organic matter decomposition and improve their availability to plants.

Weed control

Weeds compete for moisture, fertilizer and light and can be greatly reduced if the soil is not tilled. This is because tillage brings weed seeds continually to the surface, where they readily germinate with any rain. We have found that it is easier and generally better to control weeds under no-till and reduced tillage systems.

These are some other BMPs that help with weed control:

- Use herbicides in the winter and during the growing season.
- Applying transgenic technology, such as Roundup Ready® and LibertyLink® products, has made no-till and reduced-till much easier. Using these and other herbicides is essential for good weed control and prevention of resistant weeds.
- A hooded sprayer is important for weed control in sorghum (particularly for grass control) and in cotton (for lay-by applications of herbicides).
- Pre-emergence herbicides are still important. Weed control before planting prevents weeds from depleting valuable soil moisture and from creating a haven for insects. For example, wireworms may attack seed prior to stand establishment, and cutworms may damage a crop upon emergence. Following several years of no-till, weed populations may shift to those weeds that compete better under these conditions.

Roller choppers or rolling stalk choppers

We have found stalk choppers to be more effective in continuous cotton crops or where ridge-till is done farther north in Texas. The stalks are left standing all winter and spring to protect against winds, and are chopped in late winter or early spring when beds are remade. These choppers proved to be of no extra benefit in no-till and reduced-till in south Texas. They were ineffective in breaking surface compaction, but did a good job of chopping residue. Residue managers on the planter adequately removed un-chopped stalks at planting time.

The closing wheels or closing system

Using closing wheels or a closing system on the planter is *very important.* It might mean the difference between a good stand and a poor stand. Because of varying conditions at planting, you should have several types of closing wheels. Schlagel Manufacturing wheels and closely-spaced spiked closing wheels have been the most effective in tests with loose soil under most planting conditions.

We also found it is important to break any side wall compaction caused by disc openers, to firm the seed in the bottom of the seed trench and to leave the surface slightly roughened to prevent crusting and baking. The seed must be firmed into moist soil and properly covered (as with conventional tillage) to achieve a good stand. Double disc planters tend to leave smooth, slick side walls that reduce root penetration.

Planting moisture

If a small bed is made before the onset of winter, when soil moisture normally accumulates, moisture should be more consistent at planting time. You can then use a bed to remove dry soil and will not need to plant "in a hole" to find moisture.

Make sure the bed is not a high ridge, but rather only a low, rolling hump formed without burying residue. Meanwhile, keep the bed covered with as much residue as possible. Flat planting and "busting out" the dry soil on the surface to get to moisture will cause deep planting in a trench. It also will bury the seed if a heavy rain comes before stand establishment. Try to maintain as much residue on the surface as possible to increase water penetration.

Water

Covering the soil with residue rather than tilling it clean improves water infiltration. The impact of rain on base soil destroys small aggregates, or clods, causing the soil to seal over. Residue breaks the impact of rain drops, "wicks" or moves moisture into the soil, and reduces runoff.

Earthworms

Just because a field is under con-till does not automatically mean you will have a large number of earthworms, which can do a tremendous amount of tillage. Their populations rise and fall with the moisture, number of roots and amount of organic matter (their food source) in the soil. Water soaks into the soil through worm tunnels, which also helps soil gas exchanges. There are fewer earthworms in conventional till plots because planting can kill them and because soil organic matter rapidly decomposes.

Controlled traffic patterns

To prevent compaction in the seed or planting zone, controlled traffic patterns in fields are essential. Driving on moist soil causes compaction, so you need to avoid crushing the soils. Once compaction has occurred, tillage may be necessary to break up compacted zones or areas.

Stalk spreaders

Stalk spreaders are important for distributing the residue rather than pushing it into wind rows. This is particularly true for combines with larger headers, but less important for smaller combines.

Narrow rows

Making rows 30 inches instead of 38 to 40 inches can help shade the soil faster and reduce weed growth. In research around the state, particularly at Temple, sorghum yields have consistently been higher with narrow rows.

Results of BMPs

Our findings have shown us that it is extremely important to consider the effect of a single management practice 3, 4 or 6 months into the future. We have seen this principle at work with various crops and have learned that, as in any production system, the crop must be properly established to a good stand and be properly fertilized. Then, to harvest a good crop, weeds must be controlled.

Corn

Of the crops we are producing, corn is the easiest to grow. It responds well to no-till for several years, but clay soils do get firm by then and must be loosened occasionally by tillage (e.g., strip till unit, ripper-hipper or some kind of in-row tillage).

Our research has also showed us the following:

- The corn seed is large, which results in better stand establishment under less than opti-

mum conditions. It is planted early, and soil moisture at planting is generally good. Corn can be planted flat — without beds — where fields contain a lot of residue, rainfall is sufficient, and where spring moisture is usually not a problem.

- Corn is planted earlier when soils are generally wetter and the crop is finished before the onset of summer heat. LLF trials have shown that corn is most profitable under no-till, followed by reduced till, and is least profitable when conventionally tilled.
- More herbicides are available for corn than for any other crop. We found the Roundup Ready® varieties yield the same as the non-transgenic herbicides, and that weed control is simple. Without herbicide rotation and pre-emergence application, however, grasses and weeds or such species as morning glory and copperleaf will become a problem.
- In wetter regions (east and north of San Antonio and near the coast), you do not need to shred down stalks if you use residue managers on the planter or use a pre-planting rig, such as a fertilizer applicator. Corn roots, crowns and stalks decompose faster than sorghum, and it is easier to plant into them than it is to plant into sorghum. In the coastal regions where rainfall can be heavy and water runoff is significant, shredded residue will float off after a lot of rain. The option is to shred and incorporate the stalks into stale beds if they are not left standing.

However, in the dryer areas west of San Antonio where residue does not decay as rapidly, shredding the stalks will lay them on the soil surface and provide the essential mulch cover. It also reduces problems such as stalks sticking up into the planter and knocking off chains. A flail shredder works best for this.

Sorghum

This crop is the next easiest one for getting a stand. These are some of the results from our tests:

- Sorghum seed is smaller, must be planted more shallow and is planted shortly after corn.
- There is little difference in yields of sorghum among the three tillage treatments.
- The profitability of sorghum is a problem. Unless the yield is approximately 4,000 pounds per acre or more and input costs are minimized, the crop will not be profitable — even under reduced tillage. However, it still is a good rotational crop for corn and cotton. In hot, dry years when aflatoxin is a problem in corn, sorghum has a market.
- It is important to kill the sorghum with glyphosate *before or soon after* harvest so the crowns will begin to rot. If the plant survives until fall and the winter is dry, the sorghum crown is usually intact by planting time in the spring and is difficult to move with residue managers. Cotton root rot can survive on live sorghum roots, so it is important to kill the sorghum plant as soon as possible to stop the disease.
- Sorghum stalks decay much more slowly than corn stover, but shredding will cause them to deteriorate more rapidly. Shredding the stalks will lay them on the soil surface and provide the essential mulch. It helps keep stalks from sticking up into the planter and knocking off chains, for example. As we found with our corn stalks, a flail shredder works best for this. In the coastal regions where it rains a lot and shredded residue will float off after heavy rains, you can shred and incorporate the stalks into stale beds if they are not left standing.
- Most producers plant too many sorghum seed per acre. Plant populations in the 60,000 to 70,000 range are best on a 30- to 40-inch row spacing. Research in San Patricio County and Temple continues to show increased yields with narrow 30-inch row spacing.

Cotton

This crop is more difficult to establish in no-till unless conditions are optimum. Here are highlights from our studies:

- Because it requires warm soil for germination, cotton is planted later. If spring rain is late, the soil might become hard, and the moisture will be deep on flat-planted no-till.

- A bed or ridge is important for cotton. Therefore, you need to create a bed with ridge-till or even conventional-till.
- With rows, it is easier to push aside dry soil to reach available moisture. However, a tall, hipped row reduces water infiltration and drains water from fields. A high row with no residue on the soil surface becomes an excellent drainage ditch. Rain sheets off the bed and runs off.
- A row is important for cotton. When planted in a hole, rain may wash soil on top of the seed and bury it too deep. Also, when planted flat, lower bolls may not be picked up and are left in the field at harvest.
- The economics of cotton production have shown there is little difference among the no-till, reduced-till and conventional tillage treatments.

Wheat

Wheat is an excellent rotational crop and is one in which we do some rotational tillage. During the fallow period, it is also an excellent crop for cleaning up perennial weed problems, such as Johnsongrass and morning glory.

We recommend these as BMPs when growing wheat:

- Spray weeds after harvest to conserve moisture and avoid weed problems. Any time the soil is disturbed, it helps weed seed germinate and creates a continuous cycle of tillage and weed growth.
- Tillage can be delayed until rows are bedded in late fall and are sprayed during the winter to capture and hold as much water as possible.
- Leaving stubble on the soil surface keeps the soil from sealing over so that it remains porous and absorbs water.
- When following wheat, soil should be disturbed as little as possible so that the soil can be prepared for planting with a conventional grain drill. If a no-till drill is too expensive, tillage can be done with a chisel plow, field cultivator or disk when the soil is dry.

BMPs and Conventional Tillage

Conventional tillage is changing. Over the years, most producers in the LLF area have reduced the amount of tillage in conventional plots by eliminating mold board plowing. We are trying to use best management practices such as these within each tillage system:

- With the adoption of Roundup Ready® technology, even in the conventional-till plots, we are substituting herbicide applications for some tillage to kill weeds, particularly early in the season. Late-season tillage with, for example, a chisel plow or a disk when soils are dry will replace herbicide applications. As a result, the economic differences in production costs are not as great.
- Summer fallow behind wheat is best accomplished with glyphosate rather than tillage. The soil is protected, weeds are controlled and weed seed are not disturbed for germination.
- Herbicides have replaced tillage as the preferred choice for winter weed control. Unlike tillage, herbicide applications can be made in wetter conditions and will not bring up weed seed. This practice also conserves moisture.

Recommended Reading

"Management to Minimize and Reduce Soil Compaction." Nebraska Cooperative Extension, G89-896.

"Soil Compaction — The Silent Thief." University of Missouri, Bulletin G1630.

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