

# COTTON PHYSIOLOGY TODAY

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## CONSERVATION TILLAGE

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*One definition of till is to make fit or good. This meaning of the word was not lost on cotton farmers once mechanization occurred. Liberal use of cold steel in a cotton field was an accepted principle underlying successful production. That notion is being challenged by recent innovations in tillage systems. Producers now have several tillage options to choose from to enhance their management capabilities. This newsletter will discuss some of the potential benefits, opportunities and pitfalls in adopting conservation tillage systems. Interested readers are encouraged to obtain additional information from the sources listed on the back page.*

### Benefits of Tillage

Conventional (clean) tillage grew out of farmers' efforts to increase production in row crop agriculture. Its most readily apparent benefit in cotton production was to control weeds that compete with the crop for sunlight, water and nutrients during the early season. Cultivation accomplished this task through a combination of preplant soil turning to create a competition-free seedbed followed by post emergent hand hoeing in the row and mechanical plowing of the middles.

Tillage also produces other desirable benefits apart from weed control. Residue from harvested crops may interfere with several cultural practices such as planting, cultivation and directed post emergent herbicide applications. Soil incorporation of this residue simplifies field operations by creating a consistent surface that increases the precision and uniformity of these operations.

Post-harvest tillage is an important component of disease and insect management programs for cotton. Food sources and reproduction sites for microorganisms responsible for cotton diseases are destroyed as residue is incorporated and decomposed. Several important insect pests including tobacco budworm, cotton bollworm and pink bollworm overwinter just under the soil surface. Disturbance of this zone can help reduce their winter survival and spring emergence.

Certain tillage operations can favorably affect the soil environment for seed germination, seedling emergence and subsequent root growth. Seedbed preparation can produce a granular soil structure that increases seed-to-soil contact which in turn improves germination and emergence. Stand establishment is more uniform with subsequent benefits in crop uniformity and development. Tillage also temporarily reduces surface soil density improving water infiltration and retention. In coarse- or medium-textured soils that compact, subsoiling improves internal drainage as well as root penetration and exploration for nutrients. In areas where cotton is grown on

sandy soils, tillage helps to break crusts and rough up the surface so that wind does not blow soil and injure cotton.

### Problems Resulting from Tillage

Tillage practices temporarily shift the micro-environment for the benefit of the crop. Unfortunately, that shift is not universally beneficial to the plant/soil environment. Plant residue helps to protect the soil from the action of wind and water. Once the material is turned under, that protection is lost. Wind can lift, remove and redeposit soil over wide areas of the country. For instance, millions of acres of cropland were impaired or destroyed during the "dust-bowl" of the Great Plains. On sloping or undulating terrain, runoff from rain can cause severe soil erosion. In the southeastern United States, millions of acres of prime farmland have been lost to water erosion since this region was settled and cleared for crop production.

Undisturbed soil cover is composed of a wide array of plant components including live plants, intact plant residue on the surface and organic matter at various stages of decomposition. The immediate result of tillage is a greatly increased potential for erosion because of the loss of surface cover. Tillage mixes plant materials with the soil and promotes rapid decomposition of the organic matter. The modified soil environment harbors a less diverse biological ecosystem with lessened buffering capacity to further disruptions. Practical consequences of this organic matter reduction include fewer herbicide options, soil crusting, slower water infiltration and reduced seedling emergence and vigor.

Tillage practices can have a long-term negative impact on soil structure. The loss of organic matter coupled with the mechanical crushing of soil aggregates contributes to puddling and compaction of surface soils after heavy rains. Other visible symptoms of structure loss are slower water infiltration, reduced water holding capacity, increased runoff and increased erosion.

### Conservation Tillage

Tillage systems are being developed across the Cotton Belt that seek to retain the benefits of the conventional system without its drawbacks. Research trials have demonstrated that cotton can usually be grown successfully in conservation tillage systems (see table).

Conservation tillage includes any tillage or planting system that maintains at least 30% (50% in some regions) of the soil surface covered with plant residue after planting. The types of conservation tillage include no-till, ridge-till or strip-till and mulch-till. However, most researchers and farmers agree that an almost infinite number of input options are possible within each of these categories. The best system for a particular situation will depend

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upon many factors, including soil type, environmental conditions, weed pressure, availability of specialized equipment, etc. The following discussion focuses on general trends and approaches common to the different options.

### EFFECT OF TILLAGE SYSTEMS ON COTTON LINT YIELD PER ACRE

Location	Years Evaluated	Average Yield
<b>Alabama</b>		
Conventional	5	710
No-Till (no cover crops)	5	641
No-Till (wheat cover)	5	676
<b>Louisiana-Macon Ridge</b>		
Conventional	6	717
No-Till (no cover crops)	6	674
No-Till (wheat cover)	6	754
Ridge-Till (wheat cover)	6	738
<b>Louisiana-Sharkey Clay*</b>		
Conventional	4	1145
No-Till (no cover crops)	4	1195
Ridge-Till (wheat cover)	4	1190
<b>Tennessee</b>		
Conventional	10	894
No-Till (no cover crops)	10	910
Conventional	12	847
No-Till (wheat cover)	12	867
<b>Texas High Plains</b>		
Conventional	7	684
No-Till (wheat cover)	7	732

\* Estimates from seed cotton yield.

### No-Till Systems

No-till production systems have been implemented from the Carolinas to the Texas High Plains. As the name suggests, preplant tillage is either non-existent or is limited to narrow slots provided by coulters and/or subsoilers. No-till systems provide the highest level of erosion control and protection of seedlings from wind and water because of the large amounts of surface residue that are maintained. Herbicides, crop residue and cover crop mulches replace tillage as the primary means of controlling weeds.

Following harvest of the preceding crop, the residue is cut or simply left standing. In areas with high erosion potential, cover crops may be planted to supplement ground cover beyond that provided by native vegetation. If the field is tilled to establish a cover crop, potassium and/or phosphorous fertilizer as well as lime may be applied at this time. If there is no tillage to establish a cover crop, surface-applied fertilizer in the spring has proven to be adequate in most cases. Field preparation in the spring is limited to one or two preplant herbicide treatments to kill winter annual weeds and/or cover crops.

Planting cotton in no-till systems requires consider-

able attention to detail. Stand establishment problems in no-till are frequently attributable to poor soil coverage and seed contact. Heavy-duty planters with ripple or fluted coulters to cut through plant residue help prevent that problem.

Excessively wet or dry soils are also associated with many stand failures. Timely preplant herbicide applications that kill all existing vegetation several weeks ahead of planting are very beneficial for conserving soil moisture for planting. Providing adequate surface drainage and planting in slightly raised beds encourages good drainage and rapid soil warming for earlier planting in high rainfall areas.

Surface or subsoil compaction can hamper no-till efforts. In some coarse- or medium-textured soils, subsoiling at planting may be required to improve root penetration. Channels from decomposed roots of preceding crops also help penetrate these compacted areas. The cutting action of the coulters or cover crop rooting may be sufficient to loosen surface compaction.

Seeding rates are often increased 10 to 20% to account for reduced seed germination and emergence in no-till systems. This modification should be approached cautiously to avoid excessively dense stands.

Crop residue and cover crop mulches increase soil moisture levels and insulate the soil from rapid (up or down) temperature change. During the early planting period, soil temperatures may be cooler under heavy residue compared with clean-tilled fields. Once favorable planting temperatures are achieved, however, organic mulches may help reduce fluctuations in soil temperature caused by daily variations in air temperature and solar radiation.

Seedling diseases are stimulated by cooler and wetter soil conditions. In-furrow fungicides can help minimize these losses. Studies indicate that no-till cotton growing in cooler soils is more likely to respond to starter fertilizers than cotton grown conventionally.

### Cover Crops

Maintaining adequate soil cover is central to many conservation tillage systems. Some areas may obtain acceptable ground cover from a preceding crop such as corn or small grain. Native winter annuals may produce acceptable cover in some areas. However, cotton may not produce sufficient residue to satisfy that requirement, particularly when grown on eroded soils.

Planting winter cover crops offers several advantages in conservation tillage systems. They increase ground cover and reduce erosion. They increase soil organic matter and improve soil tilth with less crusting and better stand establishment. After the cover crop is terminated, they serve as excellent mulches to conserve moisture. Legumes fix atmospheric nitrogen for later utilization by the cotton crop. Grasses can utilize residual soil nitrogen, reducing leaching and runoff losses. This reclaimed nitrogen also is released to the cotton during cover crop decomposition. In many instances, yields and profitability of cotton in conservation tillage are significantly improved with winter cover crops.

Cover crops should be selected to fit within a specific

management scheme. Ongoing research has evaluated different species, with the majority of the work centered on two legume species, hairy vetch and crimson clover, and two grasses, wheat and rye. Cover crop establishment, maintenance and termination, as well as cotton stand establishment, growth and pest management must be considered.

Legumes may be attractive candidates for cover crops under certain circumstances. Their capacity to fix and supply all or part of the cotton crop's N requirement must be weighed against several potential drawbacks. Their cost of establishment is higher than grasses. They fix the majority of the nitrogen in late winter and spring, which delays their termination until mid-April or later to best realize their contribution. Two applications of a burndown herbicide are commonly required to terminate their growth, further increasing costs. Legumes must be established earlier in the fall than grasses, limiting their practicality in continuous cotton systems.

Delays in planting resulting from late burndown may reduce lint yields, particularly in more northern regions. Legumes are hosts for both root knot and reniform nematodes, making these species poor candidates for fields affected by either of these pests. Crimson clover releases chemical compounds that inhibit cotton germination and early season growth (allelopathy). Legumes may harbor cutworms that attack cotton, significantly reducing stands if not controlled. Finally, their nitrogen is released later in the season than desirable for optimum utilization. The consequences of late-season nitrogen release include excessive vegetative growth, delayed maturity and increased pest pressure. With the exception of nematode damage, most of these problems are minimized or eliminated by terminating legume cover crops at least 3 weeks prior to planting cotton.

Many researchers and producers prefer either wheat or rye as cover crops for cotton. Both species are easier and less expensive to establish in the fall. They provide more rapid ground cover, enhancing their value in areas with high erosion potential. They can be terminated earlier in the spring with one application of glyphosate, which allows for more timely cotton planting. Cotton stand establishment is less affected by grass cover crops as cutworms and allelopathy are less evident.

The choice between rye and wheat depends on management specifics. In root knot infested areas, rye is preferred over wheat because it is not a host for the nematode. On the other hand, rye growth can become excessive, complicating planting.

All cover crops draw on soil moisture until terminated. Cover crops should be terminated early to avoid delaying cotton planting or germination due to low soil moisture.

### **Ridge/Strip-Till**

Ridge/strip-till systems have evolved that retain many benefits of no-till while reducing some of its limitations. Both variations maintain more plant residue between the rows than conventional tillage while allowing soil preparation in the row. In ridge-till systems, residue in the middles is greatly reduced during the season by cultivation. This modification enhances weed management options and simplifies stand establishment. However, some additional field operations are required for these tillage systems vs. no-till options.

Minor cultural modifications are employed in the fall. Plant residue is left on the soil surface following harvest. In ridge-till, ridges may be rebuilt at the last cultivation or prior to stalk cutting. In both systems, cover crops may be planted following harvest. In short-season regions, establishment of cover crops after harvest is risky. Modified planters may be used to interseed wheat between cotton rows prior to harvest. This relay technique allows wheat cover establishment prior to the onset of cold weather.

Field preparation in ridge/strip-till during the spring differs from no-till. Vegetation burndown is similar under these conservation tillage options. In these two systems, row cleaners, rolling cultivator gangs or other tools are used to prepare a narrow seedbed ahead of the planter. This allows a producer to utilize conventional planting equipment. Preplant incorporated herbicides may also be applied at this time as well as in-row subsoiling.

One primary benefit of ridge/strip-till over no-till is expanded weed management options. Preplant incorporated herbicides can be introduced into the system to enhance grass and broadleaf weed control options. This is particularly important as weeds down the row are the most troublesome. One option within ridge/strip-till systems includes cultivation of the row middles, although this approach tends to compromise the moisture and soil conservation benefits derived from residue as a surface mulch. In exchange, the ability to cultivate does enable the producer to rebuild the ridges for next season and may help to reduce postplant weed control costs.

Ridge-till may not qualify as an effective soil conservation system for cotton unless it is rotated with higher residue crops or includes cover crops. Also, on sloping land the ridges channel water, creating severe erosion problems unless ridges are contoured with stable outlets. In cotton production, ridge-till is best viewed as another form of stale seedbed.

### **Stale Seedbeds**

Stale seedbed production is a unique system of conservation tillage. If soil erosion is not a factor, as in much of the Mississippi Delta, stale bed production offers several important advantages. Rather than conserving soil or tillage operations, the primary advantage of stale seedbeds is conservation of time during the crucial planting season. Stale seedbed production shifts the timing of field preparation operations. This time savings is important for producers with large or diverse operations. Conventional or some form of reduced tillage is performed after harvest in the fall when soil moisture conditions are usually favorable to prepare the field for planting. Then the field is allowed to sit during the winter.

The next spring, herbicides are applied to control vegetation. Specific treatment options vary with the weed spectrum and management approach. Following burndown, cotton planting may proceed with minimal tillage or seedbed preparation. From this point on, production practices can be the same as in conventional cotton.

This approach is well-suited to fields or management systems that must contend with costly delays at planting or harvesting. Clay soils in high rainfall areas are vulnerable to these kinds of delays. Raised beds that have overwintered tend to be firm with good granular structure, and

excess water from spring rains flows off quickly. Instead of delaying planting until preplant tillage operations have been completed, a grower needs only to concern himself with vegetation burndown (by air, if necessary) and planting. Favorable windows are utilized for planting rather than field preparation. In dry years, planting moisture will be conserved by reducing spring tillage. The time saved in the spring also reduces the possibility of adverse weather conditions and high populations of insects prior to harvest, saving more time and money and maintaining lint yield and value.

Additional benefits include lower equipment and fuel costs. The need for larger equipment and repeat passes is reduced as time is at less of a premium. Avoiding the spring rush also allows for more predictable, and perhaps lower, labor requirements.

This system, like the other conservation options, introduces tradeoffs compared to conventional systems. Stale seedbed systems are more dependent upon preplant herbicides. This increases input costs and/or requires a more intensive management approach to maintain economical control. Fall tillage will increase erosion on sensitive sites in the fall, but erosion in the spring will be less. Problems with perennial weeds may increase. The plant residue remaining in the spring following burndown may aggravate attempts to incorporate herbicides (if not controlled in early spring).

## Wrap-Up

Conservation tillage systems are continuously being developed and refined for specific production regions. The options available are as diverse as the soils, weather conditions, pest problems and farmers across the Cotton Belt. Local extension service and SCS personnel can provide the kind of on-site expertise that will help you adapt this technology to your management scheme.

The preceding discussion can only be considered an introduction. For more in-depth information, please refer to the following publications and plan to attend the Conservation Tillage Workshop during the Beltwide Cotton Conferences, January 6, 1994, in San Diego:

✓ Proceedings of the 1993 Southern Conservation Tillage Conference for Sustainable Agriculture, Monroe, LA, June 15-17, 1993, Louisiana State University Agricultural Center, U.S. Soil Conservation Service, Manuscript Number 93-86-7122.

✓ An Evaluation of Conservation Tillage Systems for Cotton on the Macon Ridge, Louisiana State University Agricultural Center, Winnsboro, LA, Publication 2460, December, 1991.

✓ Conservation-Tillage Systems for Cotton, A Review of Research and Demonstration Results from Across the Cotton Belt, Arkansas Agricultural Experiment Station, Division of Agriculture, University of Arkansas, Fayetteville, AR, 72701, July 1993, Special Report 160.

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