13. COTTON PRODUCTION WITH CONSERVATION TILLAGE

Keith Edmisten
Guy Collins
Cotton Extension Specialists—Crop and Soil Sciences
Rachel Atwell Vann
Graduate Research Assistant—Crop and Soil Sciences
Bill Foote
Director, North Carolina Crop Improvement Association
Alan C. York
William Neal Reynolds Professor Emeritus—Crop and Soil Sciences

COTTON AND SOIL CONSERVATION

Conventionally tilled cotton on sloping, erodible land has a well-deserved reputation for contributing to soil erosion. Cotton grows slowly during early summer and provides little crop protection from raindrop impact and soil erosion. Cultivation enhances the potential for soil erosion. Cotton also provides relatively little residue to return to the soil or to leave on the surface to protect it from erosion during the winter.

Conservation compliance was introduced in the 1985 Farm Bill and continues to be reinforced in the 2014 Farm Bill. Fundamental to these bills were efforts to reduce soil loss associated with cultivation of annual crops on highly erodible land (HEL), which is defined according to a formula that considers normal rainfall patterns, the gradient and length of slopes, and the inherent erodibility of the specific soil. To be eligible for program benefits, including “market transition payments” and conservation cost share, growers were required to have and follow an approved conservation farm plan if highly erodible land was involved. The 2014 Farm Bill maintains this focus on conservation. Provisions related to conservation tillage include cost-share opportunities for long-term no-till through the Environmental Quality Incentives Program (EQIP) and perhaps other opportunities through new conservation programs. Consult with local program offices for details. Producers need to consider that long-term no-till currently requires a five-year time commitment and that the cropping system must provide 80 percent ground cover. This practice may require careful cover crop management to insure optimum stands and sufficient residue.

Conservation tillage is often the agreed-upon and most effective approach to protect against soil erosion and to meet conservation compliance requirements on highly erodible land. No-tillage planting into a residue cover offers the additional benefits of conserving moisture on drought-prone soils and protecting young cotton seedlings from sandblasting. Also, a no-tillage system can save time during the planting season, allowing growers to plant cotton and other crops closer to the optimum planting date.

Research results, as well as the experience of growers in North Carolina and other states, show that cotton can grow successfully under conservation tillage systems. However, in these methods of cotton production, which are sometimes collectively referred to as "no-till cotton," success requires planning and a high level of management. Growers are encouraged to start with a small acreage of "no-till cotton," seeking to resolve the practical challenges of this system within their own operations. Growers who adopt such a system on small acreages are encouraged to evaluate this system in multiple environments (both wet and dry years) and scout their crop to look for signs of root obstruction before adopting a widespread no-till system. Many sources of information exist, including the successful growers in many counties where thousands of acres of conservation-tilled cotton are now being grown.

COVER CROP SELECTION AND MANAGEMENT

To meet conservation-tillage requirements in North Carolina, surface residues must provide at least 30 percent ground cover after planting. A cover crop will be required in most situations. Residues from a good previous corn crop may provide sufficient cover; residues from soybeans, peanuts, tobacco, or cotton will not be adequate. **If relying on residues from a previous crop** to provide sufficient cover, do not perform any tillage operations between harvest of the previous crop and planting of the cotton.

Cover crops are often recognized for their long-term benefits, such as soil erosion reduction and enhanced nutrient cycling; however, there are also short-term benefits that can be gained through cover crop use. Some of the most important short-term benefits include weed suppression and enhanced soil moisture availability to the cotton crop.

Potential cover crops include small grains (most commonly wheat or cereal rye) and winter legumes (winter pea, hairy vetch, or crimson clover). Nitrogen production is the primary advantage of a legume cover crop. Hairy vetch or crimson clover can provide nitrogen to cotton equivalent to 50 to 70 or more pounds of fertilizer N per acre. This nitrogen production can be difficult to accurately predict, and N release from a legume cover crop depends on environmental conditions, complicating decision-making on the amount and timing of the nitrogen release provided to the following cotton crop. Thus, it may be difficult to decide how much, if any, additional fertilizer nitrogen to apply. Excess nitrogen can lead to substantial problems for cotton producers. But in most circumstances, legume N release following termination is rapid and therefore would not be problematic for late-season N management (see the discussion of nitrogen fertilization in chapter 7, "Fertilization"). Legume cover crop residues decompose quickly, and therefore have limited value as a mulch targeted at weed control and soil moisture conservation during the cotton production season.

Small-grain cover crops have different advantages than can be achieved with a monoculture legume cover crop. The seed of a small grain cover crop is more economical, and small grains are easier to establish and to kill than legumes. Small grains can be successfully established later in the fall than can legumes, allowing more time to harvest cotton and other crops before seeding the cover crop. Small grains typically provide more protection from soil erosion during the fall and winter months than do legumes. A small grain cover crop decomposes more slowly and produces more biomass than a legume cover crop, and therefore is more beneficial as a mulch for weed suppression and soil moisture conservation in the following cotton crop. In addition, concern about nitrogen leaching and protection of water quality is increasing. Small grain cover crops also have the benefit of "scavenging" leftover nitrogen from the previous cash crop season, which can reduce excess N movement into groundwater.

Cereal rye is a popular cover crop choice in the no-till system for its ability to produce high cover crop biomass, well in excess of what can typically be achieved with wheat. High cover crop biomass production results in a more persistent cover crop mulch that can prolong the in-season benefits of weed suppression and soil moisture conservation. While high biomass production from cereal rye is advantageous for weed suppression and soil moisture conservation, it can intensify problems at planting compared to planting into a wheat cover crop where lower residue levels are typically encountered. Problems penetrating through the cover crop mulch at planting to get good cotton seed-to-soil contact can be overcome through planter modifications allowing for residue movement from the crop-row. The management of a cereal rye cover crop prior to a cotton crop will have a great impact on the benefits achieved during the following cotton season. To maximize cover crop biomass, cereal rye should be planted early at high seeding rates. If cereal rye establishment must be delayed into late fall due to weather or other management events, growers can consider fertilizing their cereal rye in an attempt to increase biomass. Cereal rye desiccation via roller-crimping or herbicide burndown should occur in close proximity to cotton planting to ensure maximal cover crop biomass is achieved prior to cotton establishment. Newly developed specialized equipment may be needed to plant cotton in a high residue system, and such equipment is now commercially available.

Cover crop mixtures of small grains and legumes can be used to maximize the benefits that can be obtained from both species. Recent research in North Carolina suggests that a crimson clover and cereal rye cover crop mixture worked well prior to cotton; planting into this cover crop mixture was not problematic for cotton establishment, and the benefits of early season weed suppression and soil moisture conservation were observed.

Under continuous cotton production, cover crop species, establishment method, and termination timing are critical to the success of a winter legume as a nitrogen source. Species selection should be based on suitability to soil characteristics to ensure ease of establishment and high biomass level. For example, vetch tends to do well in heavier soils, whereas crimson clover performs better in sandy soils. Each grower must determine which species performs best on their soils. Cover crop establishment is best achieved when the soils are warm and moist, before cotton harvest, to promote legume germination and seedling growth. Research results indicate that overseeding winter legumes approximately 14 days prior to defoliation provides adequate stands of the winter legumes, high cover crop biomass at planting, and sufficient soil N. Legume germination may be complicated by defoliant choice. Cotton defoliants containing thiadiazuron have been shown to reduce legume germination and seedling growth in greenhouse experiments, but these defoliants had little to no effect in field experiments when legumes were overseeded 14 days prior to defoliation. Soil moisture preservation must always be accounted for when determining when to terminate your cover crop. The termination date should be adjusted to assure adequate soil moisture to promote cotton germination and early season growth. Cover crop termination 10 days prior to planting proved to be optimal timing for high cover crop biomass, soil moisture preservation, adequate soil N, and high lint yield.

Soil samples should be taken in early fall to allow time for analysis before seeding the cover crop. Suggested lime and phosphorus (unless the required P_2O_5 can be applied in a starter band application) should be broadcast and worked into the soil during seedbed preparation for the cover crop. Where a strict no-till system is used, lime, phosphorus, and potassium are not incorporated into the soil. Because these amendments move very slowly into the soil, they can become concentrated in the surface soil and deficient lower in the root zone. It is imperative that adequate levels of these amendments be applied to the soil and incorporated throughout the root zone before initiating a strict no-till system. Once adequate fertility and pH are achieved throughout the root zone, decrease the soil sampling depth from 8 to 4 inches on no-till fields.

Except for sandy, less productive soils, nitrogen fertilization of the cover crop is generally unnecessary and may promote excessive vegetative growth of the cover crop. In general, it also would make the small-grain cover less effective in removing soil nitrogen for the benefit of water quality protection. Fall tillage to prepare a cover crop seedbed also will help to avoid problems with horseweed and cutleaf evening primrose and will provide some suppression of perennial weeds, and can enhance cover crop biomass production.

PLANTING METHODS

During the last decade or so, we have seen increasing acreages of North Carolina cotton being grown with some form of conservation tillage. Although often referred to simply as "no-till cotton," several approaches are being used successfully. Some of these are:

1. **In-row subsoiling** at depths of 10 to 16 inches. This practice is really a form of strip tillage in that considerable soil preparation in the row zone is provided by the coulter, ripper, and other components of the unit that closes the ripper slit in the soil. Planters may be attached to the ripper unit for one-pass planting, or the strip tillage can be done in a separate pass some time before planting. Due to the tractor power required for a six-row or eight-row ripper unit, it may be necessary to do the planting in a separate pass.

2. Strip tillage in the row zone **without subsoiling**. This tillage may be done with an arrangement of coulters or spider gangs to till a row zone of about 8 to 12 inches in width. This practice works especially well when beds have been made the preceding fall or in early spring.

Strip-till equipment currently on the market generally includes combinations of coulters, rolling baskets, spider gangs, rubber firming wheels, and/or other devices. These serve to do some soil conditioning in the row zone and to close the slits left by the subsoilers or other types of shanks that offer deep tillage and are included with these strip-till machines. However, these row-zone tillage devices also may allow shallow soil mixing, especially when rolling baskets or spider gangs are included and are properly adjusted to accomplish that function.

3. No-till planting using a row planter only. This practice commonly includes a fluted, bubble, or ripple coulter mounted ahead of the planter. The width of the tillage is narrow, typically from 3/8 inch to 1½ inches, and is determined by the lateral pushing and fracturing of the soil by the coulter flutes (waves) or by the "bubbles" on that coulter type.

BEDDING AND RIPPER/BEDDING

In general, a cotton crop is susceptible to extended periods of both wet and cool soils. Bedding provides some protection from both, especially early in the growing season. For this reason, planting cotton on raised beds is a strong preference of many conventional-tillage cotton growers. If growers decide to change to conservation tillage and wish also to plant on some degree of a bed, then special efforts are needed. Achieving **conservation-tilled cotton with bedding** requires either fall bedding or re-using the remnant bed from the previous crop. Further, **when conservation compliance is required,** or where growers simply wish to gain benefits from conservation tillage, establishment of a cover crop on these beds is generally necessary to meet the residue cover required for acceptance as conservation tillage (a minimum of 30 percent of the soil surface under residue cover after planting of the summer crop).

This establishment of a cover crop could be done by fall bedding or ripper/bedding, with a small-grain cover crop being planted at the same time or shortly after the fall bedding. This practice is successful where cotton follows tobacco, peanuts, or corn because these crops allow ample time after harvest for some root decomposition, fall tillage, and cover crop establishment. However, following cotton, fall bedding works best if the cotton stalks are uprooted by rigorous disking or by some form of stalk pulling.

In a continuous cotton operation, fall bedding (especially ripper/bedding) is often very difficult when the harvest is completed in late November or even in December. In general, we do not recommend using an in-row subsoiling device, especially a conventional ripper/bedder, running directly into the old (nontilled) cotton row positions in the fall or early winter. This practice usually presents frequent problems with roots wrapping and clogging on the rippers. Running rippers in mid-row positions would work better, but it is difficult to maintain the alignment to do this well.

Where cotton follows cotton, and where subsoiling is desired because of sandy soils and pan layers, useful alternatives are the **"Paratill"** of the Tye Company and Bigham Brothers Inc. and a similar tool known as the TerraMax of Worksaver Inc. These tools feature a deep loosening point that is carried in the soil on an angled shank ("leg"). A leading coulter cuts the residue in the path of the shank. These tools generally run without problems of root clogging, mainly because the shank enters the soil from the side of the old row. Again, careful driving to maintain tillage and row alignment is important. The effectiveness of such equipment in shattering pan layers is without question. The shatter zone is somewhat larger than that of conventional rippers. However, this equipment may require greater pulling power per shank than conventional in-row subsoilers, and there is significant expense involved in replacing the worn points on the legs of the Paratill units.

Establishment of a good cover crop in a continuous cotton system requires an emphasis on achieving timeliness. Wet weather and other time conflicts make it a challenge to establish the cover crop properly and sufficiently early to achieve the desired residue and cover benefits. Where new beds are made in the fall, some shaping or leveling of the bed is desirable before seeding the cover crop.

Because of these difficulties and the costs of achieving both bedding and good cover-crop establishment, growers are often forced to give up beds in conservation-tilled cotton. This circumstance is especially true where cotton follows cotton. Nevertheless, in typical growing seasons (when drought stress is more serious than wetness), the moisture-conserving benefits of good residue cover under conservation tillage more often than not offset the lack of benefit from bedding.

Where the following cotton crop will be flat-planted, consider using a no-till drill to plant into standing cotton stalks after the cotton is picked. This practice will save time and help to get the cover crop seeded earlier. Stalks can then be mowed afterward. These drills perform quite well if seeding depth is adjusted to compensate for ground-level differences of the beds and valleys. One exception is the case of drills having an exposed drive chain, where cotton stalks can cause the chain to run off. A homemade chain shield could be added to prevent this run-off. This approach to seeding cover crops works best on flat-planted cotton residue, or where existing beds are being used for cotton the following year. On the other hand, simply broadcasting small grain seed on freshly bedded or bed-shaped land may give adequate cover-crop establishment. Where cotton is to follow peanuts, growers often have had good cover-crop success by distributing wheat or cereal rye seed just ahead of peanut digging, assuming that the peanut "hay" is not being removed for animal feed.

Where cotton is flat-planted, rows can be offset by about 2 to 6 inches from one year to the next, thus possibly avoiding some no-till planting difficulties caused by previous crop stalks located in the exact new row position. Without beds, planting of the cover crop in the fall is easier and quicker. For flat-planted cotton, in-row subsoiling done a few inches beside the old row, either in the fall or spring, is also less problematic.

With several years of conservation tillage, there is some indication that soil porosity and drainage behavior may improve. Except in soils with naturally high water tables, this improvement could even reduce the need for bedding to protect from the risks of soil wetness. These aspects of soil management with long-term conservation tillage are now receiving the attention of farmers and researchers.

FALL RIPPING AND CARRYOVER EFFECTS OF SUBSOILING

To spread the work load and make efficient use of available tractor power, growers ask whether fall ripping is as effective as ripping at planting time. We recently completed a three-year study of "carryover" ripper effectiveness, including one site in a strong pan-layer-prone soil (Conetoe loamy sand). **Fall ripper/bedding was fully as effective for cotton yield as was ripping in the spring.** We followed the fall ripper/bedding by a wheat cover crop, strip-killed the cover crop over the intended row zone, and then no-till-planted cotton without ripping. In that study we also attempted to use the ripped zone for a full second and third year of straight no-till planting over the previous ripped row. **We lost about half of the ripper benefit in the first carryover year and about 80 percent of the benefit in the second carryover year.** These studies were done in a cotton/corn rotation.

STRIP TILLAGE VERSUS NO-TILLAGE

Strip tillage simply means some form of tillage in the row zone, generally 8 to 16 inches wide. This tillage may be only 1 to a few inches deep or, in the case of in-row subsoiling, typically 10 to 16 inches deep. This is being done with rubber wheels, aggressive coulters, rolling tines, shallow shanks, or shovels (any of these must provide appropriate closure and soil-conditioning devices). Also, it may involve deeper chisel or ripper shanks (with appropriate soil closure devices).

After some 20 replicated studies of cotton comparing conventional tillage, fluted coulters (1-inch flutes), shallow strip tillage, and in-row subsoiling, we have found that in at least three-quarters of the studies there were somewhat lower lint yields from use of the fluted coulter alone. The reasons for these lower yields from simple coulter-no-till appear to vary according to soil properties and residue conditions. In most cases there are somewhat more stand skips where no row-zone tillage is done (such as by a ripper, coulters, or rolling tines). This situation is especially likely where residue is tough or heavy (rather mature cereal rye or wheat) and the soil is soft. Under these conditions, "hair pinning" often results in inadequate closure of the seed furrow and poor seed-soil contact.

Prior killing of a narrow strip in the row-zone (**strip-killing**) has shown some benefit for cotton-stand establishment in cases of fairly heavy cereal rye or wheat residue at planting time. In other cases, soil properties influence the cotton response to some row-zone tillage. In the more sandy, pan-layer-prone soils, subsoiling generally provided the superior yield. In eroded, poor-tilth, crust-prone, coastal plain fields, shallow strip tillage was superior. In wet seasons or wet-natured soils, conventional tillage may be favored. In any case, where satisfactory cotton stand and good weed control are achieved, one of these forms of conservation-tilled cotton has generally given similar yields to conventional tillage.

CONCEPTS OF STRIP TILLAGE VERSUS METHODS OF DEEP TILLAGE

At present there are several brands of effective commercial strip tillage equipment on the market. When operating correctly, a strip-till operation should do the following:

1. Leave the row zone in a near-ready planting condition.

2. Provide deep tillage (subsoiling) to an appropriate soil depth, if desired.

3. **Not leave** large clods, sod clumps, or major surface holes or mounds that the planter would handle poorly, especially if the soil will be allowed to dry and harden before planting.

4. **Not leave** subsurface cavities in which there will be little rooting and that, during wet periods (when the soil may reach saturation and the cavities could act like a tile drain), could possibly cause root death.

Growers should keep in mind the differences between an effective strip-tillage operation, as described above, **versus** the actions and the potential advantages and disadvantages of deep-tillage tools, the most familiar of which is the subsoiler in its various configurations. On all commercial strip tillage equipment available today, the in-row subsoiler provides a major part of the row-zone soil preparation, combined with important actions of the accompanying devices, namely coulters, rolling baskets, and wheels. Therefore, depending on the depth of subsoiler operation, strip till rigs also usually perform deep tillage. Such in-row subsoiling often helps deepen the crop rooting pattern, especially if pan layers exist in the soil. You may wish to consult the publication *Subsurface Compaction and Subsoiling in NC—An Overview* (AG-353, North Carolina Cooperative Extension Service, 1985) for concepts of pan layers and deep tillage. Deep-tillage effects, however, can be minimal or even detrimental, depending on various aspects of soil properties, operational depth and travel speed, soil hardness or stickiness in the zone of the deep tillage, and the shape and size of the "point" of the deep tillage tool used.

Because of current grower interest, we have examined under on-farm conditions the effects of a typical subsoiler **in contrast with** those produced by the "no-till point" currently marketed by the DMI company. We have found that the large DMI point commonly leaves cavities in the soil at the depth of operation of the point. No such cavities were found in the zone of operation of the traditional in-row subsoiler. These DMI-point cavities were still very apparent near the end of the growing season in September after the tillage had been done in late March. The cavity typically is from 2 to 4 inches wide and about 1.5 inches high. Generally, no roots have grown directly through the cavity, although roots commonly pass around the sides. We do not yet have evidence that this tendency is detrimental to crop performance, although logically one would prefer to loosen a volume of soil in the prime zone of root growth, thus providing ideal soil physical conditions for crop root development. Attaining this objective would not include leaving a cavity zone unsuitable for root growth.

Some growers are interested in operating tools such as the DMI with winged points in a diagonal direction to the intended cotton rows, which certainly would reduce the area of such cavities directly under rows. Although this practice may be a useful compromise, it is likely to leave segments of row that would not benefit from this soil loosening, especially in specific fields where pan layers and soil hardness are actually limiting factors for root development.

AGRONOMIC CONSIDERATIONS

Research in North Carolina has shown that yields of no-till, and especially of strip-tilled cotton, are comparable to those of conventionally planted cotton if adequate stands and weed control are achieved. Yields of no-till cotton have sometimes exceeded those of conventionally planted cotton in dry years. The exception has been in wet-natured soils, where no-till cotton sometimes has not performed well. Year to year variability in rainfall and temperatures can make tillage decisions difficult at times. In some years, there is clearly an advantage to planting on a soft bed. In other years, however, there may be an advantage in flat-planting in no-till or reduced tillage systems. Growers are therefore encouraged to evaluate their tillage systems on a field by field basis, to ensure that little or no root obstruction or inhibition is occurring. Other factors also should be evaluated, such as the use of an in-furrow fungicide and starter fertilizer. Modifications to cover crop establishment and tillage should be made after careful evaluation of tillage across multiple years and environments.

The soil temperature under a good cover-crop residue generally will be 2°F to 4°F cooler than under bare soil. In addition, the soil may be more moist. The cooler and wetter environment may not be as conducive to seed germination and can contribute to seedling disease development. Plant conventional cotton first, allowing time for the soil to warm in no-till fields (see the discussion of soil temperatures in chapter 4, “Planting Decisions”). Also, because of the cooler and more moist conditions under a heavy cover crop residue, the chances of obtaining a response to an in-furrow fungicide are greater than under conventional tillage situations (see the discussion on in-furrow fungicides in chapter 9, “Disease Management in Cotton”). Also, especially in years when cool weather restricts DD-60s during the seedling development period, no-till and strip-till cotton are likely to show an economic response to starter fertilizer (see chapter 7, “Fertilization”).

Research in North Carolina has shown that stands in no-till cotton average about 10 percent fewer plants than stands in conventionally planted cotton. This finding should not be a concern unless you are using a low seeding rate (see the discussion of seeding rate in chapter 4, “Planting Decisions”).

When planting no-till cotton, adjust the planting depth carefully. Remember to plant ½-inch to 1-inch deep. Given the variability and hardness of no-till fields and the shallow depth of double-disk openers, it may be difficult to stride the line between adequately covering the seed and planting too deeply. Avoid planting when the soil is too wet for the seed furrow to be properly and consistently closed.

INSECT MANAGEMENT

In reduced or no-till cotton production, as in conventional tillage, likely damage from thrips will require the use of an at-planting, in-furrow insecticide. Because of the potentially cooler soils and resulting slower seedling growth, young plants may be subject to thrips populations over a somewhat longer period of time, putting a greater demand on the persistence of the at-planting insecticide. Alternatively, preliminary research suggests that thrips populations may be lower in reduced-till and no-till cotton. Monitoring or sampling for thrips in reduced-tillage cotton culture is the same as with conventional cotton production (see chapter 11, "Managing Insects on Cotton").

Preliminary research has shown the impact of insects such as cotton aphids, plant bugs, and late-season caterpillars in reduced-tillage cotton to be similar to that found in conventional cotton. In a limited number of experiments with strip-till cotton planted into wheat or cereal rye cover crops, some stand-reducing cutworm damage has been observed. Stand reductions in commercial cotton have been locally severe following the previously mentioned cover crops and behind corn, soybeans, and cotton in which winter annual weeds have served as a host for spring cutworms. Cutworms appear to be lower in cotton planted into hairy vetch or clover, but these covers are not commonly used in North Carolina. Because cutworms can persist at least 2 weeks following the application of a burndown herbicide, a waiting period of approximately 2½ weeks to 3 weeks is advised to reduce the possibility of damaging cutworm populations. If cotton fields have a history of cutworm damage, a broadcast or banded insecticide before or after planting may be appropriate. For example, the insecticide might be tank-mixed with a preemergence herbicide, or the insecticide alone might be sprayed into and up on the collar of the furrow in a T-band. Alternatively, if scouting reveals a stand reduction of 15 percent or more and an active population of cutworms (mostly "hiding" under soil clumps near cotton seedlings), then a banded or post-directed insecticide treatment is recommended. Cutworm-labeled pyrethroids or Lorsban 4E should provide adequate control. Grasshoppers and slugs may also be concerns in reduced-tillage systems.

DISEASE MANAGEMENT

Because conservation tillage often includes more variable seedbed conditions—including seed-soil contact, depth of coverage, zones of soil wetness, and cooler soil temperatures—it is important to use high-quality seed. Refer to chapter 4, "Planting Decisions," chapter 6, "Cotton Seed Quality and Planting Decisions," and chapter 9, "Disease Management in Cotton," for further information on these management concerns.

WEED MANAGEMENT

Most of the same weed-control techniques of conventional cotton culture are applicable to cotton produced with conservation tillage, with the exception of broadcast preplant-incorporated herbicides and most forms of cultivation. Chapter 10, "Weed Management in Cotton," gives key information on these topics.