CONSERVATION TILLAGE
Cotton Production Guide

Circular ANR-952
Alabama Cooperative Extension System
Alabama A&M and Auburn Universities

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Table of Contents

- **Cover Crops**

  Charles Burmester, *Extension Agronomist*

- **Fertility**

  Charles Mitchell, *Extension Agronomist*, Professor, Agronomy and Soils

- **Weed Control**

  Mike Patterson, *Extension Weed Scientist*, Associate Professor, Agronomy and Soils

- **Disease Control**

  William Gazaway, *Extension Plant Pathologist*, Professor, Plant Pathology

  C. Dale Monks, *Extension Crop Physiologist,* Assistant Professor

- **Insect Control**

  Barry Freeman, *Extension Entomologist*, Assistant Professor, Entomology

  Ronald Smith, *Extension Entomologist,* Professor, Entomology

- **Irrigation**

  Larry Curtis, *Extension Agricultural Engineer*, Professor, Agricultural Engineering

- **Production Costs**

  W. Robert Goodman, *Extension Economist*, Assistant Professor, Agricultural Economics and Rural Sociology

North Alabama Demonstrations

Dennis Delaney, ***Extension Program Associate, Cotton and Soybeans***

Soil Conservation Systems

Sheet and gully erosion are responsible for robbing the topsoil and nutrients from much of the productive farmland in the southeastern United States. Soil erosion rates on Alabama cropland average about 10 tons per acre per year. This represents a soil loss of less than 0.10 inch per acre per year that may not be evident to the producer. Alabama data suggest that soybean yields could drop from 40 to 26 bushels per acre within 20 to 30 years at this rate of soil loss. A corresponding decrease in cotton production could range from 600 to 390 pounds of lint per acre, seriously jeopardizing the profitability of cotton production in many areas of Alabama.

Conventional tillage systems have come under much study concerning long-term environmental and economic sustainability (Young 1989). Soil conservation practices that are currently recommended include terraces, diversions, buffer strips, grassed water ways, underground outlets, field borders, water and sediment control basins, contour farming, crop rotation, and conservation tillage. Conservation tillage includes various systems of reduced tillage such as minimum tillage, strip tillage, and no tillage. The adoption of these practices has been relatively slow in cotton-production areas outside of Tennessee, Mississippi, and Missouri (Schnittker and Allen 1990).

Legislation requires that conservation production practices must have been implemented by 1995. In the United States, approximately 505,000 acres of cotton are planted with conservation tillage practices, representing 4.6 percent of total production (Bradley 1992). In the southeastern United States, it is estimated that conservation tillage constitutes 5 to 6 percent of total cotton production.

Conservation tillage systems vary between and within states. Positive results for reducing surface runoff and erosion and for increasing soil moisture have been recorded by Auburn University researchers (Yoo and Touchton 1989). Although the overall results seem promising for conservation tillage cotton production, these systems need additional adjustment for some areas of Alabama. Researchers and Extension personnel in north Alabama are attempting to solve a subsurface soil compaction problem currently encountered by producers in that area.

Return to the Table of Contents

Planting Systems

Conservation tillage planting systems used with cotton in Alabama and throughout the Cotton Belt are as varied as the people who have implemented them. Some producers have used conventional planters and planted directly into last year's stubble. Others have used planters and equipment specifically designed or altered for conservation tillage.

Planting systems can generally be divided between those used on the red clayey soils and the sandy-loam soils. Much of the cotton produced on clayey soils is located in the Limestone Valley, but cotton is also produced on clayey soils in other parts of Alabama. The cotton produced on sandy loam soils is located primarily in the Coastal Plain area. The main difference between these two systems is in the use of in-row subsoiling.

Silty-Clay Soils

The soils of the Limestone Valley and other clayey soils throughout Alabama generally do not respond to subsoiling because hardpans are not present. Subsoiling often results in poor cotton stands due to wet clay being pulled to the soil surface where it dries into hard clods and impedes planting.

The two most widely used planting methods on silty-clay soils include planting into old cotton stubble or planting in a chemically burned down small grain cover crop. At planting, best stand results have been obtained with regular planters modified with 0.75- to 1-inch fluted coulters running directly ahead of the planter's double disk openers. (Coulters larger than 1 inch throw too much soil.) Research conducted at the Tennessee Valley Substation over the last 7 years indicates about equal yields with each system (**Table 1**). Greatest differences were found in the dry years of 1988 and 1990 when cotton planted into wheat performed the best.

Table 1. Yield Comparison Between No-Till And Conventional Tillage Cotton.

Tillage	**Seed Cotton Yield (lb. / acre)**							
	1988	1989	1990	1991	1992	1993	1994	**Average**
No-till (stubble)	1140	2440	1510	920	3160	1760	3250	2026
No-till (wheat)	1380	2490	1840	970	3150	1790	3450	2153
Conventional	1400	2780	1700	1090	2990	1900	2600	2066

Although average no-till yields with each system also compare favorably with conventional tillage cotton yields, some definite trends need explanation. In this study, 1988, 1990, 1991, and 1993 were considered dry seasons. If these years are used for comparisons, no-till cotton yields into wheat and old cotton stubble would be only 98 and 88 percent of conventional cotton yields, respectively. This points out a definite problem with no-till planting into old cotton stubble in dry years. Recent research indicates this reduction of yield may be caused by greater soil compaction in the upper 12 inches (**Figure 1**). The greatest compaction is in the upper 4 inches of soil. This compaction could be reducing both cotton root growth and water infiltration that would be critical in dry seasons.

Why cotton planted into no-till stubble and wheat out-performed conventional tillage cotton in the wet seasons of 1992 and 1994 is uncertain. Visual observations in 1994 indicated that conventional tillage cotton may have suffered from more nitrogen (N) deficiency than no-till cotton. It is possible more leaching of N occurred through the conventionally tilled soil.

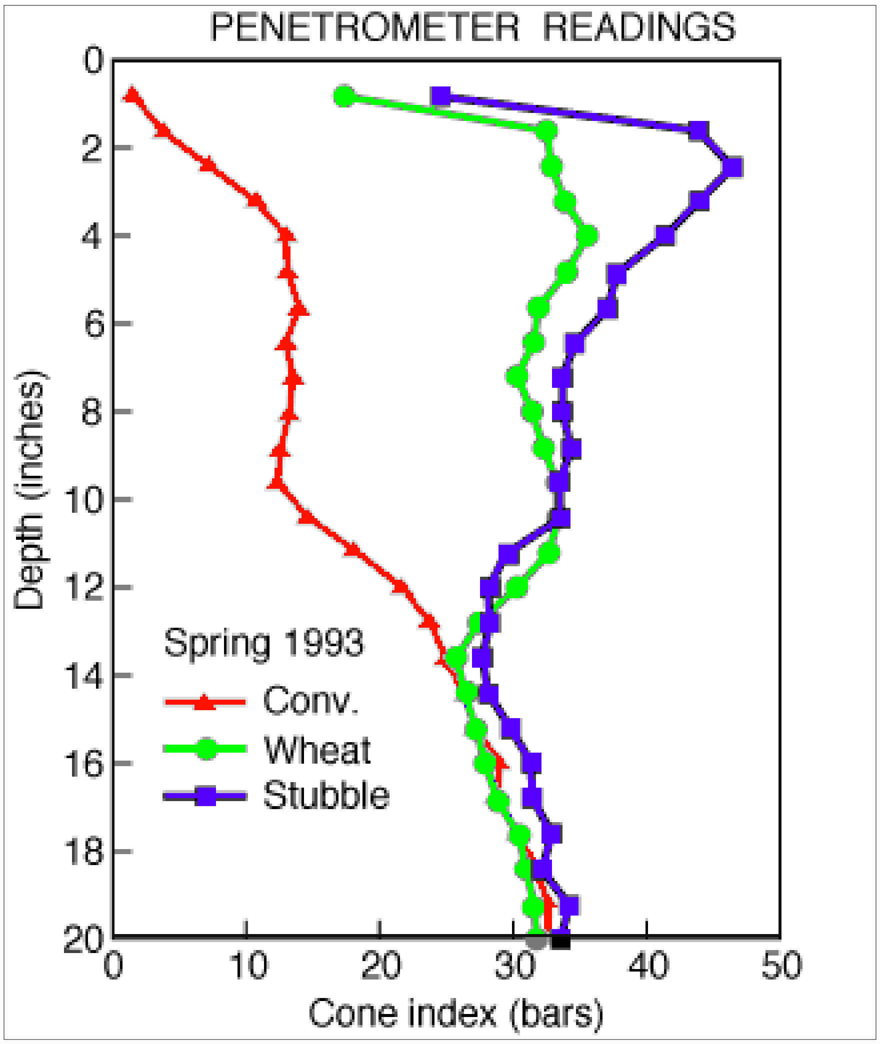

Figure 1. Soil compaction readings from research plots at the Tennessee Valley Substation, 1993.

Sandy-Loam Soils

Producers who plant cotton on loamy or clayey soils and do not have problems with traffic pans can follow the guidelines in the previous discussion. On the sandy soils that develop hardpans, the only option producers have is to incorporate subsoiling into a reduced tillage system. Subsoiling shatters the pan to allow normal cotton root growth and produce optimum cotton yields.

Producers can check for traffic pans by pushing a smooth rod or soil sampling tube into moist soil. If the tube encounters marked resistance at the normal depth of plowing, a traffic pan may exist. A true traffic pan is only 1 to 2 inches thick, and extra weight on the rod or tube will break through the resistance. The rod or tube can then be pushed considerably deeper with moderate effort. If moisture is low in either the topsoil or subsoil, checking for traffic pans in this way should not be attempted since a dry soil will always be difficult to penetrate.

Conservation tillage with inrow subsoiling can be accomplished using a strip tillage implement. These implements use rolling coulters, a subsoil shank, and rolling baskets to prepare a seedbed. The subsoil shank should be set to run deep enough to shatter the traffic pan. The width of the seedbed strip can be adjusted but is usually less than 18 inches wide, leaving approximately half of the soil undisturbed between the rows. Subsoiling and planting are often completed in separate operations because of weight, required horsepower, and equipment limitations. Strip tillage can be used in combination with cover crops or with native cover in the previous year's crop stubble. Either native vegetation or planted cover crops should be chemically burned down at least 14 days in advance of strip tillage to allow plant material to decompose.

Double cropping no-till cotton behind a small grain has been tried with limited success in extreme south Alabama. Practices described above have been used, but success depends upon adequate moisture in June and early July for rapid stand establishment and early-season growth. Producers should check with their local crop insurance representative concerning the insurability of late-planted cotton and cotton planted following small grains.

Return to the Table of Contents

Cover Crops

Over the last 10 to 12 years, much research has been conducted on the feasibility of growing cotton planted with conservation tillage systems into cover crops. The possibility of growing cotton in a legume cover is attractive since the nitrogen (N) provided by the legume could be used to offset the costs incurred in planting the cover crop. However, all researchers have come to the same conclusions:

- Legumes are hard to kill.
- Cotton stands are difficult to obtain when planting in legumes.

- **C**otton maturity is delayed when planting in legumes.
- **P**lanting no-till cotton into legumes reduces cotton yield compared to conventional-till cotton.

Because of these problems, emphasis has been shifted to growing cotton in old crop stubble or small grain cover crops. Of the small grains available, wheat and rye have been the most widely grown. Wheat usually produces less growth than rye in the early spring. A seeding rate of 1 to 1.5 bushels per acre is the standard at this time. Higher seeding rates can result in too much mulch which hinders planting and soil warming. Applying N fertilizer to the wheat in late winter may promote more vegetative growth than is desirable, causing planting problems. In this case, the planter should be equipped with row-cleaners that move surface residue away from the row at planting. The small grain should be killed at least 2 weeks before planting (sprayed 3 to 4 weeks before planting). This allows the cover to decay and the soil to warm up. Unless the cover crop is killed, a cotton crop should not be planted.

Planting into old crop stubble uses last year's crop residue and winter weeds as a cover. The crop residues that most producers plant into are cotton, corn, and soybeans. Best results have been obtained with corn residue followed by cotton and then soybeans. Green vegetation in old crop stubble should be killed at least 2 weeks prior to planting. Both the small grain and old stubble covers have been used successfully for conservation tillage cotton production in Alabama. Before planting the cover crop, producers should contact the local crop insurance office to determine the insurability of their conservation-till cotton planted following the cover crop.

Return to the Table of Contents

Fertility

In general, research does not suggest a need for varying basic fertility practices with conservation tillage cotton systems. Fertility problems encountered in conservation-till cotton are the same as those in conventional-till cotton production. By using soil tests and plant tissue analysis and by paying attention to details of conservation tillage cotton production, producers can avoid many problems and boost yields of cotton in Alabama.

Basic Fertility And Soil pH

Conservation tillage (reduced tillage) should be practiced only on productive, limed soils with a "HIGH" soil test phosphorus (P) level. Because tillage is limited, there is not much opportunity to incorporate lime and phosphate fertilizers throughout the topsoil (usually the top 8 inches). Therefore, a well-limed, productive soil with a "HIGH" soil test P level is essential for high yield potential.

The soil pH should be 6.0 to 7.0 for most soils. Finer-textured soils (Tennessee Valley and Black Belt) could have a pH as low as 5.5 and produce satisfactory cotton, but with long-term no-till or reduced tillage, there is no opportunity to lime subsurface soil unless the soil is completely tilled.

Continuous no-till will result in the surface 1 to 2 inches of soil becoming acid much faster than under conventional, deep tillage. Ammonium-containing fertilizers (ammonium nitrate, urea, N solutions, anhydrous ammonia, and ammonium sulfate) applied to the surface will result in higher soil acidity (lower pH) on the surface soil (**Figure 2**). Because lime cannot be fully incorporated under no-till management, the soil should be adequately limed initially. Regular surface applications of lime based on soil tests will be needed to maintain the surface pH and to prevent further acidification of untilled soil deeper in the profile. Only a small amount of additional lime will be needed every 2 or 3 years to neutralize the acidity in the surface inch or so of soil.

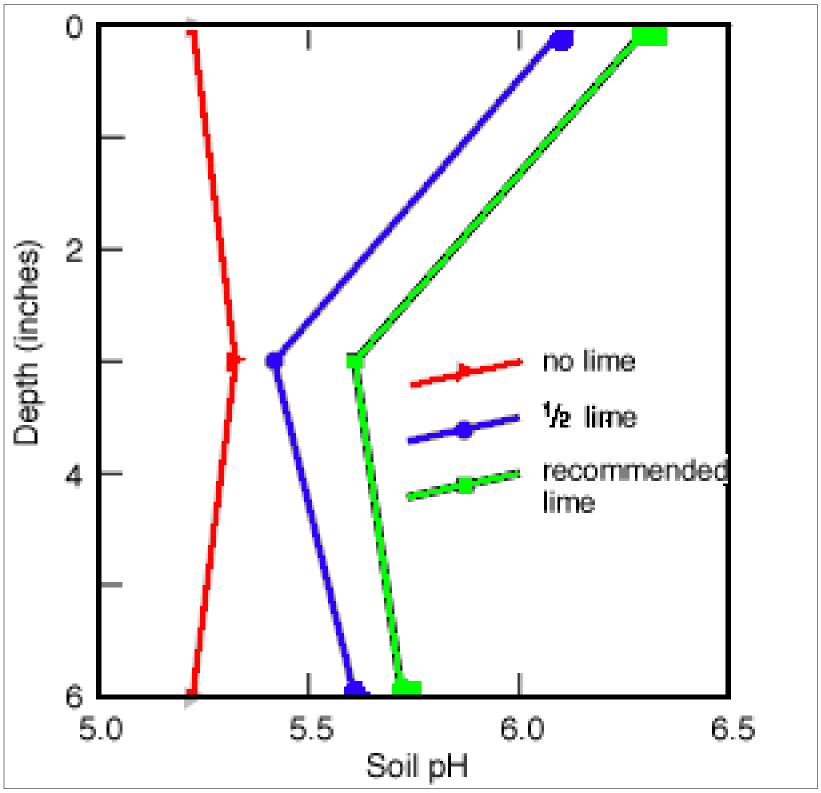

Figure 2. Effect of lime on soil pH after 10 years of no-till corn production in Pennsylvania.

Soil Testing

Soil testing under continuous conservation tillage presents a challenge. How can samples be taken and recommendations made? Certainly a shallow soil sample (0 to 3 inches) is necessary to monitor the pH of the soil surface. If fertilizer phosphates are broadcast, they will also accumulate on the surface. Fertilizer potash will also accumulate in finer-textured soils but not as much as phosphorus. Soils that are occasionally chiseled or have fertilizer phosphates or potash injected should be sampled to the depth of the chiseling or fertilizing operation.

The lime rate should be adjusted when only the surface soil is neutralized. The Auburn University Soil Testing Laboratory and most commercial laboratories recommend agricultural lime based upon an 8-inch furrow slice of soil. If the entire surface 8 inches of soil needs lime, then the entire recommended amount should be applied (**Figure 2**). Because lime is not incorporated in, the surface pH will be higher than that deeper in the soil, but the full rate should be applied. For conservation tillage situations where only the surface 2 inches of soil needs lime, the rate should be reduced proportionately. For example, only 25 percent as much lime is needed to change the pH of the surface 2 inches of soil compared to an 8-inch furrow slice.

Monitor soil fertility 3 inches below the soil surface. A subsurface sample taken below 3 inches but above the subsoil where clay accumulates is desirable to monitor changes in soil pH and nutrient level in this zone of maximum root proliferation. A general fertilizer recommendation should be based on this sample. The pH of this horizon should remain in the desired range for cotton (5.8 to 6.5 on sandy soils and 5.5 to 6.5 on finer-textured soils). Soil test phosphorus should remain "HIGH" in this zone. Samples should not be taken in or near zones where a starter or banded fertilizer may have been applied.

Nitrogen (N) Rate

Many environmental and management factors affect the optimum N rate for cotton. This is why 60 pounds per acre N is recommended on the fine-textured soils of the Tennessee Valley and 90 pounds per acre N is recommended on all other soils. The recommended rate can be adjusted up or down by as much as 30 pounds per acre N depending upon previous crop and experience. As a general rule, the total fertilizer N applied to conservation-tilled cotton in small grain residue should be increased by 30 pounds per acre compared to conventional rates. The additional N can be applied as a starter fertilizer.

Research with no-till cotton on a Decatur silt loam (Tennessee Valley) suggests at least 90 pounds per acre may be needed where conditions are favorable for high yields (2+ bales per acre) (**Figure 3**). In 2 out of 3 years, the N fertilizer requirements were higher for cotton following rye than with conventional tillage systems. Planting cotton into vetch either eliminated or reduced the need for N fertilizers when compared to conventional tillage.

The total N requirement for any cotton production system depends upon the yield potential. With non-irrigated cotton, the yield potential is usually a function of the total rainfall and when it occurs. Because the peak demand for N is during mid-bloom through boll set, extra N can always be applied if needed. Controlling excessive vegetative growth caused by residual or applied soil N is more difficult during late season. Therefore, no more than half of the total N should be applied at or near planting with the remainder prior to first bloom. Foliar N as urea can be applied in late season if good weather conditions and a high yield potential warrant the extra N.

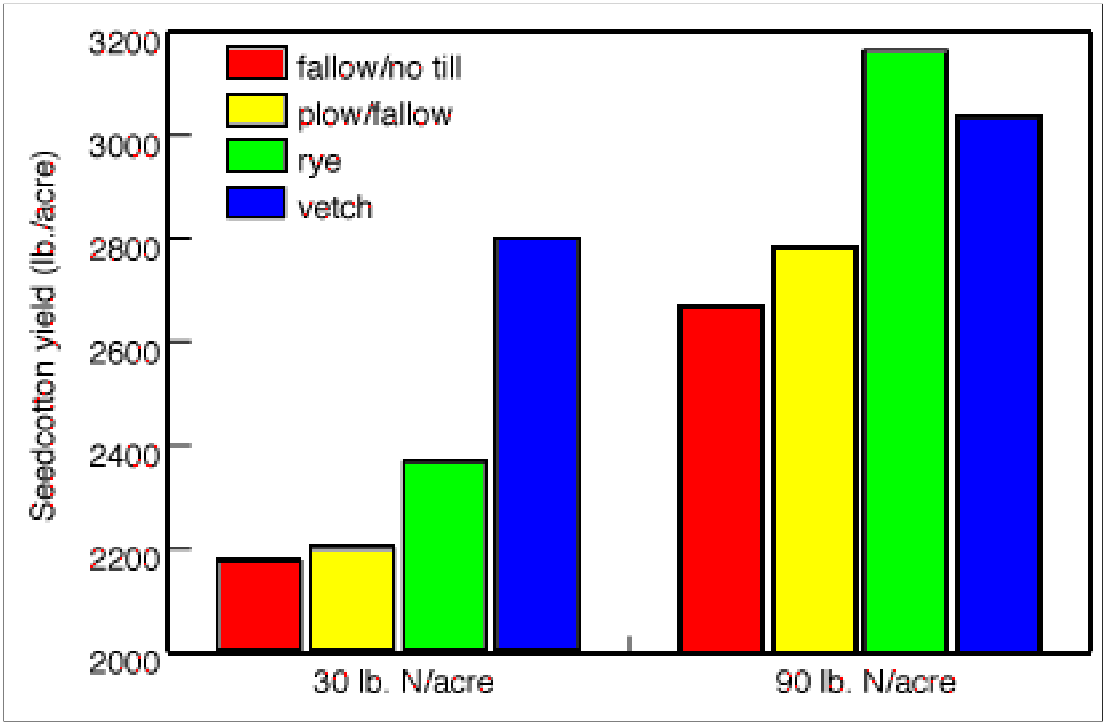

Figure 3. Effect of nitrogen rate and cover crop on seed cotton yields under no-till production (from Brown, et al., 1985).

Starter Fertilizers

Starter fertilizers are probably needed for conservation tillage cotton production on most soils. Starter fertilizer is a small amount of supplemental fertilizer (usually containing N and P) applied in a band near the drill at planting. Starter fertilizers are effective in the early spring because cold or compacted soils or conditions that restrict root growth (reduced tillage, for example) will slow down the chemical, physical, and biological processes that control plant nutrient availability.

Research with starter fertilizers on no-till cotton in Alabama has shown a significant response in 2 out of 3 years in the Tennessee Valley (Decatur silt loam) and in the Wiregrass (Dothan fine sandy loam). One-year tests at Brewton and Monroeville also showed positive yield responses to starter applications (**Table 2**).

Table 2. Response To Starter Fertilizers In No-Till Cotton.*

Location	Seed Cotton Yield (lb. / acre)		
	No Starter	Starter	Increase Due To Starter

Tenn. Valley (2 of 3 yrs.)	2415	2795	380
Wiregrass (2 of 3 yrs.)	3500	4040	540
Monroeville (1 yr.)	1600	2160	560
Brewton (1 yr.)	1935	2003	68
***Yields are only for years when a significant response to starter fertilizers was observed (data from Touchton et al., 1986, and unpublished data).			

Type of starter fertilizer, rates to use, and method of application are not clearly identified. Research in Alabama and surrounding states indicates that, in most cases, both N and P are needed in the starter. Responses to potassium (K) in the starter have occurred on sandy, compacted soils, but these are the exception rather than the rule. Effective rates have been 15 to 30 pounds of N and 15 to 50 pounds of P_2O_5. Starter fertilizers are an efficient method of applying the additional N when cotton is planted in small grain residue. Methods of applying starters include:

- **A** band 2 to 3 inches to the side and 2 to 3 inches below the seed (2 x 2 placement).
- **S**urface band 2 to 3 inches wide with a liquid 10-34-0 or 11-37-0 over the drill.
- **P**lacement 6 to 10 inches deep behind a subsoil shank.

The first method, 2 x 2 placement, is considered the most effective but may be impractical where strict no-till is practiced. It could be used effectively in strip-tilled cotton. For strict no-till, only the surface band would be practical. Because cotton seedlings are extremely sensitive to ammonia toxicity, starter fertilizers containing ammonium N should be kept away from the seed.

Starter fertilizers do not substitute for maintaining high soil P or adequate and timely N applications. Starter fertilizers are always in addition to normal broadcast or sidedress applications. A band application of a high rate of P_20_5 (40 to 60 pounds per acre) could replace a recommended broadcast application of the same amount of P in a soil testing "MEDIUM," but normally, the nutrients applied in a starter fertilizer are in addition to the regular fertilization program.

Fertilization In Crop Rotations

If no-till cotton is planted in rotation with a crop or after a crop that is conventionally tilled (turned or disked prior to planting), then the recommended P and K fertilizer could be applied to the crop in rotation with cotton. The most likely situation would be wheat or some other small grain that is planted in the fall after turning, chiseling, or disking. Cotton is planted into the dead herbage in late April or May. If the grain or forage is not harvested prior to cotton, then the recommended rates of P_2O_5 and potash (K_2O) applied to the small grain in the fall should be adequate for spring-planted cotton. If grain is to be removed, the fall P_2O_5 and K_2O recommendation should be increased by 20 pounds per acre each. If forage is to be removed, the P_2O_5 recommendation should be increased by 20 pounds per acre and the K_2O recommendation by 60 pounds per acre.

If cotton is no-tilled into peanut, soybean, or corn stubble and the soil tested "HIGH" in P, then the recommended N and K_2O can be broadcast or sidedressed anytime prior to blooming.

Return to the Table of Contents

Weed Control

Weed control is extremely important in cotton production. Total crop failure can occur if weeds are not adequately controlled.

Weed control in conventional tillage cotton production depends on primary and secondary tillage combined with herbicides. Primary tillage, including moldboard or chisel plowing and disking, controls emerged weeds and prepares a clean seedbed for planting. Cultivation between rows kills weeds and permits herbicides to be banded over the row, thus reducing herbicide use.

Weed control in conservation tillage cotton production is based on the use of herbicides. Conservation tillage can be defined as any of several systems ranging from strict no-till to mulch-till systems where a small grain crop is disked before planting cotton. Preplant foliar (burndown) herbicides including paraquat and glyphosate take the place of primary tillage in most conservation tillage systems. Preemergence herbicides must generally be broadcast in these systems since cultivation is usually eliminated.

Some aspects of weed control remain the same in both conventional and conservation tillage cotton production. The summer weeds that infest cotton fields are generally the same for both tillage systems. Sicklepod, annual morningglory, common cocklebur, prickly sida (teaweed), annual grasses such as crabgrass and goosegrass, and many other weeds are problems for cotton regardless of the tillage system used. Winter weeds, such as horseweed, cutleaf evening primrose, pepperweed, Carolina geranium, wild mustard, and ryegrass, must be controlled using preplant foliar (burndown) herbicides in conservation tillage systems. Rainfall is required for preemergence herbicide activation in both systems. Likewise, herbicides used for postemergence weed control in conventional tillage systems will also be used in conservation tillage cotton.

Some weed problems that may develop in conservation tillage cotton include a possible increase in perennial weeds such as bermudagrass, nutsedge, trumpetcreeper ("cow-itch vine"), and perennial morningglory. Also, the effectiveness of specific herbicides may decrease in conservation tillage systems due to application limitations. For example, trifluralin and pendimethalin cannot be incorporated in most conservation tillage systems. Consequently, control of annual grass and pigweed has decreased in some cases. However, alternative herbicides are available that can help control grasses. Norflurazn and clomazone (banded only) applied as a preemergence spray will increase annual grass control. Postemergence-directed sprays containing MSMA will provide control of several small annual grass species. Postemergence over-the-top grass herbicides including fluazifop, sethoxydim, quizalofop, and clethodim provide control of emerged annual and perennial grasses.

- ## Research Findings

Four years of research (1985-1988) at the Tennessee Valley Substation, Belle Mina, and the Wiregrass Substation, Headland, showed that effective weed control can be maintained in strip-till cotton with currently registered herbicides. Cotton was planted into a wheat cover that had been killed approximately 4 weeks earlier. After wheat was killed, a "Ro-Till" strip-till machine was used to prepare tilled strips about 18 inches wide. Cotton was planted in these strips, leaving the killed wheat stubble between rows. Both annual grass and broadleaf weed control were maintained at good to excellent levels in strip-till cotton at both locations over the 4-year period. Fluometuron applied preemergence and cyanazine plus MSMA post-directed formed the basis for weed control in both conventional and strip tillage. However, this research also pointed out some problems with weed control in conservation-till cotton.

Since cultivation was not used in these trials, all herbicide applications were broadcast applied in strip tillage. This type of application cost twice as much as herbicide applications with conventional tillage systems, where preemergence and post-directed herbicides were banded. Annual grass control was slightly lower in strip-till than in conventional-till plots because pendimethalin could not be incorporated as well using strip-till techniques.

Research was initiated at the Tennessee Valley Substation in 1989 to determine if cultivation in strip-till cotton with specialized cultivators could be used to decrease herbicide costs for conservation-till cotton. Results from 1989 through 1992 showed a specialized cultivator using wide (24-inch), flat, running sweeps effectively controlled broadleaf weeds and grasses between cotton rows where preemergence herbicides were banded. Weed control and cotton yields from this system were equal to conventional tillage in 1989. However, weed control in strip-till cotton with the specialized cultivator was not successful in 1990 due to poor grass control, resulting in total crop failure. Two cultivations were used in strip-till plots each year. The addition of two broadcast postemergence-directed sprays with cultivation provided acceptable weed control and cotton yields both years. Strip-till plots were cultivated in late May and early June in 1990; cultivation was followed by rain which encouraged grass growth. Since this special cultivator does not invert soil, grasses are not buried and can reestablish their root systems if moisture is available.

Strict no-till cotton has been planted into the previous year's cotton stubble at Belle Mina in field trials during 1989 and 1990. Cotton was planted using modified Max-emerge planters. Winter weeds were killed with burndown herbicides before planting. Both paraquat and glyphosate have been used for burndown treatments. If difficult-to-control weeds such as horseweed (marestail) or cutleaf evening primrose are present, then glyphosate or a paraquat/cyanazine mixture should be used.

Conservation Tillage Cotton Weed Control Systems

Specific herbicides for use in cotton weed control are listed in Extension Circular IPM-415 that is available at county offices. Producers should read, understand, and follow all manufacturer's label directions for use.

Burndown Herbicides.

Paraquat and glyphosate are two burndown herbicides commonly used. These should be broadcast at rates sufficient to kill emerged weeds or small grain covers. Weeds or a small grain cover crop should be killed at least 2 (preferably 3) weeks before cotton planting. Cyanazine can be added to paraquat to increase activity on hard-to-kill species (See **Table 3**).

Table 3. Burndown Herbicides.

Herbicide	Rate	Comment
paraquat Gramoxone Extra	0.63-0.9 lb. ai/acre 2-3 pts./acre	Use at least 20 gal./acre water carrier.
glyphosate Roundup	1-1.5 lb. ai/acre 2-3 pts./acre	Apply in 10 to 15 gal/acre water carrier.
cyanazine Bladex	0.5-1.0 lb. ai/acre	Added to paraquat.

Incorporated Herbicides.

Herbicides cannot be incorporated in most conservation tillage systems. One exception is strip tillage where a light incorporation may be accomplished in the tilled strip over each row. Pendimethalin (Prowl) can be broadcast sprayed ahead of the strip-till machine and some degree of grass control will be obtained. Higher pendimethalin rates should be used in conservation-till cotton. This treatment depends on rainfall for incorporation and activation.

Preemergence Herbicides.

These herbicides are the principal means of weed control in conservation tillage systems. They are applied to the soil surface after planting and depend on rainfall or irrigation for activation. The most consistent preemergence herbicides used are fluometuron (Cotoran, Meturon), norflurazon (Zorial), and clomazone (Command). Other herbicides that can be applied preemergence include prometryn (Caparol) and diuron (Direx, Karmex). A mixture of fluometuron plus norflurazon or fluometuron plus clomazone will give longer and more consistent weed control. However, small grains following norflurazon- or clomazone-treated cotton may be injured. Application should be made in 15 to 20 gallons per acre water carrier.

- **Postemergence-Directed Sprays.**

These treatments are critical for weed control in conservation-till cotton. If cotton will not be cultivated, these sprays must be broadcast from row to row. Early directed sprays to cotton 4 to 5 inches tall may be required if preemergence herbicides are not properly activated by rainfall. Only two herbicides should be direct sprayed on small cotton: fluometuron or MSMA/DSMA. These herbicides can be direct sprayed on each side of young cotton without serious injury. Once cotton reaches a height of 8 inches, diuron and prometryn can be direct sprayed safely. Cyanazine, oxyfluorfen (Goal), and lactofen (Cobra) should be directed only to reduced tillage cotton which is at least 12 inches tall. Application should be in 20 gallons per acre water carrier.

- **Postemergence Over-The-Top.**

The following herbicides can be applied over-the-top of cotton:

Clethodim (Select), quizalofop (Assure), sethoxydim (Poast), and fluazifop (Fusilade) control annual and perennial grasses and have no activity on broadleaf weeds.

DSMA can be sprayed over-the-top of cotton in emergency situations and will provide control of some broadleaf weeds and grasses. However, the chance of reduced cotton yields or delayed maturity increases as DSMA rate and cotton age increases.

Fluometuron can also be applied over-the-top; however, this treatment should be used as a salvage treatment only before cotton squaring. Application should be in 15 to 20 gallons per acre water carrier.

Pyrithiobac (Staple) and bromoxynil (Buctril) can be applied over-the-top for control of several broadleaf weeds. Bromoxynil can be used only in conjunction with genetically engineered, bromoxynil-resistant (BXN) varieties. Application to non-bromoxynil-resistant varieties will result in crop death.

Guidelines For Weed Control

The following are suggested guidelines for conservation tillage cotton weed control:

- **T**ry to select an area that does not have perennial weeds such as bermudagrass, nutsedge, or johnsongrass.

- **I**f using a cover crop, plant a small grain and not a legume. Legumes such as clover or vetch have been hard to kill and have contributed to seedling disease and reduced crop stands. Wheat has worked best in most situations. Kill the cover crop 3 to 4 weeks before cotton planting to conserve moisture.
- **M**ake sure all emerged weeds are killed prior to planting. Any weeds which are not killed before planting will have a competitive edge on the crop. Certain weeds such as horseweed (marestail) or cutleaf evening primrose may require applications of glyphosate followed by paraquat at planting.
- **U**se broadcast applications of preemergence and post-directed herbicides if cultivation will not be used.
- **DO NOT** attempt conservation-till cotton unless you have a postemergence-directed or shielded sprayer and know how to use it.
- **H**ave a directed or shielded sprayer ready to use no later than 3 weeks after planting.
- **W**atch your fields closely to determine when escaped weeds emerge and be ready to spray.
- **H**erbicides used to control weeds are outlined in Extension Circular IPM-415.
- **F**ollow all rates and directions for use listed on the manufacturer's label.

Return to the Table of Contents

Disease Control

Conservation tillage can increase seedling disease as a result of lower soil temperatures at planting and crop residue at the soil surface. Soil tends to warm more slowly in these systems when compared to conventional tillage systems. Desiccation of cover crops with herbicides at least 3 to 4 weeks prior to planting allows the cover to decay and the soil to warm up as quickly as possible.

The general rule for planting cotton is to wait until the soil warms to a minimum temperature of 65° F for 3 to 4 days at a 4-inch depth. The temperature should be obtained early in the day following night cooldown and before warming begins. Because of the cooler soil temperatures, in-furrow fungicide treatments are recommended when planting conservation-till cotton for the control of Pythium and Rhizoctonia. Treatments for seedling diseases can be applied only with the planting operation and are not effective if applied after emergence. Fungicides and rates used to control these seedling diseases are outlined in Extension Circular IPM-415.

Return to the Table of Contents

Insect Control

The impact of various conservation tillage systems will be much greater on agronomic and weed management practices than on insect management. Nevertheless, some changes in insect occurrence can be expected.

The following three conservation tillage systems require insect control strategies similar to those required for conventional tillage cotton:

- **P**lanting into crop stubble and winter and spring weeds.
- **P**lanting into a small grain or other grass cover crop.
- **U**sing a legume cover crop, such as clover or vetch.

The first two systems should have minimal direct effect on insect populations. However, if delayed maturity (through later planting dates, reduced soil temperature, and increased herbicide injury) results from any of the three systems, the potential for insect damage will likely be altered.

Delayed maturity most often increases the potential damage from cotton pests because of the extended season. Young bollworm and budworm larvae must have tender plant tissue available for survival, which usually means an actively growing plant. Any delay that extends the growing season increases the likelihood that late-season budworm generations will become established in cotton. In addition to increasing damage and control costs, this scenario also strains pyrethroid resistance management programs. Delay in maturity also opens the door for historic late-season pests, such as fall armyworms, beet armyworms, loopers, and whiteflies.

Delay in maturity also can have effects earlier in the season. Tarnished plant bugs cause more injury when they feed on cotton at or near the pinhead square stage. Anything that hampers the development of cotton and extends this stage brings it more in line with normal plant bug migration to cotton, thereby increasing the potential for damage.

The most dramatic change in cotton insects is associated with the third system: planting cotton into a legume cover crop. Cutworms are a rare problem in conventional-till cotton, but producers can be assured that cutworms will attack cotton grown under the legume cover system and that populations are likely to be damaging. For the past few years, cutworms have also become a fairly common problem in the other conservation tillage systems.

The cutworm most commonly encountered is the variegated cutworm. As with most cutworms, this insect feeds at night and spends the day in the soil surface. Small cutworm larvae feed on cotton leaves but destroy whole seedlings as they mature. It is essential to locate cutworm problems before many plants are destroyed. This insect can be effectively controlled with several products outlined in Extension

Circular IPM-415.

Both the corn earworm and tobacco budworm pass the winter as pupae several inches beneath the soil surface. Land preparation associated with conventional-till cotton significantly lowers populations by disrupting emergence from the overwintering stage. This suggests that significant increases in conservation tillage practices could increase cotton bollworm and tobacco budworm populations.

No direct impact has been observed on the common predators of bollworm and budworm. One excellent predator of many cotton pests, the fire ant, has been favorably affected by the adoption of conservation tillage cotton production. Fire ants have successfully colonized many fields. If conservation tillage is sustained, fire ant populations will likely increase and the resulting impact on pest populations could be substantial.

Other changes in cotton insects will become evident as more experience is gained with conservation tillage, but insect problems should not hamper any success that these systems might enjoy.

Return to the Table of Contents

Irrigation

The number of acres of irrigated cotton continues to expand in Alabama. The vast majority of this irrigated acreage is produced using conventional tillage practices. Little, if any, data are available comparing the use of conservation tillage versus conventional tillage in terms of the effectiveness of irrigation. Yields for producers who carry out best management practices and who irrigate typically average between 800 to 1,100 pounds of lint per acre. These yields have been reported from farms throughout Alabama and Georgia, and these yields have been equaled or exceeded at Experiment Station sites where irrigated yields were measured.

Observations over the years indicate that irrigation would be beneficial under certain conditions for those who practice conservation tillage. This is particularly true at planting time. Drought or dry topsoil at this time, although less frequent than during July and August, can create problems for conservation tillage systems. Planting difficulties may result if the soil forms clods or does not pulverize readily when the conservation planter is used. Obviously, some soils are much more likely to develop this condition than other soils. When poor, cloddy conditions exist, irregular stands can result. Irrigation can be used to pre-irrigate troublesome soils and thus create a more favorable environment for conservation tillage planting.

Comparative yields between conventional-till-irrigated and conservation-till-irrigated systems are not available; however, yield expectations should be as good with conservation tillage as with conventional tillage systems. Where conservation tillage systems provide soil conditions for deeper rooting and less soil moisture loss, irrigation might tend to be needed less or needed only when more adverse drought conditions develop.

Return to the Table of Contents

Production Costs

Producers who consider switching to conservation tillage systems should carefully calculate how their operations will change. The expense categories that will be most significantly different are machinery fixed and variable costs, chemical weed control costs, and labor expenses. The following summarizes the likely alternatives in each of these areas.

Machinery: Fixed And Variable Expenses

While many conventional-till planters are adequate or can be adapted to conservation-till conditions, most producers who plant a significant acreage with reduced-till or no-till own a dedicated planter. Many of these planters offer "row-tillage" or in-row subsoiling and can be fairly expensive. Horsepower requirements for in-row subsoiling can add significantly to fuel use at planting. A postemergence-directed sprayer is necessary for conservation tillage cotton production. These are not very expensive and many cotton producers already own and use one.

Machinery investment costs are not prohibitive for conservation-till cotton. Total equipment requirements are greatly reduced for these systems, both for drawn implements and tractors. However, total investment in machinery and equipment will not decrease until equipment that is no longer needed is sold or discarded. If unused equipment is held, fixed machinery costs per acre will rise. Actual fixed expenses per acre may be significant if unused equipment experiences a rapid decrease in market value. Holding older, completely depreciated equipment is likely to be much less expensive. Variable machinery expenses in terms of fuel, lube, oil, parts, and repairs will also likely decrease. Labor requirements for machinery operation will also fall.

Chemical Control Of Weeds

Most producers take advantage of modern weed control technology, and little adaptation is needed to adjust to conservation tillage production. **Table 4** outlines several recommended weed control programs, with a low-cost and a high-cost alternative shown for both no-till and conventional tillage cotton.

Labor Expenses

As previously discussed, labor requirements for conservation tillage production are usually less than for conventional tillage systems. However, labor demands at planting time and during the cultivation stages may not be significantly different from what producers experience with conventional tillage. Much of the labor saving of conservation tillage is in the primary tillage and land preparation stage of production.

Table 4. Chemical Weed Control Programs For Cotton.

Operation	Chemical [a] (lb. Ai / acre)	($ / acre)			
		No-Till		Conventional	
		Low	High	Low	High
Burndown	glyphosate, 1.0	10.00	10.00	0	0
Preplant	pendimethalin, 1.5	6.00	6.00	3.25	3.25
Preplant Incorporated	norflurazon, 1.0	0	16.00	6.50[b]	16.00
Preemergence	fluometuron, 1.5	12.00	12.00	4.80	4.80
Post-directed	MSMA + prometryn (2.0 + 0.5)	10.00	10.00	4.00[b]	4.00
Lay-by	MSMA + cyanazine (2.0 + 0.75)	11.00	11.00	11.00	11.00
Total [c]		**49.00**	**65.00**	**29.55**	**39.05**

[a] Herbicides listed are as follows: glyphosate as Roundup 4L, pendimethalin as Prowl 4E, norflurazon as Zorial 80DF, fluometuron as Cotoran 4L, MSMA as Bueno 6, prometryn as Cotton-Pro 4L,otton-Pro 4L,L,ro 4L, and cyanazine as Bladex 4L.

[b] Reflects banded application based on 16-inch band, 40-inch row spacing.

[c] Chemical expenses only at recommended application rates, no surfactant or application expenses included. These estimates are intended for demonstrational and planning purposes only and are not intended to endorse or guarantee a specific product.

Return to the Table of Contents

North Alabama Demonstrations

Cotton has been successfully grown with conservation tillage in small-plot research in North Alabama; however, producer adoption of this practice has been slow. In order to demonstrate and refine techniques for no-till cotton, more than 50 different on-farm field trials were conducted between 1985 and 1990.

Generally, demonstrations in the Limestone Valley or "red-land" area (deep clay-loam soils) have met with limited success. Economical weed control has been difficult to attain on many of these fields because of a lack of rotation, the resulting buildup of perennial weeds, and few suitable herbicides. Surface compaction, seedling diseases, and problems with in-row tillage have often reduced yields.

Results on shallow sandy-loam soils near Sand Mountain have been much more promising. Increased moisture conservation and availability on these soils resulting from the use of in-row subsoiling and other minimum-till methods have consistently resulted in better late-summer growth, along with production of 50 to 150 more pounds per acre of lint. Areas still needing to be addressed include consistent and economical weed control, deep tillage or cultivation on particular soils, and seedling disease control.

Most tests in sandy soils were conducted with cooperators who used an in-row subsoiler ("Ro-Till") in various covers and residues before planting. Cotton yields and management practices needed for no-till cotton were compared to adjacent areas of conventional-till cotton. The results are presented in **Table 5.**

Table 5. North Alabama No-Till And Strip-Till Cotton Demonstrations, 1985-88.

Area	Compared No. Of Locations	Lint Cotton Yield (lb./acre)		
		No-Till	Conventional	Difference *
Limestone Valley	19	592	718	-126
Sand Mountain	9	587	506	+81
* Indicates the difference in yields				

Return to the Table of Contents

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