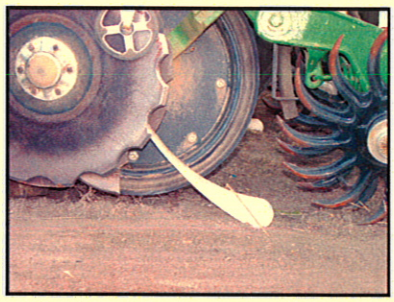
Conservation Tillage Systems for the Southeast



Getting Started

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What is Conservation Tillage?

Conservation tillage systems are cropping systems that minimize surface soil disturbance and maximize plant or residue cover on that surface. Successful conservation systems maintain or increase the organic matter content of the soil while enhancing farm profitability and sustainability.

Traditionally, conservation tillage has been defined as anything that retains at least 30% residue cover on the surface. In the southeastern USA, however, we can (and should) do better, given our warm climate and substantial annual rainfall. These two factors can cause soils to lose most of their organic matter to oxidation and erosion, damaging environmental systems and the farm's economic viability.

The best conservation tillage systems in the Southeast minimize surface soil disruption and protect as much of the surface as practical with a cover of growing plants and plant residue throughout the year.

Why conservation tillage?

Increased profits

- Yields are as high or higher than traditional tillage.
- Reduced use of fuel and labor.
- Requires less time.
- Lower machinery repair and maintenance costs.
- Reduced fertilizer and herbicide costs.

Improved environment

- Improved soil quality and productivity.
- Reduced erosion.
- Increased water infiltration and storage.
- Improved air and water quality.
- Provides food and shelter for wildlife.

Improving your soil with conservation tillage

Reducing destructive tillage operations and increasing organic matter production has a number of beneficial impacts on the soil's health and productivity.

Soil erosion is a major cause of soil degradation, and tillage is the major cause of erosion. Erosion removes topsoil from fields, reducing organic matter contents and lowering crop yields. Also, eroded soil particles carry pesticides and nutrients to nearby streams or rivers. In 2003, sheet and rill erosion on U.S. cropland was 971 million tons per year, and wind erosion was 776 million tons per year. Conservation tillage systems with cover cropping can reduce erosion up to 90%.

Organic matter is an important aspect of soil quality, improving soil structure and tilth. Southeastern soils typically have an organic matter content of less than 1%. Tillage accelerates the oxidation of organic matter, releasing CO_2 into the atmosphere. It is nearly impossible to build organic matter in intensive tillage systems. High-residue systems can help maintain and build organic matter.

Biological activity increases under conservation tillage. The increased organic matter and root exudates increase soil organisms that decompose plant residues and recycle nutrients. Soil organisms also produce organic compounds which help hold soil aggregates together. Earthworms create tunnels that improve water infiltration and root growth.

Soil structure or soil tilth will improve with conservation tillage. Increased organic matter and biological activity improves soil aggregation, resulting in increased soil porosity and reduced bulk density. Residues on the soil surface also help reduce soil crusting by protecting the soil

surface. Cover crop roots reduce compaction and loosen hard pans by creating root channels that subsequent cash crop roots can follow.

Soil moisture. Macropores from cover crop root channels and earthworm burrows reduce runoff and improve water infiltration under conservation tillage systems. A good residue cover on the soil surface can help protect the soil from soil evaporation and raindrop impact, which causes soil crusting. Preliminary data from one study in central Alabama showed an increase in soil moisture of 5% in the top 12 inches of soil under conservation tillage. This amount of moisture is equivalent to 0.6 inches or 16,300 gallons of water, which could save up to $8 per acre in irrigation costs. For cotton, if similar soil moisture contents can be assumed to a depth of three feet, soils under conservation tillage can fulfill the water requirement for five to seven days longer than those under traditional tillage.

While some studies have shown immediate yield and other improvements from conservation tillage, it may take several years to realize the full benefits of this system. Management is a key factor in a profitable conservation tillage program. It is important to plan carefully before implementation so that a successful transition can be made to conservation tillage. It is recommended that you begin planning for a transition several months in advance to help you work out challenges in advance. This publication will help start the planning process by looking at several aspects of a conservation tillage program.

Planning the Transition to Conservation Tillage

Get informed

There are a multitude of publications and papers on conservation tillage systems. Many can be found on the internet or through extension agencies. Web sites which provide conservation tillage information include USDA-NCRS (http://www.nrcs.usda.gov) and USDA-ARS (http://www.ars.usda.gov). Each state cooperative extension service has a web site loaded with information. The Georgia Conservation Tillage Alliance (http://www.gcta-ga.org) is a farmer-led, grass-roots organization that is an excellent source of information and advice.

State Cooperative Extension Services, Agricultural Experiment Stations, USDA-ARS and USDA-NRCS sponsor field days throughout the state to introduce farmers to conservation tillage systems. Contact your local extension agent or NRCS office for more information. Extension agents and USDA staff can also offer suggestions to help you get started on your farm. Getting advice from experienced conservation tillage farmers in your area is one of the best sources of practical information. Learning from others' experiences will save time and money.

Team Conservation Tillage. Alabama and Georgia agencies and farmers offer an exhibit about conservation tillage at the Sunbelt Ag Expo in Moultrie, GA every October.

Climate effects

The Southeast has a wide range of climates. It is important to recognize how climate affects soils and residues. In warmer climates, soil activity is higher and crop residues break down faster than those in cooler climates. In the Tennessee Valley region of Alabama, some high-residue research plots contain plant residues from 2 years prior (see picture below).

Accumulation of plant residue protects the soil surface.

Evaluate your equipment needs

It is important to evaluate what your equipment needs may be in a conservation tillage system. Some no-till equipment may be mandatory while other implements can be converted for use in a conservation tillage system. It is also important to learn how to set up your equipment to ensure good crop stands. Conservation tillage equipment will be discussed in a later section.

Learn about incentive programs

There are incentive programs available through the USDA-NRCS to reward and motivate conservationists. These programs have eligibility requirements that must be met by the farmer so it is important to work with your NRCS office during the planning process. More information about these programs can be found at http://www.nrcs.usda.gov, or contact your local NRCS office.

Crop Selection and Rotations

Crop and variety selection

Crop and variety selection is an important management decision with conservation tillage. Crops and varieties with early seedling vigor and disease resistance may be especially desirable in high residue systems.

Vegetable crops can also thrive under conservation tillage systems. The development of a no-till transplanter (discussed in the equipment section) has made conservation tillage a feasible option in vegetable production. Choosing varieties that will transplant well into high residue is important. Soils under residue tend to be cooler and wetter than those under plastic systems.

Crop rotations

Rotations are an integral part of any conservation tillage system. Crop rotations can result in significant yield improvements and help reduce the investment risk in farming by spreading it across several cropping enterprises. An important benefit of crop rotations is improved pest and disease control. Rotations break pest and disease cycles. Do not grow the same crop or a closely related crop continuously for more than two years in the same field.

Cash crops vary in the amount of residue left after harvest. Rotating a high-residue crop (such as corn) with a lower residue crop (such as cotton) can help maintain an adequate amount of residue on the soil surface. Crop rotations can also stimulate biological activity. Crops having residues with a high C/N ratio, such as corn or small grains, should be rotated with crops such as legumes that have low C/N ratios. Plants with low C:N ratios tend to decompose more quickly, which can greatly affect the amount of residue on the soil surface.

One popular cover crop–cash crop rotation is a clover–corn combination. This allows a nitrogen-fixing legume with low biomass, low C:N ratio to be rotated with a high biomass, high C:N ratio crop.

It is important to consider pesticide selection as a factor in your rotation. Check labels for rotation restrictions. Label information can be found on the *Crop Data Management Systems* web site: http://www.cdms.net/manuf/manuf.asp, or on *Greenbook:* http://www.greenbook.net.

Cover Crops

Benefits

Pest control – Cover crops aid in weed control by physically suppressing weeds during growth and the cash crop growing season if left on the soil surface. Most covers also release allelopathic chemicals that aid in weed suppression. Some cover crops produce biotoxins or alkaloids that have activity against soilborne pests, including nematodes.

Soil cover & quality – Cover crops are an integral part of a conservation tillage system, especially in fields where crop residue cover is low or decomposition is rapid. It is recommended that at least 50% residue cover is present at all times. An adequate residue cover protects the soil surface from wind and water erosion. Cover crops also help build organic matter. To increase soil organic matter, 4,000-8,000 lb residue/acre must be left on the soil surface.

Capture nutrients/Fix nitrogen – Cover crops can utilize excess nutrients at the end of the growing season and help recycle those nutrients back into the system for the next crop. Small grains, such as wheat and rye, are quick to scavenge excess nitrogen and other nutrients. Hairy vetch is a good scavenger of phosphorus. Legume covers fix nitrogen that can be released for the next crop, reducing fertilizer costs.

Challenges

Allelopathy – Covers may have an allelopathic effect on the subsequent crop. However, these effects are usually negligible if cover is terminated at least 3 weeks before planting.

Terminating the cover crop – It is important to completely terminate the cover crop or soil water may be depleted by the still-growing cover.

Spring soil temperatures are cooler – Residue on the surface slows soil warming in the spring, which can delay planting. If problems occur, you may consider a wide strip-till system.

Susceptibility to early-spring diseases – Diseases may occur more often due to cool, wet soils and decaying cover crop residue. Crop rotations and selecting resistant crop varieties will help reduce the frequency of disease. Using fungicides or delaying planting will also help.

Cover crop selection

Choosing a cover crop for your system is an important step in the planning process.

Several factors should be considered including:

- **Pesticide selection.** As noted in the crop rotation section, check all labels for rotation restrictions. Some labels have a special cover crop section.
- **Nitrogen requirements.** Rotating legume covers with non-legume cash crops or vice versa could be desirable options, depending on your situation
- **Amount of biomass.** Rotate high and low biomass crops and covers as needed to help manage the amount of residue left on the soil surface.
- **Soil/Pest problems.** Certain covers may be better suited to help remediate particular soil/pest problems.
- **Planting / Management costs.** The cost of cover crop seed, fertilizer application, and termination should be taken into consideration.

Information about some common cover crops has been included here to serve as a guide to help start the selection process.

Wheat

Small grains. Rye, wheat, triticale, oats and barley are all common winter annual cereals used for cover cropping. The root systems on these covers provide erosion control and scavenge nutrients from the soil. Rye typically produces the most biomass for residue cover. Wheat seeds are the most inexpensive and plentiful. Biomass production: 3000-7000 lb/acre.

Black Oat

Black oat. *SoilSaver* black oat is a winter annual cereal. It has shown high allelopathic activity, especially on broadleaf weeds. Greenhouse studies have shown that black oat residues and leaf extracts inhibit radish and cotton radicle elongation. In another study, a black oat cover crop resulted in higher cotton yields than a rye cover crop. In a study at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center, weed control in conservation tillage cotton was 34% with black oat, 26% with rye, 19% with wheat and 16% with no cover crop.

Oats can be particularly sensitive to herbicide carryover. Check herbicide labels for more information. Black oat is not as cold-tolerant as other cover crops and should only be planted in USDA Plant Hardiness Zones 8b-10a. Biomass production: 3000-7000 lb/acre.

Turnip

Brassica species (forage rape, canola, mustards, turnip) are winter annuals/biennials which have biotoxic activity against many soil-borne pathogens and pests, including insects, nematodes and weeds. Large taproots of turnips and radishes can also help break up compacted soils. Brassicas can be grown in mixtures with small grains. Biomass production: up to 8000 lb/acre.

Lupin

Lupin is a winter annual legume that can produce large amounts of surface residue and nitrogen. White lupins contain alkaloids that could aid in disease, insect and nematode control. Lupin releases from Auburn University include *AU Homer* and *AU Alpha*. Biomass production: 5000-10000 lb/acre. Nitrogen fixation: up to 350 lb N/acre.

Hairy vetch

Hairy vetch is a winter annual legume that produces a large amount of residue but decomposes relatively quickly. It tolerates a pH of 4.9 to 8.2 and prefers well-drained soils. It is a good scavenger of phosphorus and fixes nitrogen. Hairy vetch mixes well with grain cover crops, but is not recommended if are nematodes are present. Biomass production: 4000-7000 lb/acre. Nitrogen fixation: 90-200 lb N/acre.

Crimson Clover

Crimson clover is a winter annual legume that has reseeding potential. Crimson clover provides a habitat for insect predators such as pirate bugs and lady beetles. It also attracts honeybees. Two popular cultivars in Alabama are *AU Robin* and *AU Sunrise*. *AU Robin* is more widely available and is a good choice for wildlife/food plots. *AU Sunrise* is a recent release and may be more difficult to locate, but it flowers 1 to 2 weeks earlier than *AU Robin*, making it an excellent choice for a reseeding cover crop. Biomass production: 3500-5500 lb/acre. Nitrogen fixation: up to 150 lb N/acre.

Winter Pea

Austrian winter pea is a winter annual legume that grows as a vine and produces a great amount of residue. It decomposes quickly because of its low C:N ratio. It is intolerant of water logging or drought and prefers a clay or heavy loam soil. It makes a good forage if mixed with barley, oat or triticale, boosting the protein content of the forage mix. Biomass

production: 5000-8000 lb/acre. Nitrogen fixation: 90-150 lb N/acre.

Sunn Hemp

Sunn hemp is a summer legume that can produce great amounts of residue and nitrogen in as little as 8 weeks. It may be planted after a summer crop, but will be killed by frost, so it should be planted at least nine weeks before first frost. It can make a great addition to your rotation after corn, early-season vegetables or small grains, and before a winter cover or small grain crop that would utilize the nitrogen. Seed is currently expensive and in limited supply. Biomass production: 5000+ lb/acre in 8 wk. Nitrogen fixation: up to 120 lb N/acre.

Cover crop management

Generally, cover crops are established with a no-till drill or by broadcasting. Small-seeded covers, such as clovers, may be broadcast successfully, but seeding rates will need to be increased (see the table at the end of this section). Traditional drills work adequately, but will not place seeds as uniformly as a no-till drill. This may cause poor germination and emergence in high residue systems.

No-Till Drill

Aerial seeding can be used in some large areas. This allows cover crops to be planted before the cash crop is harvested, which may be particularly beneficial when harvest is delayed. Weed control is typically not a problem in a well-established cover; however, it is advisable to control serious weed problems prior to planting.

Fertilizing cover crops is a recommended practice to maximize biomass production. Nitrogen is the only nutrient that must be added to cover crops unless there is a severe deficiency of phosphorus or potassium. Legumes will fix their own nitrogen if inoculated with the correct nitrogen-fixing bacteria. Other covers, however, will likely need nitrogen fertilizer. Cereals, such as wheat or rye, will do best if 30-40 lbs N are applied on soils with low fertility. If residual N and organic matter levels are high, N fertilizer inputs may be reduced.

Research has found that earlier planting dates and later termination dates produce the greatest cover crop biomass. Correspondingly, early-season weed biomass was less in plots that had heavy cover crop biomass. Farmers in Alabama have reported saving one to two early-season herbicide applications with a heavy-residue cover crop.

Cotton in heavy residue

Cotton in low residue

With no herbicide after burndown, cotton in heavy residue has better weed control.

A head-high rye cover can be daunting. You may want to try a lower biomass cover or terminate early until you are comfortable with the system, but keep in mind that **maximum benefits are realized with maximum biomass.**

This man is 12-feet tall!

Cover crops should be terminated two to three weeks before planting to ensure a good kill without interfering with the subsequent crop. Typically, a non-selective herbicide such as glyphosate or paraquat is used, unless the cover has winter-killed or reached maturity. For broadleaf covers, it may be desirable to tank mix a burndown herbicide with 2,4-D to ensure an effective termination. However, be sure to check all labels for planting restrictions.

Rollers

Rolling rye

Researchers are studying the effectiveness of using rollers as an alternative or in addition to herbicide application. Tall cover crops (such as grains) may lodge in multiple directions, reducing planting efficiency. Rolling cover crops parallel to direction of planting helps reduce hair-pinning.

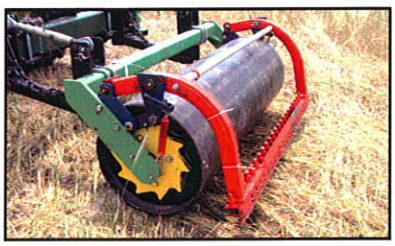
Flattening and crimping cover crops by mechanical rollers is widely used in South America, especially in Brazil, to successfully terminate cover crops without herbicides. Original roller designs consisted of a round drum with blunt, straight steel bars across the drum's length. The function of the bars is to crimp the cover crop stems without cutting them; if cut, the cover crops can re-sprout, while loose residue may interfere with planting operations. When rolling is done at the appropriate plant growth stage, such as *soft dough* or later, the roller alone can be as effective at terminating the cover crop as chemical herbicides.

Straight blade roller

The main complaint with rollers has been the excessive vibration generated by the rollers with straight crimping bars. The most effective method of alleviating the vibration has been to reduce travel speed, but this is not desirable or economical.

Curved blade roller

Two additional roller types, the curved blade roller and smooth roller with crimping bar, are being evaluated. Research with these rollers has shown reduced vibrations with adequate cover termination without the use of herbicides if the cover is terminated at soft dough three weeks prior to cash crop planting.


Smooth roller with crimping bar

Seedbed Conditioner

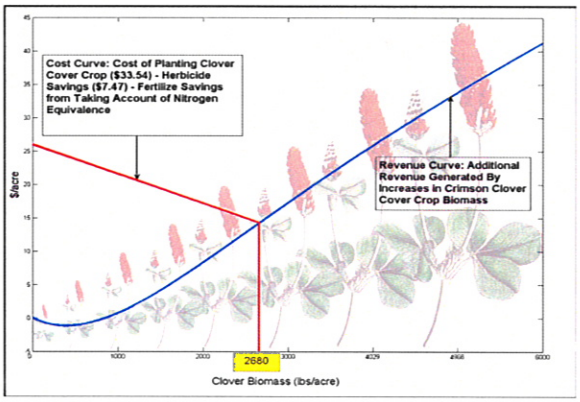
If no roller is available, another implement, such as a seedbed conditioner, may be helpful to knock down a standing cover to help create the mat of residue. These options, however, would likely require the use of herbicides to successfully terminate the cover crop.

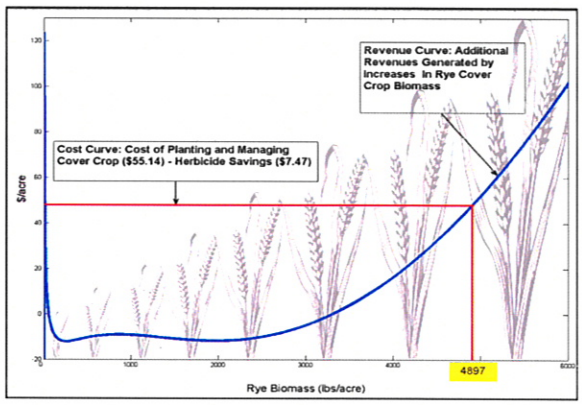
Seedbed Conditioner

Making cover crops profitable

Including cover crops in a conservation tillage system brings both direct and indirect costs and benefits. Cover crops offer many soil-building benefits that can be profitable in the long-run, but they can also show more immediate profits if properly managed. Typically, profits are realized after biomass production reaches a certain amount.

The figures below show examples from crimson clover planted prior to corn, and rye planted prior to cotton at the Alabama Agricultural Experiment Station's E.V. Smith Research Center in 2005. Revenue increased with increasing biomass due to higher crop yields. The minimum amount of biomass needed to make planting a cover crop cost effective was 2,680 lb/acre and 4,897 lb/acre for clover and rye, respectively.





To estimate the cover crop biomass, collect biomass samples (cut plants at ground level) from several areas in your field, using a tape measure to keep track of number of square feet sampled in each area. Dry samples in the sun for several days until they are *crunchy,* then weigh. Use the following equation to determine total biomass:

$$\text{Biomass (lb/acre)} = \frac{\text{Total weight of dried samples (lb)}}{\text{\# square feet sampled}} \times \frac{43560 \text{ sq. ft.}}{1 \text{ acre}}$$

For more information on cover crops, see *Managing Cover Crops Profitably*, from the Sustainable Agriculture Network, USDA Sustainable Agriculture Research & Education. An electronic version of this book is available on the internet at http://www.sare.org/publications/covercrops/covercrops.pdf.

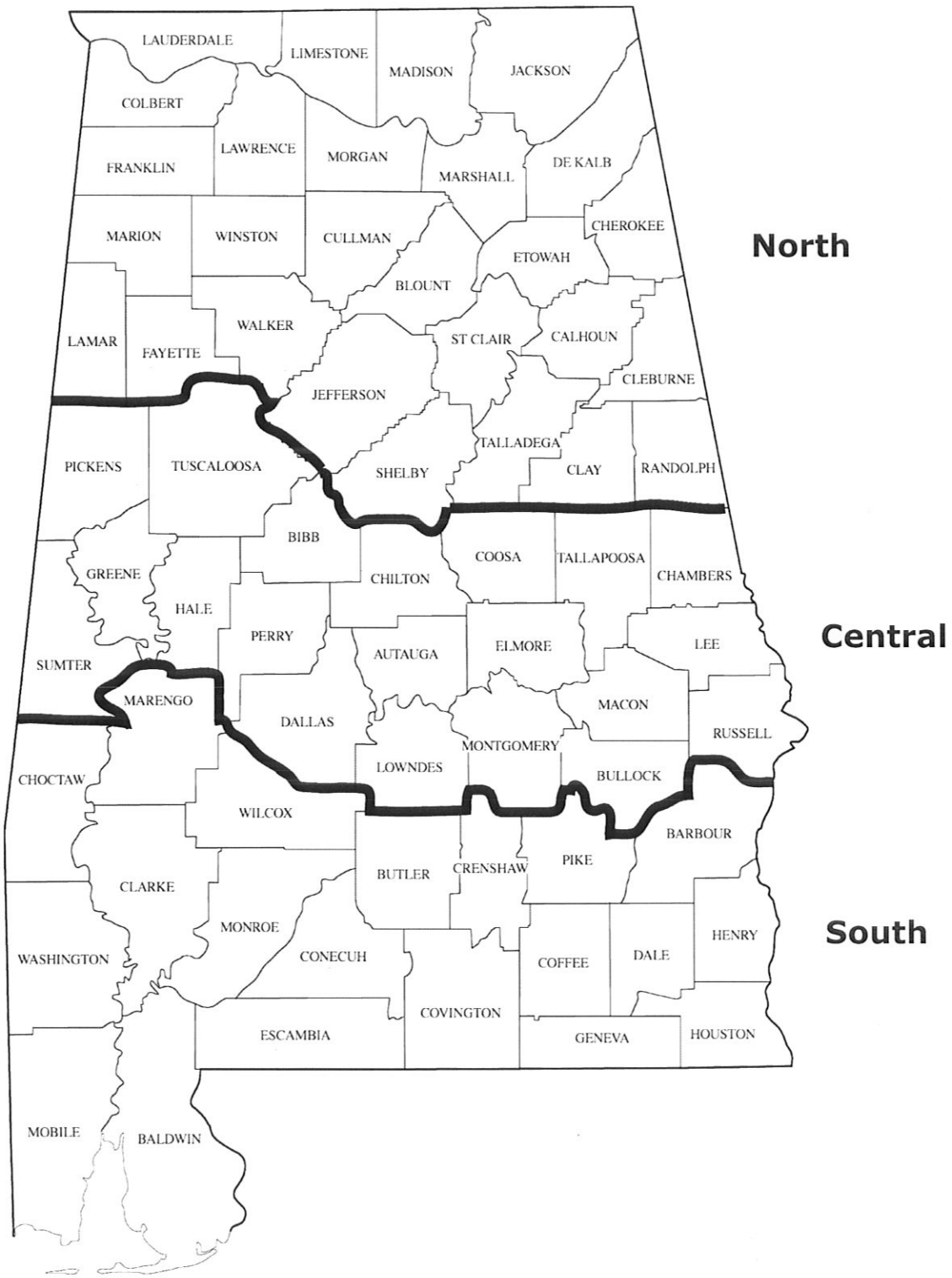
Uses of Cover Crops

	Residue Persistence	Pest Control	Nitrogen Fixation	Weed Control	Erosion Control	Compaction Reduction	Nutrient Scavenger	Forage Quality	Attracts Beneficial Insects
Legumes									
Austrian Winter Pea	F	P	E	G	G	F	G	E	E
Cowpea	F	E	E	E	E	F	F	G	E
Crimson Clover	G	P	G	G	G	F	G	G	F
Hairy Vetch	F	P	E	G	G	F	G	G	F
Lupin	F	G	E	G	G	G	F	P	E
Medics	G	F	G	G	G	F	F	G	F
Sunn Hemp	G	E	E	G	G	G	F	P	F
Velvet Bean	F	G	E	G	G	F	F	G	F
White Clover	F	F	E	G	G	F	F	E	E
Cereals									
Barley	E	G	P	G	E	F	G	G	F
Black Oat	G	E	P	E	G	F	G	G	P
Buckwheat	P	P	P	E	F	G	F	P	E
Oat	G	G	P	E	G	F	G	G	P
Rye	E	G	P	E	E	E	E	G	G
Ryegrass	G	G	P	G	E	F	G	G	F
Sorghum-Sudangrass	G	G	P	G	E	E	G	G	F
Triticale	G	F	P	G	G	F	G	G	P
Winter Wheat	G	P	P	G	G	F	G	G	P
Other									
Brassicas	G	E	P	G	G	E	G	G	F

E=Excellent; G=Good; F=Fair; P=Poor/None

Geographical Zones for Covers and Seeding Dates

Alabama



Common Alabama Cover Crops

			Planting Date		
Cover Crop	Seeding Rate	Seeding Depth	North	Central	South
	(lb/A)	(inches)			
Millet (Browntop, Proso, Foxtail)	D-20 B-30	1/2 to 3/4	May 1 – Aug. 1	Apr. 1 – Aug. 15	Apr. 1 – Aug. 15
Millet (Pearl)	D-15 B-30	1/2 to 1 1/2	Apr. 20 – Jul. 1	Apr. 15 – Jul. 1	Apr. 1 – Jul 15
Sorghum-Sudangrass	D-25 B-35	1/2 to 1	May 1 – Aug. 1	Apr. 15 – Aug. 1	Apr. 1 – Aug. 15
Sorghum, forage	D-5 B-20	1	Apr. 20–May 15	Apr. 20–May 15	Apr. 20–Jul. 1
Sudangrass	D-25 B-35	1/2 to 1	May 1–Aug. 1	May 1–Aug. 1	May 1–Aug. 1
Ryegrass	25	0 to 1/2	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 15–Nov. 1
Oats, Barley, Triticale	90-120	1 to 2	Sep. 1–Nov. 1	Sep. 15–Nov. 1	Sep 15–Nov. 15
Black Oat	50-90	12 to 1	n/a	n/a	Sep. 15–Nov. 1
Rye	90-120	1 to 2	Sep. 1–Nov. 1	Sep. 15–Nov. 1	Sep 15–Nov. 15
Wheat	90-120	1 to 2	Sep. 1–Nov. 1	Sep. 15–Nov. 1	Sep 15–Nov. 15
Winter Pea	40	1 to 2	Sep. 1–Oct. 15	Sep. 1–Oct. 15	Sep. 1–Oct. 15
Clover, Ball	4	0 to 1/4	Sep. 1–Oct. 31	Sep. 1–Oct. 31	Sep. 1–Oct. 31
Clover, Crimson	25	0 to 1/2	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 15–Nov. 15
Clover, Red	D-8 B-15	1/4 to 1/2	Sep. 15–Nov. 15 Feb. 2-Apr. 1	Sep. 15_Nov. 15 Feb. 2-Apr. 1	Sep. 15–Nov. 15
Clover, subterranean	10	1/4 to 1/2	Aug. 25–Oct. 1	Sep. 1–Oct. 31	Sep. 1–Oct. 31
Hairy Vetch	25	1 to 2	Sep. 1–Oct. 15	Sep. 1–Oct. 15	Sep. 15–Nov. 1
Canola	D - 6–8 B - 12-14	1/4 to 1	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 1–Oct. 15
Mustard	D - 5-7 B - 12-14	1/2 to 1	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 1–Oct. 15
Radish	D 12-14 B - 18-20	1/4 to 1/2	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 1–Oct. 15
Turnip	D - 4-7 B - 10-12	1/4 to 1/2	Aug. 25–Oct. 1	Sep. 1–Oct. 15	Sep. 1–Oct. 15
Lupin	70-120	1 to 2	Aug. 25–Oct. 1 Apr. 1–Apr. 15	Sep. 1–Oct. 15 Apr. 1–Apr. 15	Sep. 1–Oct. 15 Apr. 1–Apr. 15
Sunn Hemp	40-50	1/2 to 1	Apr. 1–Sep. 1	Apr. 1–Sep. 1	Apr. 1–Sep. 15

Notes:
D=Drilled, B=Broadcast
Where legumes are seeded with grasses, use the grass seeding date.
Where 2 or more grasses are used in mixture, reduce the seeding rate of each by about one-third.
Do not reduce the seeding rates of legumes when used in mixtures.
Seeding rates should be increased at least 30% when aerially seeded.
Seeding rates for a cost-share program should be the rate specified by the program.

Planting in Heavy-Residue Systems

Optimal moisture conditions are important in conservation tillage systems. Soils under heavy residue are usually wetter than traditionally-tilled soils. Wet soils may result in poor slot closure, especially on heavy soils. It is also important that residue is dry and *crispy* so that the coulter can cut through residue without hairpinning it in the row slot. Hairpinning results in poor seed to soil contact and can drastically reduce plant stands. If a roller is used to help terminate the cover crop, it is recommended that you plant parallel to the direction of rolling to avoid hairpinning and residue build up (wrapping) on row cleaners.

Setting up your planter correctly is vital for a good plant stand. Row cleaners should be set so that residue is moved away from the plant row without digging a trough into the soil surface. (Set the row cleaner tines to just barely touching the soil surface). Adjustments will need to be made with differences in residue amounts and among different cover crops. Closing wheel adjustments can help you manage slot closure in wet or dry soils. Over time, experience will help you know how to adjust your planter to combat challenges.

Soils under residue tend to be cooler in the spring than bare soil. Optimum soil temperatures are essential for good seed germination and seedling growth. It may be necessary to delay early planting for up to seven to ten days as opposed to fields under traditional tillage. For corn, soil temperatures should be 55–60°F. For cotton, the minimum temperature recommended is 65°F for three to four days at a four–inch depth. To get accurate readings, take soil temperature readings in the mornings.

In heavy residue systems, it is recommended that seeding rates are increased by 10-15 percent. This will compensate for less uniform seed placement and stand losses that may occur due to diseases or other pests.

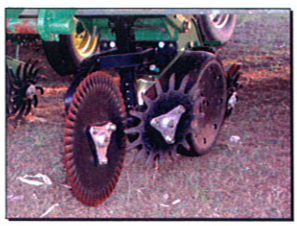
No-till planters

There are several options and modifications for no-till planters to help manage heavy residue situations.

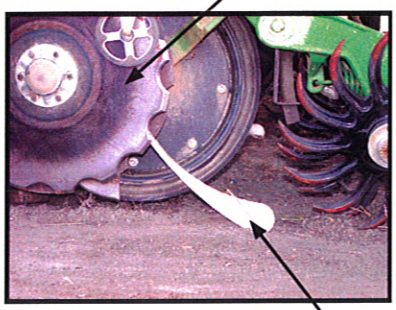
Coulters. Most no-till planters and drills have coulters in front of the seed openers to help cut through heavy residue.

There are several different coulters available. Talk to a no-tiller in your area or your local equipment dealer to determine the best type for your situation.

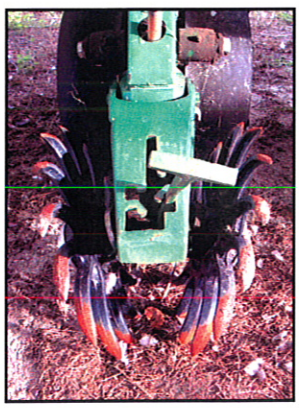
Row cleaners help move residue away from the seedbed to prevent hairpinning (residue pushed into planting slot), which interferes with seed placement and can cause poor seed-to-soil contact. Row-cleaners should not be set too low or they will dig a trench into the seed bed.



Double disk openers create a slot for seed placement. Notched openers can help move residue away from the seedbed to prevent hairpinning.

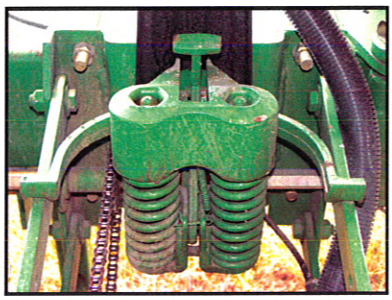


Seed firmers help ensure good seed-to-soil contact and keep the seed from bouncing out of the seed trench.



Closing wheels. Spoked closing wheels offer a good alternative to rubber closing wheels, which can compact the soil surface and cause crusting in heavy, wet soils. Spoked closing wheels, however, can kick out seed with shallow planting.

One option is to use one spoke and one rubber closing wheel per row.



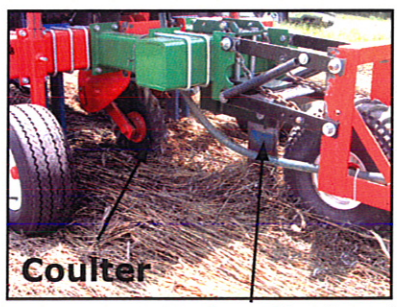
Down-pressure springs maintain the desired seeding depth in high residue or on uneven and/or firm ground.

No-till transplanter

For vegetable producers, a vegetable transplanter may be adapted for use in a conservation tillage system. The modified no-till transplanter shown here contains a coulter to cut through the rolled residue. Behind the coulter, in case of soil compaction, a shank is mounted to penetrate the compacted layer to a depth of 12-14 inches.

Depending on soil type, moisture level and degree of compaction, different shank thicknesses (from 1/2–inch to 1–inch) might be used. However, more soil disturbance may occur with a thicker shank.

For greater stability two driving wheels, one wheel on each side of the tomato row (instead of the original single wheel at the center of the row), have been used. This modification also helps minimize re-compaction of the soil opening created by the shank.



Integrated Pest Management

An effective IPM program will help ensure a successful transition to conservation tillage. Check with other conservation tillers in your area to learn what problems you may encounter during your transition. Preventive measures are best to combat pests and diseases. Scout regularly to help stay on top of problems that do occur.

Diseases and insects

Disease and insect management can be a challenge in conservation tillage systems. Residues on the soil surface can provide a host for insects and diseases. Also, cooler and wetter soils can amplify some seedling diseases. There are steps to avoid possible disease and insect problems:

- Rotate to a non-host cover crop or cash crop to break cycles.
- Variety selection - check with seed dealers to find resistant/tolerant varieties.
- Delay planting until soil temperatures are warmer or until high risk of disease/insect infestation has passed. If planting must be delayed for a significant amount of time, check with your seed dealer to see if a shorter-season variety should be substituted.
- Use starter fertilizers to give your crop an early boost.

Weeds

Weed management in conservation tillage systems can be vastly different from traditional systems. Shifts in weed composition will most likely occur. Conservation tillage tends to favor perennial species and small-seeded annuals. Weed problems will change over time; therefore, an effective weed control program must change as well. Cultivation will no longer be an option in conservation tillage systems; however, several alternatives are still available.

Practices which enhance the crop's competitiveness are effective control methods. Row-spacing and plant population can be altered easily in some cropping systems. High plant populations and narrow row spacing increase the *shading* effect, which helps inhibit weeds. Starter fertilizers can also give crops a *head start* to increase crop competition.

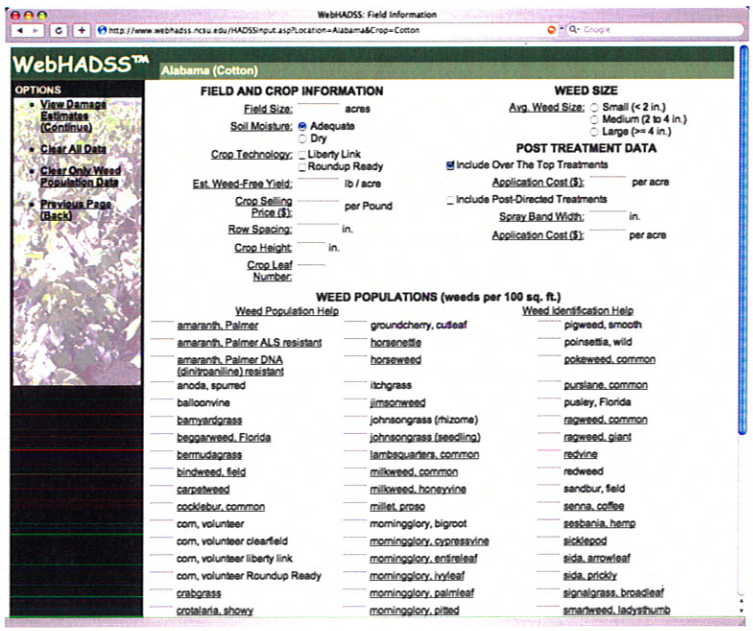
As with disease and insect control, crop rotations are very important in an integrated weed management program. Crop rotations and the use of cover crops can disrupt weed life cycles and keep any one particular species from becoming dominant. Rotations also allow the use of herbicides with different modes of action.

Herbicides are an important aspect of most conservation systems. With the development of glyphosate and other highly selective herbicides, many weeds can be controlled more easily than before. However, to avoid developing resistant weeds, it is important to not rely completely on one herbicide system. Rotating herbicide modes of action is also important to control weed resistance.

Additionally, if soil-active pre-emergence herbicides are used, residue may partially intercept those applications. For example, pendimethalin (Prowl®) requires incorporation within seven days of application if adequate rainfall or irrigation has not occurred. Check labels and be aware of such restrictions to ensure herbicide effectiveness.

Making weed management decisions can be a difficult task. A decision aid called HADSS has been developed at North Carolina State University for making effective and economical weed control decisions. WebHADSS runs interactively over

the internet and provides recommendations for cotton, peanuts, corn and soybean. Users input basic crop and field information, weed type and population, and estimated crop yield and selling price. WebHADSS chooses post-emergence treatments containing one or more herbicides. Recommendations are based on field information, prices and treatment effectiveness. Information is supplied for each treatment on cost, effectiveness, and expected yield loss. Important environmental, rotational, and other restrictions on herbicide use are also available for each treatment. Links provide detailed herbicide label information and assist in weed identification. WebHADSS has been adapted for most Southeastern states. It is available free over the internet and can be accessed at http://www.webhadss.ncsu.edu/.



Fertilization and Liming

As with all cropping systems, soil testing is an important part of a successful conservation tillage system. Recommendations for fertilizers and liming can be obtained from a simple soil test. However, some elements of a fertilization program will need to be altered to fit in a conservation tillage system.

Starter fertilizers

Starter fertilizers are typically recommended for cash crops in conservation tillage systems. Cool soil conditions that are found in high-residue systems can slow root growth. Research shows benefits from small additions of nitrogen and phosphorus at planting.

Liming

Liming takes planning in conservation systems, since it will not usually be mixed into the soil. When converting a traditionally-tilled field, incorporating lime into the upper 8 inches before the no-till transition is made may be helpful if the pH is too acid for the desired crops. Surface applications of lime are effective in maintaining a desirable pH, but are slow to remedy pH problems below the top few inches. If a no-till system already exists, tillage to incorporate lime will not be required. Higher infiltration in no-till systems, especially in cover cropping systems, allows deeper penetration of liming materials.

Once a conservation tillage system is in place, the top two to three inches of the soil should be sampled separately because higher acidity is typically found in this layer from surface fertilizer applications. Desirable pH levels can be maintained with more frequent and lighter lime applications. For more detailed information, follow state extension and local soil test recommendations.

Nutrients from cover crops

Legume cover crops produce nitrogen. Some of it is immediately available to the following cash crop, while most is released later as the residue decomposes.

Some cover crops are also effective nutrient scavengers. They utilize nutrients in the soil that might not be available to following cash crops. These scavenged nutrients become available when the cover residue breaks down.

Measuring the nitrogen available from cover crops is difficult. The nutrients in cover crop plant tissue will be partially available to subsequent crops. Much of the nitrogen fixed by legume cover crops is released for the next crop; however, the time of release may not coincide with cash crop demand. Due to the complexity of nutrient release by various cover crops, fertilizer management decisions must be on a farm-to-farm, field-to-field basis.

Over the years, a system that consistently includes winter legumes and has accumulated organic matter may meet much of the cash crop's demand for nitrogen. Research at the *Old Rotation* in Auburn, Alabama has studied this issue. A long-term winter legume rotation with cotton or corn resulted in yields equal to that which were produced by 120 lb fertilizer N per acre. However, yields increased when legumes and fertilizer were used together. Cotton and corn response to legumes *plus* 120 lb N/acre was significantly greater than the legume- or fertilizer- only treatments. Therefore, a grower may be able to cut back on fertilizer nitrogen if necessary to save

input costs, but to achieve top yields, covers should be used with additional fertilizer nitrogen. Corn, in particular, has a high nitrogen requirement that may require a nitrogen sidedress.

Soil Compaction Management

Southeastern soils are often compacted. Hard pans have developed from heavy traffic and tillage practices, such as moldboard plowing and surface tillage. Managing soil compaction is key in a successful conservation tillage system.

Identifying hard pans

Soil compaction can be measured with a hand-held cone penetrometer. This penetrometer registers the force needed to insert the probe into the soil. Readings at or above 300 psi (2 MPa) indicate a compaction problem that significantly inhibits root growth. (Note: For accurate readings, penetrometers should be used when the soil moisture content is high.)

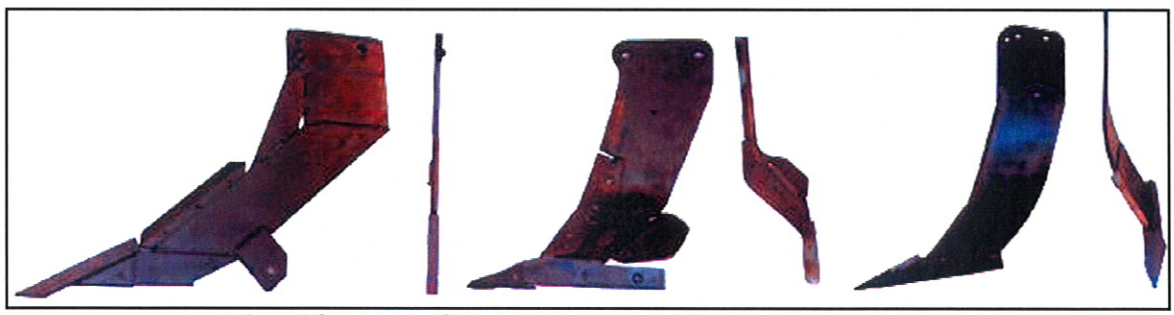
Avoid compaction

Soil compaction cannot always be prevented, but good management can often keep it manageable.

- Only traffic when the soil is dry (soil moisture is less than 60% of field capacity). Vehicle traffic conducted when soil is wet can lead to excessive soil compaction that may be battled for many cropping seasons. Or worse, the damage may be permanent.
- Minimize tracks across fields and try to build soil organic matter that may help to minimize vehicle traffic effects.
- Adopt a controlled traffic system that will limit vehicle traffic to certain areas within the field thus reducing random traffic.
- Reduce axle load by minimizing the size of the vehicle necessary for the field activity.
- Use radial tires which maximum the size of the tire footprint and reduce soil compaction, while increasing tractive effort.
- Use the lowest recommended inflation pressure for radial tires, using tire manufacturers' recommended load-inflation pressure tables.
- Consider the overall benefits of tracked vehicles while recognizing that peak pressures that occur under tracks may be similar to peak pressures that occur under radial tires for similar-sized vehicles.
- Reduce contact pressure by using duals while recognizing the wider area of influence associated with dual tires.

Controlled traffic

While conservation tillage systems may reduce overall vehicle traffic in a field, wet soils that may be found under heavy residue are still susceptible to rutting and compaction. A controlled traffic system uses traffic lanes that become compacted



Side and front view of an in-row subsoiler (left) and two bent-leg subsoilers.

enough to withstand heavy traffic without rutting, while leaving row middles free from wheel compaction. Automatic guidance systems that are now widely available can be used to control trafficking patterns. Row information can be saved and used year after year to help locate traffic lanes.

Cover crops

Cover crops are an important tool for managing soil compaction. Many cover crops have aggressive rooting systems, which open channels for subsequent cash crop roots. Cereal rye, sorghum-sudangrass and Brassica species (canola, turnip, and mustards) are known to be particularly effective at breaking through hard pans. Sunn hemp and lupins also have aggressive taproots that can penetrate hard pans. The presence of cover crops also enhances earthworm activity. Earthworm channels provide a path for roots to follow.

In-row subsoil to correct compaction

When soil compaction does develop, in-row subsoilers can loosen the compacted layers with minimal disturbance to the soil surface. Good management can minimize costs while providing a good rooting environment for the crop.

Subsoiling has been used in farm operations for many years, but has often not considered leaving the maximum amount of residue on the soil surface. Subsoiling also has not focused on disrupting only the soil immediately beneath the row. Modern subsoiling systems usually take both of these factors into consideration: (1) maximizing residue coverage after subsoiling, and (2) only disrupting the compacted soil beneath the row, while leaving trafficked row middles dirm to support vehicle traffic.

In-row subsoiling encourages deeper root growth, allowing cash crop roots to reach deep soil moisture during the growing season. In-row subsoiling also allows water infiltration through hard pans, resulting in increased water storage. In-row subsoiling is typically conducted in the fall before cover crop planting or in the spring prior to cash crop planting.

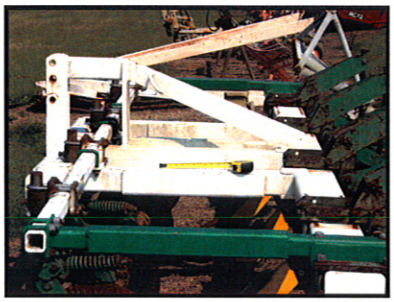
It is important to know the depth of the hard pan before in-row subsoiling. In-row subsoiling below the hard pan results in excessive soil disturbance and higher energy costs. It may also cause a hard pan to develop below the depth of tillage that cannot be reached in later years. Insert a hand-held penetrometer or wire flag into the soil to find the depth of your hard pan.

Two main types of subsoilers are bent-leg subsoilers and in-row subsoilers. Bent-leg subsoilers can be set up for a more complete disruption of a hard pan by *lifting* the soil. In-row subsoilers have a straight shank to break through the hard pan and are typically used directly before cash crop planting.

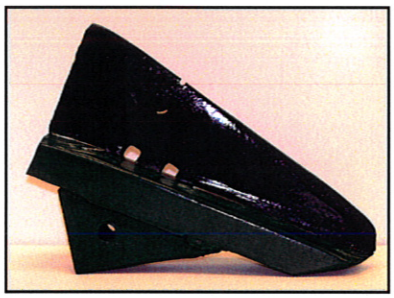
The frequency of subsoiling differs among cropping systems and soil types. A large amount of energy is required for subsoiling, so it is advantageous to perform this operation only as necessary. Research in many areas of the Southeast indicates that subsoiling every other year is sufficient for maintaining desirable yields. A study at the Tennessee Valley Research and Extension Center in Belle Mina, Alabama showed that annual subsoiling reduced bulk density compared to no-till, biennial subsoiling or triennial subsoiling. However, cotton lint yields were not statistically different among the treatments. Therefore, subsoiling on these soils (Dewey silt loams) may not result in the benefits that are typically realized in other areas.

Integrated management may prove to be the most effective tool against compaction. Using controlled trafficking patterns and cover crops can further diminish subsoiler requirements, reducing energy costs.

Subsoiler modifications



Toolbar extensions can help ensure that the coulter is running on firm ground ahead of the shank to help cut residue.



Splitter points help prevent soil blow-out, especially in dry soils. Newer shanks may incorporate this design, or a piece of metal can be welded perpendicular to the center of a subsoil shank tip.

Edge cover

Covered edges/ Polyshields. Covering sharp edges can help keep residue from building up on the shank.

Polyshields

Similarly, **polyshields** help prevent soil build-up in heavy or wet soils.

Integrating Livestock into Conservation Systems

Sod-based rotations

Sod-based rotations are a good choice for highly erosive or drought-stressed soils, and soils with restricted soil depth. Sods have extensive root systems and help build organic matter levels. Sods can also help break disease cycles and reduce nematode, weed and insect pressure.

Studies have shown significant yield benefits in peanut and cotton when incorporating a sod rotation as opposed to conventional continuous cropping or peanut-cotton-cotton rotations. In southern Alabama and Georgia and the Florida panhandle, studies examined the feasibility of a bahiagrass rotation in cotton and peanut cropping systems. Incorporating bahiagrass into cotton and peanut rotations resulted in increased earthworm activity, higher infiltration rates and soil moisture, and greater yields. Adding a livestock factor with sod rotations can also help spread economic risk in a farming system.

Grazing winter cover crops

Grazing can provide greater income stability and help offset cover crop planting and fertilization costs. Grazing cover crops, however, can compact soils to a depth of 12 inches or more. Compaction should be monitored carefully and problem areas may need subsoiled.

A study near Watkinsville, Georgia examined the effects of grazing winter cover crops on cash crop production. Cattle grazing of cover crops did not appear to have a detrimental effect on grain production in sorghum or wheat. No tillage with cover crops produced higher cover biomass production, resulting in increased cattle gain, than using cover crops with traditional tillage.

Total cover biomass production will be lower in grazed than ungrazed fields. Therefore, some soil quality and residue cover benefits will likely be sacrificed. Grazing must be monitored carefully and cattle should be removed from fields in early spring to allow the cover to reach beneficial biomass levels. Some cover crops are better suited for grazing than others, and producers should choose carefully. Talk to extension agents or other farmers in your area to discuss valid options.

Getting More Information

You're not alone.

The conservation tillage movement is dynamic – constantly growing, always changing. Farmers are experimenting with different crops, modifying systems, and adjusting or inventing equipment. To find your own solutions, talk to your neighbors who have similar crops and soils. Go to meetings and field days. Check out information sources on the internet. Extension agents and USDA staff are available for advice, and need to know what your problems are and any solutions you've found.

Agencies and Organizations

Alabama Cooperative Extension System – http://www.aces.edu

Georgia Cooperative Extension Service – http://www.caes.uga.edu/extension

University of Florida Institute of Food and Agricultural Sciences – http://solutionsforyourlife.ufl.edu

USDA Agricultural Research Service – http://www.ars.usda.gov

USDA-ARS Coastal Plains Soil, Water, and Plant Research Center – http://ars.usda.gov/main/site_main.htm?modecode=66570000

USDA-ARS Conservation Systems Research – http://www.ars.usda.gov/msa/auburn/nsdl

USDA-ARS J. Phil Campbell Sr. Natural Resource Conservation Center – http://www.ars.usda.govMain/docs.htm?docid=2275

USDA Natural Resources Conservation Service – http://www.nrcs.usda.gov

USDA-NRCS Jimmy Carter Plant Materials Center – http://www.ga.nrcs.usda.gov/technical/PMC/pmc.html

Alabama Sustainable Agriculture Network – http://www.asanonline.org

Conservation Technology Information Center – http://www.ctic.purdue.edu/CTIC/CTIC.html

Georgia Conservation Tillage Alliance – http://www.gcta-ga.org

National Sustainable Agriculture Information Service (ATTRA) – http://www.attra.org

No-Till on the Plains – http://www.notill.org

Soil and Water Conservation Society – http://www.swcs.org

Southern Sustainable Agriculture Working Group – http://www.ssawg.org

Sustainable Agriculture Research and Education – http://www.sare.org

University of California SAREP Cover Crop Resource Page – http://www.sarep.ucdavis.edu/ccrop

Pest and Weed Management

Crop Data Management Systems – http://www.cdms.net/manuf/manuf.asp

Greenbook – http://www.greenbook.net

Manage Insects on Your Farm: A guide to ecological strategies – http://www.sare.org/publications/insect/insect.pdf

WebHADSS – http://www.webhadss.ncsu.edu

Cover Crop Information

CTAHR (University of Hawaii) Cover Crops and Green Manures – http://www2.ctahr.hawaii.edu/sustainag/Database.asp

Lupins.org – http://www.lupins.org

Managing Cover Crops Profitably – http://www.sare.org/publications/covercrops/covercrops.pdf

Michigan State University Cover Crop web site – http://www.kbs.msu.edu/extension/covercrops/General

Overview of Cover Crops and Green Manures – http://www.attra.org/attra-pub/PDF/covercrop.pdf

Other Conservation Tillage Information

Building Better Soils – http://www.sare.org/publications/bsbc/bsbc.pdf

No-Tiller Farmer (Lessiter Publications) – http://www.lesspub.com

Pursuing Conservation Tillage Systems for Organic Crop Production – http://www.attra.org/attra-pub/organicmatters/conservationtillage.html