Louisiana Conservation Tillage Handbook

LSU AgCenter
Research & Extension

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Introduction

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Louisiana is blessed with some of the most fertile and productive soils in the world. The climate is ideal for the production of a wide variety of winter and summer agronomic crops.

Rainfall across the state averages about 50 inches – although seasonal rainfall distribution usually is less than ideal, especially for summer crops. The summer production season often experiences high temperatures and periods with soil moisture deficits. Rainfall often averages less than one-third of the evaporative demand of crops. Significant drought conditions occur during most years on soils with low water-holding capacity such as the silt loam soils of the Macon Ridge region in northeast Louisiana. Successful farmers have implemented crop production practices that maximize the availability of natural rainfall and/or rely on supplemental moisture from irrigation to ensure profitable yields.

During the winter months, rainfall generally exceeds the evaporative demand and the water infiltration rate of soils. Therefore, large amounts of rainfall are lost as surface runoff. Much of the annual rainfall comes from intense thunderstorms, which causes soil erosion rates to be excessive on some fields. When soil erosion exceeds natural soil-forming processes, the long-term productivity of the soil is compromised. Stated another way, the soil-loss tolerance of the site has been exceeded.

The crop production systems used by farmers across the southeast United States during most of the 20th century included intensive tillage for weed control, suppression of other pests, remediation of compacted soil layers and seedbed preparation conducive to accurate planting with conventional planting equipment used at the time. Although tillage was useful for these purposes, farmers and scientists observed that intensive tillage for crop production was adversely affecting soil productivity by depleting soil organic matter. Perhaps most important, tillage buries plant material and crop residue and dramatically increases soil erosion. Numerous studies and farmer experiences confirmed that intensive tillage also encourages rapid decomposition of crop residue and organic matter and has a negative long-term effect on soil structure or tilth. This effect normally is reflected in crusting of the soil surface after rainfall events, reduced water infiltration rates and significantly reduced soil water-holding capacity.

Crop seedling establishment problems due to surface crusting are common when rainfall precedes plant emergence while slow water infiltration rates exacerbate droughty conditions and increase the need to purchase and operate expensive irrigation equipment. Furthermore, more fertilizer is needed to replace essential plant nutrients that are removed from the field by soil erosion and decomposition of organic matter – a major source of plant-available nitrogen.

As the cost of fossil fuels escalated, the cost of operating tractors for tillage operations became a major drain on production budgets already affected by declining prices for commodities and skyrocketing equipment costs. Many progressive farmers saw reduced tillage and various conservation tillage systems as potential ways to dramatically reduce fuel , labor and equipment expenses during tough economic times. Many farmers experienced unexpected benefits from reduced tillage systems, including more timely planting and harvesting on poorly drained alluvial clay soils that are difficult to manage under conventional spring tillage systems.

Due to the successes of reduced tillage systems, most Louisiana farmers significantly reduced the total amount of tillage used for crop production. In addition, many have performed their tillage operations at times of the year (late summer and early fall) that minimized the negative effects. This adoption gave rise to the phrase "stale seedbed system," which is defined by the practice of applying most tillage and bedding operations as soon as crop harvest is completed. This application timing allows native annual winter vegetation to become established before winter – thereby providing a protective plant cover to minimize erosion.

Prior to the mid-1990s, adoption of conservation tillage was hampered by several factors. One of the most important issues was poor suitability of equipment to plant seed accurately in heavy plant residue. Over the past 20 years, however, most equipment manufacturers have successfully designed planters and other equipment that perform adequately even in heavy residue. Another impediment to the adoption of conservation tillage was the limited availability of effective pesticides to control key pests in agronomic crops, especially weeds, diseases and insects. The development of effective and broad-based weed and insect management programs based on novel transgenic technologies, such as Roundup Ready and Bollgard, had a major influence on the adoption of conservation tillage by making several major pests much easier to manage without tillage.

Among the other factors that increased adoption of conservation tillage systems was the greater awareness among those in agriculture and the general public that water runoff and soil erosion from agricultural fields was having negative effects on surface water quality across the state and nation. Public concerns about the environmental effects of agriculture were strongly addressed in the conservation compliance provisions of the 1985 Food Security Act (federal farm bill). Under this landmark legislation, farmers were required to develop an approved conservation plan for all highly erodible fields by January 1, 1990, and the deadline for fully implementing the plans was January 1, 1995. Farmers who failed to comply with these new rules could lose eligibility for most U.S. Department of Agriculture farm support programs.

The implementation of the 1985 farm bill resulted in a heightened awareness of soil and water conservation, and many farmers began to adopt proven soil and water conservation practices. Furthermore, teams of agricultural researchers in Louisiana and across the southern United States collaborated with U.S. Department of Agriculture (USDA) Natural Resources Conservation Service scientists, extension professionals, private crop consultants and farmers to develop comprehensive conservation tillage systems that addressed most of the problems associated with these systems. Over the next 20-25 years, agronomic and pest management researchers across the country continued to generate data showing that conservation tillage systems maintained or improved soil organic matter, improved water availability to crops and significantly reduced nonpoint water pollution from agricultural fields. Many of these studies also demonstrated that crop yields and profits were equal to conventional tillage systems.

Also over the past 20 years, several educational programs were developed and delivered as cooperative endeavors by the LSU AgCenter, NRCS and several private crop consultants. This joint educational effort was instrumental in helping farmers in Louisiana implement conservation tillage or some form of reduced tillage system on most of the cropland acreage in Louisiana over the past couple of decades.

Although great progress has been made in implementation of reduced tillage and conservation tillage, erosion and loss of soil quality continues to be a significant problem on many fields across the state. The reasons are varied and include resistance by some farmers to adopt new methods and technologies for fear that unexpected problems will develop and be impossible or expensive to manage. Another reason is that reduced tillage and conservation tillage generally require a greater level of understanding of agronomic and pest management inputs to achieve the desired results.

The purpose of this publication is to provide up-to-date information on agronomic and pest management practices for southern row crops in conservation tillage systems. Many of these recommendations will help producers and private crop consultants implement conservation tillage and other soil-conserving practices to maintain efficient and economical production while minimizing negative effects on soil and water quality. The discussions are based on scientific research and applied experience with these systems under Louisiana's unique soil and environmental conditions. Major emphasis also will be given to identifying and managing current and future threats from a variety of economically important weed, disease and insect pests that may be influenced by soil and residue management practices.

Chapter 1

Crop Rotation

Donald Boquet

Crop rotations are as important, or may even be more important, in conservation tillage systems than in conventional till systems. Crop rotations are especially important for cropping systems with soybeans, wheat and sweet potatoes – crops that quickly lose yield and quality potential with continuous cropping practices, because of disease, insect and weed problems. In addition to the yield benefits, other benefits are derived from crop rotation in conservation tillage systems are described below.

Rotational sequences

Farmers' experience and many years of agronomic and economic research in the LSU AgCenter have convincingly demonstrated that crop rotations increase yields of the included crops. Even without the presence of definable and identifiable causes of yield limitations, such as diseases and nematodes, yield increases from rotations usually are in the range of 20 percent. When specific problems that adversely affect crop health can be identified, the yield increases from rotations will be larger.

For example, in a 25-year rotation study at the LSU AgCenter's Northeast Research Station, continuous cotton produced 1,051 pounds of lint per acre, and cotton rotated in two-year cycles with corn or grain sorghum produced 1,241 pounds per acre, an 18 percent increase. Continuous soybeans, however, that were affected by disease (charcoal rot) and nematodes produced only 32 bushels per acre, whereas rotated soybeans produced 48 bushels per acre, a 50 percent increase (Figure 1-1). Crops such as sweet potatoes cannot be grown successfully without regular use of crop rotation to control insects, diseases and nematodes. Rotational crops for sweet potatoes must be nonhost crops for nematodes.

Figure 1-1. Soybean on the right was rotated with grain sorghum; soybean on the left was grown continuously without rotation. The continuous soybean had low yields because of the buildup of nematode and disease organisms over several years.

Figure 1-2. The high yielding wheat crop on left was planted no till into corn residue. After wheat harvest is completed, cotton or soybean can be planted into the wheat residue to complete the 3-crop, 2-year, year-long rotations that provide excellent year-round ground cover.

Likewise, crop rotations provide greater options for increased income and decreased production risk. In a seven-year study at the LSU AgCenter's Macon Ridge Research Station, monocrop cotton averaged annual net returns of $124 per acre, monocrop corn averaged $251 per acre and a cotton-corn-wheat cropping system averaged net returns of $313 per acre. Clearly, crop rotations have large yield and income advantages over continuous monocropping that make rotational cropping systems advantageous for most farmers.

All of the rotational cropping systems provide opportunities for using conservation tillage, and virtually all crops can be no-tilled. An example of an excellent rotation is the above mentioned three-crop, two-year system of corn followed by wheat followed by double-crop cotton or soybeans in year two (Figure 1-2), which provides maximum conservation benefits and an opportunity for maximum profitability. But most of the beneficial row-crop rotations in Louisiana are likely to be two-year rotations that involve corn/cotton, corn/soybeans, cotton/soybeans, sweet potatoes/grain sorghum or soybeans/rice Although all these rotations are beneficial, rotations that include corn, grain sorghum and rice are preferred for conservation efforts because those are high-residue crops and are needed for rotation with cotton and soybeans, which are low-residue crops. Using grain crops in rotations provides additional benefits for soil quality and disease, nematode and weed control (as described in the following sections).

Soil cover

Most agronomic benefits of no-tillage systems are the result of crop or cover crop residue on or near the soil surface. Properly used, residue from cash crops and from cover/green manure crops will minimize soil and nutrient loss from cropland and maintain soil organic matter. Residue management is therefore the key to improving soil quality in conservation systems and also for protecting surface water quality (Figures 1-3, 1-4).

If a soil is severely degraded because of many years of intensive tillage, it may take a few years to accrue noticeable benefits from crop rotation and conservation tillage systems (Figure 1-5). Intensively tilled soils have greatly reduced organic matter and microbial populations, and these will be restored by conservation practices, but it will take time.

In conservation systems, soil cover should be 50 percent or more at all times. Some crops, however, leave too little residue, leading to insufficient ground cover. Both soybeans and cotton are low-residue crops. Corn, grain sorghum, winter grains and rice are examples of crops that produce large amounts of residue for long-lasting ground cover. Rotating high-residue and low-residue crops helps to maintain sufficient cover because residue from the high-residue crop will carry over into the low-residue crop. After a low-residue-producing crop, it is beneficial to plant a winter grain or cover crop to help maintain residue for ground cover. Cover crops are discussed in Chapter 2.

Figure 1-3. Runoff water from tilled fields without vegetative cover is rich with sediment and nutrients, the loss of which reduces soil quality. Once transported into the surface drainage system, this runoff water will also impair the quality of surface water bodies.

Figure 1-4. Runoff from fields with ground cover and conservation tillage contains very little sediment and nutrients, preserving soil quality and water quality.

Figure 1-5. A recently planted soybean field is undergoing extreme wind erosion from March winds. Cover crop residue and conservation tillage prevents this type of soil loss and the severe damage to seedlings.

Crop residue distribution in rotations

Residue management is a crucial issue to deal with where winter grain crops immediately precede summer crops. The goal of residue management in these situations is to achieve uniform ground cover following harvest of the grain crop but also to, as much as possible, keep the residue from interfering with cropping practices for the following crops (Figures 1-6, 1-7).

Nonuniform residue distribution results in uneven stands. The coulters or openers on the planter or drill will cut through normal levels of residue but not cut through piles of residue, the bottom of which usually will be moist. This results in hair-pinning of crop residue and poor seed-to-soil contact. Depth placement also will be affected. Depending on the thickness of the residue and planter settings, seeding depth can vary from more than 2 inches where there is little residue to less than 1 inch where the residue is 2 inches or more. This will result in uneven emergence, partial stands and variable early growth.

Residue that is unevenly distributed also can lead to weed control problems because herbicides do not reach the soil or intended targets where residue is piled up.

The best way to minimize crop residue interference is to maximize the combine cutting height, which

Figure 1-6. Special row cleaning tools are usually not needed for planting into crop residue but, when biomass production is very high, such devices may improve seed placement and stand establishment.

Figure 1-7 . Winter wheat is an excellent crop or cover crop for Louisiana, producing plentiful and long lasting vegetation for ground cover that is easy to terminate and plant into. When fall and winter growing conditions favor high biomass production, one option for stubble management is to rotary cut the residue before planting the summer crop.

minimizes the amount of residue going through the combine. Vertically standing crop residue that is attached to the soil is much easier to plant into than crop residue lying horizontally on the ground. Spreaders and choppers are available for all combines to help with residue distribution. Chaff spreaders also can help to spread fine materials that otherwise would be distributed directly behind the combine. When growing conditions favor high biomass production, planter attachments are available that will manage the residue and ensure good stands (which will be discussed further in Chapter 8: Equipment).

Residue cover provides all the environmental benefits of conservation tillage, such as erosion control, infiltration improvement, evaporation reduction and enhanced soil biological activity. Properly used, residue from cash crops and from cover/green manure crops minimizes soil and nutrient loss from cropland (Figure 1-8). This is one of the most important components of conservation tillage. On the other hand, too much or badly managed residue can create significant problems during crop establishment that will have a significant effect on productivity and profitability.

Figure 1-8. No-till planted cotton following a soybean crop is a beneficial rotation that increases nitrogen efficiency - use of the legume residual nitrogen by cotton- among other benefits of rotations that increases yield. Limited interrow cultivation is used but enough crop residue remains on the surface to qualify as a conservation system.

Soil biological activity

A high level of diverse soil biological activity is indicative of good soil quality. Soil quality improves when biological activity increases. A diversity of soil organisms – bacteria, fungi, earthworms, insects and plant roots – contributes to soil biological activity.

Soil cover from crop residue and the absence of soil disturbance are beneficial for most of the beneficial soil-inhabiting organisms. Crop residue and rooting patterns play a primary role in determining the types and quantity of biological activity. It is the primary source of nutrients for soil organisms, and different crops benefit specific organisms. Greater diversity in the crop mix produces greater diversity in soil organisms. A more diverse and active soil microbial community will reduce pest and disease incidence because of increased competition for substrate as well as predation of pests and diseases by other organisms.

Rotating crops with a high carbon to nitrogen ratio, such as corn, cotton, small grains and rice, with low carbon/nitrogen ratio crops, such as soybeans and winter legumes, is highly beneficial for diversity of soil organisms. Crop mixes with different rooting patterns that explore the soil to different depths also are useful for soil improvement. Shallow root systems of grain crops improve soil tilth and increase biological activity to the extent of rooting depth. Deep taproots of crops such as cotton open avenues for deeper penetration of soil organisms and improved soil quality at deeper depths.

Efficiency of nutrient use. Rotating crops in systems that include year-round plantings increases the efficiency of fertilizers and mineralized nutrients. All types of fertilizer nutrients are more efficiently used when rotations are employed.

Nitrate losses are of particular concern because it is a highly mobile nutrient that can pollute both surface water and groundwater if it's not used in a timely manner by crops. Although a portion of applied nitrogen can be carried over for one year or even two, residual nitrogen is more likely to be lost than carried over through a Louisiana winter. Winter grain crops are extremely efficient at finding and using residual fertilizers that are left over from corn or cotton fertilization or from a legume or soybean crop.

Pest and disease cycles

Crop rotation is an important component of disease, weed, nematode and insect control and is often the primary control mechanism for nematodes and diseases. Disease-causing organisms and insects survive on crop residue and in the soil on root systems. Crop rotation for insect and disease management is therefore very important in conservation tillage.

Rotations help to control many of the common root and stem diseases that affect row crops. Control of reniform and root-knot nematodes especially requires crop rotations that facilitate the use of nonhost crops and resistant varieties.

In no-till situations, perennial weeds can become a problem, but selection of rotational sequences can minimize establishment of these species. The different herbicide programs used for different crops help to control development of herbicide-resistant weeds, too. Seeds of many weeds buried in the soil, if they require light for germination, will not germinate in no-till fields. Winter grain crops and cover crops are strong competitors with weeds and reduce weed infestations in late winter and early spring. Having a winter crop also provides the opportunity for selective herbicidal control of winter weeds while maintaining abundant ground cover.

Chapter 2

Winter Cover Crops

Donald Boquet

Winter cover crops fall into two general categories – grass (grain) crops and legumes. The grass crops include wheat, rye and oats, while the legumes include such crops as the vetches, peas and clovers.

The winter grain crops can be grown for grain harvest or can be grown as green manure crops. The legumes usually will be grown as a green manure only. Green manure crops usually do not need fertilization and grow entirely on residual fertilizers. Winter grain crops require nitrogen fertilization but usually no other applied nutrients. Legumes do not require applied nitrogen but do require the appropriate nitrogen-fixing bacteria. Legumes have the ability to "fix" nitrogen from atmospheric nitrogen. Some of that "fixed" nitrogen will be available to provide low-cost nitrogen for the following summer crop – a very important feature that makes planting of legume cover crops practical and economical.

Other factors that are important in selection of cover crops are winter survival, biomass potential, maturity time and nitrogen-fixing potential. Discussion of the specific characteristics of the many available cover crops that can be planted in Louisiana are too extensive to be included in this publication, but information on the advantages and disadvantages of each are available from LSU AgCenter personnel in parish offices and research centers across Louisiana and from USDA Natural Resources Conservation Service field agronomists.

There also are possible summer cover crops, which have not been planted in the southern United States in recent years because summer crops are used as the principal income-producing crops for this region. Farmers are unwilling and unable to forego the returns that can be realized from warm-season crop production.

Summer cover crops may have a place in sugarcane production during the fallow period before planting a new plant-cane crop but, even here, a soybean crop is preferable to a cover crop. In fact, soybeans were once grown primarily as a summer cover crop in the southern United States, but soybeans' development as a cash crop during the 1950s illustrates the strong need and preference for a summer cash crop over a cover crop.

Other possible summer cover crops range from such crops as the familiar field peas or sorghum sudan grass to the more exotic such as sunn hemp. The sections below outline some of the important features to consider when planting winter cover crops.

Planting date

Critical to the success of winter cover crops is planting date. To achieve the plant growth desired for ground cover and nitrogen fixation, cover crops should be planted early enough to establish stands and attain some growth before low temperatures limit plant development. Early establishment also is important so the cover crop can suppress winter weeds.

Clover crops can be planted as early as August. Most clovers also have self-reseeding capability and will reestablish year after year under appropriate conditions – under a cotton canopy, for example, but they will be killed by herbicide or defoliant applications.

For best results, winter peas and vetches should be planted by October 15. Later plantings through November will be successful but will not provide as much winter ground cover.

Growth termination

Proper cover crop management is important to attain benefits without penalizing the productivity of the following cash crops. For maximum benefits, cover crops should have good biomass production before growth termination. The biomass produced protects the soil during the winter and provides the residue needed for ground cover during early summer. Legumes also must have attained a high rate of nitrogen fixation. The potential for biomass and nitrogen production are shown in Table 1 for several winter cover crops.

Winter cover crops must be killed completely before planting a summer crop to prevent competition for soil

Hairy vetch

Singletary (Caley) peas

Austrain winter peas

Crimson clover

Figure 2-1. Winter cover crops with excellent potential for use in rotations in Louisiana include vetches, winter peas and some clovers. Biomass of these crops can exceed 2 tons per acre and contain 120 pounds or more of fixed and scavenged nitrogen per acre.

Table 2-1. Biomass and nitrogen production from selected legume cover crops for four years and six locations throughout Louisiana.

Cover crop	Above-ground biomass average	Range in above-ground biomass production lowest	Range in above-ground biomass production highest	Average nitrogen content
	lb/acre			
Hairy vetch	4347	2946	8699	144
Common vetch 'Cahaba white' and 'Au Early Cover'	4054	0*	4592	122
Bigflower vetch 'Woodford'	4157	2639	5925	97
Crimson clover 'Tibbee'	5827	4286	8254	147
Berseem clover 'Bigbee'	5489	2843	9498	137
Arrowleaf clover 'Amclo'	2480			135
Sub clover 'Mt. Barker'	4290	2733	5567	122
Red clover 'Cherokee'	3519	0*	5584	116
Austrian winter pea	3866	1904	7088	88
Rough (Caly) pea	3968	2704	7666	135
Wheat	4835	2103	6738	54
Ryegrass	3856	851	7285	46

* Winter killed in some years at some locations.

Data adapted from Dabney et al. Louisiana Agriculture 33:8-9.

water and to minimize insect damage to the summer crop. Desiccation of the cover crop should be complete at least two weeks before planting the summer crop to avoid providing a "green bridge" that allows insects or diseases to survive on the growing cover crop. Optimal termination timing also is important to minimize reproduction of plant pathogenic nematodes on the roots of susceptible cover crops. Warming soil in the spring speeds up nematode growth and reproduction.

Optimal termination timing is therefore a balance between attainment of sufficient biomass and nitrogen fixation with the need for timely planting of the following summer crop. Because complete kill of winter cover crops is essential before planting the summer crop, all of the benefits of a winter cover crop will not be attained when the following summer crop is an early planted crop such as corn. Winter covers will not have accumulated maximum biomass or nitrogen when terminated in late February or early March, which somewhat limits the benefits of cover crops in corn production. Winter covers are better used in rotations with cotton, soybeans, grain sorghum or sweet potatoes – crops that can be planted after mid-April, which allows the winter cover to grow until early April, if necessary.

Nutrient cycling

Both grass and legume cover crops will use the residual plant nutrients that have been applied as fertilizers to the previous crops. This sequestering of nutrients prevents their loss during the winter and early spring when rainfall in Louisiana is highest and nutrient loss through leaching and runoff is most likely to occur. Cover crops will assimilate and sequester up to 50 pounds of nitrogen per acre and significant quantities of other major and minor nutrients, as well. The sequestered nutrients in winter legume cover crops are mineralized quickly and will be available for use by the following summer crop. Grass cover crops, however, release the sequestered nutrients slowly in a process that may take three years. Until equilibrium is attained, additional fertilizer applications may be needed to replace the nutrients held in grass residues.

Soil cover

The amount of soil cover provided by cover crops and their residues varies with location, growing conditions, soil type and termination time. Variation among locations and years due to differences in growing conditions is greater than the variation among cover crop species. Still, some species of cover crops are more likely than others to produce adequate ground cover (Table 2-1).

The most consistent biomass producers for rotations in Louisiana are winter grains, hairy vetch and various types of winter peas. With warm winters and adequate water, cover crops can sometimes produce excessive biomass, in which case growth should be terminated at an earlier date to prevent problems with planting summer crops. The residue from cover crops should not be burned (which would destroy large amounts of plant nutrients) and should always be left on the soil surface to attain the conservation benefits.

Nitrogen fixation

As with biomass production, cover crops vary in the amount of nitrogen fixation. Hairy vetch and winter peas are some of the best winter legumes for Louisiana and will contain as much as 150 pounds of available nitrogen in the aboveground biomass, although 100 to 120 pounds is more typical (Figure 2-1, Table 2-1). Usually, about 70 percent of the nitrogen content of legume biomass is from nitrogen fixation, and the remaining 30 percent is from scavenging residual nitrogen sources.

Significant amounts of nitrogen are not fixed and stored in plant biomass until the plants enter reproductive growth phases. Winter peas are faster to establish and have faster early growth than vetch, providing more ground cover and nitrogen during fall and winter months. Clovers can produce higher levels of biomass and nitrogen fixation but only if planted very early. Otherwise, growth and especially nitrogen fixation occur too late in the spring for maximum benefit. Some clovers produce plenty of biomass and fixed nitrogen, but clovers are more difficult to manage than peas and vetches and have shown allelopathic effects on summer crops in Louisiana research.

Chapter 3

Variety Selection and Seeding Rates

Donald Boquet

Variety selection

Although variety selection for conservation practices is not greatly different from that used in other cropping systems, selection of suitable varieties for planting can help make conservation tillage planting more successful. This is true more so for soybeans than other crops.

Some traits that should be considered include seedling vigor, resistance to specific diseases that may survive on residue or may be common for the area, and maturity date. Full-season varieties of all crops should be planted to allow for a sufficient growing season to compensate for later planting dates and the potential of slower early season crop development, especially for double-cropped soybeans following wheat. For double-cropped cotton, however, early season varieties should be planted, since full-season varieties may not have enough time to complete development of late bolls.

Generally, it is a good idea to consult someone – an LSU AgCenter field agent or specialist or seed company agronomist – for help with variety selection. Results from the LSU AgCenter's official variety tests and on-farm demonstrations will provide information on variety performance for different soils and various planting and environmental conditions. Because of the large number of available soybean maturity groups used in Louisiana and extreme differences in varietal traits, selection of soybean varieties that match varieties with soil types and planting dates is very important.

Seeding rates

The plant population densities needed for optimal yields in conservation tillage fields are not different from those used in the past on conventional till fields (Figure 3-1). Recent advances in technology in the seed and equipment industries and advanced technology to

Doublecrop sorghum in wheat stubble

help in disease control have changed conservation tillage planting and seeding recommendations.

In the past, standard recommendations were to increase seeding rates by as much as 25 percent to ensure optimal stands. Today, some individuals still increase seeding rates for soybeans, cotton and small grains. An increase in seeding rates is needed, and is important, when planting well after the optimal planting dates – when double cropping, for example. Late planting (after June 1) requires increased seeding rates to compensate for reduced overall plant growth of soybeans, not because the crop is being planted with conservation tillage.

Generally, planting rates are not different for conservation tillage than tilled fields when using the most recent planting equipment that is properly adjusted. To determine the best seeding rates for specific circumstances, experienced producers and research center agronomists are excellent sources from which to seek advice.

Monocrop cotton in vetch residue

Doublecrop soybean in wheat stubble

Doublecrop cotton in wheat stubble

Figure 3-1. Conservation practices of reduced tillage and cover crops can be successfully used with any crop or crop sequences of monocropping, doublecropping, or cover/green manure cropping without major changes in varieties or seeding rates.

Chapter 4

Fertilizer and Lime

John S. Kruse

Conversion from a conventional tillage system in which the soil is worked extensively, to a conservation tillage system in which the soil is rarely or never disturbed, causes significant changes in the soil. For example, crop residues that were once incorporated into the soil are left on the surface, resulting in slower decomposition (Figure 4-1). Understanding these effects and ways to manage them can improve a producer's successful transition from tillage system to another and minimize potential problems.

Nitrogen

Nitrogen is found in many forms in the agricultural environment, and in some forms it is very vulnerable to loss. Urea or ammonium-based fertilizers, when placed on the surface, may convert to ammonia and can be lost into the air through a process called volatilization. These same fertilizer sources in the soil are converted over the growing season to nitrate, a type of nitrogen that can be lost either by leaching in porous soils or turning into nitrous oxide gas (denitrification) on heavy, water-saturated soils. Proper nitrogen placement and timing can minimize nitrogen loss and maximize a producer's fertilizer investment (Figure 4-2).

One of the biggest changes that occurs when conservation tillage is adopted is an increase in soil carbon as soil organic matter increases. Carbon and nitrogen are inextricably linked, so changes in carbon lead to changes in nitrogen availability. For four or five years after the adoption of conservation tillage, the increasing carbon in the soil leads to some nitrogen immobilization, meaning less nitrogen is available for plant uptake (Table 4-1). After this transition period, the soil reaches a new "steady state," and crop nitrogen requirements go back to what they were before the transition began. What is likely occurring during this transition is that the reduced tillage soil is building soil structure and creating large aggregates. Some soil nitrogen becomes trapped inside these aggregates and is unavailable to crops. After a few years, however, the aggregate building is complete, so applied nitrogen is available for plant use.

During the transition phase, a producer can manage by applying supplemental amounts of nitrogen. Another option available to producers is to knife-in the nitrogen below the surface residues (Figure 4-3). Microbes assimilate or "take up" large quantities of nitrogen as they decompose crop residues. This process is called immobilization and is temporary. Eventually the nitrogen is released back into the soil, but the process takes longer in conservation tillage. Placing the nitrogen below the top few inches of soil bypasses this zone of intense microbial activity and leaves the

Table 4-1. Cotton lint yields over time on a nonirrigated Gigger silt loam from the Macon Ridge. Based on tillage system. Note the trend toward lower yields from the conservation tillage systems compared to surface till during the first three years followed by a trend toward higher yields for the no-till system compared to other tillage systems.

	Cotton Lint Yield (lbs./acre)					
Tillage System	1987-1989	1990-1992	1993-1995	1996-1998	1999	2000
Surface till	667	782	834	759	414	495
Ridge till	598	726	748	723	408	511
No-till	604	809	901	772	472	526

(Source: Boquet et al., 2000. Cotton Conservation Tillage and Cover Crop Systems for Cotton on the Macon Ridge) nitrogen more available for crop use. A Kansas State University study on grain sorghum demonstrated that placing the nitrogen below the surface residue in a no-till system increased crop yield 17 to 30 percent compared to a surface broadcast application.

Conservation tillage systems are more conducive to nitrogen loss from volatilization or denitrification from surface-applied nitrogen, especially on heavier soils (up to 30 percent of the nitrogen can be lost). There are several practices a producer can use to overcome this challenge – timing, split applications, injection and enhanced-nitrogen products.

Timing: If the fertilizer application can be made just before a rainfall of at least a half-inch, the water will carry the fertilizer below the surface so it is not vulnerable to volatilization losses.

Split applications of nitrogen, at planting and at sidedress, reduce the amount of nitrogen in the field at any one time, allowing a greater percentage to be taken up by the crop. This lowers the overall amount of nitrogen vulnerable to loss.

Injecting or knifing-in the nitrogen fertilizer puts it below the surface where so much can be lost to volatilization.

Figure 4-1. Conservation tillage in Louisiana emphasizes the importance of leaving crop residue on the soil surface to reduce rainfall impact and slow runoff.

Enhanced nitrogen products such as a urease inhibitor and/or a nitrification inhibitor have the potential to reduce nitrogen losses. A urease inhibitor is applied in conjunction with fertilizers that contain urea, and it acts as a retardant to urea breakdown for a few days to a week. This allows the fertilizer more time to wash into the soil before it converts to ammonium or ammonia. A nitrification inhibitor slows the conversion of ammonium, which is bound in the soil, to nitrate, which is susceptible to leaching and runoff. Crops take up both ammonium and nitrate, so nitrogen loss in minimized while plants still have access to it.

Cover crops

Leguminous cover crops or green manure crops will decompose and release nitrogen in both conventional tillage and conservation tillage systems, but the breakdown and release of nitrogen occurs more slowly in the conservation system than the conventional one. This occurs because incorporated residues have much more surface area being attacked by soil microbes compared to the residues left on the surface. Plowed or disked soils are also generally warmer than comparable conservation tillage soils, stimulating more active microbial cover crop decomposition.

Although slower to break down and release nitrogen, the conservation tillage system releases as much total nitrogen as the conventionally tilled system. Decomposition may just take place over a larger portion of the growing season. This may actually be beneficial to the crop using it, since the nitrogen demand generally increases in most crops from spring to summer.

Phosphorus

Phosphorus binds strongly to soil and, unlike nitrogen, is very immobile. Most phosphorus losses from a conventionally tilled soil occur as a result of erosion, and since conservation tillage significantly reduces erosion, less phosphorus is lost from the soil.

The exceptions to that are soils heavily and repeatedly treated with manure that have become phosphorus saturated. In those cases, surface water runoff carries dissolved phosphorus with it, and conservation tillage systems can increase losses since much of the phosphorus is near the surface. Judicious use of manures can avoid this problem.

Soils under conservation systems are cooler and wetter in the spring than comparable conventionally tilled

Figure 4-2. Fertilizer sidedress application of nitrogen in a conservation tillage system. Note the fertilizer is knifed in several inches away from the crop row to prevent losses due to volatilization and reduce the risk of fertilizer injury.

Figure 4-3. Side view of liquid fertilizer applicator in a conservation tillage system. The fluted coulter opens a narrow furrow in which liquid fertilizer is dropped behind the knife that follows the coulter.

soils. Cooler soil conditions slow overall root growth of seedlings, sometimes inducing temporary phosphorus deficiencies. Producers should apply a phosphorus-containing starter fertilizer near the seed at planting to overcome this situation.

Other than this planting-phase situation, conservation systems generally have greater phosphorus availability than conventionally tilled soils. If soil test phosphorus levels indicate the need for increased phosphorus, surface-applied phosphorus will work well in conservation tillage since less of it is bound up in the mineral fraction of the soil. This surface application results in horizontal banding of phosphorus. Research was conducted to determine if a vertically applied band of phosphorus fertilizer would improve crops under conservation tillage, but no benefits, such as yield gain, were observed.

Potassium

Potassium uptake issues are similar to phosphorus issues in conservation tillage, since potassium – like phosphorus – is relatively immobile in the soil and tends to become concentrated near the surface in reduced tillage systems.

The implications for producers are root growth of recently planted crops will be slower under cool soil conditions and the roots must grow toward the potassium to exploit it. An addition of potash to a starter fertilizer application placed near the seed may be warranted.

Research by Schulte et al. (1978) conducted in Wisconsin demonstrated that adding potash to no-till soil systems that had medium levels of soil potassium was more critical than in tilled soil systems. The percentage of potassium in ear leaf tissue was lower under no-till, and yields were less, but the gap between the two systems narrowed as more potash was added. Thus, producers adopting conservation tillage systems should be diligent in testing soil nutrient levels and maintaining adequate amounts for optimal yields.

Lime

Soils under conservation tillage result in a concentration of nutrients and acidity near the soil surface. The acidity is primarily generated by urea and ammonium-based fertilizers that lower soil pH as microbes convert them into nitrate.

A few producers avoid this situation by using nitrate-based fertilizers, but cost and accessibility make this option impractical for most. Heavy, infrequent additions of lime create a cycle of high and low pH that keeps the soil system in a state of flux and has the potential to reduce the best possible crop performance. Optimal surface soil pH also is critical to ensure the activity of triazine herbicides.

After adopting conservation tillage, sample the top 2 inches of soil as well as the traditional 6-8 inches to get a clear idea of the soil pH picture. If the pH in the top 2 inches is reported to be less than 6.2 but the soil test from the full 6 inches does not call for lime addition, apply lime at the rate of 1 ton calcium carbonate equivalent per acre. If the pH of a soil is 5.5 or less for the full 6-inch depth, apply and incorporate the recommended amount of lime prior to adopting the conservation tillage system.

Research has indicated that over extended periods of time, conservation tillage systems do not increase the overall lime requirements of a soil compared to conventionally tilled soils. The studies only show that the lime applications should be lighter and more frequent.

Manure

Researchers have long noted advantages to including manure applications in a field undergoing the transition from conventional to conservation tillage. Many of the benefits likely stem from the quickly available nutrient fraction of manure that feeds the soil microbial population, as well as the immediate addition of organic matter that increases nutrient and water-holding capacity. These benefits also include greater movement and availability of phosphorus due to complexation in the organic structures of the manure, improvement of soil structure that results in increased infiltration rates and increased pH and buffer capacity.

A significant portion of manure nitrogen is in the ammonium form and has the potential to be lost through volatilization if it is surface applied. Under conventionally tilled systems, the most common practice to prevent this nutrient loss is to incorporate the manure after the application – an option not available in most conservation tillage systems. Additional concerns include the effects of a potential odor problem with neighbors and avoiding compaction problems potentially created by manure spreading equipment. Thus, some thought should be given to how manure can be used in a conservation tillage system.

When manure odors present a potential problem, producers can work with their neighbors by choosing cool days to apply. Warmer weather increases volatilization and the intensity of the odors. People also are more likely to be outdoors and have open windows during warm weather. Wind direction and the rain forecast also should factor into the decision.

If possible, manures should be applied on days when the wind direction will carry odors away from neighbors. Rainfall that occurs very soon after a manure application will incorporate much of the manure into the soil and will greatly reduce the intensity of odors. A half-inch of rain is comparable to physical incorporation. More rainfall than a half-inch may lead to nutrient-laden manure running off the field, but that depends on how saturated the field already is and how quickly water infiltrates the soil.

Although sometimes difficult to find, specialized equipment that injects manures below the surface, while only minimally disturbing the soil, has been manufactured and may be available. Research is needed in Louisiana to evaluate the benefits and potential drawbacks of these systems on the various soil types found throughout the state's crop-producing regions.

Producers should be aware of compaction caused by manure application equipment. The primary way to avoid soil compaction is to use equipment with flotation tires. Just as important is timing. Apply the manure at a time when the soil is not excessively moist to minimize ruts in the field during application. Some application systems use drag hoses that require less manure weight to be loaded onto the application equipment.

Summary

Producers who adopt conservation tillage methods can successfully manage the transition period from conventional tillage to the new system. As with all agricultural systems, thoughtful planning and an awareness of the issues involved can ensure a profitable transition.

Chapter 5

Arthropod Pest Management

B. Rogers Leonard

The widespread adoption of conservation tillage systems for Louisiana crops has indirectly created changes in the pest spectrum and severity of problems in Louisiana's crops. Species diversity and population densities for a wide range of pest and beneficial arthropod complexes are influenced by a reduction in tillage, seeding of winter cover crops, double-cropping systems and delays in winter/spring vegetation management with herbicides.

The sub-tropical climate that is responsible for potentially high crop yields also provides a favorable environment for a variety of pests attacking those crops. Successful integrated pest management, abbreviated as IPM, in conservation tillage systems requires proper attention to the timeliness of all production practices, a formal field scouting protocol to identify problems and the proper selection and implementation of control strategies.

Preventive integrated pest management strategies coupled with early detection of problems and reactive treatments are essential components in profitable conservation tillage production systems.

The objective of this section is to identify pest issues in conservation tillage systems and briefly summarize the proper integration of selected IPM strategies in these systems.

Recognize potential pest problems

The most obvious effects of conservation tillage practices on arthropod pests will be changes in those pests that live in the soil or that use winter/spring native vegetation as hosts before moving to crops in seedling stages of development.

Tillage has been an effective means of physically disturbing the soil, which results in high mortality of any pest overwintering within the crop fields. In addition, tillage is very effective in completely terminating weedy vegetation in fields and thereby eliminating those plants as hosts for pests that may eventually migrate to crops.

Fields with heavy plant residue from a previous crop, green manure or winter cover crop, weedy spring/

Figure 5-1. In spite of effective herbicide use strategies, delaying herbicide applications can create serious insect pest management issues by forcing pests from dying weeds to crop plants.

winter vegetation or straw from a winter wheat crop (common in a double-cropping operations) should be considered at high risk for potential problems with arthropod pests (Figure 5-1). For example, all legume cover crops examined to date are more likely to produce economic infestations of cutworms in a subsequent cotton crop compared to nonlegume cover crops.

Conservation tillage practices improve soil quality and crop yield sustainability after each year. These same effects can improve habitat for arthropod pests and influence management strategies. Therefore, each crop season should be examined independently for potential pest problems.

Arthropod pest status and diversity

Conservation tillage practices are designed to increase post-harvest residue and native vegetation, unintentionally creating a favorable environment for insects within crop fields. There is considerable evidence supporting an increase in the diversity of yield-limiting pest populations in conservation tillage fields compared to fields receiving conventional tillage.

Most of the common pests in Louisiana crops will be found attacking the seed or young seedlings (Figure 5-2). Examples of these pests include slugs, red im-

Figure 5-2. If not detected early or managed with preventative strategies, numerous species of arthropod pests can cause direct injury and ultimate death to cotton seedling.

Figure 5-3. One of the most common insect pests that have been a consistent problem in conservation tillage systems is a complex of cutworms that severs seedling plants at the soil line.

Figure 5-4. Red imported fire ants are both pests and beneficials in conservation tillage systems. They injure crop seeds, but also feed on other insect pests.

Figure 5-5. Cotton aphids typically reach higher peak populations in conservation tillage fields than in conventionally-tilled fields.

ported fire ants, cutworms, armyworms, southern corn rootworms, seed corn maggots, wireworms, chinch bugs, sugarcane beetles, aphids, false chinch bugs, stink bugs and spider mites (Figures 5-3, 5-4, 5-5). In many instances, these pests are present in the field when the crop is planted.

Reduced tillage increases residue from previous crops (corn, sorghum and soybeans) and covers the soil surface, which, in turn, provides a favorable environment for insect populations by mediating soil moisture and temperature extremes. Poor field sanitation of volunteer plants and crop stubble following harvest during the fall also can provide a promising overwintering habitat for pest populations. These fields serve as refuges that may be capable of supporting pests whose subsequent generations eventually will migrate into adjacent crop fields.

Examples of these pests in corn are the southwestern corn borer and sugarcane borer. In cotton, the overwintering success of tobacco budworms and bollworms is directly affected by tillage practices, since these insects usually spend the winter in the soil of crop fields infested during the late fall.

In recent seasons, producers have relied on transgenic cotton and corn cultivars that express Bacillus thuringiensis, or Bt, traits to significantly reduce the effects of caterpillar pests such as those listed above. These integrated pest management tools have greatly reduced the yield-limiting effects of these pests, despite an increase in overwintering survival for pests in conservation tillage systems. In light of this success, cultivars expressing Bt traits should be the backbone of an IPM program in Louisiana crops.

Pre-plant pest management decisions

Arthropod pests may feed on numerous native host plants that make up the winter and spring weed complex in and around crop fields in Louisiana. The application of "burn down" herbicides, prior to planting, will terminate this weedy vegetation and destroy pests' food sources. This practice forces their emigration to nearby crop seedlings as a host for survival.

Destruction of winter vegetation well in advance of planting is the most effective cultural practice for reducing potential problems. Generally, if seedbeds are completely clean of living vegetation three weeks before planting, damage to crop seedlings may be minimized.

"Burn down" herbicide treatments need to be applied a minimum of six to eight weeks before planting, depending on the specific products, to successfully terminate winter vegetation by this time interval. Complete control of all weed species within the field and on the surrounding field borders is necessary to eliminate alternate host plants.

Fields should be scouted at the time of planting to ensure weed-free seedbeds. The presence of heavy plant residue or any green vegetation on the seedbeds following "burn down" applications may create a favorable environment for arthropod pests. Incomplete termination of some weed species may provide a refuge for insect pests until crop seedlings become available (Figure 5-6).

Even at planting, a herbicide application or modified tillage treatment is warranted to ensure a clean seedbed and remove alternate hosts. Additional weeds may emerge and become established following a successful pre-plant herbicide application if the treatment was applied too far in advance of planting or if the herbicide provided no residual control. Herbicides applied too late during the spring (close to the time of planting) may not completely kill the vegetation, and the pests can survive on decaying plant roots until crop seedlings become available.

At-planting pest management decisions

Fortunately, for many of the pest problems observed on seed and seedlings of Louisiana crops, pesticides can be applied at the time of planting to reduce the potential for crop injury. The use of soil insecticides to optimize yields has been more important in conservation tillage systems than in conventional production fields. These results are related to the fact that higher and more consistent initial pest populations occur in conservation tillage fields. Therefore, the potential for plant injury is higher and the value of these treatments is much higher in conservation tillage systems.

Insecticide-treated seed or soil-applied insecticides are standard treatments used to control seed and seedling pests. Regardless of the product(s) used, an at-planting treatment is essential for optimal seedling development. Producers should not reduce seeding rates below recommended levels when using at-planting insecticide treatments. Lower than optimal plant populations cannot consistently tolerate injury from seedling insect pests and recover to produce maximum yields.

In addition, a second level of control frequently is recommended to ensure that a broader pest spectrum is controlled. A number of pyrethroid insecticides are labeled for use as preventive sprays during the planting operation. Producers should apply these treatments in a broadcast application or in a wide band across the seed furrow for maximum performance. Co-applications with “starter fertilizers” also are possible as long as the spray covers a band on the soil surface across the open seed furrow.

Many of the pests occur below the soil surface and feed on root tissue. Those pests may not be exposed to the insecticide treatment if only a small area of the seedbed is treated.

These applications become especially important if winter vegetation was not terminated well in advance of planting, if incomplete kill of winter weeds occurred, if any freshly emerged vegetation is observed on the seedbeds at the time of planting or if pests are observed in high numbers on plants in the field or along field borders.

Figure 5-6. Weeds such as henbit are promoting very early infestations of spider mites, tarnished plant bugs and corn earworms on crop seedlings. Complete spring vegetation destruction can reduce or even eliminate the impact of these pests.

Post-emergence and reactive pest management decisions

Generally, labeled rates of pesticide treatments used at the time of planting will not exhibit sufficient residual efficacy for crop seedlings to develop beyond the susceptible stages to all potential pests during the production season.

Foliar insecticide applications may be necessary at one to three weeks after emergence of cotton seedlings. For producers using herbicide-tolerant crops, the co-application of foliar insecticides with post-emergence herbicides is a cost-effective practice. This combination of treatments should be considered when summer weeds that can serve as alternate hosts for pests are present in the crop field.

Automatic pesticide applications should never be used, however, and all treatments should be based upon the detection of pests using a formal scouting protocol. Unnecessary pesticide sprays may not target the primary pest or may cause secondary pest infestations.

The ultimate goal is to maintain an optimum stand of healthy plants with the fewest inputs. Therefore, fields should be scouted regularly during the season and treated only as needed, based on pest infestations, field environment and changes in plant development.

Summary and recommendations

As conservation tillage systems continue to evolve, integrated pest management strategies will need to be refined to address emerging pest issues.

Conservation tillage production systems typically require more intensive pest management practices than conventionally tilled fields because soil arthropod populations are modified at all levels. Pest managers and producers should scout fields and identify those situations that may result in pest problems. These fields should be considered “high risk” and managed with preventive pest management methods.

An effective IPM strategy for arthropod pests should include weed-free seedbeds well in advance of planting, optimal application dates for agronomic practices and discriminate use of preventive and reactive chemical control strategies for pest problems.

Chapter 6
Weed Management

Daniel O. Stephenson IV

Weed management in conservation tillage systems can be vastly different than traditional conventional tillage systems. Managing weeds in conservation tillage requires a planned and systematic approach.

Prior to implementing a conservation tillage system, producers should identify the specific weed species and their densities present in the field(s), determine the weeds' growth habit (annual or perennial) and whether the weeds have developed resistance to herbicides based on past experiences in a specific field and surrounding areas. Scouting an area to determine the weed populations present (herbicide resistant or not) is very important in conventional tillage systems, as well, but knowing the specific weed populations and densities is more critical in conservation tillage systems due to the desire to eliminate or reduce tillage.

Figure 6-1. browntop millet; a small-seeded grass weed

Figure 6-2. Palmer amaranth; a small-seeded broadleaf weed

Producers have to be flexible and have foresight concerning current or future weed problems to implement a successful conservation tillage weed management program.

A characteristic of many weeds is their ability to invade and succeed under almost any environmental conditions. Certain habitats favor certain weeds, and conservation tillage provides a specific habitat.

Since tillage is eliminated or greatly reduced in conservation tillage, weed species that require burial for germination may become less prevalent. Conservation tillage tends to favor small-seeded annuals and perennial weeds. Examples of small-seeded annual weeds include grasses (barnyard grass, broadleaf signal grass, browntop millet, Texas millet and many others), pigweeds (redroot pigweed, Palmer amaranth and waterhemp), prickly sida, and hophornbeam copperleaf (Figures 6-1 and 6-2). Dewberry, redvine, rhizome Johnson grass, and trumpet creeper are some examples of perennial weeds (Figure 6-3).

Figure 6-3. Rhizome johnsongrass; a perennial weed

Weed issues will change over time once a conservation tillage program is implemented. Therefore, an effective weed control program must change as well.

Crop row spacing and plant population, crop rotation, cover crops and herbicides are important components of a successful conservation tillage weed management program. Use of methods to enhance the competitiveness of a crop with weeds is critical in conservation tillage. Narrow row spacing and high plant populations will increase the shading effect, which helps inhibit weed germination and subsequent growth. Crop rotation and use of a cover crop can disrupt the life cycles of weeds and prevent a specific weed from becoming dominant. Crop rotation allows for the use of herbicides with different modes of action and reduces the possibility of developing herbicide resistance.

Cover crops aid in weed control by competing for sunlight and moisture when the primary crop is not present. In addition, most cover crops release allelopathic chemicals that aid in weed suppression.

There are challenges, however, if cover crops are used for weed management in a conservation tillage system. It is extremely important to terminate a cover crop using a nonselective herbicide such as glyphosate or paraquat four to six weeks prior to planting so soil water will not be depleted by the still-growing cover crop. If broadleaf cover crops (Brassica species, lupin, hairy vetch, crimson clover, or Austrian winter pea) are used, co-applying 2,4-D or dicamba with the nonselective herbicide is needed to ensure effective termination.

In addition, the allelopathic effect provided by many cover crops may have a detrimental effect on the cash crop, but research has shown these effects usually are negligible if the cover crop is terminated at least four weeks prior to crop planting.

When deciding which cover crop to seed in the fall, a producer should check the crop rotation restrictions on the labels of pesticides they are applying in the current crop to prevent injury of the cover crop.

Herbicides should not be the primary tool used by a producer to control weeds in a conservation tillage system, but they play an important role. Herbicide-resistant technologies such as Roundup Ready corn, cotton and soybeans and Liberty Link corn, cotton and soybeans have provided producers with the tools to effectively control weeds in both conventional and conservation tillage systems. But overuse of glyphosate in Roundup Ready crops has led to the development of glyphosate-resistant weeds. History has shown that overusing one herbicide will cause weed resistance, so relying upon only Ignite in Liberty Link crops may eventually lead to glufosinate-resistant weeds as well. To avoid this monumental problem in conservation tillage systems, it is important to use herbicides with different modes of action.

Considering the need to use multiple herbicides for weed management in a conservation tillage system, a producer should understand that many herbicides have soil activity, meaning they need to be moved to the soil for absorption by the weeds to achieve control. Examples of this type of herbicide are atrazine, diuron, Dual, Prowl, Staple LX, Treflan and others.

An important component to conservation tillage systems is the dead biomass or residue on the soil surface, however, and this stubble from past crops, weed vegetation following a burndown herbicide application or terminated cover crop residue on the soil surface unfortunately has the potential to intercept and adsorb the herbicide, thus preventing it from reaching the soil. This biomass or residue on the soil surface can greatly reduce the weed control activity of many herbicides, particularly Prowl and Treflan. Producers should contact their LSU AgCenter county agent or agricultural scientists when deciding which residual herbicide to use in a conservation tillage system.

Although conservation tillage systems also involve the significant reduction, or exclusion, of tillage, the presence of weeds that are resistant to herbicides, such as glyphosate-resistant Johnson grass, Palmer amaranth or giant ragweed, may require cultivation during the cropping season. Even in the absence of herbicide-resistant weeds, preplant, in-season cultivation or post-harvest tillage are excellent methods for managing weeds.

Prior to implementation of a conservation tillage system, a producer should give careful consideration to whether cultural practices (reduced row spacing, cover crops, etc.) and herbicide applications discussed above will provide the desired management of weeds to maximize crop yields.

True conservation tillage excludes preplant and post-harvest tillage, but in-season cultivation is possible due to high-residue row-crop cultivars that are available. These cultivators can be used to help manage annual weeds. They are heavy and made to pass through larger amounts of surface residue between the crop rows without major disturbance of residue. Cultivation, along with herbicides containing different modes of action, are effective tools for management of weeds, whether the weeds are resistant to a herbicide or not.

A conservation tillage weed management program designed to provide season-long control of weeds in Louisiana includes at least four herbicide applications. The outline below assumes that a herbicide-resistant crop, such as Roundup Ready or Liberty Link ones, will be planted. If this program is followed, a producer will have applied five herbicides, with each herbicide having a different mode of action.

1. **Preplant burndown:**
    - Four to six weeks before planting.
    - Nonselective herbicide plus 2,4-D or dicamba

2. **Pre-emergence:**
    - Residual herbicide applied after planting but prior to crop emergence.

3. **Early post-emergence:**
    - Two to three weeks after crop emergence
    - Nonselective herbicide plus a herbicide that provides residual control of weeds.

4. **Mid- to late post-emergence:**
    - Three to four weeks following the early post-emergence application
    - Nonselective herbicide plus a herbicide to target any weeds not effectively controlled by the nonselective herbicide

In summary, managing weeds in a conservation tillage system is challenging, but successful producers can anticipate potential problems through planning and field scouting, applying timely solutions and using crop rotation that provides alternative pest management strategies.

- Herbicide selection should be based on the weed spectrum known to exist in the field or present at the time of application.
- Follow herbicide labels and be aware of any restrictions prior to application.
- Refer to LSU AgCenter's Louisiana Suggested Chemical Weed Management Guide for specific herbicides to determine the herbicide that best fits your needs.

Chapter 7

Disease Management

Boyd Padgett

For diseases to initiate and develop, several factors must be present and working together. These factors are 1) a favorable environment for disease development, 2) a pathogen (disease-causing organism) and 3) a plant susceptible to the pathogen.

A disease develops when these three factors are present and work together. This is referred to as the disease triangle (Figure 7-1). In some cases, a vector is necessary for some diseases to initiate and develop. The vector (usually an insect) sometimes is essential for spread of the pathogen to the host plant. Vectors usually are associated with diseases caused by viruses and some bacterial or bacteria-like pathogens. If the host or pathogen is not present to complete the triangle, or if the environment is not favorable, the disease will not develop or develops slowly.

The major environmental parameters for disease development are temperature and moisture. Conducive ambient and/or soil temperatures and ambient and/or soil moisture periods will determine if a disease will initiate and develop in the presence of a susceptible host and pathogen.

Disease development is optimized when temperatures and moisture regimes fall into specific ranges conducive for development. For example, some pathogens develop best during cooler temperatures, and some develop best when temperatures are warm or hot. This also is true for wet weather and dry weather diseases. These temperature and moisture regimes will determine what diseases are present.

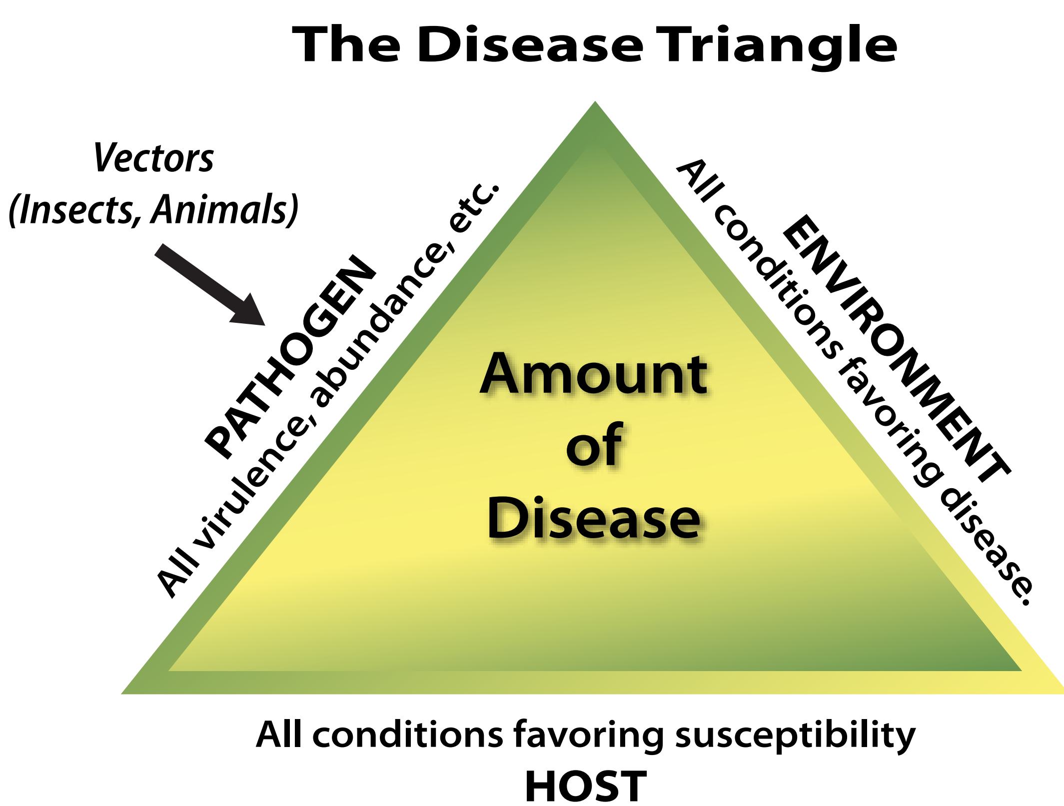

Figure 7-1. The Disease Triangle

Tillage practices have a direct effect on the establishment and development of several foliar and soil-borne diseases (Figures 7-2 to 7-7). These practices affect soil moisture, soil temperature and the amount of residual plant debris left on the soil surface.

Compared to conventionally tilled fields, soil moisture usually is higher and soil temperature usually is cooler in fields where reduced tillage practices are implemented. Increased soil moisture and cooler temperatures provide a favorable environment for some soil-borne pathogens (Figures 7-2 and 7-3), while some pathogens develop best when temperatures are hot and soil moisture is high (Figure 7-5).

Cool temperatures and high soil moisture provide conditions that are favorable for many pathogens that incite seedling disease and root rots. Increased water in the soil profile provides needed moisture for spore germination and infection. Reduced soil temperatures can slow seed germination and plant establishment. This makes the seedlings and roots vulnerable to infection.

Plant residue on the soil surface in reduced- or no-till fields increases the risk to seedling and root diseases. This also is true for some foliar pathogens (Figures 7-6 and 7-7). Some pathogens survive one or more years on infected plant debris and/or on seed left in the field after harvest. This infected plant residue harbors plant pathogens and serves as a food source for these organisms. These pathogen populations are referred to as inoculum. These pathogen populations overwinter in this infected debris and are available to infect next season's crop – increasing the risk of disease.

A recommended practice for managing some pathogens in conventional tillage systems is to plow under infected crop residue after harvest. This practice reduces the inoculum on the soil surface and decreases the risk of disease. Unfortunately, this is not possible in a reduced-tillage system. Several steps can be followed to reduce this risk, however:

Crop rotation can be used to decrease some pathogen populations. When possible, producers should rotate fields to nonhost crops. Nonhost crops reduce the available food source for some pathogens and result in decreased inoculum for subsequent years. For example, rotating a grass crop with a broadleaf crop can be used to effectively reduce the population of some plant pathogens.

Genetic resistance is another means to minimize risk. Genetic resistance should be the foundation of any disease-management strategy. When selecting a variety, always attempt to use high-yielding, disease-resistant varieties. This information usually is available from tests conducted by land-grant university scientists and seed companies.

Pathogen-free seeds will decrease the available inoculum for disease development. Always use high quality, pathogen-free seeds.

Plant when conditions favor rapid germination and plant establishment. This practice is especially important for reducing the risk to seedling disease pathogens. Rapidly growing healthy plants are less vulnerable to seedling disease pathogens. Avoid planting when

Figure 7-2. Damping-off in cotton.

Figure 7-3. Red crown rot in soybean.

the weather forecast predicts an approaching cold front or excessive rainfall.

Improving drainage also will help minimize the risks associated with the "water mold" pathogens (Pythium and Phytophthora). These pathogens develop best when free moisture is present.

Fungicides can be used to reduce diseases. This is particularly useful for combating seedling diseases. Fungicides can be applied to the seed prior to planting or placed in the furrow during planting. If producers are forced to plant during inclement weather, fungicides could be a viable option.

Figure 7-4. Root knot nematode in soybean.

Figure 7-5. Southern blight in soybean.

Figure 7-6. Cercospora leaf blight foliar symptoms on soybean leaflets.

Figure 7-7. Northern corn leaf blight (Note how the development begins at the bottom of the plant).

Chapter 8

Equipment

Adapted from the Penn State University Publication: ***Steps Toward a Successful Transition to No-Till***

Well maintained and adjusted planting and spraying equipment is crucial for obtaining good stands and weed control in conservation tillage systems. Late fall and winter are the best times to work on equipment upgrades, repairs and maintenance, because any problems from the past season that need attention are easy to recall. Planting time is not the time to be getting equipment ready. A bonus of conservation tillage is not having to maintain and repair a full line of tillage equipment, which means there is more time to fine-tune planting equipment. It also is less expensive to properly maintain a no-till planter and good post-emergence sprayer than to operate and maintain multiple pieces of tillage equipment. Figures 8-1 through 8-22 show examples of common equipment used in conservation tillage systems.

Planter and drill

A conservation tillage corn/cotton/soybean grower, in principle, only needs a planter, but drills provide many options for implementing a true conservation tillage system. Drills can seed cover crops, small grains and sometimes soybeans. There are advantages to drilling conservation tillage soybeans. Farmers can own or lease a planter or drill or may have a custom operator do the planting for them. For a beginning conservation tillage farmer, it may be beneficial to have the actual planting operation done by a custom operator who has experience with conservation tillage planting. Farmers can learn from the operator and eventually do the planting operation with their equipment.

Conservation tillage planters and drills actually differ little from modern conventional planters. Setting the planter for optimal operation is more involved, however. Conservation tillage planters can be adjusted to guarantee soil penetration to an appropriate depth in all conditions through the use of both down -pressure and depth-control settings. The planter has the ability to cut through all types of residue and ground cover and allow the residue to flow by without clogging the machinery. Seeds are planted through residue at appropriate depths for the crop and soil conditions. The seeds are covered and soil firmed around the seeds for complete seed coverage, protection against bird damage and good seed-to-soil contact. All of this is more challenging in conservation tillage, because the soil is firm but not pulverized.

To accomplish successful planting, conservation tillage planters likely will be equipped with similar but more options than conventional tillage planters. The list may include some or all of the following: 1) residue removers to move residue out of the row area; 2) a starter fertilizer opener or a device to place liquid starter in the row; 3) coulters to cut through crop residue and loosen a small volume of soil around the seeds; 4) metering unit to obtain accurate spacing between individual seeds; 5) seed tube to drop the seeds into the seed furrow; 6) double-disk openers to open a slot to the appropriate depth; 6) seed firmer to press the seeds to the bottom of the seed furrow; 7) insecticide applicator to apply insecticide in a “T”-band over the seed slot; and 8) firming and closing wheels to firm soil above the seeds and cover the seeds.

Figure 8-1. Six-row conservation tillage planter.

Forward residue removers

Residue cleaners move debris (crop or native vegetation) out of the drill area to enable easier planting and also greater warming of the soil in the row area. Multiple designs are available.

Several types of residue removers have been developed. Some with curved fingers or hoses, and these are less aggressive than residue cleaners with straight fingers. If the fingers intermesh, they maintain better cleaning action. Residue cleaners consisting of two concave disks also are available.

Residue cleaners can be unit-mounted or mounted on the toolbar. Residue cleaners mounted on the unit tend to have better depth control than those mounted on the toolbar. Some residue cleaners come as one piece with coulters.

The residue cleaners are meant to move residue, not soil. The depth has to be set appropriately to avoid creating a furrow with the residue cleaner that will subsequently compromise seed depth control.

Starter fertilizer opener

Starter fertilizer is useful in conservation tillage, as it is in conventional tillage, and is most useful for corn. Starter fertilizer openers are designed so some fertilizer can be placed next to the seed without damaging the young seedlings.

The standard method is to place fertilizer 2 inches next to and 2 inches below the seed. Liquid "pop-up" fertilizer can be placed in the seed furrow with corn but not with cotton. It is most conveniently applied through a tube situated behind the double disk openers and in front of the firming/closing wheels.

Coulters

Most conservation tillage planters and some drills have coulters in front of the seed openers – primarily to cut through crop residue and sometimes to help with opening the seed furrow and loosening soil.

If residue is not excessive, coulters usually are not needed when soil moisture is ideal to adequate and may not be needed in soil that has been in a long-term conservation tillage system. The surface soil organic matter content will have increased and the soil tilth improved to such an extent that the seed opener disks can do an excellent job without coulters.

In many instances, however, coulters can perform useful functions. There are different coulters, each having specific advantages and disadvantages. The following is a general description of commonly available coulters. Equipment dealers today will help you select the appropriate one for your conditions, or you can talk to an experienced conservation tillage farmer in your area for advice on which coulter may be best for you.

1. **Smooth coulters.** These coulters penetrate soil most easily and are usually the best choice because they have the smallest soil-to-surface area. They do not disturb much soil and therefore do not do not mix surface residue into the soil.

Figure 8-2. Residue cleaners with curved fingers

Figure 8-3. Residue cleaners with straight fingers.

2. **Bubbled coulters.** These coulters have a smooth edge and a bubbled section. They cut through residue well, just like the smooth coulters, but they sometimes move more soil than is desirable. They work well in dry soil conditions but not in wet and/or heavy soil, where they can create side-wall compaction.
3. **Fluted coulters.** These coulters have waved edges that help move and fracture some soil. There are 13-wave and 8-wave fluted coulters. They need more down pressure than smooth and bubbled coulters and are therefore suited to moist soil that is relatively "soft." Because fluted coulters disturb and fracture soil, they help dry the soil more quickly, thus increasing soil temperature and germination. Some new types of fluted coulters have waves that are angled (Turbo Coulters) to facilitate cutting residue and soil as well as reducing soil disturbance. These coulters generally are about a 20-wave coulter so they do soil fracturing.
4. **Rippled coulters.** These coulters are intermediate between smooth and fluted coulters and are a good option to the smooth coulters where only a small amount of soil disturbance is needed.

Double-disk openers and seed firmers

Double- disk openers should create a V-shaped slot, and the seed should be placed in the bottom of the trench. There are now heavier double- disk openers on the market. Some have notches to better handle residues. Some double-disk openers are offset, which helps the double disks to cut through residue and soil. For best results, use a seed firmer that gently pushes the seed to the bottom of the seed trench.

Figure 8-4. A seed firmer on a planter pushes the seed down into the seed slot to achieve optimum seed depth control. Pop-up fertilizer can be applied through the seed firmer.

Figure 8-5. Residue cleaners with concave disks.

Figure 8-6. Seed firmer on a drill also pushes the seed into the bottom of the seed slot.

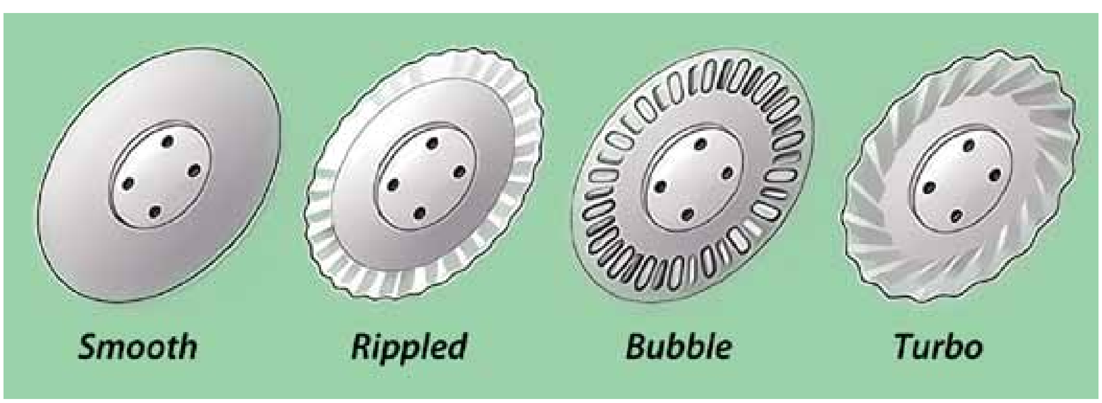

Figure 8-7. Smooth, rippled, bubble, and fluted turbo-coulters.

Depth-gauge wheels

The purpose of depth-gauge wheels is to control the operating depth of the double-disk openers and ultimately the planting depth. In conservation tillage systems, this adjustment is critical and must be evaluated when planting in different types and amounts of crop residues. It is especially important to spend the extra time necessary to get the adjustment calibrated properly when starting to plant each spring. As double-disk openers erode with use, the furrow depth will need to be appropriately adjusted to compensate for this wear.

There are different types of depth-gauge wheels. Some can leave loose soil next to the seed trench to provide additional loose soil for the closing wheels to move over the row. Other depth-gauge wheels are shaped to provide firming action next to the double disks. Many planter manufacturers will equip a planter with either type of depth-gauge wheels.

Metering unit and seed tube

Different seed metering units are available, such as finger-pickup, vacuum or pressure-driven systems.

Metering units for conservation tillage or conventional tillage usually are similar. The metering unit should be placed as close to the ground as possible.

Seed tubes should therefore also be as short as possible. Smooth and straight seed tubes are advisable to guarantee minimal interference between the metering unit and the seed placement. Worn seed tubes or tubes that are not completely smooth should be replaced immediately. It is important to inspect the seed tubes frequently to ensure no soil or residue has become lodged in a tube, blocking seed from dropping into the seed furrow.

Figure 8-8. A planter mounted with a bubble coulter.

Insecticide applicator

The insecticide applicator for conservation tillage is no different from that on conventional planters.

Closing wheels

Closing wheels can be made of cast iron or rubber and are made as solid wheels or with spikes, as well as so-called “posi-close” wheels. On planters, closing wheels are meant to seal the V-shaped seed slot but not compact the soil on the surface. On many drills, the closing wheel also controls seeding depth. Excessive down pressure on drills, however, can cause surface compaction. Closing wheels have been developed for specific purposes. In ideal soil conditions, most closing wheels work fine. Challenging, wet soil conditions generally are more difficult to manage, and differences between closing wheels tend to show up.

Cast-iron closing wheels are designed to compact soil beside and below the seed to guarantee good seed-to-soil contact in crumbling soils. If soil is moist, it is easy to excessively compact soil in the seed zone, which causes root penetration problems. It is important to limit down pressure on the iron closing wheels to avoid compaction but still close the seed slot.

Rubber closing wheels pose a lower threat of compaction, but using them in clay soils that are dry may not provide enough down pressure to fully close the slot. This also may occur when planting directly into spring-killed sod or a heavy winter cover crop.

Spading or spiked closing wheels have been designed for wetter, heavier conservation tillage soils. They are meant to crumble soil on top of the seed without

Figure 8-9. A fluted coulter with angled waves to facilitate soil penetration and reduce soil disturbance.

causing sidewall compaction. This crumbling action tends to aid in drying and warming the soil in the row. Some spiked closing wheels come with a depth band to ensure consistent operating depth. Also, some planters are equipped with one spiked and one solid cast or rubber closing wheel. Spiked closing wheels may not work in cover crops, especially when they are wet, because straw will wrap around them. The floating spader wheels apparently avoid cover crop wrapping as well as deep sinkage.

"Posi-close" wheels also are made for closing the seed slot in challenging conservation tillage conditions. The pattern is meant to prevent excessive soil compaction above the seed while still closing the slot. Drag chains can be mounted behind the seed firmers to crumble surface soil. Crumbling will only take place in low-residue conditions and if the surface soil is dry.

The Case-IH slot closing system is designed differently from that on most other planter types. In its case, the seed slot is closed by two small offset disks that push soil back on top of the seed. Then a broad rubber closing wheel firms soil on top of the seed. This closing wheel system needs good soil tilth to function properly. The closing wheel has treads to prepare a cracking pattern in crusting soils.

Figure 8-10. Cast-iron closing wheels.

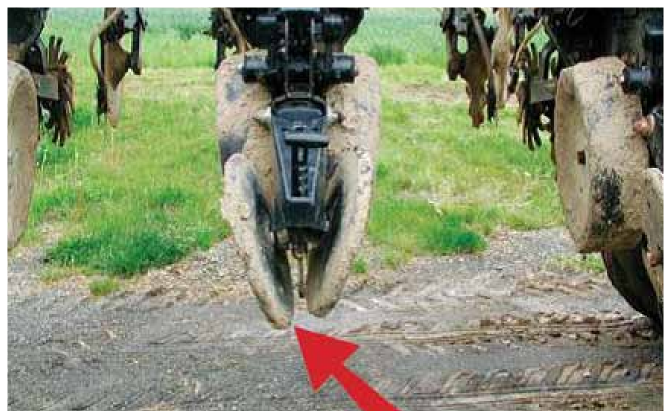

Figure 8-12. Rubber closing wheels.

Figure 8-11. Case-IH rubber closing wheel.

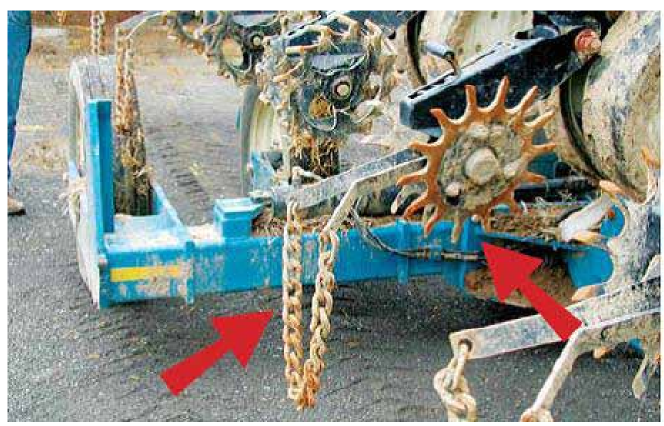

Figure 8-13. Spading/closing wheels with optional drag chain.

Figure 8-14. Some farmers mount one fingered and one cast iron closing wheel on a planter unit.

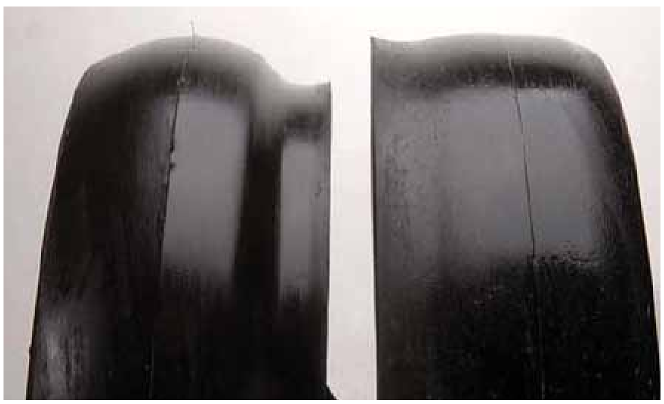

Figure 8-15. Comparison of two common types of depth gauge wheels. Case IH wheels are on the left and the other commonly used wheel is on the right.

Figure 8-16. Posi-close wheel.

Figure 8-17. Example of planter attachments available to manage heavy residue from crops or cover crops in conservation tillage.

Chapter 9

Final Thoughts

Chris Coreil and Boyd Padgett

This publication was designed to inspire producers considering moving to a conservation tillage system. As with conventional tillage, conservation tillage systems have hurdles that must be overcome. Technology exists to overcome all of these obstacles, however.

In addition, years of research have shown that conservation tillage systems 1) can significantly reduce overall energy inputs, 2) produce comparable yields to conventional tillage systems, 3) increase the water-holding capacity of the soil, thus reducing plant water stress, 4) create better harvesting conditions when the soil is saturated, 5) reduce nutrient loss by reducing runoff and increasing organic matter, 6) reduce the off-site movement of pesticides, 7) maintain a healthy environment for macro- and microorganisms, and 8) reduce erosion, thus maintain fertility and productivity of the land for future generations.

Working with experienced producers, as well as studying available conservation tillage literature produced by researchers and professionals, will allow a successful transition to a reduced tillage or no-till farming operation. Improving scouting techniques, timeliness of pesticide application and patience with the soil/nutrient balance can frustrate producers – but don't give up!

The LSU AgCenter and the USDA Natural Resources Conservation Service offer a wealth of information on all of benefits and pitfalls of adopting a conservation tillage system. NRCS also offers financial assistance to qualified Louisiana producers interested in adopting conservation tillage systems.

The links at the end of the digital version of this publication represent just few of the resources available to ensure a smooth transition to conservation tillage (www.lsuagcenter.com).

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