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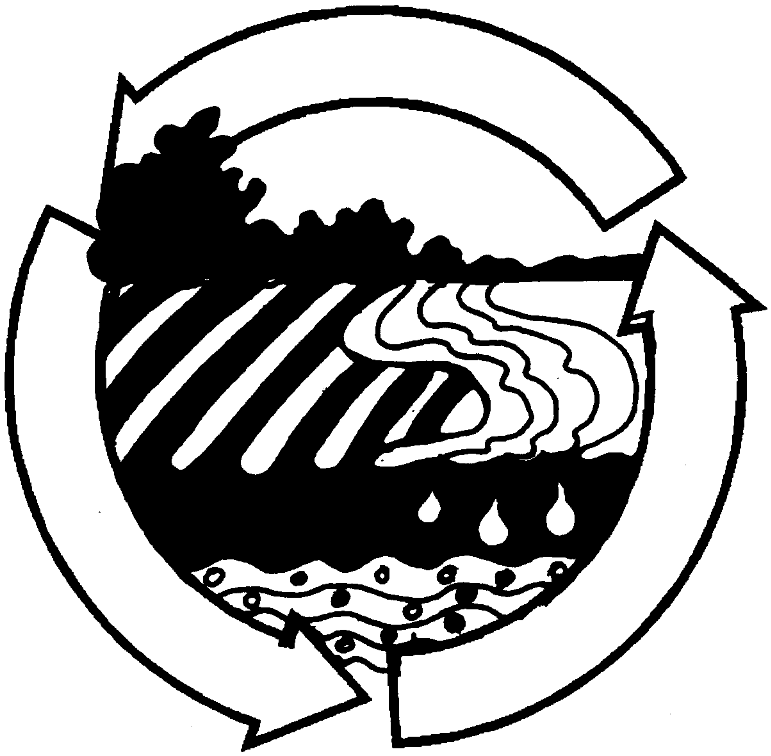

"Agricultural Water Quality and Quantity: Issues for the 21st Century"

Proceedings of the

23rd Annual Southern Conservation Tillage Conference for Sustainable Agriculture

Agricultural Water Quality and Quantity: Issues for the 21st Century

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Foreword

Over the past 15 years, agriculture has come under expanded environmental demands from society. Many of the more recent regulatory proposals directly involve land use initiatives that could limit landowner/farmer investment-backed expectation and ultimately reduce profitability. This increased agriculture-environmental quality focus began with a strong regulatory policy limiting the conversion and use of wetlands for agricultural production in the 1985 Farm Bill (Swampbuster provisions). This was followed by authorization and funding for numerous FarmBill conservation provisions, including the Conservation Reserve Program (CRP), the Wetland Reserve Program (WRP), the Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentives Program (WHIP). Other recently approved federal initiated initiatives that result in agricultural regulatory actions include the Coastal Zone Act Reauthorization Amendments of 1990 (coastal nonpoint pollution control program) and the Sustainable Fisheries Act - Essential Fish Habitat (EFH) provisions of 1997.

In August 1999, EPA published Total Maximum Daily Loads (TMDLs)/ National Pollution Discharge Elimination System (NPDES) rules that call for increased regulation of nonpoint source runoff coming from agricultural fields, forestry operations, and animal feeding operations. EPA is also proposing to re-designate some traditionally nonpoint discharges to a more restrictive point source classification, potentially requiring NPDES permits for many normal production activities.

The central issue seems to be increased leanings toward a private lands policy focused on the provision of public natural resource / environmental benefits. Many of the policy proposals and actions leading this charge have not been openly debated in legislative chambers; rather, they often appear as agency "rules" or "guidance" published in the Federal Register and are later implemented without direct congressional authorization as regulations. Many are concerned that lack of adequate policymaker debate on many of these issues can result in poor cost-benefit analysis, underestimated economic impact, and inadequate research-based decision-making.

Another serious challenge involves the growing number of environmental organizations taking extraordinary steps to affect land use in the United States through federal lawsuits demanding that governmental actions be taken to address both point and nonpoint runoff. In the case of hypoxia in the Gulf of Mexico, some are proposing that farmers in the Mississippi River Basin reduce nitrogen fertilizer application on farm fields by as much as 20-40% and expand the number of acres taken out of production and restored to wetlands by several million additional acres. Many state water quality management agencies are now largely being directed by these lawsuits, and agricultural interests are seriously lacking in most of the court orders that have resulted from these suits.

The unrecognized fact associated with many of these regulatory proposals is the willingness of agriculture and forestry to voluntarily and effectively address runoff pollution through economically feasible and effective Best Management Practices (BMPs) and incentive-based programs. Forestry, for example, has voluntarily increased BMP adoption in the South to a level exceeding 80% in some states. Additionally, southern farmers continue to implement production practices (such as conservation tillage, pesticide management, nutrient management, buffer strips, precision agriculture, and wastewater treatment) that continue to significantly reduce runoff and improve water quality.

BMP technology, however, must be developed with producer profitability taken into consideration. If many of the benefits associated with BMPs are directly accrued to society at large, many believe that public financial support should be provided to assist in implementation. Examples include incentive-based programs such as cost-share assistance, tax breaks, conservation easements, and market premiums. The decision as to which BMPs require financial assistance and which can be independently applied without assistance must often be made on a site-specific / crop-specific basis. Regardless, producers are constantly looking for ways to conserve soil and limit the application of costly fertilizers and pesticides based on both stewardship and economic considerations.

The will and support required for voluntary programs to be successful exist within the production agricultural sector. However, funding for the incentive-based programs that can make voluntary programs even more successful has been lacking Farm Bill incentive-based conservation programs, such as the Environmental Quality Incentives Program (EQIP), have been cut even though farmer interest and public support remain high. With increased conservation program funding, however, farmer adoption of voluntary BMPs will increase and improvements in water quality should result.

Other actions that should lead to increased BMP adoption include field verification studies, increased producer training (technology transfer), watershed-based programming, and additional BMP research and development.

With clear evidence of progress, policy calling for the continued implementation of effective, voluntary programs should replace calls for expanded regulation and land use control. Farmers, ranchers, and forest landowners must continue to stand together for reasonable policy that encourages (through research, extension, and incentives) the continued implementation of voluntary, research-based BMPs that help meet realistic, economically achievable water quality goals nationwide. Additionally, research scientists must continue to evaluate BMPs that will lead to continued water quality improvements, while being sensitive to cost-effectiveness and profitability.

The LSU Agricultural Center is committed to sustainable food and fiber production systems that consider both environmental stewardship and economic viability. We applaud the efforts of the Southern Conservation Tillage Conference organizers and presenters who collectively help make this goal a reality throughout the South.

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The planning committee for the 2000 SCTCSA gratefully acknowledges the special assistance of Dr. R. Larry Rogers and Mrs. Barbara McVay in planning this conference. The committee and, especially, the editor also recognize Mrs. Darlene Regan for the hard work and effort devoted to the assembly of these proceedings.

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INTERPRETIVE SUMMARIES

BEST MANAGEMENT PRACTICES (BMPS) AND AGRICULTURAL WATER QUALITY POLICY

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INTERPRETIVE SUMMARY

In an effort to better address the Best Management Practices (BMPs) education and outreach needs of agriculture, the LSU Agricultural Center re-initiated extensive commodity-specific BMP reviews in 1996. The primary goal of this effort is the development of commodity specific / voluntary/ cost-effective BMPs that will help sustain and improve environmental quality. Reviews covered swine, poultry, aquaculture, grain crops, cotton, rice, fruits & vegetables, nursery crops, dairy, sugarcane, and sweet potatoes. The review / development of beef cattle (forage and grasslands) BMPs has also been initiated recently. BMPs covering forestry and ornamentals were also reviewed; however, industry (the Louisiana Forestry Association and the Southern Nurserymen's Association, respectively) assumed a lead role in the development of BMPs for these commodities and final BMP publications are now complete.

Why BMPs?

Agriculture has been targeted as significantly contributing to both point and nonpoint source pollution nationwide. Nutrient over-enrichment caused by animal waste, fertilizer, and sediment runoff has been blamed for causing impairment in many streams and hypoxia in the Gulf of Mexico. Proposals mandating that all streams meet specific standards through the development and implementation of Total Maximum Daily Loads (TMDLs) are being considered by EPA. TMDLs are defined as the minimum amount of a pollutant that a stream can assimilate and still meet specific water quality standards. TMDLs must be allocated to all input sources that are contributing to a stream's impairment (both point and nonpoint source discharges originating from agriculture, forestry, municipal sewage treatment plants, urban runoff, etc.).

Additionally, several agricultural and sivicultural activities that have traditionally been classified as nonpoint discharges are now being proposed by EPA to be re-classified as point source discharges. This may require that National Pollution Discharge Elimination System (NPDES) permits be obtained for many routine activities such as runoff/irrigation water drainage, tree harvest, prescribed burning, and manure management.

In addition to the EPA proposals outlined above, numerous lawsuits have been filed by environmental groups nationwide challenging state environmental quality agencies for not addressing surface water impairment and for not adequately listing streams that are still not meeting EPA standards for dissolve oxygen, fecal coliform, metals, and nutrients. In Louisiana, streams listed on the Section 303(d) impaired waters list increased from 196 to almost 350 after the final court order was issued. This represents approximately 70% of all Louisiana's inland waters These and similar actions will have serious implications on agriculture and timber producers nationwide.

Recently published TMDLs for streams located in southwest Louisiana include required reductions in manmade nonpoint source discharges of 70-100%. Additionally, an EPA developed TMDL for fecal coliform in one of these streams calls for a 700% reduction.

The voluntary implementation of cost-effective BMPs by producers that result in continued water quality improvements presents the best strategy for agriculture to maintain non-regulatory initiatives. Voluntary approaches are generally less costly and lead to enhanced cooperation and partnerships with landowners.

Groundwater Resources

Because of multiple-year drought conditions and increased demand for groundwater resources, several freshwater aquifers are now beginning to experience identifiable stress. Water tables are dropping and, in many areas, chloride concentrations are increasing. In Louisiana, two aquifers are getting increased attention, the Sparta in north central Louisiana and the Chicot in southwest Louisiana.

In 1999, the Louisiana Legislature authorized the formation of a Sparta Groundwater Conservation Commission charged with evaluating potential components of a conservation plan. In March 2000, the LSU AgCenter and Louisiana Rice Research Board entered into a 3-year agreement with the U.S. Geological Survey to study the effect of rice and crawfish irrigation on the Chicot aquifer. This study was initiated due to increased demand on groundwater due to lack of surface water for irrigation and reported increased chloride levels in several rice water wells.

Increased global competition will require that our farmers increase yields and reduce costs. The development and implementation of surface and subsurface irrigation capabilities are expected to increase due the globalization of agriculture. This necessity will make it crucial that efforts be made to assure that irrigation water quantity and quality are sustained through the implementation of effective conservation practices both on the farm and in urban areas.

Planned LSU Ag Center BMP Education and Outreach Strategies

As mentioned before, the BMP draft review reports developed by the LSU AgCenter are now being used as technical references in the development of producer-friendly BMP publications that will be completed and printed in July 2000. Additionally, the following strategy actions are being proposed:

- Identify research opportunities aimed at verifying the efficacy of current and new BMP technologies.

- Seek potential research funding from state, federal, and private sources.

- Initiate survey research initiatives that document current baseline and future enhanced BMP adoption rates by commodity, watershed, and/or region.

- Develop a general Agricultural Water Quality Management educational publication that introduces producers to **(1)** water quality related environmental policy affecting agriculture, (2) the general agriculture/forestry related nonpoint source pollutants (nutrients, sediments, pesticides, fecal matter, oil & grease, etc.), and (3) recommended effective BMPs that can be implemented to reduce water quality threats.

- Using BMP Review Reports as a guide, develop easy to understand, commodity specific BMP educational publications (with illustrations and on-the-ground application designs) targeting producers. Focus on BMPs that are both effective and economically practicable and delineate BMPs that are effective but require some type of cost-share assistance.

- Develop and implement statewide AgCenter faculty training initiatives focusing on the following issues:

a) justification for voluntary implementation/cooperation
b) current water quality related policy issues important to agriculture
c) sources of nonpoint pollution (nutrients/sediments/pesticides/fecal, etc.)
d) BMP recommendations by commodity with site specificity if possible
e) cost-share assistance programs

- Develop an LSU Agricultural Center BMP web page.

- Develop and implement a statewide producer BMP educational initiative called the *Master Farmer Program*. Incorporate field trips highlighting in-the-field BMP applications.

- Develop and incorporate a "whole-farm" resource conservation assessment approach to on-the-farm environmental stewardship plan development.

- Initiate crop consultant environmental education initiative covering regulatory policy, watershed management, BMPs, and other pertinent environmental topics.

- Initiate a regulatory agency educational program that includes field trips highlighting effective producer-implemented BMPs statewide.

- Celebrate successes via media releases, fact sheets, and public presentations.

- Consider initiating a producer environmental stewardship awards program that recognizes voluntary BMP implementation by commodity, watershed, and/or region.

- Initiate watershed-based producer advisory committees that can better address water quality issues and encourage voluntary BMP implementation statewide and regionally.

Summary

Through cooperation and collaboration, natural resource agencies, universities, agri-business owners, and farmers are joining together to address environmental stewardship nationwide. This is being accomplished through a commitment to the implementation of voluntary, cost-effective BMPs/conservation practices on the ground. To assure continued success and increased adoption by farmers, research testing the efficacy and economic feasibility of these practices must be continued. Additionally, farmers and landowners must provide the leadership that will be required to secure public support for voluntary implementation policies and incentive-based programs critical to agricultural profitability - and improved water quality.

CONSERVATION TILLAGE: YESTERDAY AND TODAY

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INTERPRETIVE SUMMARY

Production agricultural is in need of meetings such as this one where researchers, consultants, state and federal agencies representatives and producers can come together to share information on better ways to conserve, protect, and enhance our environment and have a sustainable farming operation. We believe it is very important to get the message out that an economically sustainable farming operation and an environmentally sustainable farming operation can and should be one in the same.

Agriculture operations are coming more and more under a microscope due to the concerns of nonpoint source pollution related to crop, livestock, and forestry production. We are hearing more and more about how nonpoint source pollution is a major cause of many of our nation's water not meeting water quality standards or their designated uses. We hear how nonpoint source pollution could be the major cause of Hypoxia in the Gulf of Mexico. And we have read that production agricultural is the major source of nonpoint source pollution. We are hearing that global warming is a major concern with it's associated changes on weather patterns.

Prior to the early 1990's, monitoring of agriculture activities mainly dealt with soil erosion and the resulting sediments effecting water quality. We used the Universal Soil Loss Equation and then the Revised Universal Soil Loss Equation to measure tons of soil movement per acre. Today the effectiveness of cropping systems are gauge by the measurement of pollutants such as pesticides and nutrients in downstream receiving waters.

Conservation tillage started off as an erosion control practice on highly erodible lands to reduce soil movement. Now conservation tillage is being recognized as an important practice on fields with a flat topography to reduce the amounts of pesticides entering receiving waterways.

Conservation tillage is not the whole answer to address water quality issues associated with row crop agricultural but could be a principal practice in a conservation system. Conservation tillage needs to be planned along with its companion practices including nutrient management, pest management, filter strips buffers and etc.

Research has shown that conservation tillage in not only an important practice to control soil erosion and improve water quality but conservation tillage also provides many other important benefits. Some of its benefits that are well known and have been documented include: improved soil health and tilth; reduced soil compaction and temperature; increased water holding capacity; reduced runoff; serves as a carbon sink and sequestering carbon and increased pore space for root development. All of these benefits translates into healthier crops and improve yields.

On May 4, 2000, the US Senate Subcommittee on Production and Price Competitiveness held a hearing regarding carbon sequestration and other issues related to global climate change. An imbalance of the carbon cycle has been identified as a major contributor to global climate change. At the hearing, Former NRCS Chief William Richardson testified on the need to support Conservation Tillage because of its positive effects on carbon cycling through its ability to sequester carbon in the form of organic matter in the soil.

Although conservation tillage research in Louisiana dates back to the late1960s, there was virtually no conservation tillage being practiced in Louisiana until the early 1980s. Thanks to the coordinated efforts of the Louisiana State University Agricultural Center, innovated producers and NRCS viable conservation systems have been developed for most of the major cropping systems in Louisiana. Last year over 20% of all crops planted, over 792,000 acres, were planted using conservation tillage. We have come a long ways but there is still a long ways to go.

We believe that conservation tillage will protect producers against more regulations. We feel like these types of practices and the voluntary support for these types of practices incorporated into the routine cultural treatment of crop production should go a long way in reducing the need for more regulation on agriculture.

ROLLER VS. HERBICIDES: AN ALTERNATIVE KILL METHOD FOR COVER CROPS

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INTERPRETIVE SUMMARY

Research Question

Growers are always looking for effective and lower cost options to produce their crops. As cover crop use increases, their management becomes an important component of many farming systems. Timing and method of termination are the two most important factors of cover crop management. This research investigates the use of a roller as an alternative cover crop kill method and the optimum growth stage for its use on three cereal cover crops.

Literature Summary

Cover crop use in the United States is on the rise, especially in conservation tillage systems. Due to this increase, growers are looking for effective ways to manage cover crops, while reducing input costs. Mechanical roller-crimpers have been shown to be effective in southern Brazil and Paraguay in conservation tillage systems. However, in the United States, the use of the roller is a relatively new cover crop kill method. The killing of some cover crops at certain growth stages has been evaluated using herbicides to a certain extent, however, more research is needed, especially related to the roller and the potential to reduce herbicide inputs.

Study Description

During 1998-1999 at two locations in east-central Alabama, five cover crop kill methods were evaluated on three different cover crops at three growth stages. Cover crop biomass production, kill method efficacy, and soil water conservation were evaluated.

Soil type: Compass loamy sand and Cahaba sandy loam

Experimental design: Split-split plot design with four replications

Cover crops: rye, wheat, black oat

Growth stages: Feekes stages 8 (flag leaf), 10.51 (anthesis), 11.2 (soft dough)

Kill methods: roller-crimper, two herbicides (paraquat and glyphosate), and two reduced chemical rate (half label rate) combinations with the roller

Applied Questions

Is the roller as a cover crop kill method comparable with the use of the traditional herbicide methods?

When termination occurred as late as soft dough stage (Feekes stage 11.3), the roller was as effective as herbicides. However, this late stage may not provide growers with enough time to plant a cash crop. The early milk stage (Feekes stage 10.54), prior to soft dough, may prove more beneficial since it provides more time for planting, conserves soil water, and provides effective kill. The roller provides additional benefits as it lays residue flat on the soil surface providing maximum soil coverage;

to prevent erosion, decrease soil water losses, provide weed control, and facilitate planting. Economically, the roller and the roller+herbicide (half rate) treatments provided a significant savings ($5.25/A average) in the cost of cover crop termination.

Are there any differences between these three cover crops when the roller was used?

There were no significant differences between the cover crops when the roller was used. Plant height and maturity, (i.e., differences in growth stage) were the main factors determining the roller's effectiveness.

(See Full Paper on Page 64.)

TILLAGE EFFECTS ON SOIL NUTRIENT DISTRIBUTION

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INTERPRETIVE SUMMARY

Rationale: Because the surface soils of the Coastal Plain are easily compacted, some form of deep tillage is recommended to allow plant roots to explore more soil volume. For crops grown in row-widths of 30-in or more, most farmers use in-row subsoiling to loosen the soil directly under the row. Often, farmers return to the same row area with the subsequent crop to re-use old subsoil slits or to reduce the soil area compacted by tractors and equipment. We measured the horizontal and vertical distribution of soil P and K after 6 years of growing crops in 30-in rows with conservation tillage and controlled traffic. Wheat double-cropped with soybean was grown the first 3 years, corn was grown the second 3 years. Treatments were subsoiling annually and no deep tillage. To measure vertical distribution of nutrients, we separately sampled the surface 2-in, the rest of the A horizon, the entire E horizon, and the top 3-in of the B horizon. For a measurement of horizontal distribution, samples were collected from directly in the row and from random areas in the row middles. All P and K fertilizers were broadcast applied each year.

Results: As expected, highest concentrations of P occurred in the surface 2-in of the profile. Concentrations decreased with depth, and there was no measurable P in the top 3 inches of the B horizon. Higher concentrations of P occurred in the row middles than directly in the row, both with and without subsoiling. This was probably because plant roots were more numerous in that region. Higher yields with subsoiling caused greater P removal in the seed, resulting in those plots having lower P levels than those that were not subsoiled. Potassium distribution was more uniform throughout the profile than was P distribution. The horizontal distribution of K was opposite than was found for P. In the surface soil, there were higher concentrations of K in the soil in the row than in the soil in the row middles. Averaged over both row locations, K levels in the surface 3 inches of the B horizon were lower in plots that were subsoiled than in the non-subsoiled plots. This suggests greater root concentration and more nutrient uptake from that horizon in the subsoiled plots.

Implications: Substantial vertical and horizontal distributions of P and K were found after 6 years of conservation tillage in this study. These data support current recommendations for collecting soil samples from conservation tillage fields. When soil sampling for fertilizer recommendations in long-term conservation tillage, care must be taken to collect samples from both in the rows and in the row middles.

POTENTIAL USE OF SLOW-RELEASE UREA IN WATER-SEEDED, STALE SEEDBED RICE

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INTERPRETIVE SUMMARY

Problem

Stale seedbed rice production systems have increased in popularity and have significantly contributed to reducing soil erosion and improving the quality of floodwater discharged from rice fields. Proper management of fertilizer nitrogen (N) is a concern since N is not preplant incorporated in these stale seedbeds. Nitrogen has to be applied to the soil surface, which may be wet or saturated, or into the floodwater on seedling rice. In these situations, N efficiency is reduced and grain yields are decreased. Slow-release urea formulations have the potential to improve efficiency and increase grain yields in these stale seedbed, water-seeded cultural systems. The objective of this study was to compare slow-release urea products with standard urea at varying rates and N application timings in a water-seeded, pinpoint flood culture using conventional and stale seedbed tillage systems.

Literature Summary

Nitrogen efficiency is reduced when urea N is applied to wet or saturated soil surfaces, or into the floodwater on seedling rice. In southwest Louisiana, most rice is water-seeded and cultured in a pinpoint flood system in order to suppress red rice, a noxious rice biotype that cannot be selectively controlled in established commercial rice. Stale seedbed tillage does not allow for incorporation of N, and all N is applied to the soil surface either preplant (PP), postdrain (PD), or postflood (PF). Delayed flood establishment after N application, even when N is applied to dry soil surfaces, can result in N loss via ammonia volatilization or denitrification, resulting in reduced grain yields. Slow-release urea products have been shown to be effective in conventional tillage systems and in water-seeded rice. Little is known about the effectiveness of these products in stale seedbed tillage systems.

Study description

The experiment was conducted at the Rice Research Station in Crowley, LA in 1997 and 1999. Factorial treatment combinations of tillage, N source, N timing, and N rate (1999 only) were replicated four times. Tillage factors included conventional tillage and stale seedbed. Conventional tillage consisted of all necessary tillage operations to form a smooth, uniform, and weedfree seedbed just prior to planting. The stale seedbed was prepared in October or November each year, was allowed to revegetate with native weeds, and was burned down with glyphosate and 2,4-D 4 weeks before planting. N sources included a polyolefin-coated urea (PCU), a sulfur-coated urea (SCU in 1997 only), and standard urea. N timing included PP, PD, and PF. All N was applied to the soil surface. The PD application consisted of N being applied to a saturated soil surface after initial flood removal (3 to 4 days after seeding) and just prior to permanent flood establishment. The PF application consisted of N being applied 2 ½ to 3 weeks after emergence, and rice was in the 3-leaf growth stage. Days to 50% heading, plant height, grain yield, and N content of the grain and straw (1997 only) were determined. Data were statistically analyzed using ANOVA procedures and Fisher's Protected LSD for mean separation.

Applied Questions

How did performance of the slow-release N products compare with standard urea?

Both PCU and SCU increased rice grain yields compared with standard urea. The yield increases for PCU and SCU were 12 and 13% respectively, in 1997. In 1999, PCU increased grain yield by 23%. In general, plants were taller and tended to mature a few days earlier with the slow-release products.

What is the economic potential for use of slow-release N products in rice?

At the present time, the use of slow-release N products in commercial rice production is cost-prohibitive. The approach of this research was to use slow-release N to provide the total amount of N required to optimize grain yields. Future research should investigate the possibility of using slow-release N fertilizers in combination with standard urea. If the proper combination and/or application timing results in higher grain yield, improved N efficiency, and reduced fertilizer inputs, the use of slow-release N could become economically feasible.

Management Recommendations

Even though the use of slow-release N is not an economical consideration for commercial rice production, the application timings of both slow release urea and standard urea that were evaluated do show how N efficiency can be improved in water-seeded, stale seedbed rice production. In a pinpoint flood water management system, urea applied to the soil surface PP resulted in the highest grain yields. Postdrain applications were less effective. Applying N into the floodwater on seedling rice was very inefficient and resulted in significant yield losses. Although applying N in split applications was not addressed in these experiments, it is believed that such a delivery system would also be suitable. It is highly encouraged that the initial application be made either PP or PD, and the remainder applied into the floodwater on rice that has at least reached the tillering growth stage. In situations where N has to be applied into the floodwater, N efficiency is improved as the rice plant develops a more extensive root system.

Acknowledgments

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(See Full Paper on Page 70.)

SOIL AMENDMENTS TO INCREASE COTTON PRODUCTIVITY ON DROUGHT-STRESSSED SOILS

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INTERPRETIVE SUMMARY

Each year in the U.S.A., a total of 400 million tons of organic wastes are generated. Additionally, paper mills produce large quantities of boiler ash. Historically, these waste products have been stored in lagoons and landfills or incinerated. These methods of disposal are no longer acceptable because they may cause environmental degradation. Beneficial use as soil amendments would be an attractive alternative dispoal method for many by-product waste materials. This would recycle plant nutrients that would otherwise be lost and possibly enhance the productivity of land used for cotton production, especially drought-stressed soils. We conducted field experiments from 1996 through 1999 on Gigger-Gilbert silt loam to determine if cotton yields could be increased by soil applications of organic and inorganic waste materials. The waste materials were applied using two methods of application, broadcast incorporated and as vertical mulch directly under the row. The waste materials were municipal biosolids (MB), composted sewage sludge (CSS), papermill sludge (PS), and papermill boiler ash. Applications were made with each material and with selected combinations of the materials.

The method of application had little or no consistent effect on response to the waste materials. Because the broadcast method is less expensive, this would be the preferred method of application. The application of waste materials had positive effects on cotton growth and yield and soil properties. Lint yield and plant height increased with application of MB, CSS, and boiler ash in the year of application and in the following 3 years. Yield increases ranged from 55% for MB applications and 40% for CSS applications. Much of the benefits from the amendments were from the nutrients they contain, especially N. Additionally, some of the amendments increased soil pH and the soil levels of P, K and Ca. In contrast to MB and CSS, application of PS decreased yield 70% and plant height 12 to 26% in the year of application and had no consistent residual effect on yield in the following 3 years. The problem with PS was its high C:N, which caused extensive N immobilization of soil and fertilizer N. Boiler ash proved to be, as expected, an effective liming material and raised the soil pH. This was particularly beneficial in the vertical mulch treatment because of the low pH of the Gigger-Gilbert subsoil that normally contains toxic levels of Al and Mn.

In addition to the nutritional benefits, the amendments had other beneficial effects. We know this is the case because the waste treatments increased yield above that obtained with standard fertilizer and liming practices. The organic components probably provided increased water holding capacity and water infiltration. The vertical mulch treatments eliminated the shallow hardpan directly under the row, which allowed additional water storage and root development. Examination of root development patterns revealed that roots were

limited to the mulched area and did not grow into the undisturbed subsoil. The interface between the mulch and subsoil proved to be the area of greatest root development.

We concluded that waste materials with a low C:N and boiler ash were effective soil amendments that quickly improved soil productivity and cotton yield and that PS, with its high C:N, should not be applied soil-incorporated because of the potential for N immobilization.

(See Full Paper on Page 80.)

CROP RESPONSE TO ONE-PASS FALL LAND PREPARATION ON THE FLOOD PLAIN CLAY SOIL IN MISSISSIPPI

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INTERPRETIVE SUMMARY

Conservation tillage systems including no-tillage (NT) may reduce machinery, fuel, and labor costs, as well as soil erosion. Most studies have shown that after the first 2 years on coarse and medium texture soil, NT yields were equal or higher than conventional tillage (CT). However, on the poorly drained silty clay soils, NT yields have been more variable. Therefore, field studies were conducted evaluating crop yield response to selected tillage rotation and systems on a Leeper silty clay loam soil (fine, montmorillonitic, nonacid, thermic, Chromudertic Haplaquepts).

In all studies, the rotation treatments had duplicate plots so each crop-tillage treatment was present each year. Continuous cotton tillage treatments evaluated were: 1) NT (fall mowed cotton stubble and no cultivation during the growing season); 2) MT (fall-mowed cotton stubble, fall bed followed by (fb) harrow before planting with two postemergence cultivations); 3) CT (fall mowed stubble, chisel, disk, bed fb spring re-bed and harrow before planting with two postemergence cultivations); 4) RT (fall mowed cotton stubble fb a harrow before planting and two postemergence cultivations with a high clearance cultivator equipped with ridger wings (ridge-till cultivator); and 5) FPTB (fall mowed cotton stubble fb FPTB and a harrow before planting with two postemergence cultivations). Corn-cotton 2-year rotation tillage treatments evaluated were: 1) RT corn planted no-till and one postemergence cultivation with a ridge-till cultivator fb MT cotton (fall disk corn stubble, fall bed with a harrow before planting and two postemergence cultivations); and 2) RT corn planted no-till with one postemergence cultivation fb fall mowed corn stubble and RT cotton with two postemergence cultivations.

The 5-year (1994-98) cotton-corn rotation tillage study indicated that in continuous cotton, NT had lint yield equal to CT 3 of 5 years. Ridge-tillage (RT) had more variable and lower lint yield than minimum tillage (MT), and CT, 2 of 5 years. Conversely, a one-pass fall paratill bed system (FPTB) produced more lint than both NT and RT 3 of 5 years and CT 4 of 5 years. The 5-year mean lint yields for FPTB, NT, RT, and CT in continuous cotton were 861, 700, 573, and 716, lb/A, respectively. FPTB 5-year mean yield was higher than NT, RT, CT, and RT cotton following RT corn. MT cotton following RT corn had a 5-year mean lint yield of 809 lb/A, 12% more than RT cotton following RT corn and equal to FPTB in continuous cotton.

The tillage treatments for both corn and soybean in the 2-year rotation study were NT, RT, and FPTB. The 6-year (1994-99) study indicated no yield response to a 2-year rotation for either crop; therefore, the results were averaged over rotation. FPTB produced more soybean than NT 5 of 6 years and more than RT 3 of 6 years. Corn yield was similar to soybean in that FPTB produced more yield than NT 4 of 6 years and more than RT 2 of 6 years. FPTB 6-year yield average for corn was 125 and 36 bu/A for soybean. In both corn and soybean, FPTB had 8% more yield than RT and 16% more than NT.

The results indicate tillage may be more necessary on the poorly drained silty clay loam soils to optimize yield in a non-irrigated environment. Cotton following a high residue crop improved lint yield. The one-pass fall based FPTB tillage system for corn, cotton, and soybean was more productive than NT, RT, and CT. Improved yield for the FPTB system may be related to improved water infiltration and root growth. However, for the FPTB system to be successful, one must execute a fall tillage plan. In the Midsouth, this often involves doing the FPTB operation at the same time of harvest. Since this stale seedbed system involves planting no-till, spring labor needs are reduced and the system also allows for more timely planting and thereby improves crop yield potential.

SOIL DISRUPTION BY FIRE ANTS IN CONSERVATION AND CONVENTIONAL TILLAGE TREATMENTS

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INTERPRETIVE SUMMARY

Fire ants are endemic to the southeastern Coastal Plains. As measured in this experiment, mound numbers ranged from 5 to 49/A. At the higher end of this range, ants could conceivably have a significant effect on soil properties, possibly causing more leaching of nutrients to the groundwater. We measured the amount of soil disruption for a conventional management system that used management techniques similar to practices traditionally used by producers in 1995 (disking fields and in-row subsoiled-planting) vs an innovative management system that used advanced management techniques (paratilling and planting into undisked stubble). We used soil strength probes with easily detachable handles to measure soil disruption within the mounds. For comparative purposes, soil strength readings were also taken in undisturbed soil near the mounds. Our preliminary results show that the conventional treatment had a greater volume of soil disruption than the innovative treatment. However, depth of disruption was deeper in the innovative treatment. When readings taken in the mounds were corrected with data taken in nearby soil, depth and volume of disruption were greater for ant activity in the innovative vs the conventional treatment, probably because innovative tillage disrupted more of the hard subsoil than conventional tillage. Deeper disruption could lead to more leaching of nutrients to the groundwater. Tentative results indicate that innovative (conservation) tillage may be more susceptible to deep leaching of nutrients because of ant activity.

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PRESERVING GRAIN SORGHUM STAND DENSITY IN THE PRESENCE OF THE RED IMPORTED FIRE ANT

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INTERPRETIVE SUMMARY

INTRODUCTION

The red imported fire ant (RIFA), *Solenopsis invicta* (Buren) is an introduced pest that continues to spread steadily into areas of the United States with mild climates and adequate sources of food. The RIFA has been a serious pest in the southeastern United States for many years. This pest affects several agricultural crops, including soybean, corn, and grain sorghum. With the increasing adoption of conservation tillage in Louisiana production systems, the RIFA has become more important as a pest, causing severe damage to grain sorghum seeds and seedlings.

The use of reduced-tillage systems results in a favorable environment for RIFA colonies, increasing its pest severity in sorghum fields. Conservation tillage methods often leave sorghum seeds exposed in an open or partially-closed seed furrow. This is especially true when planting occurs in dry soil conditions. Conservation tillage is also less disruptive to RIFA colonies established in crop fields. The RIFA takes advantage of these conditions and attacks the exposed sorghum seeds by breaking the seed coat, and removing the germ followed by the starch. Because of their small size, sorghum seeds are also easily removed from the furrow and carried to the ant nest.

Research conducted in Louisiana has focused on developing insecticide use strategies to maintain low levels of RIFA damage while keeping control costs to a minimum. An essential component of this research has been the evaluation of seed treatments and different methods and rates of soil insecticides to prevent RIFA damage to grain sorghum. The purpose of this experiment is to study the efficacy of Gaucho (imidacloprid) as a sorghum seed treatment and compare it with the efficacy of selected soil insecticides for control of the RIFA in seedling, no-till grain sorghum.

MATERIALS AND METHODS

Experiments were conducted at the Macon Ridge location of the Northeast Research Station, near Winnsboro, Franklin Parish, LA, from 1994 to 1999. Sorghum hybrids used in the experiments across the years included Pioneer Brands 8333 and 8282, Asgrow A570 and Mycogen 3636 planted from May to early June. These hybrids were planted no-till with a John Deere planter into a Bermudagrass sod containing high densities of RIFA mounds. Insecticide treatments and years of evaluation included Gaucho 480FS from 1994 to 1999; Lorsban 15G from 1994 to 1997; Lorsban 4E from 1996 to 1999; and Furadan 4F from 1995 to 1997. Gaucho 480FS (8.0 fl oz of product per hundredweight seed) was applied directly to the sorghum seeds as seed treatment (SEEDT) prior to planting. A granular insecticide (Lorsban 15G at 0.5 lb ai/A) was applied T-banded at planting (T-BAND). Lorsban 4E (0.5 lb ai/A) was applied as a pre-emergence surface spray (PRE) immediately post-plant. Furadan 4F (1.0 lb ai/A) was applied as in-furrow spray at planting (IFSAP). A CO, charged system calibrated to deliver 5 gpa at 35 psi through 8002E flat fan nozzles (1/row) was used for the IFSAP insecticide. The PRE insecticide was applied at 10 gpa at 35 psi through 8001 flat fan nozzles (1/row) in a band 20 inches wide over the row center.

RIFA densities were recorded on a weekly basis during the first month after planting. RIFA numbers were estimated by placing in each plot an unruled index card (3 X 5 inches) baited with peanut butter and recording the number of ants attracted to it after 1 to 3 hours. Plant population densities, plant heights, and intra-row skips > 12 inches between plants were counted approximately 1 month after planting. Plant population densities were measured by sampling the entire two center rows in each plot. Plant height estimates were obtained by measuring 20 plants in each plot. Intra-row skips were recorded by counting the number of skips > 12 inches between plants in the two center rows in each plot.

All data were analyzed by analysis of variance (ANOVA), and treatment means were compared with the untreated control using Dunnett's two-tailed ***t***-test. Differences are significant at the 5.0% level.

RESULTS AND DISSCUSSION

Numbers of RIFA were reduced by both Lorsban treatments compared with all other insecticide treatments and the untreated control. RIFA numbers in the Gaucho- and in the Furadan-treated plots tended to be lower but not significantly different from those in the untreated plots. Plant population densities were significantly improved with the use of Gaucho-treated seeds and the granular Lorsban compared with all other insecticide treatments and the untreated control. Over the years, there was a consistent trend of higher plant densities in plots planted with Gaucho-treated seeds. The overall values indicate a 77% improvement in plant densities in Gaucho-treated plots compared with plots where no protection was used.

Although the average plant height was significantly improved with the use of insecticide treatments (with the exception of Lorsban 4E), yearly plant height data did not show a consistent pattern for any of the insecticide treatments evaluated during the 6 years of this study.

All insecticide treatments, except Lorsban 4E, significantly reduced the number of intra-row skips > 12 inches between plants compared with the untreated control. Plant skips were reduced by half in the Gaucho treatment when compared with other insecticide treatments and by almost two thirds when compared with the untreated control.

Gaucho seed treatment performed consistently well during this 6-year study. It improved sorghum plantings as indicated by higher plant population densities and fewer intra-row skips > 12 inches between plants. The consistent performance of Gaucho is important since effectiveness of many approved soil insecticides varies with soil moisture conditions.

USING GIS, REMOTE SENSING AND WATER QUALITY MODELING TO ESTIMATE ANIMAL WASTE POLLUTION POTENTIAL

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INTERPRETIVE SUMMARY

Nonpoint source (NPS) pollution from agricultural areas is recognized as a national problem. One of the principal sources of NPS problems is excessive application of animal manure in areas where animal production facilities are concentrated. Alabama, by having a large poultry industry, shares in this problem. Last year, the State of Alabama adopted a regulation that requires animal producers to implement best management practices to minimize surface and groundwater pollution.

One of the needs faced by poultry producers in the state is to identify areas where poultry litter may or may not be applied. Even though several researchers have used hydrologic/water quality models to identify such areas, most of these models are very complex in nature and suffer from large input data requirements. The objective of this research was to develop a GIS-based Animal Waste Pollution Potential Index (AWPPI) that can be used to rank areas based on the potential of nutrient transport from land-application areas to receiving streams.

The study was conducted in the Crooked Creek watershed in Cullman County, Alabama. There are 144 poultry houses located in this watershed. The AWPPI was developed as a function of poultry litter application rate, nutrient availability factor, and delivery ratio. The input data required by this model are watershed topography, litter application rate, and area where litter is applied. Watershed data were developed using digital elevation model data available from U.S. Geological Survey. Information about location of poultry houses was derived from high resolution color infrared photos.

The AWPPI model was developed in ArcView GIS environment. AWPPI for losses of both nitrogen and phosphorus was estimated using this method, and subwatersheds within Crooked Creek watershed were ranked based on AWPPI. No significant difference in subwatershed rankings was indicated for the two indices. Analysis of AWPPI indicated that it was significantly correlated with poultry house density and the ratio of farm area where litter is applied to the subwatershed area. The ranking of areas using this method represent a simplified approach to identifying the areas susceptible to NPS pollution from poultry litter application. Farmers and regulators can very easily use this method to identify areas suitable for locating new poultry houses or areas where poultry litter can be applied without a significant risk of NPS pollution. All the input data required can be readily assembled from on-line data sources. This method also has the potential to be developed as an internet-based large-scale AWPPI using GIS.

(See Full Paper on Page 136.)

ECONOMIC ASSESSMENT OF IRRIGATED AND NONIRRIGATED SOYBEAN CROPPING ROTATIONS ON A CLAY SOIL

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ABSTRACT

Experiments were conducted in Keiser, Arkansas, on a Sharkey silty clay soil for 3 years to examine soybean, wheat, and grain sorghum rotations. Treatments also included selected variation of conventional versus no-till and alternative wheat residue management. Both irrigated and nonirrigated strategies were investigated. Agronomic results show that irrigated soybean yields average about 20 bu/A (1344 kg/ha higher than comparably treated nonirrigated soybean treatments. Economic analysis using enterprise budgets reveals three top rotations, regardless of irrigation: continuous monocropped soybean, wheat fallow followed by monocropped soybean, and wheat-soybean double-cropped with burned wheat stubble. Statistical analysis demonstrates the profitability of irrigation and the dependence of the most economical crop rotation upon weather conditions.

IMPACT OF SOIL CONSERVING SEEDBED PRACTICES ON ANNUAL RYEGRASS-CEREAL RYE ESTABLISHMENT IN BERMUDAGRASS SOD

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INTERPRETIVE SUMMARY

Research Question

Beef and milk producers across the Coastal Plain of north Louisiana risk high levels of soil erosion on bermudagrass pastures when pastures are thoroughly prepared for fall plantings of annual ryegrass and cereal rye. If soil conserving seedbed practices are to be performed on bermudagrass pastures, producers must have information on the early season forage yield and beef and milk production potential of annual ryegrass-cereal rye following soil conserving seedbed practices. Because information is limited on soil conserving seedbed practices on a bermudagrass sod versus a thoroughly prepared seedbed for ryegrass-rye pastures, a 2-year study was conducted at the Hill Farm Research Station.

Literature Summary

Higher forage yield performances of annual ryegrass and/or cereal rye from fall plantings in bermudagrass sods grown on Coastal Plain soils were reported when no till, reduced tillage, or chemical burndown seedbed practices were compared with undisturbed sods. The comparative yield performance of these grasses from fall plantings made into thoroughly prepared seedbeds of bermudagrass sod with these soil conserving seedbed practices has not been thoroughly investigated.

Study Description

Field experiments were conducted in a common bermudagrass pasture on mixed Darley-Guyton (thermic, clayey, kaolinitic, Typic Hapludult) soil having a 0 to 4% slope. The soil tested high in P and K and had a soil reaction of pH 6.2. Each year, after the pasture was mob-grazed continuously for approximately 30 days with 3 cow-calf pairs/A, the following September seedbed preparation practices were carried-out 1) thoroughly prepared seedbed (TPSB) — 3 off-set diskings. lpulverizing disking, 1 harrowing ;2) reduced tillage A — 2 off-set diskings of the sod, 1 harrowing; 3) reduced tillage B — 1 off-set disking of the sod; 4) no till A — standing forage on sod cut to 2-inch stubble height and removed; 5) no till B — undisturbed sod; 6) chemical treatment A — Roundup at 1 qt/A (1 lb ai/A) broadcast on the sod; 7) chemical treatment B —Roundup at 1 qt/A (lb ai/A) broadcast on the sod, burndown sod burned; 8) chemical treatment C — Gramoxone Extra at 1 pt/A (.3 lb ai/A) broadcast on the sod; 9) chemical treatment D — Gramoxone Extra at 1 pt/A (.3 lb ai/A) broadcast on the sod, burndown sod burned; 10) chemical treatment E — Roundup at 1 qt/A (lb ai/A) broadcast on the sod, Gramoxone Extra at 1 pt/A (.3 lb ai/A) broadcast on burndown sod; and 11) chemical treatment F — Gramoxone Extra at 1 pt/A (.3 lb ai/A) broadcast on the sod, Roundup at 1 qt/A (1 lb ai/A) broadcast on the burndown sod. On September 20, Maton cereal rye seed was drill-planted into seedbeds at 60 lb/A and over-seeded with drill-planted Marshall annual ryegrass at 20 lb seed/A. After a broadcast application of 50 lb/A of N as ammonium nitrate on October 15, potential forage availability on TPSB was deemed sufficient by six independent observers for continuous grazing of stocker steers, stocked at 1.5 hd/A on November 12. Thereafter, forage cut to 3-inch stubble height on each seedbed practice was harvested, wet weight yields recorded, percent dry matter determined, and dry matter yields calculated. Where present, bermudagrass was separated from ryegrass-rye; the true yield for annual ryegrass-cereal rye was determined. Moreover, on the basis of dry matter yield intake requirements, beef and milk production across treatments were calculated. Overall, data collected from four replicated blocks of seedbed practices were subjected to statistical analyses using PROC GLM (SAS, 1989).

Applied Questions

Will the late fall yield performance of ryegrass-cereal rye on no till and reduced tillage prepared seedbeds of bermudagrass compare favorably with a thoroughly prepared seedbed?

No. The November yield of 1,100 lb/A for the thoroughly prepared seedbed (TPSB) was significantly higher than those of no-till practices A at 248 lb/A and B at 149 lb/A. Yields of reduced tillage practice A at 583 lb/A and B at 461 lb/A were also significantly lower than that of TPSB. Calculated stocker-steer beef production advantage of TPSB over no-till practices A and B was 106 and 138 lb/A; over reduced tillage practice A and B, it was 76 lb and 93 lb/A, respectively. Jersey cow calculated milk production advantage of TPSB over no-till practices A and B was 295 and 320 lb/A; over reduced tillage practice A and B, it was 176 lb and 216 lb/A, respectively.

Will the late fall yield performance of ryegrass-cereal rye on burndown bermudagrass sod following use of Roundup and Gramoxone Extra alone or in combination compare favorably with a thoroughly prepared seedbed?

No. The November yield of 1,100 lb/A for the thoroughly prepared seedbed (TPSB) was significantly higher than those of chemical burndown sod treatments A at 369 lb/A, B at 393 lb/A, C at 228 lb/A, D at 382 lb/A, E at 457 lb/A, and F at 289 lb/A. Calculated stocker-steer beef gain/A advantage of TPSB over chemical burndown sod treatment A, B, C, D, E, and F was 105, 102, 126, 105, 93, and 117 lb beef/A, respectively. Jersey cow milk production advantage of TPSB over chemical burndown sod treatment A, B, C, D, E, and F was 245, 240,295,245,220, and 275 lb milk/A, respectively.

Recommendations

September drill-plantings of annual ryegrass-cereal rye in thoroughly prepared seedbeds out-yielded all drill-plantings made in soil conserving seedbeds on bermudagrass sods. Soil conserving practices for seedbed preparation of bermudagrass sods that will enhance annual ryegrass-cereal rye productivity in the fall need to be developed.

COTORAN WASH-OFF FROM COVER CROP RESIDUES AND DEGRADATION IN GIGGER SOIL

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INTERPRETIVE SUMMARY

Cover crop residues on the soil surface of no-till operations will intercept a portion of spray-applied herbicides. Therefore, the effectiveness of the herbicide will depend, in part, on rainfall to wash the herbicide from the residue and onto the soil. How fast a herbicide is degraded in the soil may also depend on tillage, as well as cropping system. Ideally, a herbicide will persist long enough to be effective against target weeds but not carry-over into subsequent growing seasons. This research examined the wash-off of Cotoran (fluometuron) from native winter annuals, vetch, and wheat cover crop residue. At most, only about half of the fluometuron spray-applied to these materials was washed off by a series of three simulated 0.8-inch rainfalls. The most fluometuron was removed from the native vegetation mix. Relative amounts of fluometuron washed off were inversely related to increasing strength of adsorption of fluometuron to the different plant residues. Absolute amounts of fluometuron washed off could be predicted on the basis of how strongly the residue adsorbed fluometuron.

Both tillage (conventional- and no-) and type of cover crop (native vegetation, hairy vetch, and wheat) affected how rapidly fluometuron degraded in a loess soil. Fluometuron in no-till surface soil was degraded more than twice as fast as in corresponding conventional-till soil. This result was consistent with greater microbial activity in the no-till soil. Long-term use of vetch cover crop slowed fluometuron degradation relative to either native vegetation or wheat. In no-till soil with native mix or wheat cover crop, no fluometuron could be recovered after a 60-day incubation period. In contrast, about 35% of the fluometuron applied to no-till vetch soil remained and about 50% of the fluometuron applied to the conventional-till vetch soil remained 60 days later.

Since native vegetation produced much less biomass than either vetch or wheat, wash-off would likely play a more minor role in the efficacy and environmental fate of fluometuron than is the case for vetch or wheat. Interception of fluometuron by vetch residue, coupled with its slow release by wash-off and slow degradation in the soil, may provide longer weed control. Any prolonged susceptibility to loss in runoff would be likely counterbalanced by the high sorptive capacity of vetch residue.

(See Full Paper on Page 144.)

USE OF PRECISION AGRICULTURE TECHNOLOGY TO EVALUATE SOIL COMPACTION

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INTERPRETIVE SUMMARY

The alluvial sandy and silt loam soils of the Mississippi, Ouachita, and Red River Valley are very easily compacted. The compaction zone or hardpan will vary in depth depending upon the past history of tillage. However, the compacted zone usually begins 6 to 10 inches below the surface of the soil and may be 2 to 5 inches thick. This compacted zone restricts root growth, water penetration, and water retention, thus crop yields can be reduced

The compacted zone can be temporarily eliminated by subsoiling at depths of 12 to 15 inches. The subsoiler point should run 2 to 3 inches below the compacted zone. Research has shown that subsoiling to a greater depth will not increase yields. Research also indicates that it is best to subsoil in the fall when the soil is dry. This allows winter rains to infiltrate the soil and be retained to produce the following year's crop.

Producers often ask questions about how frequently a field should be subsoiled and if the entire field should be subsoiled. On-farm demonstrations indicate that producers who use a permanent row, controlled traffic system can maintain yields by subsoiling every second or third year. However, producers indicate they need a method of evaluating compaction problems to assist in making decisions concerning when to subsoil.

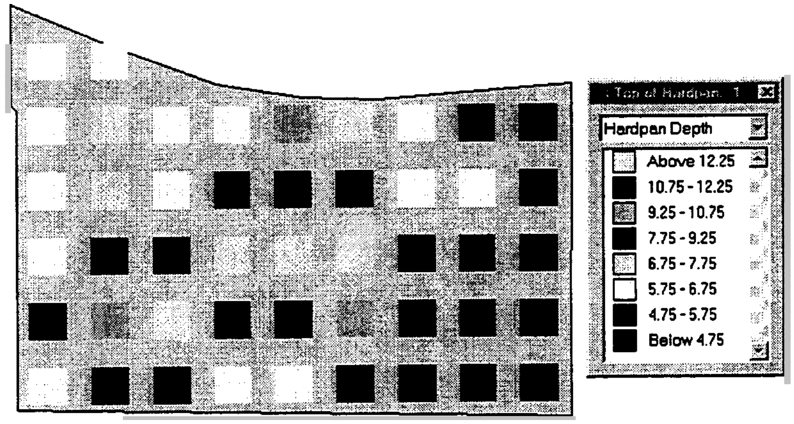
On-farm demonstrations indicate that the depth and density of compacted zones vary considerably in large fields. To obtain a better understanding of soil compaction, Extension specialists and county agents used a GPS with differential correction and a Dickey-John soil compaction tester to evaluate hardpan depth in several northeast Louisiana fields. Grid size varied from 1.0 to 2.5 acres.

To evaluate soil compaction in a cooperating producer's field, the GPS was used to locate the center of the grid. Compaction was evaluated by measuring the distance from the soil surface to the point where the resistance to penetration exceeded 300 PSI. The hardpan depth was measured in four places within a 15-ft radius of the center of the grid. The depth of the hardpan was recorded, and the average depth was used with mapping software to prepare color-coded maps of hardpan depth.

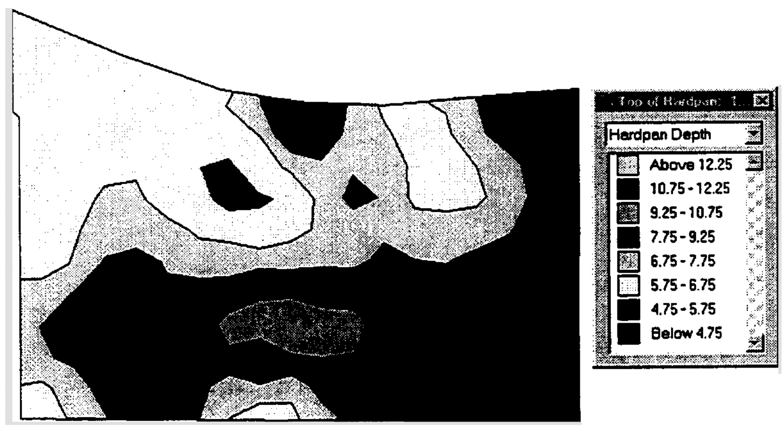
Morehouse Parish – Mer Rouge, LA Area:

Hardpan depth and thickness was evaluated using 1.0-acre grids in a 48-acre irrigated field on October 9, 1996. Rilla Silt Loam was the predominant soil type in this field. Maps illustrating hardpan data are shown below.

Base Data & Sample Sites - Hardpan Depth: 10-09-96
Min. 5.0" – Avg. 8.0" - Max. 12.0"



Hardpan Depth: 10-09-96
Min. 5.0" - Avg. 8.0" - Max. 12.0"

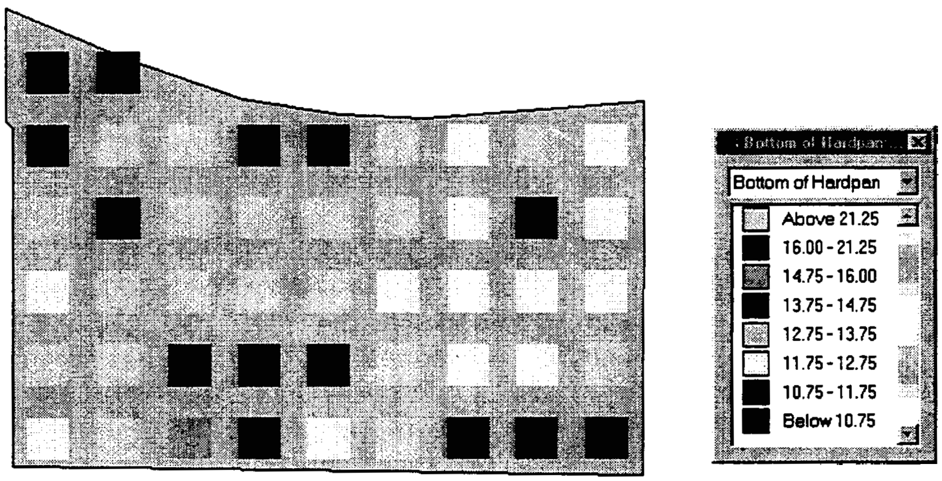


Nolan Clark Farm - Morehouse Parish
Richard Letlow, County Agent
Planted Area: 44.8 Acres

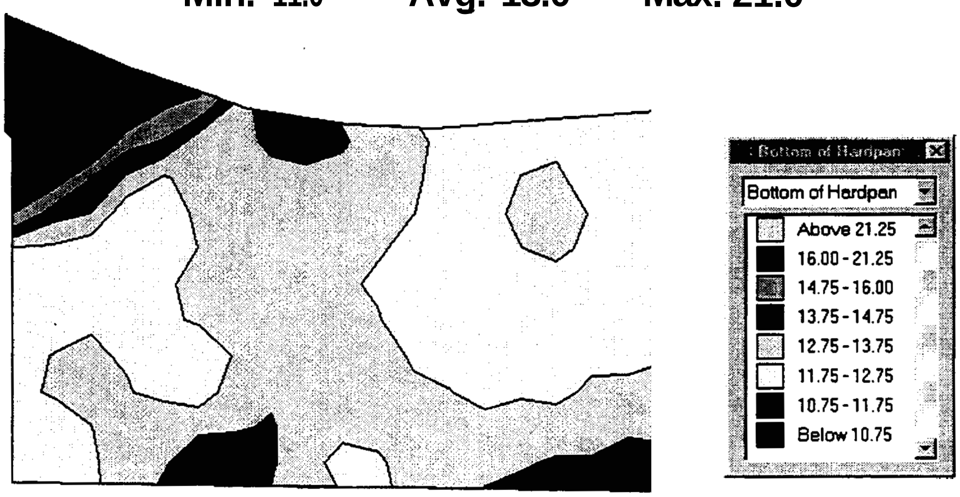
N.Clark99
11-10-99
Scale: 1"=350

Hardpan depth was 9 inches or less in 42 of the 47 grids in this field. The distance from the soil surface to the bottom of the hardpan was 14 inches or less in 43 of the 47 grids. This would indicate that a subsoiling depth of 15 to 16 inches would fracture the hardpan in these areas. The other four grids had a different soil type. The bottom of the hardpan was below the depth of a normal subsoiling operation. However, subsoiling 15 to 16 inches deep should fracture an area large enough to improve plant root development and increase soil water storage.

Base Data & Sample Sites - Bottom of Hardpan: 10-09-96
Min. 11.0" - Avg. 13.0" - Max. 21.0"



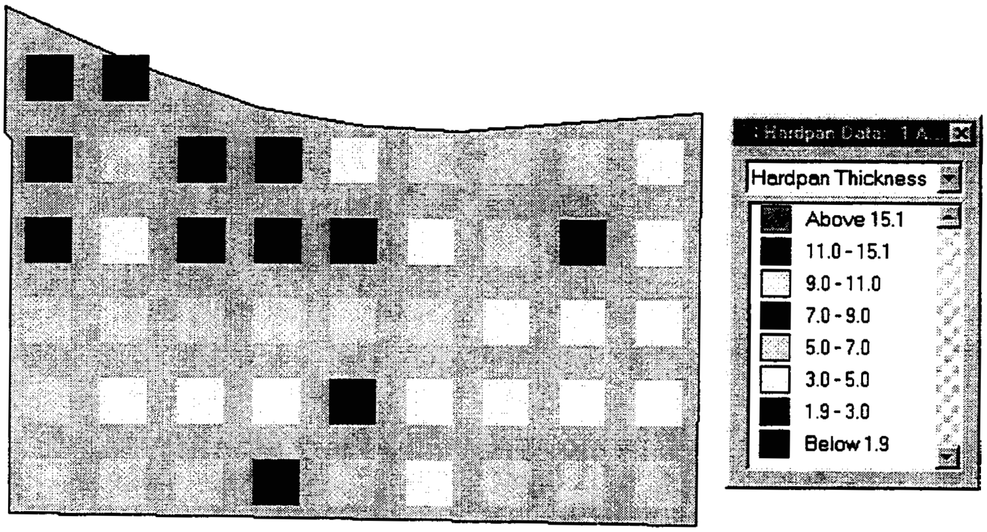
Bottom of Hardpan: 10-09-96
Min. 11.0" - Avg. 13.0" - Max. 21.0"



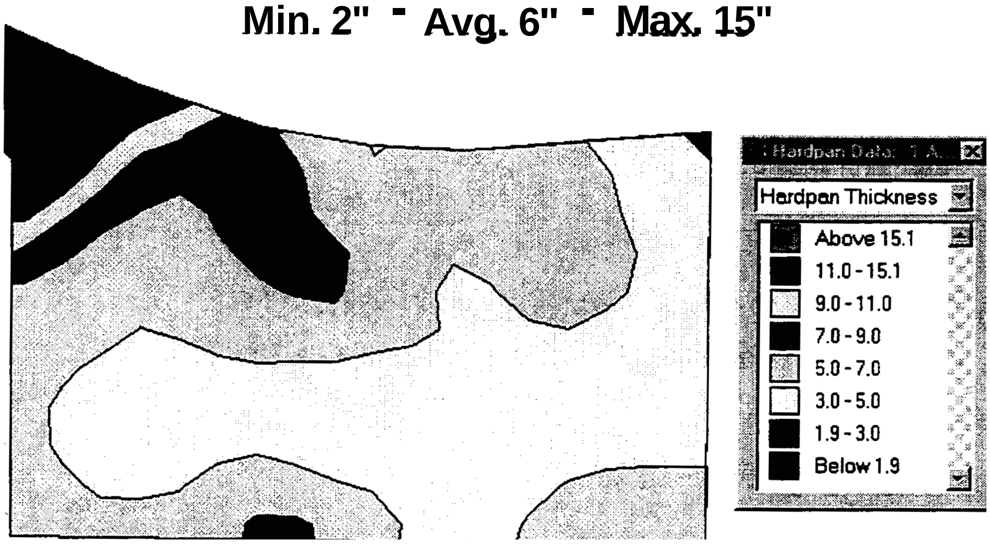
Nolan Clark Farm - Morehouse Parish
Richard Letlow, County Agent
Planted Area: 44.8 Acres

NClark99
11-10-99
Scale: 1"=350

Base Data & Sample Sites - Hardpan Thickness: 10-09-96
Min. 2.0" - Avg. 6.0" - Max. 15.0"



Hardpan Thickness: 10-09-96
Min. 2" - Avg. 6" - Max. 15"



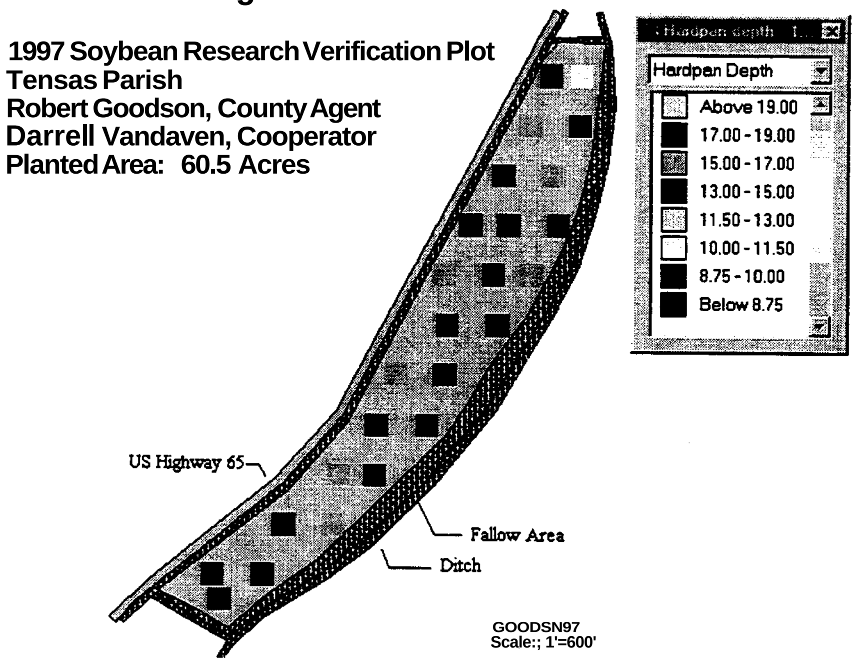
Nolan Clark Farm - Morehouse Parish
Richard Letlow, County Agent NClark99
Planted Area: 44.8 Acres 11-10-99

This field was checked for compaction a second time on November 10, 1999. The cooperator had adopted a permanent row, controlled traffic tillage system. Annually subsoiling the drill area had removed the compacted layer in this area.

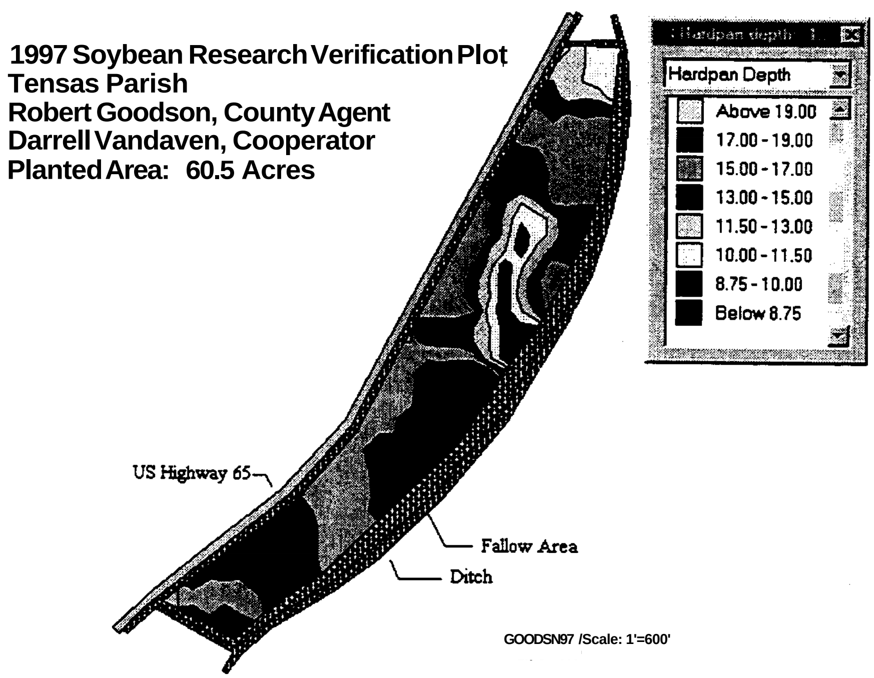
Tensas Parish - St Joseph, LA Area:

Hardpan depth was evaluated using 2.4-acre grids in **a** 60.5-acre field on October 16, **1997.** Silty Clay was the predominant soil type in this field

Base Data &Sample Sites - Hardpan Depth: 10-16-97
Min. 9.0" - Avg. 15.1" - Max.18.8"



Hardpan Depth: 10-16-97
Min. 9.0" - Avg. 15.1" - Max. 18.8'

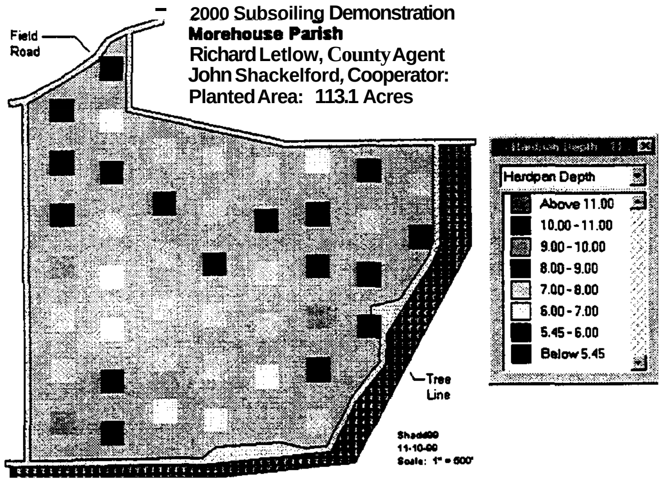


Hardpan depth was less than 15 inches in 9 of the 25 grids. This would indicate that subsoiling would probably increase yields in 36% of this field. Hardpan depth was 15 inches or more in 64% of the field. It is doubtful if subsoiling would increase yields in this area. The compacted zone was too thick to determine the distance to the bottom with the soil compaction tester. The color-coded map indicated that the compacted zones were located in the north and center portion of the field. This map can be used as a guide for subsoiling areas where hardpan depth is less than 15 inches.

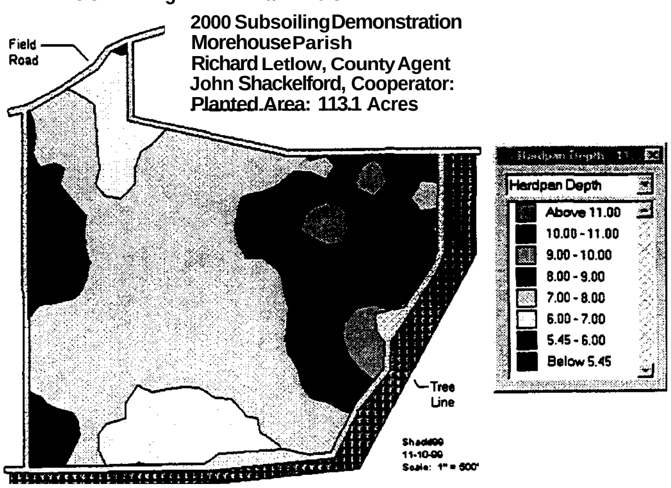
Morehouse Parish - Bonita, LA Area:

Hardpan depth was evaluated using 2.57-acre grids in a 113.1-acre field on November 10, 1999. Sandy Loam was the predominant soil type in this field. The producer was using a permanent row, controlled traffic system. However, this field had not been recently subsoiled. Hardpan depth was measured from the center of the row to the top of the hardpan or compacted layer. Hardpan depth varied from 5.5 to 10.8 inches with an average of 7.7 inches.

Base Data 8 Sample Sites - Distance From Top of Row to Hardpan: 11-10-99
Mi. 5.5" - Avg. 7.7' - Max. 10.8'

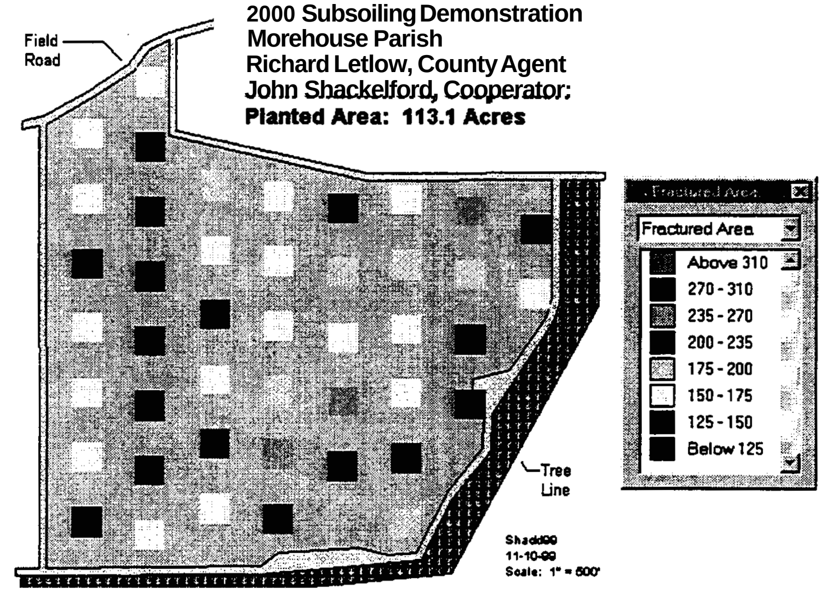


Distance From Top of Row to Hardpan: 11-10-99
Min. 5.5' - Avg. 7.7' - Max. 10.8'

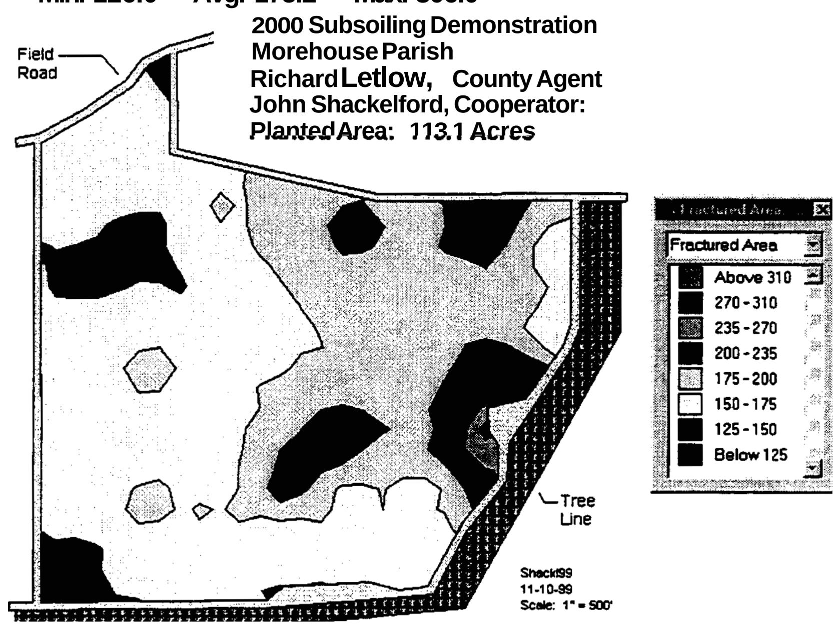


The hardpan depth in the drill area was also measured in 3-inch increments from 12 inches left to 12 inches right of the row centerline. This data was used to compute the square inches of fractured area in the center of the row. Fractured area ranged from 126 to 306 square inches with an average of 175 square inches.

Base Data & Sample Sites - Square Inches of Fractured Area In Center 24" of Row: 11-10-99
Min. 126.0 - Avg. 175.2 - Max. 306.0



Square Inches of Fractured Area In Center 24" of Row: 11-10-99
Min. 126.0 - Avg. 175.2 - Max. 306.0



Based on the shallow hardpan depth, the cooperator subsoiled the drill area. Compaction in this field will be evaluated after harvesting the 2000 crop. Based on the hardpan depth and fractured area, a decision will be made concerning subsoiling for the following years crop.

Conclusions:

This limited evaluation of compaction on cooperating producers fields indicates that a soil compaction tester, GPS and mapping software can be used to evaluate soil compaction problems. This technology can be used to record compaction data and compare changes from year to year. This will allow producers to more accurately determine if subsoiling is justified and then subsoil only those areas of the field where subsoiling is most likely to increase yields.

It is recommended that these demonstrations be continued to develop a better understanding of the processes involved in the reforming of compacted layers in fields with permanent row, controlled traffic tillage systems.

CONSERVATION TILLAGE SYSTEMS FOR COTTON ON MISSISSIPPI RIVER ALLUVIAL SOILS

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ABSTRACT

Questions remain on the optimum combination of conservation tillage practices for cotton *(Gossypium hirsutum* L.) production on some of the common alluvial soil types in Louisiana. Therefore, a field study was conducted to investigate various conservation tillage practices on Sharkey clay and Commerce silt loam. A total of 16 treatments were established by combinations of seedbed preparation techniques (no-till, stale seedbed, and conventional till), winter cover crops [wheat *(Triticum aestivum* L.), hairy vetch *(Vicia villosa* Roth.), or native vegetation], cultivation (with and without), and in-row sub-soiling in the fall (with and without) on two soil types (Commerce silt loam and Sharkey clay) from 1996-1999. On Sharkey clay, there were no treatment differences in early cotton growth or lint yield. On the silt loam, there was a year by treatment interaction with regards to early plant height, nodal development prior to flowering, and lint yield. In 1997, there was adequate rainfall but below average temperatures, thus plants in conventionally prepared beds were 1.5 in. taller with 1.1 more nodes than plants in the no-till seedbeds. Whereas with early dry conditions in 1998, plants in the no-till treatments were 1.1 in. taller with 1.3 more nodes than plants in conventional seedbeds. There was no difference in lint yield on the silt loam in 1996 and 1997. Whereas in 1998 and 1999, lint yield was increased by no-till and in-row subsoiling by 87 and 66 lb/A, respectively.

IMPROVING NITROGEN FERTILIZATION EFFICIENCY FOR NO-TILLAGE CORN PRODUCTION

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INTERPRETIVE SUMMARY

The environmental concern over nitrogen (N) fertilization of row crops has increased the emphasis to improve N efficiency. The need for improving efficiency is greater when surface application is considered for no-till (NT) corn production. Previous research indicates N efficiency for NT corn production can be increased by injecting rather than broadcasting N, but efficiency may also be increased through management practices. These practices include applying N after planting and root system establishment. Additional considerations would include N source to apply and the N rate to apply. Research was conducted over a 3-year period (1996-1998) on two loess-derived soils (Memphis silt loam and Collins silt loam) to evaluate strategies for increasing N efficiency for NT corn. Nitrogen treatments included broadcasting urea and urea-ammonium nitrate (UAN) at 150 lb N/A at planting, injecting UAN at 150 lb N/A at planting, and injecting UAN at the 6- to 8-leaf growth stage at 150, 130, 110, and 90 lb N/A. Some treatments received a 10 lb N in-furrow starter. Pioneer 3245 was planted on the Memphis soil and Pioneer 3163 was planted on the Collins soil. The experimental design was a randomized complete block with six replications. Delayed N applications were 51, 52, and 44 days after planting (DAP) on the Memphis soil and 43, 42, and 48 DAP on the Collins soil. Ear leaves were collected at mid-silking for N analysis.

The effect of N treatments on both yields and leaf N concentrations varied over the 3 years for yields produced on both soils. The 3-year average yields need to be considered since N recommendations are based on multi-year data.

In most environments, NT corn yields, leaf N concentrations, and N efficiency can be increased by delaying N application until the corn is in the 6- to 8-leaf growth stage. However, the benefit from the delayed application is dependent upon weather conditions between planting and the delayed application. These data indicate that delaying the N application can increase yields by 5 to 15% if rainfall is not a limitation and the N rate can be reduced by 15 to 20% without reducing yields. During certain years, leaf N concentrations were increased by delaying the N application, but yields were not increased due to drought stress between silking and black layer. These observations are worthy of consideration for either improved yields through management or reducing N rates either during a time of restricted capital or for production close to environmentally sensitive areas.

(See Full Paper on Page 155.)

WATER QUALITY/SOIL EROSION EDUCATION FOR MANAGERS OF CROP LAND

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INTERPRETIVE SUMMARY

A multi-year, multiple-discipline water quality educational program was initiated with partial support from EPA 319(h) water quality funds. The objective is to reduce sediment reaching streams that drain from watersheds where crops are grown. The emphasis of this grant program is on reduced tillage, no tillage, winter flooding of fields, and improving cover during non-crop periods. To evaluate the effect of this educational emphasis, any changes that managers implement during the time of the program are recorded and the results are tabulated. These data will be entered into the revised RUSLE model to estimate the amount of topsoil that is conserved as a result of the educational effort for this grant.

To get the initial momentum of this program started, we conducted a multi-agency training program in Little Rock on December 15, 1997. Natural Resources Conservation Service, Arkansas Soil and Water Conservation Commission, Arkansas Department of Environmental Quality, and the University of Arkansas Cooperative Extension Service developed the program jointly; although, it was conducted primarily by Extension staff for all of the technical personnel of the various organizations.

The educational effort contains elements of many effective technology transfer programs. A rice and a soybean field were divided into two watersheds each, one portion using the farm manager's conventional practice. Conservation practices were selected by Extension and NRCS personnel for the other portion of the field in a separate, but similar, watershed. The production practices in both fields were monitored for two growing seasons. University of Arkansas recommendations, including the conservation measures, were evaluated. Tours were conducted and the multi-agency team continues to use tours as a method of reaching growers who like to "see" a "real" field rather than see a picture of the setting in conjunction with summarized data from the sites.

The program has a good basis for developing practical conservation measures and continuing to improve water quality by working with crop land managers. Slide sets and publications have been utilized. At this point, our county Extension staff has a good understanding of the cost-effective conservation measures for watersheds, are focusing on the project goals, are advising and assisting growers on practical applications to improve water quality and are about halfway through the educational phase. The relationships between NRCS district conservationists and UA county extension agents continue to grow, to the degree that the two organizations involve one another at the county level. Meetings and consultations continue. Growers understand the long-term goals and some of the cost-effective practices, as well as the technical expertise that is available to them.

Nine counties have been chosen for the evaluation phase. Surveys will be used to assess the progress on implementing conservation measures and to report on what soil erosion has been prevented during this educational program. The focus will remain on cost-effective practices; thus, significant impact should last long after EPA 319(h) and matching funds have been expended.

INFLUENCE OF NITROGEN RATE ON RICE RESPONSE TO CONVENTIONAL TILLAGE, STALE SEEDBED, AND WHEAT COVER CROP SYSTEMS

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INTERPRETIVE SUMMARY

RESEARCH QUESTION

Production of rice and other agronomic crops in reduced tillage systems has increased over the last decade. Reduced tillage systems vary in the intensity of tillage and the use of cover crops or the extent of vegetation remaining at planting. Wheat and other cereal grain cover crops are often used in cotton and corn production. These cover crops provide excellent soil protection from wind and water erosion and often decrease infestation of weeds through allelopathy or competition and shading. Preliminary research in rice in Louisiana suggested that while a wheat cover crop reduced infestation of some weeds and eliminated need for multiple in-season herbicides in some situations, response was often inconsistent. Additionally, the wheat cover crop negatively affected rice stand establishment and growth in some studies. Therefore, if the negative effect of the wheat cover crop could be overcome by increasing the rate of N, rice producers could take full advantage of benefits offered by the wheat cover crop.

LITERATURE SUMMARY

The benefits of cover crops in improving soil tilth and minimizing wind and water erosion have been well established for major agronomic crops, such as corn, cotton, and soybean. Cover crops, especially grasses, often reduce weed infestations, and in some cases, can eliminate the need for in-season herbicides. The effect of cover crops on weed control is often specific for the cover crop and weed in question. This specificity can result in inconsistent response from a weed control perspective, and the ability to eliminate in-season herbicides does not always occur. While grass cover crops can adversely affect weed populations, they can also adversely affect the crop. This has been documented in cotton, corn, soybeans, and a variety of other row and vegetable crops. As with variation in response to weed control, a positive response to the cover crop by the production crop is often very specific. Research in Louisiana suggests that a wheat cover crop has the potential to reduce weed infestations in water- and drill-seeded rice. Barnyardgrass, ducksalad, purple mania, and yellow nutsedge were partially controlled by the wheat cover crop when compared with conventional tillage. The control that occurred, however, either through allelopathy or shading was not consistent enough to eliminate the need for in-season herbicides in all circumstances. Additionally, when rice was grown following desiccation of the wheat cover crop, poor stands, chlorotic plants, and lower yields often resulted. In these studies, the rate of N fertilizer was held constant in all tillage systems. Determining if increasing the N rate could compensate for the adverse effect of the wheat cover crop on rice growth and grain yield would be advantageous when determining the utility of a wheat cover crop in rice production systems.

STUDY DESCRIPTION

Field studies were conducted in 1996 at the Northeast Research Station located near St. Joseph, LA on a Sharkey clay soil and at the Rice Research Station located near Crowely, LA on a Crowley silt loam soil. The experiment was also conducted in 1997 at the Rice Research Station. The cultivars 'Cypress' and 'Kaybonnet' were seeded at 100 lb/A into a conventional tilled, a fall-prepared stale seedbed, and a killed wheat cover crop system (seeded the previous fall at a seeding rate of 60 lb/A). Within each tillage system for both cultivars, N as urea was applied at rates of 60, 90, 120, 150, and 180 lb/A two days before permanent flood establishment. Stand establishment (visual assessment), days to 50% heading, plant height, grain yield, and percent moisture at harvest were determined. The experimental design was a split plot with tillage systems serving as the main plots and combinations of N rates and cultivars serving as the subplots. Data were subjected to analyses of variance appropriate for the experimental design and means separated using Fisher's Protected LSD test at $p = 0.05$.

APPLIED QUESTIONS

How was rice growth and grain yield affected by tillage systems?

Stand densities were lower and emergence of the crop was delayed in the wheat cover crop at both locations in 1996. At St. Joseph, maturity measured in days to 50% heading was delayed, plant height was decreased, and grain yield was reduced by the wheat cover crop regardless of cultivar. At Crowley, plant height was decreased and grain yields were reduced by the wheat cover crop, but maturity was affected very little. The percent moisture of grain at harvest was also higher following the wheat cover crop in St. Joseph. Maturity delays, decreased plant height, and reduced grain yields suggest that the wheat cover crop negatively affected rice growth and development. At Crowley in 1997, maturity and plant height were only slightly affected by the wheat cover crop, and grain yields for all tillage systems were similar. While there was some reduction in stand density noted in the wheat cover crop system in 1997, it was not as drastic as in 1996, and the resulting effect on rice growth and grain production was minimal.

Did increasing N rate compensate for any negative effects of the wheat cover crop on rice growth and yield?

Increasing the N rate slightly increased plant height but had no effect on grain yield at St. Joseph in 1996. At each N rate, grain yields for the conventional and stale seedbed tillage systems were comparable, but yield with the wheat cover crop system was significantly reduced. The highest grain yield in the wheat cover crop system occurred with a N rate of 120 lb/A. This was well below the yields measured with conventional tillage and the stale seedbed, with the lowest N rate of 60 lb/A. At Crowley, slight maturity delays were observed, and plant height and grain yields increased as the rate of N increased. The response of grain yields to N rate was similar to that measured at St. Joseph. Grain yields were highest with conventional tillage and the stale seedbed and significantly reduced with the wheat cover crop. At the highest rate of N, grain yield with the wheat cover crop system was greater than with conventional tillage only at the lowest rate of N of 60 lb/A. All other yields from the conventional tillage and stale seedbed systems were higher than those with the wheat cover crop system. At Crowley, in 1997, the effects of N were minimal on maturity and plant height, but grain yields increased with increasing N. Grain yield was not affected by tillage, and all tillage systems yielded similarly. There was no compensation for grain yields by increasing N in the wheat cover crop system.

RECOMMENDATIONS

These studies suggest that in spite of potential benefits of a wheat cover crop in improving weed control and minimizing erosion, use in rice production systems can result in less than adequate stands, delayed maturity, and reduced grain yields. The negative impact of the wheat cover crop was noted in two of the three studies. This response has also been observed in previous research. Results from these studies suggest that increasing the N rate or planting different cultivars will probably not overcome the potential damage to rice resulting from the wheat cover crop. While growers are cautioned not to plant rice following a wheat cover crop, results from this research indicate that planting rice into a stale seedbed and controlling the natural vegetation is a good alternative to conventional tillage systems. Additional research is needed to determine rice response to other cover crops, especially legume cover crops that may contribute N to the rice crop.

ACKNOWLEDGMENTS

The authors wish to thank the Louisiana Rice Research Board for their support of this research. A special thanks is owed to W.J. Leonards, Jr. for his technical assistance.

INTERACTIONS OF TILLAGE SYSTEMS WITH SIX PEANUT CULTIVARS IN NORTH CAROLINA

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INTERPRETIVE SUMMARY

RESEARCH QUESTION

Many growers in North Carolina are interested in adopting reduced-tillage practices for peanuts. Research in this area has demonstrated that peanut response to reduced tillage systems can be inconsistent. Most reduced tillage studies in North Carolina have been conducted with a single cultivar with one digging date. Many studies also introduce production on flat ground versus bedded rows, and this most likely can affect response. Determining if cultivar selection and digging date can explain inconsistent response of peanuts to tillage would be useful in defining factors that will determine utility of these systems. The objective of this research was to determine the effect of cultivar selection and digging date on peanut yield, gross value, and pest reaction of peanut grown in conventional and reduced tillage systems.

LITERATURE SUMMARY

Farmers who produce cotton and other crops in reduced tillage systems in North Carolina also would like to adopt these systems in peanut in order to save time in the spring and reduce labor and long-term equipment costs. Improvement in long-term productivity and sustainability of cropping systems often occurs in reduced tillage systems, but only if crop yield is maintained. Conventional tillage practices are expensive and time consuming, and timing for tillage practices comes when growers are involved in many other farming operations, especially during the spring months. Research with reduced tillage systems in peanut has shown variable results. While research suggests that eliminating primary tillage practices such as moldboard plowing can be done without sacrificing yield or quality, yields in strip tillage and no tillage systems do not always equal that of conventional tillage systems. Research is needed to address the inconsistencies observed in various tillage systems.

Cultivars express a wide range of attributes that can be influenced by production practices. Seedling vigor, vegetative growth, pod retention, pest reaction, and maturity can contribute greatly to yield potential. Digging date can have a major impact on yield and quality, and timing of digging relative to peanut response to various inputs in experiments can have a major impact on conclusions drawn from these experiments. Determining if inconsistent response of peanut to tillage systems can be explained by cultivar selection or digging date could lead to more informed recommendations on implementation of reduced tillage systems.

STUDY DESCRIPTION

Field studies were conducted during 1999 at three locations in North Carolina on loam to loamy sand soils (Gates, Chowan, and Martin Counties). In these studies, the cultivars NC 10C, NC-V 11, NC 12C, Perry, VA 98R, and Georgia Green were planted in conventional or reduced tillage systems, with two digging dates spaced approximately 10 days apart. Maturity of these varieties can range by as much as 20 days. Reduced tillage systems at Chowan, Gates, and Martin Counties consisted of no tilling into a wheat cover crop with a fluted colter, strip tillage using a Ferguson implement, and strip tillage with a KMC implement, respectively. Strip tillage implements were non-PTO driven and contained an in-row subsoiler with standard rolling baskets and colters. A subsoiler was not included at Chowan County in either conventional or no tillage systems. In Perquimans County, the cultivars listed above were evaluated in a strip tillage system only (KMC implement described previously) with two digging dates. In Edgecombe County, inclimate weather prevented evaluating two digging dates. However, cultivars were evaluated in conventional and strip tillage (KMC implement described previously) systems at this location. In Chowan County, the seedbed was flat for both tillage systems. Peanut was planted on beds in Perquimans County and on beds in both tillage systems in Edgecombe County. In Gates and Martin Counties, beds were generally higher in conventional tillage systems than in reduced tillage systems. The runner market type cultivar Georgia Green was seeded at 80 lb/A. The other cultivars (Virginia market types) were seeded at 120 lb/A. The planting operation was performed from several days following strip tillage to as long as 2 weeks after strip tilling. Standard pest management and production practices were administered to the entire test area throughout the season. Disease reaction, pod yield, market grade characteristics, and gross value were determined. Means of significant main effects and interactions were separated using Fisher's Protected LSD Test at P = 0.05 for individual locations.

APPLIED QUESTIONS

Did cultivar selection or digging date influence peanut yield or gross value differently in reduced tillage systems versus conventional tillage systems?

Main effects of tillage, digging date, and cultivar were significant in most but not all experiments. The interaction of cultivar by digging date was significant in most experiments. Differential response to digging date and cultivar selection was anticipated. Delaying digging often increases yield and gross value, and this response was noted at three of four locations. Cultivar response varied across locations. Other research has demonstrated that cultivar response often varies depending on pest pressure, environmental conditions, and digging dates. However, the interaction of cultivar by tillage system was not significant at the four locations where conventional and reduced tillage systems were compared. These data suggest that cultivars do not respond differently to tillage systems. When pooled over cultivars and digging dates, peanut response to tillage systems was similar in three of four experiments. However, there was a slight trend for decreased yield in the reduced tillage system at Gates County.

How does tillage affect pest reaction in peanut?

With the exception of Martin County, experiments were established in fields without a history of Cylindrocladium black rot [caused by *Cylindrocladium crotalarie* (Loos) Bell and Sobers] (CBR), a soil pathogen that occurs frequently in the Virginia-Carolina production region. Additionally, foliar diseases, such as early leaf spot (caused by *Cercospera arachidicola),* as well as the soilborne diseases southern stem rot (caused by *Sclerotium rolfsii)* and rhizoctonia limb and pod rot (caused by *Rhizoctonia solani),* were controlled with standard fungicide spray programs. Sclerotinia Blight (caused by *Sclerotinia minor* Jagger) was not present in these experiments. At Martin County, incidence of CBR was not affected by tillage system. However, consistent with previous research, the cultivars NC 10C, NC 12C, and Perry offered some degree of resistance to this disease. Georgia Green offered intermediate resistance while NC-V 11 and, to a greater degree, VA 98R were very susceptible. Yield and gross value followed closely the trend noted for CBR reaction.

RECOMMENDATIONS

These studies suggest that cultivar selection and digging date do not appear to have a major impact on peanut response in conventional and reduced tillage systems. These studies reemphasize that yield response to cultivar selection and digging date will vary depending upon a variety of edaphic, environmental, and cultural practices. Conventional and reduced tillage systems performed equally well in three of four experiments. It should be noted that weather conditions during digging and combining in North Carolina were poor, and peanut response to these variables needs to be evaluated under normal production and harvesting conditions. However, results from these studies suggest that reduced tillage systems may be a satisfactory alternative to conventional production systems for peanuts grown in North Carolina. However, it is recommended that growers attempt reduced tillage peanut production on only a fraction of their acres to determine consistency of response on their soils under their management practices.

WET CLAY SOIL MANAGEMENT FOR RICE AND SOYBEAN

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ABSTRACT

Clayey soils have a tendency to remain wet for long periods in the spring, making it difficult to plant conventionally in early April or even before May. Winter flooding, coupled with airplane seeding, or high flotation tire technology was investigated. Surface conditions and seedling establishment were characterized under airplane seeding following (1) a 3-month flood, (2) a 3-month stale seedbed following a wetting rain, and (3) a recently tilled seedbed following a wetting rain. Characteristics of a high flotation tire planting system for both soybean and rice were observed. Experimental results and their implications will be discussed.

DRY CLAY SOIL MANAGEMENT FOR FULL SEASON AND DOUBLE CROP SOYBEAN

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ABSTRACT

Experiments were conducted at the Northeast Research and Extension Center in 1998 and 1999 to evaluate planting methods in a dry clay soil. In 1998, only a full season trial was established. In 1999, both a full season and a double crop trial were established. The planting methods in the full season were conventional 38-inch rows, drill planting, and 'hipper planting'. 'Hipper planting' is the broadcasting of soybean seed to simulate a custom application and using bedding hippers after planting. The beds are then flattened with a field roller. Immediately after rolling the beds, the 'hipper planted' plots were furrow irrigated. The other plots were maintained in accordance with the normal practices of the area. The double crop trial had only drill planted and 'hipper planted' methods in standing straw and burned straw.

In 1998 when planting was done under dry soil conditions followed by a dry period, 'hipper planted' resulted in more than a 16 bu/A yield increase in the full season trial. The 1999 results for full season showed no difference in yield for any of the planting methods. Yield averaged 62 bu/A. This showed that under conditions where there is adequate moisture at planting time, 'hipper planting' does not reduce yields. In 1999, on double cropped soybean planted in July, the 'hipper planting' yielded over 15 bu/A less than no-till drill planted or shallow seedbed preparation drill planted. It was observed that at this late planting date insufficient soybean growth occurred, and canopy coverage was much less than drill planting. Burning the wheat straw in seedbed preparation resulted in a consistent 6 bu/A yield increase regardless of planting method.

COTTON GROWTH AND DEVELOPMENT UNDER DIFFERENT TILLAGE SYSTEMS

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INTERPRETIVE SUMMARY

Interest in conservation tillage systems has grown because of the need to reduce production costs and improve soil productivity. Cotton *(Gossypium hirsutum* L) yield response to conservation tillage has been variable. Stand establishment problems have been implicated, but lower populations have not always resulted in lower yields. Analysis of crop growth and development can provide insight into differences between various treatment inputs that affect yield. Such analyses would lead to a better understanding of how conservation tillage systems improve or impair cotton productivity.

Shoot growth analyses [crop growth rates (CGR), leaf area indices (LAI), net assimilation rate, and fruiting from numbers and weights] and root growth determination (root length density or soil moisture extraction) were conducted in 1991, 1992, and 1994 on a Gigger silt loam soil for three tillage systems initiated in 1987. These systems were conventional, ridge tillage, and no tillage. Each system included four cover crops; native vegetation, winter wheat, hairy vetch, and crimson clover. The cover crops did not produce consistent interactive effects with tillage and were therefore pooled.

An important component in crop production research is knowing when treatment differences first begin to occur in the crop. In this study, treatment differences in CGR and LAI occurred prior to the appearance of flower buds and were maintained through early bloom. The no-till system produced plants that reached exponential growth sooner and at a higher rate than the ridge-till system each year of the study. Conventional tillage was similar to no till in two of three years, but less in 1991. The increased CGR was due to greater LAI development. The greater LAI and CGR resulted in numerically to significantly greater early flower bud production and earlier and greater boll set or individual boll weights. All of these factors related to final yield. Lint yield averaged over the 3 years of this study were 944 lb/A for no till, 899 lb/A for conventional tillage, and 795 lb/A for ridge tillage. Differences between tillage systems could not be attributed to plant population. Root length density and soil moisture extraction for the ridge till system often lagged behind that of the other two systems, but this was not consistent. Soil impedance data taken in 1993 indicated the ridge till system had the greatest soil impedance at 0-6 inches in the soil profile. A loss of soil structure, organic matter, and soil aggregation in the planting zone by the ridge till process may have contributed to compaction or a loss of nutrients resulting in slower crop development for that system. The slower growth and development began very early and persisted through the beginning portion of reproductive development of the crop. The no-till system had the greatest pre bloom CGR and lint yields, indicating this was the conservation tillage system with the greatest production potential for this soil type.

INFLUENCE OF CONSERVATION TILLAGE ON COTTON INSECT PEST ECOLOGY: A CASE STUDY WITH COTTON APHID, *APHIS GOSSYPII* GLOVER

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INTERPRETIVE SUMMARY

INTRODUCTION

Conservation tillage systems provide a favorable micro-environment for insect populations by increasing host plant density and mediating soil moisture and temperature extremes. Population densities of a wide range of pests and beneficial insect complexes are affected by conservation tillage practices for crops including cotton, soybean, and field corn. Conservation tillage systems for cotton are becoming widely accepted, but limited information is available to describe the impact of these systems on cotton insect pests. Agronomic practices for cotton production have a significant impact on insect pest diversity and density. Therefore, if the ecology of insect pests is modified by a change in tillage systems, integrated insect pest management strategies will need to be refined. The objective of this study was to evaluate the effects of conservation tillage systems on cotton aphid, *Aphis gossypii* Glover, population dynamics.

LITERATURE SUMMARY

Numerous insect pests are capable of injuring cotton annually. Populations of several caterpillar pests, including bollworm, *Helicoverpa zea* (Boddie); tobacco budworm, *Heliothis virescens* (F.); armyworms, *Spodoptera spp.*, and cutworms, *Peridroma spp.* and Agrotis spp.; are either directly or indirectly influenced by conservation tillage practices. Reducing tillage promotes survival of the larval and pupal stages of these pests when they complete their development just below the soil surface. Spring tillage has been recommend for many years as a cultural control strategy to reduce numbers of these insects before they emerge from their overwintering habitat in the soil. A non-caterpillar pest, the cotton aphid, has also been observed in higher numbers on cotton plants in conservation tillage systems compared with numbers on plants in conventional tillage systems. Cotton aphids are currently considered to migrate to cotton fields after plant stands have become established. Therefore, it is more likely that cotton aphid populations increase due to an increase in plant residue on the soil surface as a result of reduced tillage. Cotton seedling growth and development (plant height, leaf area, etc.) also has been significantly improved in conservation tillage systems. The physical attractiveness of plants, as well as residue from native vegetation or previous crops, has been shown to influence insect population dynamics.

STUDY DESCRIPTION

Studies to monitor cotton aphid populations in conservation tillage production were conducted at the LSU Agricultural Center's Macon Ridge Research Station located near Winnsboro, Louisiana during the 5-year period, 1994-1998. Tillage treatments that were used in these studies included conventional and reduced tillage (fall/spring re-bedding, ridge-tillage, no-tillage). Winter cover crops included wheat, hairy vetch, Austrian winter peas, and crimson clover, as well as native winter vegetation. Cotton aphid densities were monitored weekly beginning at 7 days after cotton seedling emergence to crop termination by sampling 10 whole plants or plant terminals (all apical shoot growth above and including the first fully expanded leaf) from each plot.

Applied Questions

What are the effects of reduced tillage practices and winter cover crops on cotton aphid densities in cotton?

During the 5-year study period, cotton aphid peak densities exceeded 500 insects/10-plant sample in the reduced tillage plots compared with <350 insects/10 plant sample in the conventional tillage plots. The seasonal increase in cotton aphid density occurred during early June and was similar each year. There were no significant differences in cotton aphid densities between native vegetation and winter cover crop plots, regardless of tillage system. The most important agronomic factor influencing cotton aphid populations appeared to be a reduction in tillage practices.

Is the natural control of cotton aphids by the insect pathogenic fungus, *Neozygites fresenii* Nowakowski, influenced by reduced tillage practices?

During each year of the study, populations declined abruptly in July because of an epizootic from the fungus. Population densities remained low for the remainder of the season. The spatial and temporal occurrence of this fungus was not influenced by tillage practices or winter cover crops.

What is the relationship of red imported fire ant, *Solenopsis invicta* van Buren, populations to reduced tillage practices and cotton aphid densities?

Red imported fire ant (RIFA) densities were surveyed in this study during 1998 and 1999 and were found to be higher in the no-tillage plots when compared with that in the conventional tillage plots. The highest numbers of cotton aphids were generally recorded in those plots infested with RIFA. RIFA colonize no-tillage plots and appear to reduce predation of cotton aphids from natural enemies. Tillage reduces the incidence of RIFA in cotton fields.

SUMMARY

Reduced tillage practices increase cotton aphid densities earlier in the season and produce higher peak populations compared with that in conventional tillage plots. Natural control of cotton aphids by a insect pathogenic fungus is not influenced by tillage, while RIFA numbers increase in response to a reduction in tillage. Based on these results, cotton aphid management with insecticides may be initiated earlier in conservation tillage systems. Otherwise, no major changes in cotton aphid management recommendations between conventional and conservation tillage systems are necessary at this time.

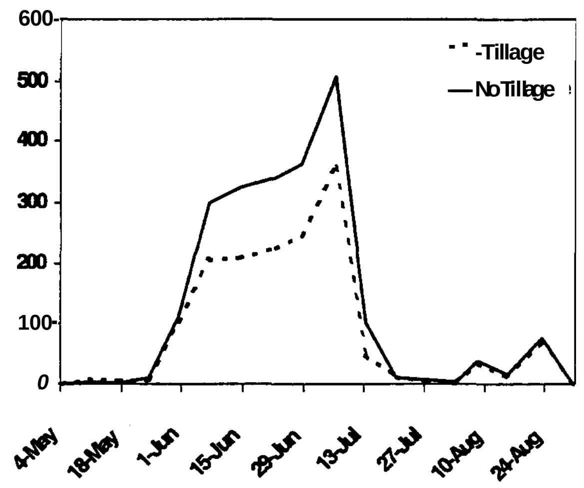

Fig. 1. Effect of tillage systems on cotton aphid population densities in Louisiana cotton fields, 1994-98.

INFLUENCE OF COVER CROP AND N RATE ON YIELD AND PLANT NUTRIENT STATUS OF CORN

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INTERPRETIVE SUMMARY

Corn acreage has increased in recent years in Louisiana. Some of this corn is grown on loessial silt loam soils of the Macon Ridge. These soils have low plant-available water due to a shallow rooting zone and low organic matter content. Rooting depth is limited by an argillic plow-pan and/or fragipan along with a very acid subsoil.

Although limited tillage research has been conducted in Louisiana, no-till and minimum tillage research for cotton on the alluvial clays of the Mississippi River and Macon Ridge have shown promise when compared with the more traditional tillage practices. The inclusion of winter cover crops in combination with conservation tillage was found to be an important component of the systems. Minimum-tillage systems reduce soil erosion, especially on the sloping silt loam soils of the Macon Ridge; increase soil organic matter; reduce soil moisture evaporation; and modify soil temperature. The use of a leguminous cover crop, i.e. crimson clover, contributes biologically fixed N, thus reducing the N fertilizer requirement and the potential for polluting ground water with nitrate-N.

Some of the water pumped from aquifers on the Macon Ridge has high salt content. The high salt content, in some years, may be detrimental to corn yield. This is borne out by a consistent relationship between yield and the quantity of imgation water applied, with lowest yield occurring in dry years when large quantities of water are applied. If cover crops enhance soil moisture, fewer irrigations may be required for maximum yield. This is not only important for soil moisture conservation but also will minimize the accumulation of salt in the soil profile.

An experiment was conducted in 1999 on a Gigger silt loam (fine silty, mixed, thermic Typic Fragiudalf) at the Macon Ridge Research Station near Winnsboro, LA, to evaluate the influence of cover crops, including a no cover crop control, and N rates on the yield performance of corn. The cover crops evaluated were wheat, Austrian winter pea, native vegetation, and a weed-free control. Nitrogen rates were 0, 100, and 200 lb N/acre injected as 32% N-solution at the five-leaf growth stage. Cover crops were killed with herbicides approximately 3 weeks prior to planting. Pioneer hybrid 3167 was planted on April 14 at about 28,000 seed/acre. The experimental design was a randomized complete block with five replications. Grain yield and yield components were determined from each plot. SPAD (chlorophyll intensity) measurements were collected during early grain fill.

There was a significant cover crop by N rate interaction for yield. When no N was applied, yields were highest when corn followed the Austrian winter peas or weed-free control treatments. Yields for the wheat and native vegetation treatments were 45% lower compared with the Austrian winter peas and weed-free control. Yields among cover crop treatments were similar for the 100 and 200 lb/A N rates, with maximum yield occurring between 100 and 200 lb N/A. Yield responses were due to both increased kernel weight and increased number of kernels/ear. Differences in SPAD readings among treatments followed the same trends as yield responses, indicating that proper N nutrition is critical to performance of no-till corn following winter cover crops.

LONG-TERM TILLAGE EFFECTS ON SELECTED SOIL PROPERTIES AND WATER RETENTION

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INTERPRETIVE SUMMARY

Soil properties and crop yields can be influenced by tillage practices through their effects on soil organic matter, soil aggregation, aggregate stability, and soil compaction. Increased size and water stability of aggregates are generally a function of decreased tillage and can affect soil porosity and, consequently, plant root proliferation. This study was conducted to determine the effects of long-term variable tillage intensities on selected soil physical properties and soil water retention.

The experiment site was located at the Texas A&M University Research Farm in southern Texas on an Orelia sandy clay loam (fine-loamy, mixed, hyperthermic, Typic Ochraqualfs). Zero-till (NT) and minimum till (MT) were compared with conventional tillage (CT) and deep moldboard tillage (12 inches, MLB) following 18 years of treatments. Conventional tillage was performed at maximum tillage depth of 6 inches with tillage operations totaling 10 to 11 inches per annum. In the MT treatment, maximum tillage depth was 3 inches with five or less tillage operations. Glyphosphate and Gramoxone Extra were used as needed for fall and winter weed control in the NT and MT systems.

Tillage treatments were evaluated as major blocks and arranged in a randomized complete block design. Corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.) were studied in split-plots in 4-year rotations in each of the tillage blocks. All treatments were replicated four times. Data are presented for the last year of corn rotation.

Degree of aggregation and aggregate coalescence were substantially improved with no tillage. Soil bulk densities and compaction were approximately 15% higher on NT compared with CT, but corn rooting in the surface 6 inches was highest in NT soil. Moisture retention was generally highest in NT at -0.01 MPa in the surface layers.

Net aggregate stability was higher in 0 to 3 inches and 3 to 6 inches depths in NT compared with CT and MLB tilled soils. However, tillage effect became less pronounced with increased profile depth. Soil aggregate size was inversely related to tillage intensity. Soil quality of Coastal Prairie soils as measured by physical attributes of degree of aggregation and aggregate stability may be improved by use of conservation tillage.

BURNDOWN WEED CONTROL PROGRAMS FOR COTTON AND CORN

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INTERPRETIVE SUMMARY

Conservation tillage systems used in cotton and corn production place greater reliance on utilizing herbicide programs that successfully remove winter vegetation to allow a clean seedbed at planting. Winter weeds common to the cotton and corn producing regions of northeast Louisiana range from easy to control weeds, such as annual bluegrass and common chickweed, to more difficult to control species, such as curly dock and annual ryegrass. Therefore, proper weed identification and herbicide selection are keys to a successful burndown weed control program.

Roundup Ultra, Touchdown, and Gramoxone Extra continue to form the "backbone" of most burndown herbicide programs in cotton and corn production in northeast Louisiana. Each exhibit particular strengths and weaknesses, and tank mixtures with other materials are often needed to increase spectrum of weeds controlled or to provide residual weed control. Previous research has shown Roundup Ultra and Touchdown to be equally effective on all winter weeds evaluated on a lb for lb basis, although initial symptoms may appear 3 to 4 days quicker with Touchdown. Research has shown little benefit to addition of ammonium sulfate over nonionic surfactants or company formulations when tested under non "hard water" conditions. In replicated research trials and recorded field observations, both materials provide excellent control of annual bluegrass, Carolina foxtail, little barley, buttercup spp., chickweed spp., dandelion, marestail, shepherdspurse, bittercress and Virginia pepperweed. Control of Carolina geranium, curly dock, henbit, cutleaf eveningprimrose, Pennsylvania smartweed, and vetch has been fair to poor. Addition of Goal 2XL has increased control of Carolina geranium, henbit, Pennsylvania smartweed, and vetch. Addition of Harmony Extra has increased control of Carolina geranium, curly dock, cutleaf eveningprimrose, henbit, Pennsylvania smartweed, and vetch. Including 2,4-D as a tank mix partner can aid in control of Carolina geranium, curly dock, cutleaf eveningprimrose, and vetch. Gramoxone extra provides excellent control of annual bluegrass, little barley, buttercup spp., Carolina geranium, chickweed spp., henbit, and shepherdspurse. Control of annual ryegrass, curly dock, cutleaf eveningprimrose, marestail, Pennsylvania smartweed, swinecress, vetch, and Virginia pepperweed has been poor. A tank mixture including Bladex/CyPro will increase control of cutleaf eveningprimrose, marestail, Pennsylvania smartweed, vetch, and Virginia pepperweed. Including Goal 2XL as a tank mix partner will aid in control of cutleaf eveningprimrose, marestail, Pennsylvania smartweed, vetch, and Virginia pepperweed. Control of curly dock, cutleaf eveningprimrose, marestail, Pennsylvania smartweed, swinecress, vetch, and Virginia pepperweed can be increased with addition of Harmony Extra. Burndown herbicide decisions should be based on activity of Roundup Ultra, Touchdown, or Gramoxone Extra on the predominant weed species present and appropriate tank mixture considered based on their ability to increase control of additional weeds present.

HIGH-RESIDUE, NO-TILL SYSTEMS FOR PRODUCTION OF ORGANIC BROCCOLI

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INTERPRETIVE SUMMARY

RESEARCH QUESTION

Per capita consumption of organic vegetables is increasing among consumers in the United States and other countries. Vegetables grown without applying synthetic fertilizers or pesticides (organic vegetables) command higher prices than conventionally grown vegetables. Weed control is the greatest production problem among organic growers, according to a recent survey conducted by the Organic Fanning Research Foundation. Without access to modem herbicides, organic growers resort to Integrated Weed Management (IWM) strategies, consisting mainly of mechanical and cultural methods. While mechanical cultivation is an effective weed control strategy, soil organic matter declines in cultivated fields. Organic mulches suppress weeds; however, growing, harvesting, and spreading cover crop mulches are both costly and labor intensive. Using legume cover crops as green manures will provide organic nitrogen (N); however, weeds flourish after leaving the soil surface uncovered when cover crops are incorporated. This study explores an alternative use of cover crops—i.e., using high-residue, no-till production systems to suppress weed growth and provide N for organically grown broccoli.

LITERATURE SUMMARY

Monoculture of leguminous cover crops and biculture grass-legume mixes can produce high biomass and N levels and have been successfully used in no-till systems to produce high yields of many vegetables. In most cases, however, either synthetic (chemical) herbicides and/or synthetic fertilizers have been needed to maximize yield. Whether high-residue, no-till systems require supplemental methods other than the organic residue mulches to suppress weeds and supply needed N is highly dependent on the vegetable crop grown. For example, broccoli has a rapid-spreading, over-lapping leaf canopy, which favors weed suppression; however, the associated sparse, confined root system combined with the rapidly developing, relatively large top growth of broccoli plants require high rates of band-applied N to obtain high broccoli yield. Conversely, in tomato, the slow developing, more open canopy favors early weed growth and the associated profuse, well-developed root systems effectively forage the soil profile for nutrients, necessitating only low rates of applied N to achieve high marketable yield. In no-till studies using white clover in California, alfalfa in Minnesota, and soybean and cowpea in Maryland and Virginia, broccoli required supplemental synthetic N to achieve high yields, comparable with conventionally grown broccoli that received recommended synthetic N rates.

STUDY DESCRIPTION

A factorial experiment was conducted in 1998 at the Kentland Agricultural Research Farm, assessing the effects of six no-till cover crop mulch treatments (no cover, foxtail millet, soybean, soybean and foxtail millet mix, cowpea, and cowpea and foxtail millet mix), each grown at three N rates (zero, 100 lb N/A from blood meal, and 100 lb N/A from ammonium nitrate). Both N sources were side-banded on the soil surface around each plant—113 at transplanting, 1/3 at 3 weeks and 1/3 at 5 weeks after transplanting. Blood meal, composed of 12% N, is commonly used by organic growers. Ammonium nitrate, composed of 34% N, is a standard synthetic N source used by conventional vegetable growers. Ammonium nitrate is readily available while blood meal is only moderately available to plant roots. All cover crops studied were seeded with a no-till drill on 25 June. Seed germination was excellent, but plant growth was slightly below normal. Above ground biomass (in tons *dry* wieght/A was 2.6, 2.5, 1.8, 1.6, and 1.8 for foxtail millet, soybean, soybean/foxtail millet mix, cowpea, and cowpea/foxtail millet mix, respectively. On August 19, all plots were subdivided into three sections----control subplots in which cover crops were rolled and broccoli received no fertilizer; organic subplots in which cover crops were flail mowed and broccoli received 100 lb N/A from blood meal; and chemical plots in which cover crops were rolled and broccoli received 100 lb N/acre from ammonium nitrate. A combination of Gramoxone (paraquat) and Goal (oxyflourfen) herbicides was applied immediately after rolling the control and chemical subplots. The organic subplots received no herbicides. Broccoli transplants were set in twin rows on August 25, using a no-till transplanter. All broccoli plots were sprayed with recommended insecticides and fungicides.

APPLIED QUESTIONS

Did no-till cover crops influence broccoli yield?

All cover crop mulches increased broccoli head yield from 6 to 37% (Table 1). Significant yield increases probably resulted from a combination of enhanced soil moisture content in all mulched plots and increased plant-available N, especially in soybean- and cowpea-containing plots. Although all plots were drip irrigated to supplement rainfall, the organic mulches undoubtedly would have increased water infiltration rate following rainfall events and reduced soil moisture evaporation throughout the growing season. Soybean alone (monoculture) or used as a biculture mix with foxtail millet outyielded all other cover crop mulches (Table 1).

Did N rate and source influence broccoli yield?

Nitrogen was a yield-limiting factor in this study (Table 1). Applied N derived from ammonium nitrate was more efficient in enhancing broccoli yield than N from blood meal. Leaf N content was increased by sidedress applications of both N sources; however, leaf N was significantly higher in plants receiving ammonium nitrate (5.6%) than in plants receiving blood meal (4.4%). Based on these data, N-use efficiency for broccoli is greater with the more soluble ammonium nitrate than the less soluble blood meal. Since broccoli yield was significantly less from plants receiving blood meal, either higher blood meal rates or using more soluble N sources should be considered. Perhaps, using organic foliar N sprays or incorporation or injection of the blood meal sidedressing, as well as preplant incorporation of other N-containing organic materials such as manure and sludge, would further enhance organic broccoli yield.

Did weed growth limit broccoli yield in organic (no-herbicide) plots?

Although weed biomass was not measured in this study, visual observations indicated that weed growth was more extensive in organic plots, especially those not containing foxtail millet residues, than in chemical plots. To minimize any deleterious effects of weeds on broccoli growth and yield, weeds were removed by hand on September 22 in all organic plots. Weeds were adequately controlled by herbicides and cover crop mulches in control (zero N) and chemical plots. Data from this study confirm the conclusions derived from other weed experiments that maintaining organic mulches at or above 2 tons/A throughout the crop's early canopy development (approximately 1/3 of the crop cycle) period will normally minimize weed growth, resulting in no reduction in crop yield. Establishing and maintaining high residue levels at or above 2 tons/A during the minimum weed-free period (length of time a crop must be free of weeds after planting in order to prevent yield losses) are therefore major steps toward successful production of organic no-till systems for producing vegetable crops.

CONCLUSION

1. No tillage is a viable option for producing organic broccoli provided that cover crop residues are maintained at levels sufficient to suppress weeds and soil N is not seriously limiting.

2. When weed levels become excessive, one critical hand weeding or mechanical weeding, especially in twin-row production systems, will lower weed populations below yield-limiting threshold levels.

3. When potential weed growth is high and weed removal by hand or mechanical methods is not feasible, maintaining no-till cover crop mulches at or above 2 tons/A during the first 3 weeks after transplanting will normally suppress weed populations below yield-limiting levels for production of fall broccoli. A biculture grass-legume mix, such as soybean and foxtail millet, is recommended to achieve adequate weed suppression and provide a source of plant-available N.

4. Nitrogen availability in no-till systems varies with the N content of the cover crops, level of biomass produced, soil environmental factors affecting rate of organic matter mineralization, and vegetable crop grown. Since broccoli has a high N requirement and possesses a sparse root system, normally supplemental organic N in addition to that derived from the legume cover crops is required to maximize broccoli yield. Future research is needed to assess the effectiveness of (a) manure and sludge either applied prior to establishing cover crops or as soil injections prior to transplanting broccoli and (b) postplant, soil applied sidedressings or injections, and/or foliar sprays.

Table 1. Influence of no-tillage mulch and nitrogen rate and source on yield and leaf nitrogen content of broccoli, 1998.

Treatment	Yield (ton/acre)	Relative yield[z]	Leaf N (%)	Relative leaf N[z]
No-tillage mulch (NTM)				
None (bare)	3.5d[y]	100	4.1b	100
Foxtail millet (FM)	4.0c	114	4.1b	100
Soybean (SB)	4.8a	137	4.9a	120
Mixture(SB/FM)	4.4b	126	4.7ab	115
Cowpea (CP)	4.0c	114	4.7ab	115
Mixture (CP/FM)	3.7cd	106	4.3ab	105
N rate and source (NRS) (lb N/acre)				
0	3.3c	100	3.4c	100
100 (blood meal)	3.9b	118	4.4b	129
100 (ammonium nitrate)	5.0a	152	5.6a	165
Interaction (NTM x NRS) (5%)	NS		NS	

[z]Relative broccoli yield and leaf N content compared with no-mulch (100).

[y]Mean separation among mulch and nitrogen treatments for yield and leaf N by LSD. Means followed by same letter within column do not differ at the 5% level.
NS = Non-significant at 5% level.

LONG-TERM TILLAGE SYSTEM EFFECTS ON CHEMICAL SOIL QUALITY INDICATORS IN THE SOUTHEASTERN COASTAL PLAIN

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INTERPRETIVE SUMMARY

Research Question

Long-term experiments are needed to generate reliable information on how different management cropping systems may impact soil quality. However, only a few experiments have been conducted under the warm climatic conditions and sandy soils of the southeastern USA. This research was undertaken to determine the effect of four tillage systems on soil quality chemical indicators on two Coastal Plain soils after 17 years.

Literature Summary

Changes in soil quality are normally observed after adoption of conservation tillage. Higher levels of soil organic matter have been observed with conservation than conventional tillage systems, but the accumulation of organic matter normally occurs only in the top few inches of soil. Profile-stratification patterns exist in conservation tillage systems where low-mobility nutrients accumulate in the soil surface. Surface soil acidification may also occur in these systems when large amounts of N are applied without adequate lime. These soil changes are documented from studies conducted in temperate climatic conditions; however, few studies have been conducted under warm climatic conditions on fine sandy soils such as those in the Southeast Coastal Plain.

Study Description

Two tillage experiments were conducted for 17 years (since 1981) in the Coastal Plain region of Southwestern Alabama. The experimental design at both locations was a randomized complete block with four replications. Treatments consisted of four tillage systems applied prior to planting the winter crop each year. Tillage treatments were: no tillage, disk, chisel plow, and moldboard plow. Various summer crops were doublecropped behind the winter crop using no-tillage. In the fall of 1997, soil cores were collected and bulked by depth (0-1, 1- 3, 3- 6, 6-9, and 9-12 inches). Soil pH, organic matter, total N, P, Mn, and Zn were assessed.

Applied Questions

Can conservation tillage maintain higher soil carbon content than conventional tillage under warm climatic conditions for coarse-textured soils?

Clear differences among tillage treatments were observed for soil carbon in the first few inches of soil. The accumulation of soil carbon was inversely related to the level of soil disturbance (no-tillage> disk> chisel plow> moldboard plow). No tillage had twice the carbon compared with the moldboard plow treatment in the top 3 inches of both soils.

Is soil acidification affected by the intensity of tillage?

No difference in pH among tillage treatments was observed on the Benndale soil (very fine sandy soil with about 10% clay content), and pH was within acceptable limits. This indicates that surface lime application can control pH in soil with low clay content. Surface lime applications resulted in a drop in pH below the 6-inch depth in the Lucedale soil (fine sandy soil with about 22% clay content).

Was there accumulation of P (an element with low mobility) near the soil surface in no tillage, disk, and chisel plow treatments?

The commonly reported accumulation of P at the soil surface did not occur with no tillage. In fact, higher values of P with depth were observed under no tillage, disk, and chisel plow compared with moldboard plow for the Benndale soil. This suggests P movement through physical, chemical, or biological processes in this soil. The Lucedale soil exhibited no accumulation of P with depth, but no tillage had greater P values compared with moldboard plow down to 9 inches, suggesting some mobility of P in this soil.

Was there a relationship between changes in soil organic matter and other soil chemical properties?

There was a close relationship between soil organic carbon and total N, effective CEC, Zn, and Mn availability. In some cases, the combination of soil carbon and pH helped predict variation in some soil chemical properties. These results confirm the importance of these chemical parameters as key indicators of soil quality.

(See Full Paper on Page 114).

SOYBEAN AND CORN RESPONSE TO TILLAGE AND ROTATION IN THE MISSISSIPPI BLACKBELT PRAIRIE

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INTERPRETIVE SUMMARY

Conservation tillage and crop rotation are methods for improved productivity and sustainability. These methods may be of use in the Blackbelt Prairie of Mississippi, a large farming area in which many of the sloping soils are classified as highly erodible. A field study (1996-98) was conducted to investigate the effect of tillage method on residue, yield, and financial return in continuous soybean and soybedcorn rotations. Treatments consisted of three tillage systems in continuous soybean or a soybedcorn rotation. Tillage systems in continuous soybean were: no-till (NT); fall applied one-pass chisel equipped with coulters and chain harrow (FC-H); and spring paratill followed by a spring harrow (SprP-H). Soybean/corn rotation tillage treatments were: NT corn followed by NT soybean; fall bed winter wheat followed by NT corn and FC-H soybean the following year; and conventional tillage (CT) corn followed by CT soybean. Duplicate treatments in the rotation were established so soybean and corn treatments were present each year. The NT treatments had at least 40% more ground cover from residue than any treatment with some form of tillage. Compared with CT, FC-H following corn increased ground residue cover and was equal to NT 2 (1996 and 1998) of 3 years.

Corn yield response also varied across years. In 1998, corn yield was reduced due to a dry June and CT corn yield was 15% more than NT NT corn yield was comparable with CT corn yield in 1996 and 1997 with a 3-year average of 5.6 bu/A more than CT. NT and CT corn had similar total costs, but NT had a higher 3-year average return above total cost than both CT and the fall bed winter wheat cover crop-NT corn.

Soybean rotation and tillage response varied across years. NT treatments had at least 19% lower soybean yield than all other treatments in 1996 within the respective rotation treatment. However, soybean showed no yield response to tillage or rotation in 1997 and 1998. FC-H generally had the most stable high soybean yield across 3 years. FC-H soybean following corn had the highest 3-year average return above total cost at $69/A, 8 and 44% more than CT and NT, respectively. FC-H soybean following NT corn in a 2-year rotation production system on the Blackbelt Prairie clay soils not only met conservation compliance requirements but also maintains returns higher than NT and equal to CT. The success of this production system is dependent upon performing the tillage operation in the fall and planting NT in the spring. Thereby, spring labor requirements are reduced significantly and allow for timely planting of both crops.

FREQUENCY OF SUBSOILING IN CONTROLLED TRAFFIC PRODUCTION SYSTEMS

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INTERPRETIVE SUMMARY

The alluvial sandy and silt loam soils of the Mississippi, Ouachita, and Red River Valley are very easily compacted. The compaction zone or hardpan will vary in depth depending upon the past history of tillage. The compacted zone usually begins 6 to 10 inches below the surface of the soil and may be 2 to 5 inches thick. This zone restricts root growth, water penetration, and water retention, thus cotton yields can be reduced. Yield reductions will usually be greater during extremely *dry* years than in years of adequate rainfall.

The compacted zone can be temporarily eliminated by subsoiling at depths of 12 to 15 inches. The subsoiler point should run 2 to 3 inches below the compacted zone. Research has shown that subsoiling to a greater depth will not increase yields. Research also indicates that it is best to subsoil in the fall when the soil is *dry*. This allows winter rains to infiltrate the soil and be retained to produce the following year's crop.

Data from a 4-year test conducted on a Commerce silt loam soil at the Northeast Research Station in St. Joseph, Louisiana, indicates that subsoiling under the row is effective in increasing yields. A permanent row, controlled traffic tillage system was used in tillage systems 5 and 6. The rows from the prior year's crop were reformed for the next year's crop.

Subsoiling the drill area assures that each seed is planted above a subsoiled area. Also, the subsoiled area will not be re-compacted with tire traffic prior to planting. Data from this 4-year test are shown in the following table. This research indicates that subsoiling increases yields, and yields in a permanent row, controlled traffic system are equal to a conventional tillage system.

Northeast Research Station − 1975-1978 Tillage Systems Research

Tillage System	Seed Cotton Yield (lb/A) No Subsoiling	Subsoiling Under Row	Yield Increase
1. Check Pulverizing Disk Harrow	**2849**	**3125**	**276**
2. Heavy Disk Harrow	**2900**	**3145**	**254**
3. Chisel Plow	**2917**	**3087**	**170**
4. Moldboard Plow	**3050**	**2938**	**(112)**
5. Rehip Old Beds	**2761**	**3182**	**421**
6. Rip and Hip With Ripper-Hipper	**2939**	**3117**	**178**
4-Year Average	**2903**	**3101**	**198**

Data from tests conducted at the USDA Research Center in Stoneville, Mississippi, indicate that controlling traffk and subsoiling under the row will increase yields. Data from this 6-year test follows:

USDA Research Center - Stoneville, MS - Controlled Traffic Tillage Test: 1977-1982

Treatment	Seed Cotton Yield
	(lb/A)
Conventional Traffic – No Subsoiling	1765
Conventional Traffic – Subsoiled Under Row	2134
Controlled Traffic – No Subsoiling	2160
Controlled Traffic – Subsoiled Under Row	2268

This test shows the advantages of controlling traffic and reducing compaction in the drill area. Another 3-year test conducted at the USDA Research Station in Stoneville, MS, also shows the effectiveness of under-row subsoiling. This four-treatment test compared a ripper-hipper subsoiling under the row with subsoiling at a 45° angle to the row. Data from this test follow.

USDA Research Center - Stoneville, MS - Subsoiling Methods Test: 1979-1981

Treatment	Seed Cotton Yield
	(lb/A)
Check: Rip and Hip	2217
Subsoil 45° to Row	2233
Subsoil 45° to Row Plus Rip and Hip	2236
Subsoil 45° to Row Plus Subsoil 45° to Row	2226

This 3-year test indicates that a permanent row, controlled traffic production system will reduce tillage cost and labor requirements while providing yields equal to those obtained with more expensive tillage systems.

Cotton producers often ask questions about how frequently a field should be subsoiled. To address this question, a two-treatment demonstration was set up on the Donnie Powell Farm in Red River Parish for the 1995 crop. Each treatment was replicated three times.

The cooperator's experience indicated that cotton yields could be increased by subsoiling the field used in this demonstration. A permanent row, controlled traffic production system was used to produce cotton in this field from 1982 to 1994. During this 12-year period, the same rows were used each year. Each year, a ripper-hipper was used to subsoil the drill area. The hipper attachment mounted behind the subsoiler reformed the existing rows.

For the 1995 demonstration, three strips, eight rows wide and 1600 to 2000 feet long were not subsoiled. Mr. Powell re-hipped the rows that were used to produce the 1994 crop. Three strips, eight rows wide and 1600 to 2000 feet long were subsoiled with a ripper-hipper in a traditional manner. This field was not irrigated.

Thls field received 1.2 inches of rain in June, 4.0 inches in July, and 0.4 inch in August, for a total of 5.6 inches. The crop was harvested on October 10, 1995. The yield for treatment one, subsoiled annually from 1982 – 1995, was 784 lb lint/A. Yield for treatment two, subsoiled from 1982 – 1994, was 775 lb lint/A. Treatment two was not subsoiled for the 1995 crop.

A soil compaction tester was used on October 19, 1995 to measure fractured area in the drill. Fractured area was defined as the soil volume where the compaction tester could be inserted with less than 300 psi resistance. The fractured area was measured from 6 inches left to 6 inches right of the row centerline for a 12-inch wide area. Yield and fractured area data are shown below.

1995 Yield and Fractured Area – Donnie Powell Farm – Red River Parish

Treatment	Yield lb lint/A	Fractured Area Square Inches
Sub-soiled Annually 1982-1995	784	289
Sub-soiled Annually 1982-1994 Did Not Sub-Soil for 1995	775	271

These differences are not significant.

It is very apparent that a controlled traffic permanent row system offers several advantages. The crop is planted in the same drill area each year. After 2 to 4 years of annually subsoiling, the drill area, the subsoiler or ripper-hipper is easier to pull. Horsepower and fuel consumption are reduced.

Yield data and compaction data from 1 year of testing plus other research data indicate that yields can be maintained by subsoiling every second or third year with a controlled traffic system. The 9 lb/A yield increase in treatment one will not pay for a subsoiling operation.

The field used in the 1995 demonstration was used for a similar demonstration in 1996. A four-treatment demonstration with three replications was set up to further evaluate the residual effects of subsoiling. Each of the 12 plots was four rows wide and 1600 to 2000 feet long. Data from this demonstration are shown below.

1996 Yield and Fractured Area

Treatment	Yield lb lint/A	Fractured Area Square Inches
Sub-soiled 1982 - 1996	**854**	**413**
Sub-soiled 1982 - 1995 Did Not Sub-Soil for 1996	**887**	**342**
Sub-soiled 1982 - 1994 and 1996 Did Not Sub-Soil for 1995	**979**	**420**
Sub-soiled 1982 - 1994 Did not Sub-Soil for 1995 or 1996	**903**	**347**

It is very difficult to draw definite conclusions from this 2-year demonstration. The field received 5.6 inches of rain in June, July, and August of 1995. The yield difference was 9 lb lint/A. By contrast, in 1996, this field received 7.6 inches of rain in June, 12.5 inches in July, and 6.5 inches in August, for a total of 26.6 inches. It was really too dry for a test of this type in 1995 and too wet in 1996. However, it would appear that after subsoiling the drill area for 3 to 4 years, profits can be increased by subsoiling every second or third year.

A special thanks goes to Mr. and Mrs. Donnie Powell, as well as Mr. John LeVasseur, their county agent. Their cooperation made this demonstration possible.

MINERALOGY OF ERODED SEDIMENTS DERIVED FROM HIGHLY WEATHERED SOILS

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ABSTRACT

Coarse textured surface horizons are common in highly weathered southeastern Coastal Plain soils. Historically, these soils have been managed under conventional tillage practices, but current trends suggest increases in conservation tillage use. Clay (< 2 µm) contents are typically low in these soils (< 10 %), but the relatively reactive nature of the surfaces of this fraction plays a dominant role in colloidal facilitated transport of pollutants. In this study, we evaluated the partitioning of clay minerals of in situ soil vs. runoff sediment under simulated rainfall. Because water dispersible clay (WDC) has been shown to be correlated with soil erodibility, we also evaluated WDC as a function of tillage practices. Plots were established at a site in the Upper Coastal Plain of central Alabama, where soils classified as coarse-loamy, siliceous, subactive, thermic Plinthic Paleudults and Typic Hapludults. Surface tillage reatments included conventional vs. no surface tillage treatments, with and without crop residue, and with or without para-tilling (non-inversion subsoiling). Mineralogical analyses and quantification were conducted using thermogravimetric (TGA) and x-ray diffraction (XRD) techniques. The amount of WDC was shown to be highly correlated with the % soil organic carbon (% SOC), which was a function of tillage treatment. Although no differences in the clay mineralogy of the sediment were observed between tillage treatments, runoff sediments were enriched in quartz and depleted with respect to kaolinite as compared with in situ soils. These results may help in the development of mechanistic models that predict sediment attached losses of nutrients and pesticides.

TILLAGE AND HERBICIDE MANAGEMENT OF TWO VARIETIES OF PEANUT

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INTERPRETIVE SUMMARY

In 1997, total Florida land area devoted to peanut *(Arachis hypogaea)* production was about 84,000 acres with a farm gate value of over $54,000,000. The real economic value to Florida and the US economy would have been over $160,000,000 due to the multiplier effect. The value of Florida's 94,000 acres of harvested peanuts in 1999 was even greater than in 1997. Peanut research is needed that leads to improved competitiveness and to help improve grower's financial condition. The objective of this research was to determine pod and seed yield and seed quality of two peanut varieties ('Georgia Green' and 'Andru 93') under five tillage and two herbicide management programs, double-cropped following a winter cover crop of rye *(Secale cereale)*. Overall pod yield for the five tillage treatments was 5,862 lb/A at 10%moisture . Pod yield was 6,136 lb/A for Georgia Green compared with 5,612 lb/A for Andru 93, a 9.3% advantage for Georgia Green. Herbicide management using Starfire plus Storm gave significantly higher pod yield (5,983 lb/A) compared with management using Cadre (5,785 lb/A). On the other hand, the most troublesome weed, fall panicum *(Panicum dichotomiflorum)*, was controlled best using Cadre. Data from this experiment provides further proof that strip-till (in-row subsoil no-till) management in Florida's sandy soils can be equal to conventional tillage in-row subsoil management, thus providing savings in soil, water, energy, and equipment conservation. If rye is not needed for cattle grazing, the ground cover by rye straw would provide significant reduction in wind and water erosion and provide numerous conservation and environmental benefits characteristic of utilizing a mulch without sacrificing yield.

(See Full Paper on Page 165.)

WINTER ANNUAL WEED CONTROL IN EMERGING CORN

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INTERPRETIVE SUMMARY

Conservation tillage systems rely on herbicides to remove winter vegetation prior to planting corn. Winter weed control is often incomplete and weeds often regrow or new weeds emerge before planting. Corn is planted in late February and throughout March in Louisiana. As a result, winter weeds do not die out naturally before interfering with corn and severely reducing yields. Questions from producers and consultants on controlling winter weeds after corn is planted are common and increasing. Burndown herbicides (Roundup, Gramoxone, Harmony Extra, and 2, 4-D) used to manage these weeds before planting are either non-selective or restricted to ground application after corn emerges. The effectiveness of postemergence herbicides registered for use in corn against many winter weeds is unknown. Studies were conducted in 1998 and 1999 to evaluate selected postemergence herbicides used in corn for controlling winter weeds common to northeast Louisiana. All studies were conducted in a randomized complete block design with three to four replications at the Northeast Research Station near St. Joseph, LA. Weed control was estimated using a scale of 0 to 100%, were 0 equaled no control and 100 equaled complete control. All data were subjected to analysis of variance and means were separated using Fisher's Protected LSD at P = 0.5. In 1998, herbicides containing atrazine, cyanazine, or metribuzin controlled swinecress 90 to 100%. Accent, Banvel, 2,4-D, Beacon, and Scorpion did not control swinecress. In 1999, herbicides containing atrazine controlled swinecress and primrose greater than 90%. Cyanazine and metribuzin also controlled swinecress. Marksman and Banvel were the only herbicides, besides 2,4-D, that controlled dock. Accent, Basis Gold, and Celebrity controlled ryegrass greater than 90%. These studies are being repeated in 2000.

NO-TILL PRODUCTION OF TOMATOES

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INTERPRETIVE SUMMARY

Reduced tillage and conservation tillage systems have been popular for row crops for many years in the Southeastern United States. Adoption of these practices for vegetable crops has been slower due to the high risk nature of most vegetable crops. Interest in reduced tillage has increased as research has shown several advantages to these systems compared with conventional production systems. Many producers are limited in available land for recommended crop rotations on level to slightly sloping land. Producers are receptive to incorporation of reduced tillage programs into their cropping systems if crops can be produced on slopes ranging from 3 to 10% slope with little or no increase in erosion and runoff and if yields and profitability can be maintained on sloping land. Several other advantages are inherent in reduced tillage systems that will encourage further adoption of these systems.

In 1996 and 1997, research was instituted at a private farm and at a university experiment station to determine the feasibility of no-till or reduced tillage tomatoes on 8 to 10% slopes. Six research plots of 20 by 75 ft were installed on a 10% slope on a private farm in Cocke County, Tennessee. The soil type on the plots was a Jefferson sandy loam with an assigned soil erodibility factor of K=0.227. Six additional research plots were installed at the Plant Sciences Unit of the Knoxville Agricultural Experiment Station about five miles southeast of Knoxville. The soil type on the experiment station plots was Etowah silt loam with an assigned soil erodibility factor of K=0.303. Three research plots at each location were planted with tomatoes using conventional tillage practices and the remaining three plots at each location were planted with tomatoes into undisturbed fescue sod with a no-till transplanter. At the Knoxville location only, six research plots were planted in burley tobacco, three no-till and three conventional tillage, to compare data collected with the tomato plots. All research plots were irrigated with 0.45 GPM drip tape. To prevent runoff from adjacent areas from entering the research plots, each plot was protected by an 8-inch high berm completely surrounding the plots. A collection triangle was constructed at the base of each research plot to catch runoff from the plots for measurement of soil, water, and nutrient losses. After each significant rainfall event, samples from each plot were collected and analyzed for runoff volume, sediment, N loss, and phosphorus loss.

Runoff from all test plots was calculated as a percentage of the total rainfall that fell on each plot. Runoff tended to be less from no-till plots compared with conventional till plots. Runoff from the tobacco plots tended to be significantly less from no-till plots than from conventional till plots. Sediment losses were significantly different for the no-till and conventional plots. Sediment losses on no-till tomato plots were four to 11 times less than on conventional tomato plots. Sediment losses were generally much greater from tobacco than from tomato plots. Sediment losses on no-till tobacco plots were 72 to 90 times less than from conventional tillage plots. Much of this loss from conventional tillage tobacco plots can be attributed to multiple cultivations throughout the growing season on a 10% slope.

Nutrient losses from the research plots were measured during the 1997 growing season only.

Overall, there was less total N loss from no-till than conventional till, and less total N loss from tomatoes than from tobacco. The greatest amounts of N were lost near the beginning of each growing season. Tillage method also seemed to have an effect on NO_3 and NO_4 movement. There was less NO_3 and NO_4 loss from no-till than from conventional till and less NO_3 and NO_4 loss from tomatoes than from tobacco. Total N losses in tomatoes were about three times greater in conventional till than no-till. Total N losses in tobacco were 21 times greater for conventional till than from no-till. NO_3 and NO_4 made up 4 to 10% of the total N losses. Total phosphorus (P) losses on all plots were similar to total N losses. However, PO_4 losses were much higher on no-till plots than on conventional till plots. A larger percentage of the total P from no-till plots was made up of PO, than the total P from the conventional till plots.

Although the primary objectives of this study were to compare runoff, sediment and nutrient losses on no-till plots with conventional till plots, yield comparisons on the tomato plots were compared to determine effects of no-till on tomato yields. All no-till tomato plot yields at all locations were equal to or better than conventional till plot yields. Quality of fruit on all no-till plots were equal to or better than fruit quality on conventional plots. Tobacco yields on no-till plots were generally equal to yields on conventional till plots.

In addition to reduced runoff and sediment losses and higher fruit yields, several other advantages of no-till tomato production compared with conventional till production were noted during the course of this research work. Less irrigation water was used on no-till plots compared with conventional plots. Application of crop protection chemicals was more timely due to mulch cover, which permitted operation of equipment on wet soil conditions. Less cleaning and preparation of fruit was required for marketing due to minimal soil splatter on fruit after rainfall events. Less weed control chemical was needed due to the suppression effect of cover mulch between the rows.

EDITORIAL REVIEW

PAPERS

ROLLER VS. HERBICIDES: AN ALTERNATIVE KILL METHOD FOR COVER CROPS

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ABSTRACT

Identifying more cost effective and perceived environmentally friendly techniques for cover crop management can increase their use. This study was conducted to determine the effectiveness and economic viability of using a mechanical roller-crimper as an alternative kill method for cover crops. Three cover crops, rye *(Secale cereale* L.), wheat *(Triticum aestivum* L.), and black oat *(Avena strigosa* Schreb.) were evaluated in terms of ease of kill and optimum time of kill using a roller-crimper, two herbicides (paraquat and glyphosate), and two reduced chemical rate (half label rate) combinations with the roller. During 1998-1999, the study took place at two locations in east-central Alabama, using a split-split plot experimental design with four replications. Three Feekes' scale growth stages were used to determine optimum time of kill: 8.0 (flag leaf), 10.51 (anthesis), and 11.2 (soft dough). Percent kill measurements were taken 14 d after treatment application. Black oat reached maximum biomass at anthesis (7660 lb/A), while rye and wheat continued to increase biomass significantly through soft dough (8480 and 9340 lb/A, respectively). There was a significant interaction between growth stage and kill method; by soft dough, kill methods were equally effective due to accelerating plant senescence (95% mean kill across kill methods). The label rate of glyphosate and 1/2 label rate+roller combination produced the best kill mean, 91 and 89%, respectively, at all growth stage levels across all cover crops. However, at anthesis, the label rate of paraquat and 1/2 label rate+roller combination were as effective (mean 89% kill) as glyphosate. This study shows that it is possible to reduce the use of herbicides and implement effective alternative kill methods for cover crops.

INTRODUCTION

Cereal cover crops are useful to growers in many ways (Reeves, 1994); however, growers must have an effective and cost efficient way to kill covers when they are ready to plant their cash crop. Mechanical rollers have been used effectively on millions of acres of conservation tilled land in southern Brazil and Paraguay (Derpsch et al., 1991). In the United States, the roller is a relatively new cover crop kill method but there is growing producer, as well as commercial, interest in this implement. The objectives of this study were three-fold: 1) determine the effectiveness and economic viability of the roller compared with herbicides as a cover crop kill method; 2) determine the optimum kill time for three cover crops in terms of growth stage; and 3) identify any differences in ease of kill for three cover crops using the roller.

MATERIALS AND METHODS

The study was conducted at two locations in east-central Alabama on a Compass loamy sand (coarse-loamy, siliceous, subactive, thermic Plinthic Paleudults) and a Cahaba sandy loam (fine-loamy, siliceous, semiactive, thermic Typic Hapludults) using a split-split plot experimental design with four replications. Whole plots were three small grain cover crops: rye *(Secale cereale* L.), wheat *(Triticum aestivum* L.), and black oat *(Avena* *strigosa* Schreb.). Three easily identifiable Feekes growth stages (Large, 1954) were the subplots: 8 (flag leaf), 10.51 (anthesis), and 11.2 (soft dough). Sub-subplots were five kill methods: roller only, glyphosate at 3 pt/A (label rate), paraquat at 1 qt/A (label rate), roller+glyphosate at 1.5 pt/A (half label rate), and roller+paraquat at 0.5 qt/A (half label rate). Herbicide treatments were applied first, immediately followed by rolling on specified plots. The roller used was a drum roller with horizontal welded blunt steel metal strips, which made it possible to crush the cover crop, facilitating kill by leaving plant stems intact yet discouraging regrowth (see photo).

Cover crops were planted into a stale seedbed at a rate of 90 lb/A on November 18,1998, using an 8-ft grain drill. Kill treatments were applied when at least 65% of the plot was at the desired growth stage. At each growth stage, prior to kill treatment, we took two biomass samples equivalent to a total of 5.4 ft^2 within each subplot for each cover crop.Percent kill measurements were taken using a visual rating method at 7, 14, 21, and 28 days after treatment (DAT). Visual measurements were made using a 0-10 scale, with 0 being no kill and 10 being complete kil1. In addition, plant moisture content was determined to backup the visual percent kill measurements. Gravimetric soil water content measurements (Gardner, 1986) were taken 28 DAT to determine the amount of soil water available to a cash crop planted after the cover crop. Soil samples were taken in the top 3 inches of soil (cash crop seed zone) in each sub-subplot using a hand-held soil probe.

There were no significant location interactions observed, so data were averaged over locations. All data were analyzed using an analysis of variance (ANOVA) with SAS (SAS Inst., 1988); means were separated using the least significant difference (LSD) test at $P \leq 0.10$.

RESULTSAND DISCUSSION

Cover Crop Biomass Production

A significant cover crop by growth stage interaction was observed ($P \leq 0.05$). Black oat reached maximum biomass at anthesis (7660 lb/A), while rye and wheat continued to increase biomass significantly through soft dough (8480 and 9340 lb/A, respectively). The early maturity of black oat may be beneficial to growers as it allows for a larger planting window for cash crops.

Percent Kill

A strong linear relationship between plant moisture content and visual percent kill ratings was observed (R^2=0.58). The visual ratings will be presented here. Percent kill measurements were taken at 7,14, 21, and 28 DAT; however, after 14 DAT, there were no significant increases in percent kill ($P \leq 0.05$). Consequently, only the 14 DAT measurements are presented.

There was a significant cover crop by growth stage by kill method interaction ($P \leq 0.01$); by soft dough, kill methods were equally effective due to accelerated plant senescence (95% mean kill across cover crops and all lull methods). The label rate of glyphosate and 1/2 label rate+roller combination produced the best kill mean, 91 and 89%, respectively, at all growth stage levels across all cover crops (Fig. 1). At anthesis, the label rate of paraquat and 1/2 label rate+roller combination were as effective (mean 89% kill) as glyphosate.

At flag leaf, the label rate of paraquat and the 1/2 label rate+roller had a significantly lower kill mean (41 and 42%, respectively), especially on black oat (24 and 27%, respectively). Cover crop plant height was relatively low and plant stems were still elongating at flag leaf, contributing to the low termination rate by the roller alone at this growth stage. The roller was not able to effectively crimp the plants at flag leaf, leading to the low kill mean

(12%) by the roller alone for all covers. Roller efficacy increased at anthesis to 47%, but this was not enough to be a suitable kill method at this growth stage.

Soil Moisture

The soil moisture content measured at 28 DAT is indicative of the amount of soil water available at cash crop planting. The soils at the two locations were different types, a sandy loam and loamy sand. However, since there were no significant location interactions, results were averaged across locations. For reference, the average field capacity of the two soil types is about 14.7% and the average permanent wilting point (PWP) is about 5% (Miller and Donahue, 1990).

A significant cover crop by growth stage by kill method interaction was observed ($P \leq 0.01$). Soil water content measurements at the flag leaf growth stage were directly related to efficacy of kill method. Ineffective kill methods resulted in depletion of soil water by still-growing cover crops. Glyphosate treatments, which resulted in the best kill, had the highest soil water content for all cover crops 28 DAT at flag leaf (11%). However, in wheat, soil water following paraquat treatments (9.5%) were not significantly different than wheat treated with glyphosate treatments (11.5%).

Paraquat treatments were especially ineffective at terminating black oat, resulting in soil water depletion significant enough to likely affect emergence of a cash crop if planted. At flag leaf, the roller only treatment was the least effective kill method and, therefore, resulted in the lowest soil water content in all cover crops (5%). Considering an average PWP of 5%, soil at this water content would not be adequately moist to plant a cash crop.

There were no significant differences in soil water 28 DAT of any cover crop as a result of kill method at anthesis or soft dough. However, soil water content was affected by cover crop, as a result of straw biomass at both growth stages. A significant but poor linear relationship was observed between cover crop growth (biomass production) and soil water content ($P \leq 0.01$, R^2=0.10). At anthesis, rye resulted in greater soil water content (12%) than either black oat or wheat (10 and 9%, respectively). At soft dough, soil water content within wheat (10%) was less than under rye or black oat (12 and 11%, respectively). These soil water contents would all be moist enough to plant a cash crop.

CONCLUSIONS

This study shows it is possible to effectively terminate cover crops using reduced herbicide inputs, especially when the cover crop is at an optimum growth stage. Farmers may be able to decrease the use of herbicides when implementing alternative kill methods for cover crops. At anthesis, it would be possible to use the combination methods and still get an effective kill (88% with roller+paraquat and 91% with roller+glyphosate), while reducing the amount of chemical used, thereby decreasing costs. The average reduction in chemical costs when using half rates and the roller rather than full label rates would be $5.25/A (reflecting current commercial prices). The cost of using the roller alone can be estimated as $1.50/A, which is the cost of running a cultipacker (Prevatt et al., 1998). Use of the roller provides benefits when killing cover crops as it lays residue flat on the soil surface, providing maximum soil coverage, thereby preventing erosion, decreasing soil water evaporation, and providing weed control. The use of a roller also facilitates planting by reducing hairpinning of residue when the planter runs parallel to the roller.

When termination occurs as late as soft dough, which in most cases is not practical due to cash crop planting windows, the use of herbicides may even be eliminated. At this late growth stage, all kill methods were equally effective (94% across all cover crops). The optimum kill time, when using the roller alone, is some point after anthesis prior to soft dough, possibly the early milk stage (Feekes growth stage 10.54). There were no significant differences between the cover crops in terms of percent lull when the roller was used. The main determining factors were plant height and maturity, which are directly related to growth stage.

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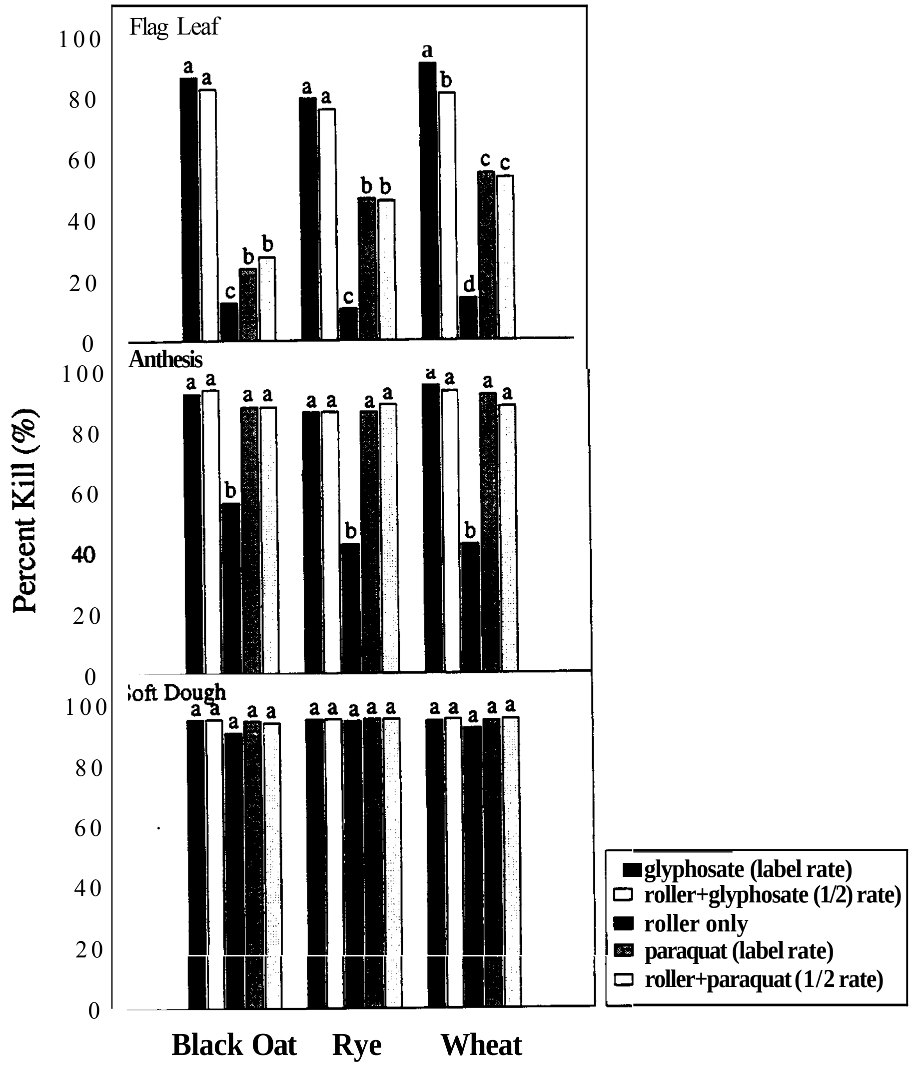

Fig. 1. Percent kill by cover crop and growth stage. Means within a growth stage and cover crop with the same letter are not significantly different (P<O.lO).

POTENTIAL USE OF SLOW-RELEASE UREA IN WATER-SEEDED, STALE SEEDBED RICE

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ABSTRACT

Management of fertilizer nitrogen (N) for optimum efficiency with stale seedbed preparation in water-seeded rice can be difficult, especially in a pinpoint flood system of water management. There is no opportunity for preplant incorporation, and all of the N is applied either preplant (PP), postdrain (PD), or postflood (PF) to a wet or saturated soil surface. Efficiency of fertilizer N is usually reduced when N is applied to wet soil surfaces or into the floodwater on young, seedling rice. Slow-release N has the potential to improve N efficiency when applied PD to wet soils or PF on seedling rice. Field experiments were conducted in 1997 and 1999 to compare the effectiveness of Meister urea (a polyolefin-coated urea, PCU), sulfur-coated urea (SCU) (1997 only), and urea in conventional tillage and stale seedbed systems. Cypress rice was cultured in a water-seeded, pinpoint flood system. An application of 135 lb N/A was made PP, PD, and PF with each N source in 1997. In 1999, PCU and urea were applied as single applications at each timing and at variable rates of 90, 120, 150, and 180 lb N/A. Days to 50% heading, plant height, grain yield adjusted to 12% moisture, and total N in the grain and straw (1997 only) were determined. Various significant interactions between tillage and N source, N rate, and N timing occurred for days to 50% heading both years. These differences represented little biological significance (1 to 2 days). Significant interactions also occurred for plant height between tillage and N timing in 1997, and N source and N timing in 1998. Plant height differences reflected differential response to N timing and these differences were not consistent with tillage in 1997 or N source in 1999. Grain yields were higher with conventional tillage in 1997 but similar for both tillage systems in 1999. Both slow-release N sources produced significantly higher yields than urea in 1997, and yields were also higher with PF and PD N timings. There was a significant interaction for grain N content between N source and N timing. Grain N was lowest for both N sources when applied PF, but was highest with PP and PD timings for PCU and SCU, respectively. Grain N content was not affected by timing with urea. Straw N content was highest with conventional tillage and with slow-release N sources, and N timing had no effect on straw N. In 1999, yields with PCU were similar with PP and PD N timings but significantly reduced with a PF timing. Highest yield with urea occurred when N was applied PP, and yields were significantly reduced with PD and PF timings. Approximately 150 lb N/A were required to optimize grain yield with both PCU and urea. Both PCU and SCU increased grain yields in the stale seedbed, indicating that slow-release N products can be successfully used in both conventional and stale seedbed systems. Cost of slow-release N products is currently prohibitive, and higher grain yields at lower N application rates must be consistently realized to offset the additional expense of these products.

INTRODUCTION

Nitrogen is the most important nutrient required for maximizing rice production, but in terms of its efficiency, fertilizer N loss can be as high as 60% (De Datta et al., 1989, Freney et al., 1990). Management of N in flooded rice culture is difficult because of the various loss mechanisms that reduce N uptake and efficiency. Denitrification and ammonia volatilization result in large losses of fertilizer N when N is applied to the surface of wet soils and when N is applied into the floodwater on seedling rice. In Louisiana, severe problems with red rice, a noxious rice biotype, requires water seeding and pinpoint flooding to take advantage of red rice suppression through cultural management offered by this cultural system. Many rice fields in southwest Louisiana are prepared in standing water and N cannot be incorporated. When soils are prepared dry, N can be preplant incorporated and fields are flooded within 5 to 10 days. Delays in flood establishment result in the conversion of urea N to nitrate, and the N is subject to loss by denitrification. Adoption of stale seedbed planting practices significantly reduces soil erosion, but with this system, N has to be applied to the soil surface rather than incorporated.

A slow-release N product has the potential to improve N efficiency in stale seedbed systems in which N is applied to dry and wet soil surfaces. A slow-release urea product sold under the trade name of Meister was developed by Chisso-Asahi Fertilizer Co., LTD, of Japan and is marketed in the United States through Helena Chemical Co. Meister slow-release urea is currently used in commercial rice production in Japan. Limited research in the United States indicates this material can be successfully used preplant in conventional tillage, drill-seeded rice (Wells et al., 1994; Bollich et al., 1994; Bollich et al., 1998). Sulfur-coated urea has also been evaluated in Louisiana for use in water-seeded, conventional tillage rice systems (Brandon et al., 1985; Bollich et al., 1986). The objective of this study was to compare the slow-release urea products with urea at varying rates and N application timings in a water-seeded, pinpoint flood culture using conventional and stale seedbed tillage systems.

MATERIALS AND METHODS

Field experiments were conducted in 1997 and 1999 at the Rice Research Station in Crowley, LA, on a Crowley silt loam (fine, montmorillonitic, thermic Typic Albaqualf). A randomized complete block design with four replications was used, with a 2 x 3 x 3 factorial arrangement of tillage, N source, and N timing in 1997, and a 2 x 2 x 3 x 4 factorial arrangement of tillage, N source, N timing, and N rate in 1999. Tillage treatments consisted of conventional tillage and a stale seedbed. Both tillage treatments included plowing, mulching, and incorporation of phosphorus and potassium (0-45-45) during October and November. To complete stale seedbed preparation, glyphosate (1.0 lb ai/A) and 2,4-D (0.75 lb ai/A) were applied 4 weeks prior to planting, and paraquat (0.66 lb ai/A) was applied approximately 1 week prior to planting. To complete conventional seedbed preparation, required plowing and mulching were performed 3 days prior to planting. In 1997, polyolefin-coated urea (PCU), sulfur-coated (SCU) urea, and urea were applied at a rate of 135 lb N/A. In 1999, PCU and urea were applied at rates of 90, 120, 150, and 180 lb N/A. Each year, N was applied preplant (PP), postdrain (PD), and postflood (PF). Preplant N was applied to the soil surface and the experiment was flooded within 48 hours. Postdrain N was applied to a saturated soil surface 3 to 4 days after the initial drain and just prior to reflooding. Postflood N was applied into the floodwater 21 and 18 days after emergence in 1997 and 1999, respectively.

The experiment was planted with the variety Cypress at a rate of 100 lb/A into 7 by 25-ft plots. In 1997, seed was presprouted before planting, while in 1999, seed was planted dry. The experiment was drained 3 to 4 days after seeding. The permanent flood was established after 4 to 5 days of drainage. Nitrogen treatments were applied as described above. In-season pest control (weeds, insects, disease) was practiced as required and according to current recommendations. Days to 50% heading (calculated from date of rice emergence), plant height, grain yield adjusted to 12% moisture (ratoon and total grain yields determined in 1999), and N content of the grain and straw (1997 only) by combustion were determined. Data were statistically analyzed using ANOVA procedures and Fisher's Protected LSD for mean separation.

RESULTS

Results from 1997 are shown in Table 1. Significant treatment interactions occurred and treatment means involved in the interactions are shown in Table 2.

Days to 50% heading was affected differentially by tillage depending on N timing. With conventional tillage, days to 50% heading was delayed **1** day with N applied PD compared with PP and PD N timings. With the stale seedbed, heading was delayed 2 days by the PF timing compared with the PP and PD N timings. There was also an interaction between N source and N timing. With PCU, 50% heading was 1 day earlier with the PP and PD timings compared with the PF timing. With SCU, 50% heading was 1 day later with the PF N timing compared with the PP and PD N timings. With standard urea, 50% heading was 2 and 3 days later with the PF timing compared with the PP and PD timings, respectively.

Plant height was significantly increased by PCU and SCU, and an interaction occurred between tillage and N timing. On average, plant heights were 98, 95, and 91 cm with PCU, SCU, and urea, respectively. With conventional tillage, plant height declined as N was delayed. Plant heights were 98, 96, and 93 cm for the PP, PD, and PF timings, respectively. With the stale seedbed, plant height was relatively constant and ranged between 93 and 95 cm for the three N timings.

Grain yield was significantly influenced by tillage, N source, and N timing. On average, grain yield was higher with conventional tillage compared with the stale seedbed. Slow-release N sources yielded higher than standard urea, and the earlier N timings (PP and PD) had higher yields than the PF timing. Grain and straw N contents were significantly higher with conventional tillage compared with the stale seedbed, and straw N was higher with the slow-release formulations compared with urea. The response of grain N to N source was dependent on N timing. With PCU, grain N content increased as N was delayed while timing of SCU and urea had little effect on grain N. In general, grain N was higher with the slow-release formulations compared with urea.

Results from 1999 are shown in Table **3,** and significant treatment interactions are shown in Table 4. For days to 50% heading, tillage, N source, and N timing were highly interactive. The influence of N timing on 50% heading was independently affected by N source, tillage, and N rate. With PCU, the PF timing delayed heading by **1** day compared with the earlier applications. With urea, heading was unaffected by N timing. In general, heading was earlier with urea. A tillage by timing interaction indicated that heading was unaffected by N timing with conventional seedbed preparation and was delayed by 1 day by the PF timing compared with the earlier timings in the stale seedbed system. The N timing by N rate interaction indicated that 50% heading was delayed slightly as N rate increased with PP and PD N timings, but with a PF N timing, rate had no effect. While all of these interactions for days to 50% heading were significant, the differences were 2 days or less and were not thought to be biologically significant.

Numerous interactions also occurred for plant height. With PCU, plant height was similar across N timings. With urea, plant height decreased as N application was delayed. In general, plant heights were taller with PCU. The interaction between tillage and N timing was the result of reductions in plant height at later N timings. With conventional tillage, plant height was reduced only by the PF N timing, while with stale seedbed tillage, plant height was decreased by the PD and PF N timings. The interaction between N source and N rate occurred because of the difference in rate of increase in plant height in response to N rate. Plant height was more responsive to increasing rates of N with PCU than with urea. In general, plant height and grain yield were both higher with the stale seedbed. Main crop and total grain yields increased significantly as N rate increased to 150 lb/A, with little difference between the 150 and 180 lb/A rates of N. Ratoon crop yield was not influenced by main crop N rate. An interaction between N source and N timing occurred in the main crop and was carried over into total grain yield. With PCU, main and total grain yields were similar with the PP and PD N timings and comparatively reduced with the PF N timing. With urea, main and total grain yields declined as N was delayed.

DISCUSSION

Field experiments conducted in Louisiana indicate that slow-release urea products are effective for use in water-seeded, stale seedbed systems. Increased plant heights and higher grain yields resulted from the use of the slow-release N products both years of this study. Efficiency of urea N is significantly affected by its application timing and placement in relation to water management, especially when water seeding. With stale seedbed preparation, there is no opportunity to PP incorporate fertilizer N, resulting in surface placement on either dry seedbeds, wet seedbeds, or in an established flood on seedling rice. Due to the various loss mechanisms that affect N stability in rice, application of urea N to either wet soils or into the floodwater on seedling rice usually results in lower grain yields (Mengel and Wilson, 1988). Both PCU and SCU applied PD to wet soil produced grain yields comparable with those produced from PP applications. With PF applications of the slow-release N products, grain yields were decreased slightly, but were significantly higher than yields produced from urea-N applications into the floodwater. The greater utility provided by slow-release urea products in situations where wet soil applications or applications into the floodwater are unavoidable would certainly be advantageous to the rice producer. Cost is a concern, and at this time, it is questionable whether commercial use of these products is economically feasible. Future research should include evaluation of these materials in fertility programs where either PCU or SCU is used to provide only part of the required N. Such an approach would possibly result in realizing the advantages of slow-release N products but at a more economical cost.

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Table 1. Influence of tillage, N source, and N timing on agronomic performance of water-seeded Cypress rice. Rice Research Station, South Unit. Crowley, LA. 1997.

Tillage	N source[1]	N time[2]	Days to 50% heading	Plant Height	Grain yield at 12% moisture	N content Grain	N content Straw
				(cm)	(lb/A)	-----(%)------	
Conventional	Pcu	PP	79	100	8272	1.27	0.82
Conventional	Pcu	PD	79	101	8466	1.34	0.85
Conventional	Pcu	PF	76	96	8768	1.36	0.79
Conventional	SCU	PP	77	99	8700	1.31	0.75
Conventional	SCU	PD	78	97	8734	1.26	0.73
Conventional	SCU	PF	77	93	8438	1.28	0.76
Conventional	Urea	PP	77	94	7878	1.14	0.64
Conventional	Urea	PD	77	91	7673	1.12	0.55
Conventional	Urea	PF	77	90	7310	1.14	0.57
Stale	Pcu	PP	79	97	7984	1.22	0.71
Stale	Pcu	PD	80	99	7913	1.26	0.74
Stale	Pcu	PF	80	96	7408	1.37	0.84
Stale	SCU	PP	79	95	7881	1.18	0.65
Stale	SCU	PD	79	95	8310	1.18	0.63
Stale	SCU	PF	80	93	7405	1.25	0.77
Stale	urea	PP	78	91	6865	1.10	0.56
Stale	Urea	PD	78	93	7272	1.11	0.52
Stale	Urea	PF	82	90	6604	1.08	0.51
C.V., %			1.22	2.30	5.64	4.08	10.86
					Main effects		
Tillage:							
Conventional			78	96	8249	1.25	0.72
Stale			79	94	7516	1.19	0.66
LSD (0.05)			1	1	210	0.02	0.04
N source:							
Pcu			79	98	8135	1.30	0.79
SCU			78	95	8245	1-24	0.71
Urea			78	91	7267	1.11	0.56
LSD (0.05)			ns	1	258	0.03	0.04
N timing:							
PP			78	96	7930	1.20	0.69
PD			78	96	8061	1.21	0.67
PF			79	93	7656	1.25	0.71
LSD (0.05)			ns	1	258	0.03	ns
Interactions:							
Tillage x N source			ns	ns	ns	ns	ns
Tillage x N timing			•	•	ns	ns	ns
N source x N timing			•	ns	ns	•	ns
Tillage x N source x N timing			no	ns	ns	ns	ns

[1]PCU = mister with 150 day release; SCU = sulfur-coated urea.
[2]PP = preplant; PD = postdrain (surface application during pinpoint drainage); PF = postflood (3 weeks after emergence).

Table 2. Interaction means for selected variables. 1997.

Interaction		Days to 50% heading	Plant height	Grain N content
			(cm)	(%)
Tillage by N timing[1]				
Conventional	PP	78	98	
conventional	PD	78	96	
Conventional	PF	77	93	
Stale	PP	79	94	
Stale	PD	79	95	
Stale	PF	81	93	
N source[2] by N timing				
Pcu	PP	79		1.25
Pcu	PD	79		1.30
Pcu	PF	78		1.36
SCU	PP	78		1.25
SCU	PD	78		1.22
SCU	PF	79		1.26
urea	PP	78		1.12
Urea	PD	77		1.11
Urea	PF	80		1.11

[1]PP = preplant; PD postdrain (surface application during pinpoint drainage); PF = postflood (3 weeks after emergence).
[2]PCU = Meister with 150 day release; SCU = sulfur-coated urea.

Table 3. Influence of N source, tillage, and N rate on agronomic performance of drill-seeded Cypress rice. Rice Research Station, South Unit. Crowley, LA. 1999.

Source [1]	Tillage	N timing[2]	N rate[3]	Days to 50% heading	Plant height	Grain yield at 12% moisture Main	Ratoon	Total
			lb/A		(cm)	----------------------(lb/A)----------------------		
PCU	**Conventional**	PP	90	78	89	7021	2004	9025
PCU	**Conventional**	PP	120	77	90	7456	1758	9214
PCU	**Conventional**	PP	150	79	90	7561	2089	9650
PCU	**Conventional**	PP	180	79	95	7447	2003	9450
PCU	**Conventional**	PD	90	78	84	7180	1882	9062
PCU	**Conventional**	PD	120	78	92	7651	2011	9662
PCU	**Conventional**	PD	150	78	94	76%	1855	9550
PCU	**Conventional**	PD	180	80	99	7766	1831	9597
PCU	**Conventional**	PF	90	79	83	6357	1871	8228
PCU	**Conventional**	PF	120	79	85	6973	1767	8740
PCU	**Conventional**	PF	150	79	96	7715	2171	9887
PCU	**Conventional**	PF	180	79	95	7809	2151	9961
PCU	**Stale**	PP	90	77	84	7055	2244	9299
PCU	**Stale**	PP	120	77	90	7466	2237	9703
PCU	**Stale**	PP	150	77	91	7773	1935	9708
PCU	**Stale**	PP	180	78	93	7863	2104	9966
PCU	**Stale**	PD	90	77	82	6868	2186	9054
PCU	**Stale**	PD	120	78	88	7630	2039	9669
PCU	**Stale**	PD	150	78	90	8022	2098	10120
PCU	**Stale**	PD	180	79	92	7929	1975	9903
PCU	**Stale**	PF	90	79	86	6536	2103	8639
PCU	**Stale**	PF	120	80	87	7277	1709	8986
PCU	**Stale**	PF	150	80	92	7321	2003	9324
PCU	**Stale**	PF	180	81	91	7602	2052	9655
Urea	**Conventional**	PP	90	77	82	5787	1923	7709
Urea	**Conventional**	PP	120	77	82	6526	2034	8560
Urea	**Conventional**	PP	150	78	86	6861	1891	8152
Urea	**Conventional**	PP	180	78	91	7192	1858	9050
Urea	**Conventional**	PD	90	77	83	5843	2185	8028
Urea	**Conventional**	PD	120	77	82	5795	1988	7783
Urea	**Conventional**	PD	150	77	84	6471	2103	8574
Urea	**Conventional**	PD	180	78	88	6603	2200	8803
Urea	**Conventional**	PF	90	78	78	4486	1941	6427
Urea	**Conventional**	PF	120	78	78	4853	1938	6791
Urea	**Conventional**	PF	150	77	79	5552	2316	7867
Urea	**Conventional**	PF	180	78	80	5447	2178	7626
Urea	**Stale**	PP	90	76	79	6069	2232	8301
Urea	**Stale**	PP	120	76	81	6802	2252	9054
Urea	**Stale**	PP	150	77	86	6789	2131	8921
Urea	**Stale**	PP	180	77	89	7166	1919	9085
Urea	**Stale**	PD	90	76	76	5666	2102	7768
Urea	**Stale**	PD	120	77	79	5870	2120	7991
Urea	**Stale**	PD	150	77	83	6824	2194	9018
Urea	**Stale**	PD	180	76	81	6807	2072	8879
Urea	**Stale**	PF	90	77	78	4892	2158	7050
Urea	**Stale**	PF	120	77	79	5066	2192	7258
Urea	**Stale**	PF	150	77	78	5382	1999	7381
Urea	**Stale**	PF	180	77	79	5378	2287	7666
C.V., %				1.16	4.44	6.56	12.49	6.46
						Main effects		
Source:								
PCU				78	90	7416	2003	9419
Urea				77	82	6005	2092	8098
LSD (0.05)				1	1	126	73	161

Continued.

Table 3 continued.

	Days to 50% heading	Plantheight	Grain yield at 12% moisture Main	Ratoon	Total
		(cm)	----------(lb/A)----------		
			Main effects		
Tillage:					
Conventional	78	87	6669	1998	8666
Stale	71	85	6752	2098	8850
LSD (0.05)	1	1	ns	73	161
N timing:					
PP	77	87	7052	2038	9090
PD	77	86	6914	2053	8966
PF	78	84	6166	2052	8218
LSD (0.05)	1	1	154	ns	198
N rate:					
90	77	82	6147	2069	8216
120	78	84	6614	2004	8618
150	78	87	6997	2065	9063
180	78	89	7084	2052	9137
LSD (0.05)	1	2	178	ns	228
Interactions:					
Source x tillage	ns	ns	ns	ns	ns
Source x N timing	*	*	*	ns	*
Tillage x N timing	*	*	ns	ns	ns
Source x tillage x N timing	ns	ns	us	ns	ns
Source x N rate	ns	*	ns	ns	ns
Tillage x N rate	ns	ns	ns	ns	ns
Source x tillage x N rate	ns	ns	ns	ns	ns
N timing x N rate	*	ns	ns	ns	ns
Source x N timing x N rate	ns	*	ns	ns	ns
Tillage x N timing x N rate	ns	ns	ns	ns	us
Source x tillage x N timing x N rate	ns	ns	ns	ns	ns

[1]PCU = Meister with a 150-day release.
[2]PP = preplant; PD = postdrain (surface application during pinpoint drainage); PF = postflood (18 days after emergence).
[3]All N source treatments applied in single applications at each timing.

Table 4. Interaction means for selected variables. 1999.

Interaction		Days to 50% heading	Plant height	Main crop grain yield	Total grain yield
			(cm)	----------------(lb/A)---------------	
N source[1] by N timing[2]					
PCU	PP	78	90	7455	9502
PCU	PD	78	90	7593	9577
PCU	PF	79	89	7199	9177
Urea	PP	77	85	6649	8679
Urea	PD	77	82	6235	8355
Urea	PF	77	79	5132	7258
Tillage by N timing					
Conventional	PP	78	88		
Conventional	PD	78	88		
Conventional	PF	78	84		
Stale	PP	77	87		
Stale	PD	77	84		
Stale	PF	78	84		
N source by N rate[3]					
PCU	90		85		
PCU	120		88		
PCU	150		92		
PCU	180		94		
Urea	90		79		
Urea	120		80		
Urea	150		83		
Urea	180		85		
N timing by N rate					
PP	90	77			
PP	120	77			
PP	150	78			
PP	180	78			
PD	90	77			
PD	120	77			
PD	150	77			
PD	180	78			
PF	90	78			
PF	120	78			
PF	150	78			
PF	180	78			

[1]PCU = Meister with a 150-day release.
[2]PP = preplant; PD = postdrain (surface application during pinpoint drainage); PF = postflood (18 days after emergence).
[3]All N source treatments applied in single applications at each timing.

SOIL AMENDMENTS TO INCREASE COTTON PRODUCTIVITY ON DROUGHT-STRESSSED SOILS

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ABSTRACT

Application of by-product waste-stream materials as soil amendments is an attractive alternative disposal method that could improve the productivity of drought-stressed soils. We conducted field experiments from 1996 through 1999 on Gigger-Gilbert silt loam (fine-silty, mixed, thermic, typic Fragiudalf-Glossaqualf) to determine if cotton *(Gossypium hirsutum L.)* yields could be increased by soil applications of organic and inorganic waste materials. The waste materials were applied using two methods of application, broadcast incorporated and as vertical mulch directly under the row. The waste materials were municipal biosolids (MB), composted sewage sludge (CSS), papermill sludge (PS), and papermill boiler ash. Applications were made with each material and with selected combinations of the materials. The rate of application for all treatments was 60 tons/A. Method of application had little or no consistent effect on response to the waste materials. Lint yield and plant height increased with application of MB, CSS, and boiler ash in the year of application and in the following 3 years. Yield increases ranged from 55% for MB applications and 40% for CSS applications. Application of PS decreased yield 70% and plant height 12 to 26% in the year of application and had no consistent residual effect on yield in the following 3 years. Waste materials with a low C:N applied as soil amendments were a fast and economic means of improving soil productivity and cotton yield. Papermill sludge with its high C:N should not be applied soil incorporated because of the potential for N immobilization.

INTRODUCTION

Loess soils of the southern U.S.A., which include large areas of cotton production, have low pH and organic matter content and natural shallow hardpans and fragipans that limit rooting depth. These problem soils are droughty and irrigation must be applied often to produce a profitable crop. The soils can be improved for cotton production by growing winter cover crops for green manure and using reduced (conservation) tillage practices (Boquet, et al., 1997; Hutchinson et al., 1991). This is a slow and expensive process requiring many years to increase soil organic matter. A faster and more economic means of improving soil productivity may be to utilize readily available organic materials from selected waste streams as soil amendments.

Each year in the U.S.A., a total of 400 million tons of organic wastes are generated (Korcak, 1998). Of these, about 208 million tons are municipal solid wastes (USEPA, 1996), 5 million tons are papermill sludge (PS) (Glenn, 1997) and 550,000 tons are biologically treated municipal biosolids (MB) (Millner et al., 1998). Additionally, paper mills produce large quantities of boiler ash. The cotton ginning industry produces approximately 800,000 tons of gin trash yearly. Historically, these waste products have been stored in lagoons and landfills or incinerated. These methods of disposal are no longer acceptable because they may cause environmental degradation. Beneficial use as soil amendments would be an attractive alternative disposal method for many by-product waste materials. This would recycle plant nutrients that would otherwise be lost and possibly enhance the productivity of land used for cotton production. The possibility of significant benefits to cotton from organic wastes applied as soil amendments has been recognized for more than 65 years (Reynolds, 1930). Waste-stream materials can be obtained at little or no cost but their value in agriculture is limited by transportation and application costs. To be practical and economic, waste products must be applied on agricultural land that is located within 50 miles of the production facility.

In recent years, the yield of dryland cotton grown on loess soils of the southern U.S.A. has been increased through the use of conservation tillage and green manure crops. The objective of this research was to determine whether cotton yields could be increased by soil applications of organic and other waste materials used in place of the green manure crop. If application of these materials proves beneficial, it will benefit not only cotton farmers but will also offer an economic and environmentally acceptable means of waste disposal.

MATERIALS AND METHODS

Field experiments were conducted from 1996 through 1999 on Gigger-Gilbert silt loam (fine-silty, mixed, thermic, typic fragiudalf-glossaqualf) at the Louisiana State University Agricultural Center Macon Ridge Research Station located near Winnsboro, Louisiana. The materials selected for evaluation were MB, composted sewage sludge (CSS), PS (primary, dewatered), paper mill boiler ash, and selected combinations of these materials. The composition of each of the waste materials is presented in Table 1. A complete list of treatments is shown in Table 2.

Methods of Application. The waste products were applied in two methods of application: i) broadcast on the soil surface and incorporated to a depth of 6 inches and ii) vertical mulch under the row in a 6-inch wide x 24-inch deep trench. The quantity of materials applied was dependent upon that needed to fill the vertical trenches, which varied from 40 to 60 tons of dry weight/A. The same rates were then used for the broadcast treatments. All of the treatments were applied in 1996 one week before planting. After application of the amendments the plots were prepared for planting by bedding with disk hippers (40-inch wide beds) and smoothing with a reel and harrow row conditioner. There were two control treatments: 1) plots that were bedded and prepared without amendments and 2) plots that were trenched and refilled without adding vertical mulch amendments.

Planting. In 1996, the plots were planted immediately after completing application of the soil amendments. After harvest in September 1996, the plots were left undisturbed except for stalk cutting. The plots were no-till planted in late April or early May 1997, 1998, and 1999 without re-applying amendments. ‘Deltapine NuCotton 33B’, ‘StonevilleLA887’, ‘Suregrow 125', and ‘Suregrow 125BR’ were planted in 1996, 1997, 1998, and 1999, respectively. Standard practices for the region were used to control diseases, weeds, and insects.

Fertilization. The N status of cotton plants in each treatment was monitored by weekly sampling of leaf petioles and blades (uppermost fully expanded leaf) for nitrate-N and total N content. Treatments that became N deficient were supplemented with inorganic N fertilizer. Supplemental fertilizer N was required by cotton in the papermill sludge and boiler ash treatments in each year. Fertilizer N was applied as surface-broadcast ammonium nitrate. Control treatments received the standard inorganic fertilization of 80 lb N/A.

Experimental design. The experiments were conducted in a randomized complete block design with four blocks. The arrangement of the treatments was a split plot with methods of application as the main plots and soil amendments as the sub plots. The experimental units were four 40-inch wide rows 50 ft long. Treatments were applied on and data collected from the two center rows of each plot.

Data collection. Data were collected on plant growth and development and yield. Plant height and node number per plant were determined 30 days after planting and at crop maturity by measuring 10 plants per plot. Node above white flower and internode length above white flower were determined at 8-day intervals during the 6-week period from bloom initiation to the end of effective bloom. Plots were harvested with a mechanical picker for seedcotton yield determination. Seedcotton sub samples were ginned in a laboratory 20-saw gin to determine lint percentage, which was used to calculate lint yield.

RESULTS

First-year effects. In the year applied, there were significant effects of the soil-amendment treatments on lint yield. Broadcast application of MB increased lint yield 22% compared with the standard fertilization practices (Control 1)(Table 2). Cotton in the vertically-mulched MB treatment produced a lower yield than with broadcast application. Combinations of MB with other wastes resulted in similar effects on lint yield as MB applied alone. None of the tested waste combinations produced higher yields than MB alone. In the year applied, CSS as a broadcast treatment did not increase yield but, as a vertical mulch treatment, CSS increased yield 25%. Application of PS decreased lint yield in the year applied (Table 2). Cotton plants in the PS treatments were N deficient throughout the growing season even though fertilizer N was applied when needed as dictated by plant N content. Papermill boiler ash had no effect on cotton yield in the year applied.

Plant growth responses to applications of amendments closely paralleled yield responses. The tallest plants were produced with application of MB, alone or in combination with PS or boiler ash (Table 3). In the initial year, the shortest plants were produced in the PS and PS plus boiler ash. With application of CSS, plant height was similar to the standard fertilizer practices.

Residual Effects. In the 3 years following application, there were significant lint yield responses to the soil amendment treatments. With broadcast application, all amendments increased lint yield above the standard fertilizer and liming practices (Table 2). Broadcast application of MB increased lint yield 55% in the year following application (first year residual) compared with the control. Averaged across the 3 residual years, broadcast-applied MB increased lint yield 264 lb/A (56%). Vertically-mulched MB had a larger residual effect on lint yield than broadcast MB, increasing lint yield 431 lb/A (57%) across 3 years. With both methods of application, the largest residual effects were from the treatments containing MB. As in the initial year, combinations of MB with other wastes resulted in lint yields similar to MB alone, and none of the residual waste combinations produced higher yields than MB alone.

The residual effect of CSS on yield from 1997 through 1999 was not as large as that of MB, but CSS did increase lint yield 41% when applied broadcast and 24% when applied as a vertical mulch. Average yield increases from residual CSS were about $^{3}/_{4}$ of the increase from MB with broadcast applications and only 1/3 of the increase from MB in the vertical mulch treatments. In contrast with 1996, when PS decreased yield as much as 70%, the residual effects of PS on cotton yield were neutral to positive. Averaged across all 4 years, PS did not significantly affect lint yield, and among the 3 residual years of 1997, 1998, and 1999, the effects of PS were inconsistent. Papermill sludge increased lint as a broadcast treatment only in 1997 and as a vertical mulch treatment only in 1998.

Although not affecting yield in the initial year, the residual effects of boiler ash significantly increased lint yield in years two through four. In some years, boiler ash was as effective as the organic amendments in increasing lint yield. The use of boiler ash in combination with other wastes did not provide any yield benefit above that obtained from organic amendments alone, but use of boiler ash in combination with MB was superior to MB and PS combinations or CSS alone. This was likely due to the fact that most of the amendment treatments contained high amounts of Ca and increased the soil pH without the addition of a liming agent (boiler ash).

As with plant height responses to waste applications in the initial year, plant height responses in the residual years closely paralleled the yield responses. In each year after the initial year, the tallest plants occurred in the MB treatments (Table 3). In the third-year residual, however, the MB combinations with PS or boiler ash no longer gave consistent increases in plant height when compared with the standard fertilizer control.

The waste treatments increased yield above that obtained with the control treatments that employed standard fertilizer and liming practices. A likely explanation for this is that, in addition to the nutritional benefits of the amendments, the organic components provided increased water holding capacity and water infiltration. The vertical mulch treatments also eliminated the shallow hardpan directly under the row, which allowed additional water storage and root development. Examination of root development patterns revealed that roots were limited primarily to the mulched area and did not grow into the undisturbed subsoil on either side of the mulch. The interface between the mulch and subsoil proved to be the area of greatest root development (data not shown).

DISCUSSION

The application of waste materials as soil amendments had positive effects on cotton growth and yield and soil properties. Much of the benefits from the amendments were from the nutrients they contain, especially N. This was evident from plant analysis that showed up to a 1400% increase in plant N from application of MB (data not shown). Additionally, some of the amendments increased soil pH and the soil levels of P, K and Ca. Greater yield increases in the year following application rather than in the year of application were related to the mineralization of nutrients and increases in soil pH that occurred after the first year. Soil incorporated PS treatments, especially, required a reduction in C:N to release the N immobilized in the first year. In other experiments, applying PS as surface mulch with soil-injected fertilizer N has prevented N immobilization in the year of application (data not shown). Boiler ash proved to be, as expected, an effective liming material and raised the soil pH. This was particularly beneficial in the vertical mulch treatment because of the low pH of the subsoil that contained toxic levels of Al and Mn.

SUMMARY

A comparison of broadcast and vertical mulch application for soil amendments revealed no consistent differences in cotton performance between the two methods. The less expensive and faster method of broadcast application would therefore be more economical. Application of organic materials with high amounts of N and narrow C:N increased plant growth and crop yield in the year of application and in the following years. Paper mill sludge with its wide C:N decreased yield in the year of application. In the year after application, the C:N in the PS treatments was narrowed by mineralization processes and cotton plant growth and yield increased, although not to the level of MB or CSS treatments. The use of these organic soil amendments appears to be a faster and more economical means of improving soil productivity and cotton yield than growing winter green-manure crops.

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Table 1 Elemental composition of materials applied as soil amendments for cotton production.

Element	Paper mill sludge	Composted sewage sludge	Municipal biosolids	Paper mill boiler ash
	----------	---------- mg/kg	----------	----------
C	42000	196000	257000	183000
N	1300	7700	45000	1800
A1	912	8230	13680	6471
As	0.0	3.0	2.9	2.6
B	84	49	73	37
Ba	49	257	295	308
Ca	3200	12170	13993	39527
Cd	0.6	5.1	6.9	1.9
Cr	28	25	38	7.7
Cu	14.8	110	317	28
Fe	844	11884	15918	2681
Hg	0.0	0.4	0.4	0.0
K	276	1758	3225	4693
Mg	417	2551	4917	2062
Mn	91	316	619	977
Na	2371	220	1883	4227
Ni	5.0	13	22	12
P	144	3213	12680	546
Pb	1.1	42	40	8.0
Se	1.1	0.0	0.0	0.0
Si	26	2024	107	64
Sr	20	73	112	282
Ti	13	80	29	115
Zn	29	191	323	75

Table 2. Yield response of cotton to broadcast-incorporated and vertical-mulch applications of organic and inorganic wastes on Gigger-Gilbert silt loam at Winnsboro LA.

Soil amendment	Lint Yield				
	1996	1997	1998	1999	Average
	---- lb/A ----				
	Broadcast Application				
Papermill sludge (PS)	178	807	397	479	465
Composted sewage sludge (CSS)	630	882	480	639	658
Municipal biosolids (MB)	736	936	588	686	737
Boiler ash (BA)	631	850	401	570	613
PS + BA 7:3	200	876	405	556	509
CSS + BA 7:3	692	970	470	652	696
MB +BA 3:2	821	991	555	724	773
PS + MB 3:1	716	855	429	614	654
PS + MB + BA 8:5:7	728	970	456	652	702
Control 1 +	605	603	378	436	510
	Vertical Mulch Application				
PS	330	648	470	534	496
CSS	650	870	541	560	655
MB	617	1137	664	689	777
BA	612	1025	470	621	682
PS + BA 7:3	364	818	508	653	586
CSS + BA 7:3	618	935	568	636	690
MB +BA 3:2	686	1164	703	783	834
PS + MB 3:1	575	1044	574	673	716
PS + MB + BA 8:5:7	662	1170	694	701	807
Control 2 ‡	519	755	378	452	526

†Standard management practice, 80 lb N/A. $Trenched and refilled, no amendment, 80 lb N/A.

Table 3. Plant height response ofcotton to broadcast-incorporated and vertical-mulch applications of organic and inorganic wastes on Gigger-Gilbert silt loam at Winnsboro, LA.

Soil amendment	Plant Height 1996	1997	1998	1999	Average
	--------	--------	inches	--------	--------
			Broadcast Application		
Paper mill sludge (PS)	33.5	33.8	28.2	41.0	34.1
Composted sewage sludge (CSS)	37.0	33.1	30.0	40.9	35.2
Municipal biosolids (MB)	40.6	42.1	32.2	47.8	40.7
Boiler ash (BA)	40.9	32.3	25.5	38.4	34.3
PS +BA 7:3	29.5	33.9	26.1	38.0	31.9
CSS +BA 7:3	38.9	33.9	26.7	41.5	35.2
MB +BA 3:2	40.6	40.6	30.4	44.6	39.0
PS+MB 3:l	40.9	37.0	25.8	40.5	36.0
PS +MB +BA 8:5:7	41.3	39.0	27.1	41.0	37.1
Control 1†	37.4	27.6	24.4	42.3	32.9
			Vertical Mulch Application		
PS	28.7	27.6	25.6	41.7	30.9
CSS	38.9	31.5	26.3	40.7	34.3
MB	43.7	39.4	28.7	44.2	39.0
BA	35.0	32.3	24.6	37.7	32.4
PS+ BA 7:3	29.5	28.7	25.2	41.7	31.3
CSS + BA 7:3	38.2	30.7	25.8	41.5	34.0
MB +BA 3:2	38.6	41.3	29.3	45.6	38.7
PS + MB 3:l	34.6	37.0	26.8	43.2	35.4
PS + MB + BA 8:5:7	39.4	39.4	29.7	41.0	37.4
Control 2‡	38.9	30.3	24.9	42.1	34.0
LSD (0.05)		(within year) 3.7	3	(across year) 2.6	[illegible]

†Standard management practice, 80 lb N/A. ‡Trenched and refilled, no amendment, 80 lb N/A.

SOIL DISRUPTION BY FIRE ANTS IN CONSERVATION AND CONVENTIONAL TILLAGE TREATMENTS

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ABSTRACT

In the southeastern Coastal Plains, fire ants *(Solenopsis invicta* Buren) can, at times, produce a significant number of mounds/A. It was our objective to analyze amount and shape of soil disruption within conventional and innovative (conservation) tillage systems and determine if management system affects disruption of soil by ants. Using strength probes with detachable handles, soil disruption by fire ants was measured in a field split on conventional and innovative tillage management systems. Soil strength readings were also taken near the fire ant mounds to measure conditions outside the mounds. Preliminary results show that the conventional treatment had a greater volume of soil disruption by ant activity while the innovative treatment had greater depth of disruption. When readings taken in the mounds were corrected for strength readings taken outside the mounds, innovative management had greater depth and volume of soil loosening as a result of ant activity than conventional management, probably because innovative deep tillage disrupted more of the subsoil than conventional tillage. The deeper disruption in the innovative treatment may cause more rapid leaching of surface applied nutrients and pesticides.

INTRODUCTION

Red imported fire ants cause an estimated $2.77 billion annual damage in the southeastern United States (Thompson *et al.,* 1999). Fire ants were introduced to the country in about 1930 in the Mobile, Alabama area. Since then, they have spread by various degrees throughout the southern part of the USA. Now, red imported fire ants are endemic to the southeastern Coastal Plains (http://www.aphis.usda.gov/oa/antmap.html, http://entweb.clemson.edu/caps/regional/rif/rifdist.htm, http://uts.cc.utexas.edu/~gilbert/research//fireants/ faqans.html#import). With normal weather conditions and large-scale use of irrigation, they are expected to spread, especially north along coastal areas (Thompson *et al.,* 1999).

Numbers of fire ant mounds can vary with differing habitat (Coulson et al., 1999) and tillage treatment (Manley, 1999). However, the amount and shape of soil disruption per mound among differing environmental conditions have not yet been determined.

It was our objective to analyze soil disruption per mound within conventional and conservation tillage systems and determine if differences in amount and shape of soil disruption by ants was affected by management system.

MATERIALS AND METHODS

In 1997, a long-term study was initiated to quantify improvements of profitability, environmental protection, and pest management between conventional and innovative management techniques (http://agroecology.clemson.edu/). The study was performed using a 14-acre field at the Pee Dee Research Center in Florence, SC. The field was split in half with common soils on both sides. The two sides were treated with conventional or innovative management practices. The conventional side used standard management practices traditionally used by producers in 1995, including disking, planting soybean in 30-inch row spacings, and chiseling or in-row subsoiling with a 45' forward angled, straight shank. The innovative side used more advanced practices, including no surface tillage, drilling soybean at 7.5-inch row spacings, and paratillage[1] at 26-inch spacing.

In 1997, both sides of the field were planted to corn using conventional management to standardize the initial conditions of the experiment. In 1998, while both were double cropped to wheat and soybean, the two sides had separate management practices instituted on them. On the conventional side, soil was disked, chisel plowed, and smoothed before wheat planting (variety Pioneer 2384). After wheat harvest, straw was burned; the soil was disked, in-row subsoiled, and soybean (NK S75-55) planted in 30-inch row widths. Conventional herbicides were applied and the soil was cultivated between rows twice during the growing season. After harvest the conventional side was disked for weed control.

On the innovative side, soil was paratilled before planting wheat (variety Pioneer 2384) into a non-disked surface. After wheat harvest, the soil was paratilled again and soybean (Roundup Ready variety N.K. S73-Z5) were drilled using 7.5-inch row widths. Roundup was applied preplant and again 3 weeks after planting (1 qt/A). Nutrients for both sides of the field were applied based upon Clemson University Extension Service recommendations. On the conventional side, nutrients were applied on a field scale; on the innovative side, they were applied based on soil type. Both sides were harvested with a CASE 2366 combine equipped with yield monitor and GPS technologies. The field was left fallow in the winter of 1999 in preparation for corn planting.

In March 1999, twelve mounds were located in the field (six on each side) and paired based on soil type and surface appearance. Mounds were located at four sites that were mapped as Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudult) and two that were mapped as Noboco loamy sand (fine-loamy, siliceous, subactive, thermic Typic Paleudult).

Strings were attached to a 3- by 3-ft frame at 4-inch spacings to make a 4- by 4-inch grid to locate positions across the surface of mounds where depth measurements of ant disruption would be taken. Grids were placed over mounds slightly raised to not disturb the soil and attract swarms of ants. Grids were oriented with one dimension along the row and the other perpendicular to the row.

For depth measurements of ant disruption, 3-ft long, 0.25-inch diameter rods were marked at 4-inch depth intervals. These rods were attached to a custom made proving ring and handle with a quick release thumbscrew. Rods were pushed into the ground until they passed through the zone disrupted by fire ants, estimated by a sudden increase in force registered on the proving ring, standardized to a pressure of 15 atm. Handles were detached from the rods while the ants swarmed over the rods. Other rods were pushed into other points on the grid in a similar manner. When ant activity subsided, depth readings were taken based on markings on each rod and recorded. Readings recorded position across the row, location along the row, and depth into the soil. Depth readings were corrected to the height of the soil when the measurement grid and/or ant mound was above it.

To determine how much of the soil disruption was based on ant activity and how much on tillage,

[1]Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture or Clemson University.

cone index readings were also taken across the rows about 2 ft from the ant mound. Cone index data were taken with a 0.5-inch diameter cone-tipped penetrometer (Carter, 1967). Cone indices were measured by pushing the penetrometer into the soil to a depth of 2 ft at nine positions across the rows; cone index positions included the same positions across the row as those measured in the fire ant mounds. Cone index data were digitized into the computer at 2-inch depth intervals using the method of Busscher *et al.* (1986). Data for all positions across the plot and depth were combined to produce cross-sectional contours of soil cone indices.

Gravimetric soil water content samples were taken along with cone indices. They were taken at the mid-position of cone index readings. Water contents were measured at 4-inch depth intervals to the 2-ft depth. These water contents were taken as representative of the water contents where penetrometer data were taken and representative of the soil just outside the disrupted volume of the ant mound where the 15 atm data were measured.

Depths outside the mounds where soil strength was 15 atm due to tillage were determined by interpolation of cone index data. These depths were subtracted from the depths measured at 15 atm in the fire ant mounds. The difference determined the amount of soil disruption by ants beyond the disruption of tillage alone. Depths were used to calculate volume of disruption by the ants, mean depth of disruption with and without correction for ant activity, and maximum depth of disruption with and without correction for ant activity.

RESULTS

Soil disruption by fire ants was greater in the conventional management treatment than in the innovative management treatment (Table 1). Though the amount of soil disruption was only a couple of cubic feet per mound, disruption could be substantial across an agricultural field since there can be a significant number of mounds/A. For example, we counted anywhere from 5 to 49 mounds/A in this experiment, ranging from 7 to 49 mounds on the conventional and 5 to 44 mounds on the innovative side. Neither management treatment had consistently more mounds/A than the other over all the measurement dates. Mounds appear to be more associated with soil type, with densities ranging from 0 to 73 mounds/A for different soils (Donald Manley, Personal Communication, 2000).

The shapes of soil volume disrupted by ant activity were different for the two management systems. Soil disruption tended to be broader and shallower on the conventional side, perhaps encouraged by disking. Soil disruption was deeper and more confined on the innovative management side, perhaps encouraged by its more extensive deep tillage (Table 1 and Fig.1). In the conventional treatment, the dip in readings on the left side of the zones of fire ant disruption (Fig. 1) was a result of readings taken in the row for the in-row subsoiled treatment. We stopped taking readings when we had no indication of ant activity on the surface and when we started to measure low strengths in the zone loosened by the subsoil shank.

Different tillage management systems lead to differences in soil strength (cone index, see Fig. 2) which may affect mound shape and amount of soil disruption by ants. Mean cone indices for the top 22 inches across 30 inches of row were greater on the conventional (31.3 atm) than on the innovative side (24.6 atm), even though the conventional side had a higher water content at the time of cone index measurement (8.4 vs. 7.2% on a dry weight basis).

We estimated the end of the soil disruption by ants at a force of 15 atm as measured by our modified probe. We assumed that the modified probe and the penetrometer measured comparable soil strengths. Therefore, we corrected the depth readings measured in the ant mounds by subtracting depths measured in the mounds by depths measured at 15 atm by the penetrometer in the soil near the mounds. Depth corrections were significantly greater for the conventional management treatment (5.4 inches) than for the innovative treatment (3.4 inches) (Table 1 and Fig. 2). Because of the greater correction for the conventional management treatment, volume of disruption after correction (i.e. volume of disruption by ants) was greater for the innovative treatment than for the conventional treatment. Despite the larger correction for the conventional management treatment, maximum depth of ant disruption for the innovative treatment was significantly greater both before and after correction. Since looser soils generally have greater infiltration rates, the greater depth of disruption for the innovative management treatment would have a greater risk for deep percolation of nutrients and pesticides than the conventional treatment.

CONCLUSIONS

Preliminary results indicate that, before correction of the data for disruption by tillage, volume of soil disruption by fire ant activity was greater in the conventional treatment while depth of disruption was deeper in the innovative treatment. After readings within the mounds were corrected for tillage treatment, volume of disruption and depth were greater for innovative than conventional tillage, probably because innovative tillage disrupted more of the subsoil than the conventional tillage treatment, providing a more suitable environment for ant activity. Deep disruption in the innovative treatment may cause greater infiltration and more leaching of nutrients and pesticides to the groundwater. We are continuing to take readings to increase the data base for this experiment. Readings in similar paired fields would also increase confidence of the results.

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Table 1. Characteristics of fire ant mound disruption as measured by a probe until a force of 15 atm was reached. Numbers in parentheses are standard deviations.

	Treatments	
Before Correction	**Conventional**	**Innovative**
Volume, ft^3/mound	**2.40 (0.92)**	**2.05 (0.55)**
Mean depth, in	**8.81 (3.80)**	**7.50 (3.86)**
Maximum depth, in	**16.3 (3.92)**	**21.8 (8.29)**
After correction		
Volume, ft^3/mound	**0.97 (0.35)**	**1.09 (0.28)**
Mean depth, in	**3.58 (2.33)**	**4.00 (3.65)**
Maximum depth, in	**9.37 (2.28)**	**18.8 (7.66)**

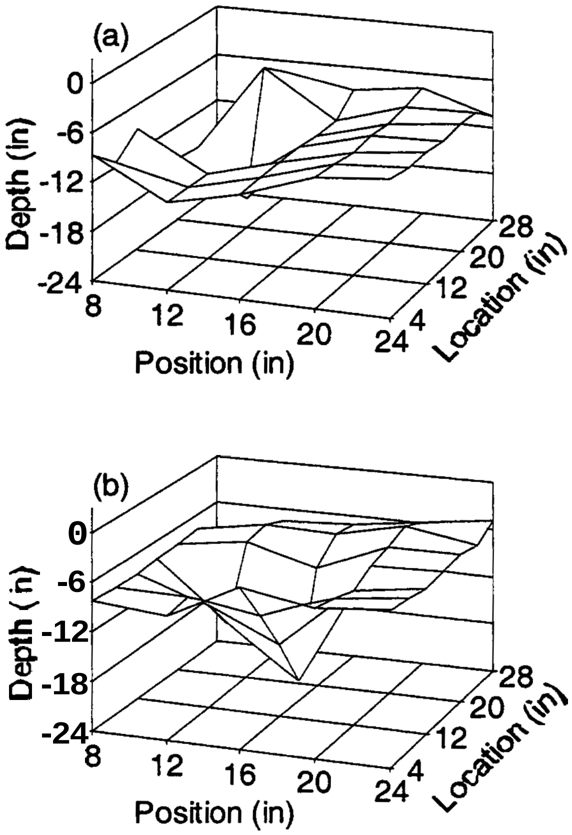

Figure 1. Depth of soil disrupted by fire ants for (a) the conventional management treatment and (b) the innovative management treatment.

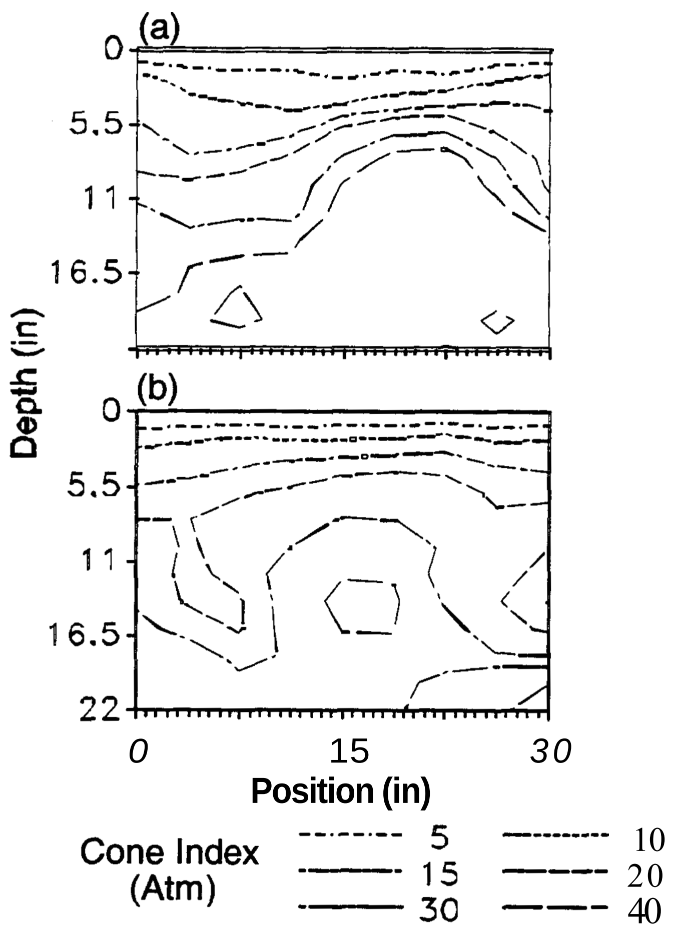

Figure 2. Soil strength patterns for (a) the conventional management treatment and (b) the innovative management treatment.

THE GREATER CARBON SEQUESTRATION IN NO-TILL SOILS DEPENDS UPON ITS DISTRIBUTION WITH DEPTH

M. Diaz-Zorita[1,2] and J.H. Grove[2]

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ABSTRACT

Soil organic matter (SOM) storage in agricultural soils has a significant effect not only on productivity but can also ameliorate the greenhouse effect via atmospheric CO2 sequestration. Several reports show a larger accumulation of SOM in the top layer of soils under no till (NT) practices but no significant differences with respect to soils under chisel till (CT) when deeper layers are considered. Our objective was to determine the effects of tillage practices upon the SOM distribution with depth in Maury silt loam soils (Typic Paleudalfs) at a similar level of crop residue production. The study used selected plots with similar corn productivity from three tillage experiments at the University of Kentucky's "Spindletop" Experiment Farm. Soil samples (0 to 8 inches in 1-inch increments) and above ground residues were taken in June and November of 1999 and expressed as levels of carbon (SOC = SOM x 0.58, $C_{residue}$ = Residue dry weight x 0.40). The bulk density (BD) of each layer was estimated from resistance to penetration measurements. A significant positive difference in C levels from June to November was observed only in the residue cover of all tillage treatments and in the 0- to 1-inch layer of NT soils. Our results confirm the positive effect of NT on the surface (0 to 1 inch) storage of C in agncultural soils, but only after a decade of continuous NT. Although the BD of deeper layers (6 to 8 inches) in NT was greater than in moldboard till (MT) soils, greater C was observed in those layers under MT than under NT. The C stored in the soil explained the differences in C storage between tillage practices, and it was maximal under either CT or NT soil management practices.

INTRODUCTION

Soil organic matter (SOM) storage in agricultural soils has a significant effect not only on productivity but can also ameliorate the greenhouse effect via atmospheric CO_2 sequestration. Although the degree of SOM loss due to cultivation of soil tends to decrease as the intensity of tillage decreases, there are not clear differences in SOM storage among conservation tillage practices. Several reports show a larger accumulation of SOM in the top layer of soils under no till (NT) practices but no significant differences with respect to soils under chisel till (CT) when deeper layers are considered. The amount and quality of the residues have been proposed as significant factors controlling total SOM storage in agricultural soils (Paustian et al. 1997; Diaz-Zorita and Grove, 1999a).

Our objective was to determine the effects of tillage practices upon the SOM distribution with depth in Maury silt loam soils (Typic Paleudalfs) at a similar level of crop residue production.

MATERIALS AND METHODS

The study was performed in different tillage experiments (Table 1) at the University of Kentucky's "Spindletop" Experiment Farm near Lexington, KY on Maury silt loam soils. The plots were selected in order to give different durations of comparative tillage treatments at similar levels of corn productivity between tillage treatments within each experiment.

Table 1: Characterization of the tillage experiments used in the study.

Experiment	B123	B166	F19
Initiation (year)	1970	1991	1996
Tillage treatments	NT-MT	NT-CT-DT-MT	CT-NT1-NT2
$N_{fertilizer}$ rate (lb N/A)	150	134	118
Crop sequence	CCC	CCC	C-S-W/S
Winter Cover crop	Rye	Rye	No

References: NT = no till, MT = moldboard till, CT = chisel till, DT = disk till, NT_1 = 1 year of NT after CT, NT_2 = 2 years of NT after CT. C = Corn, S = Soybean, W/S = Wheat/Double-Crop Soybean

In each plot, soil samples were taken in 1-inch increments from the surface to a depth of 8 inches in June and November 1999. After air drying and crushing to pass a 0.08-inch sieve, the SOM on each soil was determined by dry combustion. Two days after an intensive rainfall, the resistance to penetration (Eijelkamp Penetrologger) of the moist soil was measured in 0.4-in increments from 0 to 8 inches. The bulk density (BD) of the soils was estimated using a relationship between BD and penetration resistance (PR) determined for these soils under similar moisture conditions (Diaz-Zorita and Grove, 1999b).

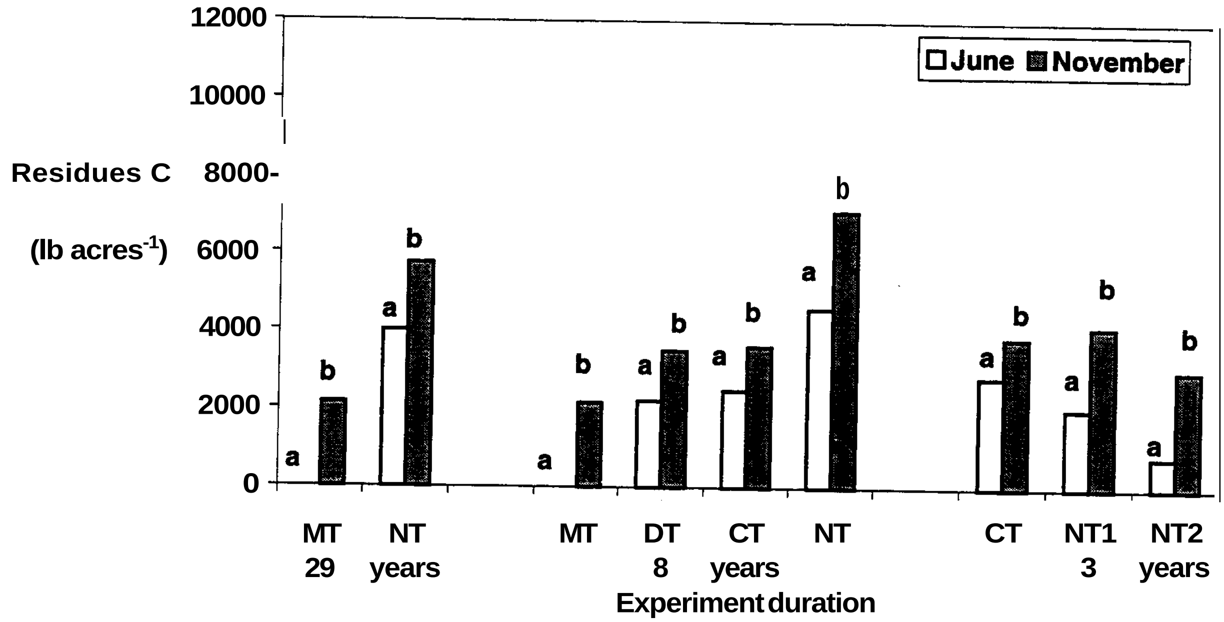
The total amount of soil organic carbon (SOC) per unit surface area was calculated from the product of estimated BD, the depth of sampling (1 inch) and considering 58.1% of the SOM to be organic C (SOC, Walkley and Black, 1934). The amount of residues was determined in June and November by collecting and weighing the residue pieces larger than 0.08 inch found in 1.94 ft^2 of plot surface. The C content of the residues was assumed to be 0.40 of its dry weight (Collins et al. 1999).

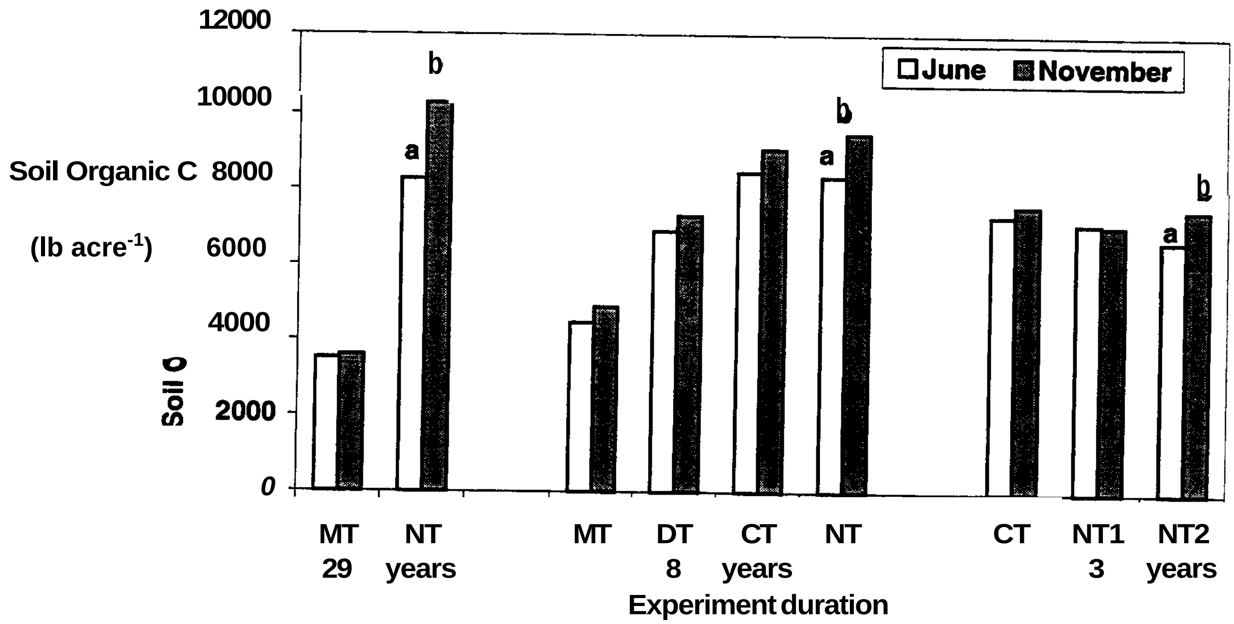
The SOC and PR results from each experiment were analyzed using appropriate analysis of variance procedures (SAS PROC MIXED, 1996), considering each experiment as a randomized block with four replications, split for sampling depth and sampling date.

RESULTS

The amount of C in the residue layer and in the 0- to 1-inch depth of NT soils was greater in November than in June (Fig. 1). The average difference in dry weight of the above ground residue levels between sampling dates (4822 lb/A) was independent of the tillage system. No significant effects of sampling date on the SOC in tilled soils and below 1 inch in the NT treatments were observed.

Figure 1 (next page): Effect of sampling date and tillage practice on residue C and soil organic C levels in the 0- to 1-inch layer of Maury silt loam soils. NT = no till, MT = moldboard till, CT = chisel till, DT = disk till, NT_1 = 1 year of NT after CT, NT_2 = 2 years of NT after CT. The same letter or the absence of letters at the top of each bar indicates there was no significant difference ($p < 0.05$) between sampling dates within each tillage treatment.


Residues C
(lb acres-1)
12000
10000
8000
6000
4000
2000
0
June
November
MT
NT
29
years
MT
DT
CT
NT
8
years
CT
NT1
NT2
3
years
Experiment duration


Soil Organic C
(lb acre-1)
12000
10000
8000
6000
4000
2000
0
June
November
MT
NT
29
years
MT
DT
CT
NT
8
years
CT
NT1
NT2
3
years
Experiment duration

Although the PR values in MT treatments were significantly lower than those in soils under NT, CT, or DT practices (Table 2), greater SOM contents were sometimes observed in deeper layers of MT treatments (Fig. 2). This behavior confirms the positive effect of NT practices on SOM accumulation in surface soil layers, suggesting a vertical redistribution of organic materials.

Table 2: Effect of four tillage systems in three tillage studies on the soil penetration resistance values (lb/in2) of a Maury silt loam soil. NT = no till, MT = moldboard till, CT = chisel till, DT = disk till, NT, = 1 year of NT after CT, NT2=2 years of NT after CT. Different letters at a given depth in the same experiment indicate a significant difference ($p < 0.05$) between tillage practices.

	Experiment duration								
Depth	29 years		8 years				3 years		
(inches)	MB	NT	CH	DT	MB	NT	CH	NT_1	NT_2
0 – 1	132a	103a	141a	42b	36b	91a	135a	131a	104a
1 – 2	249a	218a	262a	90b	100b	261a	260a	236a	218a
2 – 3	307a	315a	376a	212b	204b	407a	349a	309a	332a
3 – 4	296a	342b	418a	302b	249b	397a	381a	344a	357a
4 – 5	286a	386b	525a	396b	271 c	368b	380a	370a	355a
5 – 6	299a	394b	596a	423b	270c	368b	347a	355a	341a
6-7	329a	367a	587a	431b	245c	358b	320a	335a	351 a
7-8	348a	351a	571 a	439b	274c	352b	309a	342a	347a

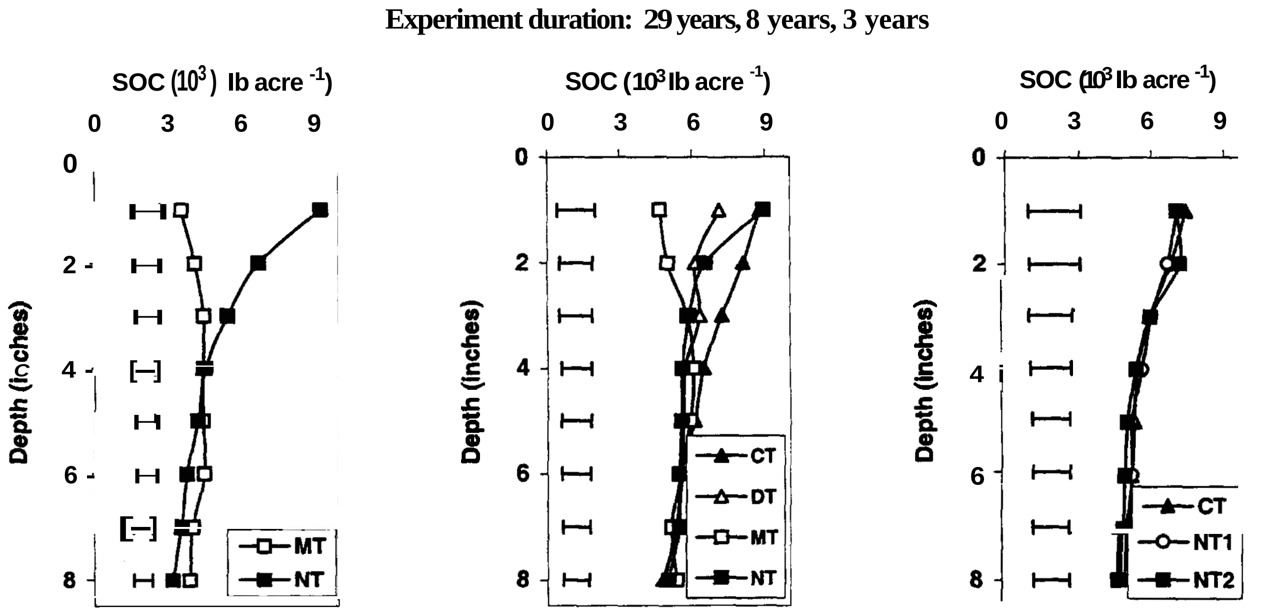


Fig. 2: Effect of four tillage systems in three tillage studies on the SOC storage in a Maury silt loam soil. Average of two sampling dates.

On average, greater C storage was observed in NT and CT treatments than in MT treatments. The differences in C accumulation between tillage practices were independent of the inclusion of the residue cover in this calculation (Table 3). This behavior suggests that the tillage effect on the absolute amount of C storage in this soil is somewhat independent of the amount of residue cover. Given a similar amount of C input from roots and above ground crop residues, differences in SOC between tillage practices can be achieved as a consequence of the promotion of SOC losses due to mineralization after aeration, breakdown, and mixing in intensively tilled systems such as MT.

Table 3: Carbon storage (1000 lb/A) in Maury silt loams under four different tillage systems in three tillage studies of different duration. Different letters in each evaluation indicate significant differences ($p<0.05$) between tillage practices in each experiment.

	Experiment duration								
	29 years		8 years				3 years		
Evaluation	**MT**	**NT**	**MT**	**DT**	**NT**	**CT**	**CT**	**NT1**	**NT2**
Soil and residue C	34.5 a	45.6 b	44.5 a	49.4 ab	54.2 bc	55.4 c	49.6 a	48.6 a	47.9 a
Only soil C	33.4 a	40.8 b	43.4 a	46.5 ab	48.4 bc	52.3 c	46.3 a	45.5 a	45.1 a

The differences in total soil C storage between MT and NT systems increased as the duration of the tillage comparison increased, as did the depth to which these significant differences in SOC between MT and NT treatments were expressed (Fig. 2 and Table 3). No significant differences in SOC level and in its vertical distribution were observed between tillage practices in the 3-year-old experiment (Fig. 2 and Table 2).

CONCLUSIONS

These results confirm the positive effect of NT on the surface (0- to 1-inch) storage of SOC in agricultural soils but only after a decade of continuous NT.

Short-term (within a season) C storage differences were only observed in the surface layer of NT soils and in the above ground residues.

Maximum SOC accumulation was obtained either under CT or NT soil management.

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TILLAGE PRACTICES FOR OVER-SEEDING BERMUDAGRASS WITH RYEGRASS

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INTRODUCTION

Ryegrass *Lolium multiflorum* Lam.) is typically grown on a conventionally prepared seedbed in Mississippi. The conventional method of seedbed preparation for seeding winter annual grazing crops is by disking several times and harrowing to form a smooth seedbed. After planting, the soil is cultipacked. Complete seedbed preparation often creates animal bogging during wet conditions and can contribute to excessive erosion. Recent USDA farm bills have restricted plowing as a system of planting forage crops. Winter annual forage production in a prepared seedbed generally provides earlier grazing and tends to yield more (Coats, 1957, Lang et.al., 1992, and Lang and Elmore 1995). Also, low sod height when planted no-till enhances earliness and improves seedling density (Evers, 1993). However, lower summer yields of perennial grasses after a fall ryegrass planting were obtained from severely disturbed seedbeds (Dudley and Wise, 1953). The objective of this study was to compare the effects of tillage on fall and winter growth of ryegrass and summer growth of bermudagrass.

MATERIALS AND METHODS

An experiment was conducted at the Leveck Animal Research Center, Mississippi State University, to evaluate the influence of different herbicide and tillage treatments on stand establishment and dry matter production of ryegrass over-seeded into a perennial grass sod. A Tye™ no-till grain dnll was used to over-seed 'Marshall' ryegrass into a 'Grazer' bermudagrass *(Cynodon dactylon* (L.) Pers.) sod. The study was conducted for 2 years, 1997-98 and 1998-99. The soil type was a Marietta fine sandy loam (fine-loamy, siliceous, thermic Fluvaquentic Eutrochrepts), a moderately well drained alluvial flood plain soil.

Plot design for the experiment was randomized complete block (RCB) with one herbicide and three tillage treatments. Treatments were replicated four times. Paraquat at 0.25 lb ai/A plus surfactant was used as a preplant burndown on the sod (no-till) plot. Vegetation removal was done with a mower and bagger set at 0.5 in. height 14 days following application. Hay was removed at 2.5 in. 1 week prior to tillage Tillage plots consisted of three levels of sod destruction: Disked 1X, Disked 2X, and roto-tilled for complete sod destruction. Analysis of Variance (ANOVA) was calculated using SAS with mean separation by LSD (SAS, 1985).

Year one: Paraquat as Gramoxone was applied at 0.25 lb ai/A on Aug. 11, 1997 on the sod plot. Remainder of plots were harvested for hay on Aug. 28, 1997. Tillage was done on sod destruction plots and herbicide plot was burned with fire on Sept. 3, 1997. Marshall ryegrass was planted Sept. 11, 1997 with 40 lb/A. Three cool season harvests and three summer harvests were made the first year. Fertilizer was applied in split applications at 268-163-206 (N-P_2O_5-K_20) lb/A. Grazon P+D at 2 pt/A was applied on Apr. 8, 1998 for broadleaf weed control.

Year two: Paraquat was applied at 0.25 lb ai/A on Aug. 20, 1998. Tillage treatments were completed on Sept. 2, 1998. Forty Ib/A of Marshall ryegrass was planted on Sept. 14, 1998. The experiment was irrigated three times: Oct. 14, 1998 (0.7 in.), Oct. 16, 1998 (0.7 in.), and Nov. 5, 1998 (1.25 in.). Stand estimations of ryegrass were made on Dec. 2, 1998, Apr. 5, 1999, Apr. 27, 1999, and May 19,1999 at each harvest date. Stand estimations for warm season grasses were made Sept. 14, 1998. Fertilizer was applied in split applications at 262-97-155 (N-P_2O_5-K_2O) lb/A. Ally was applied at 0.3 oz/A on June 21,1999 for bahiagrass control.

RESULTS AND DISCUSSION

Ryegrass germinated slowly the first year of study due to a dry Oct. and Nov. (Table 1). Complete sod destruction of roto-till and disk 2X had near perfect stands by Jan. 1998 the first year and by Dec. 1998 for the second year. However, ryegrass ground cover in roto-tilled plots were rated significantly greater than either of the reduced tillage treatments (Tables 2 and 3). Ryegrass stand and ground cover were generally the same for all tillage treatments ($P<0.05$) after April of both years except ground cover on Apr. 6, 1998 was lower ($P<0.05$) and stand on Apr. 5,1999 was lower $P<0.05$) in the no till plots. Neither stand nor ground cover were affected by different levels of sod destruction with tillage either year when observed in April.

The dry fall of 1997 reduced earliness of cool season forage production. The first harvest was March 2,1998. The three irrigations during Fall 1998 helped to increase earliness of forage production, with the first harvest being on Dec. 2, 1998 and 4 months earlier than the previous year. Roto-tilled sod treatments yielded higher at each harvest each year of study (Tables 4 and 5). In general, ryegrass production was increased in proportion to the degree of sod destruction both years.

Bermudagrass stand and composition were reduced ($P<0.05$) more by roto-tilling than the lesser levels of sod destruction of disking 1X, 2X, or no tillage both years (Tables 6 and 7). Bermudagrass stands on roto-tilled plots were less than 50% compared with either of the less disturbed sod plots.

Bermudagrass dry matter yield was lower for roto-tilled sod plots both years of study (Tables 8 and 9). Increased sod destruction encouraged other grasses to compete. Crabgrass [(*Digitaria sanguinalis* (L.) Scop.], Broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash], and yellow foxtail [*Setaria glauca* (L.) Beauv.] increased with an increase in sod destruction. Roto-tilled plots had more total grass (ryegrass, annual grass, and bermudagrass) production over the entire year than either disked 2X, 1X, or no tillage both years of study. Forage from ryegrass and annual grasses was increased , while the perennial grass yield was decreased. The total production was increased.

SUMMARY

Ryegrass was over-seeded into a bermudagrass sod with a 'Tye' no-till drill. The tillage treatments were roto-tilled, disked 2X, disked 1X, and no tillage for four levels of sod destruction with roto-tilled being complete destruction and no tillage being none. Herbicide was applied on the sod-seeded plots prior to herbage removal. Ryegrass stand and ground cover were higher under the complete sod destruction by roto-tilling and disking 2X than they were with the lesser levels of sod destruction of disking 1X and no tillage. Yearly ryegrass dry matter yields for total sod destruction were more than twice as great compared with no sod destruction. Roto-tilled ryegrass yield was 40% greater than either disking 1X or 2X. Ryegrass yield increased with increased sod destruction as compared with no tillage. Less tillage or sod destruction resulted in delayed ryegrass stand and ground cover into the winter growing season, which caused reduced dry matter yield; however, this reduction in ryegrass yield allowed for earlier summer growth of perennial and annual grasses. Complete sod destruction increased total *dry* matter yield for cool season and summer grasses when compared with no tillage. However, the composition of yield changed. Summer perennial grasses decreased in stand, ground cover, and yield, whereas, summer annual grass composition increased with a corresponding increase in sod destruction by tillage. Similar results were observed both years of this study. In general, cool season production of ryegrass was increased by the degree to which the sod had been disturbed that fall. Bermudagrass production was decreased by the degree of sod destruction the previous fall.

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Table 1. Rainfall at Plant Science Research Center, Mississippi State Universitv. 1997-1999.

	1997	1998	1999
January	7.2	6.5	8.1
February	5.2	7.4	2.6
March	4.5	4.3	4.4
April	5.1	3.6	4.5
May	7.7	2.5	3.0
June	5.0	2.0	3.6
July	3.3	5.2	4.0
August	3.5	5.3	0.9
September	3.4	0.5	3.7
October	4.9	0.9	1.4
November	3.2	2.2	2.2
December	2.5	6.5	2.9
Total	55.6 in.	44.4 in.	41.3 in.

Table 2. Ryegrass stand and cover as affected by level of sod destruction, 1997-1998.

Sod destruction	Januarv 20.1998 Stand	Januarv 20.1998 Cover	March2. 1998 Stand	March2. 1998 Cover	April 6, 1998 Stand	April 6, 1998 Cover	April 23, 1998 Stand	April 23, 1998 Cover
	---(%)---							
Roto-till	100 a	85 a	100	90 a	100	88 a	100	100
Disk 2X	95 ab	19 b	91	34 b	94	71 a	95	96
Disk 1X	79 b	14 bc	82	19 c	89	68 a	93	94
No till	81 b	11 c	66	16 c	71	44b	74	75
Mean	85	23	75	28	79	56	82	83
CV %	14	20	32	19	33	19	34	3
LSD 0.05	10	6	NS	11	NS	21	NS	NS

NS = not significantly different.
Means followed by different letters within each column were significantly different.

Table 3. Ryegrass stand and cover as affected by level of sod destruction, 1998-1999.

Sod destruction	December 2, 1998 Stand	December 2, 1998 Cover	March 10, 1999 Stand	March 10, 1999 Cover	April 5, 1999 Stand	April 5, 1999 Cover	April 28,1999 Stand	April 28,1999 Cover
	---(%)---							
Roto-till	99 a	86 a	99 a	100 a	100 a	97	100 a	100
Disk 2X	86 ab	29 b	90 ab	64 b	94 ab	96	94 a	88
Disk 1X	73 b	21 c	70 bc	54 b	86 ab	88	87 a	87
No till	32 c	6 d	47 c	31 c	63 b	66	58 b	66
Mean	52	21	62	46	74	76	71	76
CV %	32	27	32	30	31	31	28	33
LSD 0.05	22	7	26	18	30	NS	27	NS

NS = not significantly different.
Means followed by different letters within each column were significantly different.

Table 4. Ryegrass dry matter yield as affected by level of sod destruction, 1997-1998.

Sod Destruction	March 2,1998	April 6,1998	April 23,1998	May 14,1998	Total
	(lb/A)				
Roto-till	781 a	685 a	552 a	757 a	2775 a
Disk 2X	101 b	338 b	546 a	566 b	1550 b
Disk 1X	32 b	275 bc	471 a	573 b	1351 bc
No till	34 b	171 c	361 b	491 b	1057 c
Mean	259	409	465	544	1677
CV %	35	21	22	24	21
LSD 0.05	101	106	186	174	448

Means followed by different letters within each column were significantly different.

Table 5. Ryegrass dry matter yield as affected by level of sod destruction, 1998-1999.

Sod Destruction	December 2,1998	March 10,1999	April 5,1999	April 28,1999	Total
	(lb/A)				
Roto-till	**423 a**	**1193 a**	**2415 a**	**1150**	**4896 a**
Disk 2X	**153 b**	**183 b**	**1504 b**	**1107**	**2989 b**
Disk 1X	**104 b**	**140 b**	**1427 b**	**904**	**2777 b**
No till	**45 b**	**72 b**	**840 c**	**865**	**1860 c**
Mean	113	234	1193	955	2495
CV %	92	52	28	35	27
LSD 0.05	137	161	436	NS	889

Means followed by different letters within each column were significantly different.
NS = Not significantly different.

Table 6. Bermudagrass stand and composition as affected by level of sad destruction, 1997-1998.

Sod Destruction	Bermudagrass Stand June 10,1998	Bermudagrass Stand July 20, 1998	Bermudagrass Composition June 10,1998	Bermudagrass Composition July 21,1998	Bermudagrass Composition August 30,1998
	(%)				
Roto-till	58 b	65	35 b	16 b	13 b
Disk 2X	98 a	85	70 a	35 a	48 a
Disk 1X	100 a	80	66 a	24 ab	31 ab
No till	94 a	82	69 a	31 a	37 ab
Mean	91	80	65	34	44
CV %	19	22	17	55	28
LSD 0.05	23	NS	15	14	25

Means followed by different letters within each column were significantly different.
NS = Not significantly different.

Table 7. Bermudagrass stand and composition as affected by level of sod destruction, 1998-1999.

Sod Destruction	June 27,1999 Stand	June 27,1999 Composition	July 21,1999 Composition	September 30,1999 Stand	September 30,1999 Composition
	(%)				
Roto-till	38 b	38 b	2 b	36 b	20 b
Disk 2X	82 a	75 a	35 a	90 a	57 a
Disk 1X	85 a	73 a	33 a	74 a	51 a
No till	78 a	71 a	52 a	85 a	63 a
Mean	74	67	41	78	55
CV %	24	28	50	25	29
LSD 0.05	23	24	27	25	21

Means followed by different letters within each column were significantly different.

Table 8. Dry matter yield of bermudagrass (BG) as affected by level of sod destruction, 1997-1998.

Sod destruction	June 10 1998 BG	June 10 1998 Annual grass	July 21, 1998 BG	July 21, 1998 Annual grass	August 30, 1998 BG	August 30, 1998 Annual grass	Total BG	Total Annual grass
	(lb/A)							
Roto-till	129 b	248	355	2389a	1956b	0	2441 b	2637a
Disk 2X	543 a	235	997	1185 b	2356a	0	3896a	1421 b
Disk 1X	516 a	244	595	1492b	2396a	0	3507a	1736ab
No till	623 a	263	766	1348b	1246c	0	2635 b	1611 b
Mean	538	256	722	1476	1617	0	2877	1731
CV %	37	40	66	45	11		21	41
LSD 0.05	261	NS	NS	864	237		783	926

Means followed by different letters within each column were significantly different.
NS = Not significantly different.

Table 9. Dry matter yield of bermudagrass as affected by level of sod destruction, 1998-1999.

Sod destruction	June 27.1999 BG	June 27.1999 Annual grass	July 21, 1999 BG	July 21, 1999 Annual grass	September 30.1999 BG	September 30.1999 Annual grass	Total BG	Total Annual grass
	(lb/A)							
Roto-till	134 b	286	106 b	6132a	268b	1144a	508b	7562a
Disk 2X	579 a	189	1363a	2585b	937a	671 b	2879a	3445b
Disk 1X	520 a	203	1211a	2697b	916a	826 ab	2647a	3727b
No till	588 a	189	1571a	1726b	773a	566b	2932a	2563b
Mean	522	254	1317	2506	748	684	2586	3444
CV %	47	58	48	43	34	49	35	41
LSD 0.05	325	NS	830	1428	330	443	1171	1869

Means followed by different letters within each column were significantly different.
NS = Not significantly different.

DISTRIBUTION OF SOIL NUTRIENTS FOLLOWING FOUR YEARS OF DAIRY EFFLUENT APPLICATION

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INTRODUCTION

Estimates of nutrients not retained or utilized by dairy animals range from 60 to 80% (Thomas *et. al.*, 1995), indicating that a large portion of the nutrients consumed in the dairy ration become part of the animal waste system. Nutrients applied in an acre-inch of effluent from the traveling imgation gun provide a 38-23-33 fertilizer equivalent with a value of $37.79/A per application (Burcham *et al.*,.1997; Herndon *et al.,* 1998; Lang *et al.,* 1998). Application of nutrients in effluent generally provides critically needed fertilization since many pastures and hayfields test very low to medium in both potassium (K) and phosphorus (P) However, many of the fields currently receiving animal waste (particularly poultry litter) applications test high to very high in soil P and K and may be receiving excessive waste applications (Burdine *et al.,*1997). Forages utilized as hayfields provide ideal sites for dairy effluent application because of the tremendous nutrient removal capability. Long-term application of dairy lagoon effluent to the same fields (typically, those closest to the lagoon within range of the traveling gun pipe system) raises concerns about excessive quantities of nutrients building up in the soil, particularly at the soil surface. The objective of this study was to determine soil test levels of P and K at four soil depths following 4 years of dairy lagoon effluent application.

MATERIALS AND METHODS

Dairy waste effluent from two sand-bedded confinement houses representing 180 mature milking cows at the Dairy Research Center in Sessums, MS, was pumped onto a 25-acre permanent grass hayfield over a 4-year period. Soil was Freestone (fine-loamy, siliceous, thermic Aquic Paleudalfs). A traveling irrigation gun was used to distribute dairy lagoon effluent over a 1000- by 250-ft area of application. Distribution of effluent was bell shaped (Figure 1) and was applied five times each year. Four sampling locations of high (6 inches), low (2 inches), and zero rates of dairy effluent were established along the 1000-ft path of the traveling gun. Two permanent non-overlapping runs of the traveling gun provided consistent sampling sites for forage production evaluation, effluent analysis, and soil analysis. Soil samples were taken at depths of 0-1 inch, 1-2 inches, 2-4 inches, and 4-8 inches each winter for 4 years (1996-1999). Effluent was collected in pans and analyzed for total N, P, and K.

RESULTS AND DISCUSSION

An average of 200 lb N, 120 lb P_2O_5, and 30 lb of K_2O per acre per year were applied to the high effluent areas over five irrigation events. Table 1 shows typical values for 1997. Nutrient concentration was generally higher early in the spring. The quantity of fertilizer nutrients available from the lagoon generally declined through the summer. Late summer irrigation, however, may also provide significant moisture benefits during the *dry* months of September and October when forage production is generally limited.

Surface applied dairy effluent over 4 years to a summer grass hayfield resulted in accumulation of extractable P (159 ppm) at 0- to 1-inch soil depth under high effluent applications (6 inches/year) compared with areas receiving low effluent (2 inches/year; 56 ppm soil P) or 0 inches/year (28 mg ppm soil P) (Table 2). Phosphorus accumulation at 1-to 2-inch or 2- to 4-inch soil depth increased under high rates of effluent compared with 0- or 2-inch/year rates. Phosphorus movement down to a depth of 16 inches has been observed following surface applied animal wastes to a fine-loamy, siliceous, thermic Typic Kanphapludults soil (Liu et al., 1998). Potassium followed a similar pattern. Surface K (0-to 1-inch) increased from 121 to 184 to 276 ppm extractable K at 0-, 2-, and 6-inch annual effluent applications over a 4-year period.

Extractable zinc (Zn) also increased as effluent rate increased with the greatest increase at the 0- to 1-inch soil depth (Table 3). There were 14 ppm Zn in the plots receiving 6 inches effluentlyear, 8 ppm soil Zn in plots receiving 2 inches/year and 7 ppm soil Zn in control plots within the 0- to 1-inch soil depth. Copper (Cu) and Zn have both been observed to increase following application of swine lagoon waste (Liu *et al.,* 1996). Soil pH increased from 5.9 to 6.2 to 6.6 at 0, 2, and 6 inches of effluentlyear (Table 3). Based on a 0- to 8-inch soil sampling depth, there were 55 ppm extractable soil P for the high effluent rate, 19 ppm P for the low effluent rate, and 12 ppm P soil for the control. Extractable K, magnesium, and calcium within the 0- to 8-inch depth also increased as effluent rate increased (data not shown).

SUMMARY

Over the course of four summers of effluent application, soil test levels of soil P increased from 20 ppm to 159 ppm in the top inch of soil with a resulting increase in forage yield of over 40% (Lang *et al.,*1998). During the first year of dairy effluent application, there was an increase in forage production of 42% (1755 lb/A) or nearly 1 ton/A. There was a 54% increase in forage production the second year with almost 1.5 tons/A more produced. Initial soil test levels of P and K were low to very low and would be expected to respond to balanced fertilizer additions. Over the 4-year period, soil test levels of P and K increased from low to medium levels and pH increased from 6.0 to 6.6. Additional years of effluent application will likely continue to increase soil P levels. As soil test P levels increase, our current forages may not be able to remove enough P to sustain "long-term" application of effluent at 5 acre-inches per year. The long-term nutrient loading of P on a particular site will depend upon the particular soil's ability to adsorb P and the runoff susceptibility of the particular hayfield into a sensitive watershed. Soils that test high to very high in P need to have dairy effluent applications limited to expected nutrient removal (32-52 lb P_2O_5 or 2 to 3 inches of effluent/A. Dairy lagoon effluent application to an under fertilized hayfield obviously had a positive short-term impact on soil fertility and hay production on this particular field.

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Table 1. Fertilizer Nutrients Applied in Dairy Lagoon Effluent at the Dairy Research Center.

	Date of Application					
Nutrient	**4/8/97**	**5/6/97**	**6/24/97**	**7/23/97**	**7/31/97**	**Total**
	----------	----------	**lb/Acre-Inch**	----------	----------	
Nitrogen	**65**	**46**	**40**	**27**	**30**	**208**
P_2O_5	**41**	**41**	**18**	**14**	**9**	**123**
K_2O	**76**	**76**	**61**	**52**	**37**	**302**

Table 2. Levels of extractable soil P and exchangeable soil K at four soil depths following annual dairy effluent applications for four years, Dairy Research Center, Sessums, MS.

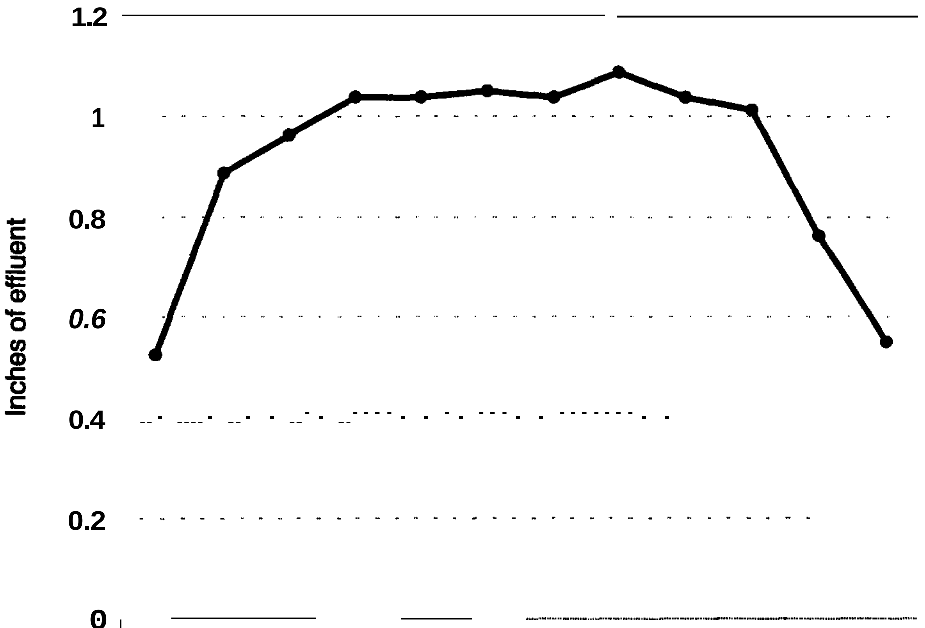
Effluent Rate	Soil Depth	P 1996	P 1999	K 1996	K 1999
	(inches)	---(ppm)---			
High	0-1	37.6	159.2	111.9	275.6
High	1-2	5.7	41.0	49.3	107.4
High	2-4	3.7	12.2	21.7	43.9
High	4-8	3.2	6.2	24.5	27.6
Low	0-1	24.8	56.5	92.7	183.9
Low	1-2	5.5	12.9	38.2	50.4
Low	2-4	4.4	4.9	25.1	25.5
Low	4-8	3.6	3.1	23.3	20.9
None	0-1	20.9	27.8	83.9	120.8
None	1-2	6.1	10.2	41.7	40.8
None	2-4	4.5	4.4	29.0	26.2
None	4-8	6.6	3.9	25.1	22.2
$LSD_{0.05}$		4.2	7.9	5.8	11.8

Table 3. Changes in soil pH and extractable Zn at four soil depths following 4 years of dairy effluent application, Dairy Research Center, Sessums, MS.

Effluent Rate	Soil Depth	**pH 1996**	**pH 1999**	**Zn 1996**	**Zn 1999**
	(inches)			**-------------(ppm)-------------**	
High	**0-1**	**6.0**	**6.6**	**3.0**	**14.1**
High	**1-2**	**5.9**	**6.6**	**1.3**	**2.4**
High	**2-4**	**5.9**	**6.6**	**1.1**	**1.7**
High	**4-8**	**6.1**	**6.4**	**1.1**	**2.7**
Low	**0-1**	**6.0**	**6.3**	**3.0**	**8.1**
Low	**1-2**	**5.8**	**6.2**	**1.5**	**1.6**
Low	**2-4**	**5.9**	**6.1**	**1.2**	**1.3**
Low	**4-8**	**5.8**	**6.0**	**1.2**	**1.4**
None	**0-1**	**5.8**	**5.9**	**3 3**	**6.7**
None	**1-2**	**5.6**	**5.9**	**1.6**	**2.6**
None	**2-4**	**5.9**	**5.7**	**1.4**	**1.0**
None	**4-8**	**5.7**	**5.8**	**1.5**	**0.8**
$LSD_{0.05}$		**0.33**	**0.26**	**0.4**	**1.3**

Pattern for Traveling Irrigation Gun, DRC

1997



	137	112	87	62	37	12	12	37	62	87	112	137
Ave. of 4 runs—	0.5	0.9	1	1	1	1.1	1	1.1	1	1	0.8	0.6

Feet from center line

Figure 1

LONG-TERM TILLAGE SYSTEM EFFECTS ON CHEMICAL SOIL QUALITY INDICATORS IN THE SOUTHEASTERN COASTAL PLAIN

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ABSTRACT

The impact of tillage intensity on chemical soil quality indicators has not been evaluated in the long-term for soils of the Southeastern Coastal Plain. The long-term influence of four tillage systems [no-tillage (NT), disk, moldboard plow (MP), and chisel plow (CP)] on chemical soil quality indicators after 17 years was evaluated on a Benndale fine sandy loam (coarse-loamy, siliceous, thermic, Typic Paleudults) and a Lucedale very fine sandy loam (fine-loamy, siliceous, thermic, Rhodic Paleudults) in the Coastal Plain region of Alabama. Soil pH, effective cation exchange capacity (CEC_{eff}), soil organic carbon (SOC), and soil N, P, Zn, and Mn were determined on soil samples collected at depths of 0-1, 1-3,3-6, 6-9, and 9-12 inches. An accumulation of SOC occurred primarily in the top **1** inch with values of 2.76,1.31,1.27, and 1.04%C with NT, disk, CP, and MP, respectively, for the Benndale soil and 1.67, 1.00, 0.98, and 0.69% C, respectively, for the Lucedale soil. A slight decrease in pH (0.3 units) was observed at 6 to12 inches with NT compared with other tillage treatments on the Lucedale soil. Extractable P was higher with NT than MP at the 9-inch depth on the Lucedale soil. On the Benndale soil, NT resulted in the greatest extractable P at the 6- to 9-inch depth. Regression showed that SOC and pH combined predicted 73 and 86% of the variation in CEC, for the Benndale and Lucedale soils, respectively. Soil organic carbon and pH were also tightly correlated to nutrient availability. The results suggest that no-tillage and double cropping are effective in increasing SOC on Coastal Plain soils, especially in the critical area at the soil surface. Surface applications of lime maintained soil pH at an acceptable level within the plow layer of both soils and all tillage systems. As determined from chemical indicators of soil quality, adoption of conservation tillage with double cropping promotes sustainability for these soils.

INTRODUCTION

Common indicators of soil properties, i.e., a Minimum Data Set, are recommended to evaluate soil quality (Doran and Parkin, 1996). Soil organic C, total organic N, pH, and extractable N, P, and K have been recommended as useful chemical soil quality indicators Doran and Parkin, 1996).

Many years are required to reach equilibrium for some soil properties after changing tillage systems. Therefore, long-term studies are recommended in order to evaluate changes in soil quality. But, long-term studies comparing tillage system effects on soil quality indicators have largely been conducted in temperate climates (Reeves, 1997), and only a few long-term studies have been reported under thermic conditions found in the Southeast. Additionally, studies have not been conducted over a range of tillage intensities.

Increasing SOC with no-tillage has been generally associated with an accumulation near the soil surface (Motta et al., 1999; Hunt et al., 1996). However, this accumulation is critical to restoring soil productivity (Bruce et al., 1995).

Another important soil quality indicator affected by tillage systems is soil pH. Surface lime application in no-tillage often does not ameliorate decreased soil acidity deep within the profile due to limits in lime mobility (Hargrove et al., 1982; Edwards and Beegle, 1988). However, results from the only long-term study conducted in the Coastal Plain region that reported soil chemical properties showedmaintenanceof soil pH at an acceptable level for crop production after 8 years with no-tillage using surface applications of lime (Karlen et al., 1989).

Like SOC, soil extractable P accumulates more at the surface with no-tillage than conventional tillage (Hargrove et al., 1982; Edwards et al., 1992). However, increased P mobility as organic P with no-tillage was reported by Ismail et al. (1994). Changes in micronutrient distribution within the soil profile have also been reported for different tillage systems for Zn (Hargrove et al., 1982; Edwards et al., 1992) and Mn (Blevins et al., 1983; Edwards et al., 1992). However, micronutrient distribution as affected by tillage in long-term studies for Coastal Plain soils has not been reported.

The objective of our research was to evaluate the long-term effect of four tillage systems on some chemical indicators of soil quality for two Coastal Plain soils in Alabama after 17 years.

MATERIALS AND METHODS

Two tillage experiments were conducted for 17 years in the Coastal Plain region of southwestern Alabama. Wheat (*Triticum aestivum* L.), rye (*Secale cereale* L.), triticale (*Triticum aestivum* L. x *Secale cereale* L.), and white lupin (*Lupinus albus* L.) were cropped during winters and soybean [*Glycine max* (L.) Merr.], grain sorghum [*Sorghum bicolor* (L.) Moench], cotton (*Gossypium hirsutum* L.), tropical corn (*Zea mays* L.), and pearl millet [*Pennisetum americanum* (L.) Leeke] were cropped during summers since 1981.

The experimental design at both locations was a randomized complete block with four replications. Treatments consisted of four tillage systems applied prior to the winter crop each year. Tillage systems were: no-tillage, Qsk, chisel plow, and moldboard plow. The no-tillage treatment consisted of planting into dessicated crop residue. The disk treatment consisted of one pass with an offset tandem disk. For the chisel plow, shanks on the front and rear tool bars were offset so that the actual distance between chisel points was 8 inches. The moldboard plow was used as a total soil inversion treatment. Chisel plow and moldboard plow treatments had a secondary tillage of disking and leveling with a disk harrow and drag board. It was estimated that disk, chisel plow, and moldboard plow reached an average depth of 3-5, 6-8, and 8-10 inches, respectively. Summer crops were planted without tillage using a no-till planter each year. Lime, P, and K fertilizers were applied according to Auburn University soil test recommendations, based on fertility levels for the top 6 inches of soil collected during the fall prior to planting the winter crop.

In the fall of 1997, 20 soil cores were collected (hand probe, 0.8-inch diameter) per plot and composited by depth (0-1, l-3, 3-6, 6-9, and 9-12 inches). Samples were air-dried and sieved (2 mm). Soil P, Mn, and Zn were extracted using Mehlich-1 (double acid) solution (Hue and Evans, 1986) and determined by Inductively Coupled Air Plasma Emission Spectrometry [ICAP]. The CEC, was obtained through the sum of bases ($Ca^{++} + Mg^{++} + K^{+} + Na^{+}$). Soil pH was determined on 1:1 soil/water suspension with a glass electrode pH meter. Total organic C and N were determined using a Nitrogen/Carbon analyzer (Fisons Instruments, Beverly, MA 01915).

Analyses of variance were conducted prior to determination of protected least significant difference (LSD) values at the 95% level of confidence. Sampling depths were analyzed as a split in the design. The soil type or location was initially included in the analysis model and proved to have interactive effects with tillage and/or depth on dependent variables; therefore, data were analyzed separately and are presented by soil type. Correlation and stepwise regression were used to analyze relationships among chemical soil quality variables.

RESULTS AND DISCUSSION

Soil organic carbon, a key indicator of soil quality, was affected by an interaction of soil type, tillage, and depth. Soil carbon accumulation occurred within the first inch of soil at both locations and was inversely related to soil disturbance (Figure 1). This increase on SOC plays an important role in soil quality due to improvement in infiltration and crop-available soil water (Bruce et al., 1995). Furthermore, the surface buildup of SOC occurred under adverse conditions of climate (Hargrove et al., 1982; Hunt et al., 1996) and low clay content (Havlin et al., 1990; Campbell et al., 1996). Our results confirm that cropping intensity and high production of crop residues combined with conservation systems can enhance or sustain SOC under thermic regimes (Reeves and Wood, 1994; Hunt et al., 1996; Reeves, 1997).

Soil N distribution mirrored the variation in SOC among treatments for both soils (data not shown). Combined over all treatments and depths, soil N was highly correlated to SOC for the Benndale ($R^2 = 0.93$) and Lucedale ($R^2 = 0.95$) soils. The results suggest that intensive cropping combined with conservation tillage may enhance the soil's ability to supply a greater portion of crop N (Wienhold and Halvorson, 1999).

Another key indicator of soil quality, soil pH, was not affected by tillage, regardless of depth, on the Benndale soil (Figure 2). This suggests that surface lime with no-tillage is as effective as lime incorporation by moldboard plowing in maintaining pH at acceptable levels. Similar results were obtained by Ismail et al. (1994), who reported a slight decrease in soil pH down to 12 inches with no-tillage compared with moldboard plow. In contrast to the Benndale soil, the Lucedale soil maintained a lower pH with no-tillage compared with other tillage systems at the 6- to 12-inch depth increment. Hargrove et al. (1982) reported lower pH with no-tillage than moldboard plow at depths between 3 and 12 inches after 5 years on a sandy loam soil in Georgia.

As observed for SOC, CEC_{eff} increased within the first inch for the Benndale soil and within 3 inches for the Lucedale soil (data not shown). In our study, the influence of SOC and pH on soil CEC, was demonstrated using multiple regression techniques for both soils types (data not shown). The results indicated that maintenance of SOC through intensive cropping and conservation tillage and with adequate lime application may inhibit cation loss.

In contrast to other studies (Hargrove et al., 1982; Edwards et al., 1992), no-tillage did not result in P accumulation in the uppermost soil layer of the Benndale soil (data not shown). However, there was an accumulation of P at the soil surface (0-1 inch) of the Lucedale soil, which was inversely related to the intensity of tillage disturbance Movement of P within the soil profile due to leaching processes is usually considered insignificant in agrosystems. However, P movement by leaching or other processes needs to be considered in our study due to several factors. First, combined low P adsorption capacity and high levels of extractable P can contribute to P mobility. Second, surface SOC accumulation decreases P adsorption capacity (Guertal et al., 1991), as well as contributing to maintenance of soil pH between 5.5 to 7.0. Third, the long-term addition of plant residues under favorable conditions for decomposition and abundant rainfall could result in ideal conditions leading to leaching of organic P (Mozaffari and Sims, 1994; Mottaet al., 1999). Fourth, preferential pathways for movement of water and nutrients are common with conservation tillage due to earthworm activity

(Edwards and Beegle, 1988) and root channels (Kanwar et al., 1997).

Regression results indicated variation in extractable Zn was strongly related to SOC, pH, and CEC_{eff} (data not shown) for the Lucedale soil. For the Benndale soil, only SOC affected extractable Zn. Relationships between Zn and SOC (Edwards et al., 1992), Zn and pH (Edwards et al., 1992; Mahler et al., 1985), and Zn and CEC (Davis-Carter and Shuman, 1993) have been reported. Effective CEC, SOC, and pH combined predicted extractable Zn on the Lucedale soil. In contrast to other reports (Mahler et al., 1985; Edwards et al., 1992), pH had no affect on Mn distribution in our study; however, SOC proved a good predictor of Mn.

CONCLUSIONS

Tillage systems affected chemical indicators of soil quality interacting with soil type. Surface SOC accumulation occurred within the first inch and was inversely related to soil disturbance (no-tillage>disk >chisel plower>moldboard plow), regardless of the adverse condition of climate and coarse soil texture. In contrast to SOC, pH was slightly affected by tillage systems for the Lucedale soil, with lower pH occurring at depths below the plow layer ($\geq$ 9 inches) under no-tillage relative to other tillage systems. However, broadcast application of lime maintained pH at an acceptable level within the plow layer for both soils, even with no-tillage. Accumulation of P in the surface soil layer with no-tillage occurred only on the Lucedale soil, and downward movement of P was indicated with reduced tillage systems in both soils. Significant changes in CEC_{eff} , total N, Zn, and Mn accumulation in the surface soil mirrored the distribution pattern of SOC. Soil organic C and pH served as co-predictors of CEC_{eff}, alone or in combination. These two soil quality indicators were also highly correlated to Mn and Zn. Our results show that, as determined from chemical indicators of soil quality, adoption of conservation tillage with doublecropping offers long-term sustainability for managing Coastal Plain soils.

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FIGURE 1. Effect of tillage system after 17 years on soil organic carbon in a Benndale and a Lucedale soil in the coastal plain of Alabama. Horizontal bars indicate LSD0.05 and ns= nonsignificant at $P \leq 0.05$.

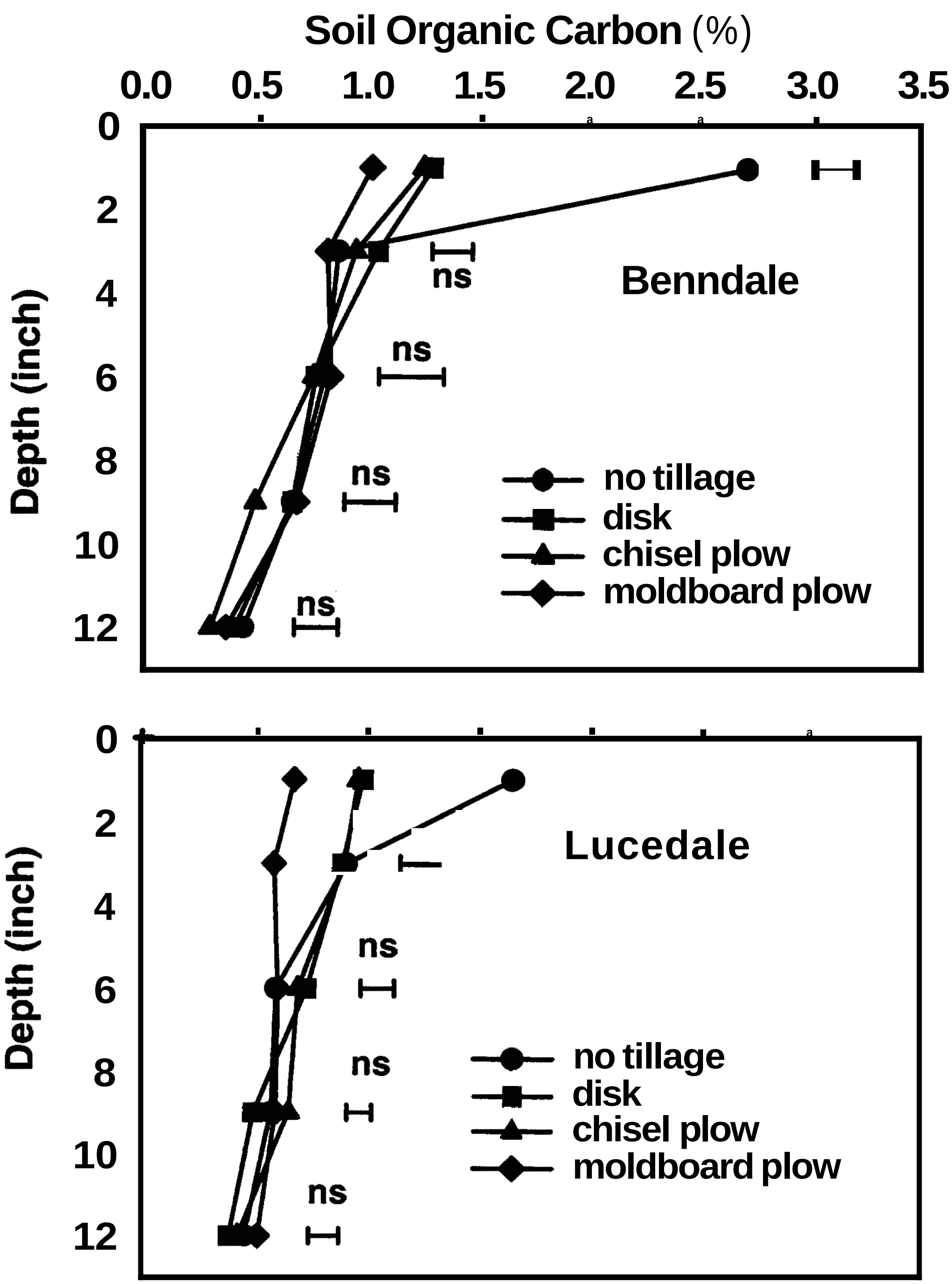
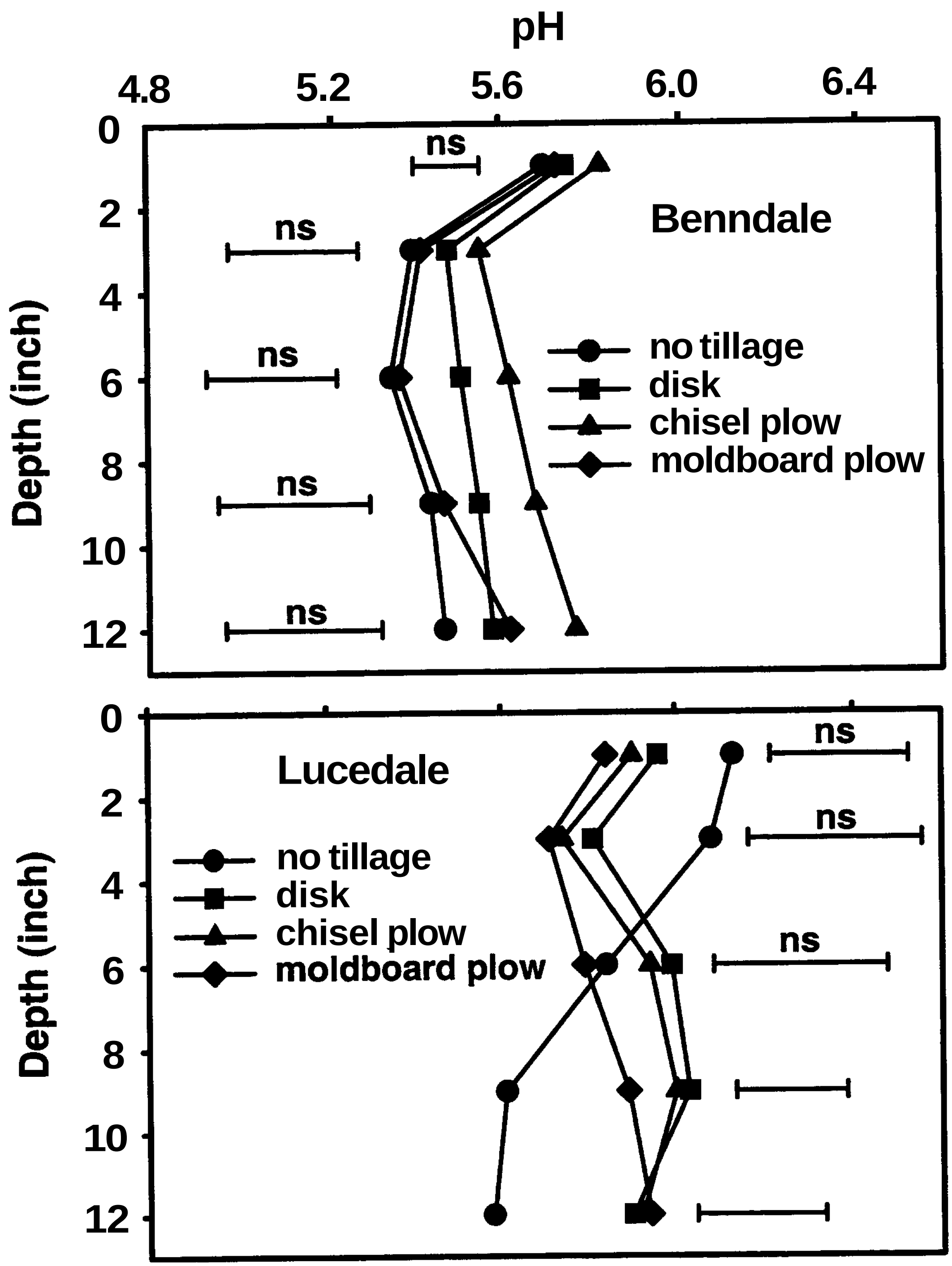


FIGURE 2. Effect of tillage system after 17 years on soil pH in a Benndale and a Lucedale soil in the coastal plain of Alabama. Horizontal bars indicate $LSD_{0.05}$ and ns= nonsignificant at $P \leq 0.05$.



SOIL NITROGEN MINERALIZATION FOLLOWING RYE AND CRIMSON CLOVER COVER CROPS IN NO-TILL COTTON

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INTRODUCTION

Crimson clover (*Trifolium incarnatum* L.) and winter rye (*Secale cereale* L.) are popular winter cover crops suitable for use with cotton in the southeast (Hoyt and Hargrove, 1986; Touchton et al., 1984). Nitrogen (N) management in cotton is critical because both under and over fertilization decrease yields (Mullins and Bunnester, 1990). Surface residues in no-till systems may reduce N availability to plants through immobilization (Rice and Smith, 1984) and slower rates of residue decomposition and N mineralization (Douglas et al., 1980; Schomberg et al., 1994). Efficient N use depends on understanding complex interactions among soil and site properties, crop characteristics, climate, and biological processes influencing N dynamics. Estimation of heat units, following residue incorporation, has been used successfully to predict N mineralization from cover crop residues (Honeycutt and Potaro, 1990). Reasonably accurate estimates of net N mineralization rates are needed to determine management influences on nutrient supply, particularly under conservation tillage conditions. Undisturbed soil cores incubated *in situ* have been used to measure N mineralization dynamics under a variety of conditions (Hook and Burke, 1995; Kolberg et al., 1997). The *in situ* technique has potential for evaluating management effects on N availability and microbial community dynamics and provide site specific information needed for improved nutrient management. The objective of this study was to evaluate cover crop effects on N mineralization in two no-tillage cotton-cover crop systems using *in situ* soil cores and the possibility of using heat units to predict N mineralization.

MATERIALS AND METHODS

Cover crop effects on N mineralization were determined during 1997 and 1998 in two no-till cotton-cover crop systems at the J. Phil Campbell, Sr., Natural Resources Conservation Center in Watkinsville, GA (33° 59' N, 83° 27' W). The study was conducted in two 3.3-acre (1.3-ha) watersheds. Cotton followed rye in one watershed and crimson clover in the other. The soil is a slightly eroded Cecil sandy loam (fine, kaolinitic, thermic Typic Kanhapludults). Cover crops were drilled into cotton residues in late October and killed with glyphosate 2 to 3 wk prior to planting cotton in May each year. Cotton was planted in May directly into cover crop residues with a four row no-till planter. Nitrogen as NH_4NO_3 was applied to cotton using a drop spreader at 30 lb/A (34 kg/ha) following crimson clover at 60 lb/A (67 kg/ha) following rye. Fall applications to rye were 50 lb/A (56 kg N/ha) at NH_4N0_3.

Nitrogen mineralization was measured from cotton planting to harvest by incubating undisturbed soil cores *in situ* for 2- to 5-wk intervals at nine locations in each watershed (DiStefano and Gholz, 1986; Kolberg et al., 1997). A 4.3-by 2-inch (110- by 50-mm, depth by diameter) aluminum cylinder was driven into the ground and removed with the intact soil. Soil from the core bottom was removed and a nylon bag containing approximately 0.5 oz (15 g) of a 50:50 mixture of anion and cation exchange resins was placed in the cavity. Cores were returned to the same hole. After each incubation period, cores were removed from the ground, soil and resin bag were removed from the cylinder and returned to the laboratory.

There were no replications of the cover crop systems for evaluating statistical differences between cover crop-cotton systems for N mineralization. Mean standarderror values were determined for each watershed using location values within a cotton-cover crop system.

RESULTS

Yield , Biomass, and Soil N

Cotton yields (seed + lint) following clover and rye were 787 and 1076 lb/A (882 and 1205 kg/ha) respectively, in 1997 and 1393 and 2100 lb/A (1561 and 2352 kg/ha), respectively, in 1998. In 1997 and 1998, clover biomass was 2.7 and 2.4 ton/A (6.2 and 5.4 Mg/ha), respectively, and rye biomass was 5.0 and 2.3 ton/A (11.3 and 5.2 Mg/ha). Slow accumulation of growing degree days (GDD) limited yields in 1997 compared with 1998 even though rain was less in 1998. Averaged for 1997 and 1998, carbon (C) and N contents of clover residue were 42.4 and 2.3% and of rye residue were 43.5 and 1.4%, respectively. Soil C and N contents were 1.01 and 0.07% in the cotton-crimson clover soil and 1.04 and 0.07% in the cotton-rye soil, respectively.

Nitrogen Mineralization

Significant N mineralization occurred during the cotton growing season in both cropping systems for both years. Soil N mineralized from May through August was nearly three times greater in the cotton-crimson clover than in the cotton-rye system [2-year average 58 vs 21 lb/A (65 versus 23 kg N/ha), respectively]. Nitrogen mineralization was occasionally influenced by periods of drought, especially in 1997. More N was mineralized during the first 35 d in 1998 than in 1997 [approximately 18 lb/A (20 kg N/ha)]. This effect was believed to be related to a combination of factors. In 1998, cover crops were killed at an earlier stage of growth and significant rainfall occurred immediately following planting and establishment of soil cores thus enhancing N mineralization. Differences in N mineralization between the clover and rye soils reflect dfferences in chemical characteristics of the cover crops and N inputs in the two systems. Although significant quantities of N were mineralized in the cotton-crimson clover soil, N availability to the cotton crop is unknown. The large difference in yield following the two cover crops was probably related more to water availability than to N availability.

Climatic Influences on N Mineralization

Soil degree days (heat units base 0 C) and rainfall for each period were evaluated for correlations with N mineralization. Soil degree days were significantly correlated with N mineralized in the crimson clover ($r = 0.56$, $P = 0.07$) and rye ($r = 0.52$, $P = 0.09$) systems. Cumulative rain for a period was not correlated with N mineralization. Nitrogen mineralization has been shown to be more closely associated with accumulation of heat units than with soil moisture (Honeycutt and Potaro, 1990). Absence of measurable water effects on N mineralization is attributed to soil water buffering capacity and the ability of microorganisms to function at low water potentials (Sierra, 1997; Doel et al., 1990). Soil water contents were low during the summer of 1998 but were apparently not below levels that significantly reduce microbial activity. Further work is being conducted to evaluate the use of heat units in predicting N mineralization.

SUMMARY AND CONCLUSIONS

Nitrogen mineralization in no-till cotton systems measured *in situ* using undisturbed soil cores was numerically greater with a crimson clover than a rye cover crop. Early season N mineralization released nearly two times more N following crimson clover compared with following rye. Heat units showed a significant positive correlation to N mineralization. A reliable method of predicting N mineralization from readily available weather data and residue characteristics appears promising and could help improve timing and estimates of N amounts needed in no-till cotton.

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TILLAGE AND NITROGEN INFLUENCE ON ULTRA NARROW ROW AND CONVENTIONAL ROW COTTON

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ABSTRACT

The study was conducted in 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located at the North Florida Res. and Educ. Center (NFREC), Quincy, FL. The objectives of this research were to compare cotton planted in 36-inch (conventionalrows) and 7-inch (UNR -Ultra Narrow Row) row spacing with different tillage practices (no paraplow, fall paraplow, spring paraplow, and fall plus spring paraplow) and nitrogen (N) rates (0, 60, 120, and 180 lb N/A) on cotton. Plants were significantly taller for UNR than conventional row width planted cotton for all N treatments. Increasing N rates increased plant height for UNR cotton. Similar to the plant height, the height to node ratio (HNR) was higher for UNR than conventional rows. There was not a significant influence of paraplowing on either plant height or HNR. Yields of cotton were significantly higher from UNR than conventional row spacing and generally low due to hard locks (not fully developed and matured bolls). For both UNR and 36-inch row spacing, cotton yields obtained from the fall paraplow treatment were higher than with no paraplow, but the yields decreased with higher applications of N. Fall and fall plus spring paraplowing gave very similar cotton yields. Obtaining lower lint yields with higher N rates could be due to hard locks. Generally higher application of N increased the percent of hard locks and at the same time decreased the lint yields of cotton.

INTRODUCTION

In recent years, cotton production has increased rapidly in Florida. In the U.S.A., minimum tillage for cotton crop production is used in order to prevent soil erosion. Minimum tillage also increases soil organic matter, soil moisture, and improves soil texture that usually results in increased yield of plants (Hargrove, 1990). According to Nabors and Jones (1991), using minimum tillage protects cotton during emergence against injury from wind and sand. Accordmg to Heitholt et al. (1993), row spacing did not influence seed cotton yields. The results suggest that some agronomic traits of cotton might be expected to be similar, regardless of row spacing. Torbert and Reeves (1994) showed that tillage had no significant effects on cotton yield components in a dry year and increasing N application increased cotton biomass and decreased lint percentage. Their results also indicate that higher fertilizer N application rates may not be needed for conservation tillage practices such as strip-till in Coastal Plain soils. In years of below-normal rainfall during the growing season, strip tillage (no-till plus in row subsoiling) was found to maintain the highest seed cotton yield (Torbert and Reeves, 1991). The objectives of this research were to compare cotton planted in 36- and 7-inch row spacing with different tillage practices and N rates on cotton.

MATERIALS AND METHODS

These studies were conducted on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located on the NFREC, Quincy, FL in 1998. The following factors were: row spacing (7-inch - UNR cotton and 36-inch row spacing), tillage treatment (no paraplow, spring paraplow, fall paraplow, and spring + fall paraplow), and N rates (0, 60, 120, and 180 lb N/A). The entire study was sprayed with Roundup Ultra at 1 qt/A on April 15 and irrigated with 1 inch H_2O on April 22. On May 15, Paymaster 1220 RR/Bt cotton was planted at 4 seeds/ft of 36-inch wide rows with a Brown Ro-till planter on May 15. The same day, Paymaster 1220 RR/Bt cotton at *2.5* seeds/ft of 7-inch wide rows was planted with a Great Plains No-till drill in the Ultra Narrow Rows (UNR). The entire study was irrigated with 1 inch H_2O on May 20 and June 4. On June 10, cotton was broadcast sprayed with Roundup at 1.2 pt/A + Orthene 75 S at 4 oz/A + Induce at 2.0 qt/100 gal H_2O Nitrogen was applied to the cotton on June 15. On July 21, cotton was broadcast sprayed with Roundup at 1 qt/A + Induce at 2 qt/100 gal H_2O and broadcast sprayed with Pix at 12 oz/A. Cotton was broadcast sprayed with Ambush at 6.4 oz/A on August 5. On August 17, cotton was broadcast sprayed with Confirm 2 F at 8 oz/A + Lutron CS-7 spreader at 12pt/100 gal H_2O Cotton was defoliated with Dropp at 0.1 lb/A + Finish at 1 qt/A on September 24, defoliated with Cotton Quick at 2 qt/A + Dropp at 0.1 lb/A on October 9 and defoliated with Finish at 1 qt/A on October 16. On November 5, wide rows (36-inch wide) of cotton were picked with an International Spindle picker, and *UNR* cotton was harvested with a Ben Pearson stripper on November 13 and 14. The lint cotton yield from the spindle picker was calculated as 38% of seed cotton yield, and lint cotton yield from the stripper was calculated as 30% of seed cotton yield. Data were analyzed using SAS (1989) by analysis of a variance and means were separated using Fisher's Least Significant Difference Test at the 5% probability level.

RESULTS AND DISCUSSION

Figure 1 presents the influence of row width and N rates on plant height of cotton. Plants were significantly higher for UNR than conventional row width planted cotton for all N treatments. Increasing N rates increased plant height for UNR cotton with the maximum values for the highest N rate. The maximum plant height for 36-inch wide rows occurred with the application of 84 lb N/A. The height to node ratio (HNR) was higher for UNR than conventional rows, with highest HNR values obtained at the application of 180 lb N/A for both row widths (Fig. 2). There was not a significant influence of paraplow on either plant height or HNR.

Figures 3 and 4 present the influence of paraplow and N rates on cotton planted in 36-inch row spacing. Generally, yields were low due to hard locks. Yields obtained from treatment with fall paraplow were higher than with no paraplow, but they decreased with higher application of N. Fall and fall plus spring paraplow gave very similar yields of cotton planted in 36-inch row width. Maximum lint yields were obtained at the application of 44 lb N/A for both tillage applications.

Yields of cotton were significantly higher from UNR than conventional row spacing. Figures 5 and 6 show the influence of paraplow on cotton yields planted in 7-inch row width. Lint yields were higher from the treatment with fall paraplow than with no paraplow, but for both treatments, the yields were decreasing with increasing N rates on cotton (Fig. 5). Similar to the previous results, the yields from treatments with spring paraplow and fall plus spring paraplow were decreasing with increasing N rates (Fig. 6). Treatments with spring paraplow and fall plus spring paraplow gave very similar yields of cotton. Obtaining lower lint yields with higher

N rates could be due to hard locks. Generally, higher application of N increased the percent of hard locks and at the same time decreased the lint yields of cotton.

CONCLUSIONS

Plant height and HNR were higher from 7-inch UNR than 36-inch row spacing and also increased with higher N rates on cotton. Lint yields were significantly higher on UNR as compared with conventional row widths and higher after application of fall paraplow than other tillage practices. Higher N rates increased the percent of hard locks and decreased the lint yields of cotton.

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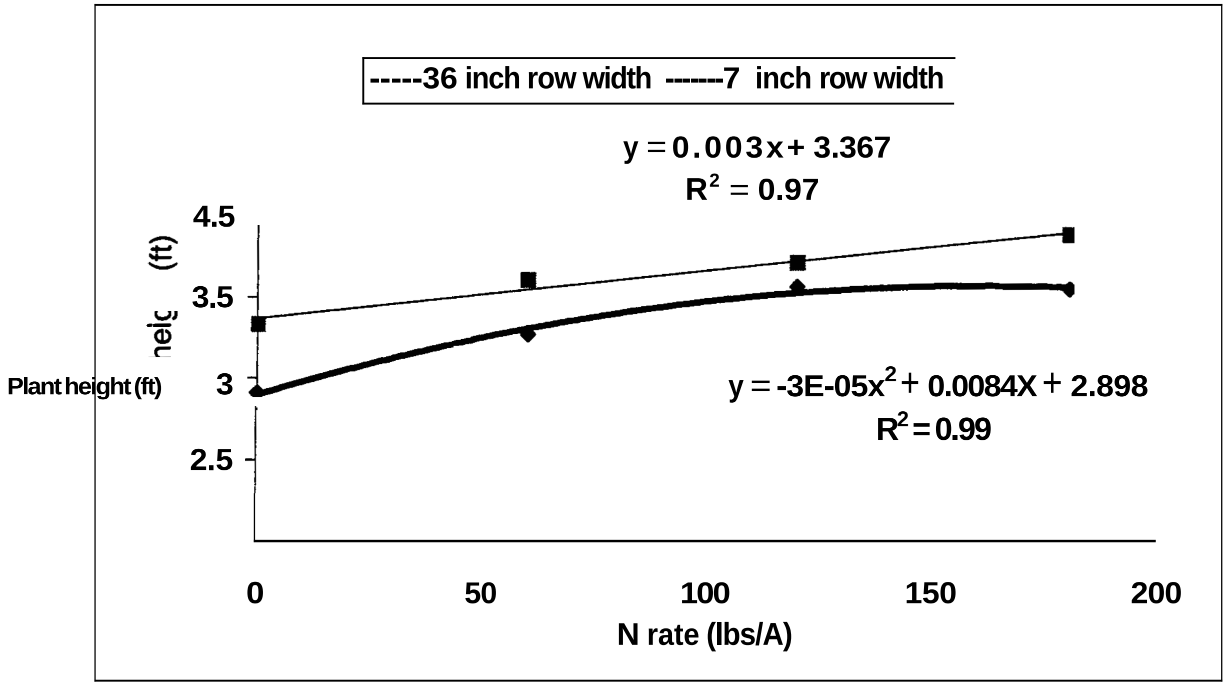

Fig. 1. Influence of row width and N rate on plant height of cotton.

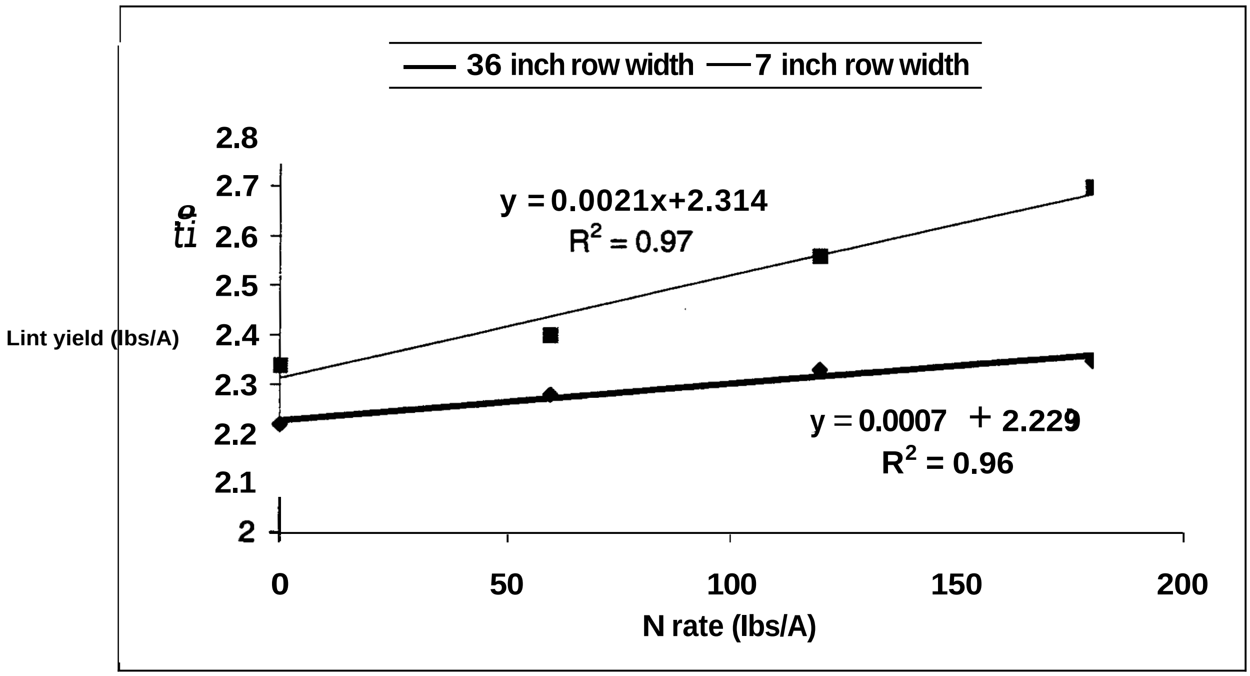

Fig. 2. Influence of row width and N rate on height to node ratio of cotton.

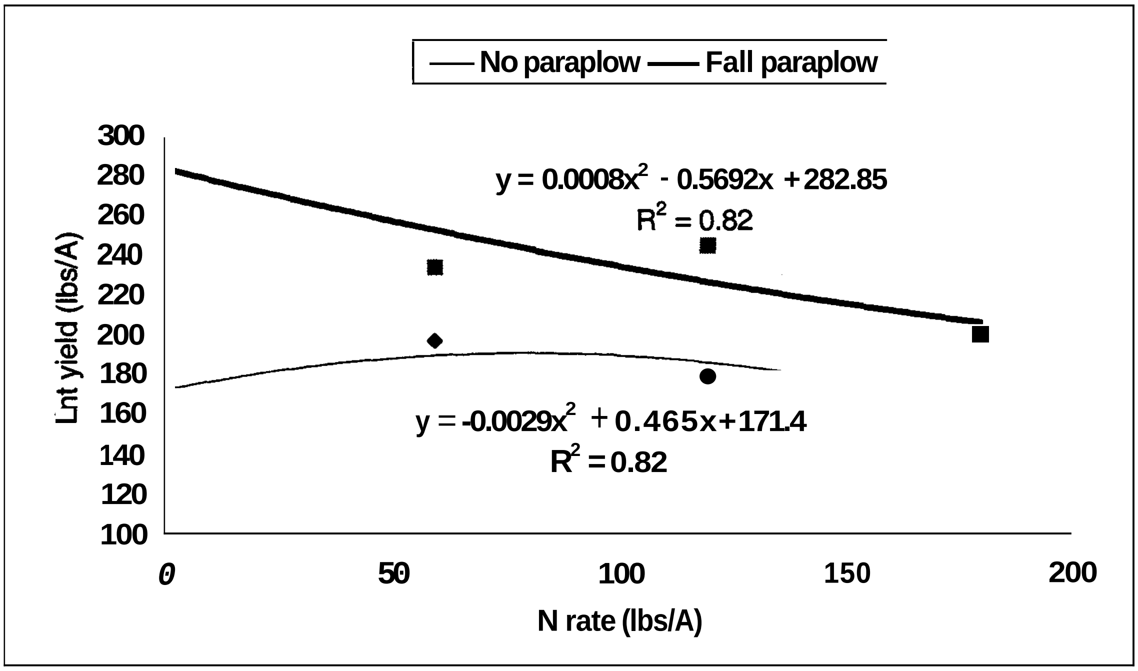

Fig. 3. Influence of tillage and N rate on lint yield of cotton (36 inch wide rows).

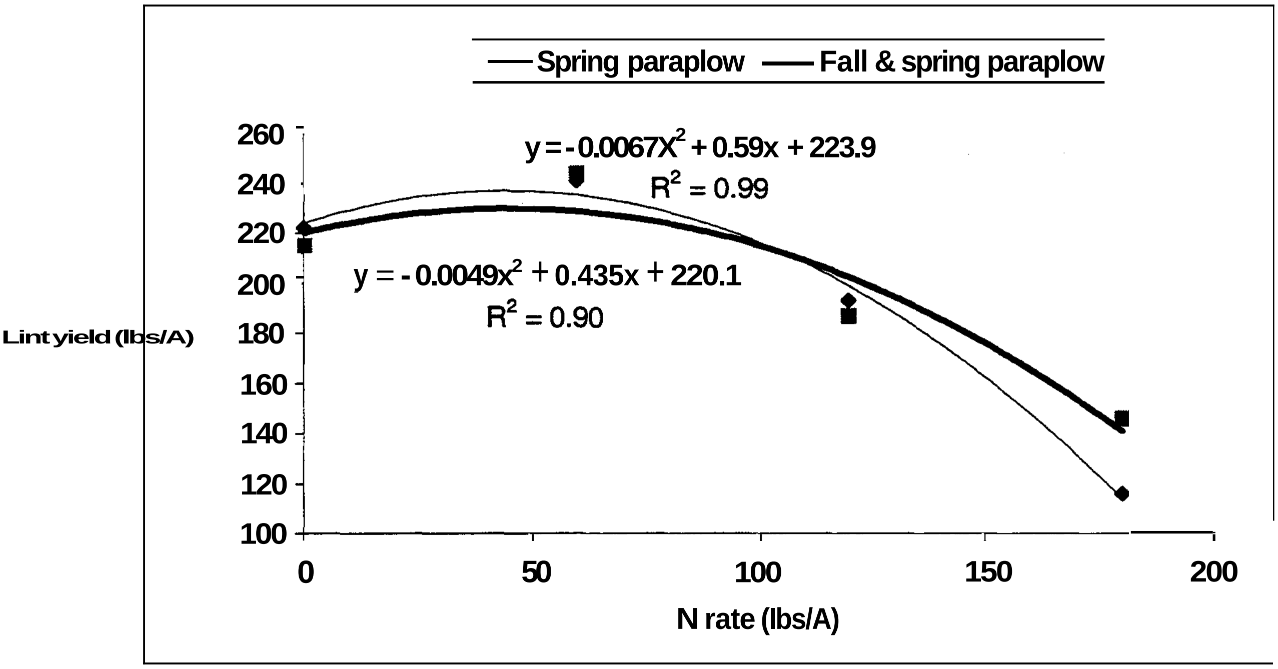

Fig. 4. Influence of tillage and N rate on lint yield of cotton (36 inch wide rows).

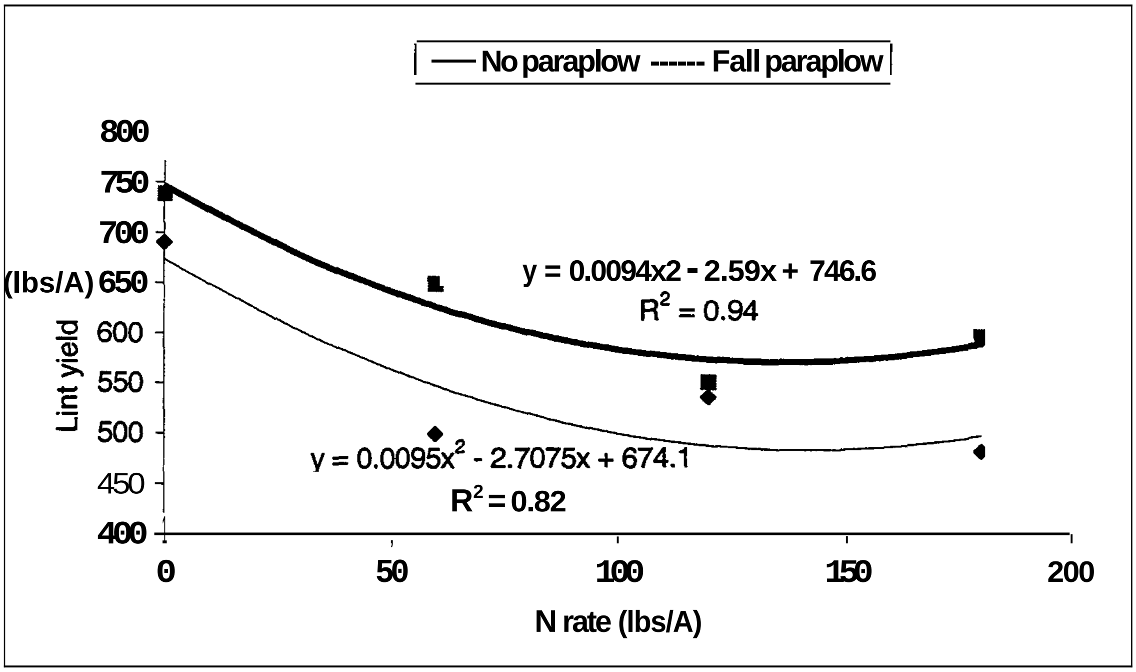

Fig. 5. Influence of tillage and N rate on lint yield of cotton (7 inch wide rows).

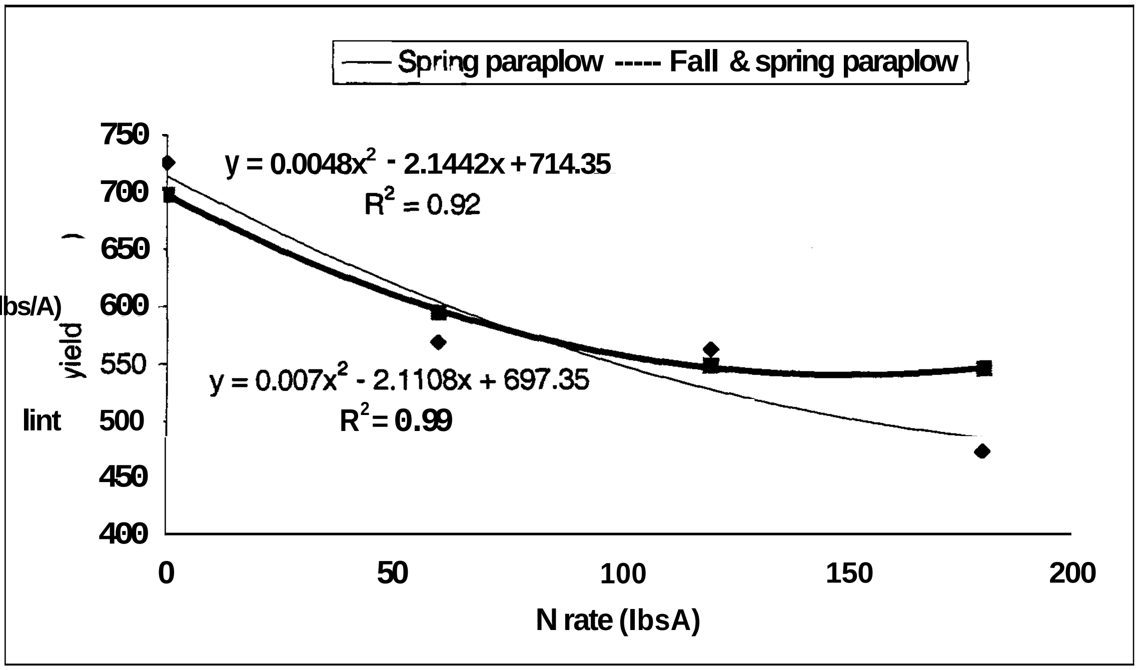

Fig. 6. Influence of tillage and N rate on lint yield of cotton (7 inch wide rows).

TILLAGE AND THIMET EFFECTS ON THREE PEANUT CULTIVARS: TOMATO SPOTTED WILT VIRUS CONTROL

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ABSTRACT

The study was conducted in 1998 on a Dothan sandy loam at Quincy and on a Chipola loamy sand (fine, loamy siliceous, thermic Plinthic Kandiudults) at Marianna, two locations of the North Florida Research and Education Center (NFREC). The objectives of this research were to evaluate the influence of tillage (strip-till vs. conventional) and Thimet application on Tomato Spotted Wilt Virus (TSWV) control and yield of three peanut varieties (Georgia Green, SunOleic 97R, and MDR 98). Georgia Green and Florida MDR are somewhat resistant to TSWV and SunOleic 97R is a susceptible check. There was no significant difference between conventional and strip tillage for,the incidence of TSWV. Georgia Green (Quincy) and Georgia Green and MDR98 (Marianna) showed less TSWV incidence when compared with S97R. Thimet significantly reduced TSWV incidence at Quincy but not at Mariana where disease was much more severe. Severity of TSWV was generally lower for strip tillage than conventional tillage at both locations. The variety with least severity of TSWV was Georgia Green (Quincy) and Georgia Green and MDR98 (Marianna). Yield of peanuts were higher from strip tillage than conventional tillage from the experiment conducted in Quincy, but the yields were not influenced by tillage systems on the experiment conducted in Marianna. Higher yields were obtained from Georgia Green than other cultivars at the Quincy site and from MDR98 than other cultivars at the Marianna site. There was no significant difference for peanut yields between Thimet applications at the Quincy and Marianna sites. Use of resistant cultivars can be an important factor in decreasing the effects of disease (TSWV), and subsequent cost of disease control and use of Thimet can be a positive addition to a management program in areas where TSWV is a problem.

INTRODUCTION

Tomato Spotted Wilt Virus (TSWV) is a serious disease of peanut (Culbreath et al., 1992). Most peanut fields in the southeastern USA are infected with this virus. According to Olson and Funderburk (1986), the tobacco thrips, <u>Frankliniella fusca</u> (Hinds), is an important vector of TSWV in Florida. Viral disease of peanut is difficult to manage due to lack of chemical control (Carrol et al., 1996). Integrated strategies using cultural practices and host plant resistance are currently the only options for management of TSWV. These strategies are updated yearly as new research is available by a checklist chart called "tomato spotted wilt risk index for peanut" (Prostko, 2000).

Conservation tillage systems are receiving increasing acceptance to reduce erosion (Berg et al., 1988). Moldenhauser et al. (1983) have shown that the effectiveness to control erosion depends on the amount of crop residue left on the soil surface. Minimum tillage increases soil organic matter, soil moisture, and improves soil texture that usually results in increased yield of plants.

The objectives of the experiments were to compare three cultivars of peanuts planted in conventional and strip tillage with and without Thimet for the TSWV incidence, severity, and yields.

MATERIALS AND METHODS

These studies were conducted in 1998 on a Dothan sandy loam at Quincy and on a Chipola sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at Marianna, both locations of the University of Florida, NFREC. The treatments were: Peanut variety (Georgia Green, SunOleic 97R, and MDR 98), Tillage (Strip-till and Conventional), and Thimet application (Thimet - 5 lb/A and no Thimet). The conventional section of the study was plowed and smoothed with an s-tined field cultivator. Rows on the strip-till section were prepared with a Brown Ro-till planter. Three varieties of peanuts were planted with KMC planters at a seeding rate of 6 seeds/ft of 36-inch wide rows in Quincy and Marianna on April 23 and 24 in 1998, respectively. Thimet was applied at planting in fun-ow at 5 lb/A on the sections with Thimet. After planting, the entire study was sprayed with Prowl at 1 qt/A. In Quincy, the test was irrigated when needed and in Marianna the test was not irrigated.

Peanuts were sprayed with Cadre DG at 1.44 oz/A + Induce at 1 qt/l00 gal to control weeds. Bravo S at 3 pt/A was also broadcast sprayed, starting about 40 days after emergence and continued every 2 weeks with Bravo Ultra at 0.7 lb/A until 2 weeks prior to harvest. During the growing season, peanuts were evaluated for severity and incidence of TSWV. Severity was the average of 20 plants from each of four replicated plots (rated from 0-5, with 0 being no symptoms; 3, general chlorosis; and 5, general necrosis). Incidence was the proportion of 20 plants with symptoms of four replicated plots. Mature peanuts were inverted and harvested in Marianna and Quincy and then dried to 10% moisture.

Data were analyzed using SAS (1989) by analysis of a variance, and means were separated using Fisher's Least Significant Difference Test at the 5% probability level.

RESULTS AND DISCUSSION

There was no significant difference between conventional and strip tillage for the incidence of TSWV, but it increased significantly with time of observation and tended to be lower throughout the season with strip tillage (Figs. 1 and 2).

The comparison of three peanut cultivars (Figs. 3 and 4) shows that Georgia Green (Quincy) and Georgia Green and MDR98 (Marianna) were more resistant to the TSWV incidence when compared with S97R. For all cultivars, incidence increased with time of observation with the highest incidence of TSWV at the end of the observation period.

There was no significant difference between the treatments with and without Thimet in Marianna (Fig. 6), but the incidence of TSWV was lower with Thimet application on peanuts grown in Quincy (Fig. 5).

Severity of TSWV on three peanut cultivars in conventional and strip tillage in Quincy and Marianna was generally lower for strip tillage than conventional tillage for both locations (Figs. 7 and 8). Georgia Green was the most resistant variety to TSWV. The differences were more significant at the end of the vegetation period for peanuts (Figs. 9 and 10).

At Quincy, there was a tendency to reduce the seventy of TSWV on peanuts with the application of Thimet (Fig. 11), but the results obtained from Marianna did not show any benefits of Thimet application to reduce this severity (Fig. 12).

Yields of peanuts were higher from strip tillage than conventional tillage at the experiment conducted in Quincy (Fig. 13), but yields were not influenced by tillage systems on the experiment conducted in Marianna (Fig. 14). Higher yields were obtained from Georgia Green than other cultivars at Quincy (Fig. 13), but yields of peanuts were higher from MDR98 than other cultivars at Marianna (Fig. 14). There was no significant difference for peanut yield with and without Thimet at Quincy or Mariana (Figs. 15 and 16).

CONCLUSIONS

1. There were little differences in yields of peanuts grown in strip or conventional tillage, although severity of TSWV was lessened by strip tillage as compared with conventional tillage.

2. Use of resistant cultivars can be an important factor in decreasing the effects of TSWV and subsequent yield.

3. Use of Thimet can be a positive addition in areas where TSWV is a problem but may be less effective under extremely high disease pressure.

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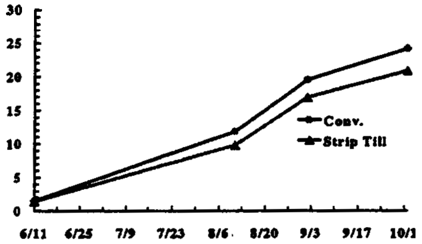

Fig. 1. Incidence of TSWV on three peanut cultivars in conventional and strip tillage in Quincy

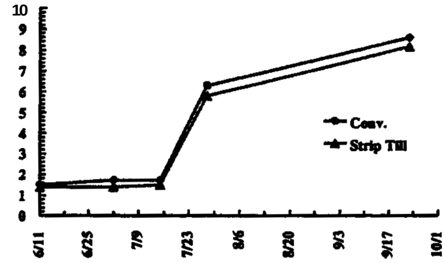

Fig. 2. Incidence of TSW on three peanut cultivars in conventional and strip tillage in Marianna

Fig. 3. Incidence of TSWV on three peanut cultivars across two tillage methods in Quincy

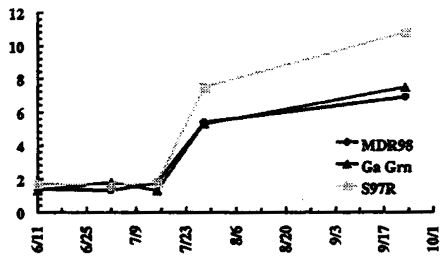

Fig. 4. Incidence of TSWV on three peanut cultivars across two tillage methods in Marianna

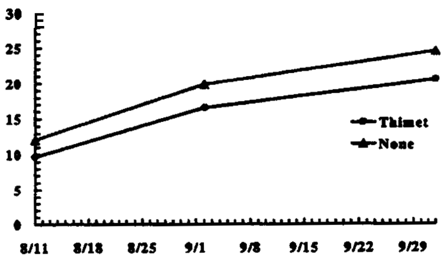

Fig. 5. Incidence of TSWV on Thimet use in conventional and strip tillage in Quincy

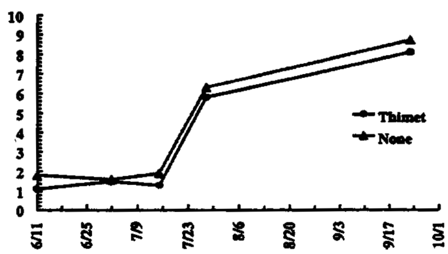

Fig. 6. Incidence of TSWV on Thimet use in conventional and strip tillage in Marianna

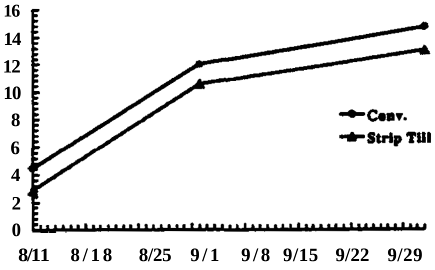

Fig. 7. Severity of TSWV on three peanut cultivars in conventional and strip tillage in Quincy

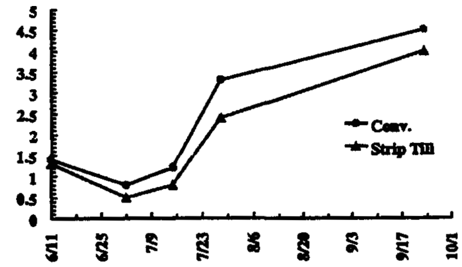

Fig. 8. Severity of TSWV on three peanut cultivars in conventional and strip tillage in Marianna

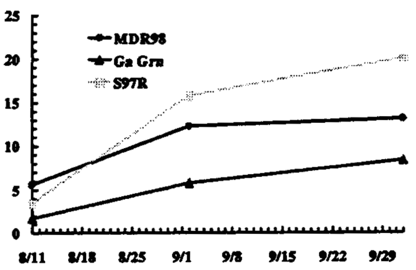

Fig. 9. Severity of TSWV on three peanut cultivars across two tillage methods in Quincy

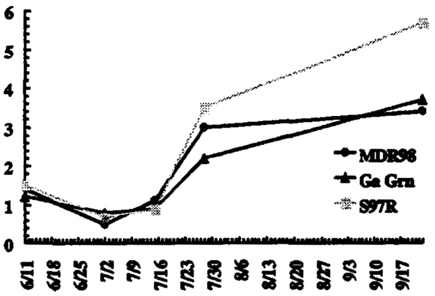

Fig. 10. Severity of TSWV on three peanut cultivars across two tillage methods in Marianna

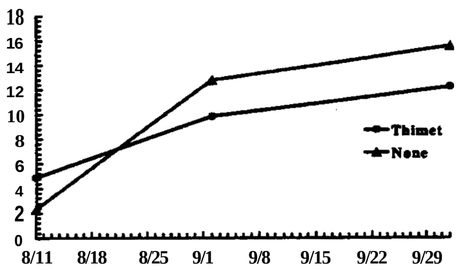

Fig. 11. Severity of TSWV in relation to Thimet use in conventional and strip tillage in Quincy

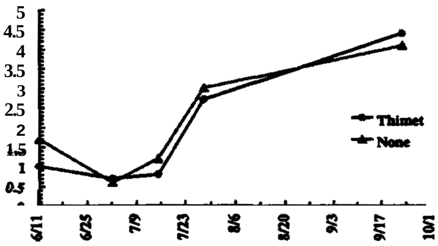

Fig. 12. Severity of TSWV in relation to Thimet use in conventional and strip tillage in Marianna

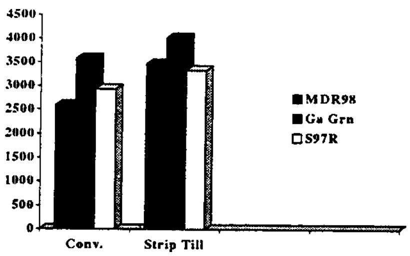

Fig. 13. Pod yields (lb/A) of three peanut cultivars in conventional and strip tillage in Quincy

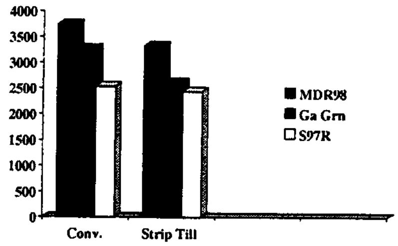

Fig.14. Pod yields (Ib/A) of three peanut cultivars in conventional and strip tillage in Marianna

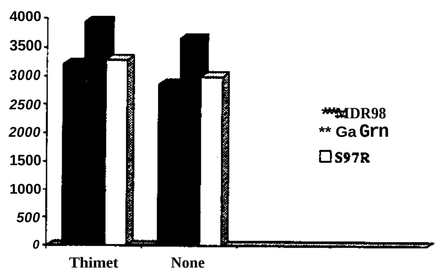

Fig. 15. Pod yields (Ib/A) in relation to Thimet use in conventional and strip tillage in Quincy

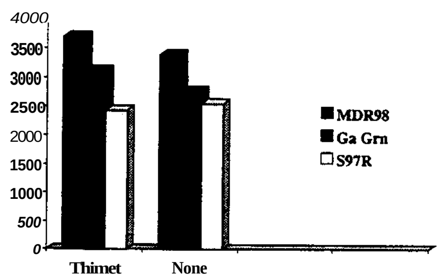

Fig. 16. Pod yields (lb/A) in relation to Thimet use in conventional and strip tillage in Marianna

PEER REVIEW

PAPERS

USING GIS REMOTE SENSING AND WATER QUALITY MODELING TO ESTIMATE ANIMAL WASTE POLLUTION POTENTIAL

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ABSTRACT

Watersheds having a dense population of poultry production facilities frequently receive relatively high rates of poultry litter application. This often leads to surface and ground water pollution problems. The State of Alabama recently adopted an animal waste disposal regulation that requires farmers to adapt a waste management practice considering rate of application and watershed and land use characteristics. The objective of this study was to develop an animal waste pollution potential index (AWPPI) that can be used by farmers and regulators to rank areas based on susceptibility to nonpoint source (NPS) pollution from land application of poultry litter. This study was conducted in a watershed with an area of 56 mi^2. The AWPPI was developed as a function of manure application rate, nutrient availability rate, and delivery ratio. The watershed data required for this method were derived from 7.5 minutes USGS digital elevation models. High resolution infrared aerial photos were used to derive information about number and location of poultry houses in the watershed. Two indices, N-based and P-based AWPPI, were evaluated in this study. No significant difference was found between the two indices. The AWPPI was found to be significantly correlated to poultry house density in a watershed and ratio of litter application area to watershed area. This method presents a simple approach to identify areas having higher susceptibility to NPS pollution and where best management practices may need to be implemented to reduce NPS pollution from animal waste application.

INTRODUCTION

Agncultural nonpoint source pollution (NPS) created by excessive application of fertilizer and pesticides and improper animal waste management is one of the most damaging and widespread threats to the environment (National Research Council, 1989). Improper animal waste management has gained increasing attention in the past decade, and land application of animal manure has been the focus of many studies. Excessive land application of animal manure is common in regions where animal production is concentrated. This leads to surface and ground water pollution problems that are potentially threatening to human health and recreational activities.

Poultry production is the largest agricultural industry in Alabama. Alabama ranks third nationally, behind Georgia and Arkansas, in both quantity and cash value of poultry production (Alabama Agricultural Statistics, 1998). For the past 20 years, growth in the poultry industry has contributed to potential pollution of the state's water resources due to excess land application of poultry litter to farmland. Recently, the State of Alabama adopted a regulation that requires animal producers to implement Best Management Practices (BMPs) to minimize surface and groundwater pollution, if the animal manure is applied at higher than agronomic rates. Currently, the Alabama Department of Environmental Management recommends the application rate be based on soil N content and agronomic N requirements. If the poultry litter application rate is higher than the agronomic N requirement or if it is applied in an area with higher susceptibility of loss to receiving water bodies, a BMP that minimizes the off-site transport of nutrients to receiving streams must be implemented.

There is a need to identify the areas where poultry litter may or may not be applied. Several researchers have used water quality models to identify such 'hot spots' within a watershed that may potentially be the principal source of NPS pollution. However, most of these models are very complex in nature and suffer from the limitation of large input data requirements. Most of these models cannot be easily used by people outside the academic and research community due to these limitations. There is a need to develop a simple methodology that can be easily used by farmers and regulators to identify areas that may not be suitable for animal manure application or which may need implementation of BMPs to minimize NPS pollution.

The objective of this research was to develop an Animal Waste Pollution Potential Index (AWPPI) that can be used to rank areas based on the potential of nutrient transport from land application areas to the receiving streams. One criterion used to develop this methodology was to minimize the input data requirements so that a user can easily construct an input data file from readily available information.

MATERIALS AND METHODS

This study was conducted in the Crooked Creek watershed in Cullman County, Alabama. Cullman County is the largest poultry producing county in Alabama. The poultry industry has expanded rapidly in this region in the past decade and represents the major source of agricultural income. Crooked Creek has been identified in the 303 (d) list of Alabama streams having water quality problems from intense animal feeding operations. The water quality parameters of concern in this creek are nitrogen (N), organic enrichment, and pathogens. Nutrient runoff from land areas to which poultry litter has been applied is believed to be one of the principal sources of NPS pollution in this region. Figure 1 shows the location of poultry houses within the Crooked Creek watershed. Watershed characteristics are shown in Table 1.

The primary purpose of developing the AWPPI was to identify areas that have a high susceptibility for nutrient losses to receiving streams. It can be used to provide a relative ranking of the suitability of particular areas for land application of animal manure with minimum potential impact on stream water quality. The methodology outlined by Heatwole and Shanholtz (1991) was used to develop the AWPPI. The Heatwole and Shanholtz model estimates the waste pollution index as a function of waste load, land slope, and distance to stream. The index is estimated both for the animal production site and for the surrounding crop and pasture areas where animal manure is potentially applied. The most sensitive parameters for this model are the site load and the site deliver ratio. Based upon the data from two counties in Virginia, the authors concluded that the model reflected a primary response to the suitability of the site itself but was also affected by the suitability of the surrounding area.

The potential delivery of nutrients from the treated areas to the receiving streams is estimated as a function of nutrient application rate, a nutrient availability factor, and a delivery ratio. Mathematically, it can be represented as

$$AWPPI = \frac{1}{A}\sum_{i=1}^{n} L_i * a_i * AF * DR_i$$

where L is the nutrient loading rate in lb/A, AF is availability factor, DR is delivery ratio, and a is the area (acres) of the field treated with poultry litter, i = 1, 2, 3, ...n is the number of fields in a subwatershed where litter is applied.

The availability factor represents the fraction of nutrients that move into runoff from surface-applied manure. Heatwole and Shanholtz (1991) have suggested a value of 0.05 for the nutrients applied in the field and 0.06 for the nutrients lost from the confinement areas. The delivery ratio is the function of available pollutant load that reaches the nearest stream. It can be calculated as a function of the flow distance between the point where manure is applied and the receiving stream and slope along this flow path,

$$DR = e^{-k_1 dSF}$$

$$SF = SF\min + e^{-k_2(S+S_o)}$$

where d is distance to the stream (ft), S is slope along that distance (ft/ft), k_1, k_2 So and SFmin are parameters. Slope factor affects the delivery ratio by changing the flow distance (d) as the slope changes. SFmin was included to maintain the greater importance of distance over slope in the delivery ratio (Heatwole and Shanholtz, 1991).

The model was developed in ArcView GIS environment. Basic data needed to estimate AWPPI are watershed topography, location of poultry production facilities, area where poultry litter is applied, and poultry litter production rate. Watershed topography data were obtained from 7.5 minutes, 1:24000 Digital Elevation Models (DEMs) from U.S. Geological Survey. The Crooked Creek watershed was divided into 159 subwatersheds based on stream channel network and watershed drainage characteristics. The advantage of dividing the watershed into a set of subwatersheds based on channel network is that once the subwatersheds are ranked based on AWPPI, individual stream sections most susceptible to NPS pollution in a watershed can be identified. Any subsequent watershed management plan can focus on protecting these segments of streams. Stream characteristics, flow direction, and flow accumulation were derived for each subwatershed. Average flow path distance (d) and average slope (s) along the flow path was estimated using ArcView for each subwatershed.

Six color infrared aerial photos with 1-meter resolution were used to derive the land use and location of the poultry houses within the watershed. Color infrared aerial photo film is manufactured to record green, red, and the photographic portion (0.7 to 0.9μm) of the near-infrared scene energy in its three emulsion layers. The result is a false color film in which blue images result from objects reflecting primarily green energy, green images from objects reflecting red energy, and red images from objects reflecting near-infrared portion of the spectrum. Poultry houses, along with other urban and built up lands, appear in very bright tones and can be easily identified from the color infrared aerial photos. After image registration and rectification, the aerial photos were mosaiced and resampled at 20 x 20 m resolution for further analysis. Green band, along with a high-pass filter, was used to screen out poultry production facilities. The major characteristic of the poultry houses in the aerial photo is that they are shown in bright straight parallel lines. Using the technique of on-screen digitizing, all the poultry houses were converted to a point coverage in ArcView GIS.

Input parameters needed to develop AWPPI are nutrient loading rate, nutrient availability factor, and delivery ratio from field to stream. The amounts of total poultry litter, as well as total N and phosphorus (P), produced were obtained from literature values. Each poultry house was estimated to hold 20,000 broilers producing 100 tons of litter per year. Assuming a N content of 4.0% and P content of 1.5% (Edwards and Daniel, 1992), total N and total P production were estimated as 8800 lb N and 3300 lb P per house per year. Nutrient availability factor used for poultry litter was 0.22 for N and 0.09 for P (Robinson and Sharpley, 1995). Estimation of delivery ratio requires values for slope factor, average flow length from field to stream and average slope along this flow path. A value of SFmin = 0.60 was used for steep slopes. Values for the parameters $k^1 = 0.049\ ft^{-1}, k^2 = 16.1$, and So = 0.057 were used as suggested by Heatwole and Shanholtz (1991). Average flow length from field to the nearest receiving stream and average slope along this flow path were obtained using ArcView GIS.

Site specific data about the area of the watershed where poultry litter is applied are very difficult to obtain. Average farm size in Cullman County in Alabama is 94 acres (Alabama Farm Statistics, 1998). It was assumed that poultry litter from each house was applied in the surrounding 94-acre farm land.

RESULTS AND DISCUSSION

Animal waste pollution potential from surface application of poultry litter was estimated for losses of both N and P. The basic statistics for N- and P-based AWPI are shown in Table 2. A difference between the N- and P-based AWPPI was due to the differences in nutrient loading rates for N and P in each farm and nutrient availability factor. Even though the values for AWPPI are different for N- vs. P-based rankings, no difference in subwatershed rankings was indicated for the two methods. Figure 2 shows the N-based AWPPI ranking of the subwatersheds. A correlation analysis showed a significant correlation between N and P based AWPI ($r^2 = 0.999$, $p < 0.001$). Hence, the subsequent discussion is based on AWPPI for N losses. It should be noted that the AWPPI discussed here does not consider the current practices implemented at a particular site. For example, a BMP, such as vegetative filter strips, may reduce the actual losses of nutrients and may lower the ranking of the site based on pollution potential.

The AWPPI for the Crooked Creek ranged from 0 to 4.09 (Table 2). The minimum AWPPI was obtained for the subwatersheds where no poultry house was located or where poultry litter was not applied. Factors affecting AWPPI for a subwatershed are delivery ratio, nutrient application rate, and subwatershed area. The delivery ratio is affected by watershed topography. A high slope and shorter distance from the land application area to the stream results in a high delivery ratio. Application of poultry litter near streams or in areas with steep slopes would result in a high AWPPI. Nutrient application rate depends upon density of poultry houses in a subwatershed (number of houses per square mile of subwatershed area) and total farm area available for application of poultry litter. A regression analysis between AWPPI and poultry house density indicated a significant correlation ($r = 0.60$, $p < 0.01$). This indicates that a large number of poultry houses present in a watershed will result in a high AWPPI. This can be expected if no significant litter is exported outside the watershed.

Another variable that influences AWPPI ranhng is the ratio of farm area where poultry litter is applied to the subwatershed area. A ratio of "1" would indicate that poultry litter is applied in the entire watershed, whereas, a ratio of "0" would indicate that no poultry litter is applied in the watershed. This ratio was larger than 0.95 for all subwatersheds having AWPPI greater than 2.0. A regression analysis indicated that the ratio of litter-applied area to the watershed area was significantly correlated ($r = 0.41$, $p > 0.01$).

The ranking of areas based on AWPPI discussed in this paper presents a simplified approach to identify the area susceptible to NPS pollution from poultry litter application. Figure 2 shows that such 'hot spots' in a watershed can be very effectively identified using this approach. Traditionally, hydrologic/water quality models have been used to identify such areas and to develop watershed management plans to reduce NPS pollution. Most of these models are very complex in nature and require large input data sets. Preparation of input data sets before these models can be run can be a tedious and time consuming task. These models also need to be calibrated for site-specific conditions before they can be used to make reliable watershed response predictions. In many cases, fanners or regulators may be interested only in identifying the areas where a new poultry house can be located or where poultry litter can be applied without a significant risk to NPS pollution. The methodology presented here can be used to screen such areas. Another advantage of this method is that all the watershedcharacteristicdata can be developed from DEMs, readily available at no cost from U.S. Geological Survey. This method can also be used for other types of animals, if the data about animal manure application rate and area where the manure is applied are available. One of the limitations of this approach is that it can not quantify the exact response of a watershed under certain land use and management conditions. If the effect of certain land use changes on water quality needs to be assessed to evaluate a BMP's effectiveness, a more complex hydrologic/water quality model will have to be used. The AWPPI also does not estimate the sediment erosion from the field and transport of sediment-attached N and P from the field to the stream. Runoff losses of N from the land areas treated with animal manure are mostly in the dissolved form. Phosphorus is attached to the sediment and a significant portion of the P moves with eroded soil particles. Researchers have also shown that continuous build up of P in soil can increase potential for P transport in runoff (Robinson et al., 1995). The AWPPI for agricultural areas having significant erosion problem should also consider sediment-attached nutrient transport.

Recently, Internet-based GIS application for natural resource management has generated interest. The methodology presented here can be effectively used to generate countywide or statewide Internet-based AWPPI using GIS. Currently available computing and GIS technology offer the capability to develop such applications. Watershed topography and stream network hydrology data can be assembled and watersheds can be delineated for a county and stored on the Internet-based GIS In order to see the suitability of a particular area for animal waste application, a farmer may only need to click in the watershed where waste will be applied and input information about waste application rate. This type of application may eliminate the need for costly watershed reclamation programs from NPS pollution.

ACKNOWLEDGEMENT

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Table 1. Crooked Creek watershed characteristics.

Watershed Area	56.4 mi^2
Land use	
Forest	61%
Pasture and Cropland	38%
Urban	0.5%
Other	0.5%
Number of poultry houses	144

Table 2. AWPPI for Crooked Creek Watershed based on N and P losses from poultry litter.

Statistic	AWPPI(Nitrogen)	AWPPI(Phosphorus)
Mean	0.377	0.057
Range	0-4.09	0-0.61
Variance	0.35	0.008

Figure 1. Drainage network and location of poultry houses in Crooked Creek watershed.

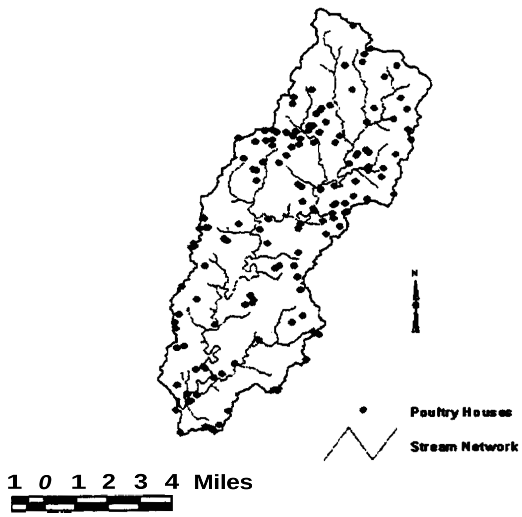
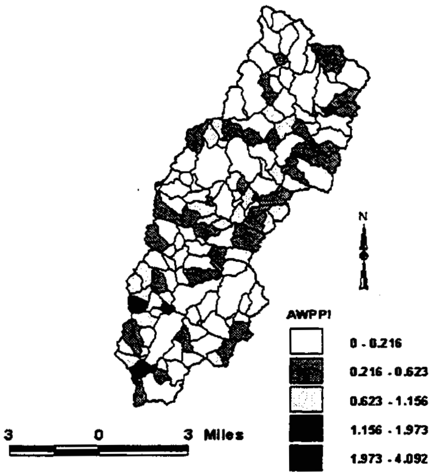


Figure 2. AWPPI ranking of subwatersheds in Crooked Creek watershed



COTORAN WASH-OFF FROM COVER CROP RESIDUES AND DEGRADATION IN GIGGER SOIL

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ABSTRACT

Cover crop residues on no-till soil will intercept a portion of applied herbicides. Thus, herbicide efficacy in no-till systems depends, in part, on rainfall to wash the herbicide onto the soil. Tillage and cover crop residue may also influence degradation of a herbicide in soil. This series of studies examined Cotoran (fluometuron, *N,N*-dimethyl-*N*r-[3-(trifluoromethyl)phenyl] urea) wash-off from native vegetation, hairy vetch *(Vicia villosa),* and wheat residue *Triticum aestivum),* related wash-off to sorption on these residues, and compared fluometuron degradation in soil from long-term native, vetch, and wheat cover crop plots used with either conventional or no-till cotton *(Gossypium hirsutum).* A rainfall simulator was used to wash spray-applied fluometuron from plant material. Through-flow was analyzed for fluometuron by HPLC. The most fluometuron was washed off samples of native vegetation. Vetch and wheat residues retained fluometuron about equally. Fluometuron sorption on these residues was determined in a batch study. Sorption was least with native vegetation. There was little difference between vetch and wheat in fluometuron sorption. Fluometuron wash-off could be modeled on the basis of batch sorption data. The degradation of fluometuron in soil from each tillage by cover crop combination was determined by incubating fortified samples for 6, 15, 30, and 60 days. Soil extracts showed that degradation was more rapid in no-till soil than in conventional-till soil. Within either tillage treatment, degradation was slowest in vetch soil. Microbial activity was higher in no-till soil, consistent with faster degradation.

INTRODUCTION

Plant residue management that combines no-tillage with cover crops offers maximal soil coverage with protective residue and, therefore, maximal benefit for reduced erosion and preserved or improved soil quality. Hairy vetch and wheat are winter annuals commonly used as cover crops. These produce large amounts of residue that affect weed populations in no-tillage systems. Weed germination and emergence are suppressed by reduced light and temperature under cover crop residue (Teasdale et al., 1991; Teasdale and Daughtry, 1993). Allelophathy may also enhance weed suppression (White et al., 1989).

These positive effects of cover crop residue on weed suppression, however, are typically insufficient for adequate weed control so herbicides are also needed. Since a portion of applied herbicide is intercepted by the residue (Banks and Robinson, 1982; 1986), this fraction must be washed off the residue before it can contact the soil where it is active. Depending on how strongly the intercepted herbicide is retained by the residue, wash-off may be slow. Gradual transmission to the soil may provide extended weed control. Cover crop residue at the soil surface may also sorb a portion of herbicide dissolved in runoff water before it leaves the field, thus, offering an additional environmental benefit beyond reduced erosion. On the other hand, strong adsorption may increase persistence with the possibility of crop injury in the next season (Johnson and Talbert, 1993).

Previous research has shown that sorption of chlorimuron (ethyl-2-[[[[(4-chloro-6-methoxy-2-pyrimidinyl)amino]carbonyl]amino] sulfonyl]benzoate) and cyanazine (2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile) on cover crop residues is strong, increases with degree of residue decomposition, and not completely reversible (Reddy et al., 1995; 1997). However, no attempts have been made to directly account for herbicide wash-off on the basis of sorption.

Plant residue at the soil surface or incorporated into the soil may affect the rate of herbicide degradation. The parallel effects of decreasing organic matter and microbial biomass with increasing depth in soil on the degradation of fluometuron were examined by Mueller and Moorman (1992). Fluometuron half life increased from 2½ weeks in the upper 6-inch (7.5-cm) to 21 weeks in the 35- to 47-inch (90- to 120-cm) depth, where organic matter and microbial biomass were less than half that in the surface soil. Effects of increased organic matter due to either long-term no-tillage or hairy vetch cover crop, however, were not reflected in fluometuron degradation rate (Brown et al., 1994). Whereas greater rate of degradation due to enhanced microbial populations may have been expected in the surface no-till, vetch soil than in the surface conventional-till soil without cover crop, the opposite was found. The half life of fluometuron in soil from all treatments in Brown et al. (1994) was longer (average, about 9 weeks) than found in other studies (Rogers et al., 1985; Mueller and Moorman, 1992).

The objectives of the work reported in this paper were to: 1) determine the rate at which fluometuron is washed off three different cover crop residues; 2) relate wash-off rate to fluometuron sorption onto these residues; and 3) determine the effects of tillage and cover crop on fluometuron degradation in soil.

MATERIALS AND METHODS

Plant and Soil Samples

Cover crop residue and surface Gigger (fine-silty, mixed, thermic Typic Fragiudalfs) soil were collected from a long-term cotton tillage (conventional-, ridge-, and no-till) by cover crop (native vegetation, hairy vetch, wheat, and vetch plus wheat) by N fertilization rate (45 and 90 lb/A) field plot study at the Macon Ridge location of the Northeast Research Station, Winnsboro, LA. Duplicate (12 x 12-in area) samples of native, vetch, and wheat biomass were collected from six no-till plots prior to burndown with glyphosate (*N*-(phosphonomethyl)glycine) or paraquat (1,lr-dimethyl-4,4r-bipyridinuim ion). Plant residues were dried at 131°F, chopped into approximately 1-inch pieces and stored until use in the adsorption and wash-off studies described below. Table 1 gives average area densities of native vegetation, vetch, and wheat.

Surface 0- to 1-inch soil samples (2-in diameter, four per plot) from conventional- and no-till, native, vetch, and wheat plots fertilized with 45 lb N/A were collected before planting, application of fluometuron and pendimethalin (N-(1 -ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine), and application of N fertilizer. These were stored at 39°F until use in the fluometuron degradation and microbial assay studies described below. Organic matter and pH of these soils are given in Table 2.

Adsorption of Fluometuron to Cover Crop Residue

Approximately 0.035 oz (oven-dry equivalent) samples of cover crop residue were placed in 1.0 oz Teflon centrifuge tubes and 0.67 oz of 13.9,3.48, or 0.87 ppm fluometuron in 555 ppm $CaCl_2$ added. Three replicates of each residue by initial concentration were used. Plant material was equilibrated with fluometuron solution by shaking for 24 h, then a 0.33 oz aliquot of solution passed through a conditioned C_{18} solid phase extraction column. Fluometuron trapped on the C_{18} column was then eluted with 0.10 oz of methanol and these concentrated samples analyzed by HPLC (Mueller and Mooman, 1991). Fluometuron sorption was calculated by change in solution concentration. Input concentrations were confirmed by HPLC.

Fluometuron Wash-off from Cover Crop Residues

Approximately 0.14 oz of each residue were uniformly placed on a steel screen in each of three 4-in diameter PVC caps drilled with a drain hole. Fluometuron (nominally, 25.5 ppm, dilute suspension of Cotoran) was spray-applied to each cover crop sample at a rate of 1.0 lb ai/A. Input concentration of fluometuron was confirmed by HPLC. Plant material was allowed to dry and then subjected to a series of three simulated rains (see Gaston and Locke, 1996, for description of rainfall simulator). For each rain, water was applied at a rate of 0.80 in/h for 1 hour using a metering pump. To help ensure uniformity of application, the sprinkler head was periodically rotated. Through-flow from each rainfall was collected as a composite sample. A 1.67-oz aliquot of through-flow was passed through a C_{18} solid phase extraction column and fluometuron trapped on the C_{18} adsorbent was eluted with 0.10 oz of methanol. Fluometuron analyzed by HPLC as previously described. Experimental units were allowed to air-dry between rainfalls.

Tracer Wash-off from Cover crop Residues

To determine whether fluometuron sorption data could be used to predict its rate of wash-off from cover crop residues, a simple mixing-cell model (Eq. 1, below) was used to account for retardation of fluometuron transport through the plant residue.

$$V\,(dC/dt) + m\,(dS/dt) = \beta\, q\, C \qquad [1]$$

where C is solution concentration (ppm solution), S is sorbed concentration (ppm residue), V is volume of water held by the wet residue (oz), m is mass of residue (oz), q is volumetric flow rate (oz/h), t is time (oz), and β is an empirical constant that accounts for flow dynamics in the residue. Least-squares estimates of β were based on measurements of the time-course wash-off of Cl^- applied to duplicate samples of these residue materials. In particular, 0.067 oz of 555 ppm $CaCl_2$ were spray-applied to each experimental unit, the residue sample allowed to dry, then applied salt washed off under simulated rainfall of the same intensity and duration as above. Through-flow was collected in fractions, and these were analyzed for Cl^- concentration using a Cl^- specific electrode.

Fluometuron Degradation in Surface Gigger Soil

Apparent plant residue was removed from soil samples. Approximately 0.70 oz (oven-dry equivalent) of each tillage by cover crop field plot replicate were placed in each of four 8-oz Erlenmeyer flasks (72 experimental units) and 0.033 oz of a 13.0 ppm fluometuron solution uniformly added. Sufficient distilled water was then added to increase water content to field capacity (-0.3 bar, as determined using a pressure plate apparatus). Each flask was covered with pardilm, a small hole pricked in this cover for aeration, and these treated soils allowed to incubate at 77°F for 6,15,30, and 60 days in the dark. Weights of flasks and contents were checked weekly for evaporative losses and additional water added if needed to restore -0.3 bar potential.

After prescribed incubation, soils were extracted with 1.34 oz of 80:20 methanol to 555 ppm $CaCl_2$ for 24 h on a wrist-action shaker. The suspensions were vacuum filtered and soil remaining in the flask extracted with a second 1.34-oz portion, which was then quantitatively transferred to the filter. The soil on the filter was washed with an additional 0.67 oz of extractant. The fluometuron extract was then rotary evaporated at 95°F, diluted with 2.5 oz 555 ppm $CaCl_2$, and concentrated by solid phase extraction as previously described. Extracted fluometuron was measured by HPLC.

Microbial Activity and Biomass in Gigger Surface Soil

Microbial activity in the conventional- and no-till, native, vetch, and wheat Gigger surface soils was estimated by the fluorescein diacetate (FDA) hydrolysis method (Schuner and Roswall, 1982). Microbial biomass C was determined on these soils and adjusted to field capacity using the chloroform fumigation method (Voroney and Paul, 1984).

RESULTS

Fluometuron Sorption by Residues

Figure 1 shows sorbed and equilibrium solution concentrations of fluometuron for the three cover crop residues. In all cases, sorption, *S* (ppm residue), was apparently a linear function of solution concentration, C (ppm solution), and adequately described by $S = K_D C$. Sorption of fluometuron to vetch (K_D = 17) and wheat (K_D = 18) was nearly twice that of sorption to native vegetation (K_D = 11). Therefore, it was expected that fluometuron would be less subject to wash-off from vetch and wheat than from native vegetation.

Fluometuron Wash-off from Cover Crop Residues

Figure 2 shows average cumulative fraction of applied fluometuron removed by each of three simulated rainfalls. Beginning with the first rainfall, more fluometuron was washed off native vegetation residue than from either vetch or wheat. Despite somewhat greater sorption of fluometuron to wheat than vetch (Fig. 1), cumulative wash-off from vetch was not significantly greater than wash-off from wheat, even after the third rainfall.

With the term dS/dt set equal to zero (no sorption), the transport model (Eq. 1) could adequately describe Cl^- wash-off from all residues. Optimized values for the empirical constant, β, were similar regardless of cover crop type (Table 3). Therefore, the average value, 0.19/h, was used in simulations of fluometuron wash-off from the different residues. In order to account for retarded wash-off due to sorption, the term dS/dt was set equal to K_D dC/dt. Predicted removal of fluometuron agreed well with average through-flow concentrations for the first rainfall but exceeded measured wash-off after the third simulated rain. Results for native vegetation (Fig. 3) are typical of those also seen for vetch and wheat residues. Although Eq. 1, together with sorption K_Ds, in general described the slow wash-off of fluometuron and accurately described the amount washed off by the first and second rains, the model consistently over-predicted wash-off by the third simulated rain.

Effects of Tillage and Cover Crop on Fluometuron Degradation

Table 4 gives average extractable fluometuron remaining after 6, 15, 30, and 60 days incubation. In general, fluometuron degradation was faster in the no-till than in the conventional-till Gigger soil. This difference was clear by 15 days incubation. Within each tillage treatment, differences due to type of cover crop also occurred. Fluometuron degradation was significantly faster in the native vegetation and wheat soils than in the vetch soil. There was no difference in the rate of fluometuron degradation in the native vegetation and wheat soils. The greatest difference among all treatments, therefore, was between no-till, non-vetch soil and conventional-till, vetch soil. By 60 days incubation, negligible fluometuron was recovered from no-till, native, and wheat soils, whereas about half of the fluometuron initially applied was recovered from the conventional-till, vetch soil.

In all cases, fluometuron degradation was adequately described by first-order kinetics (Eq. 2)

$$dM / dt = -k_d M \qquad [2]$$

where M is mass of substrate remaining after t (d) of incubation and k_d is the degradation rate coefficient (d^{-1}) Table 5 gives best-fit values of K_ds for these soils. Figure 3 shows typical agreement between decreasing fluometuron recovery with time and first-order degradation lunetics.

Effects of Tillage and Cover Crop on Microbial Activity

Average FDA hydrolytic activity and microbial biomass C for the different soils are given in Table 6. Variability was high in both FDA and biomass measurements. This precluded significant differences due to type of cover, either in FDA hydrolytic activity or microbial biomass. However, FDA hydrolytic activity was significantly greater in the no-till samples. This result was consistent with more rapid fluometuron degradation in the no-till soils than in the conventional-till soils.

DISCUSSION

Interception of spray-applied fluometuron by cover crop residues and subsequent slow release to soil may affect herbicide efficacy, persistence, and fate. Results indicate that fluometuron is not readily washed off either native vegetation, vetch, or wheat residue and that the type of residue has some bearing on how fast wash-off occurs. Furthermore, the amount of fluometuron washed off residue can be predicted on the basis of sorption K_Ds However, over-predictions of the amount of fluometuron washed off by continued simulated rains suggest that sorption K_Ds may not have been constant but instead increased during the course of the study. Reddy et al. (1995) found that an increasing degree of decomposition of hairy vetch and rye *(Secale cereale)* increased sorption of chlorimuron ethyl. Similar results were reported for cyanazine sorption on ryegrass *(Loliurn multiflorum* residue (Reddy et al., 1997).

Applied fluometuron that is not intercepted by crop residue in the field or that is washed off residue comes in contact with soil. In the Gigger soil, fluometuron degradation rate was affected both by tillage and cover crop. Average half-live for degradation in the no-till soils was approximately one-third of that in the conventional-till soils (Table 5). Furthermore, degradation was much faster in the native vegetation and wheat soils than in the vetch soils. These results are in contrast to those of Brown et al. (1994) who found no differences in fluometuron degradation due either to tillage or cover crop.

Native vegetation produced much less biomass than vetch or wheat. Therefore, potential interception of applied fluometuron is less than potential interception by vetch or wheat. Furthermore, interception by wheat would depend on whether it was standing or flattened. In contrast, a close, dense residue of vetch is expected to intercept a high fraction of applied fluometuron. In Gigger soil under native or wheat cover, fluometuron is quickly degraded with less than one-tenth remaining 4 weeks after application. Interception by vetch residue, coupled with slow release by wash-off and slow degradation in the soil (more than one-half remaining 4 weeks after application), may provide longer weed control. Also, any prolonged susceptibility to loss of fluometuron in runoff would be likely counterbalanced by the high sorptive capacity of vetch residue.

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Table 1. Cover crop biomass.

Native Vegetation	Vetch	Wheat
---------- tons/A ----------		
0.33 (0.26†)	0.97 (0.14)	2.25 (0.72)

† Standard error.

Table 2. Chemical properties of Gigger soil as affected by tillage and cover crop.

	Conventional-till			No-till		
Property	Native	Vetch	wheat	Native	Vetch	wheat
pH†	5.70 ab¶	5.53 ab	5.80 a	5.17 b	5.50 ab	6.07 a
Organic matter‡ %	0.34 d	0.46 cd	0.49 c	0.72 b	0.91a	0.92 a

† 1:2, soil to water.

‡ Nelson and Sommers (1982).

Means within a row followed by the same letter are not significantly different (Fisher's LSD, " = 0.05).

Table 3. Best-fit values of the through-flow parameter, β, (Eq. 1) for different cover crop residue materials.

Replicate	Native	Vetch	Wheat
	.... (1/h) --------		
1	0.17 (0.03[†])	0.26 (0.05)	0.22 (0.04)
2	0.22 (0.03)	0.10 (0.01)	0.16 (0.04)

[†] Standard error.

Table 4. Fraction of applied fluometuron recovered from conventional- and no-till soils under native, vetch and wheat vegetation after different periods of incubation.

Incubation	Conventional-till			No-till		
(d)	Native	Vetch	Wheat	Native	Vetch	Wheat
6	0.699 cd[¶]	0.884a	0.761bc	0.586e	0.810ab	0.594de
15	0.630a	0.681 a	0.553a	0.208b	0.556a	0.265b
30	0.460b	0.670a	0.328b	0.058c	0.467b	0.141c
60	0.313bc	0.506a	0.186c	0.022d	0.368ab	0.000d

[¶] Means with a row followed by the same letter are not significantly different (Fisher's LSD, P = 0.05).

Table 5. Influence of tillage and cover crop on fluometuron degradation in Gigger soil.

	Conventional-till			No-till		
Parameter	Native	Vetch	Wheat	Native	Vetch	Wheat
Rate constant, k_d (1 / d)	0.026(0.004[†])	0.014(0.002)	0.036(0.003)	0.097(0.004)	0.022(0.003)	0.083(0.005)
Half life (d)	27	51	19	7	31	8

[†] Standardemor.

Table 6. Means for FDA hydrolytic activity and microbial biomass.

	Conventional-till			No-till		
Property	Native	Vetch	Wheat	Native	Vetch	wheat
FDA[†]	0.190 b[¶]	0.228 ab	0.257 ab	0.273 ab	0.376 a	0.332 ab
Biomass C[‡]	0.899 a	0.760 a	1.154 a	1.351 a	1.487 a	0.726 a

[†] Increase in optical density at 490 nm/g-h.

[‡] ppm C.

[¶] Means with a row followed by the same letter are not significantly different (Fisher's LSD, P = 0.05).

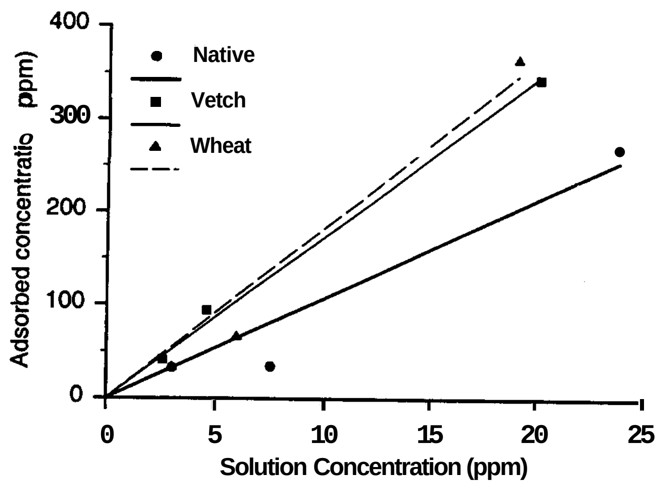

Figure 1. Isotherms for fluometuron sorption on native vegetation, vetch, and wheat residues.

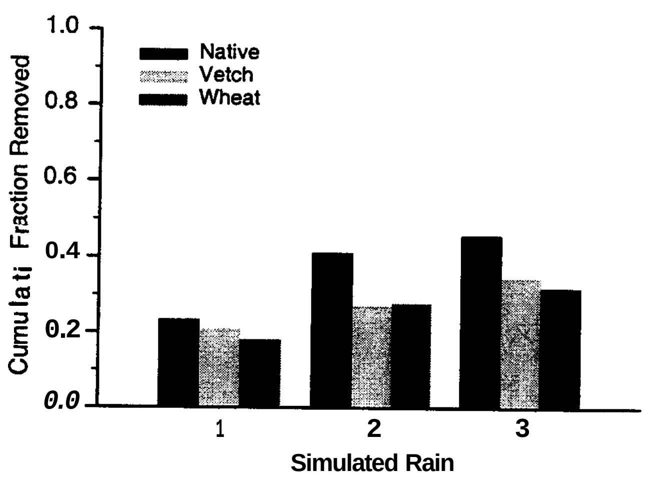

Figure 2. Cumulative fluometuron washed off cover crop residues by three simulated rains.

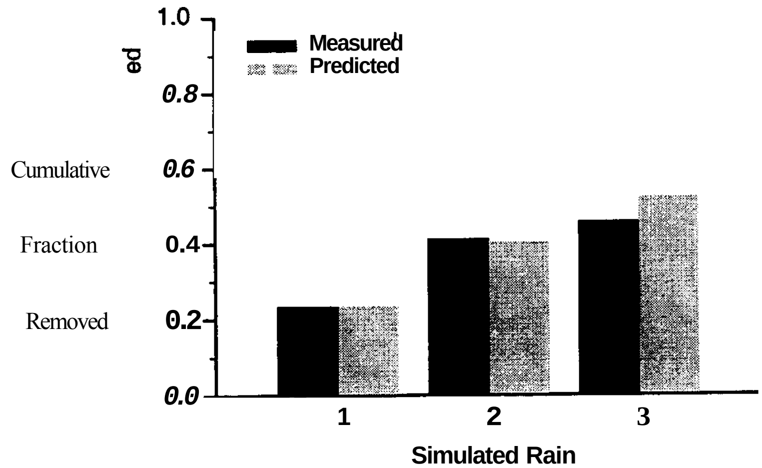

Figure 3. Measured and predicted fluometuron wash-off from cover crop residues.

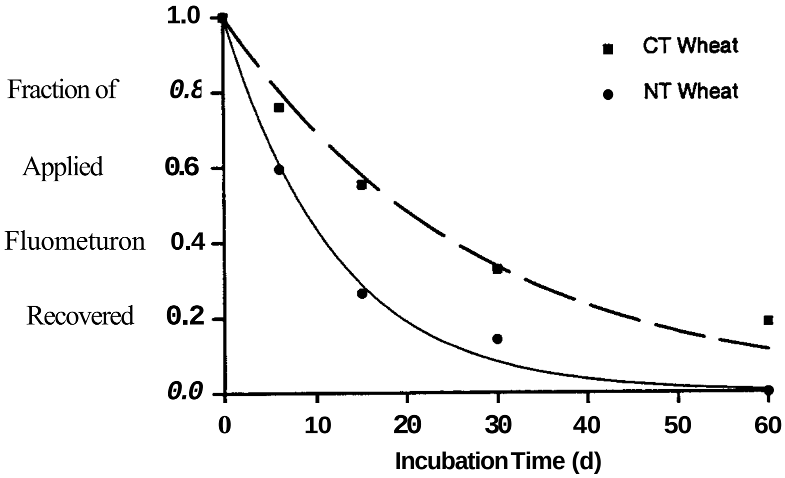

Figure 4. Fluometuron degradation in conventional-till (CT) and no-till (NT) Gigger soil with wheat cover crop. Smooth curves show degradation described by first-order kinetics.

IMPROVING NITROGEN FERTILIZATION EFFICIENCY FOR NO-TILLAGE CORN PRODUCTION

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ABSTRACT

Application of nitrogen (N) fertilizers for no-till corn (*Zea mays* L.) production is an environmental concern. Research is needed to evaluate methods for improving N efficiency through either reduced N rates or delayed injected applications. Research was initiated in 1996 and continued through 1998 on two soils located in West Tennessee. Nitrogen treatments included broadcasting urea and urea-ammonium nitrate (UAN) at 150 lb N/A at planting, injecting UAN at 150 lb N/A at planting, and injecting UAN at the 6- to 8-leaf growth stage at 150, 130, 110, and 90 lb N/A. Some treatments received a 10 lb N in-furrow starter. Delayed N applications were 51, 52, and 44 days after planting (DAP) on the Memphis soil and 43, 42, and 48 DAP on the Collins soil. Ear leaves were collected at mid-silking for N analysis. Injecting N at planting produced higher yields than broadcasting N. Delaying N application increased yields approximately 6 to 10% during years that weather did not restrict treatment effects. The combination of high temperatures and/or lack of rainfall between time of delayed applications and harvest affected yields and restricted treatment effects. In some years, the combination of starter fertilizer and delayed N application improved N efficiency. Either higher yields were produced or lower N rates (90, 110, 130 lb N/A) were needed to produce yields comparable with those produced from application of higher N rates at planting.

INTRODUCTION

Concern over nitrogen (N) use efficiency has increased over the past decade with increased emphasis on environmental issues. Nitrogen efficiency may be improved by using a management method as simple as applying the nutrient closer to the time of increased plant utilization rather than applying it before the plant develops an adequate root system for nutrient uptake. For corn production, applying N at such a growth stage would require that the N application be delayed until after plant emergence, which may require a change in the current management program. Producers routinely broadcast N several days to 1 month before planting. Applying N at, or in advance of, planting contributes to N losses through volatilization, immobilization, leaching, and erosion. Additional production factors that affect N efficiency for no-till (NT) corn include N source, rate of application, and method of application (Howard and Essington, 1998; Howard and Tyler, 1989a).

Surface broadcasting ammonium nitrate (AN), urea, and urea-ammonium nitrate solution (UAN) produced significantly lower yields than injecting UAN (Howard and Essington, 1998). They reported the efficiency of N sources to decrease in the following order ammonium nitrate (AN)>UAN (liquid 32% N)>urea when 150 lb N/A was surface broadcast on NT corn. Efficiency of urea-containing N sources for NT corn was increased by injecting UAN compared with surface applications (Howard and Tyler, 1989a; Howard and Tyler, 1989b; Howard and Essington, 1998). Even though injection improves N efficiency, it costs more than broadcasting because it requires more time and equipment (Roberts et al., 1995). Even with the increased application cost, injecting N was more profitable for NT corn produced on a soil having a winter wheat cover. Splitting a surface band UAN application improved NT corn yields compared with surface banding the rate at planting (Howard and Tyler, 1989a). Injecting UAN at planting produced higher yields than were obtained from either surface banding at planting or splitting the band. Howard and Duck (1987) reported that delaying the application of AN to conventional-tilled corn until the 5- to 7-leaf growth stage did not reduce yields compared with applying AN at planting.

Additional strategies for increasing N efficiency for NT corn are needed. The objective of this research was to evaluate delayed N applications on NT corn compared with applications at planting.

MATERIALS AND METHODS

Research was established in 1996 and continued through 1998 on a loess-derived Memphis silt loam (fine-silty, mixed, thermic, Typic Hapludalfs) at the Milan Experiment Station, Milan, TN, and on a Collins silt loam (coarse-silty, mixed acid, thermic, Aquic Udifluvent) at the West Tennessee Experiment Station, Jackson, TN. Standard soil test results indicated that the Memphis soil tested low-P and medium-K while the Collins soil tested high-P and high-K (Mehlich-I extractant).

Nitrogen treatments included broadcasting urea and UAN at 150 lb N/A at planting, injecting UAN at 150 lb N/A at planting, and injecting UAN at the 6- to 8-leaf growth stage at 150, 130, 110, and 90 lb N/A. A 10-lb N/A in-furrow (I-F) starter was applied to certain treatments. Individual treatments are listed in Table 1. The starter, 2.8 gal/A of 32% UAN, was applied through a straight stream metering orifice, No. 24 Delavan Co. The metering orifice was attached to a special bracket for insecticide tubes that was attached to the rear of each planter unit. The starter was applied using a CO_2 pressurized system. Broadcast treatments were hand-applied, while the injected treatments were applied using a four-row injector having a knife configured behind a coulter. The injected treatments were applied approximately 2 to 5 inches off the row and approximately 3 inches deep.

The cultivar Pioneer 3245 was planted on the Memphis soil and Pioneer 3163 was planted on the Collins soil. Planting dates for the Memphis soil were Apr. 1, 1996, Mar. 31, 1997, and Apr. 6, 1998, while the Collins soil was planted Apr. 10, 1996, Apr. 10, 1997, and Apr. 2, 1998. A seeding rate of 25,500 kernels/A were planted at each location. The experimental design was a randomized complete block with six replications. Individual plots were 30 feet long and 10 feet wide (30-inch centers). Delayed N was applied May 24,1996, May 21,1997, and May 20,1998 on the Memphis soil and May 22,1996, May 23, 1997, and May 20,1998 on the Collins soil. The applications were delayed 51, 52, and 44 days after planting (DAP) on the Memphis soil and 43,42, and 48 DAP on the Collins soil for the 3 years, respectively. Phosphorus and potassium were broadcast before planting at 60 to 75 lb P_2O_5/A using triple super-phosphate and 60 to 75 lb K_2O/A using potassium chloride.

Weed control measures included broadcasting Paraquat (1, 1'-dimethyl-4, 4'-bipyridinium ion) at 1 qt/A plus Bicep II [atrazine(6-chloro-N-ethyl- N'- (1methylethyl)-1, 3,5-triazine-2,4- diamine) plus metolachlor 2-chloro-N-(2-ethyl-6-me thylpheny1)-N-(2-methoxy- 1-methylethyl) acetamide] applied at 2 qt/A and atrazine (6-chloro-N-ethyl- N'- (1methylethyl)- 1, 3,5-triazine-2,4-diamine) at 1 pt/A for residual weed and seedling johnsongrass control. The broadcast application contained 0.5% (v/v) nonionic surfactant. One month after emergence, Accent (2-(((((4,6-Dimethoxypyrimidin- 1-yl)aminocarbonyl)) aminosulfonyl))-N,N-dimethyl-3-pyridinecarboxamine) was applied at 2/3 oz/A for rhizome johnsongrass control. Carbofuran (2, 3-dihydro-2, 2- dimethyl -7-benzofuranyl methylcarbamate) was applied I-F at 1lb/A for insect control.

Twenty ear leaves were collected from the two middle rows at mid-silking (1st week of July), dried, ground, and stored until N analysis. The N concentrations were evaluated using a Leco CNS-2000, Leco Cooperation, St. Joseph MI. Yields were determined by harvesting the two center rows and adjusting grain moisture to 15.5%.

Statistical analyses of yield and ear-leaf N concentrations were performed utilizing mixed model SAS procedures (SAS Ins., 1997). The mixed model procedure provides Type III F statistical values but does not provide mean square values for each element within the analyses or the error terms for mean separation. Therefore, mean separation was evaluated at a probability level of 0.05 through a series of protected pair-wise contrasts among all treatments (Saxton, 1998).

RESULTS AND DISCUSSION

Yields and leaf N concentrations of NT corn on each soil were affected by N treatments (Table 2). The treatment effects were inconsistent across the 3 years on both soils as indicated by the significant treatment-by-year interactive effect of yields and leaf N concentrations. Results are described by year and soil type.

Memphis silt loam yields

Injecting N at planting in 1996 and 1998 increased NT corn yields compared with broadcasting urea or UAN at planting (Table 3). Treatment differences in 1997 were limited to two treatments, broadcasting 150 lb N/A as UAN at planting and delayed injecting 150 lb N/A as UAN. No-till yield differences due to application methods have been reported (Howard and Tyler, 1989b; Howard and Essington, 1998). The effect of rainfall (amount and frequency of events after surface N application) on yearly treatment yield differences has been reported (Fox and Hoffman, 1981).

Delaying the 150lb N/A application until the 6- to 8-leaf growth stage increased yields in 1996 (Table 3). Injecting 150 lb N/A at planting produced comparable yields with delayed injection of either 130 or 110lb N/A plus starter. The increased yields from the delayed 150 lb N/A injection application compared with injecting 150 lb N/A at planting allow additional comparisons with delayed N rate injections. Yield increases from delaying the N application were not evident for 1997 or 1998 even though mean yields for 1997 were higher for the delayed applications. The lower overall yields in 1998 may have restricted the full expression of the treatment on yields.

The 3-year average yields need to be considered since N recommendations are based on multi-year data. For the 3 years, injecting UAN at planting resulted in higher yields than broadcasting the two N sources. The higher yields from broadcasting UAN compared with broadcasting urea agrees with earlier research (Howard and Essington, 1998; Howard and Tyler, 1989a). Yields were higher for injecting 150 lb N/A as UAN at the 6- to 8-leaf growth stage than for injecting at planting. The data suggest that over the 3 years, delayed injection of 110 lb N/A (plus 10 lb N/A starter) resulted in comparable yields with injecting 150 lb N/A at planting. Averaged across 3 years, delayed injection of 150 lb N/A increased yields by 7% over injecting N at planting. The data also indicate that, without lowering yields, the N rate can be reduced by 20% by delaying the application. These two observations should be worthy of consideration for producers seeking methods to improve yields through management or reducing N rates either during a time of restricted capital or for production close to environmentally sensitive areas.

These data indicate that N efficiency, 3-year average (yield/N rate) x 100, was affected by N source applied at planting, method of application at planting, delaying the N application, and reducing the delayed N rate (Table 3). Injecting UAN at planting increased N efficiency from 68 to 77% compared with broadcasting N. The efficiency was greater for broadcasting UAN than for broadcasting urea. Delaying the 150 lb N/A application increased N efficiency from 77 to 82%. Nitrogen efficiency was increased from 82 to 109% by reducing the delayed N rate from 150 to 90 lb N/A. Fowler et al. (1990) reported maximum N use efficiency at low N rates and decreased efficiency as N rates increased.

Collins silt loam yields

Injecting 150 lb N/A at planting in 1996 resulted in higher yields than broadcasting urea (Table 4). Delaying the 150 N rate increased yields 6.6% when compared with injecting UAN at planting. By delaying the N application, the N rate could be reduced by 6.6% to 130 lb N/A plus starter or by 20% to 110 lb N/A plus starter while maintaining comparable yields. In 1997, injecting N at planting increased yield relative to broadcasting the two N sources. In 1998, injecting N at planting generally resulted in higher yields than delaying applications.

The 3-year average yields indicate no significant differences for delaying the N application when compared with injections made at planting. Injecting N at planting resulted in 22% higher yields when compared with broadcast N applications. Nitrogen efficiency for applications at planting ranged from 75 to 87% whereas the efficiency ranged from 91 to 122% for the delayed applications.

Memphis silt loam leaf N concentrations

In 1996, injecting UAN at planting produced higher leaf N concentrations than broadcasting UAN, but broadcasting UAN produced higher leaf N concentrations than the broadcast urea treatment (Table 5). Injecting 150 lb N/A 51 DAP resulted in higher leaf N concentrations than was observed for injecting UAN at planting. Leaf N differences were not observed between injecting 150 lb N/A at planting and delayed injection of the three lower N rates. In 1997, there were no differences in leaf N concentrations among treatments applied at planting. These data are possibly responsible for the year-by-treatment interaction since differences were evident in 1996. Delaying the N applications resulted in higher leaf N concentrations than treatments applied at planting. In 1998, treatment effects on leaf N concentrations were similar to the 1996 data. Injecting UAN resulted in higher N concentrations than broadcasting either urea or UAN. Leaf N concentrations were not increased by delaying the application.

Averaged across years, delayed injection of the three high N rates resulted in higher leaf N concentrations than injecting N at planting. These data indicate that injecting 150 lb N/A as UAN at planting resulted in leaf N concentrations comparable with injecting 90 lb N/A plus starter at the 6- to 8-leaf growth stage. These data closely resemble the yield data except that yield differences were slightly less than leaf N concentration differences. For the 3 years, leaf N concentrations were greater for delayed injecting 110, 130, and 150 lb N/A rates relative to injecting 150 lb N/A at planting. Three-year average yield differences were limited to the 150 Ib N/A rate applied at planting or delayed (Table 3).

Collins silt loam leaf N concentrations

Leaf N concentration in 1996 was greater for injecting UAN at planting than for broadcasting UAN at planting (Table 6). Leaf N concentrations with delayed N application varied with application rate, as would be expected. Differences were not significant for delayed injection of the lowest N rate and applying N at planting. In 1997, delayed injection of the three highest N rates increased leaf N compared with applying N at planting. Delayed injection of N in 1998 increased leaf N relative to applying N at planting.

Averaged across years, delayed injection of the three highest N rates resulted in higher leaf N concentrations than N injected at planting. Based on leaf N concentrations, delayed injection of 90 lb N/A plus a starter resulted in N concentrations comparable with injecting 150 lb N/A at planting. These data are similar to the leaf N concentrations for the Memphis silt loam.

RAINFALL

The yield and leaf N concentration data show differences each of the 3 years for both soils. Both yield and leaf N concentration differences between broadcast and injection application methods may be attributed to rainfall within the first several days following N application at planting. For the Memphis soil, rainfall totals following application varied among years. In 1996, 0.1 inch of rain was recorded (not presented) within 3 days following planting with an 11-day interval between the next event of 0.2 inch. In 1997, a total 1.1 inches of rain was recorded within **5** days after planting with an additional 0.7 inch of rain the next day. In 1998, 0.1 inch of rain was recorded within 3 days after planting with an additional 0.8 inch recorded the 11th day after application. These data suggest that rainfall was sufficient to incorporate the broadcast N applications and possibly promote leaching from the injected N thus restricting yield and leaf N differences in 1997 (Table 3). For the Collins soil, 0.3 inch of rain was recorded within 4 days after planting in 1996, 0.3 inch of rain was recorded the second day after N application in 1997, and 1.0 inches of rain were recorded within 7 days following application in 1998. Apparently, 1 inch of rain within 7 days after N application was sufficient to reduce yield and leaf N concentration differences between broadcast and injected application methods while the 0.3 or less inches was insufficient in 1996 or 1997.

Generally, the greater the yield difference between applying N at planting and later (6th to 8th leaf) the greater the rainfall recorded between planting and time of the delayed application. In 1996, corn yield and leaf N concentrations on the Memphis silt loam were increased with delayed N application. During the 51-day interval between planting and applying N, 5.3 inches of rain were recorded (Table 7). The 1997 yields were not improved by delaying the N application (Table 3), but leaf N concentrations were increased by delayed applications (Table 5). This observation indicates that weather conditions between the first week of July (leaves for N evaluation collected) and harvest in September affected yields. A total of 5.9 inches of rain was recorded between planting and injecting N 52 DAP. A total of 15.8 inches of rainfall was recorded in 1997, which was approximately 2 inches less than that recorded for 1996. The 1998 data indicate that delayed applications did not increase either yields or leaf N concentrations. Thus, conditions existing before silking or at silking reduced the yields. The 1998 yields were generally one-third lower than the other two years. The 1998 weekly average high temperatures and cumulative rainfall were 94°F with 0.1 inch of rain for the week of June 24, 92°F with no rainfall for the week of July 1, 90°F with 2.1 inches of rain during the week of July 8, and 90°F with 0.2 inch of rain during the week of July 15. Pollination of corn may be hampered when air temperatures are this high and rainfall is restricted. These weather conditions would restrict yields, as indicated by the data, and thus restrict the treatment effects.

On the Collins silt loam, the 1996 and 1997 yield and leaf N concentrations indicate that delaying N application was beneficial (Tables 4 and 6). During this interval, 5.6 inches of rain were recordedin 1996 with 4.8 inches recorded in 1997. Rainfall recorded between the delayed application and the black layer formation was 15.1 inches in 1996 and 23.5 inches in 1997. The 1998 yield and leaf N data indicate that delayed application affected only N concentration. However, the rainfall data would suggest that differences in yield and leaf N concentrations should exist based on the 1996 rainfall and yields. As was pointed out with the 1998 Memphis data, factors other than rainfall may be responsible for the lack of response. The 1998 weekly average high temperatures and cumulative rainfall were 95°F with no rain during the week of June 24, 93°F with 0.7 inch of rain during the week of July 1, 90°F with 0.2 inch of rain for the week of July 8, and 90°F with **1.1** inches of rain for the week of July 15. These conditions are similar to those reported for the Memphis silt loam except that rainfall appears to be slightly less.

CONCLUSIONS

In most environments, NT corn yields, leaf N concentrations, and N efficiency can be increased by delaying N application until the corn is in the 6- to 8-leaf growth stage. However, the benefit from the delayed application is dependent upon weather conditions between planting and the delayed application. These data indicate that delaying the N application can increase yields by 5 to 15% and if rainfall is not a limitation, the N rate can be reduced by 15 to 20% without reducing yields. During certain years, leaf N concentrations were increased by delaying the N application, but yields were not increased due to drought stress between silking and black layer.

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Table 1. Treatments applied to no-till corn to evaluate N source, application rate, application method, and timing.

Nitrogen			Application	
Source	Rate	Starter	Method	Timing
	----- lb/A -------			
Urea	150	0	Broadcast	Planting
UAN	150	0	Injection	Planting
UAN	150	0	Broadcast	Planting
UAN	150	0	Injection	6- to 8-leaf
UAN	130	10	Injection	6- to 8-leaf
UAN	110	10	Injection	6- to 8-leaf
UAN	90	10	Injection	6- to 8-leaf

Table 2. ANOVA of N treatments on yield and ear-leaf N concentration of NT corn produced on two soils.

Source	df	Memphis silt loam				Collins silt loam			
		Yield		Leaf N		Yield		Leaf N	
		'F'	Pr >F	'F'	Pr >F	'F'	Pr>F	'F'	Pr>F
Year (Y)	2	253.3	0.0001	39.8	0.001	98.3	0.0001	137.9	0.0001
Error a	10								
Nitrogen (N)	6	15.8	0.0001	55.1	0.0001	16.0	0.0001	28.4	0.0001
Y*T	12	3.1	0.001	4.6	0.0001	10.9	0.0001	4.8	0.0001
Error b	88								

Table 3. Effect of N source, application method, and time and rate of N application on no-till corn Memphis silt loam.

N source	A M†	ToA‡	N Rate	Star§	Yield 1996	Yield 1997	Yield 1998	Yield Avg.	N Effic.¶
					lb/A				%
Urea	B	P	150	0	91e#	136ab	57c	95e	63
UAN	I	P	150	0	123bc	133ab	87a	115bc	77
UAN	B	P	150	0	114d	123b	70b	102d	68
UAN	I	D	150	0	135a	144a	88a	123a	82
UAN	I	D	130	10	129ab	142a	88a	120ab	86
UAN	I	D	110	10	115cd	142a	83a	113bc	94
UAN	I	D	90	10	112d	132ab	81a	109cd	109

† Application method - B=broadcast; I=Injection.
‡ Time of N application - P=applied at planting; D=delayed until 6- to 8-leaf growth stage.
§ Starter application - in direct contact with the seed.
¶ Efficiency of N (yield/lb N x 100) for three-year mean yields.
# Within a yield column, means followed by the same letter are not significantly different at a = 0.05.

Table 4. Effect of N source, application method, and time and rate of N application on no-till corn yields on a Collins silt loam.

N Source	A M†	ToA‡	N Rate	Star&	Yield 1996	Yield 1997	Yield 1998	Yield Avg.	N Effic.
					lb/A				%
Urea	B	P	150	0	128c#	102d	108ab	113d	75
UAN	I	P	150	0	137b	140bc	115a	130ab	87
UAN	B	P	150	0	130bc	104d	106ab	113d	75
UAN	I	D	150	0	146a	156ab	106ab	136a	91
UAN	I	D	130	10	136b	162a	103b	134a	96
UAN	I	D	110	10	136b	155ab	103b	131a	109
UAN	I	D	90	10	126c	139c	101b	122c	122

† Application method - B =broadcast; I = Injection.
‡ Time of N application - P=applied at planting; D=delayed until 6- to 8-leaf growth stage.
§ Starter application - in direct contact with the seed.
¶ Efficiency of N (yield/lb N x 100) for three-year mean yields.
# Within a yield column, means followed by the same letter are not significantly different at a= 0.05.

Table 5. Effect of N source, application method, and time and rate of N application on no-till corn ear-leaf N concentrations on a Memphis silt loam.

N Source	A M[†]	ToA[‡]	NRate	Star[&]	Leaf N concentration			
					1996	1997	1998	Avg.
			----------lb/A---------		-------------------------% N-------------------------			
Urea	B	P	150	0	1.97e[¶]	2.42c	2.42b	2.27c
UAN	I	P	150	0	2.45bc	2.48c	3.05a	2.66b
UAN	B	P	150	0	2.24d	2.35c	2.36b	2.32c
UAN	I	D	150	0	2.63a	3.00a	3.10a	2.91a
UAN	I	D	130	10	2.55ab	3.03a	3.00a	2.86a
UAN	I	D	110	10	2.58ab	2.93ab	3.06a	2.86a
UAN	I	D	90	10	2.38cd	2.81b	3.02a	2.73b

† Application Method - B = broadcast; I = Injection.
‡ Time of Application - P = applied at planting; D = delayed until 6th - 8th leaf growth stage.
§ Starter Application - in direct contact with the seed.
¶ Within a yield column, means followed by the same letter are not significantly different at a = 0.05.

Table 6. Effect of N source, application method, and time and rate of N application on no-till corn ear-leaf N concentrations on a Collins silt loam.

N Source	A M[†]	ToA[‡]	NRate	Star[&]	Leaf N concentration			
					1996	1997	1998	Avg.
			----------lb/A---------		-------------------------% N-------------------------			
Urea	B	P	150	0	2.80c[¶]	1.84d	2.80d	2.48c
UAN	I	P	150	0	2.80c	2.35c	2.90cd	2.68b
UAN	B	P	150	0	2.61d	1.97d	2.88cd	2.49c
UAN	I	D	150	0	3.05a	2.71ab	3.17a	2.98a
UAN	I	D	130	10	3.01ab	2.71ab	3.21a	2.97a
UAN	I	D	110	10	2.89abc	2.79a	3.16a	2.95a
UAN	I	D	90	10	2.77cd	2.50bc	3.09ab	2.78b

† **Application Method -B=broadcast; I=injection.**
‡ **Time of Application - P-applied at planting; D=delayed until 6- to 8-leaf growth stage.**
& **Starter Application - in direct contact with the seed.**
¶ **Within a yield column, means followed by the same letter are not significantly different at a = 0.05.**

Table 7. Rainfall recorded for selected periods between March and August by year.

Recorded time	Rainfall recorded					
	Memphis silt loam			Collins silt loam		
	1996	1997	1998	1996	1997	1998
Rainfall month before planting (in.)	5.3	12.1	5.1	5.5	5.2	5.2
Rainfall between planting & delayed application (in.)	5.3	5.9	13.0	5.6	4.8	12.2
Days after planting & delayed N application	51	52	44	43	42	48
No. of events for period	16	12	19	11	10	20
Largest event during period (in.)	1.6	1.1	5.3	1.3	1.1	3.3
Rainfall following delayed N application (in.)	17.9	15.9	19.2	15.1	23.5	19.0
No. of events for period	30	41	37	27	38	34

TILLAGE AND HERBICIDE MANAGEMENT OF TWO VARIETIES OF PEANUT

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ABSTRACT

Peanut *(Arachis hypogaea)* research is needed that leads to improved competitiveness and helps improve grower's financial condition. Research was conducted to determine pod and seed yield and seed quality of two peanut varieties ('Georgia Green' and 'Andru 93') under five tillage and two herbicide management programs, double-cropped following a winter cover crop of rye *(Secale cereale)*. A split-split plot experimental design with six replications was used to evaluate two varieties of peanut grown under five tillage systems with two herbicide programs. Four variations of conservation tillage using strip-till management following winter rye provided peanut pod and seed yield equal to the conventional tillage in-row subsoil system. Overall average pod yield for the five tillage treatments was 5,862 lb/A at 10% moisture. Pod yield was 6,136 lb/A for Georgia Green compared with 5,612 lb/A for Andru 93, a 9.3% advantage for Georgia Green. Herbicide management using Starfire plus Storm gave significantly higher pod yield (5,983 lb/A) compared with management using Cadre (5,785 lb/A). On the other hand, the most troublesome weed, fall panicum *(Panicum dichotomiflorum,* was controlled best using Cadre. Data from this experiment provide further proof that strip-till management in Florida's sandy soils can be equal to conventional tillage in-row subsoil management.

INTRODUCTION

Peanut *(Arachis hypogaea)* farmers are faced with increasing global competition, thereby placing greater emphasis on the need for research that will lead to improved competitiveness (Baldwin, 1998). In 1997, total Florida land area devoted to peanut production was approximately 84,000 acres with a farm gate value of over $54,000,000. The actual economic value to Florida and the US economy would be over $160,000,000 due to the multiplier effect (Anon., 1998).

Positive results were achieved with in-row subsoil no-till (strip-till) peanut in the 1980s (Costello, 1984; Costello and Gallaher, 1985; Gallaher, 1983), however, many growers were reluctant to modify their conventional production practices. No-till/conservation tillage management programs have recently received greater attention. Much of this attention was initiated with the Food Security Act (Anon., 1985) and the Food, Agricultural, and Conservation Trade Act (Anon., 1990). These acts, passed by US Congress, provided token dollar support to participating farmers and required that they implement an approved conservation plan by the end of 1994.

Because of renewed interest in conservation tillage peanut, strip-till (no-till plus subsoil) research on peanut was initiated again in 1997. No-till plus subsoil (Strip-till) planted peanut research on weed control during the 1997 and 1998 growing seasons at Gainesville, FL has shown good results, with pod yields as high as 3,900 lb/A in 1998 (Edenfield et al., 1999). Yield differed between years and was likely due to the use of 'Georgia Green' variety in 1998 versus 'Florunner' in 1997. In both years, pod yield was positively related to the degree of weed control. With proper management for good disease control, 'Florunner' peanut yields over

6,000 lb/A are possible (Overman and Gallaher, 1990). This latter yield should be our goal for peanut farmers and newly developed varieties should make this possible.

The objective of this research was to determine pod and seed yield and seed quality of two peanut varieties under five tillage and two herbicide management programs double-cropped following a winter cover crop of rye *(Secale cereale)*.

MATERIALS AND METHODS

The experiment was conducted in 1999 at the Green Acres Agronomy Field Research Laboratory near Gainesville, FL on an Arredondo fine sand (Sandy Siliceous Thermic Paleudult) (Anon. ,1994). The experimental area was harrowed and 60 lb rye/A was seeded November 20, 1998 and fertilized with 200 lb/A of 12-4-8 (N-P_2O_5-K_2O). On February 12, 1999, 200 lb/A of ammonium nitrate were applied and followed by 2,4-D Amine 4 at 1.0 lb ai/A for winter broadleaf weed control. Rye straw treatments were implemented on May 13,1999, followed by 30-inch wide strip-till rows made with the Brown-Harden in-row-subsoil planter.

The split-splitplot experimental design consisted of six replications with two rows 5 ft wide by 20 ft. There were five main plot tillage treatments, two split-plot peanut variety treatments, and two herbicide treatments as final split-split-plots. Tillage treatments were: 1) strip-till into undisturbed rye straw (no-till plus subsoil); 2) strip-till into rye stubble that had been mowed and straw removed (no-till plus subsoil); 3) strip-till into rye stubble and residue after rye straw was mowed (no-till plus subsoil); 4) strip-till into rye stubble after rye straw was mowed and removed followed by mechanical cultivation (no-till plus subsoil plus conventional tillage cultivation); and 5) strip-till after rye straw was incorporated by conventional tillage (conventional tillage plus subsoiling followed by conventional tillage cultivation). The two varieties were 'Georgia Green' and 'Andru 93'. The two herbicide treatments included: a) Starfire (paraquat) (0.125 lb ai/A) plus Storm (bentazon plus acifluorfen) (0.75 lb ai/A) plus Activate Plus (0.25% v/v) and b) Cadre (imazapic) (0.063 lb ai/A) plus Activate Plus (0.25% v/v).

Peanuts were planted over the strip-till rows at 6 seed/ft of row on May 25,1999. The entire experiment was treated with Roundup Ultra (glyphosate) at 2 lb ai/A plus Prowl (pendimethalin) at 1.0 lb ai/A preemergence on May 27, followed by 0.5-acre inch irrigation on May 28. A sidedress application of 250 lb/A of 17-4-20 (N-P_2O_5-K_2O) was made on June 14. The Starfire plus Storm herbicide treatment was applied on June 17, and the Cadre herbicide treatment was applied on June 24. Insects and diseases were controlled by sprays as follows: Bravo (chlorothalonil) at 0.52 lb ai/A on June 17 and 22 and July 12, and 0.73 lb ai/A on July 22, August 6, 16, and 27 and September 8 and 22; Lannate (methomyl) at 0.30 lb ai/A on June 17, 0.45 lb ai/A on June 22, July 12, and August 16, and 0.60 lb ai/A on September 22; Folicur 3.6 F (tebuconazole) at 0.13 lb ai/A on June 22, July 2, *12* and 22, August 6 and 27, and September 8; Solubor (6.2% Boron) at 3 lb/A on June 22; and applied 900 lb gypsum/A in a 12-inch band over the row on July 8. Weed control ratings were made on October 6, 1999. A rating of 100% weed control represented the presence of no weeds in a plot and 0% control represented complete plot coverage of weeds.

Peanut yield was determined from digging the two row plots on October 11, followed by thrashing with a combine on October 14. Pod subsamples (2.2 Ib) were taken to determine moisture, shelling percent and quality. These subsamples were dried in a forced air seed dryer at outside air temperature (averaged 86°F) for 10 days, removed and weighed to determine moisture loss. A 0.44-lb subsample was taken from these dry samples and used to determine percent shelling, moisture, shrivel seeds, cracked kernels, large kernels, and empty pods. From these measurements, field weights were adjusted to 10% moisture on a pod and seed yield basis.

Data tabulation and transformations were completed by use of Quattro Pro Spreadsheets (Anon., 1993). Analysis of variance and mean separation were conducted for a split-split plot with whole plots in a randomized complete block design using MSTAT (Freed et al., 1987). Means were separated by use of the Least Significant Difference test (LSD) at $p = 0.05$.

RESULTS AND DISCUSSION

No interactions occurred among tillage, varieties, and herbicides for seed yield (Table 1). Shelling percent averaged 79% and sound seed made up 95.5% of total seed yield. These pod yields of over 5,500 Ib/A are well above the 1999 average for the state of Florida (2,800 lb/A) and shows that strip-till peanut was equal to the conventional tillage in-row subsoil treatment. Similar results were documented in the early 1980s (Gallaher, 1983).

In every category of yield, Georgia Green provided greater yield compared with Andru 93 (Table 1). Sound seed yield for Georgia Green was 11.6% greater than Andru 93 but had 35% more cracked kernels and shrivels.

Starfire plus Storm provided greater pod and seed yield in every category except cracked kernels and shrivels compared with Cadre (Table 1). Sound seed yield was 3.8% greater with Starfire plus Storm than Cadre.

The only weed escape was fall panicum *(Panicum dichotomiflorum)*. No interactions occurred between tillage treatments and peanut varieties or herbicide management treatments for fall panicum control. However, an interaction for fall panicum control was observed between peanut variety and herbicide treatment (Table 2). Overall, Starfire plus Storm provided less control of fall panicum than Cadre. However, herbicide Starfire plus Storm gave higher fall panicum control for Andru 93 compared with Georgia Green while Cadre gave equal control of fall panicum for both peanut varieties. Even though Cadre gave better weed control for both varieties compared with Starfire plus Storm, use of Cadre resulted in a reduction in yield for both varieties in this study.

These data show that conservation tillage using strip-till management into winter rye cover crop can be as successful as conventional tillage, which was similar to data from Florida in the early 1980s (Costello, 1984; Costello and Gallaher, 1985; Gallaher, 1983). Some Florida farmers are practicing growing winter rye as a cover crop, grazing the rye until near planting time, then ship-till planting directly into the rye stubble, followed by subsequent cultivation for supplemental weed control. They have also demonstrated that this practice provides yield comparable with strip-till and conventional tillage in-row subsoil practices for peanut. These data show that yield of strip-till peanut where rye straw from the winter cover crop is left undisturbed or is mowed and left is equal to conventional tillage. If rye is not needed for cattle grazing, the ground cover by straw would provide significant reduction in wind and water erosion and provide numerous conservation and environmental benefits, characteristic of the benefits of a mulch, without sacrificing yield (Gallaher, 1977; Gallaher and Laurent, 1983).

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Table 1. Peanut yield for five treatments averaged over variety and herbicide treatments; two varieties averaged over tillage and herbicide treatments; and two herbicides averaged over tillage and variety treatments, Gainesville, FL, 1999.

Tillage	Pod Yield	Total Seed	Sound Seed	Seed – C&S	C Seed
	------------------ lb/A at 10% moisture ------------------				
ST-RSU	5,866	4,637	4,452	4,203	248
ST-RSMR	5,816	4,612	4,401	4,128	274
ST-RSML	6,216	4,932	4,739	4,490	249
ST-RSMRC	5,817	4,662	4,448	4,175	273
ST-RSICT	5,595	4,410	4,194	3,923	271
Level of p	NS	NS	NS	NS	NS
Variety					
Georgia Green	6,136	4,886	4,690	4,389	302
Andru 93	5,612	4,414	4,203	3,979	224
LSD = 0.05 p	264	225	220	215	35
Herbicides					
A	5,983	4,745	4,530	4,258	272
B	5,765	4,557	4,363	4,109	254
LSD = 0.05 p	197	156	153	148	NS
CV	9.14	9.15	9.37	9.66	29.58

ST = strip-till; RSU = rye straw undisturbed; RSMR = rye straw mowed and removed; RSML = rye straw mowed and left; RSMRC = rye straw mowed and removed followed by mechanical cultivation. RSICT = rye straw incorporated by conventional tillage. Sound Seed = All seed minus shrivels; C&S = Cracked kernels and shrivels; C = Cracked kernels. Herbicide A = Starfire + Storm + Surfactant; Herbicide B = Cadre + Surfactant. CV = Coefficient of Variation.

Table 2. Percent control of fall panicum averaged over five tillage treatments for two peanut varieties and two herbicide treatments, Gainesville, FL 1999.

Variety	Herbicide A	Herbicide B	Average
	%		
Georgia Green	71	96	84
Andru 93	85	96	91
Average	78	96	

Level of p for varieties = 0.006; for herbicide = 0.000; for interaction = 0.011. LSD at 0.05 p for interaction = 7.

Interaction comparisons between varieties within a herbicide and comparisons between herbicides within a variety can be made. Herbicide A = Starfire + Storm + Surfactant; Herbicide B = Cadre + Surfactant

APPENDIX A

Past Conferences and Contact Persons

Year	Location	Contact
1978	Griffin, GA	W.L. Hargrove Agronomy Department Georgia Station 1109 Experiment Street Griffin, GA 30223-1797 (404) 228-7330
1979	Lexington, KY	W.W. Frye Agronomy Department University of Kentucky Lexington KY 40546 (606) 257-1628
1980	Gainesville, FL	David Wright N. Florida Res. & Educ. Ctr. Route 3 Box 4370 Quincy, FL 32351 (904) 627-9236
1981	Raleigh, NC	M.G. Wagger Soil Science Department North Carolina State Univ Raleigh, NC 27650 (919) 737-3285
1982	Florence, SC	Jim Palmer Agronomy Department Clemson University Clemson, SC 29634 (803) 656-3519
1983	Milan, TN	Don Tyler West Tennessee Ag. Exp. Stn. Jackson, TN (901) 425-4747
1984	Dothan, AL	Joe Touchton Agronomy Department Auburn University Auburn, AL 38301 (205) 844-4100
1985	Griffin, GA	W.L. Hargrove Agronomy Department Georgia Station 1109 Experiment Street Griffin, GA 30223-1797 (404) 228-7330
1986	Lexington, KY	W. W. Frye Agronomy Department University of Kentucky Lexington, KY 40546 (606) 257-1628
1987	College Station, TX	Tom Gerik Blackland Research Center Temple, TX 76501 (817) 770-6603
1988	Tupelo, MS	Normie Buehring Northeast Ms. Branch Stn. Verona, MS 38879 (601) 566-2201
1989	Tallahassee, FL	David Wright N. Florida Res. & Educ. Ctr Route 3 Box 4370 Quincy, FL 32351 (904) 627-9236
1990	Raleigh, NC	M.G. Wagger Soil science Department North Carolina State Univ. Raleigh, NC 27650 (919) 737-3285
1991	N. Little Rack, AR	Terry C. Keisling Soil Testing & Research Lab P. 0. Drawer 767 Marianna, AR 72360 (501) 295-2851
1992	Jackson, TN	Paul Denton University of Tennessee P. 0. Box 1071 Knoxville, TN 37901 (615) 974-7208
1993	Monroe, LA	Bob Hutchinson Northeast Research Station LSU AgCenter P.O. Box 438 St. Joseph, LA 71366 (318) 766-3769
1994	Columbia, SC	Jim Palmer Agronomy Department Clemson University Clemson, SC 29634 (803) 656-3519
1995	Jackson, MS	Normie Buehring Mississippi State University P, 0. Box 456 Verona, MS 38879 (601) 566-2201

Year	Location	Contact	Year	Location	Contact
1996	Jackson, TN	Paul Denton Don Tyler University of Tennessee 605 Airways Blvd. Jackson. TN 38301-3201			
1997	Gainesville, FL	Ray Gallaher University of Florida 631 Wallace Bldg. Gainesville, FL 32611			
1998	N. Little Rock, AR	Stan L. Chapman Terry C. Keisling Arkansas Agri. Exp. Stn. Univ. of Arkansas Division of Agriculture Fayetteville, AR 72701			
1999	Tifton, GA	Jim Hook University of Georgia Crop & Soil Science Dept. P. O. Box 748 Tifton, GA 31793-0748			
2000	Monroe, LA	Pot Bollich Rice Research Station LSU AgCenter P. O. Box 1429 Crowley, LA 70527-1429 (337) 788-7531			

A P P E N D I X B

Southern Conservation Tillage Conference for Sustainable Agriculture Award Recipients

Year	Recipient	Affiliation
1998	Dr. Raymond Gallaher	University of Florida, Gainesville,
1999	Dr. George Langdale	USDA-ARS, Watkinsville, GA