Proceedings

20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture

"PARTNERS FOR A WHOLESOME FOOD SUPPLY"

June 24-26, 1997

Holiday Inn West o Gainesville, Florida

UNIVERSITY OF FLORIDA
Institute of Food and Agricultural Sciences

in cooperation with

Federal and State Agencies, Industry and Producers

Special Series SS-AGR-60
University of Florida, Institute of Food and Agricultural Sciences
Cooperative Extension Service, Gainesville, FL

PARTNERS

FOR A

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Edited by:

R.N. Gallaher and R. McSorley
Institute of Food and Agricultural Sciences (IFAS)
University of Florida
Gainesville, Florida

Special Series SS-AGR-60, the Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

1997 Southern Conservation Tillage Conference for Sustainable Agriculture Planning Committee

Dr. Raymond N. Gallaher, Professor of Agronomy, and Program Chairman, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Dr. David Wright, Professor of Agronomy, Agronomy Dept., NFREC, IFAS, University of Florida, Quincy, FL.

Dr. Robert McSorley, Professor of Entomology and Nematology, Entomology and Nematology Dept., IFAS, University of Florida, Gainesville, FL.

Mr. Daniel L. Polk, Coordinator of Research and Programs, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Dr. Ben Whitty, Professor of Agronomy, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Dr. Carrol G. Chambliss, Associate Professor of Agronomy, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Mr. Winston D. Tooke, Agronomist, UDSA-NRCS, Gainesville, FL.

Mr. Pat Cockrell, Director/Agricultural Policy Division, Fl. Farm Bureau, Gainesville, FL.

Dr. Edwin C. French, Associate Professor of Agronomy, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Dr. Ken Quesenberry, Professor of Agronomy, Agronomy Dept., IFAS, University of Florida, Gainesville, FL.

Editors: **R.N. Gallaher** **R. McSorley**

Administrative Advisors:
Dr. Jim App, Assistant Dean for Extension, IFAS, UF
Dr. E.R Emino, Assistant Dean for Research, IFAS, UF
Dr. Joe Joyce, Associate Vice President, IFAS, UF

FOREWORD

The "20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture" is another milestone in the historyof the advancement of conservation tillage management of crops and the land on which they grow in the South. The idea of these conferences was initiated fiom conversations with Mr. Tony Rutz,, a representative of Chevron Chemical Co. in the mid-1970s. We decided to see if other no-tillage leaders in the Southeast would be interested in participating in such a conference and if we could obtain commitments from key individuals in each of these states to host the conferences for the first 7 yr. Dr. Raymond Gallaher rejected the suggestion that Florida host the first conference due to the youthfulness of our program. As an alternative, we decided to attempt to begin the conferences in Georgia, the most central location and where we had just completed an experiment station project entitled "Multiple Cropping and Minimum Tillage Systems for the Southeast," and where USDA-ARS had a long history of work in the area. Dr. Joe Touchton had just replaced Dr. Raymond Gallaher at Georgia, had a new project underway, and was willing to coordinate the first meeting. We further agreed to attempt to rotate the first seven meetings north and south after the initial Georgia meeting until the first 7 yr were completed. Agreements were reached with Associate Dean Shirley Phillips at Kentucky to host the second meeting. Dr. Gallaher, in Florida, agreed to coordinate the third; Drs. Doug Worshum, M.G. Wagger and W.M. Lewis, at North Carolina, provided leadership for the fourth; and DrJim Palmer provided leadership for the fifth at South Carolina. The sixth meeting was at the University of Tennessee under the leadership of Dr. Elmer L. Ashburn and Dr. Tom C. McCutchen, and finally, Dr. Joe Touchton, who had changed professorshps fiom the Univ. of Georgia to Auburn Univ., again provided leadership for the seventh at Auburn, AL. This made the first 7-yr commitment complete.

The general agreement was that the conferences would have a proceedings published and ready to pass out to those who registered on the first day of each conference. We wanted to have a wide range of participants including: university scientists, USDA scientists, other state and federal agencies, farmers, industry, etc. We wanted the publication to be in English units and papers presented and published so that the information would have immediate usefulness to everyone. Whenever possible we wanted to include successful farmerson the program to tell their story of how they made no-tillage and multiple cropping systems work on their farm.

As we approached the 7th "Southeastern No-Tillage Systems Conference," Dean Shirley Phillips at Kentucky suggested that we open up these conferences to the entire Southern states and change the name to "Southern Region No-Tillage Conferences." Dr. Fred Boswell at Georgia suggested that we petition the Research Deans from the Southern region and make this annual conference an official working group under their advisorship. This petition was accepted and the University of Georgia became the first to host the conferences with the new title under the leadership of Dr. W.L. Hargrove and Dr. Fred Boswell. The conferences changed the name again in 1988 by replacing 'no-tillage' with 'conservation tillage,' and Mississippi State University was the first to host with the new name "Southern Conservation Tillage Conference," under the leadership of Dr. Normie Buehring. The conferences continued to rotate among the Southern states under this name until 1993 when the words "for Sustainable Agriculture" were added to the end of the name of the working group. This name, "Southern Conservation Tillage Conference for Sustainable Agriculture," has continued up until the present time.

Much of our success with the advancement of no-tillage multiple cropping in Florida can be traced to the first "No-Till Plus" equipment, invented by Mr. Gerald Harden, a fanner fiom Banks, AL. Florida received the first hand-made unit for our research program in 1976, a gift fiom the Harden family and Brown Mfg. Co. This invention made no-tillage a greater reality for easily compacted soils of the southern Coastal Plain. Kelly Mfg. Co., Tifton, GA and Cole Mfg. Co. of NC soon marketed other versions of this planter as well. In the 1970s and early 1980s, we saw tremendous adaptation of conservation tillage in Florida as measured by no-tillage equipment sales. At one time we had 10 no-tillage planters and drills and six post direct sprayers scattered across central and north Florida, available for on-farm use and demonstrations, all donated by industry. The initial "no-tillage plus" idea soon changed names to "in-row subsoil no-tillage'' and has since changed first to "row-till" and today many are calling it "strip-till." Whatever you want to call this type of conservation tillage, it is still alive and well in Florida.

Hundreds of manuscripts have been published in the 19 proceedings by this working group over the past 20 yr. We have had a proceedings every year hut one. The nature of this show and tell working group has made a highly significant impact on conservation of our natural resources, not only in the southern U.S.A. but also literally all around the world. Many of the leaders of conservation tillage systems in the South have traveled all over the world giving short and long courses, consulting in other ways, hosted international visitors at our workplaces and in our homes, communicated in other ways, trained national and international graduate students, etc., and have made a huge impact on conservation of natural resources for the good of mankind.

Each time a state plays host to this conference, tremendous effort is expended to involve as many of the players in conservation tillage as possible. We not only are expected to have a good proceedings and an extensive exchange of oral and poster presentations but we are also expected to provide tours to show and tell what we are doing. This mode of exchange forces us to do the best job possible when it is our turn to perform thls work.

Industry has been indispensable in making these conferences a success. They have come through in providing the necessary extra assistance, without which the conferences would likely not have happened. We all owe this group a round of applause. Another group who also deserve recognition include the administrative leaders of our Land Grant Institutions. For example, if it were not for the leadership of Dr. K.R. Tefertiller, former Vice President of Agriculture and Natural Resources, Univ. of Florida, many of us involved, here in Florida , with the present conference would not be here today. His leadership was the major factor in obtaining legislative approval for many new positions in IFAS (Institute of Food and Agricultural Sciences), Univ. of Florida, in the mid 1970s and 1980s in the areas of conservation tillage, multiple cropping, water conservation, pest management, etc. His leadership at national level resulted in the establishment of CARET (Council of Agricultural Research, Extension, and Teaching), a nation-wide grass roots advisory group who provide a unified national voice to promote agricultural interest. His international leadership included his promotion and support of IFAS faculty to be. involved at both the national and international levels to enhance information exchange. He provided leadership in helping establish the Land Grant Teaching, Research, and Extension model in many developing countries.

Other administrators can also be cited, who have dedicated themselves to the upward movement of conservation tillage such as Dr. John Woeste, former Dean of Extension (recognized for his tremendous ability to network and his leadership in the area of a safe environmental agriculture and Dr. Al Wood (deceased), former Dean for Research who was co-author of the "Silver Bullet" that was written in cooperation with OMB and was included into President Reagan's budget that established Biotechnology as a major national research effort We will see the results of some of this technology on 26 June as a part of the tour, in the form of Roundup Ready cotton, Roundup Ready soybean, and Liberty Link corn. Dr James M. Davidson, present Vice President for Agriculture and Natural Resources, Univ. of Florida, among other major accomplishments, provided major local, regional, and national leadership in the area of water quality from which we are seeing millions of dollars being invested today throughout the U.S.A. (conservation tillage plays a major role in this national research thrust area). Dr. James (Jim) App, Asst. Dean of Extension, IFAS, Univ. of Florida, is another unsung hero who, day in and day out, networks with faculty, other administrators, and the public to see that the job of carrying out major extension efforts gets done and reports are made in a timely and professional way. Another faithful individual to this conference is Dr. John I. Sewell, long-time Administrative Advisor to our working group, he deserves a note of special recognition. He faithfully participates in our meetings and provides encouragement gives us updates on what's happening in the region and assists the working group in keeping focused on our goals.

Many people deserve recognition for providing support to make this "20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture" possible. Key people and organizations are listed in the program, a copy of which is permanently attached in the appendix of this proceedings. However, two organizations deserve special mention, the Florida Farm Bureau Federation and its leadership (Mr. Pat Cockrell and Mr. Carl Loop) and the USDA-NRCS and its leader (Mr Niles Glasgow) for providing significant monetary support. Many others made significant contributions as well and are recognized as mentioned above. Special appreciation is extended to Dr. Robert McSorley and Ms. Wanda Gallaher for their long hours assisting in editing and compiling the proceeding.

We decided the theme for this conference would be "Partners for a Wholesome Food Supply." Although not all are represented, we have attempted to involve many of the partners in this conference. We have an outstanding slate of participants. You should focus on the fact that, we, the partners, are interdependent in the production of a wholesome food supply! Which of the partners can we do without? I say, none of them! Otherwise, our progress for production of this wholesome food supply, while maintaining a wholesome environment for us to live in, would be greatly diminished. All of the partners are essential to our ability to meet the goal of a greater sustainable agriculture, necessary not only for people today but also for generations to come. Therefore, we must not only answer to the people in general, but we must also answer to and effectively network and communicate with all of the players in the infrastructure who are involved in the production of a wholesome food supply. Life and the natural resources on this good earth deserves no less of us.

Raymond N. Gallaher
Program Chairman

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Ricky W. Telg and *Larry J. Connor

INTRODUCTION

With the incorporation of new and evolving communication technologies, such as satellites, compressed video, and computers, education has taken on a new "flavor" in recent years. In the classroom, computer presentation software and multimedia computer workstations are becoming the chalkboards and overhead projectors of a new generation. More schools are getting "wired to the Internet (Slater, 1996), universities are placing entire degree programs on the World Wide Web (Thorson, 1989), and corporations are investing millions into professional development using computers and television (Arnall, 1987; Bruce et al., 1991; Galagan, 1989; Portway, 1993).

With this emphasis on communication technologies as a means of teaching students, professional educators and corporate businesspeople will have to learn how to leam by and teach with these evolving communication technologies, both in the classroom and at a distance. This paper examines some of these communication technologies and their use in information dissemination, some major educational concerns related to them, options for using communication technologies in the classroom, implications for professionals, and major policy issues.

COMMUNICATION TECHNOLOGY

Many people have expressed concerns about teaching with new communication technologies. "Why change?" they ask. "We've been doing fine for years teaching our courses the way we've always taught our courses." That may have been true for the past and for the present, but the future may very well belong to those who incorporate communication technology-mediated education. In classrooms, technology can aid in students' retention of information. Studies have shown students at a distance do as well or better than their student counterparts in traditional classrooms (Chu and Schramm, 1975; Whittington, 1987). Using new technologies means communication no longer has to occur in "real time" (synchronous). The asynchronous ("non-real-time") communication that technology-mediated instruction allows means information can be moved to the people who need it, at their time, at their location.

Communication technologies have advantages beyond their demonstrated educational effectiveness. In the case of teaching to students at a distance, instructors do not have to invest large amounts of travel time going to and from a distant location. Travel costs also are cut considerably. As a result of the up-ffont time that goes into planning a distance education program, instructors have noted that their teaching materials (videotapes, computer programs/applications, detailed printed hand-outs, computer graphics) are better than those they would design for a regular "face-to-face" classroom.

Teaching with communication technologies does have drawbacks, though. Interaction tends to be stilted; communication seems impersonal because it is not "really" face to face. Start-up costs tend to be expensive. And faculty do have to invest a great deal of up-ffont time to develop their classes.

Communication Technologies in the Classroom

The face of classrooms is changing. Multiple media-- or multimedia -- is the "buzz word in education today. Computers with video, audio, and text capabilities, linked to CD-ROMs, videodisk players and the Internet, have taken "multimedia" to a new level. Students now can reach beyond the constraints of their classroom's four walls. For example, many universities are placing classroom material on-line for students on-campus, not just for those at a distance. On-line manuals and textbooks in hypertext and hypermedia formats are becoming commonplace. Lectures can be live (synchronous) or on demand (asynchronous) through World Wide Web pages in a hypertext format (Kouki and Wright, 1996; Oakley, 1997). Libraries are placing relevant material directly on the World Wide Web. Listservs (electronic mailing groups) are used in an ever-growing number of classes so students can discuss subjects of global interest to other students in their class. Instructors use "virtual" office hours through e-mail to stay in contact with students throughout the day or night. Following are some other examples of new classroom technologies and their uses.

[1]R.W. Telg and [2]LJ. Connor. [1]Agr. Educ. and Comm. Dept., and [2]Dean of Academic Programs, College of Agriculture, Univ. of Florida, Gainesville, FL Manuscript received 3 March 1997. * Corresponding author.

Computer slide/graphic programs (Powerpoint, Harvard Graphics, Persuasion). More instructors are using computer graphics programs, instead of transparencies, to display their classroom notes, video, graphics, and photographs with a small laptop computer, coupled with a high-intensity overhead projector. If the room has a network connection, material from the Web also can be shown. Once the notes are input in the computer, instructors can easily revamp them for future classes, place them on the Web, or print out notes for student use.

Multi-user dimension (MUD) environments. This new Internet tool is for real-time, text-based, multi-party communication. These computer programs offer their users text-based shared virtual environments that they can explore using simple commands. Users meet, have brainstorming sessions, and exchange information via computer.

Multimedia computers in the classroom. Multimedia computers with CD-ROMs, installed in classrooms and networked to the Internet, allow instructors to bring a new dimension to the learning environment. Students can read text, see graphics and video, and hear audio.

Communication Technologies at a Distance

In this section, the major technologies available for distance education and their advantages and disadvantages (Smaldmo, 1995) will be briefly outlined. "Low-tech" methods (Table 1) can be characterized by limited or no interactivity between instructor and student. "High-tech" methods (Table 2) allow more interactivity through more advanced technology.

Implications for Professionals

This section describes some of the implications professionals will have to consider as they develop programs to be taught with communication technologies. Although this section focuses more on a distance education model, many of the methods apply when incorporating technology in the classroom.

Teamwork. Providing instruction to students at a distance is not the responsibility of the instructor alone. In the distance education framework, teamwork, comprised of instructional designers, television-production specialists, computer specialists and other technical support personnel, becomes important in the development and dissemination of instructional materials (Brinkley et al., 1991; Collins and Murphy, 1987; Kelly, 1990).

Instructors or subject matter specialists are experts in their areas of content. Subject-matter specialists should not become technology experts; rather, they should be able "to understand the basics of the technology and how communication is being mediated" (Thach, 1993, p.295). The distance education instructional designer must function in relationship to the infrastructure as a reference for the resources available in that academic institution, must know how certain technologies and media work, and must serve as an intermediary and mediator between the instructor and technical specialists (Brinkley et al., 1991). Educational technologists, such as computer specialists and educational television producers, have the production expertise to assist in the development of the program or course. Because of their professional backgrounds, they understand the specific instructional design needs dictated by the requirements of the media (Smith, 1991) and how to better provide instruction through this form of mediated communication (Garrison, 1989; Hart, 1984).

Support staff ensure that all of the little details are taken care of so a distance education program can run smoothly and successfully by handling such tasks as student registration, materials duplication and distribution, and facilities scheduling. Site facilitators should be able to handle technical problems that may arise at the sites and be well-versed in interactive strategies to involve the students as much as possible in the course activities.

Instructional Design. Instructional design is important in any educational setting and is defined by Gaff (1975) as the systematic and continuous application of learning principles and educational technology to develop the most effective and efficient learning experience for students. Several instructional design models exist for teaching with technology (Kemp, 1985; Murphy and Taylor, 1993; Price, 1994). In any instructional design model, the following questions must be asked. The instructional design elements then will be discussed.

What is the need for the distance education program?
What are the goals and objectives?
Who will be the learners?
What will be the subject content (message)?
What teachmg methods and media will be used?
How will learners be assessed?
How will the course or lesson be evaluated with a view to improvement?

A needs assessment, to determine why the instruction is required, should take place before the rest of the design process is undertaken. Goals and objectives structure the instructional plan of action. A goal is a general statement of what you hope the course (or program) will achieve, perhaps expressed in terms of what you, the teacher, will be presenting to the learner. An objective is a statement of what learners should be able to do (or do better) as a result of having worked throughthe course(or program).

In any instructional environment, it is imperative to know as much about the learner -- the intended audience -- as possible. The audience for each course most likely will be somewhat different. However, there aresome common characteristicsregarding the "distance learner." Distance learners tend to be older, have established jobs and families, are self-motivated, expect limited interaction with their instructors,and are usually excited about taking a much-needed distance education program.

The message should be decided even before a medium is chosen. What are you trying to say? Is it appropriate for communication technologies? How is the best way to integrate the message with the technology? The technology should be selected to meet the needs of your class. The medium/media choice should come after you decide what you want to say. In your courses, you want to provide media variety to your students, integrate voice, video, and data technology with print resources.

Assessment and evaluation should be components of any instructional endeavor. Assessment can take the form of a needs assessment to determine why the courseis necessary and student assessments (tests and assignments). Evaluation should be part of the course throughout the span of its existence -- through formative evaluations given during a semester and a summative evaluation given at a course's completion. The purpose of the evaluation should be improvement of the course. Revisions should be done as a direct result of the evaluation process and feedback from colleagues and content specialists. Because assessment and evaluation is so important, yet often overlooked, in the design of a technology-mediated program, a closer look at assessment and evaluation components is provided here.

Teaching Strategies. For the most part, effective distance teachmg requires enhancing existing skills, rather than developing new abilities. For example, educators will have to "chunk" their instruction more, by spending no more than 10 to 15 minutes lecturing without some type of "break." The "break" allows students to process what they have just been exposed to. Also, educators must prepare for the course in advance and not wait until the day before (or morning of) a class to get ready. This helps to allow for time to built in for course materials sent in the mail to get to their intended destinations.

Interaction. Distance education requires different communication methods than those needed in traditional classrooms (Zvacek, 1991) because information technologies are predominantly visual, as opposed to the textual and auditory environment of the conventional classroom (Dede, 1991). Designing systems of feedback is of concern in mediated communication (Garrison, 1989). However, interaction does not have to occur in "real time" to be effective. "Virtual interactivity," occurring through asynchronous means, such as computers (e-mail), facsimile, and surface mail, is effective in bridging the communication gap between instructors and off-campus students who view videotape programs in their homes (Russell, 1994).

Perhaps the biggest headache for faculty members in the distance education environment is the lack of nonverbal cues. Not being able to gauge how well one is teachmg has been seen as a disadvantage of a distance education system The educator must have confidence in yourselfthat the content is what should be taught The feedback from the formative evaluations, the telephone calls and electronic mail messages will help gauge the teaching's effectiveness. The key, then, *to* interactivity is thoughtful instructional design that takes into account teachmg objectives, creative teaching methods, and appropriate distance delivery technologies (Murphy, 1992). For example, educators should call on sites, because rarely will someone break in with a question. And when an educator asks a question *to* a site, the educator should employ the "10-second rule" -- wait at least 10 seconds before saying anythng else or going to another site. This allows students some time *to* think about a response.

MARKETING

Probably the area that is thought about the least in a distance education production is marketing. But without some marketing plan, a distance education program is doomed from the point of view of low enrollment. The consideration of marketing a program should come on the very heels of the idea for the program itself. When identifying the audience, thought should be given about how to let the target audience know about the distance education production. With no audience, there is no program.

After a target audience is identified, the next step is to advertise. People need to know how the course would benefit them. Some places or ways that agriculture-related programs may advertise are the following: word of mouth and direct contact, commodity magazines and newspapers, other organizations that are partners in the distance education program, paid advertisements on radio and television stations, newsletters and fliers, and county Extension agents.

EMERGING POLICY ISSUES

Evolving communications technology and information delivery systems have precipitated some emerging policy issues. To date, major policy issues appear to be the determination of user needs, the financing of technological infrastructures, the resolution of communications, property rights, and the professional development of instructors. In some cases, market forces will have a major impact upon the resolution of these policy issues. However, other issues will necessitate public policy resolution at governmental or legal levels. Major examples of emergmg policies issues are included in this section.

User Needs

Which users will receive the primary attention, and which of their needs will be addressed? In the agricultural sector, evolving communications technology can be used to work with the infrastructure serving farmers (agribusiness, extension agents, federal agency personnel, and others). Alternatively, evolving communication technology may be used directly with production and marketing firms.

User needs may be met in a variety of ways: formal degree programs, college credit courses, short courses, and seminars, to name a few. If profits can be realized from providmg these types of mformation, competition can be expected in the private sector as well as from competing universities and other public sector institutions. Determining user needs has always been a difficult process, as many Extension and Soil Conservation Service personnel can testify.

Financing Technological Infrastructures

Start-up and maintenance *costs* may be significant in the provision of distance education technology, and in the enhancement of classroom settings with modern multimedia equipment. Satellite delivery systems include uplink and downlink equipment, transponder *costs,* faculty development costs, and materials. Two-way audio-visual systems also may have considerable start-up and maintenance costs.

The manner in which these costs are financed will influence the adoption rates of evolving communications technology. User fees, tuition charges, and other assessments may cover part of the *costs.* However, most public institutions will require some "up-front" funds to initiate their programs. To date, the response is very different between states. States such as Iowa, Georgia, and Maine have made major financial commitments to distance education. Many other states have done little.

Property Rights

Classroom instructors have long been sensitive to the reproduction of notes and classroom materials for sale. Computer users have become increasingly sensitive about property rights in the utilization of computer-based materials. Communications property rights can be expected to become increasingly more complex with the advent of new technology.

As an example of the complexity, consider inter-university cooperation in the provision of courses. At some universities, it is extremely difficulty to transfer credits from other universities. Some universities cannot offer distance education courses unless students are fully matriculated. Some colleges do not wish to relinquish the provision of some of their courses to competing state universities for fear of losing state financial support.

Professional Development

The advent of modem communication technology and information delivery systems has resulted in a major need to retrain generations of instructors. The ability to use modern educational technologies is probably at least as demanding as the ability to use modem laboratory research equipment. Many faculty historically only used overhead projectors, blackboards, and slide projectors. Moving to higher-level technologies will require major human capital investments. Determining who supplies this training, and how it is financed will be major factors in the evolving communications movement.

The resolution of the above emerging policy issues will require major private sector initiatives and public sector investments. The current conservative political environment and interest in "budget cutting" will unquestionably influence public expenditures for communications technologies and information delivery systems.

CONCLUSIONS

Educators will have to stay abreast of communication technologies in order to inform and teach effectively in the future. Not only that, but communication technologies also will affect how educators receive information. For example, many academic journals already seek manuscript submissions in an electronic format, and produce on-line editions of the journals.

Universities and corporations are promoting research and products on the Web. Communication via e-mail with colleagues across campus, the state, country, and world, many times, is easier and less expensive than "conventional" communication with telephone or the Postal Service. Many professors are using Web sites, instead of formal textbooks, with which to teach courses.

Communication technologies for classroom and distance instruction will continue to evolve, expand, and improve. As has been shown in this paper, evolving communication technologies are causing educational methodologies to change, as well. Educators, themselves, will have to become life-long learners so their teaching methods will evolve as the technology evolves. But educators will not have to do it alone. They can make the transition with assistance from educational technology experts and instructional designers and through the suggestions presented in thls paper.

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Tabk 1. "Low-tech" methods.

	Advantages	Disadvantages
***Audio* cassettes**	Portability Student can work at own pace Support materials (print) Students can review audio tapes	Low completion rate Lecture-style presentation Time-delay Difficulty in communicating between teacher and student
***Video* cassettes**	Use of motion and audio Student can work at own pace Students can review videotapes	Same as audio cassettes Lecture-style presentation (although can be supplemented with video segments)
Radio	Audio -- listen to teacher Review materials (print) Similar to on-site lectures	Same as audio cassettes Student can't work at own pace (specific time)
Compuier programs (Computer-aided instruction)	Same as video cassettes	Access to computer Difficulty in communicating between teacher and student
Broadcast and* cable *TV	Motion and audio Review materials (print) Similar to on-site lectures	Same as audio cassettes Student can't work at own pace (shown at specific times) unless videotaped Lecture-style presentation (although can be supplemented with video segments)

Table 2. "High-tech" methods.

	Advantages	Disadvantages
Computer conferencing (Internet/World Wide Web, audiographics, "chat" groups)	Many *courses* offered this way Students can read teacher's presentations Work at own pace Review computer materials Live dialogue with e-mail	Access to a computer Time-delay for written materials "Computer phobia"
Ardioconferencmg ***(Use*** of telephones to bring many people together in an audio-only format.)	Access to telephone Listen to teacher's presentation Student can work at own pace Live dialogue with teacher and other students	Long-distance charges Time-delay for written materials Limited conversations
Satellite	Motion and audio Can see and hear teacher's presentation Student can review (iftaped) Students can *speak* to teacher via telephone	Access to facilities Weather/technical problems Expensive Students can't work at own pace (shown at specific times) unless videotaped Time-delay for written materials
Two-way audio/video conferencing (CU/See Me, compressed video, microwave)	Review materials Students can see and hear teacher and be seen and heard	Technical problems Costs of greater bandwidth Access to classroom (or computer) Poor video quality Time-delay for written materials

Role of the Institute of Food and Agricultural Sciences in the Production of a Wholesome Food Supply

Joseph C. Joyce

To understand the role of the University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) in the production of a wholesome food supply, one need only look at the organization's mission and vision statements which were developed as a part of a strategic planning process known as *Florida 2000 and Beyond* (Anon., 1995).

MISSION

"To develop knowledge in agricultural, human, and natural resources, and to make that knowledge accessible to sustain and enhance the quality of human life."

VISION

"The vision for UF/IFAS is to increase and strengthen the knowledge base and technology for:
EXPANDING the profitability of global competitiveness and sustainability of the food, fiber, and agricultural industries of Florida.
PROTECTING and SUSTAINING natural resource and environmental systems.
ENHANCING the development of human resources.
IMPROVING the quality of human life."

In order to implement the mission and vision in response to Florida's rapid socio-economic, technological and environmental changes, UF/IFAS has established nine initiatives. These initiatives represent specific interdisciplinary program areas and are included in the UF/IFAS annual budget request as critical issues to be funded as partnership programs with other agencies or private entities. These initiatives are:

Environmentally Compatible Pest Control

As new exotic pest, environmental restrictions, and the loss of traditional control methods increase, agriculture and urban pest management will become more difticult threatening the $6.0 billion agricultural industry and urban environments. Integrated Pest Management (IPM) programs will target crop protection, urban pest management, and the protection of natural areas.

Food Safety and Quality

Research and education programs will identify critical issues affecting the safe production, processing, and marketing of seafood and other meats, and vegetables These programs will protect and enhance the economic viability of Florida food industries and provide for increased consumer safety and satisfaction.

Sustainable Water Resources

In order to protect the state's water resources from agriculture operations and urban development, Best Management Practices (BMPs) will be developed for water quality protection, water conservation, urban and rural nutrient and pesticide management, exotic pest management, soil subsidence reduction, and wetland restoration

Sustainable Food and Agricultural Production Systems

Increasing food and fiber needs must be met with our current resource base. UF/IFAS programs will improve production efficiencies of farms, ranches, forest, nurseries, and groves while maintaining environmental compatibility. These efforts will require multi-disciplinary efforts among production agriculture, businesses, and human and natural resources.

Animal Health and Environmental Toxicology

The public demand for a safe and wholesome food supply has never been greater. However, microbial agents like *E. coli* and *Salmonella* have been found in food of animal and plant origin and caused numerous human and food borne illnesses. Hazard analysis and critical control point (HACCP) programs are being developed to provide on farm and ranch training to make certain that food is disease and residue free when marketed.

Youth and Family Development

Research and education programs will focus on parenting, resource management and nutrition, in an effort to reduce the number of low birth weight infants, improve nutrition and health and to reduce juvenile

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J. C. Joyce, Associate Vice President for Agriculture and Natural Resources, University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL.
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crime, school drop out rates and violent crime rates among teenagers.

Developing Sustainable Rural Communities

Rural communities need assistance to develop alternative, sustainable sources of economic activity in order to prevent further decline in rural economies. The program will concentrate on economic development though altemative enterprises, community development, and the development of community leadership.

Expanded Quality Educational Experiences

UF/IFAS will expand the opportunity for all Floridians to receive a high quality educational exprience both on the central Gainesville campus and at other UF locations throughout the state. UF/IFAS is concentrating on increased availability of formal and informal programs through distance learning technologies, increased traditional classroom situations throughout the state, expanded multi-cultural experiences, interdisciplinary curricula, and improved recruiting and instruction.

Agricultural and Natural Resource Policy

Decisions and rules regarding land use rights, water allocation, and natural resource allocation among competing interests are rapidly evolving. These decisions affect all citizens including the food, agriculture and natural resource based industries; rural, urban, and coastal homeowners, developers and the tourist industry. However, little attention has been given to what the costs actually are nor to the resulting socio-economic effect. Research and education programs will inform policy makers on the economic impacts of agriculture and natural resource policies and regulations.

Because these initiatives integrate the functions of research, teaching, and extension *so* effectively, their existence reflects the strongest traditions of the Morrill Act of 1862 which established the Land Grant University system and later the Agricultural Experiment Stations through the Hatch Act of 1887 and the last of the triad, the Cooperative Extension Service, established in 1914 by the Smith-Lever Act. The UF/IFAS system has expanded through the establishment of a diverse and wide-spread system with faculty located at the main campus in Gainesville, at Research and Education Centers (RECs) throughout the state and county extension offices in each of Florida's 67 counties (Figure 1). Under this arrangement approximately 40 % of the faculty are located at the statewide RECs, but are tenured within their disciplinary department on the Gainesville campus.

The unique organizational feature of UF/IFAS is the close integration witlun a single organization of the functions of research, extension, and teaching to meet the needs of the state in agriculture, human, and natural resources. This organizational structure was envisioned by Dr. E.T. York in 1964 with the establishment of UF/IFAS As Figure 2 indicates, UF/IFAS has 645.5 FTEs of faculty effort; however, by spreading this effort through split assignments UF/IFAS is able to have 340 faculty involved in teaching activities, 565 in research, and 242 in extension. There are also an additional 245 county extension faculty. Thus, one can easily see that the value and unique role of UF/IFAS is the complementary faculty effort, thus maximizing efficiency, as opposed to competitive activities, among the functions of research, extension, and teachmg. Faculty, students, and statewide clientele benefit from the integration of these functions within an individual faculty appointment. For example, research efforts provide up-to-date information to solve customer driven problems through the extension program. Likewise, the research effort receives the benefit of feedback from the extension program on the nature of emerging problems upon which to focus new research efforts. The teachmg program benefits from a diverse pool of human capital that possesses the latest research information. Undergraduate students benefit from direct contact with faculty expertise and a greater efficiency of delivery. Graduate students benefit from faculty-directed hands-on research training and from financing derived from sponsored research efforts.

SUMMARY

As the state's Land Grant University, the University of Florida and UF/IFAS represent an ongoing investment in Florida's agriculture human and natural resources. Programs are conducted statewide within the context of a vision for expanding the profitability, global competiveness, and sustainability of Florida agriculture protecting and sustaining natural resource and environmental systems in Florida, and enhancing the development of Florida's human resources (Koukas et al., 1997). This unique capability allows UF/IFAS to provide a service in partnership with Florida's sister agencies, as well as Federal and private entities.

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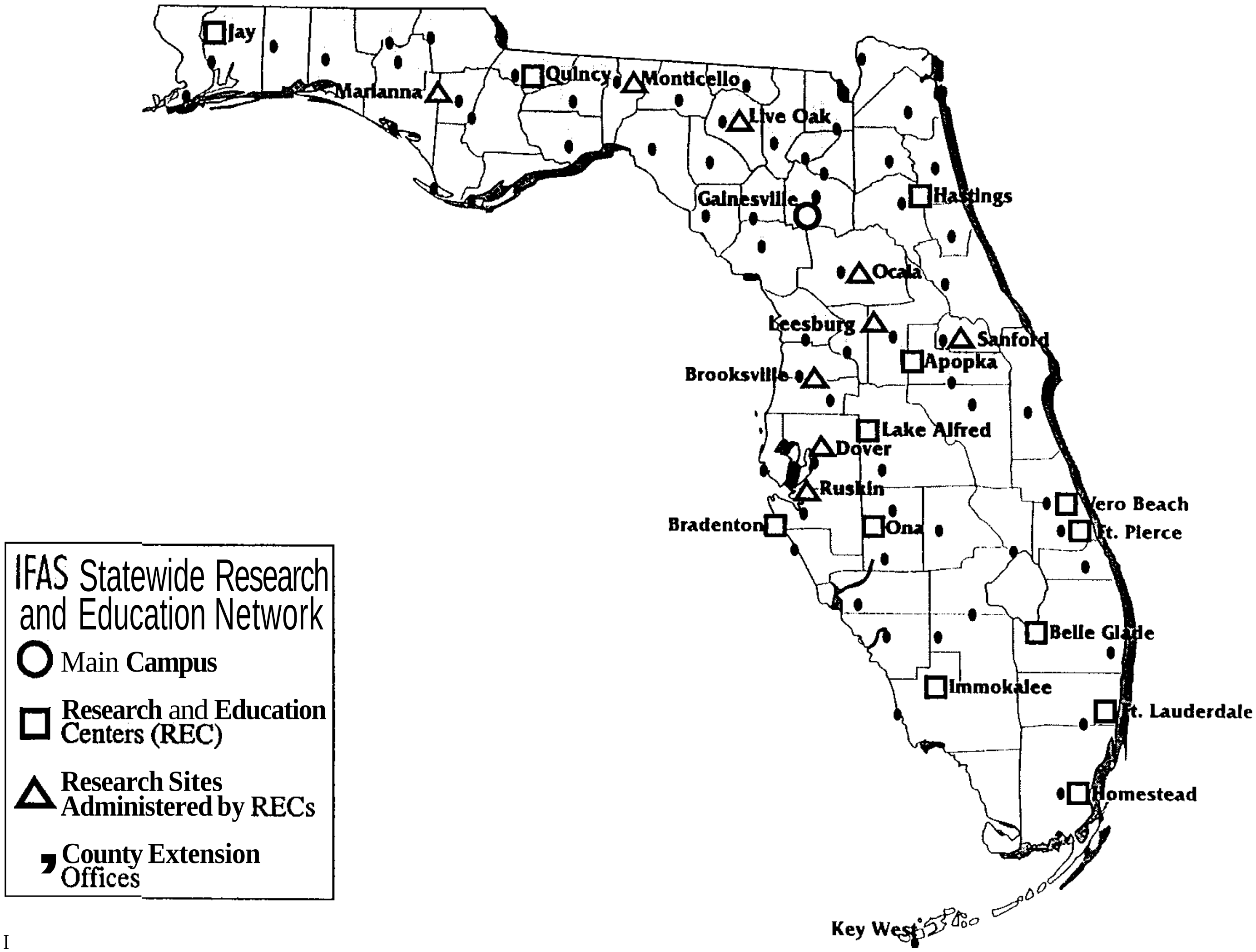
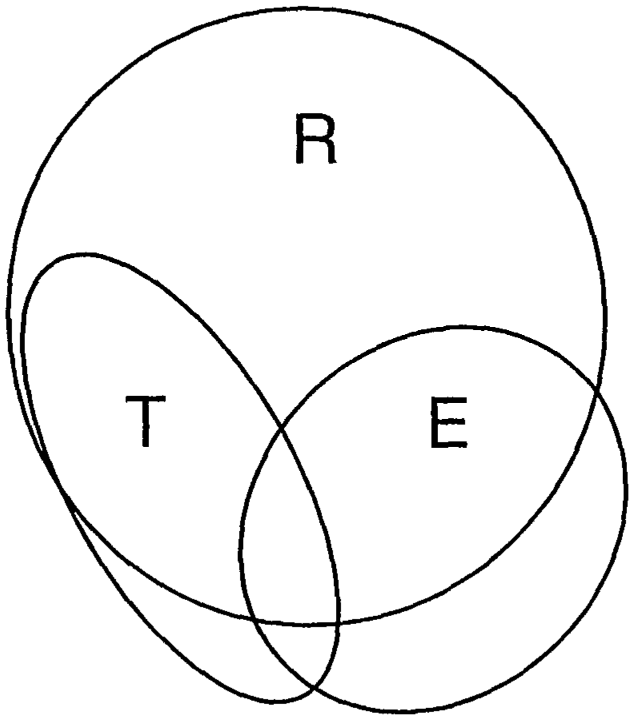


FIGURE I

Figure 1. The UF/IFAS faculty located at the main campus in Gainesville, at Research and Education Centers (RECs) throughout the state, and county extension offices in each of Florida's 67 counties.

1995-96 UF/IFAS Faculty Effort Distribution



	FTEs Allocated	Faculty Assigned
Research	390.0	565
Teaching	118.5	340
Extension*	138.0	242
TOTAL	646.5	

* Excludes 248 FTE county faculty.

FIGURE 2

Figure 2. Numbers and distribution of UF/IFAS faculty among teaching, research, and extension assignments for 1995-1996.

Role of USDA, Natural Resources Conservation Service (NRCS) in Production of a Wholesome Food Supply

T. Niles Glasgow

United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS) provides conservation planning and technical assistance to clients (individuals, groups, and uhits of government). These clients develop and implement plans to protect, conserve, and enhance natural resources (soil, water, air, plants, and animals) and to address their social and economic interest (SWAPA + H).

Planning involves more than considering individual resources. It focuses on the natural systems and ecological processes that sustain the resources. The planner strives to balance natural resource issues with social and economic needs through the development of conservation management systems (CMS) often referred to as conservation plans.

To achieve the goal of sustained wholesome food supply, many partners work together to provide the decision maker (client) with viable alternatives. These alternatives provide different ways to meet the client's objective and meet the quality criteria of the resource concerns. Each alternative is evaluated to determine its effect and impact on the natural resources.

The development of alternatives and the implementation of a conservation plan is the culmination of many cooperative efforts. State and federal agencies such as Colleges and Universities; Research from Institutes of Food and Agriculture Science; USDA, Agriculture Research Service; Cooperative Extension Service; private individuals, commodity groups and agriculture cooperatives have all played a major role in developing and transferring present day knowledge and technology to the decision maker.

The end product is a conservation plan that combines management and conservation practices that, when installed, will achieve a specified level of treatment for all resources. Plans contain soil maps with interpretations; worksheets and jobsheets such as forage inventories, erosion estimates and cost estimates; operation and maintenance agreements and procedures; a plan map showing land use, fields, acres, and locations of various practices to be applied, a record of the client's decisions, other useful maps, sketches, and designs; and a Conservation Effects for Decision making worksheet reflecting site-specific information.

The planned conservation system is evaluated as to the effect it will have on the resource concerns (SWAPA + H). The following considerations and/or problems are evaluated:

soil

Erosion - Sheet and rill, wind, and irrigation induced concentrated flow (ephemeral, classic gully, streambank; soil mass movement; roadbed and construction sites)

Condition - tilth, compaction, soil contaminants

Water

Quantity - Seeps, flooding, subsurface water, restricted capacity, conveyance
Inadequate outlets
Restricted capacity, water bodies
Water management - irrigated
Water management- nonirrigated

Quality - Contaminants
Aquatic habitat suitability

Air

Quality - Sediment, smoke; chemical drift, odors; fungi, molds, pollen

Condition - Temperature, air movement, humidity

Plants

Suitability - Adapted to site, intended use

Condition - Productivity, health and vigor

Management - Establishment, growth, harvest, and nutrient management

Pests

Animals
(Domestic and wildlife)

Habitat - Food, Cover/shelter, water

Management- Population/resource, balance, animal health

A simplified example of a partial alternative considering the resources is provided below:

Farmer X has 100 acres of row crop and 200 acres of grazing land. Water for the livestock

T. N. Glasgow, State Conservationist, USDA, Natural Resources Conservation Service, Gainesville, FL.
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is supplied in two 100 acre pastures. The planner follows a three phase, nine step process. In the process an inventory and analysis shows soil loss from sheet and rill erosion rates of 15 tons/a (3 times that to maintain the soil resource base), a near by steam laden with sediment and fish kills occurring 2-3 times a year, production of the row crop is about state average, input of fertilizer is high, there is a large lake down stream from the farm and it is experiencing eutrophic conditions and has periodic undesirable algae bloom, the grazing area has several shallow gullies throughout the two pastures, the pasture grasses have some areas that arevery short and over grazed while other areas have mature grasses that are not grazed, game birds and deer are seldom seen on the farm.

One alternative Farmer X may consider is to apply the following conservation practices as a part of an overall conservation plan.

Residue Management, Strip Till

Effect Reduces soil loss to the level sothat it will maintain productivity; water quality improvement by reducing the amount of sediment carrying attached nutrients, reducing the amount of sediment in the stream, and reduce one possible cause of eutropication of the off site lake; increased crop production build organic matter in the soil thus improving nutrient and water holding capaciy, reduced cost from most inputs, increased management level.

Nutrient Management

Decreased cost and increased production by applying only the amounts needed, in the appropriate form, and in a timely manner; reduced eutropication of lake by reducing the amount of dissolved nutrients going to the lake.

Pest Management

Increase net profit by scouting and applying appropriate pest control measures (biological, chemical, and/or mechanical). Improve water quality and wildlife habitat by using pesticides with less potential for leaching and/or runoff and considering the aquatic index, reduce chemical health hazards to human, plants and animals; promote beneficial insects.

Prescribed Grazing (Includes Support Practices such as Fencing, Watering Trough, and Pipeline)

Develop a more desirable plant community, better utilization of forage, increase production of forage, produce more animal units (domestic and wildlife), reduce erosion, improve water quality.

There are many alternatives that could be chosen and each would have different effects on the resources. Our natural resources are so closely related and interdependent. The example above only demonstrates a partial alternative with some of the possible effects described.

When one or more resource is manipulated, the impacts on the others must be considered. The production of a plentiful, wholesome, sustained food supply must have the support of the many partners and we must provide the best available assistance to the land use decision maker.

Role of the Florida Farm Bureau in Production of a Wholesome Food Supply

Wm. Patrick Cockrell

INTRODUCTION

The objectives of my presentation are to: 1) present information on the Florida Farm Bureau's role at the state and national levels in maintaining farm profitability, sustainability and resource protection, 2) give examples of the policy impacts of the Food Quality Protection Act, the Florida Nitrate Law, and the Farm Bill, 3) explain Florida Farm Bureau's role in those public policy debates and grass roots farm initiatives, 4) give an international perspective of the public debate, and 5) discuss the effects of chemophobia as it relates to the European Community and the possible correlation in the united states.

Subjects to be Covered

FQPA

Law
Implementation/Regulation

Farm Bill

Programs Market-Oriented
EQUIP & Other Programs

Nitrate Bill

Grower Buy-in
Research

Chemophobia vs. Sustainability

FACTS ABOUT FLORIDA FARM BUREAU

Oldest Farm Organization

Florida Farm Bureau is Florida's oldest and largest general farm organization. It was organized in November 1941 and today has a membership in excess of 110,000 member families. A general farm organization, in this sense, means one which represents all major agricultural commodities i.e.; citrus, forestry, row crops, beef, dairy, etc.

Farm Bureau is an independent, nongovernmental voluntary organization of families who are united for the purpose of analyzing and solving common problems It is local, state, national, and international in scope and influence One of its major purposes and thrust is legislative involvement and influence on behalf of the agricultural industry.

Grass-Roots Organization

Florida Farm Bureau is a "grass-roots" organization, one which gets its direction and policy from bona fide farmer-rancher members who adopt policy each year at the state's annual meeting. The real strength of Florida Farm Bureau lies in the counties...where the members live. It's here that the basic needs, thinking and interests are generated and ideas for service programs are begun. Being a federation, a state organization can be no stronger or effective than the sum total of its county member units.

Sixty-Two County Farm Bureaus Make up Florida Farm Bureau

There are 62 organized county Farm Bureau units in Florida. Each county Farm Bureau has a county president, vice-president, secretary, treasurer, and board of directors. A person must be actively engaged in production agriculture to be eligible to serve on a county Farm Bureau board of directors.

Service-to-Member Organization

Farm Bureau is a service-to-member organization. Only members may participate in Farm Bureau programs, activities, and services. Farm Bureau's purpose is to increase total net income to its members. Some of the many services available to members are: 1) full time legislative staff (lobbyist) in Tallahassee and Washington, 2) free accidental death coverage for members, 3) marketing program - fresh, top quality produce and farm products are available through the Farm Bureau, i.e. orange juice, fresh oranges, hams, cheese, apples, jellies, etc., 4) discounts at Busch Gardens, Coast-to-Coast Vision, Disney World, Sea World, and Universal Studios, 5) pharmaceutical program - direct prescription and non-prescription items at 30% discount, 6) insurance - life, auto, Blue Cross/Blue Sheld, estate planning, 7) $500 reward program - theft, arson, vandalism, 8) information - monthly state publication, fast facts, news releases, 9) Women's program - Kidney Fund, Youth Speech Contest, Agri-Fest, county, district, and state information

W.P. Cockrell, Director/Agricultural Policy Division, Florida Farm Bureau Federation, Gainewille, FL.
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meetings, 10) young farmer and rancher program - open to Farm Bureau members ages 18-35-outstanding Y&R contest, discussion meet, district and state conferences, 11) youth county scholoarships, Miss Florida Agriculture Queen Contest, Youth Speech Contest, 12) Ag Advisory Committee - working directly with 15 major agricultural commodity producer groups, and 13) Ag in the Classroom - workshops and mini-grants, etc.

Farm Bureaus Federated Together

Florida Farm Bureau Federation is comprised of 62 county units federated together. The Florida Farm Bureau Federation federates itself with 49 other states and Puerto Rico, to form the American Farm Bureau Federation. The American Farm Bureau Federation boast of almost five million member families. The Farm Bureau state office is located at 5700 S.W. 34th Street, Gainesvile, Florida 32608, telephone number (352) 378-1321. The Florida Farm Bureau Federation president is Carl B. Loop, Jr. from Jacksonville. President Loop is a nurseryman by profession.

State Board of Directors

The 24-member State Board of Directors, which meets every other month, is comprised of bona fide fanners and ranchers fiom across Florida. They are elected for a 2-yr term by other farmers and ranchers within a three to four county district.

Farm Bureau Objectives

The purpose and objectives of Farm Bureau, as previously mentioned, is to increase net income for its members. This is done through legislative action, service-to-member programs, and information and education efforts. Farm Bureau is the "Voice of Agriculture," representing every major commodity produced commercially in our state. It is an organization designed to provide a means by which farmers can do together...the job that can't be done alone. It represents the thinking and will of the "man on the land." It also reflects the thinking of many non-farm people who share basic conservative philosophy.

Annual Dues

Farm Bureau activity is financed primarily through members paying annual memberstup dues. The average dues are approximately $35. A Farm Bureau membership is a family membership.

Opportunity for all Ages

Farm Bureau attempts to provide opportunities for involvement and participation by members of the family, i.e. Women's Program and activities, Young Farmer and Rancher Program, Scholastic Scholarships, Youth Speech Contests, etc.

We are proud of Florida Farm Bureau and the good it has done for its members and all agriculture for almost 60 yr. Our many accomplishments and achievements are proof of our success. Farm Bureau continues to launch ahead and provide services to its members through legislative, marketing, and other programs designed to increase member's net income. It can safely be said...Farm Bureau doesn't cost...it pays!

Role of Soil and Water Conservation of the Office of Agricultural Water Policy

David S. Vogel

INTRODUCTION

The Department of Agriculture and Consumer Services Office of Agricultural Water Policy (OAWP') was created under state law to ensure that agriculture is effectively represented in the development, implementation, and evaluation of statewide water policy. The primary purpose of this involvement is to participate in water policy issues as they relate to agriculture, to better communicate the needs of our industry to the Legislature, appropriate agencies and the public, to provide greater equity and certainty in water use, allocation and planning processes, and to provide better service to agriculture.

As a part of overall water policy coordination, the OAWP has undertaken specific initiatives to establish a process for agricultural regulatory streamlining, to develop alternative approaches for achieving resource conservation and protection through non-regulatory, incentive-based strategies, to participate in South Florida and Everglades ecosystem restoration activities to ensure that restoration activities are conducted in a manner consistent with sustainability of agriculture and resource conservation, and to provide assistance to Soil and Water Conservation Districts in carrying out conservation activities at the local and watershed level. This process includes participating in pilot demonstration projects for regulatory streamlining, working with the agricultural community and conservation partnership at the local level to provide improved delivery of resource management services to landowners, and establishing a problem-solving approach to compliance and responding to operational problems as an alternative to enforcement.

SOIL AND WATER CONSERVATION

The Soil and Water Conservation Program is charged, under Chapter 582, F.S., to provide administrative and technical support to Florida's 63 Soil and Water Conservation Districts, including funding, education, training and overall leadership. As a part of the above water policy initiatives, the Soil and Water Conservation Program has begun a revitalization effort of the state's Soil and Water Conservation Districts, and has redefined the scope and level of services provided by the Department. In addition to ongoing program assistance, the Department is introducing Soil and Water Conservation Districts to new opportunities for participation at the local level in critical agricultural and water-related issues, including those described above.

During the past year, the Department began efforts to expand the traditional conservation partnership to reach out to additional agencies with jurisdiction in water and land management. The Commissioner has made new appointments to the Soil and Water Conservation Council, and has reformed the role of that advisory council in water- and conservation-related issues. The program has also begun a process to better integrate the local efforts of Soil and Water Conservation Districts into state water management objectives, and to provide greater access for agricultural producers and landowners in water policy decision-making. In partnership with the Florida Association of Conservation Districts (FACD) and the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), the Department is also assisting Soil and Water Conservation Districts in their role as leaders in locally-led conservation efforts under the 1996 Farm Bill, and in building a local network around Soil and Water Conservation Districts for better community-based services to Florida's landowners in resolving natural resource problems. These efforts are intended to expand the scope of services already provided by Soil and Water Conservation Districts (such as those activities related to conservation tillage and field days) to provide additional benefit to landowners and producers as they deal with today's resource management requirements.

NEW OPPORTUNITIES FOR AGRICULTURE

Through efforts of the OAWF and other divisions, the Department is working to expand services to the agricultural community, and to create new opportunities for locally-led, voluntary management approaches to resolve agricultural and environmental issues This involves not only regulatory streamlining and participation in water policy development, but requires better local participation in land and water

D. S. Vogel, Soil and Water Conservation Administrator, Florida Department of Agriculture and Consumer Services, Soil and Water Conservation, Tallahassee, FL.
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management processes. These efforts represent new opportunities for agriculture in that success will provide greater flexibility and profitability for agricultural producers. These also pose new challenges for agriculture in that success will depend upon the willingness of producers, public agencies, researchers and educators to work together on new approaches. The remainder of this presentation describes new approaches under development or consideration.

Soil and Water Conservation Districts (SWCDs) will play a critical role in this process. This is because a cultural change is occurring in regulatory agencies, encouraged by Congress and the state Legislature, which has created a need for better local, or community-based, services as a preferred alternative to command-and-control regulation. SWCDs represent a unique local perspective to resource management, and have provided resource management services to landowners for many years related to resource conservation and protection on private lands. As we explore alternative approaches to resource management, especially non-regulatory choices, we must redefine and revitalize the role of SWCDs to provide improved local delivery of those alternatives.

Concurrent with these efforts, the 1996 Farm Bill has created an opportunity to help rebuild local networks around SWCDs through establishment of Local Working Groups to implement the Farm Bill's Environmental Quality Incentives Program. The Department is cooperating with FACD and NRCS to help SWCDs organize these local networks which will provide the needed coordination at the local level as resource management services are expanded beyond Farm Bill programs.

ANIMAL AGRICULTURE

A recent conference on Southeastern animal agriculture explored issues associated with animal production, and emphasized the need to develop and apply new solutions to problems in animal waste management, land management, grazing lands, and farmland sustainability. Since that conference, we have been workmg with producers and regulators to consider how to apply a voluntary, incentive-based approach to managing animal waste associated with dairy and poultry operations. This process is a result of recognition that traditional command and control regulatory programs are not the most effective approach to working with people to solve these types of problems. The voluntary approach also maximizes the delivery of technical and financial services to landowners, and applies resources more directly to *the* problem In response to a request for help by animal producers the Department is taking a leadership role in this process.

The primary components of a suggested approach to animal waste management are as follows:

Voluntary participation. The best way to ensure that improved practices become a part of a producer's operation is to provide an opportunity for a producer to make his or her business decision to adopt such practices. This decision means that practices, or an operational plan, belong to the producer, rather than to government, and that government's role is to assist the producer in achieving his or her goals. A voluntary approach offers producers a choice of following the regulatory path or an alternative which provides greater flexibility.

Incentive-based participation. Producers must be given proper incentives to change their practices or to install technical solutions. These should include appropriate relief from burdensome regulatory requirements otherwise satisfied through adoption of improved practices, including a presumption of compliance with applicable water quality standards through use of BMPs or other practices shown to be effective in resource protection, and a reduction in regulatory oversight and duplication. Increased and simplified financial cost-share assistance should also be made available as an incentive, as agencies should be encouraged to apply funding toward putting practices on-the-ground, as a substitute for traditional regulatory program costs. An important part of the regulatory incentive is the shift from regulatory inspections (often involving multiple agencies) to a more local, non-regulatory partnership where Department personnel and Soil and Water Conservation Districts work with the producer to track progress and assist with his or her plan, replacing traditional regulatory inspections.

Research-based Best Management Practices (BMPs) or Recommended Management Practices (RMPs). Government, researchers and producers must cooperate to develop and demonstrate improved practices (BMPs), and to implement RMPs on a trial basis, to provide a menu of sound management practices from which to choose. These practices must meet two tests - they must be effective in meeting the resource protection objective, and they must be feasible (cost-effective) for a producer to implement. By working with producers to install practices, the partnership will be in a position to identify where practices must be refined and where additional research is needed (such as manure management and land application to crops).

A problem-solving approach to compliance. As described above, a local, non-regulatory partnership will replace a regulatory or enforcement program to ensure most effective adoption of improved practices. Through this same partnership producers will be granted flexibility while installing corrective actions where problems are encountered. This involves employing the same personnel who assist producers with their plan to help resolve cases of actual or suspected non-compliance. For example, where a problem (e.g., delay in a producer's construction schedule, a structural failure, poor housekeeping) is identified through routine on-farm visits, a producer receives a recommendation for corrective measures, and is allowed a specified period of time during which no regulatory enforcement will occur to work with partners (Soil and Water Conservation Districts, NRCS, private. consultant engineers) to solve the problem. This provision, sometimes referred to as safe harbor, facilitates greater efforts by producers to identify problems, helps producers apply their resources directly toward fixing the problem, and gives producers credit for successful problem-solving. It also achieves greater and more timely compliance with resource protection objectives at a reduced cost to the public.

The Department is working with producers, the Florida Farm Bureau, legislators, and the Department of Environmental Protection to develop and implement this approach. While specifics are uncertain as of this writing it is anticipated that voluntary, incentive-based approaches will play a significant role in responding to these animal waste management issues. Soil and Water Conservation Districts will play a crucial role in this process, by providing a local, non-regulatory partner through which resource management services can be delivered to landowners, and through which landowners and producers can receive additional benefits in dealing with regulatory requirements.

Role of Water Management Districts in the Production of a Wholesome Food Supply

Jerry Scarborough

Every three-and-a-half minutes, one acre of Florida farmland is lost to development; and we are fast becoming a state at risk of destroying what remains of our rural heritage. A report prepared by American Farmland Trust (1992) shows that Florida has the highest conversion rate of farmland in the nation. This alarming trend is being repeated in rural communities all across America, but what I want to address is how we can -- and must -- reverse that trend here in Florida.

Agriculture has always been, and always will be, extremely important to our state. In 1995, Florida farmers led the nation with 20 major agricultural products including fruits vegetables and houseplants. They produce 7.5 percent of the nation's citrus, 10 percent of its vegetables, and 2.5 percent of its domestic sugar supply.

Florida is the nation's 9th leading agncultural state, with cash receipts totaling $6 billion annually. Annual average farm employment exceeds 80,000 people, and farm-related economic activity generates more than $18 billion each year.

But urban development and competition from foreign imports are tightening the noose around Florida's ag industry. It is therefore incumbent on all of us to become partners with growers and producers, working together to ensure agncultural sustainability and environmental protection.

I've been invited here today to talk about the role of water management districts in the production of a wholesome food supply. I can tell you what the districts are doing to help keep agriculture alive and well in Florida -- but as for the wholesome part, I'll have to leave that up to the farmers!

Raised on a farm in rural Suwannee County, I've come to learn a little bit about agriculture. I've seen the ups and downs that farmers have faced over the years, and understand their economic struggles. I also value the quality of life found in our rural communities.

The Suwannee River region is one of the most beautiful and unspoiled parts of Florida, *so* I know how vital it is to protect and preserve our natural resources. I believe the regional water management districts are uniquely qualified to lead the way in finding creative and cost-effective ways to help meet the needs of local farmers and at the same time fulfill the districts' mission.

And what exactly is our mission?

When the districts were created by the legislature in 1972 under the Florida Water Resources Act, we were told to control two things: flooding and water supply. Eleven years later the legislature gave us stormwater permitting responsibilities. The State also has expanded our duties to include wetlands permitting, water well construction permitting, and land acquisition and management.

Critics argue that water management districts have grown too big, and we've often come under fire for branching out into programs that some consider to be outside of our primary purpose. Maybe we have grown and stretched beyond our original scope. But as times and circumstances change, so do the ways by which we must address our state's complex environmental and economic needs.

The role of water management districts today and in the future will require a new way of operating, which I can sum up in one word: partnerships. It will mean shifting away from traditional regulation to a more cooperative spirit between government and those who are governed. It will mean streamlining the permitting process, and replacing penalties with incentives as the preferred means of encouraging stewardship and compliance.

We have a better understanding today than we did in 1972 about how land use and water use are closely linked. We've discovered that good water management requires good land management -- you cannot separate the two. Improved technology now offers us solutions we've never had before, especially in the field of agriculture.

Central to agncultural sustainability is the availability of water. The districts' role as we enter the 21st century will be the same as it's always been -- to determine how much water is available for use, to protect the quality of that water, and to help develop more efficient methods of conservation and distribution.

What will that mean to the farmers?

Right now, agncultural irrigation accounts for nearly half (49.7%) of all freshwater withdrawals. In the 40-year period between 1950 and 1990, agricultural water withdrawals jumped by 915% statewide:

J.A. Scarborough, Executive Director, Suwannee River Water Management District, Live Oak, FL. Manuscript received 12 March 1997.

1950 - 315 mgd
1970 - 2100 mgd
1990 - 3805 mgd

I am happy to report, however, that total freshwater withdrawals decreased by 281 mgd between 1990 and 1995, from 3805 mgd to 3524 mgd, according to preliminary figures compiled by the US in Tallahassee. This is due to a number of factors, including the use of more efficient irrigation techniques, and a willingness to rely less on freshwater and more on alternative sources. The water management districts are committed to working with agriculture to find ways to achieve even better results.

Each district is in the process of establishing minimum flows and levels for the ground and surface water resources within its region. This means calculating how much water flows in our rivers, lakes, streams and aquifers during various times of the year, and determining how much water can be withdrawn for human use. without causing harm to the natural systems. The districts will use these calculations as part of the basis for reviewing requests for water use. permits. We're also supporting legislation that would allow us to issue long-term consumptive use permits, valid for 20 years, to applicants who use conservation techniques or who rely on alternative water sources.

In response to recommendations made by the Water Management District Review Commission in late 1995, the districts, along with the Florida Department of Environmental Protection (DEP), Florida Department of Agriculture and Consumer Services (DACS), and the Florida Game and Fresh Water Fish Commission (FGFWFC), signed a memorandum of understanding to work together to streamline, consolidate and simplify the existing agricultural permitting process. We've all agreed to develop voluntary, incentive-based alternatives to traditional permitting for agricultural activities, and we formed the Agricultural Regulatory Streamlining Group (ARSG) to accomplish these tasks.

Currently the group is evaluating the Environmental Resource Permitting (ERP) process as it relates to agricultural activities. The group is working to: clarify existing statutory exemptions; develop more consistent rule exemptions, develop streamlined (Notice General) permits for specific ag activities under ERP; and make it easier to obtain and comply with ERP permits through 1) permit consolidation, 2) team permitting, 3) one-stop permitting.

The group's intent is to create more consistency and uniformity in the statewide ERP agricultural program, while at the same time allowing for some variation based on regional differences in water resources, agricultural practices and water management district priorities. Throughout this process, the group will seek input from the ag community around the state.

The districts also are expanding their efforts to develop alternative sources, especially in regions experiencing declining or deteriorating freshwater supplies. Farmers are encouraged to use desalinated or reclaimed water, which are highly suitable for agricultural use, in combination with more efficient irrigation methods. Four of the five districts offer a matching grants program to assist agriculture and other users in developing alternative water supplies.

Working together hasn't always been easy, but I think we're all getting better at it. The level of trust and communication between the districts and the agricultural community is good and getting better, because we realize we have more to gain as partners than as adversaries.

Each time we work through a challenge and can point to a success story, we are more encouraged about our chances to resolve future differences. Let me share a few of those success stories.

For years, farmers in Indian River County had depended on the Blue Cypress Water Management Area to provide surface water for imgation and freeze protection, and as a place to store floodwater from their lands. The area also was designed to divert agricultural runoff from the rest of the St. Johns Marsh.

But the area was found to be a nesting site for the endangered Everglades snail kite and its primary food source, the freshwater apple snail. Officials were concerned that water withdrawals for irrigation and freeze protection might impact the lutes and their only food source. They were also concerned about the potential affects of farm runoff on the water quality of the marsh. At the request of the U.S. Fish & Wildlife Service, a management plan was issued to control water withdrawals from the area.

This created hardslup for local farmers and citrus growers, and hard feelings between them and government In an effort to meet the needs of farmers and still protect the endangered kites, the St. Johns River Water Management District arranged meetings between the state and federal agencies, University of Florida fish and wildlife researchers, and farmers and growers.

The result was a series of studies followed by recommendations for alternative water sources and agricultural runoff arrangements. It was also decided that growers could conduct short-term freeze protection withdrawals without harming the ecosystem.

Another example is the Southwest district, which has been working to improve relations with the ag community through its Agriculture Surface Water

Management (AGSWM) program that offers farmers an alternative to formal permitting. The St. Johns and Suwannee districts also have similar programs in place.

In the Middle Suwannee basin, where we've recently seen an increase in nitrates in our rivers and springs, the Suwannee district is working with the Natural Resources Conservation Service (NRCS) on a PL-566 cost-share program to install best management practices at 44 local dairy operations. We were able to add $1.2 million in SWIM (Surface Water Improvement and Management) dollars to NRCS funding for the installation of site-specific best management practices (BMPs) which will provide economic benefits to farmers as well as benefits to the environment.

Most of my remarks have been directed toward the dairy, field crop and citrus producers, but I don't want to fail to mention what we're doing to assist another very important segment of the agriculture industry -- aquaculture.

A record $73 million in aquaculture products was sold in 1993. The aquaculture industry depends more than anything else on clean water, and the districts are working to ensure that our coastal areas have good water quality to support them.

We continually monitor inland and upstream activities to make sure they don't adversely impact the water quality in downstream shellfish harvesting areas. Where we find problems, we try to help fix them. A good example is the wastewater treatment project for the Town of Suwannee in Dixie County.

In 1991, the U.S. Food and Drug Administration (FDA) ordered the closure of Suwannee Sound for shellfish harvesting, due to high bacterial contamination caused by poor septic systems in the Town of Suwannee. To help preserve and protect the area's water resources and the local shellfish industry, the District allocated $25,000 for a detailed feasibility study that addressed the town's wastewater treatment needs. The District also helped local city and county officals obtain $8.4 million in federal grants and loans, and groundbreaking on the project took place in June 1996.

The Suwannee district also recently agreed to purchase Atsena Otie island off of Cedar Key. Residents there were concerned that planned development of the island would create water quality problems, and threaten the lucrative local shellfish industry. The district agreed to help Levy County seek grant funds for the land purchase and, if none were available, to acquire the land until such time as the county could purchase it.

Should the districts be in the real estate business? when the end result is the protection of our natural systems, I would say the answer is a definite "yes."

Should we help local governments to design stormwater plans? When we have the fmancial and technical means to assist those who do not have adequate resources, again I would say the answer is yes.

Turning to water quantity, Levy County farmers in our district recently agreed to participate in a voluntary pilot project to install time totalizers to measure agricultural water use. Until now, the Suwannee district has depended on a voluntary self-reporting system which, quite frankly, has not been very successful in terms of willing or consistent participation. The return rate on our twice-yearly water use surveys has been low, about 17%-20% District-wide. We're now looking at the possibility of requiring the use of more traditional means of reliable data collection.

The only available statewide water use numbers are the ones compiled every five years by the U.S. Geological Survey, and those figures alone are not always a true reflection of agncultural water use. Climate conditions, gain or loss of cropland, and even the definition of what constitutes "agricultural" use tend to blur the picture somewhat.

Collectively, the districts must find ways to: use more accurate, consistent reporting and collection methods; eliminate some categories that fall under the definition of agricultural use"; clarify the "gray areas" in our permitting rules, and figure out how to factor in all of the variables. We may discover that farmers are using less water than we thought. Or some farmers may discover they are using more water than they need for a crop, and as a result will look for more efficient and economical ways to irrigate.

Finally, the water management districts can and should support state and local efforts to preserve agricultural lands. This can be done through conservation easements and PDR (purchase of development rights) programs; Blue Belt laws or other tax incentives; and creation of voluntary agricultural districts

These programs offer financial relief to cash-strapped farmers who might otherwise have to sell their land to developers. It also keeps valuable and productive agricultural lands under private ownership and on county tax rolls.

Keeping land in agriculture and open spaces is good for the environment and the economy. It also provides many environmental benefits. Unpaved lands serve as aquifer recharge areas, floodwater storage areas, and habitats for plants and animals. They serve as buffers between urban development and the state's natural areas, providing scenic and open spaces enjoyed by outdoor recreationists and ecotourists.

The 1996 Farm Bill has made millions of

dollars available through a new Farmland Protection Program that matches federal fundswith state and local money for the purchase of conservation easements. Last year the St. Johns district received $400,000 to arrange a conservation easement in Osceola County aspart of the Upper St. Johns project Other districts will likely submit their own proposals in the future.

During the 198Os, a poll was conducted by American Farmland Trust and the Soil and Water Conservation Society to find out what Americans thought about the need to preserve farmland. Urban residents, farmers and rural landowners all expressed overwhelming support for farmland protection programs: 73% of the general public said that good farmland should not be used for houses and industry;77% of the general public agreed on the need for a government policy to protect Florida's best farmland from urban growth, and 65% of the general public supported providing economic incentives to farmers to keep their land in farming.

The reasonis simple: American consumers still want to see home-grown food on their tables. We know that U.S. farmers must meet the highest food production standardsin the world. We want to be able to enjoy juicy Florida oranges, fresh Plant City strawberries sweet Zellwood corn and North Florida potatoes. I can't imagine a summer picnic without iced-cold watermelons, boiled peanuts, or that favorite of all Southern dishes -- fried, baked, or barbecued chicken - all of which are produced right here in Florida.

We don't want to see our rural areas or way of life disappear. Agriculture is an important part of our heritage and of our future.

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Role of Conservation Tillage in Production of a Wholesome Food Supply

***Raymond N. Gallaher and Larry Hawf**

INTRODUCTION

Erosion of farmland continues to be a major conservation issue facing the United States today. Agricultural lands can lose many tons of valuable topsoil to wind and water erosion, as much as 20 large truckloads/yr from an average-sized farm. This much soil can change the course of a river, altering ecosystems by destroying fish spawning areas and preventing light from reaching aquatic life. In addition, eroded soil carries nutrients, pesticides, and other harmful chemicals into rivers and streams (Gallaher and Lauret, 1983).

Most of the Southern states have a high average annual rainfall and are subject to flash flooding. Erosion from rainfall is a major problem. While the flat lands of some areas such as in Florida, are less likely to erode, sandy soils and heavy rainfalls make erosion and related water quality problems a concern for farmers to deal with. A Best Management Practice, or BMP, which reduces soil erosion and protects water, while at the same time increasing land productivity and conserving fuel, is conservation tillage. The objectives of this paper are: 1) to provide a review of conservation tillage management, 2) to present mformation on new emerging biotechnologies and equipment impacting conservation tillage, and 3) to provide information on changing trends in farmer adaptation.

DEFINITIONS

Conservation tillage - Any tillage and planting system that covers 30% or more of the soil surface with crop residue, after planting, to reduce soil erosion by water. Where soil erosion by wind is the primary concern, any system that maintains at least 1,000 lb/a of flat, small grain residue equivalent on the surface throughout the critical wind erosion period (Anonymous, 1996a). No-till, no-tillage, ridge-till, mulch-till, row-till (in-row subsoil no-tillage; drip-tillage), minimum tillage, etc. are examples (Anonymous, 1996b).

No-till - Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. The soil is left undisturbed from planting to harvest except for nutrient or pesticide injection. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control (Anonymous, 1996a; 1996b).

Ridge-till - Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. The soil is left undisturbed from planting to harvest except for nutrient injection. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation (Anonymous, 1996a; 1996b).

Mulch-till - The soil is disturbed prior to plantmg. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. Weed control is accomplished with herbicides and/or cultivation (Anonymous, 1996; 1996b).

Strip-till (Row-till or in-row subsoil no-till) - Planting is accomplished by use of a subsoil unit following in sequence after the no-tillage coulter. Subsoil depth is extended 2-in below the average hardpan layer. The subsoil slot is closed immediately with coulters or other appropriate devices following the subsoil units and in front of the seed placement attachments. Approximately 3- to 6-in of bare soil seedbed is prepared over the row with minimum disturbance of crop residue between the rows. Injection of fertilizers and pesticides can be accomplished in the row area during the planting operation. The soil is usually left undisturbed from planting to harvest. Weed control is accomplished with herbicides and/or cultivation (Anonymous, 1996b; Gallaher and Lauret, 1983).

Reduced tillage/minimum tillage - Tillage types that leave 15-30% residue cover after planting or 500 to 999 lb/a small grain residue equivalent throughout the critical wind erosion period (Anonymous, 1996a; 1996b; Gallaher and Lauret, 1983; Gallaher, 1980).

Conventional tillage - Tillage types that Leave less than 15% residue cover after planting, or less than 500 lb/a of

[1]R.N. Gallaher and [2]L. Hawf, [1]University of Florida, Institute of Food and Agricultural Science, Gainesville, FL, and [2]Monsanto Chemical Co., Sasser, GA.
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small grain residue equivalent throughout the critical erosion period. These types generally involves plowing or intensive tillage where seedbed preparation is by use of cultivation equipment such as harrows, moldboard plows, offset harrows, subsoilers and/or rippers (Anonymous, 1996a; 1996b; Gallaher and Lauret, 1983).

Multiple cropping - Intensive cropping *systems* where two or more crops/yr are grown on the same land area (Gallaher and Lauret, 1983).

Double cropping - A form of multiple cropping where two crops are grown on the same land area in one yr, usually in sequence, like wheat *(Triticum aestivum* L.) followed by soybean *(Glycine max* [L.]Merr) (Gallaher and Lauret, 1983).

CONSERVATION TILLAGE AND WATER QUALITY

Since conservation tillage disturbs less soil than conventional tillage, wind and water erosion is reduced (Langdale and Leonard, 1982). Conservation tillage is usually practiced in combination with multiple cropping where the second crop is planted in the residue of the first crop. This residue acts as a mulch to conserve moisture and protect soil (Gallaher, 1977).

THE BENEFITS OF CONSERVATION TILLAGE

Conservation tillage is well-suited to the South, especially in Florida's sandy and medium-textured soils. In addition to soil and water conservation, this farming method has several other benefits (Gallaher and Lauret, 1983): 1) fuel is saved because fewer trips over a field are necessary, 2) higher yields often result due to compatibility with multiple cropping, 3) land use is intensified since it is possible to plant a second or third cash crop without delay of elaborate seedbed preparation; 4) lower-cost land can be farmed because it is possible to plant row crops on sloping pasture land; 5) soil structure is improved near the soil surface due to organic material in residue, particularly if burning of residue is required under conventional tillage; 6) time and labor are saved throughout the season because of fewer field operations; 7) machinery costs are lower, since only one machine is required, and 8) stress of drought is reduced because a more vigorous root system is fostered, especially with in-row subsoil no-tillage systems (Gallaher, 1980; Gallaher and Lauret, 1983; Langdale and Moldenhaure, 1995; Anonymous, 1996a).

PROBLEMS

The risk that weed control will not be effective is a major drawback associated with conservation tillage. Herbicides often developed for use in conventional tillage have been adapted for control of grass and broadleaf weeds in conservation tillage management. Only in the last few years have new herbicides been developed specifically for conservation tillage systems. These new herbicides have lessened the weed control problem to a large extent Other disadvantages of conservation tillage are: 1) herbicides necessary to make conservation tillage a success may be costly; 2) some pests can be more troublesome because crop residues are a haven for breeding insects and diseases (A spraying program may have to accompany the practice of conservation tillage in some instrances); and 3) if farmers do not have up-to-date equipment they must plant about 10% more seed since seed may not be uniformly buried in rough seed beds. However, subsoiler attachments can alleviate this problem, as well as new planters specifically designed for conservation tillage.

HOW TO DO IT

Careful management of fertilizer is essential for the success of most conservation tillage cropping systems because, in most cases, fertilizer lies on the soil surface, not in it. However, with in-row subsoil planters it is possible to have greater precision of placement of fertilizers in the soil and at specific distances from the seed being planted. When legumes like soybean and peanut *(Arachis hypogaea* L.) are part of a multiple cropping operation, less fertilizer may be needed because the legume creates its own N, enriching the soil for the next crop as well. These legumes may also obtain recycled nutrients from the previously fertilized crop in the sequence. Data shows that many multiple cropping systems, dependmg on the soil type, can be fertilized effectively with a one-time application of lime, P and K in the fall. In extremely sandy soils, more fertilizer may need to be applied with the second crop as well.

Growers who opt for a conservation tillage/multiple cropping system sometimes need to step up their application of pesticides. The reduction of intervals between crops may not leave enough time for roots to decompose and cause root pests to flourish. On the other hand, selecting some cropping sequences may result in reductions of crop pests (Gallaher et al., 1988). Crop rotations have been used historically and continue to be used today to aid in control of pests (Gallaher et al., 1988; Gallaher et al., 1991; McSorley and Gallaher, 1994; 1995). Wise use of crop management strategy can result in reduced need of pesticides if proper selection of herbicides, insecticides, and nematicides are chosen.

CROPS FOR CONSERVATION TILLAGE

Soybean planted in small grain residue is the most widely used no-tillage double cropping system in the Southeast, and probably the world, among agronomic crops. In some areas of the United States, more than 50% of corn *(Zea mays* L.) and soybean are grown by conservation tillage (Anonymous, 1996). Generally speaking, the most common crop combinations are: 1) soybean, grain sorghum *(Sorghum bicolor* [L.] Moench), and forage crops following small grain (for grain); 2) field and pasture crops following corn; 3) corn, grain sorghum, and soybean following green manure crops, like vetch *(Vicia vilosa* L.), lupin *(Lupinus angustifoilus* L.), crimson clover *(Trifolium incurnatum* L.), and rye *(Secale cereale* L.); and 4) corn, soybean or grain sorghum following temporary winter pasture, like rye, oat *(Avena sativa* L.), and ryegrass *(Lolium* spp.) (Gallaher, 1980; Gallaher, 1981a; 1981b; Gallaher, 1989. Experimentation and some application is on-going with many other agronomic and horticultural crops such **as**: tobacco *(Nicotiana tabacum* L.), cotton *(Gossypium hirsutum* L.), squash *(Cucurbita pepo* L.), okra *(Hibiscus esculentus* L.), bushbean *(Phaseolus vulgaris* L.), sweet corn, and cowpea *(Vigna unguiculata* [L.]Walp.).

EQUIPMENT

The availability of planting equipment designed to operate underunplowed stubble or mulched conditions is another reason for the rising popularity of conservation tillage. Several makes of planters and drills are now on the market. A good planter and associated tractor can be adapted so that application of herbicides(s), insecticide, and fertilizer can be performed in a single pass over the field. Even with all the successes with conservation tillage there may be times when the moldboard plow will still have to be used. Past and present research indicate that elimination of conventional tillage may be possible, particularly with the in-row subsoil (row-till or strip-till) equipment. If tillage does become necessary, it is possible to plow part, say 25%, of the area over the row each year. Strip-tillage allows seedbed preparation over the row, while allowing crop residue to remain for conservation uses between the rows to offset the need to plow.

NEW BIOTECHNOLOGIES AND EQUIPMENT

New discoveries in biotechnology are quickly providing cultivars of crops that have been altered to be resistant to herbicides and other chemicals. New biotechnologies to be discussed in this presentation will include: 1) Roundup Ready (RR) crops (Woodruff, 1997) such as soybean and cotton, 2) Liberty Link corn, 3) *Bacillus thurgiensis* (Bt) technology, etc. Additionally, this presentation will include information on new equipment inventions, such as various versions of the hooded sprayer that allows the safe and effective use of previously unusable herbicides. These new and emerging technologies are having a significant impact on the ability to use conservation tillage management on previously difficult situations and thus providing for the conservation of our natural resources and a greater sustainable agriculture for the future.

ADOPTION OF CONSERVATION TILLAGE

It has been reported that there are 149.7 million a of highly erodible land in the U.S. Of this acreage, indications are that 127.2 million acres are currently reported as "adequately treated." Total U.S acreage in crop production was up in 1996. Total cropland planted in 1996 was 290.2 million a, compared to 278.6 million in 1995. The increased cropland acres planted in 1996 likely reflects land returned to production following the end of commodity-based, government set-aside programs.

Conventional-till gained 1.9 million a for a total of 115.5 million a in 1996. Over the last 8-yr, conservation tillage systems have experienced phenomenal growth. For example, in 1989 the U.S. had 71.7 million planted a of conservation tillage (25.7% of U.S.total). In 1996 conservation tillage had increased to 103.8 planted a (35.7% of U.S. total). The upward trend continued in 1996 over 1995. In 1996, no-till increased 2 million planted a for a total of 42.9 million a. Mulch-till gained 2.9 million a for a total of 57.5 million a. Ridge-till was unchanged at 3.4 million a. Reduced-till gained 4.7 million a for at total of 74.8 million a. Two of the Southern states are among the top five no-till states in the U.S., based on % of acres planted to no-till in 1996. These states are, number one Kentucky with 51% and number three Tennessee with 44%. The Southern states had a total of over 17.2 million conservation tillage planted a in 1996 (Anonymous, 1996a). New discoveries in biotechnology, equipment, and production research, education and communication efforts, and the continual improvement in the U.S. agricultural infrastructure, among all those involved with the production of a wholesome food supply, should keep this upward trend of conservation tillage planted acreage on the move.

Conservation tillage technology advancements are not only on the move in the U.S.A. but are also rapidly advancing in other parts of the world (Gallaher, 1981a; 1981b; 1989; Landers, 1996). One example is the Brazil, where in 1981 there were only a few thousand a of no-sage planted crops (Gallaher, 1981a) and today there are almost 14 million planted a (Landers, 1996). This same phenomenon is occurring in Canada, Australia, Europe, Africa, Asia, etc. As in the U.S.A., conservation tillage farmers all over the world are living in harmony with their environment and doing their part to not only provide a wholesome food supply for people today but also are providing for a more sustainable agriculture for future generation to come.

HOW TO GET HELP

Many types of conservation tillage require an innovative, highly skilled, and informed individuals who want to make the management work on their farm. Therefore, if you are considering conservation tillage, learn before, not after you make mistakes. Attend short courses, conferences, field days, and demonstrations. It is best to test conservation tillage, especially no-tillage, on a small scale acreage first. The USDA-Natural Resource Conservation Service (NRCS) in your district may know of conservation cost-share programs for small-scale learning. The USDA-NRCS can help with farm plans that include conservation tillage. The Farm Service Agency may be helpful as well. Major companies who manufacture conservation tillage equipment or make and sell products for conservation tillage management of weeds, insects, and diseases in cropping systems have college-trained personnel. These individuals can also provide expertise to those beginning into conservation tillage as well as those who are established conservation tillage producers.

Because planning is so important for successful conservation tillage management, you will benefit from guidance of your county Extension agent. The agent can advise you of the conservation tillage/multiple cropping system best suited to your land and crops. Several publications related to conservation tillage and multiple cropping are available through the county Extension service.

CONCLUSIONS

Conservation tillage is a BMP that guards water quality and controls erosion as well. For maximum conservation of soil and water, you may want to develop a conservation plan of BMPs that includes a conservation tillage/multiple cropping system. Your USDA-NRCS can assist in developing such a plan. Others in the farming infrastructure of research and extension can help solve and provide answers to make your operation successful. Industry is indispensable in this infrastructure as well. The seed, chemical, fertilizer, etc. industries have products and expertise to aid in your success with conservation tillage/multiple cropping systems. Utilizing knowledge from all of the partners involved with production of a wholesome food supply, while adopting conservation tillage management, will help ensure a greater sustainable agriculture for future generations.

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Sustainable Agriculture in Production of a Wholesome Food Supply

E.T. York, Jr.

Agricultural Sustainability

I have been asked to discuss the topic of agricultural sustainability and the global challenge of meeting the wholesome food supply needed for an ever-increasing population.

Sustainability concepts have been applied in some disciplines for many years. However, the term "sustainabilitycame into widespread use within the past 5 to 10 years when it began to be applied primarily to Third World development issues.

During the 1980s there emerged a growing, global concern over the manner in which many of the earth's natural resources were being used and whether, with such usage, the needs of a steadily increasing population could be sustained. To put this concern in perspective, however, it should be noted that the 20th century has seen remarkable progress in all areas of human endeavor, such as education, medicine, industry, commerce, and agriculture. These advances have resulted in better living conditions, increased life expectancy, better educational opportunities and higher literacy rates, improved food supplies, better nutrition, and a general improvement in the quality of life for many (but not all) people around the world.

There is growing concern, however, that this progress may not be sustainable because, in making these advances, we have exhausted inordinate amounts of nonrenewable resources; we have used, misused, and abusedmany of our renewable natural resources; and we have contributed to the degradation of many facets of our environment in ways that could jeopardize the very future of humankind itself

While reflecting on this progress, it should be noted that millions of people around the world have not enjoyed the advances and improvements in living quality to which I have alluded. The global community is, therefore, faced with the challenge of trying to include those who have been largely by-passed by human progress while, at the same time, sustaining the progress that has been made by others. Moreover, there is need to do this in ways that do not limit the ability of future generations to enjoy similar progress.

E.T. York, Jr. Distinguished Service Professor, Emeritus, University of Florida, Gainesville, FL. Manuscript received 26 March 1997.

Commission On Environment And Development

This challenge was the motivation for the United Nations to establish the Commission on Environment and Development in 1983. This commission, chaired by Prime Minister Brundtland of Norway, was charged with the task of formulating long-term strategies to achieve sustainable global development by the year 2000 and beyond. In its 1987 report (Anon., 1987), *Our Common Future,* the commission defined sustainable development as "development that meets the needs of the present without jeopardizing the ability of future generations to meet their needs."

In applying these sustainability concepts to agriculture, a panel of the commission said, "Enduring food security will depend on a sustainable and productive resource base. The challenge facing governments and producers is to increase agricultural productivity and thus insure food security, while enhancing the productive capacity of *this* natural resource base in a sustainable manner."

The panel suggested the magnitude of this challenge in these words: "The next few decades present a greater challenge to the world food systems than they may ever face again. The effort to increase production in pace with unprecedented increase in demand, while retaining the essential ecological integrity of food systems, is colossal, both in its magnitude and complexity. Given the obstacles to be overcome, most of them man-made it can fail more easily than it can succeed" (Anon., 1987).

Trends In Agricultural Production

Given the emphasis that the commission places on increasing global food production to meet growing needs, what about current trends in agncultural production and prospects for meeting such greater needs?

Before World War II, most of the increase in global agricultural production occurred as a result of expanding cultivated areas - as more production was needed, more land was brought into cultivation.

The post-World War II period has seen an unprecedented growth in agricultural production. On a global basis, agricultural output has grown at a rate of approximately 2.5% per year. Moreover, this growth in global production has generally exceeded the growth in poulation, resuilting in an overall increase in per capita food production of approximately 0.6% annually between 1950 and 1986.

This growth can be attributed not so much to an expansion in the total area under cultivation but rather to a greater productivity resulting from the development and application of improved technology. This improvement in agricultural output was made possible not only by large production increases in industrialized regions, including Western Europe, North America, and Australia, but also in many Third World countries, especially Asia.

Hunger And Malnutrition Remain Serious Problems

With such growth, one might assume that global food supplies would be adequate; however, such statistics are often misleading. Africa, for example, has not shared in this impovement. In fact, for the past 20 yr or so, per capita production of food in Africa has declined at the rate of approximately 1% annually.

While average production in the other major regions of the world may reflect significant progress, there are extensive areas in Asia and Latin America that, for various reasons, have not enjoyed the progress necessary *to* accomodate basic food requirements. Moreover, even in regions that normally have good supplies, temporary shortages and even famine can result from war, floods, droughts, earthquakes, and other disasters that disrupt production.

The World Bank estimates that more than 700 million people, about one-third of the developing world population, do not receive enough calories for an active working life. Part of this difficulty grows out of a lack of purchasing power, which limits the ability of many of the worlds hungry and malnourished to buy the food that is available.

Future Prospects For Agricultural Production

If the sort of spectacular growth that has occurred in agricultural production in the last half of the 20th century has fallen short of meeting global food needs, what are the prospects of doing better - of more adequately accommodating these needs?

Current trends in food production do not offer great promise in this regard. Indeed, it is readily apparent that growth in agricultural production in much of the Third World is slowing significantly. For example, in four of the six developing country regions (North and sub-Saharan Africa, and South and West Asia), the annual growth in per capita food production was less during the last 9 yr (1977-86) of 1950 to 1986 than for the entire 36-year period. These data suggest that, in recent years, significant parts of the developing world are falling behind in efforts to meet growing needs for agricultural products.

Moreover, since 1986 there have been some sharp reversals in gains in cereal production. With only slight increases in cereal production globally in 1985-86, there were major declines in production in 1987-88. Brown (1988) indicates that in the mid-1980s, grain production plateaued in some of the worlds most populous countries - India, Indonesia, Mexico, and China - countries that earlier had enjoyed tremendous growth in cereal production.

Herdt (1988) and others have pointed to the closing gap between actual national yields of major food commodities and potential yields, as reflected by work at research stations. In tests at the International Rice Research Institute in the Philippines, maximum yields of rice *(Oryza sativa* L.), for example, have apparently not increased since 1965.

Many believe that the Green Revolution, which saw remarkable progress in cereal production in the last two to three decades, has essentially runs its course, and future advances in agricultural output will depend on further significant breakthroughs in the development of production technology through research.

Concerns Over Future Prospects

These trends are not encouraging. Moreover, there are ominous dark clouds on the horizon that suggest the problem could become much worse. Below is some evidence to support this contention.

Population Growth

The demand for food is steadily growing as some 90 million people are added to the global population annually. Significantly, more than 90% of this growth is occuring in the developing world, where serious problems of hunger and malnutrition already exist.

Arable Land

Another cause for concern is the growing difficulty in expanding areas of productive arable land well suited for cultivation. It is estimated that from 1975 to 2000, the area of cultivated land globally will expand only 4% while global population will increase approximately 40%.

Environmental and Natural Resource Degradation Problems

A third and most disconcerting concern related to agriculture's ability to achieve continued improvement in productivity is the belief by many that we are, in fact, compromising the ability of future generations to meet their food needs by our current misuse of the natural resources on which agriculture depends.

Nothing in recent years has captured the attention and generated the concern of the world community more than the evidence of serious global environmental and natural resource degradation problems. These problems include the rapid destruction of tropical forests, the increasing concentration of atmospheric CO, levels, and what some believe is the related global warming trend; the destruction of the ozone layer, as well as ozone pollution problems near the earth's surface; major problems of soil erosion; the contamination of underground aquifers, as well as lakes and streams; acid rain, and myriad other difficulties. Agriculture is viewed as a contributor to, as well as a victim of, some of these global environmental difficulties.

Agricultural Sustainability In The United States

As a consequence of many of these environmental problems, agricultural sustainability has emerged as a very prominent issue in recent years within the United States. The focus, however, has not been nearly so much on meeting global food needs as on environmental and natural resource issues.

Alternative Agricultural Systems

In recent years, the concept of alternative agricultural systems has evolved within the United States. Such a term refers to agricultural systems that are "alternative" to so-called "conventional" systems.

The U.S. Dept. of Agriculture (USDA) has defined alternative agriculture as "a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives to the maximum extent feasible...." Increasingly, the term "alternative agriculture" is being used to include what is commonly referred to as organic farming, regenerative agriculture, and low-input agricultural systems. In some circles, these alternative systems are being equated with sustainable agriculture. In fact, these terms are often used interchangeably. For example, Robert Rodale, the late head of the Rodale Institute of Pennsylvania, suggested that "sustainable was just a polite word for organic farming" (Anon., l989).

LISA (Low-Input Sustainable Agriculture)

The term "LISA," advanced by the USDA, has gained widespread use as a form of alterative agriculture. Many have stressed, however, that it is inappropriate to attempt to treat low inputs as synonymous with sustainability. Using commonly accepted definitions, sustainable systems may or may not involve lower inputs. Lower usage of herbicides, for example, may result in higher inputs of labor. Some have also objected to the imprecise nature of the term "low inputs." What inputs? Low in relation to what? How low?

It would appear that the basic concept of sustainability is being significantly distorted by the term LISA and by the manner in which alternative systems, such as organic farming and regenerative agriculture, are being equated with sustainable agriculture. Such alternative systems tend to focus primary attention on the goal of reducing or eliminating the use of chemical inputs-advocating in their place the use of animal and green manures, crop rotations, and other related practices.

Many of these practices endorsed by alternative-agriculture advocates have well-recognized merit. However, one must question the feasibility or practicality of generally incorporating many of these practices in U.S. commercial agricultural operations in ways that can achieve productivity and profitability objectives.

National Research Council's Report On Alternative Agriculture

In 1989, the National Research Council (NRC) of the National Academy of Sciences published what has become a highly controversial document entitled "Alternative Agriculture" (National Research Council, 1989). This report strongly espouses the merits of alternative agricultural approaches in contrast to conventional *systems.* Many individuals and groups have criticized the report, suggesting that it lacks the research information and background to justify its strong endorsement of alternative agricultural practices. Dean Kleckner, president, American Farm Bureau Federation, suggests that it gives "an inaccurate and too optimistic view of both the environmental and economic benefits of alternative agriculture" (Hileman, 1990).

The most comprehensive analysis and commentary of the NRC report was provided by the prestigious Council for Agricultural Science and Technology (CAST). More than 40 scientists provided commentaries on the report, and in June 1990, CAST representatives testified before a Joint Committee of Congress on the subject of alternative agriculture. CAST and its member scientists were generally complimentary of the goals of the NRC but highly critical of the techniques used in the study and the conclusions reached (Council for Agricultural Science and Technology, 1990).

More Balanced And Substantive Approaches

It should be noted that other individuals and organizations in the United States are approaching sustainable issues on a much more balanced and substantive basis by taking into account not only environmental issues, but also the productivity and economic viability of such systems.

The American Society of Agronomy, for example, defines a sustainable agriculture as "one that over the long term (1) enhances environmental quality and the resource base on which agriculture depends, (2) provides for basic human food and fiber needs, (3) is economically viable and (4) enhances the quality of life for farmers and society as a whole" (Wail, 1990). I think this is a very sound characterization of what sustainable agriculture is all about.

The Research Advisory Committee (RA) of the U.S. Agency for International Development (USAID) addressed at some length the issue of low-input and sustainable agriculture. In response to the contention by some that modem or conventional agricultural systems were not sustainable, RA said, '...Many modem agricultural production systems are not only sustainable, they have, in fact, created the fertility and resource base that sustains them. Some of the nation's most productive soils were once considered infertile and nonproductive.... Most low input systems require high labor input and are often characterized by low output." Michael Lipton, International Food Policy Research Institute (IFPRI), refers to the "dangerous nonsense of believing that one should strive for low input, high output agriculture" (Lipton, 1989).

John Ikerd, Univ. of Missouri, provides further perspective on this subject, suggesting that "...a sustainable agriculture must be made up of farming systems tha! are capable of maintaining their productivity and usefulness to society indefinitely.... In the long run, farming systems must be productive, competitive and profitable or they cannot be sustained economically. Also, systems must be ecologically sustainable or they cannot be profitable in the long run" (Ikerd, 1989).

It might be noted that USDA seems to be modifying its stance with regard to LISA. In a recent speech, Charles Hess, former USDA Assistant Secretary for Research and Education, said this about sustainable agriculture: "Overall, agriculture is endeavoring to operate in an environmentally responsible fashion, while continuing to produce both economically and profitably. Sustainable agriculture is most emphatically not a return to the 'low tech' production methods of the 1930s. On the contrary, it is the use of the very best in technology in a balanced, well-managed, economically viable, and environmentally responsible system" (Hess, 1991). To me, this is an excellent characterization of what sustainability is all about.

Public Concern About Chemicals

The great emphasis on alternative approaches to conventional farming methods results, in part, from the concern of many people about the potential harmful effects of chemicals. Unquestionably, problems have arisen from the use and, especially, the misuse of chemicals. Illnesses and even deaths have been caused by the use of pesticides, particularly by applicators who were not using the materials correctly. Certain pesticides have also caused damage to wildlife species, especially in earlier years when more persistent forms, such as DDT, were used. Furthermore, there is evidence that agricultural chemicals are finding their way into surface and subsurface water supplies.

How serious this problem may be is still subject to some conjecture. The fact that there may be minute quantities of chemicals in water supplies does not necessarily mean that such levels may pose problems to human health.

Chemicals And Human Health

If agriculture is to be sustainable, it must, among other things, provide safe and healthy food. There is growing evidence that the hazards of chemical residues on food are not nearly as great as some contend.

Sanford Miller, dean, Graduate School of Biomedical Science, Univ. of Texas Health Science Center, said, "The risk of pesticide residues to consumers is effectively zero." In referring to the Delaney Amendment, which could ban the use of any chemical that gives a positive test for cancer in rodents - no matter how low the concentration, Miller concluded, "If we apply Delaney (standards) to all foods, we would never get to die of cancer - we would all starve to death because we would have to ban all the foods we now eat" (Brookes, 1990).

Bruce Ames, professor of biochemistry and molecular biology, Univ. of California, Berkeley, suggests that 99.9% of all pesticide carcinogens now ingested by humans are natural, that is, they are generated as defense mechanisms within the plants themselves" (Brookes, 1990). He further reports on the level of natural carcinogens in various foods and says, "You get more carcinogens in a cup of coffee than in all the pesticide residues you absorb in a year" (Ames, 1991).

The U.S. Food and Drug Administration also contends that the risk from natural carcinogens in food is much greater than that from pesticides, suggesting that the public is worried about the wrong risk in their diets, partly because of the exaggerated news accounts of such scares as Alar in apples, cyanide in grapes, and dioxin in milk (Scheuplein, 1989).

Dr. Everett Koop, perhaps the most visible and respected U.S. Surgeon General in history, strongly opposed the recent "Big Green" initiative in California, saying that the banning of pesticides under *this* proposal would not have positive health effects and emphasizing that "public policy should be based on science, not on scare tactics" - such as those used by the Big Green proponents (Brazil, 1990).

Serious harm has been done to agricultural enterprises by scare tactics such as those claiming that Alar on apples represented a serious threat to human health. The assertion by Ed Bradley on the television show "60 Minutes" that "the most potent cancer-causing agent in ourfood supply is a substance (Alar) sprayed on apples to keep them on the tree longer and make them look better" (Bradley, 1989) proved to be totally unsubstantiated and, in fact, ludicrous. Yet the Alar episode *cost* apple growers an estimated $100 million or more in lost sales.

Thereis not much humor in situations like this - especially for those directly affected. Every now and then, however, someone comes along to inject a little humor into such matters and helps keep them in perspective. Recently, I came across an article by syndicated newspaper columnist Dave Barry entitled "Organic Gardening Concept Has Bugs In It" (Barry, 1991). Below are some excerpts from his column:

"Spring is here, and as an educated, environmentally sensitive nutrition fanatic, you should definitely think about organically growing your own h i t s and vegetables. What do we mean when we say 'organically grown' fruits and vegetables? Technically, we mean 'fruits and vegetables with insects living in them'. Insects are an important source of protein, which is highly nutritious.

Look at bats. Bats eat a lot of insects, and they're extremely healthy. They can spend a wild night of flying around screeching and sucking blood from unwary victims, yet when they get back to the cave they still have enough 'zing' left to sneak behind a stalactite for some hot sonar-enhanced sex...

This is in stark contrast to the average American consumer, who rarely makes it through the monologue on 'The Tonight Show.' Why? Because the average American consumer is eating SUPERMARKET fruits and vegetables, which are known to contain - prepare to be alarmed - chemicals.

Of course not all chemicals are bad. Without chemicals such as hydrogen and oxygen, for example, there would be no way to make water, a vital ingredient in beer. But many of the fruits and vegetables that you buy in supermarkets have been saturated with a class of chemicals that are defined, technically, as 'chemicals with long scary names,' such as dioxyethylickylucyBOOGABOOGAcide.' These chemicals can be harmful. In one laboratory experiment, they were fed to a group of rats for six months, at the end of which 68 percent of the rats had become cigarette smokers.

Why do fruit and vegetables growers put such dangerous substances on your food? Actually, there's a very sensible explanation: They want to kill you. No, seriously, they use chemicals for many good reasons, which will be thoroughly discussed about a week from now in an irate letter to the editor written by the attorney for the Fruit and Vegetable Growers Association.

Nevertheless, as a modern concerned paranoid consumer you should definitely grow your own food organically. We do this in our household. We have a tree in our yard, planted by the former owner, Bob, who told us that is was either a lime tree or a grapefruit tree, we forget which

We never put chemicals on it, and every year it produces a nice crop of organic units the size of either large limes or small grapefiuits with some kind of skin problem that looks like fruity leprosy. We monitor these units carefully until the exact moment when they have ripened to perfection, then we continue to monitor them as they fall on the ground and are consumed by gnats.

We've done this for two years now and have yet to notice any serious illness in the gnat community."

Yes, a sense of humor is helpful to put things in better perspective.

Despite widespread evidence that the health hazards of pesticides are often exaggerated, I would emphasize that it is incumbent on those in agriculture to do everything possible to reduce and, to the extent possible, eliminate such potential hazards. As long as the public perceives there to be a problem, there is, indeed, a problem. More research is needed with chemical inputs to determine optimum levels of usage while avoiding undesirable consequences, if any, from such usage.

Such research can undoubtedly lead to reductions in the use of some pesticides through various approaches, including the continuing development of genetic resistance to many plant diseases and insects. Research can also help develop more effective biological approaches to pest control, as well as improve systems of integrated pest management.

Opportunities to reduce the use of fertilizers are not as apparent as with pesticides, since agricultural productivity is often correlated very directly with levels of fertilizer use. The Food and Agricultural Organization (FAO) of the United Nations estimates that from 1965 to 1976, approximately 55% of the increase in crop yields in developing countries could be attributed to fertilizers (*Food* and Agricultural Organization, 1981).

Research must continue to determine what levels of fertilizers should be used to meet the demands for agricultural products and give the producer adequate economic return, as well as ensure adequate food supplies at a reasonable cost to consumers. Where fertilizers contribute to environmental difficulties, such as nitrate or phosphate pollution of water sources, research must be accelerated to develop the means of overcoming these problems.

An Antiscience Bias

There seems to be a significant antiscience bias that characterizes much of the current alternative-agriculture movement. Such attitudes are truly unfortunate because the challenge of achieving sustainable agricultural systems rests, in large measure, with scientific institutions. Science is not the problem.

Indeed, science offers the key to achieving sustainable systems. Traditional agricultural systems were sustained indefinitely until greater demands were placed on such systems by increasing population pressures. Research is essential to develop the technology needed to sustain these systems at levels above their natural steady state.

Research must focus increased attention on developing and applying the technology needed to achieve both the economic and ecological dimensions of sustainability. The planet Earth cannot achieve a sustainable agriculture and meet the ever-growing needs of people without the use of modern technology, including the appropriate usage of agricultural chemicals.

Humanity In Harmony With The Environment

A long-time friend and colleague, Orville Freeman, former U.S. Secretary of Agriculture, recently sent me a copy of a speech he had given at the World Future Society Conference dealing with the future of the biosphere. In his paper, "Humanity vs. Environment," Freeman addressed the basic dilemma of protecting our planet's environment while feeding its rapidly growing hungry population (Freeman, 1989). He referred to those who oppose the use of modem technology to improve food production for fear of contributing to environmental problems and responded to such arguments by emphasizing that humanity's need for food will not be met without the use of modem technology. I agree fully with such as assessment. And I would add that science and technology can and must help deal with those problems that might grow out of the use of such technology.

The issue is not one of humanity vs. the environment This suggests some irreconcilable conflict that I do not believe exists. Perhaps a more appropriate title would be "Humanity in Harmony with the Environment." This is what we must strive to achieve - helping agriculture and, indeed, all of humanity to become truly in harmony with the environment.

The agricultural science professions have a great challenge to contribute to such an objective. I commend you for what you have already done in this area and wish you well in future efforts.

It is a great pleasure to be with you.

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Recycling Urban and Agricultural Organics in Fields and Forests

***Wayne H. Smith and Aziz Shiralipour**

About 750 million dry metric tons of biodegradable organic wastes are produced annually in the US. The 1995, official Florida population was more than 13.8 million and the total amount of municipal solid waste produced annually grew to about 24.3 million tons (Anon., 19%). This translates into 9.6 lb/person/d or 1.7 ton /person/yr. On a per capita basis, Floridians generate twice the national average. The total organics stream includes materials produced by livestock, crop residues, biosolids, food processing, logging, and wood manufacturing, other industries, and municipal refuse. The current method for processing of organic residues leads to environmental problems and is not sustainable. However, there is a growing recognition and appreciation of the need for and the benefits resulting from effective management of biodegradable organic materials, to the point that such materials are often regarded as resources. Because of this, alternative methods of organic material recycling and processing which promote conversion to useful products are being advocated. Cost-effective integrated organic resources management to provide soil amendments and other useful products linked to a system to redirect the products to beneficial uses would lead to sustainable ecosystems and solve the environmental and economic problems facing society.

Organic materials represent a significant quantity of feedstocks for conversion to compost, stabilized residues that can improve soil physical and chemical conditions. Utilization of organic material is of utmost importance in maintaining the tilth, fertility, and productivity of agricultural soils, protecting them from water and wind erosion, and preventing nutrient losses through runoff and leaching. Organic materials can also increase soil water-holding capacity, water infiltration, aeration and permeability, aggregation and rooting depth; decrease soil crusting and bulk density; keep soil organisms balanced; and reduce soil pathogens (Shiralipour et al., 1992).

Several ongoing projects coordinated by the UF/IFAS Center for Biomass Programs are designed to demonstrate the benefits and safe use of compost applications in various uses. There are *two* comprehensive statewide projects and several others that target specific uses. The two active comprehensive projects build upon an earlier large project addressing water conservation benefits (Smith, 1994; 1995).

W.H. Smith and Aziz Shiralipour. Center for Biomass Programs, University of Florida, Gainesville, FL. Manuscript received 31 March 1997. * Corresponding author.

A MARKET DEVELOPMENT PROGRAM FOR COMPOSTS IN FLORIDA

Demonstration of Safe Use of Compost

To remove barriers to compost acceptance, a set of projects was designed to: 1) demonstrate the biological and chemical remediation of pesticides during composting, and 2) compost maturity/stability measures important to N and toxic metal availability and accumulation in crop parts.

Demonstrate the biological and chemical remediation of pesticides during composting

Black Kow[R] manure compost and cornposts from various facilities in Florida were used for pesticide assays. A quality assurance (QA), quality control (QC) testing protocol was established for pesticide (endnn, lindane, methoxychlor, toxaphene) and herbicide (2,4-D, silvex) detection in compost. Samples tested thus far have confirmed the hypothesis that pesticides are not present in mature/stable composts. This is either from not being present to begin with or from remediation of the chemicals through the composting operation. Air-tight composters have been designed to study the bioremediation when composts are "spiked with known quantities of a pesticide. Radio-labeled atrazine is the model herbicide being used.

Compost maturity/stability measures important to N and *toxic* metal availability and accumulation in crop parts

Several methodologies were utilized to measure the maturity/stability of the compost products. These methods include total C/N ratio, water-extractable organic C and N and also its ratio, optical density of the water-extract, and respiratory study based on CO, evolution. The most reliable and clear indicator for compost maturity/stability was determined to be respiratory release of CO,.

Although the total nutrient and heavy metal quantity varied in different composts, in all cases, the levels were far lower than the limits established by Department of Environmental Protection (DEP) regulations. Waterextractable metals were low, verifying that the bioavailability of metals from these materials do not pose risks.

Demonstration of Compost Benefits

A set of projects was designed to demonstrate the benefits of compost applications to: 1) *sandy* soils used for vegetable crop production, 2) landscape beds to enhance establishment of woody ornamentals, and 3) turfgrass soils to determine effect on N release and on leaching of nutrients and organic compounds.

Several compost types were utilized in these projects, These included urban plant debris (yard waste) compost obtained from Enviro-Comp Facility (Jacksonville, FL), biosolids composted with UPD from Palm Beach Solid Waste Authority Facility (Palm Beach, FL), municipal solid waste (MSW) composted with biosolids from Bedminster Facility (Sevierville, TN), and MSW compost from Sumter County, FL.

Benefits of compost applications to sandy soils used for vegetable production

Thisproject was initiated to build upon the base knowledge obtained in 1992 and 1993. Compost was applied to tomatoes *(Lycopersicon esculentum)* planted in rotation with watermelons *(Citrullus lanatus)* and tomatoes in rotation with bell peppers *(Capsicum annuum)*. The results indicated that: a) immature compost delayed tomato plant growth due to N-rob; b) when tomatoes were planted in rotation following peppers grown in compost treated soil, yield of tomatoes was 30% greater than yield without compost treatment; c) watermelons planted in rotation following tomatoes produced 30% to 50 %yield increase compared to soil with no compost treatment; and d) compost increased soil organic matter concentration, water-holding capacity, soil mineral concentrations, and pH in proportion to rate.

The objectives of the subsequent project were to determine the optimum scheduling of compost applications for improvement of soil physical properties important to transplant health, stand establishment, crop yield, and crop quality. Although the bell pepper and tomato plants grew well in both compost-amended and unamended plots, benefits were obtained in terms of increased yield and fruitquality. Extra-large tomato yield was significantly greater where Enviro-Comp compost was applied compared to unamended soil. Marketable yield in 25-lb cartons/a was 1158 for Enviro-Comp in comparison to 939 for the unamended soil. The unamended treatment produced the largest yield of medium tomatoes (410 cartons in comparison to 325, 370, and 337 cartons for Bedminster, Palm Beach County, and Enviro-Comp, respectively), had the highest percentage of fruit with "yellow shoulder" (28% in comparison to 9%, 16%, and 7% for Bedminster, Palm Beach County, and Enviro-Comp, respectively), and produced the firmest tomatoes. Tomatoes from the Bedminster compost treatment took 1 to 1.5 d longer to naturally turn from green to red at room temperature (15.1 d in comparison to 13.5, 13.3, and 14.1 d for Palm Beach County, Enviro-Comp, and unamended treatment). There were no statistically significant differences among tomatoes for plant dry weight (195 g, 175 g, 165 g, and 174 g per plant for Bedminster, Palm Beach County, Enviro-Comp, and unamended treatment, respectively) or any of the other yield or quality variables measured (percent of fruit rots, fruit scars, fruit puncture, fruit cracks, fruitzipper, andfruitshrivel).

'Fancy' bell pepper yield was greatest in the Bedminster compost treatment compared to the other treatments (397 cartons compared to 323,335, and 349 for Bedminster, Balm Beach County, and unamended treatments, respectively). There was no differences in total pepper yield between the treatments (1335, 1325, 1340, and 1254 cartons for Bedminster, Palm Beach, Envirc-Comp, and untreated, respectively). The Enviro-Comp treatment produced the firmest peppers, and the unamended treatment produced the softest. There was no difference between treatments in terms of fruit color or post-harvest variables measured. Benefits were also evident with the spring watermelon crop (in the ground at the time of the reporting).

The soil water characteristic curve was determined for unamended sandy soil that was amended with the high rate of Bedminster (80 ton/a), Palm Beach County (27 ton/a), and Enviro-Comp (80 ton/a) composts. Soils used for the measurement of water-holding capacity were sampled from plots immediately after tomato and bell pepper seedlings were transplanted, which was 2 to 4 mo. after compost incorporation. Only the Enviro-Comp treatment showed slightly higher water-holding capacity than unamended soil.

Compost applied to landscape beds to enhance establishment of woody ornamentals

In earlier experiments, woody plants were grownin pots with media mixes. In the potting media, composted materials from various facilities were evaluated in treatments ranging from 100% compost to 100% replacement of just the peat portion of the container media. Biomass data were compiled for some woody ornamentals grown in containers with composts and compared to a control commercial mix. Biomass production in stand-alone composts was greater than in the control medium in many cases. Other compost treatments produced biomass levels similar or better than the control.

As a follow up, this project is determining if cornposts incorporated in landscape soils hastens establishment of container grown woody shrubs and the causes for the improved root growth and other biological measures associated with the compost application. Three types of composts (Bedminster, Palm Beach County, and Enviro-Comp) were applied at 1, 2, 3, and 4 in layers. Two irrigation regimes were applied: heavy irrigation (daily for the first 2 mo, every other day for the 3rd and 4th mo, and twice a wk afterwards) and light irrigation (every other day for the first 2 mo, twice a wk for the 3rd and 4th mo and once a wk afterwards). Compost treatments had no significant effect on estimated root mass for ligustrum *(Ligustrum* sp.). However, the control and the lowest levels of compost amendments had the greatest root mass for Viburnum *(Viburnum* sp). Imgation regime appears to have little effect on root growth of any species. Soil treatments, however, are having significant effects on root growth. Analysis of data suggests that canopy effects are opposite to those measured in the roots. Plants grown in highest levels of compost appear to have larger canopies and higher levels of tissue N. High N levels in the tissue my explain what appears to be lower root:shoot ratios. All compost amendments appear to have completely substituted for fertilization requirements. The optimum soil treatment to date appears to be 2 in of the Palm Beach County compost.

Effect of compost in turfgrass soils on N release and on leachig of nutrients

Earlier tests indicated that a rate of 30 to 70% compost to sandy soil in pots was optimum for growth and quality of turfgrass (St. Augustinegrass) *(Stenotaphrum secundatum)*. A municipal solid waste compost was incorporated into a fine sandy soil. Compost incorporation consistently increased the quality of St. Augustinegrass. Clipping weights generally were greater from compost amended plots. During dry periods, the established turfgrass did not wilt as quickly, thus reducing the frequency of irrigation.

Although composts contained nutrients in addition to those from fertilizer, nutrients in the leachmg water were reduced. In compost treated soil, pesticides were not detected in water leached from the soil. Compost treatments up to 30% resulted in improved nutrient retention (less leachmg). This project is determining the rate of N mineralization in three compost (yard trimmings, biosolids, MSW) and identifiig laboratory indices related to the mineralization.

Field, greenhouse, and laboratory studies were conducted subsequently to evaluate N release from three compost sources. The Palm Beach Solid Waste Authority biosolid compost had the highest content of N, and the Enviro-Comp had both the lowest content of N and the highest C/N ratio. Based on available mineralization data from the first year, Palm Beach compost released the greatest amount of N and the Enviro-Comp source. the least. No volatile or semi-volatile organic were found in $CaCL_2$ extracts from compost-topsoil mixes.

Evaluation of Composted Materials to be Utilized in Florida Road and Median Plantings

Under a grant awarded by the Florida Department of Transportation, the University of Florida's Department of Environmental Horticulture and the Soil and Water Science Department are conducting both field and greenhouse studies to evaluate and recommend specifications for compost as a soil amendment in roadside plantings. The 3-yr project will examine germination, growth, and establishment of utility turf in soil amended at three different rates with three types of commonly available, commercially produced compost and will evaluate turf response to the nutritional value of manure - and biosolid-based composts applied as top dressing.

The three types of compost utilized in the study are: 1) a straight yard waste compost provided by Enviro-Comp in Jacksonville and *AmeriGro* in south Florida, 2) a yard waste with biosolids compost provided by the Palm Beach County Solid Waste Authority, and 3) a municipal solid waste with biosolids compost provided by the Bedminster facility in Sevierville, TN. Because the study seeks to establish the high-end loading tolerance for the often poor and severely disturbed soils found along newly constructed roads, compost application rates in the field were 100,200, and 300 dry metric ton/ha. The compost is tilled into existing soil to a depth of 15 to 20 cm. The field study portion of the project is being conducted at sites in south, central and north Florida (Broward, Hernando, and Taylor counties, respectively).

Two greenhouse studies have been completed, and a third is under way in the University of Florida Envirotron in Gainesville. These tests use three soil types (< 1% organic matter, > 1% organic matter, and sand) and three rates of incorporation (15%, 30% and 60%) for each of the composts The amended soils and the controls are seeded with an 80:20 mix of bahiagrass (*Paspu1um notaturn)/bermudagrass (Cynodon dactylon* In addition to evaluating rates of germination, establishment, and yields, the investigators are collecting and analyzing pot leachates.

Preliminary plans for a field study evaluating several types of compost as top dressing for existing stands of grass have been developed and a site selected. Also, included in the project is a literature search, which has been conducted, as well as a telephone survey of Departments of Transportation in selected states regarding their specifcations for and utilization of compost. Telephone interviews have also been conducted with various government and private environmental and waste management agencies as well as with academic researchers at this and other institutions. The standards specified by the University of Florida team must go through the approval process and be finalized by the Florida Department of Transportation (DOT) before production of the educational materials for use with training DOT personnel.

Selected Projects

Below are some projects supported by the Center to position faculty to be competitive for extra-mural funding and/or solve short-term problems:

Impact of Compost on Plant Growth and Irrigation Demand (Demonstration)

Composted municipal solid wastes (MSW) from the Sumter County Solid Waste Facility were applied at the Alachua County Extension Office. The material was spread on the plot in a 4-in-thick layer (approximately 200 ton/a) and was rototilled to a depth of approximately 5 to 6 in.

Both areas, with and without the compost, were planted with identical landscape plants. For the large background plants, fetterbush *(Lyonia lucida),* radish palm (fam. *Palmae*), and needle palm *(Rhupidophyllum hysterix)* were selected. For medium size filler, dwarf nandina *(Nandina* domestica) and in the front, liriope (Liriope *muscari)* 'Evergreen Giant' were planted. After planting, the lateral lines of the irrigation system were installed and the area was mulched with pine straw. The addition of composted material resulted in significant water use reduction. The soil water potential remained higher for the longer time and the irrigation system did not operate as frequently. During the test period, the total water savings in the compost treated area were 12% compared to the untreated area

Municipal Solid Waste Compost Application to Annual Ryegrass

Municipal solid wastes (MSW) compost from Sumter County was applied and disked in at either 26, 52, or 104 dry tons/a (dt/a). For comparison, yard waste composts from three. sources were applied and disked in at either 9, 18, or 36 dt/a, and combined kitchen and yard waste compost was applied and disked in at either 4, 8, or 16 dt/a. These plots were compared to plots treated with 0,150,300, or 600 lb. N/a as ammonium nitrate. Annual ryegrass was grown and harvested monthly. Without irrigation, a good stand of ryegrass was achieved on plots treated with MSW compost. The rate of application that appeared to give the best growth was 52 dt/a for the MSW compost. The kitchen and yard waste combined compost applied at 8 dt/a resulted in the highest yields for that type of compost. All of the yard waste compost applications resulted in spotty germinatino and relatively reduced yield. It is expected this may be due to N immobilization or physical impedient of germination or reduced water infiltration.

Grass Forage Production Following Land Application of Urban Plant Debris.

Plots were set up in a Gilchrist County field where 200 ton/a of urban plant debris (UPD) had been incorporated into the soil without any processing 3 or 9 mo prior to planting. Nitrogen fertilizer was added at 0, 100, and 200 lb/a. Where UPD had been applied 9 mo before planting: sorghum-sudangrass *(Sorghum bicolor* x S. sudanense) showed no N deficiency, produced just as much without N fertilizer as with N fertilizer, and averaged 21 tons of fresh forage (2.5 tons of dry weight)/a. Where W D had been applied 3 mo before planting: sorghum-sudangrass growth was stunted without N fertilizer, yield was considerably less than where UPD had been incorporated for 9 mo, either 100 or 200 lb fertilizer N/a produced an average of 13 tons of fresh forage /a (1.4 tons of dry weightla), and yield without fertilizer N was 7.3 tons of fresh forage/a (0.8 ton dry wt/a).

Compost Application in Forests

Growth and elemental content of slash pine *(Pinus elliottii)* 16 yr after treatment with garbage composted with sewage sludge.

This study has assessed tree growth and elemental tissue concentrations in a slash pine In plantation treated 16 yr previously with four rates (0, 112, 224, and 448 metric ton/ha) of municipal solid waste (MSW) composted with sewage sludge. Tree growth was significantly greater where MSW compost was applied Stem wood biomass increased from 55.7 to 94.7 metric ton/ha, a 1.7-fold increase over the control for the heaviest compost application rate. Annual tree basal area increment responses were also largest and most long-lasting (up to 9 yr) for the 448 metric ton/ha rate. Significant but modest treatment-associated increases in concentrations of N, P, B, Fe, Al, and Zn in pine tissues (foliage, stem wood), and of P and Ca in Rubus spp., a dominant understory plant, were found after 16 yr. Analysis of pine xylem tissues corresponding to the juvenile and post-crown closure growth phases revealed significantly higher concentrations of K, Ca, Mg, Cu, Al, and Zn in the later period. Results suggest that land spreading and recycling degradable organic wastes in forests can increase tree and understory growth without long-term deleterious ecosystem effects.

Compost test demonstration in slash pine forested watershed.

In 1970, an experiment using composted garbage was installed that doubled slash pine growth where composts were applied. Subsequently another pine research project was installed to demonstrate the benefits of composted MSW for tree growth and to observe the resulting physical and chemical changes. Composted MSW was applied on 15x30 m plots, at levels of approximately 100, 200, and 300 dry metric ton/ha, at two different flatwoods sites. At one site (seedling site), compost was applied and incorporated into a sandy bare soil and slash pine seedlings were subsequently planted. At the other site (forest site), the compost was top dressed between the rows of a 6.5-yr-old slash pine plantation. Weed competition at the seedling site was severe, and by the second yr after planting, < 5% of the seedlings had survived. Tree growth increased about 50% with the two higher application rates at the forest site. Soil water content increased at the seedling site where the compost was incorporated, but decreased at the forest site where the compost was top dressed.

CONCLUSIONS

The research projects presented here are addressing several important compost parameters and utilization opportunities. These projects revealed that application of compost pose no serious threats and if mature, composts are safe and can result in benefits to plant production.

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Use of Animal Manure in Production of Wholesome Food

***H. H. Van Horn and P. W. Joyce**

INTRODUCTION

Nutrients in manure are recyclable. Applications of manure nutrients to plants that benefit from nutrient fertilization is the most used method to recycle. To avoid excessive applications of environmentally sensitive nutrients at inappropriate points, it is helpful to budget nutrient flow through the total animal-producing farm system (e.g.,Van Horn et al., 1991; 19%). Critical elements to develop a whole-farm nutrient budget to balance nutrient use in the environment include: 1) nutrients excreted by food animals, 2) potential nutrient removal by plants, 3) losses of nutrients within the manure management *system* and in fertility management for crop production, 4) combining steps 1 to 3 to assess whole-farm nutrient status, and 5) alternatives that permit export of nutrients off-farm, ifnecessary.

NUTRIENTS EXCRETED BY FARM ANIMALS

It has been demonstrated previously (Morse et al., 1992; Van Horn et al., 1994; 1996; Tomlinson et al., 1996) that original nutrient excretions are easily estimated by simple animal input-output comparisons. Thus, farmers are encouraged to use information from their feeding program to predict nutrient excretion. Accurate nutrient intake is the most important single sourceof information needed to estimate original nutrient excretions. Nutrition managers of large animal-food production units, who have access to computerized records of feed nutrient deliveries to animals, are key consultants in developing nutrient budgets. Records of food production sales off-farm along with measured or estimated nutrient content of the products provide the output component needed to accurately estimate manure nutrient excretions. Nutritionists also are skilled in balancing nutrients in diets so that animal nutrient requirements (e.g., Anon., 1984; 1989) can be met with as little excess of environmentally sensitive nutrients as possible.

Eliminating dietary excesses where they exist is the first step to reduce on-farm nutrient surpluses. It is well documentedthat many, perhaps most, dairy and beef cattle producers overfeed P; for example, dairymen often feed 0.50 to 0.60% P when NRC (Anon., 1989) recommends an average of about 0.42% for lactating cows. Reducing P to NRC (Anon., 1989) recommendations would reduce P excretion per cow by at least 20 lb/yr (Van Horn et al., 1996). The principles are the same for all animal species, i.e., reduce intake of environmentally sensitive nutrients to the fullest extent possible because excretions will be reduced to an even greater extent than intake.

[1]H.H.VanHorne and [2]P.W.Joyce. [1]Department of Dairy and Poultry Sciences and[2] Duval County Extension, IFAS, University of Florida, Gainesville, FL. Manuscript received 21 March 1997. * Corresponding author.

NUTRIENT REMOVALS BY PLANTS AND AGRONOMIC ALLOWANCES

One generally acceptable philosophy of land application of manure is that nutrients can be applied slightly above the amounts removed by the crops harvested. A key question is, how much above the amounts of nutrients removed should be applied and what factors influence this? Nutrient removals by crops *are* easily calculated if we know dry matter (DM) removals and nutrient compositions on a DM basis. Table 1 illustrates the importance of N, P, and K concentrations on nutrient removals. Luxury consumption of nutrients (or increased concentrations in response to fertilization in the absence of a yield increase) have significant implications for nutrient budgeting even though potential for luxury consumption of P seems to be less than the potential with N and K The surest method for increasing P removal seems to be to increase crop yield by avoiding moisture stress and deficiencies of other nutrients.

Total nutrient removals with multiple-cropping are illustrated by a long-term research project at Tifton, Georgia, which was designed to identify a maximum, environmentally safe application rate of manure nutrients with a triple-cropping system (Newton et al., 1995). Flushed dairy manure nutrients were applied through center-pivot irrigation. The cropping system included 'Tifton 44 bermudagrass *(Cynodon dactylon* L.) into which corn *(Zea mays* L.) was sod-planted for silage in spring and 'Abruzzi' rye *(Secale cereale* L.) was sod-seeded in fall. Harvests included rye for grazing from about 1 December until 15 February, rye for silage about 20 March (corn planted the day following), corn for silage in mid-July, low-quality bermudagrass hay about 10 d later, and high quality bermudagrass hay or grazing until rye was planted again about 1 November. Although this is an example of one best-case scenario for nutrient removals, the Georgia data showed that harvests of 510 lb N and 90 lb P/a or more were achieved with application rates that were environmentally acceptable (Figure 1). These N and P removals were in a forage DM harvest of 12.9 ton/a annually which, for the example budget represented in Figure 1, was fed to 4.2 cows supplemented with purchased feeds to meet NRC protein requirements based on ruminally undegradable protein to minimize dietary N. The manure N was applied as fertilizer as quickly as possible to minimize N volatilization losses. Similar crop N removal rates have been reported for other environmentally acceptable manure utilization/forage crop systems, and even higher nutrient removals may be possible with an alternate system using two crops of corn silage per year plus winter rye or triple-crop sod-based systems utilizing high-yielding bermudagrasses.

Surface runoff and loss to groundwater are usually within acceptable limits but management practices must control these losses *so* that violations of state water quality standards do not occur. In Figure 1, values for budgeting of about 20 lb N/a passing to groundwater and 30 lb/a to surface water were assumed to be environmentally acceptable.

The budget illustrated in Figure. 1 is based on N. Thus, it assumes that in this location there is no environmental risk for surface runoff of P, which was applied in excess, or to allowing P to accumulate in the soil. Note also in this budget that manure N recovered as fertilizer was 646 lb or 70% of excretion (646/923). We think this is about the best possible recovery of manure N for fertilizer. If a P budget had been used, only manure from 2.3 cows could have been utilized in producing those crops which had a total removal of 90 lb P/acre (Van Hom et al., 1996). Thus, an appreciable amount of commercial fertilizer N would have been required to supplement manure nutrients and achieve proper balance for fertilizer N and P.

Denitrification is a bacterial process which converts nitrate in solution to N gas. It is dependent upon a bacterial energy source, usually in the form of soluble organic matter, and progresses most rapidly under high moisture and/or low oxygen soil conditions. For irrigated, highly diluted manure (less than 100 to 150 ppm N) the loss of ammonia during irrigation is often proportional to the evaporation loss of water. Denitrification losses are harder to estimate on the farm but can be large. Measured denitrification losses have been found to be in excess of 120 lb/a during some years when manure application rates were similar to that shown in Figure 1.

NUTRIENTS RECOVERED

It is important to differentiate between excretion and recovery. The difference has both environmental and economic implications. After excretion, manure may be stored wet, stored after being allowed to dry, flushed with water to a lagoon or holding pond, spread fresh on land, or spread in some other form at a later time. The N in urine, which may be about half of total manure N, is easily lost to the atmosphere as ammonia because it is excreted in the form of urea, or in poultry, asuric acid. Urease enzyme of bacterial origin is present almost everywhere, so N voided as urea is converted readily to gaseous ammonia (NH_3). The most important practical factors controlling ammonia volatilization losses are ammonia concentration (slower for dilute solutions) and surface area. Other important factors are temperature, pH (acid conditions reduce volatilization by converting NH,,a gas, to NH_4^+, which is not volatile), and air movement If voided on a paved surface in warm weather and only moderate air movement, essentially all of the urinary N will be lost unless the area is flushed frequently or the urine is diluted with water from cow cooling sprinklers or other sources. Most of the fecal N is in organic compounds and thus, is much more stable than urinary N.

A key measure needed on-farm to help evaluate manure management systems is the amount of N and P recovered and recycled relative to the amount excreted. Also, nutrient quantities are needed in order to know the dollar value realized when crops are fertilized with manure. Weighing enough loads of manure hauled to the fields to estimate amount and analyzing enough samples to predict N, P, and K composition are necessary. Nutrient recoveries are obtained by multiplying concentrations by load weights and number. If an irrigation system is used to distribute wastewater from a lagoon or holding pond, wastewater analyses are needed to go with the volume of wastewater distributed. Volume meters on irrigation pumps are important; if not available, gallons pumped must be estimated by hours pumped and estimated gallons/min from pump specifications. Some suggested estimates for preliminary budgeting if amounts recovered and compositions have not been measured are:

With quick application and incorporation, for example irrigation of flushed manure within 5 days after excretion to crops grown under sprayfield, N recovery: 65%.

Application of wastewaters from anaerobic lagoon with a 21-day or longer holding time, N recovery: 20 to 30%.

An average recovery for N in most manure handling systems: 40%.

For P, estimate recovery of 90% or more unless an anaerobic lagoon is used and a discount applied for what likely remains in the sludge in bottom of the *lagoon.* That amount could be as much as 50% in lagoons with 21-da or more average hydraulic retention time.

For K, estimate recovery of 80 to 90%.

Many underestimate N volatilization losses from manure and manure-containing wastewaters utilized for irrigation and fertilizer (e.g., Gallaheret al., 1995). When this occurs, crops are undernourished and nutrient removals are limited by N deficiency, P is overapplied and accumulates because P removals are less than budgeted.

WHOLE-FARM **NUTRIENT** STATUS: **NUTRIENT** BUDGETS

Figure 1 represents a specific nutrient (N) budget In this case, the cropping system was chosen first and a cow density selected wluch aclueved balance based on assumed N losses. In most cases, budgets are developed with animal numbers and animal production fixed and calculations are made to estimate nutrients that need to be utilized for crop production and the cropping system that can utilize them.

For example, let's assume an animal-producing farm recovers 24,000 lb N in manure per yr, 7,000 lb actual P per yr, and 14,000 lb K. Recoveries in approximately these proportions are common. Let's assume the triple-cropping program represented in Figure 1 is utilized, wluch removed 510 lb N/a annually in harvested crops Application would have to be somewhat greater than removals to allow for environmentally acceptable losses to volatilization of N after a field application, to denitrification, to groundwater, and to surface runoff.. In Figure 1, the allowance for N was 150% of removal if we calculate application as what went to the field in irrigated wastewater, i.e., 760 lb N applied versus 510 lb N recovered in crops harvested. With this *scenario,* it would take 27.6 a to utilize available manure N (21,000 lb N divided by 760 lb N applied/a). For comparison, let's assume recommended applications for P and K are 110% of crop removals. The Tifton, Georgia triple-cropping experiments (Newton et al., 1995; Van Horn et al., 1996) removed 90 lb P and 425 lb K/a. Thus, agronomic application rates would be 90 x 1.1 = 99 lb/a for P and 425 x 1.1 = 468 lb/a for K. The 7000 lb manure P would require 70 a of triple-crop production and the 14,000 lb manure K would require 30 a. This example, like almost all manure examples, shows the manure is P-rich relative to N, e.g., more than twice as much *crop* production was needed to utilize P than N. If soils can be permitted to build up P storage, it may not be a problem in the short-run to apply manure based on N content and permit P to accumulate in the soil. In the long run however, it is expected that over-application of P will be discouraged and perhaps prohibited. The value of the fertilizer nutrients recovered is greater when manure nutrients are applied utilizing a P budget as well (Henry et al., 1995). Usually K budgets require acreage intermediate to N and P budgets.

ALTERNATIVES THAT PERMIT EXPORT OF NUTRIENTS OFF-FARM

Often, food-animal producing farms do not produce sufficient crops to utilize nutrients on-farm. This will be true for most farms if P budgeting is required to avoid pollution and utilized to capture the economic value of manure. With P budgeting, many more farms will need to find ways to export manure nutrients for use as fertilizer on other farms.

Manure Application on Nearby Farms

Large food-animal producing units vary greatly in land resources that are available on the same farm to produce crops that will consume the manure nutrients produced. For example, most dairy farmers have sufficient forage needs *so* that traditionally they have maintained a sizeable farming operation in conjunction with the dairy. Thus, most dairies, but not all, can recycle their fertilizer nutrients on-farm if they increase sufficiently the intensity of crop production on the land they have. Large beef cattle feedlots and poultry producers, however, almost assuredly will need to export manure nutrients. Based on excretion estimates of about 100 lb N/steer-yr, a feedlot of 50,000 head with 80% occupancy will generate about 4,000,000 lb N/yr. If 50% of the N is utilized effectively as fertilizer (50% volatilized) for crops requiring 400 lb N/a, about 5000 a cropland is needed for utilization of the N. If the feedlot is in a *dry* area, irrigated cropland will be required or application rates reduced accordingly to match productivity of the *dry* land. One significant advantage of locating large feedlots in *dry* regions is that the manure can be scraped and hauled off-site very easily, as compared with feedlots located in wet regions. Earthen structures to contain runoff are very modest in size compared to high-ramfall areas.

Burning

Some regions that do not have sufficient crop production near the animal production unit have needed to find other means to utilize or transport manure nutrients off-farm. Burning manure is a possibility The first large-scale resource recovery project in the world to bum cattle manure as fuel to generate electricity was in the Imperial Valley of southern California. It was designed to utilize manure from the many beef cattle feedlots in the valley. Utilization of oultry litter for fuel is expected to approach 80% of the litter produced in the United Kingdom within 5 to 10 yr. When manure is burned, the ash nutrients still need to be managed accountably.

Composting

A significant amount of dried manure, composted manure, or a combination of dried and composted manure is bagged and sold as organic fertilizer. An example with dairy manure is a dairy cooperative in the Chino Valley in California which was set up to move manure off of large, intensive drylot dairies located in an urban area. Firms exist in the Southeast also that market manure-based fertilizers.

Composting is a logical way to process wetter manures (but not slurries) when livestock producers must create a product that must move off-farm and be stable enough when suburban users or agricultural users near urban centers want to utilize it. Composting is relatively costly, labor intensive, and some of the most valuable fertilizer constituent, N, is dnven off to the atmosphere during processing. Therefore, dairies and feedlots usually consider the process only if a marketable product is created that will help them remove the excess nutrients from the farm that they must remove. Several advantages include: aerobic composting reduces volume and converts biodegradable materials into stable, low-odor end products; thermophilic temperatures of 54°C (130°F) to 71°C (160°F), achieved in the process, kill most weed seeds and pathogens.

The physical form of cattle manures often does not provide optimal composting conditions. Fresh manure is too wet, and screened solids are usually too low in N content and other fertilizer nutrients. Thus, mixing materials from other sources may be required. Supplies of manure, bulking and drying agents, as well as market demand for the finished compost, should be investigated before animal producers invest in composting equipment.

DISCUSSION

Animal agriculture often is perceived by the public as having negative environmental effects, e.g., concern with swine units in North Carolina, Iowa, and Missouri; poultry units in Georgia, Maryland, Alabama, Arkansas, and Connecticut; cattle feedlots in Texas, Oklahoma, Kansas, and Colorado, dairies in Wisconsin, California, Florida, and Washington. Perceptions usually emphasize manure threats to water quality but nuisance concerns, especially odors and flies, are critical.

Agriculture is based on biological systems that effectively process manure nutrients and other biomass in cost-effective, environmentally acceptable ways. Most animal producers utilize these systems effectively and those with on-farm nutrient excesses are correcting them. Manure nutrients are manageable and the recovered fertilizer value can pay for a large part of the system costs if agronomic recycling is utilized. The public sector needs to be aware of this and to monitor agricultural systems based on real concerns and not perception so as not to impose unnecessarily costly processing methodology.

In many regions, the public is imposing more strict nutrient application requirements on manure than on commercial fertilizer. Actually, there appears to be less likelihood of manure nutrient losses to ground and surface water than from commercial fertilizer. Frink (1971) indicated that rarely are the N recovery percentages in crop plus soil from commercial fertilizers as high as with the three lowest manure applications reported in the Tifton, GA, experiments (Newton et al., 1995). The reasons that recoveries with commercial fertilizer systems (and some manure application systems) often are only 50 to 70% of the N applied is due to leaching or runoff during periods when crops are not growing, volatiliztion of ammonia N, denitrification, etc. Active roots are needed to utilize the fertilizer, which often is applied when the crop is planted, or before, rather than side-dressed in smaller applications as needed by the growing crop. One major advantage of sprayfield applications of manure-containing wastewaters, the method used in the Tifton, GA, experiments, is that nutrient applications are frequent, in small amounts, and most is in soluble form that can be taken up quickly by active roots.

The urban population may benefit from an assessment of the ability of agriculture to help process urban wastes. That avenue has potential to reduce costs of processing urban wastes and, at the same time, give better environmental accountability to the public sector. This already is happening, with some municipalities managing agricultural land or contracting with farmers to utilize treated wastewater (reclaimed water) and sewage sludge (residuals).

How important is it to create a partnership between farmers and the public to recover and recycle waste nutrients to create a more sustainable world? It is more important to consider how agriculture can help sustainability than it is to worry specifically about a sustainable agriculture. Food production on our remaining agricultural land must be increased. It is a challenge to do that and maintain all of the other environmental qualities that are important. Achieving those desired environmental qualities will require some regulations. However, skillful use of incentives and regulatory standards based ondesired outcome rather than process will give farmers much more freedom to increase food production while at the same time demonstrating environmental accountability.

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Table 1. Estimated range in N, P, and K harvests in crops at a given DM yield due to variation in composition.

	Yields (tons/a)[1]			N harvests		P harvests		K harvests	
Crop	Wet	DM	CP%	% of DM	lb/a	% of DM	lb/a	% of DM	lb/a
Corn silage	18.0	6.0	9.0 to 13.0	1.4 to 2.0	168 to 240	.22 to .47	26 to 57	1.0 to 1.5	120 to 180
Rye or wheat haylage	6.0	3.0	16.0 to 21.0	2.6 to 3.3	156 to 198	.23 to .50	14 to 30	.7 to 1.5	42 to 90
Bermuda grass hay	6.0	5.0	11.0 to 18.0	1.8 to 2.9	180 to 290	.20 to .34	20 to 34	1.3 to 2.2	130 to 220
Forage Sorghum silage	18.0	6.0	8.0 to 12.0	1.3 to 1.9	156 to 228	.22 to .44	26 to 53	1.0 to 1.5	120 to 180
Alfalfa haylage	10.0	5.0	18.0 to 25.0	2.9 to 4.0	290 to 400	.22 to .49	22 to 49	1.5 to 2.5	150 to 250
Perennial peanut haylage	10.0	4.0	14.0 to 22.0	2.2 to 3.5	176 to 280	.21 to .39	17 to 31	1.5 to 2.2	120 to 176

[1]Ranges obviously exist in wet weight and dry matter (DM) yields. Farmers should use yield histories to estimate yields and their own composition history, if known.

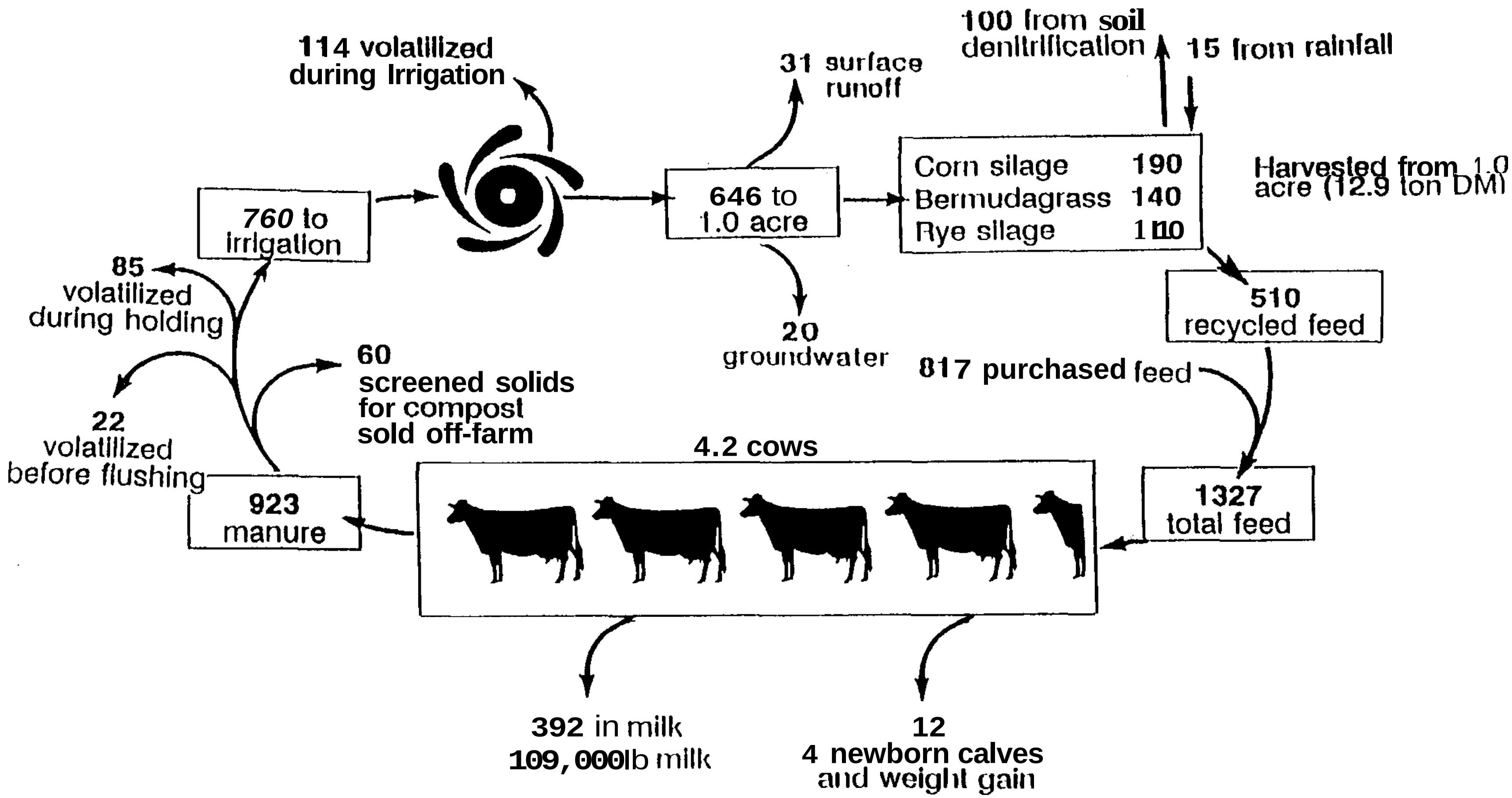

Figure 1. Example N budget for dairy manure system. Bold numbers represent pounds of N. Crop yield data are from experiments at Coastal Plain Experiment Station at Tifton, GA; excretion data from University of Florida experiments. Figure adapted from Van Horn et al. (1996).

Organic Farming Practices

***J.J. Ferguson and M. Mesh**

Organic farming was described as a system prior to World War I by Sir Albert Howard who taught that except for "natural phosphate rock and limestone, imported off-farm plant nutrients should be avoided". During World War II, J.I. Rodale applied these methods on an experimental organic farm in Pennsylvania and published *Organic Farming and Gardening* magazine which, along with other Rodale Press publications, popularized organic farming. In the 197Os, regional organic groups like the Califomia Certified Organic Farmers, Oregon Tilth, the Organic Growers and Buyers Association, and other groups in the U.S., Canada, and Europe established standards for organic production and certfication. In the 198Os, Florida Certified Organic Growers and Consumers, Inc. (FOG) was formed in Gainesville and has become the major organic certifying agency in this state, certifying 71 out of 88 organic enterprises in Florida (Anon., 1997). On the national level, the Organic Foods Production Association of North America developed as the major trade association in the 1980s, representing growers, shippers, processors, certifiers, distributors, and retailers. The International Association of Organic Agriculture Movements (IFOAM) has established international production, processing, and trading standards, and represents the international organic movement in parliamentary, administrative, and policy-making forums like the Food and Agriculture Organization of the United Nations,

Increasing interest in organic farming prompted passage in 1990 of the Florida Organic Fanning and Food Law and the federal Organic Foods Production Act. The Florida law established a regulatory framework for organic certification and created an organic food advisory council to advise the Commissioner of Agriculture on organic farming issues, licensing of certifying agents, and policies to promote organic products. The federal law provided for USDA to develop national standards for organic crops, livestock, processing and handling; establish a materials list of approved inputs; set up an accreditation process for the review of certification agencies and establish protocols for imported organic products. Since 1990, the USDA has obtained public input in regional meetings throughout the U.S. in developing recommendations made by a 14 member National Organic Standards Board (NOSB), leading to eventual rule-makmg by the USDA. Long awaited implementation of the Organic Foods Production Act is expected to bring nationwide standardization of organic methods, materials and processing, stimulating industry growth domestically and internationally.

Organic agriculture has been generally defined as a "holistic system with the primary goal of optimizing the health and productivity of interdependent communities of soil life, plants, animals, and people". Management practices are carefully selected with an intent to restore and then maintain ecological harmony on the farm, its surrounding environment and ultimately the whole planetary system.'' (Anon., 1995a). Organic farming is a subset of sustainable agriculture that stresses ecological balance in agricultural and livestock production by developing healthy soils, which is the basis for organic production, and high quality crops and livestock. Careful selection of crops and plant cultivars complements continuous improvement of soil organic matter and soil fertility, particularly through green manuring and addition of composted materials, manures, and rock minerals. Although organic certifying agencies and NOSB tentative recommendatinos differ somewhat in allowed, regulated, and prohibited practices, a general review of current organic standards and certification procedures will be presented here.

CERTIFICATION PROCEDURES

Certification focuses on intent (a farm management plan), evidence (history of a 3-yr transition period free of prohibited materials), and documentation (soil, leaf and water analysis, crop plans, field history sheets, receipts, and afficavits). At the heart of organic management is the farm plan, including Written strategies for ecologically sound resource management, plans and evaluations of farm management practices and tangible improvements in the fanning operation. This plan must address soil, crop, and resource management, as well as crop protection and maintenance of organic integrity through growing, harvest, and post-harvest operations. Buffer zones up to 30-A and/or appropriate barriers must

[1]J.J. Ferguson and [2]M. Mesh. [1]Hort. Sci. Dept., Univ. of Florida, Gainesville, FL. [2]FL. Certified Organic Growers and Consumers, Inc., Gainesville, FL. Manuscript received 25 March 1997. *Corresponding author. Florida Agnc. Exp. Stn. Journal Series No. R-01400.

separate organic from conventionally-farmed fields or other lands subject to synthetic spray or fertilizer programs. Separate records, physical facilities, machinery, and management practices must be established to prevent the possibility of mixing organic and non-organic products. Areas may not be switched back and forth between organic and non-organic management practices. If individual fields are certified, the entire farm must be certified within 5-yr of certification of the first field, according to international standards (IFOAM) but not according to those of some U.S. certifying agencies. However, NOSB recommendations leave this to the discretion of the grower. In general, synthetic materials are prohibited, but some synthetic materials are considered to be compatible with the goals of organic agriculture and are allowed. (e.g. pheromones and insecticidal soaps). A transitional status, involving management without the use of prohibited materials for 12-m before harvest, may also be obtained by previously uncertified farms and livestock operations. For "wild land," documentation is required that the land has been pesticide-free for 3-41, along with a management plan. Abandoned fields or groves to which no prohibited materials have been applied for 3-41 will not be certified because of lack of active management.

Packets containing certification information (40 to 60 pages) can be obtained from certifying agencies for $25 to $35, with additional first-year and annual renewal fees ranging from $125 plus a flat 0.0025% of gross annual sales which exceed $15,000 for one certifying agency (Anon., 1996) to a sliding scale based on projected sales for the first year and on actual gross sales from previous years for another agency. In the latter case, fees vary from 7.4% and 4.5% for first and second year Certification for sales of 0 to $5,000 to 0.5% and 0.4% of total sales of $500,000 (Coody, 1994). Processors pay *0.5%* of net invoice sales for certification and handlers pay 0.1% of gross profit. Growers who sell less than $5,000 annually may be exempt from certification under future NOSB agency standards but will be required to prcduce and handle organic products in accordance with organic production and handling standards.

LIVESTOCK

Anunals must be raised for their life on organic feed and pasture under living conditions that foster herd and flock health, without the application of prohibited drugs and substances except as allowed. Livestock must also be provided with living conditions that minimize stress and are suited to individual and collective needs, with enough room to comfortably sit up, lie down, groom normally, turn around and stretch. Breeding stock may be bought from whatever source, provided the animal is not in the last third of gestation, but may be sold as certified organic only if raised in compliance with organic standards for one year following purchase. Dauy stock purchased from non-certified sources is restricted. New and certifiable herds should be fed a minimum of 50% daily ration of organically grown feed for 6-m followed by being fed 100% certified feed for 6 to 12 m (depending on the certifier) prior to the milk being certifiable. Antibiotics and Normanist are generally prohibited in organic dairies and water for dairy animals must be less than 10 mg nitrate N per liter. Plastic roughage, urea, intentional manure refeeding, and similar practices are prohibited. Stacked cage confinement and overcrowding of poultry is prohibited, and laying stock must be managed in accordance with organic production standards for at least 4-m before eggs can be certified. Although certified organic meat products can be produced and sold in-state, final USDA rules on organic meat production must first be promulgated before interstate shipment of these products can occur, creating additional temporary marketing problems for organic beef, poultry, and other products.

SOIL MANAGEMENT

A basic tenet of organic farming is that a healthy soil produces healthy plants. Accordingly, application of soil amendments and fertilizers, especially soluble ones, must be judged by the criteria of soil health and crop requirements, for optimum, not maximum, production. Soil fertility is maintained by managing organic matter and mineral content through tillage, crop rotation, incorporation of green and animal manures, and addition of soil amendments and natural fertilizers like rock minerals. Crop rotation includes alternation of sod and row crops and crops which do not share similar pest complexes; N-fixing crops; green manure crops, cover and nurse crops; alternation of heavy and light feeders and use of plants with allelopathic or mineral accumulating properties. Tillage is used to control weeds, disrupt pest and disease cycles, and improve nutrient levels, tilth, and organic matter. Mono-cropping is prohibited, with two-crop rotation regulated and a three-crop rotation accepted as a minimum. Plant tissue and soil testing, including organic matter content, levels of macro and micronutrient, pH, cation exchange capacity, soil texture, bulk density, and water infiltration rate, are used to monitor soil health and indicate the direction of a soil management program. Animal manures, especially chicken manure, are the primary fertilizer used by organic growers but only as a supplement to other soil building practices. Records must be maintained on manure type, source and application date, site, method, and rate. Composted rather than aged or raw manure is encouraged, preferably produced on-farm and if produced off-farm, free of contaminants Some certifying agencies specify that fresh manure be applied only when soil temperatures are greater than 50°F or higher, moisture content between field capacity and wilting point, and that application must not result in contamination of surface or ground water or in excessive nitrate concentrations in produce. Fresh manure may not be used on crops destined for human consumption less than 4-m before harvest. Manure aged by the producer 90-d or more can be applied 30-d before harvest of such crops. Approved N sources include green manures and animals manures, N-fixing crops, composted materials, and N-fixing organisms, with certifying agencies differing on recommendations for fish emulsion, vegetable meal, bone meal, and other animal by-products. Although certifying agencies generally prohibit Chilean or calcium nitrate (16-0-0), the National Organic Standards Board recommends that this material be limited to not more than 20% of the total N supplied to a crop. Furthermore, farmers must develop strategies to substantially reduce the use of Chilean nitrate over time. Approved P sources include colloidal and rock phosphate, with synthetic materials like ortho phosphoric acid (0-50-0), superphosphate (0-20-0) and triple superphosphate (0-46-0), prohibited, as are other excessively soluble and acidfying materials with a high salt index. Approved K sources include rock dust (granite, feldspar, greensand), mined potassium sulfate, sulfate of potash magnesia (sulfamag or langbeinite) and kainite. Application of biosolids is regulated by some certifying agencies and prohibited by others.

PLANTING STOCK

Organic production methods apply to the entire life of the plant. Seedlings and other planting stock should not be treated with any prohibited materials. However, use of planting stock treated with synthetic materials is regulated if organic materials are not available. Transplants must be organically grown but some certifying agencies allowed conventionally-grown transplants for strawberries, caneberries, potatoes, garlic, shallots, and bare-root nursery stock for perennials. Organic management for 1-yr prior to harvest is required for perennial planting stock (tree fruits, grapes and small fruits of genus *Rubus, Ribes,* and *Vaccinium)* which are not produced from organic stock. In greenhouse production, lumber treated with copper-chromium arsenate is classified as a restricted material but can be used where plant leaves or roots do not contact such treated wood. Organic and non-organic sites must be separated by an impermeable wall and ventilation systems must ensure that prohibited materials do not drift from non-organic to organic production sites. Apiaries must be located on certified land more than two miles from areas like golf courses, major townsites, cities, major traffic polluting areas, garbage dumps or crops sprayed with prohibited pesticides that could contaminate the honey.

DISEASE *AND* PEST MANAGEMENT

Careful management, *use* of resistant varieties, timing to avoid cycles of pest emergence, crop rotations, inter-cropping, avoidance of excessive fertilization, and general maintenance of soil health is the first line of defense against weeds, pests, and disease. Mechanical controls, such as traps, repellant crops, vacuuming water jets, and physical and sound barriers are generally recommended as are the release of natural predators and parasites, mating disruptors, and the creation of environments fostering wild predators such as birds, toads, and snakes. Sprays including insecticidal soaps, microbial sprays, rock powders and diatomaceous earth, herbal preparations, dormant oil sprays in orchards, solutions of pureed insects or plants used as repellents are allowed. Botanical and other natural insecticides such as pyrethrum rotenone, sabadilla, quassia, ryania, and neem that have broad-spectrum effects are generally regulated. Weed management includes prevention, avoidance and sanitation; mechanical methods including tillage - discs, choppers, mechanical hoes, and non-tillage - rotary mechanical mowers, sickle-bar mowers, and devining equipment; grazing, including weeder geese and animal rotation in pastures; heat treatments, including flame hoes with gas and superheated water, mulches, including use. of organic material, intercrop plants as well as covers of different types; crop rotation and smother crops. Polycarbonate plastic mulches (polypropylene and polyethylene), mulching with recycled newspaper and magazines containing inks and dyes and herbicides from naturally occurring fatty acids are regulated as are polyvinyl chloride plastics. When inadvertent environmental contamination or pesticide drift occurs, tolerance levels are set at no more than 5% of Environmental protection Agency (EPA) tolerance levels, with responsible private parties liable for damages.

GENETICALLY MODIFIED ORGANISMS

Genetic engineering refers to organisms "made with techniques that alter the molecular or cell biology of an *organism* by means that are not possible under natural conditions or processes. Genetic engineering includes recombinant DNA or RNA techniques, cell fusion, micro-and macro- encapsulation, gene deletion and doubling, introducing a foreign gene, and changing the positions of genes but not breeding, conjugation, fermentation hybridization, in-vitro fertilization, and tissue culture" (Anon., 1995b). Genetically-engineered organisms and irradiation of crops are prohibited, but the results of classical plant and animal breedmg are allowed. Genetic engineering is prohibited in order to guarantee a common standard for all organic farmers and consumers, many of whom are both philosophically opposed and wary of the Pandora's box this approach may open. Artificial insemination is also allowed but not embryo transfer.

Although state Department of Agriculture and certifying agencies maintain data for organic certification, farm location, acreage farmed, and commodities grown, it is difficult to obtain accurate informatino, especially on crop production, and sales .According to a recent Florida Department of Agriculture listing (Anon., 1997), 88 enterprises were certified organic by 1997 by five of the six certifying agencies licensed in Florida, with acreage and crops of only 67 enterprises specified. Thirteen of these 67 firms were juice, fruit, and vegetable packers and processors. Of the remaining 54, 52 were farms producing fruit and vegetable crops on 2,836 acres (27 citrus groves on 1,941 a, 17 vegetable farms on 740 a, with two more enterprises on 15,267 a or 84% of the total Florida organic acreage, in wilderness crops (saw palmetto berries and herbs).

More specific information indicating trends is available from California, which has an older and better organized organic farming industry (Klonsky and Tourte, 1997). In 1992-93, in California, 1,159 organic farmers sold more than 70 individual commodities produced on 45,493 a with sales of $75.4 million. Fruit and nut crops and vegetable crops represented 96% of the gross sales on 75% of all acreage. Fruit and nut crops comprised 42% of the total organic acreage, vegetable crops about 31%, and field crops 18%.

Vegetable crops were the highest value commodity with $37.7 million, representing 50% of the total gross sales (Table 1). Although approximately 4,050 U.S. organic *crop* and livestock producers on 0.2% of total U.S, farms were certified by 1994 on approximately 0.1% (1,127,000 a) of total U.S. agricultural land (Dunn, 1995), consumer and farmer interest in organic farming is increasing because of personal concerns about food safety and environmental stewardship as well as marketing opportunities. With dramatic sales increases predicted for this well defined and documented agricultural sector, especially in large urban markets (Burfield, 1996), national agricultural policy, regulatory and marketing leaders are watching this emerging industry carefully.

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Table 1. Characterization of California organic farms by commodity group, 1992-93*

Commodity group	Number of farms	Median a	Median sales (%/farm)	Median sales ($/a)
Vegetable crops	293	2.3	9,500	3,250
Fruit and nut crops	652	6.0	6,000	1,393
Field crops	25	80.0	50,000	361
Combined fruit, nut, and vegetables crops	70	3.3	5,235	2,009
Livestock, layer hens and poultry	5	N/A	5,000	N/A
Nursery and flowers	1	3.0	10,000	3,333
Mixed commodity groups	113	9.0	13,000	1,406
All farms	1,159	5.0	7,500	1,685

* Klonsky and Tourte, 1997.

Converting Conservation Reserve Program Contracts To Cropland in Oklahoma

***J.H. Stiegler, T.H. Dao, and T.F. Peeper**

INTRODUCTION

Holders of the 1.3 million acres of Conservation Reserve Program (CRP) contracts in Oklahoma will have to choose the future use of this land in 1997. Many of these acres will eventually be converted back to cropland because they will not meet the requirements of CRP-2. There is a general lack of knowledge and no best management practices guidelines on how these highly erodible lands should be economically converted back to cropland and still remain in compliance. A multi-agency research and demonstration project was funded by Southern Region USDA Sustainable Agriculture Research and Education Program/EP/A Agriculture in Concert with the Environment Program (SARE/ACE) in 1994. The objectives were: 1) to identify dryland production systems for converting the CRP grass (Old World Bluestem [OWB]) *(Andropogon gerurdii)* to annual production of wheat *(Triticum aestivum* L.) and 2) to evaluate the profitability and sustainability of the production system compared to managing the grass for livestock production.

MATERIALS AND METHODS

Field-Scale Evaluation of Cropping Systems

Field studies were conducted on two CRP fields under contract since 1987. The Forgan, OK, site is 160 a of Dalhart fine sandy loam 1-3% slope in Beaver Co. (NW) with 18 in of annual precipitation. The Duke, OK, site is 160 a of LaCasa-Waymouth clay loam, 1-3% slope in Jackson Co. (SW) with 29 in of annual precipitation. In May, 1994, 1995, and 1996, 25 to 30 a were either control burned or mowed and baled to remove the old grass growth. Four replications of 1-a plots were established at Forgan, while one 4-a and three 0.5-a plots were established at Duke. At Forgan, sweep tillage (ST) consisted of undercutting the existing sod with a 36 in V-blade sweep in mid-July. No other tillage was performed during the summer of 1994, but in 1995 an offset disking was needed to control sod regrowth and to smooth the seedbed prior to planting. In 1996, the Tillage was further modified to include two diskings after the sweep tillage. At Duke, disk tillage (DT) consisted of offset disking twice to kill and partially incorporate the sod in July of 1994, 1995, and 1996 and one tandem disking was performed prior to planting in October. In all the no-till (NT) plots, the OWB grass was treated with 1 lb/a of glyphosate in July or August and re-treated with an additional 1 lb/a of glyphosate in September before drilling the wheat. In 1996, the OWB grass was treated once with 2 lb/a of glyphosate in July. All glyphosate was applied with a surfactant and ammonium sulfate. A Tye 10-in-spacing (1994) or Great Plains 7-in-spacing (1995, 19%) no-till drill was used to plant all plots with 70 lb/a of wheat seed and place 100 lb/a of 18-46-0 with the seed. Sixty lb/a of urea-N was applied broadcast at planting or topdressed to plots in March. The wheat was treated in November, 1994 with 10 oz parathion for fall armyworms *(Laphygama frugiperda),* and in March of 1994 and 1996 with 1/6 oz of chlorsulfuron and 0.25 lb chlorpynfos for broadleaf weed and greenbug control, respectively. Grain was harvested using a plot combine. The ST, DT, and NT plots were maintained after wheat harvest each year and replanted. The ST and DT plots were swept or disked once in July and again in September. The NT plots were treated with 1 Ib/a of glyphosate in September and all plots were annually planted back to wheat.

Small plot herbicide and tillage methods for re-cropping CRP lands to winter wheat

Plots (20 ft x 25 ft) were established at both CRP experimental sites without any pre-treatment and treatments were applied directly to the standing OWB biomass to evaluate the effectiveness of selected tillage-herbicide combinations to kill the sod. Two hundred lb/a of 18-46-0 and 100 lb/a of urea-N were applied to plots that were either moldboard plowed, disk plowed, or no-tilled. Glyphosate was applied at 0.25, 0.5, 0.75, 1.0, and 1.5 lb ai/a and glyphosate-2,4-D mixture (Landmaster BW) at 40 and 54 oz/a were applied across the plots before tillage in either May, June, or July. All tilled plots were disked once before planting wheat at a rate of 80 lb/a, The wheat was topdressed with 100 lb/a of urea-N in March Old world bluestem, weeds, wheat vigor, and stand counts were made periodically. Yields were determined with a plot combine.

'J.H. Stiegler, 'T.F. Peeper, and 'T.H. Dao, 'Oklahoma State University, Stillwater, OK, and 'USDA-ARS, Bushland, TX. Manuscript received 28 March 1997. *Corresponding author.

Fertilizer requirements of winter wheat in re-cropping CRP fields

Plots (20 ft x 25 ft were established to evaluate the effects of N and P fertilizers for winter wheat production in re-cropping CRP lands and the decomposition of the grass residues. OWB was treated with 1 lb/a of glyphosate in mid June. Liquid fertilizer was applied to the biomass before the primary tillage treatments of either moldboard plowed, disk plowed, or no-tilled. Fertilizers applied were: 0 lb/a N, 100 lb/a N as 34-0-0, and 100 lb/a N + 50 lb/a of P_2O_5. The plots were planted to wheat at a rate of *80* lb/a. Visual ratings of wheat vigor and stand density were made periodically during the growing season Grain yields were determined with a plot combine.

RESULTS AND DISCUSSION

Wheat yield data for 1994 and 1995 from field-scale plots are shown in Table 1. The 1994 wheat yields ranged from 13 bu/a to 26 bu/a, with the higher yields at Duke. Due mainly to drought conditions in 1995, wheat yields were much lower, ranging from 4 bu/a to 14 bu/a. In general, (NT) wheat yields were significantly higher than ST yields at Forgan in 1994 and the disk (DT) plots at Duke in 1995. At Duke, better herbicide suppression of OWB and soil moisture improved wheat emergence and growth in both systems. Although the crop seemed to grow better under the high residue-NT system, grain yields were not significantly different. Delays in herbicide suppression and tillage of the grass in 1994 depleted soil moisture, especially in the ST plots at Forgan. Sweep tillage was found to be an economically effective means of controlling OWB. If the soil remained dry for several days following tillage and the air temperatures were high, more than 90% of OWB was killed. Rates of glyphosate up to 1.5 lb/a were less reliable in suppressing OWB than tillage. Except when applied in July, glyphosate did not effectively control the grass in small plots (Table 2). Field applications at rates up *to* 2.0 lb/a were also less than satisfactory.

In small plots without prior removal of old grass growth, wheat yields were higher than in similar field studies. This is due to the larger amounts of N fertilizer applied. In this study, wheat yields from disk and moldboard tillage plots were significantly higher than NT yields (Table 3). The data also shows that glyphosate rates higher than 0.5 lb ai/a did not significantly increase wheat yields. Applying glyphosate before tillage of the plots did increase wheat yields in disked but not in moldboard plowed plots. Large amounts of surface residue interfered with seed placement, row closure, and soil-seed contact during planting. Stand counts were 2.4, 5.8, and 6.6 plants/ft^2 for NT, disk, and moldboard, respectively. Glyphosate applied to the thick residue also reduced its effectiveness in controlling OWB.

In nutrient depleted CRP fields, N fertilizer is essential for producing acceptable wheat yields regardless of tillage method. Data showing wheat yields from fertilized and unfertilized plots are presented (Table 4). Unfertilized small plots yielded 34% and 60% of N-fertilized plots at Forgan and Duke, respectively. Additions of P appeared to increase wheat yields but the amounts were not significant. When the old grass growth was not removed before tillage and herbicide application, highest wheat yields were attained with moldboard tillage.

CONCLUSIONS

Although it is hghly desirable to conserve as much of the fixed C in the surface mulch, there appears to be too much mulch to effectively plant wheat either minimum or NT and get acceptable stands and crop yields unless the mulch is either burned or mowed and baled A controlled burn is an inexpensive and effective way to remove the old *grass* growth and the resulting new grass growth is controlled more effectively with herbicides. Moldboard tillage is an excellent way to bury the old *grass* growth and kill the grass if pre-treatment is not done. With high amounts of supplemental fertilizer, good wheat stands and high crop yields were attained, but this clean till practice makes the soil more susceptible to wind and water erosion and the tillage greatly enhances the mineralization of the residual carbon. Sweep tillage is an effective minimum till system that provides good OWB control and loosens the soil surface. No-till wheat production into control burned and killed OWB *sod* offers the highest degree of soil erosion control and maintenance of organic matter. In most cases, wheat yields have been as good as conventional or minimum till production. However, it is more difficult and costly to chemically control perennial, warm season grasses. Early suppression of OWB is vital to crop production in much of this semi-arid region. Adequate lead time is necessary to allow for partial decomposition of the organic residue and to re-supply the soil profile with moisture. The wheat responses are very dependent on the soil and climate.

Economic evaluation of the cropping systems and livestock *comparisons* have not been completed. The lower wheat yields of these highly erodible lands in a semi-arid region suggests that wheat will provide a negative return due to the high costs of conversion. Many farmers would be better advised to not convert to crop production. They should be advised to re-enroll these.

acres in CRP-2. If they are unsuccessful in getting into the program, then they should consider developing a forage and livestock enterprise. Under managed conditions, the OWB will produce substantial forage that should yield 100 to 150 lb beef/a and a positive cash flow. For many farmers, the final decision about post-CRP land uses will depend on prices of crops and livestock. Loss of government payments in 7 yr will cause many to re-evaluate their earlier decisions.

Table 1. Dryland wheat yields on former CRP lands.

Location	Year	Tillage System'	First year	Second-year
			------------(bu/a)----------------	
Forgan, OK	1994	ST	13b[3]	
		NT	17a	
	1995[2]	ST	12a	3a
		NT	4b	2a
Duke, OK	1994	DT	24a	
		NT	26a	
	1995[2]	DT	7b	6b
		NT	14a	14a

[1] ST = sweep tillage, DT = disk tillage; NT = no-till
[2]Drought of 1995-96
'Letters represent crop yields in each year that were significantly different at $p = 0.05$

Table 2 . Percent control of Old World Bluestem in CRP fields four wk after application date shown.

Roundup rate lb/a	DUKE. OK June	DUKE. OK July	FORGAN. OK May	FORGAN. OK July
	---------- %	----------	----------	----------
0.25	33	10	12	37
0.50	59	39	13	47
1.0	73	69	13	87
1.5	61	83	13	93
	LSD 05	13	LSD,,	9

Table 3. Effects of tillage and herbicides on suppression of intact OWB sod.

TREATMENT	A[1]	B	C	D	E	F	G
Forgan, OK	.... bu/a	------------					
No Till	19	20	24	24	24	17	18
Moldboard	29	28	32	31	30	30	31
Disk	27	28	28	31	27	31	31
Duke. OK							
No-Till	17	19	21	24	26	21	18
Moldboard	37	39	39	36	40	38	37
Disk	34	35	39	36	38	38	36

[1]A=Gly, 0.25 lb/a; B=Gly, 0.50 lb/a; C=Gly, 0.75 lb/a; D=Gly, 1.0 lb/a; E=Gly, 1.5 lb/a
F= Gly-2 ,4D, 40 oz/a; G= Gly-2, 4D, 52 oz/a

Table 4. Effect of tillage and fertilizer on wheat yields (small plots)[1].

Fertilizer	No-till	Moldboard plow	Disk	Mean
Forgan, OK	------------	bu/a	------------	
0	1	10	6	5.7a
100 lb N/a	14	26	24	21.3b
100 lb N + 50 lb P_2O_5/a	15	28	25	22.7b
Duke, OK				
0	8	20	14	14.0a
100 lb N/a	22	30	28	26.7b
100 lb N + 50 lb P_2O_5/a	26	32	29	29.0b

[1]No removal of the old OWB growth before tillage or spraying.

Telogia Creek Conservation Tillage Project

***B.F. Castro, J.C. Love, B.R Durden, F. Johnson. and H. G. Grant**

ABSTRACT

A Best Management Practice demonstration project on crop and pasture land in the Telogia Creek Watershed was conducted by making reduced tillage equipment available to farmers, establishing on-farm demonstration plots, and holding field days to demonstrate and evaluate reduced tillage, new conservation tillage and new subsoil tillage technology. An evaluation of a Dyna Drive, a new rotary surface ground driven cultivator, and a Terra Max subsoiler with a newly designed bent-leg shank was performed. Primary tillage demonstrations of the Dyna Drive revealed that this implement can reduce the number of trips required for soil preparation. In normal field conditions where 80 to 90% field residue exists, one pass of the Dyna Drive left an excellent seed bed while leaving 30 to 50% residue. The Terra Max subsoiler was successful in disrupting existing hard pans and reducing soil compaction. Substantial growth response was observed in winter annual and summer perennial forage plots where subsoiling was performed.

INTRODUCTION

The focus of this grant project was on Gadsden County and North Florida area beef cattle producers, although the project was not restricted to this audience. Best management practices (BMPs) for all sectors of agriculture are currently being evaluated and established because of federal and state mandates. The Environmental Protection Agency estimates that agriculture accounts for two thirds of non-point sources of pollution nationwide. One significant way to reduce non-point source pollution from farm fields is to implement a conservation tillage system. Livestock producers in North Florida often utilize conventional tillage equipment in the soil preparation for planting cool and warm season forages. The planting of forage crops generally involves a mulch tillage system that involves tilling the complete field surface with some type of tillage implement such as a disk harrow, chisel plow, turn plow, field cultivator, combination tool or rotovator. Often fields are left with little surface residue to combat wind erosion, water erosion, and the leaching of nutrients or chemicals. Cattle producers experience forage yield losses due to the constant treading of hooves that causes severe soil compaction in most soils. Many of the existing tillage systems do not go deep enough to disrupt soil hard pans. Project goals were to identify BMPs that reduce soil erosion improve water quality, reduce fuel consumption, while at the same time, improve soil health and crop yields.

According to the Natural Resource Conservation Service (NRCS), conservation tillage is defined as any tillage method that leaves 30% of the field covered with residue after planting. Previous research had demonstrated that the Dyna-Drive[R] (registered trademark of Alamo Group Inc., Gibson City, IL), described as a rotary surface cultivator that was designed in England and widely used throughout Europe, could produce a very level, small clod and residue protected seedbed (Smith, 1995). Studies have shown that quality seedbeds could be produced with one pass of the Dyna-Drive into corn *(Zea mays* L.) stubble (Smith, 1995.).

Subsoiling increases yields while doing minimal damage to soil strength, while conventional tillage creates significant damage to soil strength (Busscher et al., 1995.).Deep tillage that does not disturb surface residue or existing forages is needed in many Southeastern Coastal Plain soils to disrupt subsoil hard pans that restrict root growth (Khalilian and Hallman, 1996.). North Florida cattle producers have not established BMPs that reduce soil compaction and effectively disrupt hard pans.

MATERIALS AND METHODS

In the Spring of 1995, a cooperative project among the Gadsden Soil and Water Conservation District, Gadsden County Extension Service, Florida Department of Agriculture and Consumer Services' Bureau of Agriculture Water Policy, and Gadsden County

[1]B.F. Castro, [2]J.C.Love, [1]B.R. Durden, [3]F. Johnson, and [1]H. G. Grant, [1]Gadsden County Extension Service, IFAS, Univ. of Florida, Quincy, FL, [3]Florida Department of Agriculture and Consumer Services-Office of Agriculture and Water Policy, Tallahassee, FL, [3]USDA Natural Resource Conservation Service, Quincy, FL. Manuscript received *26* March 1997. *Corresponding author.

NRCS was initiated. Grant funds were secured through the Florida Department of Environmental Protection's Section 319 Program to do a conservation tillage demonstration project in the Telogia Creek watershed and Gadsden County. The purpose of the project was to evaluate and demonstrate new technology and establish BMPs that enhance soil health and increase forage yield. A project goal was to show farmers how conservation tillage and deep tillage can reduce nonpoint source pollution from cropland and pasture land. The project ran from April 1995 to April 1997 and included a conservation tillage equipment loan program, field days, and tours.

A new, eight-ft-wide (8'7"), ground-driven, rotary-surface cultivator called a Dyna-Drive and a new bent-leg (parabolic and curved) three-shank subsoiler called a Terra Max (registered trademark of Worksaver, Inc., Litchfield, IL) was purchased to loan to farmers to allow them to evaluate reduced tillage practices on their farms. The Dyna-Drive is suitable for conservation tillage as well as conventional tillage and can be used for seedbed preparation, chemical incorporation, pasture renovation, and overseedmg. The Dyna-Drive is ground-driven and it is designed to be operated at six to eight-mph. A Tye (registered trademark) grain drill box (seeding attachment) with hydraulic-driven motor was attached to the Dyna-Drive to allow seedbed preparation and seeding in one pass. Seed tubes were designed to drop seed in front of the crumbler roller, just behind the twin rotor tines. The attachment of a seeder like this is not necessarily recommended by either company, the manufacturers of Dyna-Drive or Tye equipment. The project provided a custom operator who used a 110 PTO horsepower tractor to operate the equipment. Tractor power selection was based on soil conditions, depth of tillage, tractor speed requirements, and manufacture suggestions. The Terra Max subsoiler manufacturer literature states that their patented, narrow, helical shank design conditions the soil to a depth of 20 in, leaving soil structure intact. The Terra Max was set up with three shanks spaced at 30 in. The Terra Max was equipped with coulters to slice residue in front of the shanks and an attached roller-conditioner to level the raised soil after subsoiling.

Demonstration plots were established with the Dyna-Drive/seeder combination on crop land, pasture land and hay land. Plots were seeded with oat *(Avena sativa* L.), rye *(Secale cereale* L.), ryegrass *(Lolium multiflorum* L.), and clovers. Also, the Dyna-Drive was used to incorporate 'Alicia' bermudagrass *(Cynodon dactylon* L.) sprigs on cropland while simultaneously planting ryegrass.

Demonstration plots with the Terra Max subsoiler were established on temporary pastures where small grains are planted in the fall and annual crops are planted in the spring or native forages such as crabgrass *(Digitaria* spp.) are grazed in the summer. Deep tillage is not a common practice on these fields and pastures. Subsoil demonstration plots were also established on permanent pastures and hayfields, which were bermudagrass and bahiagrass *(Paspalum notatum* L.). An established bermudagrass pasture/hayfield was subsoiled in strips leaving non-subsoiled strips in the field and was followed by a 7-in-spacing grain drill (Dyna-Drive was not used here) where ryegrass and *two* varieties of clover, Cherokee Red and Dixie Crimson, were planted in the fall. The Cherokee Red *(Trifolium pratense* L.) and Dixie Crimson *(T. incarnatum* L.) were not *mixed,* however, the individual clover varieties were mixed with the same variety of 'Surrey' ryegrass and clover performance was also evaluated where subsoiling was and was not performed. A Dicky-John[R] (registered tradename) Soil Compaction Tester was used to analyze soil compaction through out the upper soil profile, identify hard pan depths, and evaluate the before and after effects of subsoiling.

RESULTS AND DISCUSSION

Forty-four farmers utilized either or both the Dyna-Drive and the Terra Max through the loan program that paid about 65% of the equipment operation costs. Additionally, seven sites were donated by producers for the purpose of demonstrating and evaluating this equipment. The Dyna-Drive was used on approximately 300 a and the Terra Max was used on a little over 150 a. Gadsden County soils are highly variable ultisols and more sand content is generally the rule in the surface profile and clay content is usually higher in varying depths of these mostly mineral North Florida soils. Most of the farm land this equipment was used on was upland soils with loamy fine sand surface soils and *sandy* clay loam to fine sandy clay subsoils. A few fields had some loamy sands to coarse sand sections. Gadsden County is not typical for most Florida soils as it borders the lower Chattahoochee River Valley and its soils are typical of many Coastal Plains Soils found in Georgia.

Under these soil conditions, the Dyna-Drive performed well and the twin rotor tines that work the soil appear to not suffer from abnormal wear. Based on observational wear, the Dyna-Dnve tines will have to be replaced at about the same interval as a disk on a conventional disk harrow,.

The Terra Max subsoiler did not stand up as well under these soil conditions. After 150 a of use, three sets of points had worn out and all three bent-leg shanks had wom out There was not a close-by representative for the Terra Max manufacturer and no one was aware that the manufacturer has a solution for this excessive wear. Worksaver Inc. Sales and Marketing Manager, Chuck Bellew, stated that the Terra Max should have been equipped with wear plates and chromium carbide points, which the company has to offer to be installed to the subsoiler shanks. Bellew stated that the Terra Max is getting about 800 a of use with the wear plates and chromium carbide points. With the wear plates installed, the shanks should get thousands of acres of use (Bellew, 1997, personal communication).

Farmers were well satisfied with the performance of the Dyna-Drive. The District NRCS District Conservationist sampled 10 fields where primary tillage was performed on a variety of cropping systems and found the surface residue to be above 30% and sometimes as high as 50%. In secondary tillage operations and where residue was less than 50% to begin with, surface residue did fall below 30%. Growers were extremely pleased with how level the Dyna-Drive leaves a field and how good the seedbed is after one trip over the field.

The Dyna-Drive was field tested on a cotton field in the fall of 1996. In rank cotton *(Gossypium hirsutum* L.) stalks of recently harvested cotton, the self-cleaning tines worked quite well where the cotton stalks were 5 A or less. Where cotton stalks exceeded 5 A or more, the stalk coverage and burial of large stems was not adequate in one primary trip. The stalks were still somewhat green and contained high moisture,. Had the stalks gone through a frost, the Dyna-Drive would probably have performed better in cotton residue. Compared to one pass of a disk harrow, the Dyna-Drive was better in cotton stalks. The cotton stalks had not been mowed The conventional tillage practice is the mowing of stalks which is followed up by discing. In cotton that has not been allowed to get excessively high or too rank, which usually causes severe lower boll rot and reduced yields, the Dyna-Drive may be a good implement for growers to consider. More research needs to be performed.

The seeding of winter small grains by simultaneously seeding with the attached (Tye) seeder met with mixed results. In the fall of 1995, nine fanners planted small grains for forage which were rye, ryegrass, and oats. A small seed clover attachment made it where clover could also be simultaneously planted. Four of the nine fanners interseeded clover. Plantings in fall 1995 proved successful and good stands were achieved. In the fall of 1996, 15 producers planted winter small grains with this combination seeder and tillage implement. There was a substantial dry period in October 1996, and mixed results were achieved. Some stands of rye, ryegrass, and oats were slow to establish and in some cases, undesirable plant populations or stands resulted. An inspection of the actual placement of *seed* in the soil and seed soil contact was evaluated. The placement of *seed* behind the tines and in front of the roller conditioner was not leaving a substantial portion of the seed at a satisfactory depth or with the appropriate seed to soil contact, particularly where moisture was marginal for germination. The broadcasting of rye, oats, or wheat in front of the Dyna-Drive appeared to be a better method. More uniform stands were achieved by spreading the larger seeded small grains prior to tillage. Observations of utilizing the attached seeding apparatus for planting ryegrass and clover met with better results. Also, in permanent pastures overseeded with the Dyna-Drive in the Fall, the bermudagrass or bahiagrass was quicker to reestablish in early summer as compared to conventional tillage. More research is needed before precise recommendations can be made for the practice of simultaneously seeding in combination with ground driven rototillers.

The Terra Max subsoiler was very effective in reducing soil compaction and shattering hard pans. The curved or bent-leg shank breaks up hard pans as it lifts the soil above the shank point. With a one-half (1/2)-in tip installed on the soil compaction tester, readings in most fields showed there was a definite hard pan at a 6- to 8-in depth. Prior to subsoiling, soil compaction of hard pans often measured above 300 psi. One subsoiling brought hard pan zone readings to less than 100 psi. The 30-in shank spacing seemed adequate, however, sometimes a complete shatter was not achieved between shanks. Communication with the manufacturer was made about this possible problem. Their suggestion was that in order to accomplish a more complete shank-to-shank disruption of hard pans, off-setting shanks, which they sell as an option, are the solution. The Terra Max tool bar is designed for two in-line shanks, one is installed behind the first. One shank would curve left and the other would curve right. These were manufacturer suggestions and more research is needed. All of the three shanks used in this project curved the same direction. A ridging effect was created at the shank soil entry locations in permanent pastures. The manufacturer stated this could be corrected by removing the gauge wheels which would create more down pressure ***on*** the roller-conditioner. It should also be well noted that it takes considerable more tractor size or horsepower to subsoil with bent-leg shanks versus straight leg shanks.

The Terra Max yield response in three test plots where subsoiling was compared to no subsoiling (other tillage seeding, and fertilization practices were identical) increased forage yield. In a I-a field that was strip subsoiled in front of the Dyna-Drive, only a slight marginal growth response was noticed in rye. In a permanent bermudagrass pasture, a dramatic growth response was observed where subsoiling was performed. A 9-in average height advantage was observed, although the grass height was somewhat up and down between the shanks. In the ryegrass-clover mix demonstration where subsoiling was followed by a grain drill, based on observatinoal results, total forage yield was about double or twice as much (ryegrass and clover) as the control.

CONCLUSIONS

Both implements tested appear to be good BMP candidates, while this equipment takes considerable power to operate, both actually reduced energy use in producing quality forage. The Dyna-Drive revealed that this implement can successfully reduce the number of passes needed for soil preparation in most field conditions. In compacted permanent pastures, The Dyna-Drive substantially outperformed conventional disk harrows in the pulverization of sod It leaves an excellent seed bed while leaving a higher percentage surface residue. Although more research is needed, it appears to be a viable BMP implement. The Terra Max subsoiler shattered hard pans, reduced soil compaction by asmuch as 200 PSI and exhibited substantial growth response. Because of improved internal soil characteristics, drainage, permeability and the amount of surface residue left, subsoilers of this design are worth considering as conservation tillage tools.

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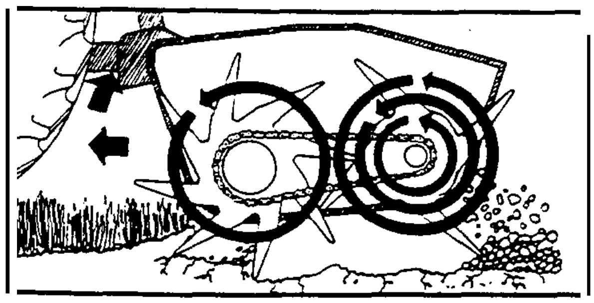
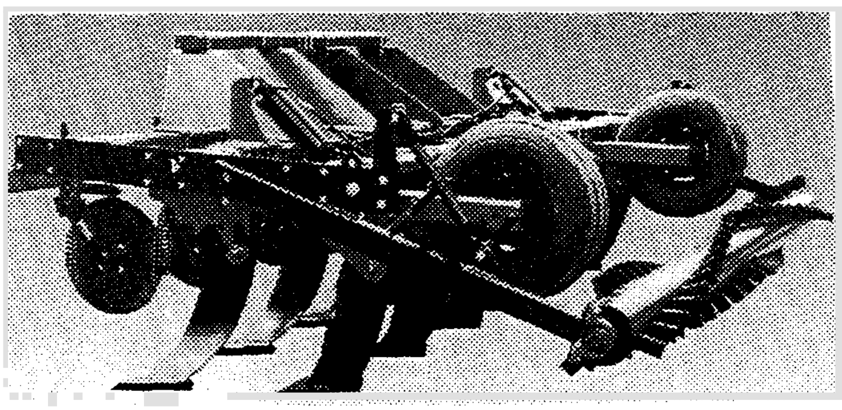


The Dyna-Drive is a very uncomplicated twin rotor ground-driven tillage tool that has no PTO or gearbox. The Dyna-Drive's front rotor is geared directly to the ground and drives the rear rotor with a heavy duty roller chain arrangement.



Obstacles to Sod-Seeding Winter Annual Forages in Mississippi

***David J. Lang, Robert Elmore, and Billy Johnson**

INTRODUCTION

Winter annuals such as ryegrass *(Lolium multiflorum)* provide outstanding forage during the fall, winter, and spring months (October through May) throughout the southeastem United States. Tillage invariably increases the earliness and fall yield production of ryegrass compared with any type of no-till or sod-seeding (Lang and Elmore, 1995; Lang etal., 1992; Lang, 1989). A general pattern of two to three months of reduced growth of sod-seeded ryegrass in the fall followed by equal or slightly increased growth in the late winter and early spring as compared with ryegrass seeded into plots that were disked has been observed (Lang, 1989; Brock et al., 1992; Ingram et al., 1993; Lang and Elmore, 1995).

Various factors such as summer growth removal, sod type and density, soil moisture, nutrient immobilization (particularly N), insects, seedling disease soil type, and allelopathy may affect the success or failure of sod-seeded ryegrass (Lang, 1993). Although tillage may stimulate fall ryegrass growth, soil moisture may be lost by exposing the bare soil to wind and solar evaporation. Chemical summer fallow with glyphosate or paraquat may conserve soil moisture; this has been observed on the Prentiss sandy loam soil at Newton, MS. In fact, seeding ryegrass into a killed volunteer annual grass on the Prentiss soil has been found to be equal to or greater than seeding into a disked seedbed, particularly when late summer and early fall rainfall was limited (Brock et al., 1992). Insects such as crickets *(Gryllus* spp.), grasshoppers *(Melanoplus* spp.), and armyworms *(Pseudaletia* spp.) have been suspected (but not verified) of adversely affecting stand establishment in one out of every four years according to a recently completed researcher survey (Lang, 1997, unpublished). However, stand density is generally observed to be similar in both sod-seeded and tilled plots (Lang, 1989; Lang, 1993; Lang and Elmore, 1995).

The objective of this study was to compare results of several experiments over a number of years at multiple locations from various ryegrass sod-seeding experiments in order to identify various factors which may be obstacles (challenges) to successful sod-seeding of winter annuals.

[1]D. J. Lang, [1]R. Elmore, and [2]B. Johnson, [1]Mississippi State University, Mississippi State, MS and [2]Coastal Plain Branch Exp. Station Newton, MS. Manuscript received 10 March 1997. * Corresponding author.

MATERIALS AND METHODS

Various sites, tillage practices, and summer forage systems were utilized over several years at different locations. Particular details about each study are contained in the footnotes of each table along with its reference citation if previously published. Sod type was either volunteer annual grasses such as crabgrass *(Digitaria* sp.), broadleaf signalgrass *(Brachiaria platyphylla)*, or permanent sod with bermudagrass *(Cynodon daclylon)*. Tillage practices included single or double disking at 0, 30, or 60 d prior to seeding, moldboard plow followed by disking and cultipackmg, rototilling followed by disking and packing or seeding directly into sod. Sod suppression and summer growth removal treatments included herbage removal by haying or grazing, herbicide bumdown 1 to 30 d prior to seeding, herbicide bumdown followed by herbage removal by mowing or fire, or sod-seeding without herbage removal. Sites and soil types were Starkville, MS (Savanna sandy loam or Manetta silt loam), Newton, MS (Prentiss sandy loam), and Raymond, MS (Loring silt loam). Each treatment was replicated four times and experimental design was generally a randomized complete block in small plots (6 ft x 18-24 ft) strips within pastures, or replicated pastures. Analysis of variance (ANOVA) was determined at each location by year and over multiple years. Means were separated by LSD(p=0.05).

RESULTS AND DISCUSSION

Tillage improves the growth of winter annuals sown into either summer annual sod (Tables 1 and 2) or into bermudagrass (Table 3). Yield of winter annuals is generally greater when sown into volunteer annual grasses as compared with sowing into permanent sod (Lang et al., 1992), which is in agreement with current work reported in Tables 1-3. Permanent sods of bermudagrass tend to be denser than annual sods which may provide greater hindrance to seed to soil contact. However, stand density has generally been reported to be excellent regardless of the type of sod involved (Lang, 1989; Lang et al., 1992; Ingram et al., 1993; Lang and

Elmore, 1995). The difference in winter annual forage growth between annual sods and permanent sods is most likely due to the quantity of herbage and root mass remaining after hay removal and herbicide burndown. This material may contribute to nutrient immobilization (e.g., N), contain inhibitory substances (allelochemicals), or reduce soil atmospheric oxygen during decomposition (Lang, 1993).

Herbicide burndown and herbage removal were shown to stimulate winter annual growth compared with no herbicide burndown in some, but not all years (Tables 1-3). Lang and Elmore (1995) concluded that herbicide bumdown of volunteer annual grasses was beneficial in a wet year (1992), but not in a dry year (1993). There was no difference between using paraquat or glyphosate. In 1994-95, all plots were irrigated during establishment and the ryegrass growing in the burndown plots yielded more than the ryegrass sown into live annual sod indicating that soil moisture can be conserved by using a burndown herbicide. However, yield response in individual years was small (800 to 1000 lb/a) and may not be economical compared with removing the herbage with a final hay harvest or late summer grazing. Averaged over three yr, there was no advantage to using a burndown herbicide at the Starkville site (Table 1). No advantage to using a burndown herbicide was also not found in the small plots at the Newton site (Table 2); production pastures at Newton, however, have been routinely sod-seeded into volunteer annual grasses following herbicide bumdown 30 d prior to planting ryegrass in order to eliminate the herbage and conserve soil moisture.

Fall growth of summer annual grasses generally diminishes, although in wet, warm years, growth may be quite vigorous until first frost. Bermudagrass growth rate, however, reduces rapidly in the fall after about 15 September even when well fertilized and irrigated (Burton et al., 1988). Yields of winter annuals growing in live or suppressed bermudagrass were equal (Table 3) and this was in agreement with previous work (Lang et al., 1992; Johnson and Lang, 1997). However, plants sown in tilled plots yielded significantly more than those sown into sod.

Total winter annual forage growth enhanced by tillage has been found to be primarily due to enhanced fall growth (Lang, 1989; Brock et al., 1992; Lang et al., 1992; Lang and Elmore, 1995). Early fall enhanced forage growth provides for early fall grazing; average initial grazing date over four yr at the Brown Loam Experiment Station in Raymond, MS was 23 November for pastures seeded to ryegrass in a prepared seedbed, 4 December for those seeded NT into an annual *sod,* 17 December when seeded NT into an annual *sod* plus paraquat, 3 or 5 January for bermudagrass pastures seeded to ryegrass following light disking or paraquat, and 24 January for bermudagrass pastures seeded NT without herbicide supression (Ingram et al., 1993). Sod-seeding ryegrass into volunteer annual grasses provided nearly the same economic return ($80.94/a) compared with seeding into a prepared seedbed ($ 99.32/a). Using paraquat for sod-suppression of either the annual or perennial pasture reduced the economic return to $48.09 or $38.83, respectively (Ingram et al., 1993). They concluded that "planting ryegrass into volunteer summer annual grasses is a viable alternative to conventionally tilled ryegrass pastures in Mississippi".

Fully prepared seedbeds may provide additional forage growth particularly early in the seaso, but soil erosion may be high on some soil sites and year-round utilization of the land resource may be reduced. There may be numerous obstacles to sod-seedmg winter annuals, but most of these challenges can be overcome with timely utilization of moderate tillage, herbage removal prior to seeding, and limited herbage suppression with burndown herbicides. Insect control has not been fully investigated. A preliminay study at the Starkville site indicated there was no benefit to applying insecticides, a l lplots, including the control, had excellent stands. Insect damage, seedling disease, soil to seed contact, and soil moisture may contribute to some winter annual sod-seeding failures; however, there remains an unexplained suppression of sod-seeded winter annual forages that occurs regardless of stand success, N rate, soil moisture, sod type, or forage species.

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Table 1. Effect of burndown herbicide on yield of ryegrass sown into volunteer annual grasses (crabgrass and broadleaf signalgrass) at Starkville, Mississippi.

Seedbed Preparation	1992-93[1]	1993-94[2]	1994-95[3]	Three-Year Average
	------- Total Yield by Year -------------			
	--------- lb dry matter per/a -------------			
Burndown	4694 B	3218 B	5055 A	4322 B
Live Sod	3948 C	3323 B	4767 C	4021 B
Tilled[4]	7586 A	4243 B	4767 B	5532 A
LSD (0.05)	497	308	264	463

Means followed by the same letter within each column do not differ.
[1] Paraquat at 2 pts/a applied 11 Aug. 1992; planted 7 Oct. 1992; (Lang and Elmore, 1995).
'Roundup at 2 qts/a applied 10 Aug. 1993; planted 24 Sept.1993; (Lang and Elmore, 1995).
[3] Roundup at 2 qts/a applied 3 Aug. 1994; planted 16 Sept. 1994; 100 lbs N/a.
[4] Tillage (roto-tilling) was initiated when herbicide was applied on burndown plots

Table 2. Yield of ryegrass as affected by tillage, herbage removal, and burndown herbicide sown into broadleaf signalgrass at Newton, Mississippi, 1994 to 1996.

Seedbed Preparation	1994-1995	1995-1996	Two Year Average
	------------------- lb dry matter/a ------------------		
Deep Disk (DD) July	4319 AB	5076 A	4698 A
Deep Disk August	4585 A	4388 BC	4487 AB
Light Disk July	4015 BC	4667 AB	4341 ABC
Light Disk August	3967 BCD	4433 ABC	4200 BC
Hay Cut September + DD	4303 AE?	4216 BC	4260 BC
Hay Cut September + RU	3588 CD	3890 C	3739 D
Roundup (RU) September	3798 CD	4288 BC	4043 CD
Hay Cut September	3526 D	3911 C	3719 D
LSD (0.05)	463	649	425

Means followed by the same letter within each column do not differ. 'Marshall' ryegrass was planted the first week of October each year. Roundup at 1 qt/a was applied two to three weeks prior to planting. Final hay harvest was also two to three wk prior to planting as was the deep disking following hay harvest treatment. All plots received 65-65-65 at planting and an additional 34 lb N/a per harvest each yr.

Table 3. Yield of winter forages sown into bermudagrass sod as affected by tillage, herbicide suppression, and subsequent effect on bermudagrass growth and persistence at Newton, MS.

Seedbed Preparation	----- Three Year Average Total Yield ------ Winter Forages	Bermudagrass	Final Stand of Bermudagrass
	------------------- lb dry matter/a	-----------------	---- % ----
No-Till (NT)	4068 AB	3826 A	74 A
NT + Roundup	3961 B	3093 B	63 AB
Single Disk	3956 B	2585 BC	33 B
Double Disk	4471 A	2154 C	27 B
LSD (0.05)	448	626	37

Means followed by the same letter within each column do not differ. Three-year average from 1989 to 1992. Data from Johnson et al., 1991; 1992; 1993. Roundup at 1 pt/a was applied in late August each year. Tillage was done in late August and all plots were seeded by the first wk of October. Winter forages were ryegrass, ryegrass +rye, and ryegrass +red clover. Means presented are the average yield of the three forages.

Alternative Arkansas Rotations and Tillage Practices

C.R Dillon, *T.C. Keisling, RD. Riggs, and L.R Oliver

ABSTRACT

The objective of this study was to provide agronomic, nematode, and economic analysis of alternative production rotation systems for soybean *(Glycine max*) on an Arkansas silt loam. Monocropped soybean and soybean double-cropped with wheat *(Triticum aestivum*) was included as well as grain sorghum *(Sorghum bicolor)* under dryland conditions in order to reduce soybean cyst nematode *(Heterodera glycines)* populations. A total of seven crop rotations and 11 treatments that included alternative tillage conditions and wheat stubble management practices were analyzed using data from experiments conducted from 1980 to 1984 at the Arkansas Cotton Branch Experiment Station on a Loring-Calloway-Henry silt loam. Although crop rotation was effective for nematode suppression, yields for double-cropped soybeans were comparable to soybean yields under monocropped, continuous management practices. Economic results indicated that average net returns of %137/a were highest for the continuous double-cropped wheat-soybean production management systems which combine the conventional tillage method with burning of wheat stubble. For the conditions analyzed and level of soybean cyst nematode present, this research provides evidence that control of the soybean cyst nematode through rotation practices that utilize grain sorghum is not economically efficient where continuous double-cropped wheat-soybeans systems can be incorporated.

INTRODUCTION

Crop rotation has been recognized for years as a primary strategy for the effective control of soilbome diseases. With the removal of dibromochloropropene, usually the most cost-effective nematicide in soybean *(Glycine max* [L.] Merr.) production, the use of resistant soybean cultivars, coupled with crop rotation, is seemingly the only remaining control strategy for the cyst nematode *(Heterodera glycines* Ichinohe). Previous research has indicated that non-host crops for one year in the rotation dramatically decreased the nematode population (Slack et al., 1981; Dabney et al., 1988). Research conducted in Kentucky indicated that the combination of no-till and leaving wheat *(Triticum aestivum* L.) straw generally suppressed nematode populations (Hershman and Bachi, 1995), whereas Alabama evidence shows little effect (Edwards et al., 1988). In the Mississippi Delta and Loessial Terraces regions of Arkansas, several million acres of loess-derived soils are very low in organic matter and are subject to severe cyst nematode problems.

In these regions, nonirrigated silt loam soil not cropped to cotton *(Gossypium hirsutum* L.) is almost exclusively cropped to continuous soybean or double-cropped wheat-soybean. The wheat residue usually is burned. This practice of wheat straw burning has been perceived by agronomists as an undesirable practice on soils with very low organic matter (<0.8%) for as long as it has been practiced. The objective of this study was to examine the profit potential of alternative soybean production rotation systems on an Arkansas silt loam within a multidisciplinary (agronomic, pathologic, and economic) framework.

MATERIALS AND METHODS

As a multidisciplinary study, several methodological aspects are discussed. Procedures for the agronomic component, nematode assay, and economic analysis are presented.

Agronomic Component

Experiments were conducted from 1980 to 1984 at the Arkansas Cotton Branch Experiment Station on a Loring-Calloway-Henry silt loam. The initial soil test values were 6.2 for soil pH with 0.6% organic matter and 64 lb P/a and 170 lb K/a.

The study included seven rotational cropping systems composed of continuous soybean (monocropped), wheat-soybean double-cropped, and five biennial rotations of which two were single crops per year and the remaining three were double-crop systems. The exact cropping sequences are shown in Table 1.

[1]C.R. Dillon, [2]T.C. Keisling, [3]R.D. Riggs, and [4]L.R. Oliver. [1]Agri. Economics Dept., [3]Plant Pathology Dept., [4]Agronomy Dept., University of Arkansas, Fayetteville, AR, and [2]Agronomy Dept., University of Arkansas at Northeast Research and Extension Center, Keiser, AR.
Manuscript received 10 April 1997. * Corresponding author.

Also defined in Table 1 are various cropping-system designations. Additional cultural practices were imposed on selected crop rotations. The continuous soybean and wheat-soybean double-crop systems were grown under both conventional tillage and no-till methods. The wheat-soybean double-crop system also had residue management treatments in that the wheat stover was either burned or left on the surface. This plan resulted in a total of four double-cropped wheat-soybean production systems and two continuous soybean systems.

A total of 11 crop production systems were arranged in a randomized complete block design with three replications. Individual production *system* plots were 13.7 ft wide x 100 ft long. Grain sorghum and soybean were planted on 38 in. rows with a conventional planter (John Deere 7000®) equipped for no-till by using cutting coulters, double disk openers, cast iron press wheels and heavy down pressure springs while the wheat was sown in 7.5-in. rows with a Crust Buster no-till drill. Wheat residue was burned in all cases where the crop production system is not otherwise specified.

The study area was planted to soybean in the summer of 1980. The study began with wheat planted that fall and summer crops in the spring of 1981. Yields were determined by harvesting the two middle rows in each plot for both grain sorghum *(Sorghum bicolor* [L.] Moench) and soybean and a 60-in.-wide swath in the middle of the wheat plots. Grain yields were adjusted to 14.0, 13.0, and 13.0% moisture for grain sorghum, soybean, and wheat, respectively. The specific features of each production system were commensurate with commercial production practices used in the area.

Nematode Assay

Every plot was sampled each fall for soybean cyst nematode population density determinations. Soil samples from the 0 to 4 in. depth were taken from the seedling row with a soil probe to generate 20 samples per plot. Second-stage juveniles of *H. glycines* were extracted (Southey, 1986), counted, and analyzed statistically using a square root transformation

Economic Analysis

Economic analysis was conducted using enterprise budgeting techniques. Budgets were compiled on each cropping *system* annually by using the Mississippi State Budget Generator computer program (Spurlock, 1992). In order to remove the effects of market fluctuations and focus upon production economic issues, *crop* prices were based on a 10-yr average (1985-1994) for each crop (Anon., 1995). These prices were $5.92/bu for soybeans, 03.12/bu for wheat, and $1.95bu for grain sorghum. Recent data were used to reflect current conditions. Total income was calculated by multiplying yield and average crop price. Direct expenses were calculated using the average prices paid for seed, chemicals, fertilizer, custom work, labor, repairs, maintenance, fuel, and interest on operating capital. Input requirements were those actually used for seed chemicals, fertilizer, etc., with standard American Society of Agricultural Engineers (ASAE) machinery *costs* calculations for the remainder using recent ASAE coefficients. Recent input prices for Arkansas (Anon., 1994) were also used. Fixed expenses include depreciation, insurance, property taxes, and interest on capital invested associated with tractors, combines, and other field equipment. Total expenses included both the direct and fixed expenses. Net returns are considered the difference between total income and total expenses. Average net returns are calculated over the 4-yr period. Gross income, total expenses, and net returns for the double-crop rotations include the total income, expenses, and returns for both crops produced in each system. No charge was issued for land, risk, overhead labor, other overhead, crop insurance, real estate taxes, or management.

RESULTS AND DISCUSSION

Although economic considerations are a primary motivation of production management decision-making, knowledge of the underlying production processes is crucial to the realization of economic objectives. Consequently, results are presented, in turn for three components that affect performance: agronomic, pathologic (nematode), and economic.

Agronomic

Grain yields for the study generally follow expectations for the crops and cultivars used in the study area without irrigation (Table 2). These particular crop rotations were selected for the alternation of host crop for the management of soilborne plant pathogens, a weed spectrum easily controlled by available herbicides, and economic potential. Other production practices were included to reduce mechanical inputs (no-till) or to retain crop residue.

Nematode

The nematode analyses indicated that leaving wheat residue or burning it did not significantly influence the associated nematode population which averaged 700 and 509 juveniles per pt of soil for wheat residue burned or unburned, respectively. This reduction in nematodes from leaving wheat straw, while not significant, tends to agree with that reported by Hershman and Bachi (1995).

Crop rotations used in this study were of two types: 1) those recommended for nematode suppression that contain a year of non-host crop and 2) those not recommended for nematode suppression that contain host crops planted every year. Rotations were, therefore, classed according to these two schemes. The crop rotation x year interaction was highly significant (P=0.01) and is shown graphically in Figure 1. Essentially, in the fall following a year of non-host crop, the nematode populations were suppressed to a very low level as compared to rotations containing a host crop every year. This finding illustrates the effectiveness of crop rotation for nematode suppression.

The tillage effect on nematode populations was found to be highly significant (P=0.01) and to be independent of crop rotation and year. The data are presented only for continuous single and double-crop soybean (Figure 1). Both rotations had host plants seeded each year. However, the no-till resulted in substantially fewer nematodes than the tilled systems. The no-till production system suppressed the nematodes as well as non-host crop rotation. This result suggests that no-till could well be considered as an alternative to crop rotation for nematode suppression. However, on some sods, the reduction in nematode population density made during a no-till crop may not be sufficient to prevent damage the next year if a susceptible cultivar is planted.

Economic

As expected, net returns varied across years and treatments (Table 3). Over the entire 4 yr of the study, average net returns/a ranged from a high of $136.99 for conventionally produced double-cropped wheat-soybean to a low of $39.44 for no-till continuous soybean (Table 4). Of the crop rotation systems, the wheat-soybean continuous double-cropped systems regardless of tillage practice and stubble management, produced the largest net returns. The least favorable of these four was for soybean no-tilled into wheat residue. At the time of this study the technology was not available to make this treatment yield as it should (Keisling et al., 1994). Therefore, the net returns reported for continuous double-cropped wheat-soybean with wheat residue left and *soybean* no-tilled into the wheat straw will be lower than what can be currently expected.

The next most profitable systems were continuous double-cropped wheat-soybean-monocropped soybean, monocropped grain sorghum-soybean, and double-cropped wheat-grain sorghum-monocropped soybean. These crops were about two-thirds as profitable as the most profitable system. The least profitable rotation was continuous no-till soybean. Net returns for wheat-summer fallow-monocropped soybean were the next lowest. Net returns for the least profitable continuous no-till soybeans were less than one third of the net returns achieved by the most profitable group.

In order to expand the potential for application of the research results to a more diverse set of conditions and address the limitation of the study related to the yield data used, sensitivity analysis was conducted. Specifically, given the wide range of production management abilities, soil potential, and different resources and conditions, yields understandably varied dramatically. This variation in yield obviously has a substantial impact on the net returns that a producer receives. Furthermore, yields have been impacted by changes in technology, cultivar availability, and management information. Consequently, average net returns for selected treatments are calculated under a range of soybean yields and other crop yields. The yield sensitivity analysis focused upon four treatments: conventional, continuous GS/S; conventional, continuous soybeans: no-till continuous soybeans; and conventional continuous, doublecropped wheat-soybeans with burned wheat stubble. In all cases, soybean yields were varied in 10-bu increments from 10 to 40 bu/a. Grain sorghum yield was varied in 10-bu increments from 60 to 80 bu/a and wheat yield was varied in 10-bu increments from 30 to 50 bu/a. The results are presented in Table 5. Notably, all double-cropped wheat-soybean yield levels examined still earned positive net returns and, with a 60 bu/a sorghum yield exception on the GS/S rotation, all 20 bu/a soybean yield levels were sufficient to result in positive net returns for the remaining treatments and yield levels considered.

CONCLUSIONS

In conclusion, the results of the study emphasize the advantage of conducting research within a multidisciplinary framework, given the complicated environment which faces farm managers in their production management decisionmaking. While inclusion of grain sorghum in the rotation was effective in reducing soybean cyst nematode populations, the agronomic production function was such that soybean yields under continuous double-cropped wheat-soybean production practices were comparable to continuous monocropped soybeans. Furthermore, the additional net returns achieved from wheat complemented the continuous double-cropped wheat-soybean production strategy enough to compensate for the lower soybean yields compared to the grain sorghum rotations.

Although control of soybean cyst nematode is essential to good production management, one should consider the economic impact of switching to less profitable enterprises.

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Table 1. Cropping Sequences and Seedbed Preparation for Eleven Crop Production Systems from 1981 to 1984

Crop Rotation'	Tillage'	Wheat Stubble Mgmt.	Year 1980 Winter	1981 Summer	1981 Winter	1982 Summer	1982 Winter	1983 Summer	1983 Winter	1984 Summer
GS/S	Conv.			GS		S		GS		S
S/S	Conv.			S		S		S		S
S/S	No-till			S		S		S		S
W-F/S	Conv.	Bum	W			S	W			S
W-GS/S	Conv.	Bum	W	GS		S	W	GS		S
W-GS/W-S	No-till	Bum	W	GS	W	S	W	GS	W	S
W-S/S	Conv.	Bum	W	S		S	W	S		S
W-SiW-S	Conv.	Bum	W	S	W	S	W	S	W	S
W-S/W-S	No-Till	Burn	W	S	W	S	W	S	W	S
W-S/W-S	Conv.	Leave	W	S	W	S	W	S	W	S
W-S/W-S	No-till	Leave	W	S	W	S	W	S	W	S

'Yearly cropping rotations are divided by '/' and individual crops harvested same year are divided by '-', crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W' for wheat, and 'F' for fallow.

[1]Mgmt refers to management (Burn indicates wheat stubble is burned, Leave indicates the stubble is left unburned on the surface).

Table 2. Grain Yield for the Eleven Crop Sequences

Crop Rotation’	Tillage	Wheat Stubble Mgmt.‡	Crop	Year 1981	1982	1983	1984	Avg.
				--	bu/a	--		
GS/S	Conv.	---	GS	86.0‘	---	107.1	---	96.6
GS/S	Conv.	---	S	---	40.8	---	36.8	38.8
S/S	Conv.	---	S	28.7	31.2	17.1	35.4	28.1
S/S	No-Till	---	S	34.6	20.2	10.7	31.2	24.2
W-FIS	Conv.	Burn	W	34.0	---	38.6	---	36.3
W-FIS	Conv.	Bum	S	---	34.7	---	34.6	34.6
W-GSIS	Conv.	Bum	W	34.0	---	40.6	---	37.3
W-GSIS	Conv.	Burn	GS	62.3	---	62.3	---	62.3
W-GSIS	Conv.	Bum	S	---	36.7	---	36.9	36.8
W-GS-IW-S	No-Till	Bum	W	34.0	28.0	40.1	32.3	33.6
W-GSIW-S	No-Till	Burn	GS	36.0	---	35.5	---	35.8
W-GSIW-S	No-Till	Burn	S	---	28.7	---	33.9	31.3
W-S/S	Conv.	Burn	W	34.0	---	40.1	---	37.1
W-S/S	Conv.	Burn	S	27.1	32.1	16.4	39.0	28.8
W-S/W-S	Conv.	Burn	W	34.0	34.7	37.6	42.1	37.1
W-S/W-S	Conv.	Burn	S	34.6	30.3	19.4	33.9	29.5
W-S/W-S	No-Till	Burn	W	34.0	32.0	38.6	43.9	37.1
W-S/W-S	No-Till	Burn	S	35.3	31.2	19.0	35.4	30.2
W-S/W-S	Conv.	Leave	W	34.0	31.4	35.1	34.1	33.8
W-S/W-S	Conv.	Leave	S	33.1	31.0	16.8	36.5	29.4
W-S/W-S	No-Till	Leave	W	34.0	34.0	37.1	23.7	32.2
W-S/W-S	No-Till	Leave	S	39.5	29.4	19.0	26.6	28.6

† Yearly cropping rotations *are* divided by '/' and individual crops harvested same year divided by '-', crops *are* shown as ‘GS’ for grain sorghum, ‘S’ for soybean, ‘W’ for wheat and 'F' for fallow.

‡Mgmt refers to management (Bum indicates wheat stubble is burned, Leave indicates the stubble is left on the surface).

’Measured plots yields of 16 bu/a were based on experiment station average on 300 a. Small plots of early grain sorghum were heavily damaged by birds.

Table 3. Total Income (TINC), total Expenses (TEXP) and Net Returns Above Expenses (NRET) for the Eleven Crop Systems

			1981			1982		
Crop Rotation'	Tillage	Wheat Stubble Mgmt.ǂ	TINC	TEXP	NRET	TINC	TEXP	NRET
GS/S	Conv.	---	167.70	114.41	53.29	241.71	129.22	112.49
S/S	Conv.	---	170.08	71.20	98.88	184.88	131.98	52.91
S/S	No-Till	---	204.83	81.85	122.98	119.58	125.83	-6.24
W-FIS	Conv.	Bum	106.08	71.64	34.44	205.25	128.29	76.96
W-GSIS	Conv.	Bum	227.62	173.13	54.49	217.26	128.60	88.66
W-GSN-S	No-Till	Burn	176.22	149.00	27.22	257.44	178.98	78.46
w-SIS	Conv.	Burn	266.69	141.48	125.21	193.58	127.99	65.59
W-S/W-S	Conv.	Burn	310.73	140.48	170.25	287.46	166.76	120.70
W-SN-S	No-Till	Burn	314.88	152.23	162.65	284.37	170.40	113.97
w-SN-s	Conv.	Leave	302.03	162.87	164.14	281.76	167.81	113.95
W-SN-S	No-Till	Leave	339.92	157.94	181.98	280.04	179.76	100.29
GIS	Conv.	---	208.90	117.60	91.30	217.86	128.61	89.24
S/S	Conv.	---	101.23	69.44	31.79	209.57	128.40	81.17
SIS	No-Till	---	63.34	80.72	-17.37	184.41	126.03	58.38
W-F/S	Conv.	Burn	120.43	72.34	48.09	204.83	128.28	76.55
W-GSIS	Conv.	Burn	248.22	174.16	74.06	218.45	128.63	89.82
W-GSN-S	No-Till	Bum	194.40	149.88	44.51	301.37	172.49	128.88
W-S/S	Conv.	Bum	222.20	140.81	81.39	230.70	128.94	101.76
W-SN-S	Conv.	Bum	232.25	138.76	93 .50	331.96	168.46	163.49
W-SN-S	No-Till	Bum	233.09	150.49	82.60	346.71	172.89	173.82
W-SN-S	Conv.	Leave	210.76	136.96	73.79	322.56	169.05	153.51
W-S/W-S	No-Till	Leave	228.32	155.32	72.99	231 24	169.79	61.45

'Yearly cropping rotations are divided by '/' and individual crops harvested same year are divided by '-', crops are shown as *'GS'* for grain sorghum, 'S' **for** soybean, *'W'* for wheat and 'F' for fallow.

ǂMgmt refers to management (Bum indicates wheat stubble is burned, Leave indicates the stubble is left unburned on the surface.

Table **4.** Averages for Total **Income (TINC),** Total **Expenses (TEXP)** and **Net Returns** Above **Expenses (NRET)** for **the Eleven Crop Systems**

Crop Rotation'	Tillage	Wheat Stubble Mgmt.[‡]	Average of 1981 through 1984 TINC	TEXP	NRET
GS/S	Conv.	---	209.04	122.46	86.58
S/S	Conv.	---	166.44	100.26	66.19
S/S	No-till	---	143.04	103.61	39.44
W-F/S	Conv.	Bum	159.15	100.14	59.01
W-GS/S	Conv.	Bum	227.89	151.13	76.76
W-GS/W-S	No-till	Burn	232.36	162.59	69.77
W-S/S	Conv.	Burn	228.29	134.81	93.49
W-S/W-S	Conv.	Burn	290.60	153.62	136.99
W-S/W-S	No-till	Burn	294.76	161.50	133.26
W-S/W-S	Conv.	Leave	279.28	159.17	126.35
W-S/W-S	No-till	Leave	269.88	165.70	104.18

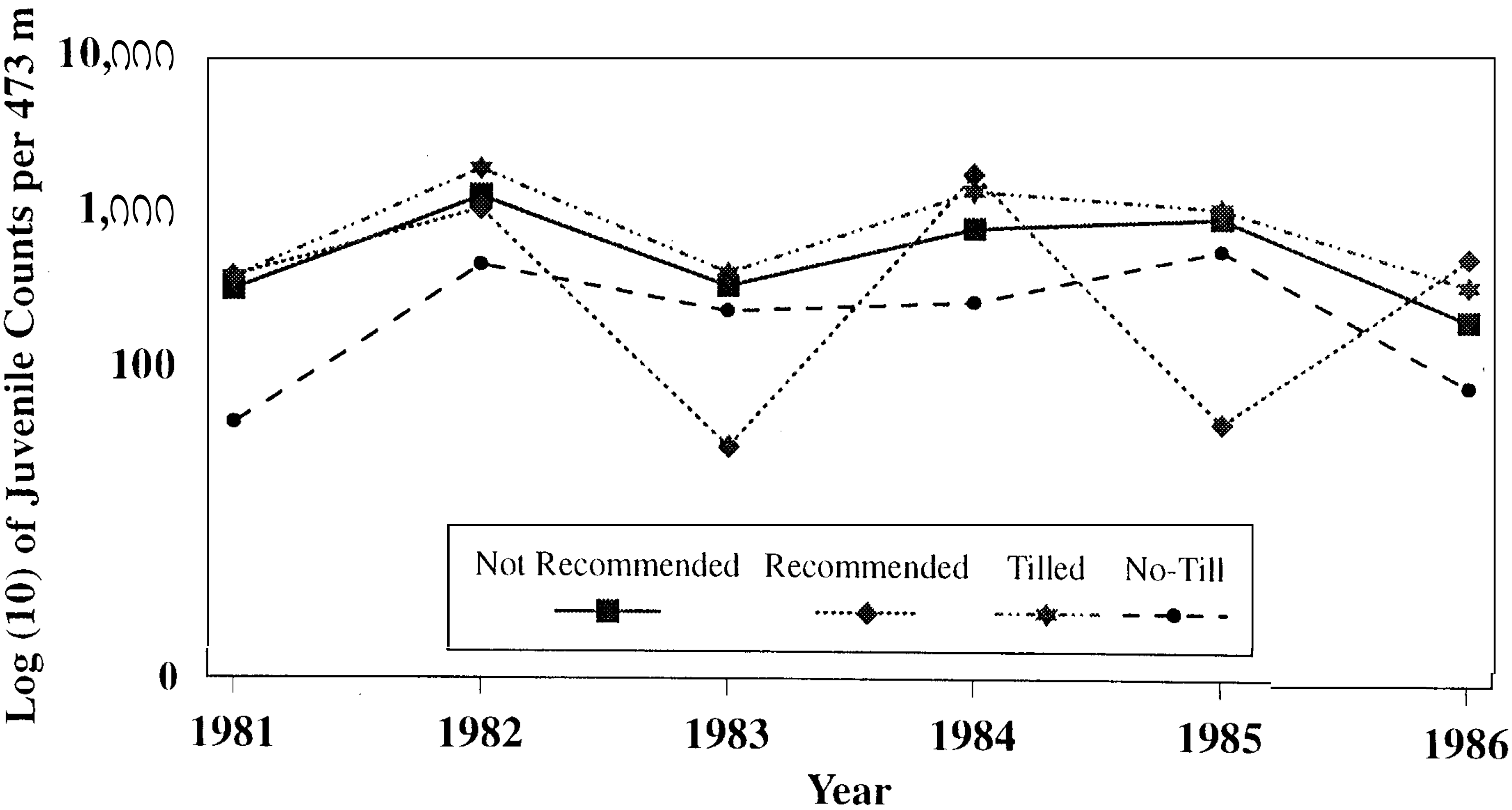
'Yearly cropping rotations are divided by '/' and individual crops harvested same year are divided by '-', crops are shown as 'GS' for grain sorghum, 'S' for soybean, 'W for wheat and 'F' for fallow.

[‡]Mgmt refers to management (Bum indicates wheat stubble is bumed, Leave indicates the stubble is left unburned on the surface).

Table 5. Average Net Returns' ($/a) Sensitivity Analysis of Yield Effects for Selected Treatments

		Nonsoybean		Soybean Yield			
Rotation'	Tillage	Crop	Yield	10	20	30	40
GSlS	Conv.	*GS*	60	-29.42	-0.58	28.27	57.11
GSlS	Conv.	*GS*	70	-20.43	8.42	37.27	66.11
GSlS	Conv.	*GS*	80	-11.43	17.42	46.26	75.10
S/S	Conv.	NA	NA	-39.37	18.32	76.01	133.70
S/S	No-till	NA	NA	-41.29	16.41	74.10	131.78
W/S[‡]	Conv.	W	30	3.24	60.93	118.62	176.31
W/S[‡]	Conv.	W	40	32.89	90.58	148.26	205.95
W/S[‡]	Conv.	W	50	62.53	120.22	177.91	235.60

'Yearly cropping rotations are divided by '/' and individual crops harvested same year are divided by '-', crops are shown as 'GS' for grain sorghum, 'S' for soybean, ' W for wheat and 'F' for fallow.
[‡]The wheat stubble was burned.



Note Recommended includes grain sorghum in 81, 83 and 85.
Not recommended excludes grain sorghum.

Methods for Managing Nematodes in Sustainable Agriculture

***R. McSorley and R. N. Gallaher**

ABSTRACT

The efficacy of tillage, yard-waste compost amedment, and crop rotation for management of plant-parasitic nematodes were examined in a number of field tests in north-central Florida. Tillage practices affected (P<0.10) nematode population densities in only a few cases. Yard-waste compost had little effect on nematode numbers in the first season following application, but there was evidence of long-term effects on some nematodes. Crop rotation was effective in reducing nematode population densities in many tests. Rotation with velvetbean *(Mucuna deeringiana)* was effective in reducing numbers of *Meloidogyne incognita* (in 7 of 7 tests), *Criconemella* spp. (5 of 7 tests), and Pratylenchus spp. (4 of 7 tests). Velvetbean and certain cultivars of cowpea *(Vigna unguiculata)* and sorghum *(Sorghum bicolor)* were particularly effective against *M.* incognita, the key nematode pest in many cropping systems in the region.

INTRODUCTION

A number of non-chemical methods are available for managing plant-parasitic nematodes and reducing their population levels in sustainable agricultural systems (McSorley, 1994; 1996; Trivedi and Barker, 1986). These include use of resistant cultivars, crop rotation and cover crops, fallow, flooding, tillage, soil solarization, organic amendments, destruction of weeds and group residues, and other practices (McSorley, 1996; Trivedi and Barker, 1986). The design of cropping systems and crop rotation schemes using nematode-resistant crops and cultivars has been particularly important in nematode management (McSorley, 1996; McSorley and Gallaher, 1992b; Trivedi and Barker, 1986).

In north-central Florida, a number of experiments have been conducted to examine the effects of tillage (McSorley and Gallaher, 1993a; 1994a,b), organic amendments (McSorley and Gallaher, 1995a; 1996a), and crop rotation (McSorley and Gallaher, 1991; 1992a; 1993b) on plant-parasitic nematodes. The purpose of this paper is to review the results from a large number of tests to assess the relative utility of tillage, organic amendments, and crop rotations for nematode management.

MATERIALS AND METHODS

From 1990 to 1995, a variety of tests were conducted evaluating effects of tillage, organic amendments, or crop rotation on population densities of plant-parasitic nematodes in soil. All tests were conducted in Alachua and Marion counties in north-central Florida, on sandy soils consisting of 90 to 94% sand, 2 to 5% silt, and 2 to 6% clay. Treatments were imposed on small plots replicated in split-plot or randomized complete block designs. A variety of crops were examined in spring or summer experiments. Soil samples for nematode analysis were collected at the time of planting and harvest of each crop. Nematodes were extracted from soil using a sieving and centrifugation technique (Jenkins, 1964) and counted under a microscope. Nematode count data were subjected to analysis of variance followed by Duncan's multiple range test to determine whether significant (at P<0.05 or P<0. 10) treatment effects had occurred.

Tillage effects were evaluated in tests comparing conventional and no-till treatments in the management of tropical corn *(Zea mays)* cultivars during the summer. A total of eight different tests were conducted. Of these, five tests involved corn at different sites following various cover crops or N regimes (McSorley and Gallaher, 1994a). Three other tests were conducted in another site, but in three different years (McSorley and Gallaher, 1993a; 1994b).

Organic amendment effects were evaluated in tests involving treatments with 269 mt/ha of yard waste composts with C:N ratios of 35:1 to 46:1. The three treatments involved in each test were: compost applied to the soil surface as a mulch, compost incorporated into the soil by rototilling, and an unamended control. Ten tests involved evaluation of nematode numbers in the first season after compost application on field corn at two sites (McSorley and Gallaher, 1996a), and on four different

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'R. McSorley and 'R. N. Gallaher. 'Department Of Entomology and Nematology and 'Agronomy Department, University of Florida, Gainesville, FL.
Manuscript received 24 March 1997. * Corresponding author.

vegetable crops (sweet corn, cowpea *[Vigna unguiculata]*, squash *[Cucurbita pepo]*, okra *[Hibiscus esculentus])* at two sites each (McSorley and Gallaher, 1995a). In two other tests, nematode population densities on field cornwere evaluated at two sites in the third year following compost amendment in each of the previous years (McSorley and Gallaher, 1996a).

Rotation effects were evaluated at seven different sites in whichnematode numbers following four different summer rotation crops were compared with nematode numbers following tropical corn cv. Pioneer 3098 (McSorley and Gallaher, 1992a). The four rotation crops evaluated in each test were: soybean *(Glycine max* cv. Howard), velvetbean *(Mucuna deeringiana),* cowpea cv. California Blackeye #S, and sorghum *(Sorghum bicolor* cv. Asgrow Chaparral). Nine addition comparisons were made between nematode numbers following a summer cover crop of tropical corn cv. Pionem X304C and sorghum cultivars DeKalb FS2SE or DeKalb BR64 or sorghum-sudangrass *(S. bicolor* x *S. sudanense)* cv. DeKalb SX-17 (McSorley and Gallaher, 1991; 1993b).

RESULTS AND **DISCUSSION**

Plant-parasitic nematodes commonly found in the study sites included ring nematodes *(Criconemella* spp. = *Criconemoides* spp., primarily *C. ornata),* the root-knot nematode *(Meloidogyne incognita),* the stubby-root nematode *(Paratrichodorus minor),* and lesion nematodes *(Pratylenchus* spp., primarily *P. scribneri). Meloidogyne incognita* is considered the key nematode pest in this system (McSorley and Gallaher, 1992b).

Nematodes numbers did not differ much between conventional and no-till treatments (Table I). At $P<0.05$, only five significant differences were observed, while at $P<0.10$, eight such differences occurred In some of these instances, nematode numbers were greater under no-till treatment, while in other cases, numbers were greater following conventional tillage (McSorley and Gallaher, 1993a). There is some evidence that higher soil populations of *Pratylenchus scribneri* result from conventional tillage (McSorley and Gallaher, 1993a; 1995b).

In the first season following application, yard-waste compost was rather ineffective in reducing numbers of plant-parasitic nematodes (Table 2). Although in one test numbers of *M. incognita* were reduced by mulch, in one other case *M. incognita* numbers were greater in mulched plots than in unamended control plots, and in another test *M. incognita* numbers were greater in plots with incorporated compost than in unamended plots (McSorley and Gallaher, 199Sa). There was evidence that compost was more effective against nematodes after a longer period of time, as shown in tests which had received compost treatments for three years (Table 3). However, even after this length of time, there were no significant effects of compost on *M incognita,* the most serious nematode pest present in these sites.

Several rotation crops were effective in lowering nematode numbers compared to levels found on tropical corn (Table 4). Several different crops were effective against *M. incognita* and *Criconemellu* spp., and velvetbean was an effective rotation crop against the widest range of nematodes. Velvetbean and the cowpea cultivar used here reduced levels of *M. incognita* in all seven tests. Compared to population levels on corn, reductions ranged fiom 37.4% to 98.6% following cowpea and from 70.6% to 99.9% following velvetbean. The average ($\pm$ standard deviation) reduction following velvetbean was 91.0% ($\pm$12.8).

In the nine comparisons of tropical corn and various sorghum cultivars, numbers of *M. incognita* following sorghum were reduced fiom those following corn in 9/9 cases (data not shown). Reductions ranged from 96.7% to 100%, with a mean ($\pm$ standard deviation) of 98.4% ($\pm$*1.06).* Note that the sorghum cultivars used in these tests (McSorley and Gallaher, 1991; 1993b) are different from the rather ineffective cultivar used in the seven tests presented in Table 4 (McSorley and Gallaher, 1992a).

In the cropping systems of north-central Florida, it is evident that crop rotation is much more effective than tillage or yard-waste compost amendment for management of plant-parasitic nematodes, especially *M. incognita.* For yard-waste compost application, the principal benefit against nematodes may not be any reduction of numbers, but the improvement of crop tolerance to nematodes (McSorley and Gallaher, 1996b). A number of summer and winter rotation crops can be effective in reducing nematode numbers in this region (McSorley, 1994; 1996; McSorley and Gallaher, 1991; 1992a,b; 1993a,b). However, with these crops, cultivar choice can be critical, particularly with sorghum (McSorley and Gallaher, 1991; 1992a; 1993b) and cowpea (Gallaher and McSorley, 1993). Future research is needed to identify candidate crops and cultivars effective in rotations in Florida and other regions.

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Table 1. Number of tests in which significant (at P<0.05 or P<0.10) differences between conventional and no-till treatments were observed in nematode numbers measured at planting or harvest of corn.

	Number of tests			
	Differences at P≤0 05		Differences at P≤0.10	
	Planting	Harvest	Planting	Harvest
***Cnconemelia* spp.**	0/7†	018	on	018
Meioidogyne incognita	on	018	on	018
Paratrichodorus minor	2/7	018	2 n	1/8
***Pratyienchus* spp.**	1/7	218	2/7	318

†No. of tests with differences/Total no. of tests observed.

Table 2 Number of tests in which a significant (at P≤0.10) reduction in nematode numbers measured at planting or harvest of corn and vegetable crops was obtained by a yard-waste compost (incorporated or mulch) treatment in the first season after compost application.

	Numbers of tests			
	Incomorated		Mulch	
Nematode	Planting	Harvest	Planting	Harvest
***Criconemelia* spp.**	0/10†	1/10	0110	1/10
Meloidogyne incognita	0/10	0110	0110	1/10
Paratrichodorus minor	0/10	1/10	0110	0110
***Pratylenchus* spp**	0110	0110	0/10	0/10

†No. of tests with significant reductions compared to control/Total no. of tests observed

Table 3. Number of tests in which a significant (at $P \leq 0.10$) reduction in nematode numbers measured at planting and harvest of corn was obtained by a yard-waste compost (incorporated or mulch) treatment, in plots which had received compost treatments for three years.

	Number of tests			
	Incorporated		Mulch	
Nematode	Planting	Harvest	Planting	Harvest
Criconemeiia **spp.**	1/27	212	1/2	2/2
Meloidogyne incognita	0/2	0/2	0/2	012
Paratrichodorus minor	1/2	1/2	1/2	1/2
Pratylenchus spp.	212	012	2/2	0/2

†No. of tests with significant reductions compared to control/Total no. of tests observed

Table 4. Number of tests in wbicb nematode numbers following a summer cover crop were significantly lower (at $P \leq 0.05$) than numbers following tropical corn.

	Number of tests bv cover crop			
Nematode	Soybean	Velvetbean	Cowpea	Sorghum
Criconemelia **spp.**	4/7	5/7	2n	0/7
Meloidogyne incognita	4/7	7n	7/7	2/7
Paratrichodorus minor	1/7	in	in	0/7
Pratylenchus spp.	0/7	4/7	in	on

†No. of tests with significantreductions compared to corn/Total no. of tests observed.

Cover Crop and Herbicide Burndown Effects on No-Till, Water-Seeded Rice

P.K. Bollich

ABSTRACT

The majority of no-till, water-seeded rice *(Oryza sativa)* in southwest Louisiana is planted into native vegetation grown over the winter months prior to spring planting. Cover crops that produce uniform growth, do not compete with the following rice crop during the critical stand establishment stage, and are easily controlled by burndown herbiidea could provide a more desirable seedbed in which to establish rice. A study was conducted in 1995 and 1996 to evaluate various cover crop and preplant vegetation management combinations for their potential use in no-till rice production. Nine cover crops included both clover and grass species, and four preplant vegetation management strategies included three burndown herbicides and a no-herbicide treatment. Significant interactions occurred between preplant vegetation management and cover crops for days to 50% heading, plant height, and grain yield. Maturity was delayed in most cover crops when no herbicide was used to control preplant vegetation and was most pronounced in the clover cover crops both years. Maturity was significantly delayed in a ryegrass *(Lolium multiflorum)* cover crop in 1995 and in both berseem clover *(Trifolium alexandrinum)* and ryegrass cover crops in 1996, regardless of preplant vegetation management treatment. Influence of mver crop and preplant vegetation management on plant height was less dramatic. Plant height reductions in 1995 generally occurred when no burndown herbicide was used to control preplant vegetation. In 1996, plant height reductions were also caused by some cover crops. Grain yields were reduced in most cover crop/no-herbicide mmbinations each year. Rice grain yields were also reduced with berseem clover and ryegrass cover crops, regardless of preplant vegetation management treatments each year. When burndown herbicides were used to control preplant vegetation, most cover crops behaved similarly to native vegetation. When no burndown herbicides were used, only spring triticale *(Triticosecale)* and wheat *(Triticum aestivum)* were suitable alternatives to native vegetation. Regardless of preplant vegetation management, berseem clover and ryegrass are the least desirable cover crops to use for no-till rice establishment

P.K. Bollich. Louisiana State University Agricultural Center, Rice Research Station, Crowley, LA. Manuscript received 27 March 1997.

INTRODUCTION

Rice *(Oryza sativa* L.) production in Louisiana with reduced tillage systems has steadily increased since 1990. Approximately 15% of the state's rice acreage is currently devoted to conservation tillage practices (J.K. Saichuk, 1997, personal communication). A small percentage is rice seeded drectly into crop residue from the previous season. The most popular practice, however, is to prepare a seedbed in the fall, allow it to revegetate with winter weeds, use a chemical bumdown in the spring two to four wk preplant, and either water seed or drill seed. The mild winters in Louisiana are very conducive to establishment of native vegetation in most years.

There has been little interest in utilizing a planted cover crop for no-till rice production. In a study conducted by Eastman (1986), crimson clover *(Trifolium incarnatum* L.) and subterranean clover *(Trifolium subterraneam* L.) were evaluated for their potential as a cover crop for rice. Stand densities were reduced four wk after rice establishment, but rice grain yields were affected at only one location in one yr. This study was conducted in a drill-seeded cultural system. The potential for stand reductions in rice no-tilled into preplant vegetation is greater in a water-seeded system (Bollich, 1996).

A disadvantage of native vegetation as a cover crop is that its composition varies due to previous tillage practices, soil area differences, and whether the rice field remains drained or flooded over the winter. Successful termination of preplant vegetation is dependent upon the ability of a bumdown herbicide to effectively control a wide array of weed species. Since the composition of native vegetation can range from easily controlled, small winter annuals to more difficult to control perennial weeds, complete control of all preplant vegetation is seldom achieved. A planted cover crop with modest winter growth potential that is easily controlled with a preplant bumdown herbicide should provide a more uniform and problem-free seedbed into which no-till rice can be planted.

The. objectives of this study were to: 1) evaluate clover and grass cover crops as alternatives to native vegetation in a water-seeded, no-till rice system, and 2) evaluate three bumdown herbicides and a no-herbicide control for preplant vegetation management.

MATERIALS *AND* METHODS

An experiment was conducted at the South Unit of the Rice Research Station, Crowley, LA, in 1995-1996 to evaluate the effects of cover crops and bumdown herbicides on no-till, water-seeded rice. Approximately 45 lb/a of P_2O_5 and K_2O were incorporated in the fall prior to cover crop establishment.

Various grasses and clovers were evaluated to determine their potential as alternatives to a native vegetation cover crop. In 1995, berseem clover *(Trifolium alexandrinum* L.), ladino clover *(Trifolium repens* L.), red clover *(Trifolium pratense* L.), rose clover *(Trifolium hirtum* All.), yellow sweetclover *(Melilotus officanalis* &.I Lam.), cereal rye *(Secale **cereale*** L.), ryegrass *(Lolium multiflorum* Lam.), and wheat *(Triticum aestivum* L.) were evaluated. In 1996, ladino clover, rose clover, yellow sweetclover, and cereal rye were replaced with white clover *(Trifolium repens* L.), 'Morey' wheat (a very short season wheat variety), spring triticale *(Tritosecale* Wittm.), and buckwheat *(Agropyronrepens).* Buckwheat is a cool-season forage sensitive to low temperature, and 6-wk after planting, an early frost terminated its stand. It was replaced with a multiple bumdown treatment (repeated herbicide applications to maintain a vegetation-free seedbed). Three bumdown herbicides and a no-herbicide control were evaluated in combination with each cover crop. Roundup (glyphosate), Liberty (glufosinate), and Gramoxone Extra paraquat) were applied at 1.0, 1.0, and 0.66 lb ai/a, respectively, 1 wk preflood and preplant. In the multiple-bumdown treatment, herbicides were also applied 3-wk preflood and preplant.

A shallow flood was established 2 d prior to seeding with pregerminated 'Cypress' rice and drained 3 d later. The experiment was flush-irrigated as needed, and the permanent flood was established 3-wk after seeding. Nitrogen (150 lb/a) was applied in three equal split applications at the 3-leaf, mid-tillering, and panicle initiation growth stages.

The experiment was designed as a randomized complete block with four replications in a factorial arrangement. Factors were preplant vegetation management and cover crops. Data were analyzed with the SAS System (SAS Institute, 1988). Analysis of variance with the GLM procedure was used to determine significance. Means were compared using Fisher's Protected LSD Test at the 5% level. Days to 50% heading, plant height, and grain yield were determined.

RESULTS

Main effect means are shown in Tables 1 and 2 for 1995 and 1996, respectively. Significant interactions occurred between cover crop and preplant vegetation management for days to 50% heading, plant height, and grain yield in each year of the study. These interactions are depicted in Figures 1 to 6. LSD values are listed in the figure captions, and the native cover crop is considered the control.

There were no differences in days to 50% heading due to preplant vegetation management with cereal rye, ryegrass, and wheat cover crops in 1995 (Figure 1). Days to 50% heading were significantly increased with all other cover crops when no herbicide was used to control preplant vegetation. Within a cover crop, there was generally little difference in maturity due to the three burndown herbicides with the exception of a Roundup and berseem cover crop cornbination. Maturity was delayed by 4 and 5 d when compared with Liberty and Gramoxone Extra, respectively.

Days to 50% heading were not affected by preplant vegetation management in the spring triticale, multiple burndown, or Morey wheat treatments in 1996 (Figure 2). Maturity was increased in the berseem, white, and red clover cover crops and in the ryegrass cover crop when no burndown herbicide was used. In the berseem, white, and red clover cover crops, maturity was significantly delayed by Roundup and Gramoxone Extra when compared with Liberty. Maturity was also delayed by Roundup in the ryegrass cover crop and by Gramoxone Extra in the wheat cover crop when compared with Liberty.

Cereal rye and ryegrass were the only cover crops for which preplant vegetation management influenced plant height in 1995 (Figure 3). Plant height was significantly reduced in these cover crops when preplant vegetation was not controlled with a burndown herbicide. Plant height within a cover crop was not affected by burndown herbicide.

Preplant vegetation management within a cover crop had no influence on plant height in 1996 (Figure 4). Plant height was similar among the three burndown herbicide and no-herbicide treatments.

The influence of cover crop and preplant vegetation management on grain yield in 1995 is shown in Figure 5. Grain yields were reduced when no burndown herbicide was used on berseem, ladino, red, and rose clovers and in ryegrass and native vegetation cover crops. Rice yields from cereal rye and wheat were not affected by preplant vegetation management. In the yellow sweetclover cover crop, rice yield was reduced in the no-herbicide treatment when compared with the Gramoxone Extra treatment.

In 1996, grain yields were significantly reduced in the berseem white, and red clover cover crops and in the ryegrass cover crop when no burndown herbicide was used. In the multiple burndown treatment, yield was significantly reduced with Gramoxone Extra. Roundup and Liberty had no effect on grain production in this treatment. Yields in the spring triticale, Morey wheat, wheat, and native cover crops were not affected by preplant vegetation management.

DISCUSSION

The influence of cover crop and preplant vegetation management combination on days to 50% heading, plant height and maturity were quite variable each year. The use of a planted cover crop does provide more uniform and consistent preplant vegetation than can normally be expected from native Vegetation. The negative influence imposed by some cover crops on rice maturity, plant height, and grain yield does indicate that cover crops in general are not necessarily suitable alternatives to native vegetation. These influences were significantly greater when no herbicide was used to control preplant vegetation. Relying on natural senescence of the cover crops or their control with floodwater alone caused longer delays in maturity, reduction in plant height, and significant yield reductions in rice.

Delayed maturity and reduced grain yields experienced when rice is planted into some clovers and the ryegrass cover crops can be attributed to poor stand establishment and low stand densities. Density was not determined in this study, however, it was observed that in some treatments or treatment combinations, rice stands were significantly reduced. In these situations, there was a strong tendency for maturity to be delayed and yields to be decreased. Adequate plant populations in water-seeded rice are essential for optimum growth and yield (LSU Agricultural Center, 1987).

It is not fully known what mechanisms are involved for certain cover crops to negatively affect rice plant growth and grain yield. The type of vegetation, the amount of biomass produced, or allelopathic effects, either individually or in combination, could explain the interference observed. It was beyond the scope of this study to identfy these factors. It will be important to further evaluate the influence of cover crops on rice plant growth and grain yield. An understanding of the interactions involved will afford the opportunity to better manipulate cover crops to the benefit of no-till rice establishment.

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Table 1. Effect of preplant vegetation termination and cover crops on agronomic performance of water-seeded, no-till Cypress rice. Rice Research Station, South Unit, Crowley, LA. 1995.

Main effect	Days to 50% heading	Plant height	Grain yield at 12% moisture
		-(in)-	-(lb/a)-
Preplant vegetation management (PVM) Mean			
Roundup	88	36	6666
Gramoxone Extra	87	36	7029
Liberty	87	36	6918
None	94	35	4824
LSD (0.05):	1	1	437
Cover Crop (CC) Mean			
Berseem clover	92	35	4960
Ladino clover	89	37	7180
Red clover	91	36	6354
Rose clover	89	37	7152
Yellow sweetclover	86	36	7120
Cereal rye	84	35	7128
Ryegrass	102	34	2453
Wheat	84	36	7402
Native	87	37	7483
LSD (0.05):	2	2	656
CV %	2.82	2.52	14.71
PVM x CC	*	*	*

Table 2. Effect of preplant vegetation termination and cover crops on agronomic performance of water-seeded, no-till Cypress rice. Rice Research Station, South Unit, Crowley, LA. 1996.

Main effect	Days to 50% heading	Plant height	Grain yield at 12% moisture
		-(in)-	-(lb/a)-
Preplant vegetation management (PVM) Mean			
Roundup	91	33	7215
Gramoxone Extra	92	33	6914
Liberty	88	33	1863
None	95	34	6392
LSD (0.05):	1	1	275
Cover Crop (CC) Mean			
Berseem clover	105	34	3410
White clover	92	34	7819
Red clover	96	34	6923
S. Triticale	87	32	7864
Multiple burndown	87	32	8003
Morey wheat	87	32	7716
Ryegrass	96	34	6040
Wheat	88	33	7857
Native	87	31	8305
LSD (0.05):	2	2	413
CV %	2.49	3.42	8.28
PVM x CC	*	*	*

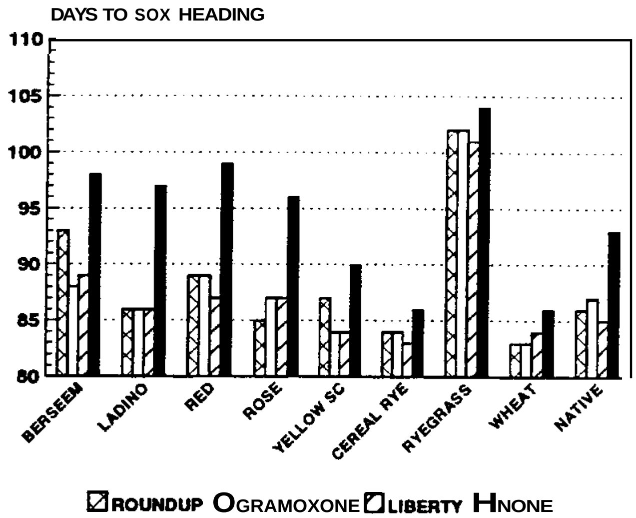

Figure 1. Influence of cover crop and preplant vegetation management on days to 50% heading of Cypress rice, 1995. LSD = 4 (P=0.05).

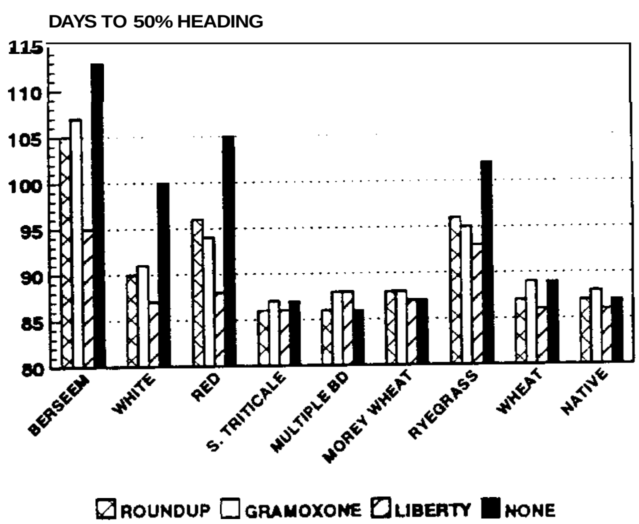

Figure 2. Influence of cover crop and preplant vegetation management on days to 50% heading of Cypress rice, 1996. LSD = 4 (P=0.05).

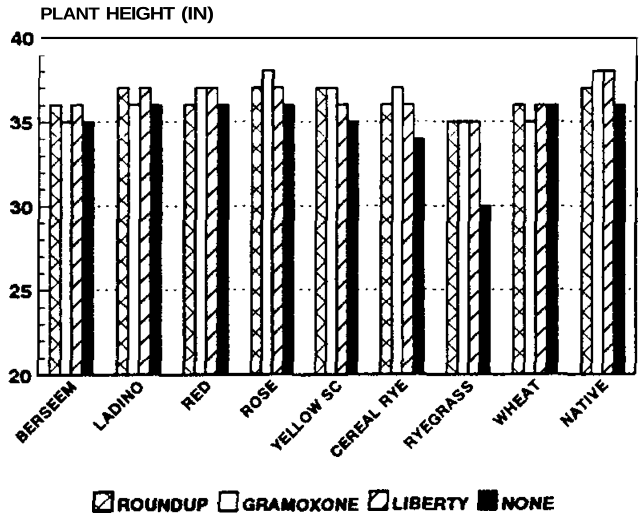

Figure 3. Influence of cover crop and preplant vegetation management on plant height of Cypress rice, 1995. JSD = 3 (P=0.05).

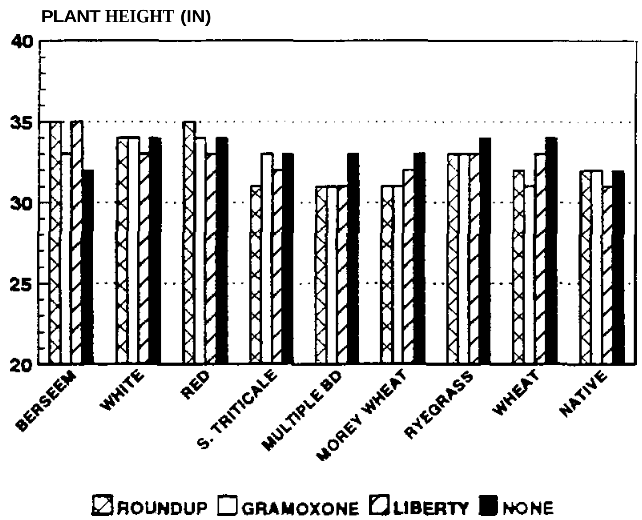

Figure 4. Influence of cover crop and preplant vegetation management on plant height of Cypress rice, 19%. JSD = 4 (P=0.05).

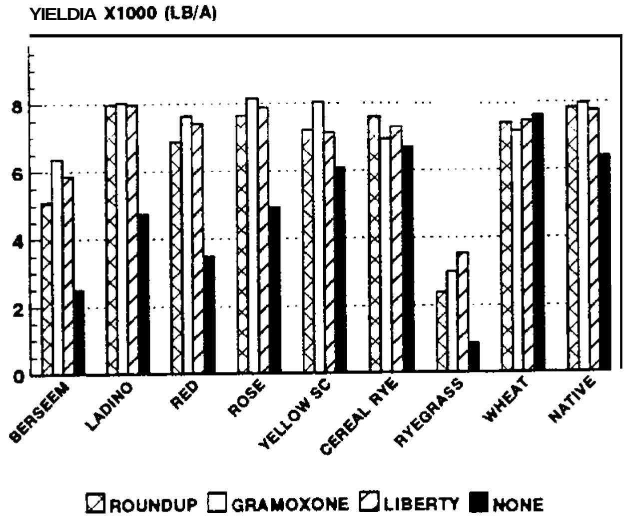

Figure 5. Influence of cover crop and preplant vegetation management on grain yield of Cypress rice, 1995. LSD = 1310 (P=0.05).

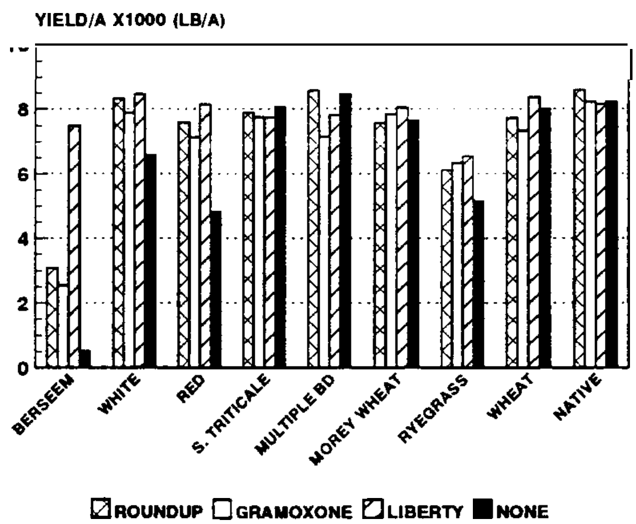

Figure Influence of cover crop and preplant vegetation management on grain yield of Cypress rice, 1996. LSD = 824 (P=0.05).

Mineral Concentration and Content for No-Tillage Tobacco Following Simulated Excessive Rainfall and Supplemental Nitrogen Fertilizer

E.B. Whitty and *R.N. Gallaher

ABSTRACT

Soil erosion and fertilizer nutrients can both result in environmental pollution without good crop production management. Leaching loss of N fertilizer from excessive rainfall events not only results in inadequate N available to maximize crop growth but also results in inefficient utilization of other crop nutrients. The objective of this research was to determine the plant nutrient concentrations and contents of no-tillage flue-cured tobacco *(Nicotiana tabacum)* transplanted into a winter cover crop of rye *(Secale cereale)* that had been treated with supplemental N rates following a large simulated rainfall event under two weed control treatments. An in-row subsoil no-tillage planter was followed by a conventional one-row Mechanical Brand Transplanter in a second operation. Diagnostic leaf concentrations of P, K, Mg, Fe, Mn, and Zn were all in the sufficiency range, Ca was on the borderline of being low, and Cu was low. Crop removal of macronutrients P, K, Ca, and Mg were generally greatest from herbicide-treated plots and from the application of 25 to 50 lbs of supplemental sidedress N fertilizer. Contents of these nutrients were two to four times greater in leaves compared to stems. Greatest macronutrient whole plant content of the above elements at 25 lb supplemental N/a was in the order of K (range from 66 to 109 lb K/a) > Ca (range from 16 to 32 lb Ca/a) > Mg (range from 5.1 to 9.0 lb Mg/a) > P (range from 5.8 to 8.6 lb P/a). The apparent loss of N due to heavy rainfall not only resulted in a need for supplemental N to maintain yield but also resulted in increased uptake of other plant nutrients as well. Precise N fertilizer applications are important to the efficient use of all fertilizer elements, not only to protect the environment but also to maximize production of tobacco.

INTRODUCTION

Soil erosion can be excessive from conventional tillage flue-cured tobacco *(Nicotiana tabacum* L.) (Doyle and Worsham, 1986). No-tillage transplanting of tobacco into winter cover crops has been successful in North Carolina (Doyle and Worsham, 1986; Wiepke et al., 1988) and is presently receiving new emphasis in North Carolina (Worsham, 1995), Tennessee (Fowlkes, 1995; Krueger et al., 1995) and Kentucky (Pearce, 1995; Pearce et al., 1995) as well as in this work in Florida. This continued and renewed emphasis on conservation tillage tobacco as well as other crops is in part due to actions of the U.S. Congress in the passage of the Food Security Act (Anon., 1985) and the Food, Agriculture, and Conservation Trade Act (Anon., 1990). The Food Security Act (Anon., 1985) required farmers who want to remain eligible for U.S.D.A. program benefits and are farming highly erodible land to develop, actively apply, and fully implement a conservation plan according to schedule by the end of 1994. The Food, Agriculture, and Conservation Trade Act (Anon., 1990) reinforced these farm management requirements first required by the Food Security Act (Anon., 1985).

Precise and timely application of N fertilizer to crops grown on sandy soil is important in order to reduce leachmg and economic losses by farmers as well as possible ground water pollution from nitrates. Excessive rainfall or irrigation can leach applied N from root zones of soils used for tobacco in Florida and can be avoided to some extent by using multiple sidedress applications of small increments of N (Smith, 1980) or corrected by replacement of the leached N (Person and Whitty, 1982). Leaching losses can be excessive from heavy rainfall events in Florida and corn *(Zea mays* L.) and grain or forage sorghum *(Sorghum bicolor* L.) Moench) responded best to N being applied in three or four split applications from planting to layby (Gallaher et al., 1992; Lang, 1994). Winter cover crops in succession multiple cropping systems have been found to be effective in reducing nitrate leaching (Hargrove et al., 1992) and many cover crops can provide substantial supplemental N (Gallaher, 1993). The objective of this research was to determine the plant nutrient concentrations and contents of no-tillage transplanted flue-cured tobacco into a winter cover crop of *rye (Secale cereale* L.) that had been treated with supplemental N rates following a large simulated rainfall event under two weed control

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E.B. Whitty and R.N. Gallaher, Agronomy Department, IFAS, Univ. of Florida, Gainesville, FL. 32611
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treatments.

MATERIALS AND METHODS

The field experiment was conducted in 1994 at the University of Florida's Green Acres Agronomy Farm near Gainesville, Florida. 'Wrens Abruzzi' rye was dnlled into a harrowed seedbed at 90 lb/a in November 1993 on an Arredondo fine sand (fine-sandy siliceous, Hyperthermic Grossarenic Paleudult). Rye received 500 lb/a of 12(N)-4(P_2O_5)-8(K_2O) on 10 January 1994 and 2 pt/a of 2-4-D to control winter broadleaf weeds 24 January 1994.

Two pints Gramoxone (Paraquat)/a plus labeled rate of nonionic surfactant was broadcast over the rye at early anthesis on 7 April 1994. Rows 48 in. wide were laid off on 11 April using an in-row subsoil no-tillage planter (Brown-Harden). This unit did a strip tillage 12 in. deep under the row and prepared a clean seedbed in the standing rye about 4 to 6 in. wide over the row. Rye was partially pressed down in the middles, especially near the strip tilled areas. Flue-cured tobacco cultivar 'K326' was transplanted at a spacing of 16 in. into the subsoil strips with a one-row Mechanical Brand Transplanter on 12 April. The transplanter had to be operated in the same direction as the no-tillage subsoil unit in order to eliminate dragging and disruption due to the compressed rye. Fertilization consisted of 650 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 28 April, 650 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 9 May and 300 lb/a of 6(N)-6(P_2O_5)-18(K_2O) on 16 May. This represented a total of 96 lb N + 42.5 lb P + 243 lb K/a and, under normal circumstances, should have been adequate for maximum flue-cured tobacco production under Florida conditions (Stocks and Whitty, 1992).

Whole-plot treatments consisted of application of the herbicide Poast (Sethoxydin) broadcast on 18 April at 1 pt formulated product/a with a nonphytotoxic oil versus a control that received no weed control. Subplot treatments consisted of a supplemental sidedress application of N as ammonium nitrate at rates of 0, 25, 50, and 75 lb N/a. The sidedress N was applied 19 June followed by 0.2 acre in of irrigation to immediately move the N into the root zone. Rainfall was supplemented by overhead sprinkler irrigation as needed once or twice per wk. The supplemental N was applied following a few days of heavy rainfall (1 acre inch on 18 June) and irrigation which simulated 2 acre in. of ramfall on 18 June and an additional 1 acre in. on 19 June.

The final subplot area was 22 ft long and 48 in. wide. Tobacco was topped at early flowering Suckers were chemically controlled by a broadcast spray of 3 lb a.i. Maleic hydrazide [MH(WSSA)] immediately after topping. One wk following topping, the top most leaf was collected at random from six plants in each subplot for N analysis. The end plants were removed between plots prior to harvest leaving 15 plants per 20-ft-long subplots. Bottom leaf harvest was on 13 July and top leaf harvest was on 27 July. Leaves were cured in a commercial tobacco barn Stalks were harvested on 27 July. All leaves and stalks were dried at 70 C in a forced air oven until dry weighed, chopped as necessary, and ground to pass a 2-mm stainless steel screen using a Wiley mill. Samples were stored in sterile air-tight plastic bags.

Nitrogen analysis was reported earlier (Whitty and Gallaher, 1995). Prior to mineral analyses, tissue was redned at 70 C for approximately 2 hr. After *dry* combustion preparation for mineral analyses (Gallaher et al., 1996) nutrient concentrations for Ca, Mg, Cu, Mn and Zn was by AA spectrophotometer. Potassium was analyzed by atomic flame emission spectrophotometer; P by colorimeter.

Data were tabulated, transformed as necessary, and ASCII files prepared using Quattro Pro (Anon., 1987). Analyses of total leaf and stem elemental concentrations were multiplied by total leaf and stem *dry* matter yields (Whitty and Gallaher, 1995) resulting in plant nutrient contents (total nutrient uptake or yield of nutrients removed by the crop on a per acre basis. Analysis of variance was conducted using MSTAT 4.0 (Freed et al., 1985).

RESULTS AND DISCUSSION

The no-tillage subsoil strip tillage transplanting of tobacco was successful with 100% survival of the seedlings. Tobacco plants appeared to have good root systems and experienced no lodging from the subsoil management. Fanners who are interested in this management should be able to utilize an in-row subsoil no-tillage planter with the transplanter units attached to the subsoiler frame. Because of the long distance from the rear of the tractor to the seats on the transplanter, one or two hydraulic helper wheels on the transplanter would likely be necessary to achieve successful planting in one operation.

Either the 96 lb N/a applied earlier was not sufficient to maximize yield or the excessive simulated rainfall event leached needed N below the root zone (Whitty and Gallaher, 1995). Additionally, it was determined that from 50 to 75 lb N/a (depending upon the treatment) was required to maximize dry matter yield following the rainfall event (Whitty and Gallaher, 1995).

As was indicated earlier, a total of 42.5 lb P/a and 243 lb K/a was applied to the tobacco crop prior to the simulated ramfall event. The total N applied in the complete fertilizer was 96 lb/a and should have been adequate for high yield tobacco under Florida conditions. Leaf analysis showed that average N concentration increased by 76% from the 0 lb N/a treatment to the 75 lb N/a treatment (Table 1). This indicated that either not enough N was applied or that the excess rainfall/irrigation did, in fact, leach N below the tobacco roots.

Diagnostic leaf concentrations of P, K, Mg, Fe, Mn, and Zn were within reported sufficiency ranges for all treatments according to Jones et al. (1991). However, Ca was on the borderline of being below desired levels for adequate plant growth and Cu was low according to published sufficiency ranges (20 to 50 ppm) (Jones et al., 1991). None of the concentrations of P,K, Ca, Mg, Cu, Fe, Mn, and Zn in diagnostic leaf tissue were affected by weed control treatment nor supplemental N rates (Tables 1 and 2). This was not the case for diagnostic leaf N concentrations. Leaf N was in greater concentration for the herbicide-treated plots compared to the check at all levels of N fertilizer applied. This indicated that the greater amount of weeds in the check plots were competing with tobacco for N. Leaf N appeared to approach sufficient levels at the 50 lb N/a rate in the herbicide treated plots but would require 75 lb N/a or greater fertilizer N in the check plots (Whitty and Gallaher, 1995).

Nitrogen concentration in the diagnostic leaf was positively related to dry matter yield. Leaf yield responded to 50 lb supplemental N/a, stalk yield to between 25 and 50 lb N/a, and whole plant yield to 25 lb N/a (Table 2). Herbicide treatment resulted in greater leaf and total plant yield compared to the check. Twice as much N was recovered in the leaf dry matter at the 50 lb supplemental N/a rate compared to the control. "his relationship held true for the total plant as well. Consistently greater amounts of N was removed by tobacco parts and total plant from the herbicide treated plots compared to the control (Whitty and Gallaher, 1995).

Leaf and whole plant N contents of P, K, Ca and Mg were all increased by application of 25 to 50 lbs of supplemental N fertilizer/a (Tables 3 to 6). The increased yields of recovery of these elements ranged from 100 to 400% from addition of 25 lb N/a, showing the importance of adequate N for the efficient utilization of other fertilizer elements.

At the supplemental N fertilizer rate of 25 lb/a the tobacco plant removed 8.6 lb P/a for the herbicide-treated plots (Table **3).** This represented a total of only 20% ***of*** P recovered in relation to 42.5 lb P/a that was applied in fertilizer. Since P concentrations (Table 1) were sufficient in the diagnostic leaftissue, data indicate that excess fertilizer P was likely applied to this crop. At the same 25 lb supplemental N/a the tobacco plant removed 108.5 lb Wa for the herbicide treated plots (Table 4). This represented 45% of the 243 lb Wa that was applied in fertilizer. As with P concentration, the K concentration (Table 1) was well within the sufficiency range in diagnostic tissue for good growth. Based on recovery (contents) of N, P, and K in relation to fertilizer applied in this study, the simulated rainfall event resulted in the need for additional N fertilizer, while apparent recoveries of P and K indicated that excess P and K were applied to this tobacco. Further testing could determine more precise amounts and timing of N, P and K fertilizer to maximize tobacco under no-tillage plantings into rye cover crop. Diagnostic leaf data indicate that the tobacco might have responded to an application of Cu (Table 2).

SUMMARY AND CONCLUSIONS

Erosive soils and national U.S. Policy may necessitate that some farmers adapt conservation tillage management for tobacco as has been done for other crops. This study demonstrated that no-tillage subsoil transplanted tobacco into rye cover crop could be successful in Florida. Modification of existing equipment should make this management practical for erosion prone soils. Weed control is essential to reduce competition with tobacco under these conditions. The herbicide treatment consistently gave larger leaf contents of P, K, Ca, and Mg. However, even the herbicide treatment had some weeds that may have been controlled with a second application of the same herbicide. Excess application of water from either rainfall, irrigation, or both can result in losses of fertilizer N either due to leaching or erosion. Based on the results of this study it is recommended that 50 lb supplemental N/a be sidedressed immediately on tobacco, if rainfall/irrigation amounts of 3 acre inches or more are received in a 3day period within a 2 to 3 week period prior to flowering. These data showed that supplemental application of N resulted in significant recovery of P, K, Ca, and Mg. However, only 20% of the P and 45% of the K were recovered in relation to the amount of fertilizer applied at the 25 lb N/a rate. This would indicate, based on yield response, that this tobacco was under-fertilized with N and over-fertilized with P and K. More precise fertilizer practices need to be determined under conservation tillage management.

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Table 1. No-tillage tobacco diagnostic leaf macro nutrient concentrations from weed control and supplement N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		% P				
Yes	Leaves	0.27	0.25	0.29	0.26	0.27 NS
No	Leaves	0.27	0.26	0.27	0.28	0.27
Average	Leaves	0.27 a	0.25 a	0.28 a	0.27 a	
LSD (0.05) among P means = NS						
CV sub plot N means = 11.12%						
		% K				
Yes	Leaves	3.17	3.09	2.89	2.92	3.02 NS
No	Leaves	2.76	2.89	3.17	3.04	2.96
Average	Leaves	2.96 a	2.99 a	3.03 a	2.98 a	
LSD (0.05) among K means = NS						
CV sub plot K means = 14.97%						
		% Ca				
Yes	Leaves	0.94	0.85	0.86	0.83	0.87 NS
No	Leaves	0.74	0.88	0.94	0.94	0.88
Average	Leaves	0.84 a	0.87 a	0.90 a	0.87 a	
LSD (0.05) among N means = NS						
CV sub plot Ca means = 15.51%						
		% Mg				
Yes	Leaves	0.30	0.28	0.31	0.28	0.29 NS
No	Leaves	0.24	0.29	0.30	0.31	0.29
Average	Leaves	0.27 a	0.29 a	0.31 a	0.30 a	
LSD (0.05) among N means = 0.05						
CV sub plot Mg means = 13.70%						

Values among average N fertilizer means not followed by the same letter are significantly different according to LSD test at the 5% level. No significant interactions occurred between weed control treatments and N treatments. NS = no significant difference between herbicide means @ p = 0.05.

Table 2. No-tillage tobacco diagnostics leaf micronutrient concentrations from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
				ppm Cu		
Yes	Leaves	10.8	9.0	12.3	10.5	10.6 NS
No	Leaves	12.8	10.5	12.3	12.3	11.9
Average	Leaves	11.8a	9.8 a	12.3 a	11.4 a	
LSD (0.05) among N rate means = NS						
CV sub plot N rate means = 20.24%						
				ppm Fe		
Yes	Leaves	55	58	63	60	59 NS
No	Leaves	53	55	60	63	58
Average	Leaves	54 a	56 a	61 a	61 a	
LSD (0.05) among N rate means = NS						
CV sub plot N rate means = 11.29%						
				ppm Mn		
Yes	Leaves	61	76	75	83	74 NS
No	Leaves	60	72	70	88	72
Average	Leaves	61 a	74 a	73 a	75 a	
LSD (0.05) among N rate means = NS						
CV sub plot N rate means = 15.64%						
				ppm Zn		
Yes	Leaves	40	36	43	48	41 NS
No	Leaves	47	39	45	42	43
Average	Leaves	44 a	38 a	44 a	45 a	
LSD (0.05) among N rate means = 0.05						
CV sub plot N rate means = 14.74%						

Values among average N fertilizer means not followed by the same letter are significantly different according to LSD test at the 5% level. No significant interactions occurred between weed control treatments and N treatments. NS = no significant difference between herbicide means @ p = 0.05.

Table 3. No-tillage tobacco plant P content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb P/a				
Yes	Leaves	4.31	5.98	5.94	5.38	5.40 NS
No	Leaves	3.58	3.85	6.02	5.42	4.72
Average	Leaves	3.95 a	4.91 ab	5.98 a	5.40 a	
LSD (0.05) for N rate means = 1.21; CV for N rate means = 22.87%						
Yes	stalks	2.10	2.63	2.34	2.40	2.36 NS
No	stalks	2.59	1.96	3.04	2.36	2.48
Average	Stalks	2.34 a	2.29 a	2.69 a	2.38 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 21.39%						
Yes	Plant	6.41	8.61	8.28	7.78	7.76 NS
No	Plant	6.17	5.82	9.06	7.78	7.20
Average	Plant	6.29 b	7.21 ab	8.66 a	7.68 ab	
LSD (0.05) for N rate means = 1.55; CV for N rate means = 19.75%						

Values among aver N means within a weed treatment not followed by the same letter are significantly different according to LSD test **at the** 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at **the** 0.05 level. NS = no significant difference between herbicide means @ **p** = 0.05.

Table 4. No-tillage tobacco plant K content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb K/a				
Yes	Leaves	51.1	77.4	66.1	69.5	66.0 *
No	Leaves	39.5	44.2	67.8	57.4	52.2
Average	Leaves	45.2 b	60.8 a	67.0 a	63.50 a	
LSD (0.05) **for** N rate means = 14.8; CV for N rate means = 23.94%						
Yes	stalks	23.9	31.1	24.6	28.4	27.0 NS
No	stalks	26.8	22.1	28.8	23.9	25.4
Average	Stalks	25.3 a	26.5 a	26.6 a	26.2 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 25.98%						
Yes	Plant	74.9	108.5	90.7	97.9	93.0 NS
No	Plant	66.4	66.2	96.6	81.2	77.6
Average	Plant	70.6 a	87.4 a	93.6 a	89.6 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 22.17%						

Values among average N means within a weed treatment not followed by the **same** letter are significantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at **the** 0.05 level. * = significant difference between herbicide means @ **p** = 0.05. NS = no significantrence between herbicide means @ **p** = 0.05.

Table 5. No-tillage tobacco plant Ca content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate lb/a 0	25	50	75	Average
		lb Ca/a				
Yes	Leaves	16.3	26.3	22.9	25.3	22.7 *
No	Leaves	11.0	12.7	20.3	18.8	15.7
Average	Leaves	13.7 b	19.6 a	21.6 a	22.10 a	
LSD (0.05) **for** N rate means = 5.0; CV for N rate means = 24.68%						
Yes	stalks	4.69	5.59	5.40	6.98	5.66 NS
No	stalks	5.59	3.77	5.87	4.73	4.99
Average	stalks	5.15 a	4.68 a	5.63 a	5.86 a	
LSD (0.05) for N rate means = NS; CV for N rate means = 25.36%						
Yes	Plant	21.0	31.9	28.3	32.3	28.3 *
No	Plant	16.6	16.4	26.2	23.5	20.6
Average	Plant	18.8b	24.1 ab	27.2 a	27.8 a	
LSD (0.05) **for** N rate means = 6.0; CV for N rate means = 23.29%						

Values among average N means within a weed treatment not followed by the same letter are significantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatments at the 0.05 level. * = sigxuficant difference between herbicide means @ **p** = 0.05. NS = no sigxuficant difference between herbicide means @ **p** = 0.05.

Table 6. No-tillage tobacco plant Mg content from weed control and supplemental N treatments, Florida 1994.

Herbicide Applied	Plant Part	N Rate, lb/a 0	25	50	75	Average
		lb Mg/a				
Yes	Leaves	4.08	6.72	6.16	6.44	5.84 *
No	Leaves	2.82	3.64	5.71	5.26	4.30
Average	Leaves	3.46 b	5.17 a	5.82 a	5.86 a	
LSD (0.05) for N rate means = 1.34; CV for N rate means = 25.79%						
Yes	stalks	1.60	2.28	2.36	2.86	2.28 NS
No	Stalks	1.76	1.44	2.39	2.18	1.94
Average	Stalks	1.68 c	1.86 bc	2.38 ab	2.52 a	
LSD (0.05) for N rate means = 0.56; CV for N rate means = 25.85%						
Yes	Plant	5.68	9.00	8.52	9.30	8.12 *
No	Plant	4.60	5.08	7.88	7.44	6.24
Average	Plant	5.14 b	7.04 a	8.20 a	8.36 a	
LSD (0.05) for N rate means = 1.75; CV for N rate means = 23.19%						

Values among average N means within a weed treatment not followed by the same letter are sigxuficantly different according to LSD test at the 5% level. * and NS = Significant and non significant difference, respectively between weed treatment at the 0.05 level. * = sigxuficant difference between herbicide means @ **p** = 0.05. NS = no sigxuficant difference between herbicide means @ **p** = 0.05.

Nematode Population Levels on Vegetable Crops Following Two Winter Cover Crops

***R. McSorley and R N. Gallaher**

ABSTRACT

Population densities of plant-parasitic nematodes were compared on cowpea *(Vigna unguiculata)*, yellow squash *(Cucurbita pepo)*, okra *(Hibiscus esculentus)*, bush bean *(Phaseolus vulgaris)*, and sweetpotato *(Ipomoea batatas)* following a winter cover crop of rye *(Secale cereale)* or crimson clover *(Trifolium incarnatum)*, in a field test in north-central Florida. Nematode levels showed few differences among the five vegetable crops. Numbers of ring nematodes *(Criconemella* spp.) and the root-knot nematodes *(Meloidogyne incognita)* were greater following clover than following rye, but the stubby-root nematode *(Paratrichodorus minor)* was more common on one sampling date on vegetable crops that followed rye. Yields of all vegetable crops except sweetpotato were lower ($P<0.05$) following clover. Results demonstrate the efficacy and advantage of a suitable winter cover crop for lowering densities of a key nematode pest and improving yields of susceptible vegetable crops grown in rotation.

INTRODUCTION

Plant-parasitic nematodes cause problems on a variety of crops grown in the southeastern United States (Christie, 1959; Riggs, 1982). Nematode problems are often rather site-specific, and the rise and fall of nematode populations in a site depends on the crops grown. Therefore crop rotation (Johnson, 1982; McSorley and Duncan, 1995; McSorley and Gallaher, 1992; 1993; 1994; Trivedi and Barker, 1986) and use of winter cover crops (McSorley, 1996; McSorley and Gallaher, 1992) have been important methods for managing plant-parasitic nematodes.

These practices have been applicable in north-central Florida (McSorley, 1996; McSorley and Gallaher, 1992; 1993; 1994), particularly against the root-knot nematode, *Meloidogyne incognita*, which is the key nematode pest in many cropping systems in the region (McSorley and Gallaher, 1992). The objectives of the research presented here were to demonstrate the effects of two winter cover crops on population levels or root-knot and other nematodes and their buildup in subsequent susceptible vegetable crops.

[1]R. McSorley and [2]R. N. Gallaher. [1]Department of Entomology and Nematology, and [2]Agronomy Department, University of Forida, Gainesville, FL. Manuscript received 24 March 1997. * Corresponding author.

MATERIALS AND METHODS

This research was conducted at the University of Florida Green Acres Agronomy Research Farm in Alachua County on an Arredondo fine sand (92% sand, 4% silt, 4% clay). In November 1995, adjacent sites were planted with cover crops of either crimson clover *(Trifolium incarnatum* cv. Dixie) or rye *(Secale cereale* cv. Wrens Abruzzi). Cover crops were killed by application of labelled rates of gramoxone (Paraquat) plus non toxic surfactant. Vegetable crops were planted on 18 April with an in-row subsoil no-tillage planter. At each site, five different vegetable crops were planted in a randomized complete block design with four replications: cowpea *(Vigna unguiculata* cv White Acre), squash *(Cucurbita pepo* cv. Yellow Crookneck), okra *(Hibiscus esculentus* cv. Clernson Spineless), bean *(Phaseolus vulgaris* cv. Blue Lake), and sweetpotato *(Ipomoea batatas* cv. Georgia Red). Sweetpotato slips were hand planted into previously formed in-row subsoil no-tillage rows. Individual plots consisted of four rows, 10 ft long. Plots were irrigated with sprinklers as needed, and fertilized with 48 lb N, 16 lb P, and 32 lb K/a on 22 April and an additional 75 lb n/a on 14 May. Weeds were controlled by one post direct application of gramoxone and by hand. Cowpeas were harvested on 29 May; okra and beans were harvested twice, on 29 May and 17 June; squash was harvested four times between 29 May and 17 June; and sweetpotato was harvested on 2 October. For each harvest, marketable fresh weight in a 1.0-m^2 area was measured.

All plots were sampled for nematodes on 25 April and 28 June. Each nematode sample consisted of six cores of soil (2.5-cm diameter x 20 cm deep) collected in a systematic pattern and then combined into a plastic bag for transport. In the laboratory, a 100-cm^3 soil subsample was removed for nematode extraction using a modified sieving and centrifugation procedure (Jenkins, 1964). Extracted nematodes were identified and counted under an inverted microscope. Data were analyzed by an analysis of variance for a split-plot design with cover crops (sites) as main plots and vegetable crops as subplots, followed by Duncan's multiple-range test to compare means among vegetable crops.

RESULTS AND DISCUSSION

Because the rye and clover crops were maintained in separate but adjacent sites, differences between these treatments could be due to site factors other than cover crop. Nevertheless, the main difference between these two sites was the cover crops; other factors were similar in both sites.

Four different kinds of plant-parasitic nematodes occurred in these sites, and all were affected by cover crop (Table 1). Ring and root-knot nematodes were more abundant following clover than rye, but numbers of stubby-root nematodes on 28 June were greater in the site following rye. Except for root-knot nematodes on 28 June, nematode numbers were not affected (at $P \leq 0.10$) by the vegetable crops present (Table 1).

Root-knot nematodes are important pests of vegetable crops in Florida (McSorley, 1996; McSorley et al., 1994; McSorley and Gallaher, 1992), and their numbers were not detectable in April following rye. Even in June, numbers in plots following rye were only half as great as numbers following clover. Yields of four vegetable crops were lower ($P \leq 0.05$) following clover than after rye (Table 2), and attributed to damage from root-knot nematodes. Sweetpotato yields were low and highly variable. These data demonstrate the advantage of a winter rye cover crop over crimson clover for reduction of root-knot nematode levels, and confirm other studies in which graminaceous cover crops were more effective than legumes for this purpose (McSorley, 1996; McSorley and Gallaher, 1992).

Although a rye cover crop appeared to be useful for reducing root-knot nematode numbers and improving yields of vegetable crops high numbers of nematodes had built up on the vegetable crops by 28 June, even in the site which had the rye cover crop (Table 2). Root-knot nematode population levels recover quickly once a susceptible vegetable crop is planted. A similar resurgence of root-knot nematodes was also observed on eggplant *(Solanum melongena)* (McSorley et al., 1994). Thus, the benefits of the crop rotation lasted only a single vegetable season, so that another nematode-suppressive cover crop or rotation crop would be needed before a susceptible vegetable crop could be grown again. Nevertheless, the use of winter cover crops to manipulate population levels of root-knot nematodes is a relatively convenient and inexpensive method for managing these pests and improving crop production. Additional research is needed to identify a wider range of crops and cultivars useful for this purpose.

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Table 1. Nematode population densities on vegetable crops following winter cover crops of crimson clover or rye.

Vegetable crop	Nematodes per 100 cm^3 soil				
	25 April		28 June		
	Clover	Rye	Clover	Rye	Mean
	Ring nematodes, *Criconemella* spp.				
Cowpea	92	34	251	78	
Squash	100	29	413	77	
Okra	40	30	262	80	
Bean	88	33	275	104	
sweetpotato	51	28	403	279	
Mean	74	31**	321	124**	
	Root-hot nematode, *Meloidogyne incognita*				
Cowpea	76	0	480	372	426 abc[†]
Squash	52	0	110	366	238 bc
Okra	31	0	990	374	682 ab
Bean	59	0	1220	381	800 a
sweetpotato	26	0	234	30	132 c
Mean	49	0**	607	305*	
	Stubby-root nematode, *Paratrichodorus minor*				
Cowpea	10	3	6	15	
Squash	8	9	6	62	
Okra	12	6	15	52	
Bean	3	5	20	26	
sweetpotato	3	5	14	32	
Mean	9	6@	12	38**	
	Lesion nematodes, *Pratylenchus* spp.				
Cowpea	1.0	1.2	1.2	0.5	
Squash	0.5	1.2	2.0	1.0	
Okra	0.5	1.2	3.0	4.8	
Bean	0.5	3.0	5.8	3.5	
sweetpotato	0	0.2	0.8	1.8	
Mean	0.5	1.4*	2.6	2.3	

**,*,@ indicate significant differences from clover at $P \leq 0.01$, $P \leq 0.05$, and $P \leq 0.10$, respectively.

[†]Means in column followed by the same letter are not different ($P \leq 0.10$), according to Duncan's multiple-range test

Table 2. Yields of vegetable crops following winter cover crops of crimson clover or *rye*.

Vegetable crop	Fresh weight (g per m²)	
	Clover	Rye
Cowpea	215	658**
Squash	1276	4525*
Okra	13	439*
Bean	0	522**
sweetpotato	0	635†

**,* indicate significant differences from clover at $P \leq 0.01$ and $P \leq 0.05$, respectively.
†Highly variable, not different from clover at $P \leq 0.10$.

Lupin Hay as an Organic Fertilizer for Production of 'White Acre' Cowpea

*Cindy E. Wieland, Jorge A. Widmann, and Raymond N. Gallaher

ABSTRACT

In many countries, sources of fertilizer are scarce or unaffordable by small fanners. In the U.S., many farmers wish to use organic sources of fertilizer in production of crops. However, information is lacking on potential use of home grown legumes as a source of complete fertilizer. During the Fall 1996 in Gainesville, FL, a field study was conducted to determine the effects of the incorporation of air-dried lupin *(Lupinus angustifolilus)* hay into the soil on 'White Acre' cowpea *(Vigna unguiculata)* yield and soil quality. Ten treatments of air-dried lupin were applied at rates of 1000 lb/a from 0 lb/a to 9000 lb/a Analysis of nutrient concentrations in the soil and diagnostic leaf were used to indicate the result of treatment effects Pod yields at two harvest dates, as well as plant part yields were also determined. Results indicated increasing rates did not have an affect on pod yield at the first harvest date, but pod yield was affected at the second harvest with increasing application rates. Soil analysis indicated lupin was significant in increasing K ($p=0.01$) and Mg ($p=0.10$) in the soil with increasing rates of lupin. Diagnostic leaf N and P concentrations increased with increasing lupin rate. Treatment rate was significant in whole plant, pod, and stem yields in the undried fresh plant parts. Data indicated whole plant yield would be optimal between 4000 and 6000 lb lupin hay/a

INTRODUCTION

Cowpea *(Vigna unguiculata* L.), has become a most important food legume in the semihumid and humid tropics, effectively providing high protein and essential nutrients. However, due to its high protein content in the grain, this crop demands a significant supply of N. As a legume, much of this supply can be obtained through N fixation (Fernandez and filler, 1986), but additional N and other essential nutrients must be obtained from the soil for successful growth.

[1]C.E. Wieland, [1]J.A. Widmann, and [1]R.N. Gallaher. [1]Environmental Horticulture Department, and [2]Agronomy Department, IFAS, Univ. Of Florida, Gainesville, FL. Manuscript received 1 March 1997. *Corresponding author.

Recent studies indicate at least half of the N in cowpea is supplied from atmospheric N^2, and the other half is provided by soil N or via fertilizers (Awonaike et al., 1991). Awonaike et al. (1991) showed that 80% of the N in the aboveground plant parts in cowpea was provided by the soil until the late vegetative stages. During the reproductive stages, most of the N was supplied from the atmosphere (Awonaike et al., 1991). These studies indicate soil N content is especially important in the early stages of cowpea development. Therefore, adjusting soil properties early during planting is essential for obtaining optimal yields.

Nutrients can be made available in the soil through recycling of nutrients or by addition of organic or inorganic fertilizers. Many tropical soils containing low concentrations of inorganic nutrients rely partly on the recycling of nutrients, but find it is still necessary to amend the soil by adding organic or inorganic fertilizers to provide additional N, as well as other essential nutrients (Lindsay et al., 1993).

With the movement towards sustainable agriculture, use of organic fertilizers is becoming increasingly important and has shown to be effective in helping to amend soil quality. Either by the use of multiple cropping systems or use as a mulch, green manure or cover crop, many crops successfully provide an organic source of nutrients which aid in plant development (Hagendorf and Gallaher, 1992; McSorley and Gallaher, 1994). Of particular interest in this research is the use of green manures as fertilizer sources. These amendments have been found to help improve soil properties including organic matter content, water holding capacity, cation exchange capacity (CEC), water conservation, and soil aeration. Unlike many inorganic fertilizers, green manures are capable of supplying a wide range of N and minerals as well as improving overall soil quality.

When applying organic fertilizers, it is especially important to know their nutrient concentrations. Since nutrient concentrations in organic fertilizers vary depending on previous cultural methods, determining nutrient concentrations in green manures is essential when determining application rates needed. The decomposition rate of these materials is also important in determining when these nutrients are available for the plant. In particular, N mineralization has been shown to be dependent on incubation time and incorporation rate (Li and Mahler, 1995).

Of interest in this research is the effect of the incorporationof lupin *(Lupinus angustifoilus* L.) into the soil. The purpose of this experiment was to determine the fertilizer treatment effects caused by 'Tilt Blue 78' lupin on 'White Acre' cowpea yield. Lupin treatment effects on soil properties and nutritional sufficiency was examined.

MATERIALS AND METHODS

The experimentwas conducted at the University of Florida Agronomy Soil Teaching lab off Museum Road in the Fall of 1996. The design was a randomized complete block with four replications. Plots were marked off, 4 rows each, 8 ft long x 10 ft wide with the two outer rows acting as border rows. Initial soil samples were taken from the site 27 August, and were sent to the IFAS Soils Testing Laboratory at the University of Florida for analysis and recommendations. On 29 August, 10 rates of air-dried 'Tift Blue 78' lupin were applied to the corresponding plot at 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, and 9000 lb/a and were rototilled into the *soil* to a depth of 6 in. It later rained 1.5 in to wet the soil to a depth of 6 to 8 in. On 30 August, 'White Acre' cowpea was planted at a rate of 12 seeds per ft of row. On 1 September, it rained 2.0 in. Rainfall or irrigation, by means of an overhead sprinkler system, was used when necessary to maintain a minimum of 1.25 in water per 6 days. On 26 September, soil samples were taken from each of the plots. Three samples were collected between every two rows, 6 samples per plot. Soil sampleswere air dried in open paper bags. The soil was sieved using a 2 mm stainless steel screen and placed in new bags before analysis. Tests were conducted to determine soil organic matter, soil pH, buffer pH, Kjeldahl N, and Mehlich I extractable nutrients (Peech, 1965; Jackson, 1958; Horwitz, 1975; Gallaher et al., 1975; Mehlich, 1953).

On 8 October, diagnostic leaves were taken from the inner two rows of each plot following Jones' et. al. (1991) recommendations. Ten of the most newly developed leaves were collected from each plot and placed in paper bags. Each samples was washed, dried, and weighed (Futch and Gallaher, 1994; Gallaher, 1995).

The diagnosticleaves were then ground to pass a 2.0-mm stainless steel screen using a Wiley Mill and placed in labeled plastic bags. Previous to analysis, all bags were reopened and redned for 2 hours at 70C. Nitrogen concentrations and the concentrations for the extractable nutrients P, K, Ca, Mg, Cu, Fe, Mn, Na, and Zn were determined (Gallaher, et al., 1975).

A Perkin-Elmer Atomic Absorption Spectrophotometer was used in determining elemental concentrations. Potassium concentrations were determined using atomic emission spectrophotometry, and atomic absorption spectrophotometry was used to determine Mn, Fe, Cu, Zn, Ca, and Mg concentrations. Phosphorous concentrations were determined using a colorimeter.

On 11 November, the first cowpeas were harvested for each of the treatments. All mature pods were removed from the inside *two* rows of each plot (40 sq ft) and placed in paper bags. On 21 November, all mature and immature pods were removed from the inside two rows of each plot. At each harvest date, fiesh pods were weighed and used to determine fiesh cowpea pod yields for each of the treatments. On 15 November, plants were removed froma 1 square meter area from the inside border row of each plot. Roots, stems, leaves, and pods were separated and weighed fiesh.

Data were entered into a Quattro Pro spreadsheet (Anon., 1987). All analysis ofvariance and lsd mean separation statistical analysis was computed using MSTAT software (Freed et al., 1987).

RESULTS AND DISCUSSION

Table 1 gives the average nutrient concentrations for N, P, K, Ca, Mg, Cu, Fe, Mn, and Zn for air-dried lupin. Actual nutrient contents applied to each of the 10 treatments can be calculated from the nutrient concentrations. For example, 1000 lb lupin hay would contain 14.4 lb N, 2.15 lb P, 15.5 lb K, 5.3 lb Ca, 2.0 lb Mg, 4.5 g Cu, 205 g Fe, 55 g Mn, and 45 g Zn. Therefore, the lupin hay is a complete fertilizer source. Initial soil tests analyzed by the UF IFAS Soil Testing Laboratoy recommendedthat 65 lb N/a be applied to the soil when growing this crop. Lupin treatments between 4000 lb/a and 5000 lb/a with N nutrient contents of 57.6 lb/a and 72.0 lb/a respectively would be expected to provide adequate N for growth and development. Initial soil tests found P, K, and Mg to be in high concentrations in the soil. Initial pH was 6.0 previous to lupin fertilizer applicationswith a buffering pH of 7.82. Table 5 shows the results of the soil pH, buffering pH, CEC, organic matter, Mehlich I extractable elements and Kjeldahl N taken on 26 September, approximately one month after fertilizer application. Magnesium concentrations were significant at $p=0.10$, and K concentrations at $p=0.01$. The fertilizer rates did show an increase in K in the soil with increasing rates of lupin. Magnesium concentrations peaked at a lupin rate of 6000 lb/a applied. There was an increase in K concentration in the soil as treatment rate increased with the exception of the plants treated with 2000 lb/a lupin applied having a slightly higher K concentration at 47.4 ppm versus the following treatment, 3000 lb/a lupin, having a K concentration of 43.6 ppm. Potassium availability increased with increasing rates of lupin applied. The corresponding Mg concentrationsprobably resulted from the classical K:Mg relationship interaction. When 6000 lb/a was applied, the Ca, Mg, and K concentrations all were near their peaks indicating this rate may be optimal in providing high concentrations of each of these nutrients to the soil. Sodium was also significant at p = 0.01, Cu at p=0.10, and Zn at p=0.05. Neither the soil pH nor the buffering pH appeared to be affected by treatment differences (Table 5). Neither a significant acidifyingnor a liming affectoccurred indicating lupin may be useful for soils which do not need pH adjustment. The CEC, organic matter, N, P, Ca, Fe, and Mn did not show statistical differences in treatments at this date either Taking measurements at a later date may have resulted in treatment differences. Further studies would be useful in determining the decomposition rate of lupin. This would also provide an understanding as to when specific nutrients become available.

Pod yields for each of the treatments is shown in Table 2. The first harvest did not show any statistical significance among treatments. Although the first harvest was not statistically significant, there appeared to be visually observed differences in the number of immature pods remaining on the plants, plant height, and leaf color. Plots treated with 9000 lb/a lupin were taller, greener, and appeared to have more immature pods than plots treated with 1000 lb/a lupin which were shorter, lighter green and yellow in color, and had fewer pods. The second harvest on 21 November showed treatment differences at p=0. 10 with an increase in pod yield with increasing fertilizer rates. Lupin applied at a rate of 4000 lb/a seemed to be at a peak for pod yield.

Additively, the two harvests were not statistically significant with the treatments applied. Although the lupin treatments between 4000 and 6000 lb/a at around the recommended N application rates did produce some of the highest pod yield values of 6942, 6853,6996 lb/a respectively with the exception of the highest fertilizer rate producing the most total pods at 7378 lb/a If using lupin as a fertilizer, determining soil N needs with a soil test may be the key in determining amounts of lupin to apply for optimal pod yield.

Fertilizer treatments affected yields of leaves, stems, pods, and whole plants, but not for roots Tables 3 and 4 illustrates yields of fresh and dried plant parts sampled over a 1 sq m area. Lupin rates were significant in fresh undned parts at p = 0.01 for the whole plant, stem, and pod, and p = 0.05 for leaves.

Fresh weights of whole plant and stem yield increases until 4000-5000 lb/a lupin is applied, at wluch point the curve tends to plateau (Table 3). Pod and leaf yield appears to follow the same trend as for whole plant and stem except the slope is not as steep. Fresh pods were affected by treatment with an increase in pod yield as treatment rate increased.

In comparison, Table 4 shows that the effects on dried White Acre cowpea parts follow a slightly different pattern than for fresh material. The whole plant appears to increase nearly linearly. The stem, pods and roots show similar trends. The dried pods did not show treatment affects, indicating differences in dried and undried pods was probably due to pod water retention.

Table 6 gives the plant nutrient concentrations obtained for each of the elements, N, P, K, Ca, Mg, Cu, Fe, Mn, and Zn for the diagnostic leaf obtained just prior to early bloom. For each of the elements, sufficiency ranges are listed (Table 6) according to Jones et al. (1991) and Hochmuth et al. (1991) in Florida. Nitrogen diagnostic leaf concentrations were lugh according to both sources indicating the plant were receiving more than necessary amounts of N from either soil residual N left by the previous crop or by symbiosis. Differences in sufficiency ranges between Jones et. al. (1991) and Hochmuth et. al. (1991) is dependent on sampling sites. Hochmuth's recommendations are specific to Florida, whereas Jones' recommendations are more general. Although concentrations may be slightly higher according to one source versus another, none of these elements seemed to show any visible toxic effects at the lupin rates applied.

Table 6 shows N, P, Cu, and Zn were affected by increasing treatment rates of lupin. Due to cowpea's ability to fix N, these treatment differences may not have been as great as they would be in a nonleguminous plant. Some of the N utilized by the cowpea plant may have been obtained via denitrification versus the uptake of N from the soil and/or all of the lupin may not have decomposed. Studies indicate 87% of the N found in the pods was contributed by denitrification versus fertilizer treatment (Awonaike et al., 1991).

Research has shown that lupin can be grown without additional inorganic N (Ayisi et al., 1992). Using lupin in organic farming may be an economical organic crop when moving away from inorganic fertilizers since less N will be necessary for growth.

CONCLUSIONS

According to our data, it is recommended that approximately 5000 lb/a lupin be applied to maximize fresh cowpea pod yield. This study indicated there was an increase in N concentrations in the diagnostic leaves when using lupin. Further studies on nonleguminous crops may show the utilization of lupin more effectively. Sampling the soil at a later date may also show differences in soil N with the further decomposition of lupin. Lupin did appear to be an effective source of providing K to soil one month after application. Further studies are needed to confirm which rates would be most effective.

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Table 1. Plant nutrient analyses of air dried lupin used as an organic fertilizer for White Acre cowpea, Gainesville, Florida, 1996.

	Nutrient Concentration								
	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	---------- % ----------					---------- ppm ----------			
	1.44	0.22	1.55	0.53	0.20	4	183	49	40

Nutrient concentration values are the average of four replications

Table 2. Fresh cowpea pod yield at two dates from a 40 sq ft area when treated with air dried lupin hay, Gainesville, Florida, 1996.

Lupin Treatment	12 November	21 November	Total
lb/a	---------- lb/a ----------		
0	3373	2341	5714
1000	3427	2554	5981
2000	3559	2554	6150
3000	3978	2857	6835
4000	3542	3400	6942
5000	3658	3195	6853
6000	3667	3329	6996
7000	3747	3097	6848
8000	3640	3355	6995
9000	3471	3907	7378
CV	15.9	21.6	12.0
Significance	NS	+	NS
Probability	----	0.06	0.17
LSD @ p = 0.10		792	

CV = Coefficient of variation, NS = Non significant; + = significant at p = 0.10; * = significant at p = 0.05; ** = significant at p = 0.01

Table 3. Fresh cowpea plant parts taken near maximum fresh pod maturity treated with air dried lupin, Gainesville, Florida, 1996.

Lupin Treatment	Root	Leaf	Stem	Pod	Plant
lb/a			lb/a		
0	716	1007	5715	3176	10614
1000	679	1385	5990	3157	11211
2000	650	1474	6993	3253	12370
3000	724	1944	8192	3901	14761
4000	770	1668	7723	3530	13691
5000	863	1598	7988	4139	14588
6000	793	1645	8838	3988	15264
7000	724	1726	9317	3857	15624
8000	819	2612	10296	4456	18183
9000	789	1339	8128	3524	13780
CV	17.0	33.0	13.2	12.2	12.7
Significance	NS	*	**	**	**
Probability	---	0.02	0.00	0.00	0.00
LSD @ p = 0.05		773	1493	642	2543

CV = Coefficient of variation, NS = Non significant; + = sigrufcant at p = 0.10; * = sigruficant at **p** = 0.05; ** = significant at **p** = 0.01

Table 4. Dry cowpea plant parts taken near maximum fresh pod maturity treated with air dried lupin, Gainesville, Florida, 1996.

Lupin Treatment	Root	Leaf	stem	Pod	Plant
lb/a			lb/a		
0	346	542	1363	1283	3516
1000	326	583	1489	1299	3697
2000	231	717	1549	1284	3781
3000	368	704	1788	1445	4305
4000	357	650	1663	1349	4019
5000	425	741	2054	1555	4775
6000	393	689	1790	1526	4298
7000	324	795	2094	1388	4601
8000	352	795	2072	1414	4633
9000	371	754	1901	1304	4330
CV	16.0	13.9	12.0	15.1	9.7
Significance	NS	**	**	NS	**
Probability	---	0.01	0.00	---	0.00
LSD @ p = 0.05		137	320		585

CV = Coefficient of variation; NS = Non sigrufcant, + = significant at p = 0.10; * = sigrufcant at **p** = 0.05; ** = significant at **p** = 0.01

Table 5. Soil pH, buffer pH, CEC, organic matter, Kjeldahl N and Mehlich I extractable elements from cowpea soil site treated with rates of air dried lupin, Gainesville, Florida, 1996.

Lupin Treatment	pH	BpH	CEC	OM	N	P	Ca	Mg	K	Na	Cu	Fe	Mn	Zn
lb/a			Meq/ 100g	%	%	----------	----------	----------	----------	ppm	----------	----------	----------	----------
0	5.7	7.77	3.98	1.14	0.050	80.5	312	43.0	38.4	31.4	0.82	19.7	6.00	2.24
1000	5.6	7.77	3.54	1.14	0.051	76.8	236	34.5	38.7	22.2	0.77	21.2	6.03	1.63
2000	5.7	7.76	3.68	1.01	0.050	71.9	246	38.8	47.4	25.3	0.95	18.0	5.73	1.96
3000	6.0	7.79	4.18	1.06	0.049	79.8	380	44.6	43.6	23.9	0.71	15.7	6.48	2.06
4000	5.8	7.77	3.91	1.10	0.046	76.9	296	45.6	45.5	26.4	0.91	14.8	6.35	2.49
5000	5.8	7.77	3.91	1.18	0.048	79.0	298	43.7	46.1	24.0	0.85	14.8	6.25	2.43
6000	5.9	7.77	4.53	1.11	0.058	79.2	394	53.1	57.5	32.8	0.69	17.4	6.20	2.25
7000	5.8	7.76	4.03	1.18	0.056	78.8	281	46.5	56.3	30.9	0.76	18.1	6.43	2.12
8000	5.7	7.77	3.73	1.18	0.052	78.4	258	39.0	59.9	22.9	0.73	18.5	6.13	1.72
9000	5.9	7.79	4.09	1.18	0.059	80.2	342	51.7	64.8	23.9	1.06	17.8	7.33	2.12
CV	3.1	0.4	16.0	9.2	13.7	9.5	32.9	19.2	13.1	18.2	19.7	24.7	10.4	17.7
Significance	NS	NS	NS	NS	NS	NS	NS	+	**	**	+	NS	NS	*
LSD @ P = 0.10							10.0			0.17				
LSD @ P = 0.05								9.0	7.0				0.52	

CV = coefficient of vanation; NS = non significant; + = significant at p = 0.10; * = significant at p = 0.05; ** = significant at p = 0.01; CEC = cation exchange capacity; OM = organic matter

Table 6. Plant nutrient analyses of the diagnostic leaf of cowpea treated with air dried lupin, Gainesville, Florida, 1996.

Lupin Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
lb/a	%					ppm			
0	6.30	0.49	2.43	1.37	0.41	15.0	158	108	53.5
1000	6.49	0.50	2.49	1.17	0.41	13.8	173	109	52.5
2000	6.31	0.49	2.61	1.25	0.41	14.0	170	123	54.3
3000	6.35	0.49	2.43	1.39	0.40	13.5	155	102	48.0
4000	6.37	0.47	2.43	1.38	0.41	12.8	163	115	51.0
5000	6.55	0.52	2.40	1.17	0.39	16.3	173	94	55.0
6000	6.74	0.51	2.39	1.20	0.39	14.5	165	85	51.0
7000	6.32	0.48	2.37	1.24	0.40	14.3	188	98	49.3
8000	6.50	0.51	2.41	1.17	0.39	15.5	168	91	54.8
9000	6.66	0.52	2.47	1.14	0.38	15.0	163	90	51.5
CV	3.6	5.0	6.0	16.7	10.7	9.5	16.8	13.9	10.2
Signficance	+	+	NS	NS	NS	*	NS	**	NS
LSD @ p = 0.10	0.28	0.03							
LSD @ p = 0.05						2.0		20	
	Sufficiency Ranges by Jones et al. (1991)								
Low range	3.00	0.25	1.80	1.50	0.25	<6	40	<50	18
	3.99	0.29	2.19	1.99	0.29		49		19
Sufficient range	4.00	0.30	2.20	2.00	0.30	6	50	50	20
	5.00	0.60	3.00	3.00	0.50	25	100	300	100
High	>5.00	N.60	>3.00	>3.00	>0.50	>25	>100	>300	>100
	Sufficiency Ranges by Hochmuth et al. (1991)								
Low	<2.50	<0.20	<2.00	<1.00	<0.30	<5	<30	<30	<20
Adequate range	2.50	0.20	2.00	1.00	0.30	5	30	30	20
	4.00	0.40	4.00	1.50	0.50	10	100	100	40
High	>4.00	>0.40	>4.00	>1.50	>0.50	>10	>100	>100	>40

CV = coefficient of variation, NS = non significant; + = significant at p = 10; * = significant at p = 0.05; ** = significant at p = 0.01; refer to literature cited section for Jones et al., 1991 and Hochmuth et al., 1991.

Assessment of Soil Incorporated Crimson Clover Hay as an Organic Fertilizer Source in the Production of Bush Bean

*Brett L. Wade, Stuart J. Rymph, and Raymond N. Gallaher

ABSTRACT

Alternatives to crop fertilization practices reliant upon the use of synthetic materials that require high energy production cost and present potential agricultural pollution problems are increasingly being sought for inclusion into low input sustainable agricultural systems. For this purpose, an organic fertilization experiment was carried out under field conditions to determine the effect of soil incorporated air- dried chopped crimson clover *(Trifolium incarnatum)* on the yield of 'Blue Lake' bush bean *(Phaseolus vulgaris)* Clover was applied 10 d before planting at rate increments of 1000 lb/a for amendment levels ranging from 0 lbs/a up to 9000 lb/a. Analysis of soil and diagnostic leaf nutrient concentrations were made at 28 and 43 days after planting. Measurements of both fresh and dry yield for whole plant, pod, leaf, stem, and root components were taken. Highly significant yield effects in pod and total plant yield were observed ($P < 0.01$). Highest pod yield occurred with an application rate of 4000 lbs acre-' of air dried crimson clover. There appeared to be a threshold response to nutrient input at this level of amendment, as no significant increase in fresh or dry yield was realized at bigber treatment rates Diagnostic leaf nutrient levels were reflective of yield trends, although these trends were not significant. Soil N differences among treatments were significant with a probability of ($P=0.03$). There was also a highly significant positive correlation between Mehlich I extractable K soil concentration and clover application rate with a probability of ($P<0.01$).

INTRODUCTION

Common bush bean *(Phaseolus vulgaris* L.) is an important staple crop in nearly all parts of the world. In many areas where beans are grown as a subsistence crop, production is restricted to marginal soils, where sufficient nutrients are not available (Smithson et al., 1993).

Although bush bean is capable of fixing large amounts atmospheric N_2, some additional N provided through fertilizer is usually required for maximum yields (Tsai et al., 1993). Fertilizer inputs are costly and are often limiting in production systems of developing countries. Recently, interest in alternatives to growing crops without synthetic fertilizer inputs for environmental or aesthetic, rather than economic reasons has also increased. Concern about NO_3 pollution has been noted as a source of impetus for using legumes as an N source (Varco et al., 1993). The purpose of this study was to examine such a production system by providing nutrients to a bean crop by the addition of soil incorporated chopped air-dried crimson clover *(Trifolium incamaturn* L.). Several considerations to be made include nutrient content of the material used for fertilization, environmental factors and cultural practices which effect nutrient availability, and the specific nutrient requirements of the selected crop. Tissue analyses of crimson clover show that it is capable of providing significant amounts of N. Analyses also reveal that clover can also be a significant source of K. Although considerable research has been done in the investigation of clover use as a green manure, limited information is available on the ability of clover to provide K, or where plant material is dried and chopped before application and incorporation into the soil.

In comparison to allowing clover residues to remain on the soil surface, incorporation into the soil increase the decomposition and N release rate of crimson clover (Wilson and Hargrove, 1986) and also significantly reduces volatilization losses of NH_3 (Janzen and McGinn, 1991). Studies with soil incorporated white clover *(Trifolium repens* L.) have shown that 33% to 55% of the plant total N is readily decomposable, with a decomposition half-life of 9 to 11 days. (Breland, 1994). Management practices may be adapted to offset some of the N losses associated with no-till systems Allowing crimson clover to attain the late bloom stage prior to desiccation and crop planting, maximizes top growth N content and subsequent N release into a no-till system (Rannells and Wagger, 1992).

Several factors regarding bean production are worth noting when considering the production environment in which this experiment was conducted, and the nutrient amendment levels of N and K provided by this

B.L. Wade, S.J. Rymph, and R.N. Gallaher, Agronomy Department, IFAS, Univ. of Florida, Gainesville, FL. 32611.Received 1 March 1997.*Corresponding author.

fertilization method. When well balanced nutritional conditions exist and soil fertility is high, addition of N has a synergistic effect on N_2 fixation even at high N rates. If nutritional conditions are unbalanced, N amendments have the effect of suppressing N_2 fixation (Tsai et al., 1993). In K-deficient soils, application of N and K has been shown to increase pod yield and leaf concentrations of these nutrients, but depress the concentrations of other major and minor elements in the leaves (Smithson et al., 1993). Excess application of K can exacerbate Mn toxicity when soils are too acid (Lemare, 1972). Deficiency in K results in increased shoot/root dry weight ratios (Cakmak et al., 1994). High bean yields are positively correlated with pH and exchangeable Ca and Mg, but shoot and root growth are negatively correlated with exchangeable Al, which occurs with low pH (Fageria et al., 1989). In one *study* highest yields and rates of NO_3- consumption for bean grown in a sand culture, occurred when Ca/K ratios of the nutrient solution approached 1.0. In the same experiment, Mg consumption decreased as Ca/K ratio increased (Penalosa et al., 1995).

MATERIALS AND METHODS

This experiment was conducted in the fall of 1996 at the University of Florida in Gainesville, in field plots having a sandy soil. The selected crop was 'Blue Lake' bush bean. A randomized complete block design, consisting of four replications with 10 treatments, was chosen. The treatments were variable levels of organic fertilization based on N inputs, with nutrients being supplied in the form of air-dried, chopped crimson clover hay harvested at early bloom stage. The previous crop in selected plot area was a summer planting of field *corn (Zea mays* L.). Corn stalks were mowed, and crop and weed residues were turned under with a moldboard plow. On 27 August, four-row plots were marked off at 8-ft long by 10-ft wide, with a 2-A alley between plots and a 4-ft alley between each block.

A preliminary composite soil sample was taken from each block. Samples were analyzed for determination of pH, P, K, and Mg (Mehlich, 1953). Potassium and Mg were analyzed by ICAP (Inductively Coupled Argon Plasma) spectroscopy, P was determined colorimetrically. and soil pH was determined using a 1:2 soil to water ratio by volume (Peech, 1965).

Treatments were applied on 29 August by uniformly hand spreading the air-dried chopped clover over each treatment plot. Rates of application ranged from 0 lbs/a to 9000 lbs/a, in increments of 1000 lbs a. The clover was incorporated into the topsoil by roto-tilling to a depth of 6 in. Blue Lake bush bean was planted at a rate of 7.5 seed/ row/ ft (130,000 seed/ a). Emergence results from the initial planting were inadequate. This was attributed to several factors including seed quality, pest pressure, and a excessive planting depth. Plots were replanted 10 days after initial application of treatments. Irrigation was applied to insure adequate soil moisture to a depth of 6 in during germination. Additional irrigation was applied as needed to supplement rainfall during the duration of the experiment.

On 26 September, 28 d after application of treatments, soil samples were taken from all treatments in all replications. Soil samples were analyzed for Mehlich I extractable nutrients (P, K, Ca, Mg, Na, Cu, Fe, Mn, and Zn). All extractable soil cation concentrations, except K and Na, were determined by atomic absorption spectophotomety. Potassium and Na were determined by atomic emission. Phosphorus was determined by colorimetry, soil organic matter content by a modified Walkley-Black procedure (Black, 1965; Horwitz, 1975; Jackson 1958), and soil cation exchange capacity by cation summation (Hesse, 1972; Jackson, 1958). Soil pH was determined by electrode with 1:2 soil to water ratio, and buffered pH using an Adams/Evans buffered solution. Analysis for N was by micro-Kjeldahl procedures and techniques described by Bremner (1965) and Gallaher et al.(1975).

At 43 days after planting (DAP), when bean plants were at early bloom stage of growth, 12 young mature complete trifoliate leaves were sampled. Leaves were washed using a four-step procedure to eliminate any possible contamination (Futch and Gallaher, 1994; Gallaher, 1995), dried at 70"C, and then ground to pass through a 2-mm stainless steel mesh screen. Diagnostic leaf tissues were analyzed for N by micro-Kjeldahl procedures. Leaf nutrients were extracted by dry ashing and wet acid digestion with 12.1*N* HCI . Solution nutrient concentrations were determined by atomic absorption or emission spectrophotometry as appropriate. Phosphorus determination was by colorimetry Nutrient content of the crimson clover used for the treatments had been previously determined using these same methods, except that the clover had been air dried versus being oven dried. Quantification of the total nutrient amendments made for each treatment rate were based on these analyses. Whole plants were harvested 64 DAP. Plants were separated into leaf, pod, stem and root components. Fresh weight and dry weight were obtained. Yield data was tabulated on a per plant basis and adjusted to represent a planting density of approximately 69,000 plants/a due to problems with stand establishment.

Assessments of nutrient release, nutrient availability, and crop uptake, are based on observable yield and the analyses of diagnostic leaf and soil nutrient concentrations. Analysis of variance and determination of LSD at the 5% and 10% levels of significance was conducted using MSTAT 4.0 software (Freed et al., 1987). Interpretations of nutrient status are based upon sufficiency levels outlined by (Jones et al., 1991) and (Hochmuth et al., 1991).

RESULTS AND DISCUSSION

Soil Nutrient Analyses

Nutrient analyses of the air dryed crimson clover harvested at early bloom stage, revealed that with each 1000lb/a increment of clover applied, 19.8 lb N, 3.4 lb P, 18.6 lb K, 7.8 1b Ca, 2.6 Ib Mg, 0.004 Ib Cu, 0.243 lb Fe, 0.039 lb Mn, and 0.045 Ib of Zn were potentially made available to the crop (Table 1). At an application rate of 5000 lb/a, N and K are provided in excess of the recommendations of 90 lb N and 66 lb of Wa, suggested by the Inst. Food and Agr. Sci., Cooperative Extension Soil Testing Laboratory preliminary soil test results. The recommendation for K can be met by application of only 4000 lb/a of clover, which provides 74 lb K/a, but only 79 lb N/a. This rate of application appeared to be a threshold for total dry matter (DM) yield in Blue Lake bush bean (Table 2).

The cation exchange capacity (CEC) of the soil in all plots was quite low, typical for a sandy soil, with measurements ranging from 2.89 to 2.61 meq $100g^{-1}$. The soil pH was a relatively low 4.8, and may have had some negative affect on nutrient uptake ability of our crop in all treatments. The CEC and percentage of organic matter (%OM) of soil in the treatment plots were not significantly affected by the application of clover amendments. There were also no significant treatment effects for the parameters of pH, bufferpH, P, Na, Cu or Fe (Table 3).

There were significant differences among treatments for soil nutrient concentrations of Mg and Mn. Although there was a significant difference between the Mg concentration in the control and plots receiving a treatment level of 4000 lb/a, any definite trend in Mg concentration was difficult to establish. None of the levels of Mn concentration differed sigruficantly from the control, making it imprudent to suggest any correlation. A similar situation existed with the results involving Zn and Ca concentrations. Although highly significant differences occurred among treatments, suggesting any correlation to treatment rates would be difficult, especially considering the high CV values (Table 3). In all of these cases, nutrient concentrations among the control plots appeared to be at or slightly below the overall mean concentration level for all treatments. Nutrient concentrations decreased as treatment levels approached 4000 lb/a, increased significantly in the range between 4000 lb/a and 6000 lb/a, and then leveled off or began to decline again beyond this point (Table 3).

Soil N concentrations were significantly different between treatments (P= 0.03). There was some evidence of a positive correlation between N concentration and clover application rate. Nitrogen concentration increased from 0.044% in the control to 0.053% at a treatment rate of 7000 lb/a at a fairly constant rate before levels slightly decreased for the two highest treatment rates. The increases in N concentration were likely short lived. Any mineralized $NH,^{+}$ would be loosely held on the few cation exchange sites available. This NH_4^+, and any aminized NH_4^+ in the soil solution would be rapidly converted to NO; and readily leached.

The most notable trend in soil nutrient concentrations occurred with K. There were highly significant differences in K concentrations among treatments (P<0.01) (Table 3). Soil K concentration increased from 28.4 ppm in the control plot to 50.3 ppm at the highest clover treatment level of 9000 lb/a. There was clear evidence of a strong positive correlation between soil K concentration and increased clover amendments.

Diagnostic Leaf Analyses

There were no significant differences among nutrient concentrations in diagnostic leaves of Blue Lake bush bean at different clover amendment rates with one lone exception. Differences in Mg concentration were highly significant with a probability of (P=0.01) (Table 4) . Any trend however, would have been one of decreasing Mg concentrations with increased clover treatment levels. Although there were no other significant differences among nutrient concentrations, a definite trend of decreased cation concentrations with increased clover application rates was evident. This reduction is most likely related to increased soil concentrations of K and tends to concur with the findings of (Smithson et al., 1993).

Based on the nutrient sufficiency ranges outlined by (Jones et al., 1991), the diagnostic leaves had deficient concentration levels for the nutrients N, P, K, and Ca for all clover treatment rates. Nutrient concentrations of Mg, Cu, Fe, Mn and Zn however, were all within sufficiency ranges. If the guidelines Hochmuth et al (1991) were followed, the diagnostic leaves had sufficient nutrient concentrations of P, Mg, and Fe; and high concentrations of Mn and Zn for all clover treatment rates. There were deficiencies for N, K, Ca and Cu at all treatment rates, the only exception being a barely adequate N concentration of 2.6 % N at a treatment rate of 8000 lb/a (Table 4). The low pH conditions that existed probably resulted in increased solubility and availability of micronutrients.

Environmental Factors

The fact that deficiencies existed for N, K, and Ca under both sets of nutrient sufficiency guidelines is not surprisingly if the environmental factors that were present during production are considered. Almost 4.5 in of rainfall were recorded during a 12-d period of time between treatment application and 2 DAP. Given the quantities of nutrients applied in the clover treatments and the observed nutrient concentrations of the diagnostic leaves, it is apparent that there was a problem with nutrient recovery, and or availability in this study. If consideration is given to the soil temperatures that typically exist in Florida during the production period, a lag time of nearly 12d between application of treatments and germination, and the rainfall amounts recorded, it is not unreasonable to assume that asignificant majority of the N made available by the clover treatments had undergone nitrification and been subjected to leaching losses before the first trifoliate leaves appeared. The resultant reduction in initial plant growth rate, would be reflected in subsequent root growth, plant transpiration, and nutrient uptake rate of K and Ca. Potassium inputs provided by the clover treatments would also have been susceptible to significant leaching during this period of delayed crop establishment. Calcium concentrations in diagnostic leaves were at inadequate levels even at the relatively lower ranges set forth by (Hochmuth et al., 1991. Soil concentrations of Ca should have provided adequate amounts for sufficient uptake (Table 3). Because Ca uptake occurs by mass flow in young unsuberized root tips any conditions that inhibit root growth, such as other nutrient deficiencies, would also limit Ca uptake.

Yield

Because of problems in crop establishment, yield data was recorded on a per plant basis and adjusted to reflect a population density of 69,000 plants/a. This was representative of the population density achieved in the field of approximately one-half that of the seeding rate. This adjustment was necessitated by seed germination problems acknowledged by the seed supplier and pest problems. Stem damage was evident in many seedlings and was likely incurred from lesser corn stalk borer *(Elasmopalpus lignosellus)*. During harvesting a noticeable amount of incidental leaf damage caused by leaf roller larvae *(Platynota flavadena) was* also evident.

There were highly significant differences ($P<0.01$) in stem, leaf, pod and total dry matter (DM) yields among treatments. Root DM yield was significantly different among treatments at ($P = 0.07$) level of significance (Table 2). There was a strong positive correlation between total DM yield and increased clover application rates from 0 lb/a to 4000 lb/a. This correlation also applied to plant component DM yields. Pod DM and total DM yields were highest when clover was applied at a rate of 4000 lb/a (Table 2).

In examining leafweight data, it is interesting to note the trend of reduction in *dry* leaf weight yields with increasing clover application rates of above 5000 lb/a. No significant negative effect was observed on pod yield, because of decreased leaf weights, although some increase in yield could have been unrealized.

SUMMARY

Highest dry pod yields occurred with a soil incorporated air dried chopped clover amendment rate of 4000 lb/a. Increased clover application beyond 4000 lb/a had no significant effect on pod or total DM yield. At this treatment level, plant component yields were at, or not significantly different from the highest reported yields. Greatest rates of increase. in yield occurred as application rate of clover increased from 0 lb/a to 4000 lb/a. These trends were reflected in both soil and diagnostic leaf nutrient concentration levels. There appeared to be a threshold effect at the 4000 lb/a treatment rate. This effect may likely have been a response to K availability as much as a response to N. Increases in soil concentrations of K were positively correlated with clover applications. There was some evidence of decreased micronutrient cation uptake by the plant as a result of competition due to increased soil extractable K concentrations.

Due to limiting factors such as pest pressure, low pH , low CEC, and timing of application relative to germination, it is highly probable that there was some unrealized potential response to clover application rates exceeding 4000 Ib/a. This experiment did demonstrate, however, that soil-incorporated clover could be a viable alternative nutrient source for bush bean production. It would be insightful to repeat this study in a cropping environment with less negative pressure.

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Table 1. Plant nutrient analyses of air dried crimson clover used as an organic fertilizer for Blue Lake bush bean, Gainesville, Florida, 1996.

	Nutrient Concentration								
Crimson Clover	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
	%					ppm			
	1.98	0.34	1.86	0.78	0.26	4	243	39	45
	Nutrient Content								
Clover Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
lb/a	lb/a								
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	19.8	3.4	18.6	7.8	2.6	0.004	0.243	0.039	0.046
2000	39.6	6.8	37.3	15.7	5.3	0.008	0.485	0.079	0.091
3000	59.4	10.2	55.9	23.6	7.9	0.012	0.728	0.118	0.137
4000	79.2	13.6	74.6	31.4	10.5	0.016	0.971	0.157	0.182
5000	99.0	17.0	93.2	39.3	13.2	0.020	1.213	0.196	0.228
6000	118.8	20.3	111.9	47.1	15.8	0.024	1.456	0.236	0.273
7000	138.6	23.7	130.5	55.0	18.4	0.028	1.698	0.275	0.319
8000	158.4	27.1	149.2	62.8	21.0	0.032	1.941	0.314	0.364
9000	178.2	30.5	167.8	70.7	23.7	0.036	2.184	0.353	0.410

Nutrient concentration values are the average of four replications. The average concentration value **was** used to calculate the plant nutrient contents applied as crimson clover organic fertilizer for Blue Lake bush bean.

Table 2. Dry Blue Lake bush bean yield at 69,000 plants per acre from rates of soil incorporated air dried crimson clover harvested at the early bloom stage.

Clover Rate	Plant Part				
	Root	Stem	Leaf	Pod	Total
----- lbs/a-----	---------- lbs/a ----------				
0	47.3	90.1	107.1	62.5	306.0
1000	49.1	125.8	128.5	99.9	403.3
2000	58.0	179.3	181.1	133.8	552.3
3000	57.0	187.4	199.0	142.8	584.4
4000	70.5	232.0	230.2	173.1	705.7
5000	69.6	221.3	244.5	141.9	677.2
6000	74.9	215.0	228.4	143.6	662.9
7000	61.6	244.5	231.1	151.7	689.7
8000	65.1	229.3	217.7	168.6	680.7
9000	81.2	236.4	210.6	165.1	693.2
CV%	24.0	19.4	18.6	24.9	15.7
Significance	+	**	**	**	**
Probability	0.07	0.00	0.00	0.00	0.00
LSD	18.7	55.3	53.5	50.0	135.6

LSD values given at the bottom of each column of means are significantly different at P = 0.05; Data is adjusted to 69,000 plants/a. + = significant at P = 0.10; and ** = significance at P = 0.01.

Table 3. Soil pH, buffer pH, CEC, organic matter, Kjeldahl N and Mehlich I extractable elements from soil of plots ammended with air dried crimson clover and planted in Blue Lake bush bean, Gainesville, Florida, 1996.

Treatment	pH	**BpH**	CEC	OM	N	P	Ca	Mg	K	Na	Cu	**Fe**	Mn	Zn
Ib/a			meq/100g	%	%	----------	----------	----------	----------	ppm	----------	----------	----------	----------
0	4.8	7.72	2.83	1.04	0.044	78.5	63	15.3	28.4	21.4	0.84	36.6	4.70	1.22
1000	4.9	7.74	2.65	1.08	0.044	78.8	62	14.5	30.6	18.5	0.78	39.3	4.00	1.04
2000	4.8	7.74	2.61	1.02	0.044	76.9	52	13.3	31.4	16.8	0.73	31.8	3.80	0.98
3000	4.9	7.73	2.76	1.09	0.048	78.8	61	15.8	36.5	21.3	0.77	37.0	4.10	1.03
4000	4.8	7.74	2.84	1.17	0.047	80.9	80	18.6	40.0	19.8	0.79	31.1	5.30	1.28
5000	4.8	7.73	2.89	1.16	0.051	80.0	76	17.3	40.9	18.2	0.86	33.8	5.10	1.15
6000	4.9	7.77	2.67	1.06	0.049	77.2	74	19.5	39.4	22.9	0.65	28.4	5.40	1.32
7000	4.8	7.75	2.78	1.22	0.053	75.8	76	17.9	45.8	20.3	0.72	28.8	5.20	2.04
8000	4.8	7.76	2.64	1.04	0.047	15.4	67	16.9	43.9	20.5	0.67	24.0	4.30	1.39
9000	4.7	7.75	2.75	1.09	0.049	80.2	69	17.5	50.3	20.6	0.74	36.5	5.10	1.28
CV % =	3.0	**0.3**	7.2	9.0	7.8	6.2	18.4	15.9	18.2	15.6	18.6	15.4	18.4	26.5
Significance	NS	NS	NS	NS	*	NS	**	+	**	NS	NS	NS	+	**
Probability		0.15		0.11	0.03		0.00	0.06	0.00	0.36	-	0.14	0.09	0.00
LSD @ p = 0.10								3.1					1.0	
LSD @ **p** = 0.05					,002		18.7		10.1					0.48

CV = Coefficient of variation, NS = Non significant; + = significant at **p** 0.10; * = significant at **p** 0.05;
** = Significant at **p** 0.01; CEC = Cation exchange, meg/100g soil; OM = organic matter

Table **4**. Plant nutrient analyses of the diagnostic leaf of bush bean treated with air dried crimson clover, **Gainesville, FL, 1996.**

Clover Treatment	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
kg/ha	----------	----------	%	----------	----------	----------	ppm	----------	----------
0	2.26	0.32	1.49	1.37	0.43	10.0	138	143	60.0
1000	2.39	0.33	1.52	1.17	0.44	10.5	143	143	54.0
2000	2.38	0.32	1.54	1.25	0.38	10.5	123	130	59.0
3000	2.40	0.33	1.59	1.39	0.43	11.0	155	150	58.0
4000	2.35	0.34	1.71	1.38	0.37	11.3	145	133	62.3
5000	2.22	0.32	1.5	1.17	0.37	9.3	140	143	50.3
6000	2.43	0.34	1.66	1.20	0.42	9.5	140	135	57.8
7000	2.38	0.33	1.71	1.24	0.38	9.8	123	121	54.8
8000	2.60	0.34	1.79	1.17	0.39	11.0	128	116	55.5
9000	2.16	0.31	1.55	1.14	0.33	9.8	135	134	48.8
CV%	8.9	8.3	11.7	16.7	10.3	18.0	14.7	18.3	16.2
Significance	NS	NS	NS	NS	**	NS	NS	NS	NS
Probability	0.24	-		0.36	0.01		0.43		
LSD @ p = 0.05					0.06				
	Sufficiency Ranges by Jones et al., 1991								
Low range	4.24 4.99	0.25 0.34	1.80 2.19	2.00 2.24	0.25 0.29	4 6	40 49	15 49	18 19
Sufficient range	5.00 6.00	0.35 0.75	2.20 3.00	2.25 4.00	0.30 1.00	7 30	50 300	50 300	20 200
High	>6.00	>0.75	>3.00	>4.00	>1.00	>30	>300	>300	>200
	Sufficiency Ranges by Hochmuth et al., 1991								
Low	<2.50	<0.20	<2.00	<1.50	<0.25	<15	<25	<20	<20
Adequate range	2.50 4.00	0.20 0.40	2.00 4.00	1.60 2.50	0.25 0.45	15 40	25 200	20 100	20 40
High	>4.00	>0.40	>4.00	>2.50	>0.45	>40	>200	>100	>40

CV = Coefficient of variation; NS = Non significant; + = significant at p = 0.10; * = significant at p = 0.05; ** = significant at p = 0.01; Refer to literature cited section for Jones, et al., 1991 and Hochmuth, et al., 1991

No-Till Production of Irish Potato on Raised Beds

Ronald D. Morse

INTRODUCTION

In an extensive review of organic mulches applied on conventionally tilled (plow-disk) fields, Dutton (1957) concluded: 1) that organic mulches such ashay and straw often increased both yield and quality of Irish potato *(Solanum tuberosum* L.) and 2) that improved soil physical properties under the mulch, particularly lower soil temperatures and conservation of soil moisture, were responsible for the yield and quality enhancement. In these mulching studies, highest yield increases generally occurred in hot climates where temperatures were above optimum during tuber development and where soil moisture deficits are prevalent. Thus, applying organic mulches in hot, dry climates normally results in increased potato yield (Dutton, 1957).

Although mulching generally retards growth and reduces tuber yield in cool, wet climates, yield of potato often increases in hot, humid regions, if provisions are made to assure adequate soil drainage. Under conditions of adequate soil moisture in hot climates, reduced soil temperatures under organic mulches can increase tuber yield and quality. However, many potato mulch experiments (Dutton, 1957) have clearly shown that, when heavy (thick) mulches are prematurely applied (at or soon after planting), slow emergence, poor stands, and stunted early growth often result.

Because applying thick layers of organic mulches is economically prohbitive on large-scale commercial farms, researchers have assessed the potential of reduced tillage systems for production of Irish potato (Midmore, 1991; Lanfranconi et al., 1993; Hoyt and Monks, 1996). Although the results of reduced tillage systems have been encouraging, in most cases potato planted in flat, untilled, or strip-tilled soils have required conventional hilling practices to achieve yields equal to that of conventional tillage systems (Lanfranconi et al., 1993; Hoyt and Monks, 1996). In such cases, organic residues were either incorporated or buried, leaving bare soil which minimizes or even negates potential soil-cooling and moisture-conserving effects during tuber bulking.

R. D. Morse. Virginia Polytechnic Institute and State Univ., Blacksburg, VA. Manuscript received 7 April 1997.

In Mame, potato seed pieces were planted on 6 June 1990 on bare tilled soil (conventional tillage, CT), flat untilled soil (NT), and fall preformed, ridged soil (RT). A sparse cover of barley *(Hordeum vulgare* L.) was grown on NT and RT plots. All plots were hilled on 30 July 1990. Marketable yields were 98, 117, and 56 cwt/a for CT, RT, and NT respectively (Tindall, 1991).

After reviewing the available data on organic mulching of conventionally planted potato fields (applied organic mulches) and reduced tillage potato systems *(in situ* mulches), the following conclusions can be drawn:

1. Applying thick layers of organic mulches after crop emergence will often increase tuber yield in hot climates where summer temperatures are above the optimum for tuber development and particularly where summer droughts are common.

2. Except in areas where spring planting temperatures are unusually high, thick mulches applied at or near planting may slow germination, reduce stands and retard early plant growth. Premature application of thick mulches is particularly harmful in humid climates.

3. Applying thick mulches in cool, wet soils is likely to retard growth and reduce yield.

4. To achieve high yields with no-till mulch systems the untilled soil must have good drainage, be of adequate tilth to provide sufficient aeration and structure for tuber growth and enlargement, and be adequately covered with an *in situ* mulch to improve soil physical properties during tuber bulking, yet not be excessively covered at planting that might delay plant emergence, reduce plant stands and retard early growth.

5. Applying mulches or using no-till mulch systems in hot, dry climates should improve soil physical properties and increase tuber yield. In hot, arid regions, growing potato on preformed beds is not recommended, particularly where imgation is not practiced.

6. In hot humid areas where no-tilled mulching might improve soil properties and increase tuber yield and quality, using preformed beds should minimize the danger of excessive moisture (waterloggmg).

A strong movement in the 1990s toward a more sustainable agriculture has stimulated the development of the Subsurface Tiller Transplanter (SST-T), which was released in late May 1992 (Morse et al., 1993). The transplanter component of SST-T has an upright, highclearance design with a double-disc shoe. In addition, the SST-T has a unique subsurface tiller (SST) aligned in front of the double-disc shoe of the transplanter. The conceptual design and functioning of the SST-T is uniquely different from that of the earlier NT transplanters. With the NT models of the 1980s (NT80s), the cultivator-type shoe performs both the tilling and the planting functions. Under compacted, rocky conditions, the rigid-mounted shoe of the NT80s was easily bent or broken, which seriously reduced its usefulness for conservation tillage system. In contrast, the Spring-loaded in-row soil looseness device (Morse et al., 1993) of the SST has heavy-duty construction and subsurface tills a narrow strip of soil ahead of the double disc shoe of the transplanter. The double-disc shoe moves through the residues and tilled strip with relatively little resistance and with minimal surface soil and surface residue disturbance. The SST-T is an efficient (less equipment breakdown) and effective (less resetting needed) transplanting system that, when used in heavy residues, maximizes soil and water conservation and early field reentry, permitting planting, spraying, and harvesting operations to be done within a few hr following irrigation or rainfall. In 1995, the SST-T was modified to plant potato seed pieces in flat or bedded NT fields.

In 1994/1995 and 1995/1996, experiments were conducted at Vigmia Polytechnic Institute and State University to assess the potential of using *in situ* cover crop mulches in no-tillage production systems to modify soil properties for production of Irish potato. The objectives were to assess the potential of 1) using preformed raised beds to assure adequate drainage, 2) using the SST-T and grain rye *(Secale cereale* L.) no-till systems to provide *in situ* mulch and adequate soil tilth for tuber development, and 3) applying additional rye straw *after* plant emergence to maintain surface coverage during tuber bulking on yield of marketable Irish potato.

MATERIALS AND METHODS

Field experiments were conducted in 1994/1995 and 1995/1996 at the Virginia Polytechnic Institute and State University, Kentland Agriculture Research Farm, Blacksburg. The soil was a Hayter loam (fine-loamy, mixed, mesic, Ultic Hapludalf), with a pH of 6.4. The experimental design was a randomized complete block with a split-split plot arrangement of treatments and three replications. Main plots (12 x *50* ft) were bed elevation: flat and raised (6 in. high). Subplots (6 x 50 ft) were tillage: conventional tillage (CT) and no-tillage (NT). Sub-subplots (6 x 25 ft) were applied mulch: control (no mulch applied) and mulched (0.1 1b rye straw/ft² of bed surface, applied 2 wk after emergence of first potato plants).

In early fall of 1994 (27 Sept.) and 1995 (28 Sept.), cereal rye was drilled in all plots in rows 7 in. apart at 140 lb/a on 6-ft. wide beds made 2 d prior to seeding with a KMC bedmaker (Kelley Manufacturing Company, Tifton, Ga). Beds were flat on top (42 in. wide). In mid-March of both 1994 and 1995, granular fertilizer was surface broadcast by hand with 50 lb N/a as NH_4NO_3 on all NT plots to maximize growth of cereal rye, and 1.1-dimethyl-4-4-bipyridiniumum ion (paraquat) was used at 0.5 a.i./a to desiccate rye and weeds on all CT plots.

One wk prior to planting, the rye and weeds of all plots were desiccated with paraquat at 0.5 a.i./a and CT plots were tilled twice with a 42-in.-wide, Ferguson Tilrovator (Ferguson Manufacturing Company, Suffolk, Va). On 28 April 1995 and 25 April 1996, a 2-row SST-T was used to establish and precision place fertilizer in all plots. In a one-pass operation across the field, the SST-T cleared a 10-in.-wide in-row area of rye residues; loosened an in-row soil area (8 in. wide x 8 in. deep); precision banded granular fertilizer (in lb/a, 90N-39P-82K) 6 in. below the soil surface (2 in. below the seed); and planted and covered seed pieces (2 oz/seed piece) in twin rows, 28 in. apart, 8 in. in-row, and 4 in. deep Martin row cleaners (Martin & Company, Elkton, KY), mounted in front of the SST, were used to clear in-row rye residues. One wk after planting, all plots were sprayed with a herbicide tank mixture of 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-l-methylethyl) acetamide (metolachlor) at 2.5 lb a.i./a and N'-(3,4-dichloropheny1)-N-methoxy-N-methylure(linuron) at 0.8 lb ai./a. Overhead sprinkler irrigations were used as needed (≤ 1 in./wk) to supplement rainfall in all plots throughout the growing season to minimize moisture stress. Pesticides were applied at planting and at regular intervals thereafter, according to the Virginia Commercial Vegetable Production Recommendations (Baldwin et al., 1995).

During the first wk of September, a 20-ft. section of each sub-subplot was hand harvested, separated into size grade categories according to United States Department of Agriculture standards (Anonymous, 1991), counted, and weighed. Yield data were analyzed across years by analysis of variance (Gomez and Gomez, 1984). The Statistical Analysis System (SAS) was used to perform all statistical analysis procedures (Schlotzhauer and Littel, 1987).

RESULTS AND DISCUSSION

Although first-emerged plants (at 3 wk after planting, WAP) were mainly in CT plots, final emergence at 5 WAP was high (90% average) for all treatments. There were no significant differences among treatments in percentage emerged or plant height at 5 WAP (data not shown). Rye residues were cleared at planting in a 10-in.-wide, in-row area in the NT beds, which probably resulted in a more uniform seedling emergence among treatments.

There were no significant ($P \leq 0.05$) yield interactions among treatments or between years and treatments. Although differences were nonsignificant, yield response to tillage appeared to differ with bed elevation--NT yields increased (4%) on raised beds but decreased (7%) on flat land, compared to CT yields. Research is needed to delineate any possible interactions. In hot, humid climates where irrigation is uncommon, yield response would be expected to vary considerably among treatments with differences in frequency and distribution of rainfall.

Bed Elevation

Growing potato plants on raised beds increased tuber yield by 24%, compared to plants grown on flat soil (Table 1). Increased tuber yields on raised beds occurred in both NT (> 30%) and CT (> 18%) plots. Since rainfall was above average both yr, apparently improved soil drainage increased tuber yields in raised CT and NT beds. Soil tilth appeared to be better in NT beds than flat beds and could explain the additional yield enhancement (30% for NT vs. 18% for CT).

In areas where irrigation is unavailable, the advantages of fall bedding would probably be less in dry years or in arid regions. Possibly, unbedded fields would even outyield bedded fields in dry years without irrigation.

Tillage

Similar yields occurred in NT and CT plots (Table 1). Rye biomass was similar in raised and flat NT plots (averaging 1,800 lb dry matter/a). Based on the yield data of these experiments, the growing environment created by the rye NT cover crop and the in-row soil loosening of the SST-T planting system alleviated any potential yield-lowering compaction and aeration problems that can occur in NT plots (Tindall, 1991). Soil moisture deficits probably did not differ significantly between CT and NT plots because there was ample rainfall and irrigation water was applied as needed.

Marketable tuber yields were high in all plots, more than doubling the average commercial yield in Virginia (Anonymous, 1996). There were no quality differences (size, shape, visual deficits, incidence of pest damage) in tubers from CT and NT plots. All visual observations from planting to harvest indicated that the soil tilth in the NT plots was as good and probably better than that in the CT. In these experiments, cultural practices were followed that maximized soil tilth in the root and tuber growing area without disturbing the entire bed. With exception of in-row soil loosening at planting, the integrity of the rye covered NT bed was undisturbed, maintaining the soil quality advantages of an overwintering rye sod. The rye cover crop was thick and relatively uniform over the entire bed. After plant emergence, hilling was done only on the CT, flat plots.

A custom made twin-wing shank was mounted on the SST that effectively loosened the in-row soil ahead of the modified planter. The potato seed pieces were placed in the center of this loosened area and subsequent root and tuber growth occurred predominantly in this loosened zone.

Applied Straw Mulch

Application of straw mulch 2 wk after crop emergence resulted in increased yields in both CT and NT and bedded and flat plots (Table 1). Possibly the rye residues (both *in situ* and applied) increased tuber yield by cooling the soil and creating more d o r m soil moisture levels (even in irrigated fields) during tuber set and tuber bulking. In dry yr, these favorable yield-enhancing effects from applied mulch would probably be greater than obtained in 1995 and 1996 (both wet years), especially in unirrigated fields.

CONCLUSIONS

Based on 2-yr data the no-till (NT) system used in these studies is a viable option for improving soil physical properties and sustaining tuber yields. Preformed raised beds and post-emergence applied straw mulch significantly increased tuber yield. However, applying thick organic mulches at or shortly after planting potato seed pieces is known to delay crop emergence, reduce stand, and reduce tuber yield. Future research is needed to determine if the presence of thick cover crops *(in situ* mulch) retained over the entire bed surface after planting would be deleterious to tuber yield in NT systems.

On-going and future experiments will determine the advantages and disadvantages of the NT raised bed systems for Irish potato. Detailed soil quality measurements will be taken. Also, cover crop species, residue management techniques, and relay intercropping will be studied to determine best management practices to minimize deleterious early season mulchmg effects and favorably alter mid-late season soil properties of no-till raised beds to improve tuber set and tuber bulking in hot climates.

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Table 1. Effects of bed elevation, tillge, and applied mulch on yield of Irish potato ('Yukon Gold'), 1995 and 1996.

Treatment	Marketable tuber	yield (U. S. No. 1)[1]
	(cwt/a)[2]	(%)[3]
Bed elevation		
Flat	294	100
Raised	365*	124
Tillage		
Conventional (bare soil)	334	100
No-tillage (in *situ* mulch)	325[NS]	97
Applied mulch (rye straw)		
Control (no straw)	319	100
Straw mulch	340*	107

[1]US no. 1, all marketable tubers equal or greater than 1 7/8 in. diameter and free of exterior blemishes.
[2]Cwt/a, hundred weight (100-lb units) per a.
[3]Relative yield, compared to the standard or control treatment (100).
[NS, *]For *each* treatment category, F-test nonsignificant or significant at $P \leq 0.05$, respectively. Yield values are means of two years (1995 and 1996). There were no interactions among treatments or between years and treatments.

Use of New Genotypes of Small Grains and Soybeans in Conservation Tillage Systems

***R D.Barnett, A. R Soffes Blount, and D. L. Wright**

INTRODUCTION

The use of small grains and soybeans *(Glycine max* [L.] Merr.) in a double cropping scheme is one of the most popular conservation tillage systems used in the Southeast. Both crops can now be planted with limited tillage, and the opportunity of high yields and good profit margins are readily available. New genotypes of both small grains and soybean are released each year which have significant improvements that make them good choices in conservation tillage systems and will enhance the opportunity for profit utilizing these systems.

One of the most exciting and useful new developments is the availability of new soybean varieties with genetic resistance to the broad-spectrum herbicides. They allow growers to simplify weed control programs and manage weeds with one or two applications of a single herbicide. Weed control is not very costly with the small grain portion of this system, and genetically engineered small grains with broad-spectrum herbicide resistance are not yet available, but quite likely will be available in the future.

SMALL GRAINS

Wheat *(Triticum aestivum* L.). The small grain portion of this double cropping system can be quite risky if poor choices are made with variety selection. If you choose varieties that are susceptible to diseases or insects, major yield and quality reductions can occur. When wheat is used, it is very important that the newest varieties have good resistance to leaf rust powdery mildew, and Hessian fly *(Phytophaga destructor)*. After a wheat variety has been grown on a large acreage and exposed to diseasee epidemics over a period of time, it will become susceptible to these diseases. So it is important to use new varieties before the disease organisms have had a opportunity to change and more virulent strains become prevalent.

Another factor to consider in selecting wheat varieties is maturity. Some excellent early varieties are available and do very well at later planting dates (after 1 December). However, they are quite susceptible to damage from a late season freeze if planted early because they head early in the spring and are not cold tolerant after they have begun jointing. Normally, early maturing varieties would be preferred in double-cropping systems because it is important to harvest the crop early in order to get the second crop planted in a timely manner. Late maturing varieties usually perform well if they are planted early (in November), but they can have problems if planted late. In a mild winter, these late maturing varieties will not receive enough chilling hours for vernalization if they are planted late. They do not head properly or head late and are filling the grain during high temperatures. It is risky to take wheat varieties foo far from the region where they were developed.

Oat *(Avena sativa* L.). Another small grain that works well in conservation tillage systems is oats. Oats are well adapted and are very valuable in a diversified farming operation, particularly one that includes livestock. Oats are an excellent feed grain that can be used in a number of animal rations. They are also an excellent forage crop and can be used for winter grazing or even as hay or a silage crop. Oats are very nutritious and animals perform very well when consuming oats, either the forage or the grain. Oat has a reputation, undeserving in our opinion, of not being winter hardy and thus very risky to grow. We have grown oats quite successfully in 25 of the last 27 yr here in North Florida. Oats were severely damaged in 1984 and 1985 during the cold winter that moved the citrus industry at least 50 miles south in Florida. Oats occasionally suffer some leaf bum during cold periods but they normally recover quite rapidly.

Data to illustrate the performance of some of the newer oat varieties is presented in Table 1. Both the 'Chapman' and the 'Harrison' varieties are winter hardy and have excellent resistance to crown rust, the most important production hazard. Chapman is a relatively short variety that should work particularly well in conservation systems.

Rye *(Secale cereale* L.). Rye can also be used in conservation tillage systems and seems particularly popular when used just as a cover crop in the winter and as a mulch for the second crop. Our Southeastern ryes are early maturing and normally stem up early in the spring and are well suited for early planting dates for the second crop. Rye can also be grown as a seed crop and followed very successfully with soybean. Variety

[1]R.D. Barnett, [2]A.R.S. Blount, and [1]D.L. Wright, [1]Agronomy Professor and [2]Biological Scientist, University of Florida, North Florida Research and Education Center, Quincy, FL. Manuscript received 16 April 1997. * Corresponding author.

selection is not as critical with rye as with wheat or oat but if you want to grow it as a seed crop, variety selection would be important. You should select a variety that is popular among forage producers so that you could easily sell the seed. It is also important to select an early maturing variety and one that is resistant to leaf rust. 'Wrens 96', released in 1996, is a new variety that fits these requirements quite nicely. It is an improved version of the popular 'Wrens Abruzzi' variety.

Soybean One of the problems with soybeans in conservation tillage is that they are very sensitive to day length and won't produce adequate yields if planted too early or too late. We are working with some new genotypes that could give growers some flexibility in planting their crop. We believe that producers could plant these soybean over a 90- to 100-d period from 1 April to early July and still maintain good yields.

Southern growers now have a much narrower window for planting their crop - only 35 to 40 d from about 10 May to mid-June in the north Florida area. If farmers try to plant outside that narrow window, yields decrease because normal flowering is disrupted and seed production declines.

When the days are long, the soybean plant channels its energy into making leaves, stalks, and other vegetative growth. When the days shorten, the plant detects the reduction in sunlight and begins its reproductive period, producing flowers, pods, and seed.

Juvenile-types. These new genotypes are referred to as 'long-juvenile type' - meaning that the plants remain in their juvenile, vegetative growth stage for a longer time. Then, at a fixed time after planting, the plant leaves its juvenile stage, beginning its reproductive period and producing seed. The idea behind developing these juvenile soybean lines was to offer growers a variety that allowed the maximum flexibility for widening the planting window, while still maintaining good yields, and resistance to insect pests, nematodes, and diseases.

Some new genotypes that we are presently testing can be planted from mid-April to mid-July and will still yield competitively with popularly grown soybean varieties planted during the recommended planting window in North Florida. In Table 2, yields of the juvenile soybean lines from the April planting date at both Quincy and Jay are comparable to the yields of many commonly grown varieties. Similarly, yields are also comparable among the juvenile soybeans and the standard varieties planted in May at the Jay location. However, when you compare the yields of the long juvenile soybean lines planted in July to those of the popular varieties, the juvenile soybean outproduce the standard varieties. This occurs because the juvenile gene delays the reproductive period of the soybean until the plant has made sufficient growth. At that time, the soybean plant will begin flowering, followed by pod development. Because of the juvenile gene, the plant has obtained some height and can therefore support more of a pod load. Standard varieties, when planted in July, will generally remain short and become reproductive relatively early, hence lower yields from a poor pod set. Many juvenile lines had yields in the 30+ bu/a range from the July planting. Notice that 'Vernal' also yielded well. Vernal was the first released variety of soybean (developed by the USDA-ARS at Stoneville, Mississippi) which utilized the long juvenile trait.

There is a degree of variability among the juvenile soybean lines for yield in early or late plantings as is illustrated in Table 2. Some juvenile soybean lines perform better when planted early, while others lines yield comparatively better from a later planting. Several of the juvenile lines yielded 35+ bu/a from the late planting, although yields were reduced overall from such a late planting date.

Juvenile-type maturity. The benefit of early or late soybean planting fits the time frame for many double cropping systems, especially in conservation tillage, where an early soybean harvest is readily followed by small grains in the fall of the year, and late planted soybeans would follow corn (*Zea mays* L.) or small grains harvested in spring. Maturity observations indicate that early planted juvenile soybeans will mature in September and early October, while the late planted juvenile soybeans would mature in late October and November.

Among the juvenile lines that have been tested in Florida, there is considerable variability in maturity and many of these lines can be categorized in maturity groupings from MG IV to IX. This would be important if you desire a shorter season or full season soybean. Likewise, the juvenile lines vary in their resistances to various pests and diseases. While emphasis has been primarily on yield, the need for good resistance to southern and peanut root-knot nematodes (*Meloidogyne* spp.), frogeye leafspot, stem canker, and phomopsis has not been neglected. Many current lies have good resistance to multiple pests and diseases, as well as excellent seed quality, a trait of great importance when harvest may not occur during optimal harvest conditions.

A short coming in the development of these juvenile soybean lines has been that the resistance to the broad spectrum herbicides has not been added. However, such resistance can be readily transferred and the availability of the long juvenile soybean with broad-spectrum herbicide resistance will be possible in the near future.

Table 1. Elite oat nursery grown at the three locations in Georgia and one location in Florida, 1995.

Entry	Grain yield (bu/a)					Test weight-4 location avg	Average plant
	Plains	Calhoun	Griffin	Quincy	4 locationavg.	(lb/bu)	height (in)'
Chapman	112.7	43.2	100.5	50.0	76.6	31.1	34
Florida 502	108.3	29.1	75.6	45.5	64.6	33.3	35
ACS-Harrison	107.7	42.9	117.3	23.7	72.9	34.4	40
Citation	94.2	29.1	106.1	2.3	57.9	33.7	37
ACS-811	56.2	37.5	111.7	27.2	58.2	34.2	34
GA-Mitchell	53.4	43.5	101.7	27.0	56.4	32.3	32
Grand mean	108.1	39.1	108.1	20.1			
$LSD_{(P=0.05)}$	13.5	19.6	15.9	13.6			
C.V. (%)	7.7	24.9	9.1	41.7			

'Average of Plains, Calhoun, and Griffin locations
[2]0 = no disease, 9 = very severe disease.

Table 2. Yield comparisons of long juvenile soybean lines with popular varieties that are yield competitive with either an early or late planting date in North Florida, 1996.

		Yield (bu/a)			
		Quincy[1]		Jay[2]	
	Juvenile line/Variety	April	July	April	May
Early-planted competitive	F91-2420	65.5	24.3	42.9	44.4
	F95-1935	64.5	23.7	----	----
	F94-1054	63.6	23.7	35.9	40.3
	F95-1299	61.3	14.3	----	----
	F95-1254	60.8	17.2	----	----
	F95-1765	60.7	32.9	----	----
	F94-2119	60.1	28.0	47.7	43.6
	F95-1119	56.4	28.3	----	----
Late planted competitive	F95-1774	59.7	36.4	49.1	29.0
	F95-1714	60.6	36.2	----	----
	F92-2127	42.0	35.9	40.3	37.4
	F94-1586	52.0	35.1	41.8	31.9
	F91-3597	57.7	32.9	53.5	38.5
	F91-1235	52.5	32.6	35.2	42.5
	F91-3076	52.9	32.5	39.6	47.7
	F94-1104	55.6	30.2	36.4	33.7
Standard varieties	Cook	63.2	25.3	58.7	51.3
	Doles	62.1	21.4	49.9	50.2
	DPL 105	61.9	18.0	----	----
	Haskell	60.3	13.9	44.4	49.1
	RA 452	60.2	9.6	----	----
	Davis	59.6	16.9	----	----
	Vernal	56.8	34.2	32.3	39.2
	Forrest	55.8	14.3	----	----
	Hutcheson	53.9	9.0	41.2	43.3

[1]Quincy location planted 26 Apr. 1996 and 17 July 1996, 3 replications.
[2]Jay location planted 24 Apr. and 31 May 1996, 3 replications. Conducted by H. A. Peacock

Value of Roundup Ready Technology in Strip-Tilled Soybeans

*D. L. Wright, P. J. Wiatrak, B. Kidd, W. Koziara,
T. Piechota, J. Pudelko, and D. Zimet

ABSTRACT

Research was conducted during 1995 and 1996 on a Dothan sandy loam to evaluate: 1) Roundup Ready (RR) soybean *(Glycine max* in a Roundup only herbicide program as compared to a conventional herbicide program using strip tillage, and 2) the economic comparisons based on yield and costs. In 1995, most Roundup treatments controlled weeds better than preemergence Prowl and postemergence Classic, except when morningglory *(Ipomoea* sp.) was present. Applications of Roundup (especially repeat applications) significantly increased plant height. Yields of soybean in 1995 varied from 3.8 bu/a to 20.4 bu/a with best yields from treatments where Roundup was applied three times. In 1996, two applications of Roundup Ultra provided good nutsedge *(Cyperus* spp.) control (at least 70%) except the lower rate of Roundup Ultra, 1.5 pt/a followed by 1.5 pt/a. Yields were higher after most Roundup treatments as compared to conventional treatments or the control. Cost of the conventional herbicide program in 1995 was about %17/a as compared to almost $34/a for the three applications of Roundup plus Prowl However, yield was 9.6 bu/a more in the RR system resulting in about $30/a more profit when including the techology fee and extra seed cost. Cost in 1996 was about $21/a for the conventional herbicide program as compared to $9/a for Roundup with a 9.6 bu/a yield advantage, resulting in about a $67/a advantage **to** RR technology. Both of these trials were conducted using strip tillage which would have **additional** savings over conventional tillage, probably resulting in an even greater economic advantage.

INTRODUCTION

Roundup Ready (RR) technology in soybean *(Glycine max* [L.] Merr.) was approved recently and has gained high grower interest and *acceptance*. Weed control and planting method in soybean will experience radical changes as varieties adapted to the region become available to growers. Research across the United States has consistently shown that RR systems will control weeds in a cost-effective manner (Woodruff, 1997). Preliminary studies have indicated that one application of Roundup in narrow rows may be adequate to control weeds season long, while two applications may be necessary for season long control on wide row soybean (Murphy, 1997). Roundup Ready technology has not been shown to cause. yield reduction. However, many of the current varieties on the market are not adapted to Southern conditions because they mature too early. Therefore, improvements in yield can be expected as better adapted varieties become available. Due in part to RR technology, more strip till or no-till and use of conservation tillage and narrow rows will be used since weeds *can* be controlled more efficiently than in the past. The objectives were to evaluate: 1) RR soybean in a Roundup only herbicide program as compared to a conventional herbicide program using strip tillage, and 2) the economic comparisons based on yield and costs.

MATERIALS AND METHODS

In 1995, Roundup at 1 qt/a +Induce 0.5% v/v was applied on 25 May and on 6 June, 500 lb/a of 3-9-18 fertilizer was applied over the entire study. On 9 June, soybean was planted strip tillage with a Brown Ro-till implement and KMC planters in four row by 20-ft-long plots. Two middle rows of each plot were planted with a transgenic cultivar (Asgrow) at a seeding rate of 3.6 seeds/1 ft of row. Two outside rows were planted with the soybean cultivar 'NK4884'. Preemergence herbicides were applied on the day of planting. Biocot @ 2 pt/a + Dimilin 2L @ 4 oz/a + Crop oil @ 1 qt/a were applied on 14 August to control insects. Postemergence herbicides were sprayed on 28 June (Classic and Roundup), 11 July (Roundup), 26 July (Roundup), and 25 August (Roundup). The influence of treatments on soybean plant height was evaluated two wk after the first application of Roundup and 140 d after planting.

Estimation of weed control was performed on a percent basis, where 100%= highest weed control and 0% = no weed control. Weed control was estimated 40 and 80 d after planting. Number of weeds per plot were counted two wk after planting and after every postemergence treatment application. Because the leaves had not dropped and were still green, soybean was

[1]D.L. Wright, [1]P.J. Wiatrak, [1]B. Kldd, [2]W. Koziara, [2]T. Piechota, [2]J. Pudelko, and [2]D. Zimet. 'University of Florida, North REC, Quincy, FL. and [2]Agric. Univ. of Poznan, Plant and Soil Cultivation Dept., Mazowiecka, Posnan, Poland. Manuscript received 21 April 1997.
*Corresponding author.

defoliated with Harvade @ 8 oz/a + Dropp @ 1/8 pt/a + Crop oil @ 1 pt/a and harvested on 1 Dec.

In 1996, Roundup Ultra at 1 ptla was applied to the study area on 13 June (2 d before planting). The entire study was planted with 'HARTZ 7550' Roundup Ready soybean cultivar using a Brown Ro-till implement and KMC planters in strip tillage at 10 seeds/ft and in 3 ft wide rows on 15 June. Plot size was 4 rows x 25 ft long.

Preemergence herbicides were applied on the day of planting and postemergence herbicides were applied on 10 July and 18 July. Ambush at 6 oz/a + Penncap M at 0.5 pt/a + Dimilin 2F at 4 oz/a were applied to control insects on 5 September.

Soybean growth (plant height) was evaluated two wk after Roundup application and 140 d after planting in 1995, and 30 days after herbicide applications in 1996. Soybean was harvested on 4 December. Both tests were arranged in a Randomized Complete Block design with four replications. Data were analyzed by analysis of a variance and means were separated using Fisher's LSD test at the 5% probability level.

RESULTS AND DISCUSSION

In 1995, all plots treated with residual herbicides, except where Roundup was used in the combination, had three times more weeds (mainly nutsedge *[Cyperus* spp.] and grasses) growing in the second half of the vegetative period. Main weed species in the control plots were: crabgrass *(Digitaria* sp.) (1.5/sq.ft.), junglerice *(Echinochloa colonum* [L.] Link) (1.2/sq. ft.), bahiagrass *(Paspalum notatum* Flugge) (0.3/sq. ft.), nutsedge (5.4/sq. ft.), morningglory *(Ipomoea sp.)* (0.7/sq. ft.) and pigweed *(Amaranthus* sp.) (1.0 sq.ft.). Most treatments with Roundup controlled weeds better than preemergence Prowl and postemergence Classic, especially at 80 DAP evaluation (Table 1a and Ib). The exception was morningglory control where an application of Prowl + Classic gave best results.

Applications of Roundup significantly increased height of soybean plants when cornpared to the control (Table 2). This effect was visible throughout the season. Soybean was shortest in control plots due to competition from weeds. Plant number was not influenced by any herbicide treatments. Grain yield of soybean varied from 3.8 bu/a to 20.4 bu/a (Table 2). The highest yields were obtained from treatments where Roundup was applied three times. Low yields of soybean were due to use of the Asgrow variety not adapted to Florida conditions.

In 1996, both yellow *(Cyperus esculentus)* and purple *(Cyperus rotundus)* nutsedge species were present, and none of the preemergence herbicides controlled nutsedge. Two applications of Roundup Ultra provided good control (at least 70%) of nutsedge (Table 3). Only Roundup Ultra at 1.5 ptla followed by 1.5 pts./a gave less than 70% control of nutsedge. Roundup Ultra applied once provided lower control of nutsedge when compared to two applications of Roundup Ultra. Application of Roundup Ultra at 3 pts./a controlled only 64% of nutsedge. One application of Roundup at 1.5 ptla gave less than 20% control of nutsedge.

There were no differences in plant height of soybean among treatments with the applications of Roundup. Good stands and fast growing soybean developed a closure which covered weeds. Nutsedge was not present before harvest. Differences in height of soybean were observed soon after application of postemergence herbicides (Table 4). Plants treated with Prowl + Canopy and Fusilade DX + Classic + Agridex were shorter then untreated ones. Soybean was taller in the plots treated with Squadron than in the control plots. Later, during the vegetation season, herbicide treatments did not affect the height of soybean. The yields of soybean were higher after applications of Roundup Ultra as compared to other treatments (Table 4).

The conventional herbicide program in 1995 cost about $17/a as compared to the Prowl +Roundup system which cost about $34/a. If the technology fee and extra seed cost were added to this an extra $11 would need to be added to the $34 for a total cost of $45/a. However, an extra 9.6 bu/a of soybeans were produced at a value of $67.20, making the Roundup system about $39/a more profitable.

In 1996, the conventional program of Prowl + Canopy cost about $21/a while the best Roundup treatment cost $9/a. At the same time yield was 9.6 bu/a better for the Roundup system making the Roundup system about $67/a more profitable after the seed price and technology fee are taken into account. These figures are for strip till soybean and do not make a comparison with conventional soybean which would require more tillage, labor, fuel, and have more soil erosion over the long run. This new genetic technology is exciting since it can cut weed control costs, aid in transformation to conservation tillage and perhaps result in higher yields.

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Table la. Weed control at 40 and 80 d after herbicide treatment of Roundup Ready soybean in 1995.

Treatment	Crabgass (%)		Junglerice (%)		Bahlagrass (%)	
	40	80	40	80	40	80
Check						
Roundup 1.5pt/a*+Roundup 1pt/a*	89.8	78.2	77.8	71.5	72.0	74.2
Prowl 2.3 pt/a PRE **Classic** 0.5 oz/a 20 days later	83.0	56.2	71.2	55.8	75.5	70.5
Prowl 2.3 pt/a PRE Classic 0.5 oz/a 20 days later Roundup 1.5 pt/a*	75.0	80.0	76.5	80.5	87.0	83.5
Prowl 2.3 pt/a PRE Roundup 1.5 pt/a*	84.5	67.5	74.8	58.0	83.8	70.0
Prowl 2.3 pt/a PRE Roundup 1 qt/a**	86.0	74.0	82.0	71.8	94.2	72.5
Prowl 2.3 pt/a PRE Roundup 1.5 pt/a* as needed (3x)	91.8	93.8	77.0	85.2	83.5	89.8
Roundup 1.5pt/a* + **AMS** 2%	88.0	71.8	91.5	65.0	84.5	65.8
Roundup 1pt/a* + **AMS** 2% Roundup 1 pt/a* + AMS 2%	86.8	87.2	93.2	86.8	87.5	79.8
Prowl 2.3 pt/a PRE Roundup 1pt/a* + AMS 2%	84.2	70.8	77.5	63.0	86.2	68.0
Prowl 2.3 pt/a PRE Roundup 1qt/a** + **AMS** 2%	92.0	79.2	84.5	80.5	88.2	76.8
Roundup 1.5 pt/a* + **AMS** 2% **as needed** (3x)	86.8	83.5	89.5	86.7	85.0	83.0
Mean	86 2	76 6	81 4	73 2	84 3	75 8
LSD$_{(0.05)}$	13.6	10.6	n.s.	14.5	n.s.	9.3

PRE - preemergence, * - when weeds were 2-3 in. tall, ** - when weeds were 4-6 in. tall

Table lb. Weed control at 40 and 80 d after herbicide treatment of Roundup Ready soybean in 1995.

Treatment	Pigweed (%)		Morningglory (%)		Purple Nutsedge (%)	
	40	80	40	80	40	80
Check						
Roundup 1.5 pt/a*+Roundup 1 pt/a*	98.8	94.2	79.2	75.8	73.2	73.0
Prowl 2.3 pt/a PRE Classic 0.5 oz/a 20 days later	83.2	68.2	93.8	82.0	83.5	69.0
Prowl 2.3 pt/a PRE Classic 0.5 oz/a 20 days later Roundup 1.5pt/a*	87.8	85.0	91.2	85.2	81.8	82.5
Prowl 2.3 pt/a PRE Roundup 1.5 pt/a*	82.0	75.5	74.2	57.5	86.5	64.0
Prowl 2.3 pt/a PRE Roundup 1 qt/a**	83.2	73.8	83.0	60.5	85.2	55.8
Prowl 2.3 pt/a PRE Roundup 1.5pt/a* as needed (3x)	84.2	86.2	79.2	77.5	86.5	78.5
Roundup 1.5 pt/a*+ AMS 2%	81.2	65.2	89.5	73.8	83.5	64.5
Roundup 1 pt/a* + AMS 2% Roundup 1 pt/a* + AMS 2%	83.0	65.5	87.5	79.5	89.8	73.0
Prowl 2.3 pt/a PRE Roundup 1 pt/a* + AMS 2%	80.0	62.5	86.2	70.5	85.8	70.2
Prowl 2.3 pt/a PRE Roundup 1 qt/a** + AMS 2%	86.5	76.2	77.2	63.8	89.2	66.5
Roundup 1.5pt/a* + AMS 2% as needed (3x)	91.5	89.5	71.8	70.0	85.5	84.5
Mean	85.6	76.5	83.0	72.4	84.6	71.1
$LSD_{(0.05)}$	11.4	8.9	16.9	11.0	14.9	8.7

PRE - preemergence, * - when weeds were 2-3 in. tall, ** - when weeds were 4-6 in. tall.

Table 2. Influence of herbicide treatment on plant number per 1 ft of row, plant height, and grain yields of soybean in 1995.

Treatment	Plants per 1 ft of row	Plant height (in.)		Grain yield (bu/a)
		2 weeks *after* Roundup appl.	140 days after planting	
Check	2.4	11.8	15.8	3.8
Roundup 1.5 pt/a* + Roundup 1 pt/a*	2.4	12.7	20.8	15.2
Prowl 2.3 pt/a PRE Classic 0.5 oz/a 20 days later	2.4	15.2	25.2	8.6
Prowl 2.3 pt/a PRE Classic 0.5 oz/a 20 days later Roundup 1.5 pt/a*	2.2	13.6	22.8	12.7
Prowl 2.3 pt/a PRE Roundup 1.5 pt/a*	2.3	13.4	22.8	10.8
Prowl 2.3 pt/a PRE Roundup 1 qt/a**	2.3	13.5	23.2	12.2
Prowl 2.3 pt/a PRE Roundup 1.5 pt/a* as needed (3x)	2.2	12.9	21.5	19.1
Roundup 1.5 pt/a* + AMS 2%	2.5	12.6	22.7	13.1
Roundup 1 pt/a* + AMS 2% Roundup 1 pt/a* + AMS 2%	2.5	12.8	22.1	16.4
Prowl 2.3 pt/a PRE Roundup 1 pt/a* + AMS 2%	2.3	13.1	22.8	11.6
Prowl 2.3 pt/a PRE Roundup 1 qt/a** + AMS 2%	2.1	13.6	23.0	12.6
Roundup 1.5 pt/a* + AMS 2% as needed (3x)	2.4	12.4	21.0	20.4
Mean	2.3	13.1	22.0	13.0
$LSD_{(0.05)}$	0.26	0.96	1.23	3.63

PRE - preemergence, * - when weeds were 2 in. tall, ** - hen weeds were 4-(n. tall.

Table 3. Weed control after herbicide treatment of roundup ready soybean in 1996.

Treatment	Nutsedge 30 d after postemerg. appl. (%)	Morningglory (%)		
		30 d after first appl.	30 d after second appl.	Late season
Roundup Ultra 1.5pts./a POST.	12.50	75.50	69.5	62.50
Roundup Ultra 2.0pts./a POST.	15.0	92.50	70.0	62.50
Roundup Ultra 3.0 pts./a POST.	57.50	92.50	82.5	80.00
Roundup Ultra 1.5pts./a, 1 pt./a POST.	81.50	97.25	96.3	95.00
Roundup Ultra 1.5pts./a, 1.5pts./a POST.	61.25	97.25	94.5	92.50
Roundup Ultra 2.0pts./a, 1.0 pts./a POST.	72.50	95.50	97.0	92.50
Roundup Ultra 2.0pts./a, 1.5pts./a POST.	70.00	95.75	91.3	90.75
Roundup Ultra 2.0pts./a, 2.0pts./a POST.	81.25	99.00	98.5	97.00
Prowl 1.8pts./a+Canopy 8 oz/A PRE.	0.0	68.75	75.0	65.00
Squadron 3 pts./a PRE.	0.0	12.50	12.5	12.50
Fusilade DX 1pts./a + Classic 0.5 oz/a + Agridex 1% v.v. POST.	22.50	0.00	0.0	0.0
Check	0.0	0.00	0.0	0.0
Mean	39.5	68.9	65.6	62.52
$LSD_{(0.05)}$	9.34	9.0	10.9	10.6

PRE - preemergence, POST - postemergence, fb -following by, ae - acid equivalent.

Table 4. Height of plants and grain yields of roundup ready soybean as influenced by herbicide treatment in 1996.

Treatment	Plant height (in.) 30 d after planting	Plant height (in.) 30 d after post-emergence herbicide appl.	Grain Yield (bu/a)
Roundup Ultra 1.5 pts./a POST.	14.15	37.50	42.9
Roundup Ultra 2.0 pts./a POST.	14.95	37.67	38.5
Roundup Ultra 3 pts./a POST.	15.0	37.72	40.3
Roundup Ultra 1.5 pts./a, 1.0 pt./a POST.	14.08	37.40	41.7
Roundup Ultra 1.5 pts./a, 1.5 pts./a POST.	14.33	35.97	40.3
Roundup Ultra 2.0 pts./a, 1.0 pt./a POST.	14.73	38.28	39.3
Roundup Ultra 2.0 pts./a, 1.0 pt./a POST.	14.33	38.45	41.7
Roundup Ultra 2.0 pts./a, 2.0 pts./a POST.	13.85	36.57	40.6
Prowl 1.8 pt/a + Canopy 8 oz/a PRE.	13.98	37.15	33.3
Squadron 3 pt/a PRE.	16.42	38.63	34.0
Fusilade DO 1 pt/a + Classic 0.5 oz/a+ Agridex 1% v.v. POST.	12.98	36.20	35.9
Check	13.92	38.22	35.4
Mean	14.39	37.48	38.7
LSD,,,,,	1.00	NS	5.17

PRE - preemergence, POST - postemergence, fb - following by, ae - acid equivalent.

Wheat Residue Management In Arkansas Double-Cropped Soybeans

Caleb A. Oriade, Carl R. Dillon and *Terry C. Keisling

ABSTRACT

Residue management is the central issue in conservation compliance. While the compliance legislation encourages residue retention, growers ~eemto prefer burning crop residues. Little information exists on the impact of these residue management options on the viability of different crop production systems. The objective of this study was to investigate the economic implications of leaving or burning wheat *(Triticum aestivum)* stubble on the production of double-cropped soybean *(Glycine max)*. Data from stubble management experiments conducted at various locations in Arkansas between 1992 and 1995 were used for this study. Net returns to different production systems were estimated from enterprise budgets and stochastic dominance analyseswere used to identify risk-efficient strategies. Results indicated that the effect of leaving or burning wheat stubble would be contingent upon the full complement of production practices employed. Depending on the production systems, experimental location, and year, net returns to soybean could range from a net loss of about $45 to a profit of $17l/a. However, stubble retention generally improved returns in fields that were tilled prior to planting while burning wheat stubble was a superior strategy in no-till systems. Stochastic dominance analyses uniquely identified a production system comprising pre-plant tillage and stubble retention under narrow row-system as the overall dominant and risk-efficient strategy. Also, no production system without pre-plant tillage ever dominated those with tillage.

INTRODUCTION

Crop residue management is the centerpiece of conservation compliance requirements. Research has consistently shown that farming systems which retain crop residues continuously on the soil surface reduce water erosion losses when compared to practices that leave residue for only a portion of the year (Alberts and Neibling, 1994). Prior to the enactment of conservation security act, voluntary participation and incentives were compliance (CC) provisions of the 1985 U.S. food preferred policy initiatives for promoting conservation practices (Zinn, 1994). The failure of these voluntary initiatives in maintaining a satisfactory level of erosion control made the introduction of CC provisions inevitable.

The Soil Conservation Policy Task Force of the American Agricultural Economics Association (AAEA) offered two reasons why an enabling legislation was required to protect soil productivity (Harman, 1994). The first reason, which is economic, is the failure of the market to signal farmers that investments to protect productivity are needed. The second reason is a philosophical one. It holds the present generation responsible for maintaining resource productivity for the sake of future generations. Consistent with these views, the CC provisions of 1985 food security act required farmers who produce agricultural commodities on highly erodible soils to fully implement approved conservation plans by January 1995. Noncompliance with this requirement leads to termination of govemment farm program participation. While the conservation provisions of the1996 farm bill have been simplified in order to enhance efficiency and flexibility, the bill has retained the essential features of 1985 CC provisions.

The whole experience with the implementation of compliance requirements suggests that it may be appropriate to reevaluate the appeal of compliance legislation. The main criticism of CC legislation centers on its lack of adequate enforcement capabilities. In a survey, Consolidated Farm Service Agency found only 1944 producers in violations of CC provisions since its enactment in 1985 to 1992 (Zinn, 1994). However, the 1995 Annual Tillage Surveys conducted by Conservation Technology Information Center (CTIC) put the estimates of total acreage under conservationtillage at 98.8 million, or 35% of the total cropland acreage of 278.6 million (CTIC, 1996).

Conservation compliance can be in further jeopardy as farm support programs are scaled back since the denial of participation in government programs is the current penalty for violations. For this reason, alternative

[1]C.A Oriade, [1]C.R.Dillon and [2]T.C. Keisling. [1]Dept. Of Agricultural Economics and Rural Sociology, University of Arkansas, Fayetteville, AR. and [2]Agronomy Department, University of Arkansas, Northeast Research and Extension Center, Keiser, AR. Manuscript received 10 April 1997. * Corresponding author.

strategies for supplementing mandatoly legislation may be needed to d a n c e the attractiveness of conservation strategies, especially on highly-erodible soils. Strategies for promoting the appeal of conservation practices need to address the economic concerns raised by AAEA. In essence, the conservation production practices should demonstrate, especially in the short run a potential for superior profitability relative to conventional practices. Unfortunately, the often touted benefits of conservation tillage (Harman,1994; CTIC, 19%) are rather intangible and fall within the class of social benefits. However, the decision making process of growers is often driven by private benefits and costs. In fact, the compliance legislation will be redundant if there are conservation -production practices that are clearly superior to conventional methods in terms of profit potential and efficient risk management.

Harman (1994) provides a detailed review of economic studies of residue management over the past several decades. While there is no conclusive evidence as to the economic advantage or disadvantage of conservation practices compared to the conventional ones, a key observation is the fact that both practices respond differently to alternative resource conditions and production environment. Consequently, the objective of this study is to investigate the economic effects of leaving or burning wheat *(Triticum aestivum* [L.] em Thell) straw on production of double-cropped soybeans *(Glycine* max [L.] Merr.) These competing wheat residue management options will be investigated under alternative cropping systems and row spacing arrangements.

Like in some other southern states, growers in Arkansas double-crop almost all their wheat acreage with soybeans. The usual practice is to bum the wheat straw which is followed by disking and planting. The study is expected to help growers adopt profitable production practices that address both the conservation and safety concerns implicit in both federal and certain state regulations. Specifically, the analysis would aid the identification of the set of production practices and resource conditions under which the conservation practice of leaving wheat straw is more profitable than the conventional practice of burning.

MATERIALS *AND* METHODS

Agronomic

Data for the study were obtained from stubble management experiments conducted at the experimental sites of Cotton Branch Experiment Station and Northeast Research and Extension Center of the University of Arkansas in Arkansas between 1992 and 1995. The soils were a silty clay, a silt loam, and a very fine sandy loam.

Experimental design in all locations was a randomized complete block with four replications. The treatment design was a split-split plot with four replications. The main plot sizes of 25.3 ft by 80 ft were established for two tillage treatments: till and no-till (NT). The first split (sub-plot) was used for row spacing treatments which comprised wide row (WR) spacings (of between 19 and 22.5 in) and narrow row spacings (NR) (less than 15 in.). In the second split, two wheat residue treatments, i.e., burning of wheat straw and leaving the straw on the soil surface, were imposed.

All pre-plant NT plots received a burndown treatment of glyphosate (Roundup) at 0.9 lb ai/a. Till plots were disked once with imazequin (Scepter) at 0.28 Ib ai/a being incorporated on the second disking. Subsequent post-plant weed control decisions followed Arkansas Cooperative Extension Service recommendations on a plot-by-plot basis. No fertilizer was applied in any of the years as the management practices were tailored to the prevalent growers' practices in the study area.

Harvesting of soybean yields in all plots was undertaken with the aid of a small-plot combine harvester. Soybean yields adjusted to 13% moisture content were determined from the harvest. Analysis of variance tests were conducted in order to detect the statistical significance of various treatments. Significant year and treatment interactions occurred for tillage, stubble management, and row spacing treatments. Therefore, the data were analyzed and presented separately for these treatments in each year. *Also,* for the treatments whose effects were significant mean separation was done with Fisher's protected least square difference (LSD) test at a = 0.5.

Economic

The enterprise budgeting t e c h q u e was used to assess the economic perfonnance of alternative stubble management practices under different row spacing and tillage systems for soybean production. The budgets, which set out the structure of costs and returns associated with these practices, were generated with the aid of Mississippi State Budget Generator (MSBG) developed by Spurlock and Laughlin (1992). MSBG is a computer-based budgeting program that can produce the cost and returns for specified crop or livestock enterprises. The program is driven by user-specified data regarding the input quantities and prices as well as output levels and prices.

The 10-yr average of seasonal prices of soybeans in Arkansas from 1985 to 1994 (Anon., 1994). was applied to the respective yields in each year to obtain gross returns per acre. This uniform average price was used, rather than the seasonal price that prevailed in each year, so that differences in returns could be solely attributed to the effects of alternative production systems under consideration.

Relevant input costs were obtained from the production cost estimates produced annually by the University of Arkansas Cooperative Extension Service (Windham et al., 1992). Variable *costs* were direct expenses that are dependent on a particular production system. These expenses were estimated from average published costs for seeds fertilizer, pesticides, custom hire, repairs, maintenance, fuel, and other operating expenses. Fixed costs included depreciation, insurance, property taxes and interest on capital invested in farm machinery. Total costs included both the fixed and variable costs. However, total *costs* did not include charges for land, risk, overhead, crop insurance, real estate taxes or management. Uniform cost structures were assumed for farm operations that are similar and cut across all strategies but the costing process duly recognized the differences in input requirements of various systems. For example, planting and seeding costs were higher for narrow row systems but no post-plant tillage costs were incurred.

Economic evaluation based solely on yields and associated profits has implicitly assumed that the outcome of the decision-making process is known with certainty. However, if a conservation practice of NT system or leaving the wheat straw is expected to gradually replace conventional practices as preferred strategies for residue management, the attitude of growers towards risk becomes an important consideration in the evaluation. Information on both the magnitude and variability of outcomes could be used to identify optimal production practices for decision makers of different risk classes.

Stochastic dominance methods were used to identify efficient production systems for decision makers of different risk groups. These methods are often preferred for their relative ease of use and because they do not require the restrictive assumptions of normality or explicit specification of the utility models. Generalized stochastic dominance (GSD), otherwise called stochastic dominance with respect to a function (SDRF), which is a more general and flexible type of stochastic dominance measures, can evaluate strategies for a broad group of decision makers ranging from those who are risk-loving to risk-averse . Further information on the intricacies of stochastic dominance measures is presented elsewhere in Meyer (1977) and King and Robison (1981). For practical implementation, a computer program, GSD, developed by Raskin and Cochran (1986) and based on Meyer's (1977) method, was employed in this study.

Stochastic dominance methods have been widely used in studies that evaluate both profits and risk in crop production management. Similar studies that have employed these tools include Williams et al. (1990), Weersink et al. (1992), and Epplin et al. (1 993). In this study, stochastic dominance criteria were applied to the cumulative probability distribution of net returns associated with eight production systems in order to determine the risk-efficient ones. These practices were: NTLNAR (no-till, left wheat stubble, and narrow row), NTBNAR (no-till, burned wheat stubble, and narrow row), NTLWIDE (no-till, left wheat stubble, and wide row), NTBWIDE (no-till, burned wheat stubble, and wide row), TLNAR (tilled, left wheat stubble, and narrow row), TBNAR (tilled, burned wheat stubble, and narrow row), TLWIDE (tilled, lef? wheat stubble, and wide row) and TBWIDE (tilled, burned wheat stubble, and wide row).

RESULTS AND DISCUSSION

While the yield information provides a means of assessing the agronomic performance of alternative practices, the overall economic implications will depend also on the magnitude of *costs* and returns associated with these practices.

Yields

Table 1 presents mean soybean yields associated with alternative tillage and stubble management practices in all locations and years. Pre-plant tillage generally resulted in a yield increase which ranged from about 0 to 25 bu/a, although there were few instances when NT yields surpassed tillage yields, especially when the production system included burning of wheat stubble. In a similar vein, narrowing the rows also resulted in general yield improvement which could be as high as 18 bu/a. However, there were several occasions when wide-row yields exceeded narrow-row yields. This finding is consistent with the lack of conclusive evidence reported in earlier studies (Boquet et al., 1982; Board et al., 1990) concerning the superiority of narrow row production systems for determinate soybean cultivars that are common in the southern USA.

The effect of leaving or burning wheat straw was also largely driven by the full complement of production practices used. For instance, for NT plots, burning the wheat straw, rather than leaving it, was clearly a superior strategy regardless of whether the rows were wide or narrow. However, narrowing the rows generally provided an opportunity to improve the yield.

Conversely, for plots that were subjected to pre-plant tillage, leaving the wheat straw on the soil surface, rather than burning it, enhanced yield. Also, narrowing the rows did have positive effect on the yields. This suggests that growers should not be expected to combine both conservation practices of NT practices and leaving straw for maximum soybean yield production. The yield loss from such practices may be the result of the attendant heavy straw load and for high weed pressures. Therefore, a choice might be necessary between NT *systems* and wheat straw retention. This choice would be influenced by whichever conservation strategy displays a higher potential for optimal yield and minimal soil erosion and other disturbances.

Comparing the growers' present practice of burning the straw under narrow row, tillage system one can see from Table 1 that the production system of leaving the straw was in fact superior because of its yield advantage. However, the growers have possibly assumed that this yield increase would not be high enough to offset the potential risks of sustaining high yield losses from wheat residue retention under undue stress situations. The difference between the yields of both strategies can be perceived as the yield premium the growers are willing to sacrifice to avoid such a risky prospect.

Net Returns

Comparisons of strategies based purely on yield considerations may sometimes be biased in favor of production practices which result in high yields but which also display high production costs. For instance, the additional costs of tillage may account for the increased yields associated with this practice. Also, the increased plant populations as a result of additional seeding and planting costs may account for the yield advantage of narrow systems. For this reason, these extra costs were considered while determining the net returns that are shown in Table 1. In general, the net returns follow the same pattern as yields except that it is now possible to observe instances when economic losses would be sustained if certain production practices were used.

The NT system does not seem like a preferred strategy for profitable soybean production under extreme stress conditions, e.g., drought. The net returns for Marianna experiments in 1993 are particularly striking where negative returns would be realized under NT system regardless of row width and stubble management practices. The results at Marianna in 1993 were influenced by a 3-wk drought in late June and early July and another 2-wk drought about the first of September. Also, positive returns were reported only in tilled plots where the stubble was retained in Marianna in 1993. This evidence is at variance with farmers' preference for burning wheat stubble to hedge against yield fluctuations under adverse conditions.

Risk Analysis

Table 2 presents the preferred complements of production practices as ranked by FSD, SSD, and GSD. The results show that when all eight Combinations are considered, FSD identifies two dominant strategies, TLNAR, and TBNAR that belong to its efficient class. SSD which assumes risk neutrality or aversion of decision makers improves upon the ranking ability of FSD. It uniquely identifies TLNAR as the dominant complement of production practices. GSD affirms the choice of TLNAR for moderate degrees of risk preference and all degrees of risk aversion. This ranking is preserved when the stochastic dominance analysis focused exclusively on four complement of production practices for tilled plots.

Focusing on the no-till strategies, results shown in Table 2 indicate that FSD does not exist for any complement of production practices. NTLNAR and NTBNAR are dominant practices according to the SSD criteria. GSD uniquely identifies NTBNAR only for decision makers whose degrees of risk aversion range from moderate to high.

The results of these stochastic dominance analyses have some important remifications. First, it is instructive to observe that no combination of production practices without pre-plant tillage ever dominated those with tillage. Therefore, conservation advocates need to recognize that no-till systems may not be profitable or risk efficient enough to expect widespread use of this practice without additional incentives. From the conservation standpoint, it is gratifying to notice that production practices that involve stubble retention dominate burning of wheat stubble for tilled systems. Conversely, for no-till *systems,* the unique dominant practice includes the burning of wheat straw. Therefore, the stochastic dominance analyses further confirm the earlier observation that a choice has to be made between a conservation practice of either no-till or residue retention for optimal crop production management. Finally, the growers' popular practice of TBNAR **is** not among the risk efficient strategy identified by FSD, SSD, or GSD. There are two possible reasons for this choice. One probable reason is that the decision making environment of the growers is not characterized by risk aversion. A rather more compelling argument is that the growers do not have perfect knowledge of the risk implications of all strategies which may account for their erroneous preference for TBNAR production practices.

CONCLUSIONS

Mandatory legislation for enforcing conservation practices may be unnecessary once profitable and risk-efficient ones are identified. Results from this study indicate that the conservation practice of retaining wheat stubble can be an optimal and risk-efficient strategy for double-cropped soybean production. The profitability of this practice is further enhanced if it is complemented with tillage and narrow row systems. The study finds no justification for growers' preference for burning wheat stubble except under no-till systems.

Non-optimal returns were obtained when dual conservation practices of no-till soybean production and the retention of wheat residue were combined. Therefore, conservation advocates may need to make a choice between both practices depending on their potential to increase profitability and soil productivity. On the basis of net returns, stubble retention appears to be a superior strategy.

The relevance of these findings lies in the potential to promote conservation practices that are consistent with growers' objective of optimal returns. Therefore, future research aims at validating these results for different cropping systems will be germane.

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Table 1. Average Yields and Net Returns Associated with Alternative Practices

		Without pre-plant tillage (No-Till)							
		Narrow Rows				Wide Rows			
		Burned		Left		Burned		Left	
Location	Year	Yield	Net Returns	Yield	Net Returns	Yield	Net Returns	Yield	Net Returns
		Bu/a	$la	Bu/a	$la	Bu/a	$la	Bu/a	$la
Keiser	1994	38.20	111.55	34.00	84.59	38.80	130.68	39.40	134.49
	1995	41.70	129.91	43.80	142.60	35.20	103.94	36.30	110.71
Little Rock	1992	31.50	71.89	23.90	27.16	21.30	21.65	13.70	-23.08
Marianna	1992	27.50	45.62	22.90	18.87	16.70	-0.15	11.30	-31.86
	1993	13.90	-34.21	17.00	-16.05	10.10	-44.65	12.40	-30.78
Pine Tree	1994	22.30	15.06	20.50	4.67	17.10	-3.21	15.10	-14.80
	1995	20.30	3.22	21.00	7.63	16.90	3.24	16.50	1.13
		With Pre-Plant Tillage (Tilled)							
Keiser	1994	33.00	88.44	36.60	110.01	33.40	101.10	38.2	129.77
	1995	45.30	161.26	39.50	127.18	34.10	103.87	39.9	138.47
Little Rock	1992	44.70	152.56	47.90	176.91	26.60	60.84	34.2	106.09
Marianna	1992	24.20	36.34	28.30	60.87	15.20	-6.65	19.4	18.48
	1993	16.00	-12.20	23.20	30.68	16.10	-1.32	19.3	17.88
Pine Tree	1994	27.20	54.10	25.00	41.34	20.30	22.18	19.8	19.48
	1995	23.20	30.42	22.20	24.76	17.10	4.60	16.1	-1.06

Table 2: Stochastic Dominance Rankings of Alternative Soybean Production Systems

Efficiency Criterion	Absolute risk-aversion Coefficient† Lower Bound	upper Bound	Set of Dominant Strategies‡ Overall	Tilled	No-Till
FSD	-∞	∞	TLNAR TBNAR	TLNAR TBNAR	NTLNAR NTBNAR NTLWIDE NTBWIDE
SSD	0.000	∞	TLNAR	TLNAR	NTBNAR NTLNAR
GSD:					
Risk Preferring	-0.005	0.000	TLNAR	TLNAR	NTBNAR NTLNAR
Risk Neutral	0.000	0.000	TLNAR	TLNAR	NTBNAR NTLNAR
Slightly risk averse	0.002	0.005	TLNAR	TLNAR	NTBNAR NTLNAR
Moderately risk averse	0.005	0.009	TLNAR	TLNAR	NTBNAR
Highly risk averse	0.009	0.020	TLNAR	TLNAR	NTBNAR

† The **absolute risk** aversion function coefficients have been scaled to allow comparisons on net returns per acre basis (Raskin and Cochran, 1986; Boggess and Ritchie, 1988).
‡ TLNAR = tilled, retained wheat residue, narrow **row,** TBNAR = tilled, burned wheat residue, narrow row; NTLNAR **= no-till**, **retained** wheat residue, narrow **row,** NTBNAR = no-till, burned wheat residue, narrow row; NTLWIDE = no-till, retained wheat residue, wide row NTBWIDE = no-till, retained wheat residue, wide row.

Cover Crops for Weed Control in Conservation-Tilled Soybean

***D. W. Reeves, M. G. Patterson, and B. E. Gamble**

INTRODUCTION

In the southeastem USA, soybean *[Glycine max* (L.) Merr.] is generally grown doublecropped with wheat *(Triticum aestivum* L.). Doublecropped soybean in wheat stubble is the most common conservation tillage practice in the South. In southern Brazil, however, soybeans are.grown in rotation with the cover crop black oat *(Avena strigosa* Schreb.). This practice has become the major production system on millions of acres of conservation-tilled soybean. One principal advantage of black oat is its demonstrated ability to suppress weeds. The Brazilian system for managing cover crops and growing conservation-tilled soybean is much different than that used in the southern USA. The Brazilian system is based on terminating the cover crop during early reproductive growth by treating with a herbicide and mechanically rolling the covers to form a dense mat on the soil surface. In 1995, we began a study to determine the suitability of black oat as a cover crop for conservation-tilled soybean using the Brazilian system of managmg cover crops. We wanted to compare the Brazilian system using black oat and *two* common cover crops used in the southeastem USA, i.e., rye *(Secale cereale* L.) and wheat *(Triticum aestivum* L.). Results reported here are for the first 2-yr of the *study* (1995 and 1996).

MATERIALS *AND* METHODS

The study site was a Dothan fine sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudult) in southeastern Alabama. It had been in conservation tillage (strip-tilled) for the previous 8 yr and had a high population of Palmer Amaranth *(Amaranthus palmeri* S. Watts.). Soybean was grown in a strip-plot design of four replications. Horizontal plots were winter covers of black oat, rye, wheat, or fallow. Dominant winter weeds in the fallow system were cutleaf evening primrose *[Oenothera laciniota* Hill] and chickweed *[Stellaria media* (L.) Vill.]. Cover crops were sown in November of 1994, 1995, and 1996 and were terminated with an application of glyphosate (1.0 lb a.i./a) 3 wk prior to planting 'Stonewall' soybean in early May each year. Within 3 d following glyphosate application, the covers were rolled with a modified stalk chopper to lay all residue flat on the soil surface. Soybean was drilled on 7-in. row widths using a Great Plains no-till drill. Seeding rate was 100 lb/a. In 1995, soil crusting resulted in a stand failure in the winter fallow plots, and this treatment was replanted on 23 May, 14 d after the first planting.

Vertical plots were herbicide input levels: none, low, or high. The low herbicide input level consisted of a preemergence application of pendimethalin (0.75 lb a.i./a) + metribuzin (0.38 lb ai/a). For the high input level, preemergence applications of pendimethalin (0.75 lb a.i./a) + Canopy@[metribuzin+chlorimuron(0.60 lb a.i./a)] were followed by a post-directed application of clorimuron (0.5 *oz* a.i./a) approximately 40 d after planting. Because the site has a well developed hardpan, it was paratilled prior to planting the cover crop in November of 1994; in 1996, the site was paratilled 2 wk prior to planting soybean. Residue disturbance was minimal and residue formed a dense mat over the soil surface.

Weed control was determined by visual ratings (0 to 100 % control scale) early in the season (approximately 30 d after planting) and late in the season at 51 and 80 d after planting, respectively, in 1995 and 1996. In 1995, we also determined weed biomass and control ratings for grasses (primarily large crabgrass *[Digitaria sanguinalis* (L.) Scop.] and Texas panicum *[Panicum texanum* Buckl.]) and sedges *(Cyperus esculentus* L. and *C. rotundus* L.), sicklepod *(Cassia obtusifolia* L.), and Palmer amaranth. We then determined Pearson correlation coefficients between ratings and weed biomass to measure the validity of visual ratings. Correlation coefficients ranged from 0.77 to 0.94; consequently, in 1996 we only used visual ratings to measure weed control. Weed control ratings in Table 1 are averaged over all dominant weed species.

Recommended practices were used for insect control. Soybean yield was determined by combining a 5-ft wide section from within the 30-ft long plots.

RESULTS AND DISCUSSION

In 1995, residue production was similar for all

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[1]D.W. Reeves, [2]M.G. Patterson, and [2]B.E. Gamble, [1]USDA-ARS National Soil Dynamics Laboratoxy, Auburn, AL and [2]Alabama Agricultural Experiment Station, Auburn University. Manuscript received 14 March 1997. *Corresponding author.

winter cereal covers, averaging 4665 lb dry matter/a. Winter weeds produced 1260 lb dry matter/a in fallow plots. The severe winter of 1996 resulted in differences in residue produciton by the covers. Dry matter averaged 5580, 3900, 1175, and 780 lb/a for rye, wheat, black oat, and winter fallow, respectively, in 1996.

In 1995 there was a significant cover x herbicide input level interaction. Without herbicide, all covers provided better control than winter fallow but wheat was inferior to black oat and rye for weed control (Table 1).

Severe low temperatures during the winter of 1995-96 killed the black oat, resulting in similar residue production as winter weeds in the fallow plots. As in 1995, there was a significant cover x herbicide input level interaction. Without herbicide, weed control was related to biomass production, with the exception that rye offered superior weed control to wheat. When herbicides were used, weed control was similar regardless of winter cover crop.

In 1995, soybean yields averaged across herbicides were 40, 18.3, 38, and 35.7 bu/a for black oat, winter fallow, rye, and wheat covers, respectively (Table 2). Yields were similar with the low and high herbicide input levels, averaging 30% greater than when no herbicides were used. Highest yield was obtained with the black oat cover and the low herbicide input system (44 bu/a).

In 1996, the rye cover resulted in the highest yields (48.1 bu/a), averaged across herbicide input levels (Table 1). As in 1995, yields were similar for the high and low herbicide levels, averaging 112% greater than when no herbicides were used. The 1996 season was extremely wet and weed pressure was severe. Surprisingly, at the low herbicide input level, soybean yield following the winter killed black oat cover was significantly greater than when soybean followed winter weeds (fallow) with similar residue amounts. Yield levels at the low herbicide level closely matched weed control ratings (Table 1). Some researchers have reported allelopathic interactions with herbicides where certain plants can increase the effectiveness of some herbicides. Whether this is the case with the winter killed black oat or whether the effect was due to some unknown residual rotational response, we cannot say at this time.

Preliminary results indicate: 1) rye and black oat are more effective cover crops than wheat for weed control in conservation soybean but inferior cold tolerance of black oat compared to rye may limit its zone of adaptation; 2) a strong yield benefit for planting conservation tilled soybean using the Brazilian management system, i.e., cover crops grown to produce large amounts)>4,000 lb/a of residue rolled to form a dense mat on the soil surface. In addition, evidence suggests that black oat may provide some type of a residual rotational or synergistic response to soybean yield when used within a standard herbicide program. This needs to be investigated further.

Table. 1. Soybean yields as affected by cover crop and herbicide system.

	1995				1996			
	Herbicide Input System				Herbicide Input System			
Cover Crop	High	Low	None	*mean*	High	Low	None	*mean*
	-----grain yield (bu/a)-----							
Black oat	38.9	43.7	37.5	*40.0*	47.7	51.0	17.2	*38.6*
Fallow	24.1	22.3	9.4	*18.6*	51.2	41.7	15.2	*36.1*
Rye	37.7	39.8	36.2	*37.9*	52.3	54.5	37.7	*48.2*
Wheat	40.4	38.9	27.9	*35.7*	52.5	47.7	24.0	*41.4*
mean	*35.3*	*36.2*	*27.7*		*50.9*	*48.8*	*23.5*	

1995 $LSD_{(0.10)}$ for cover crop = 7.9; for herbicide level = 6.4; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.
1996 $LSD_{(0.10)}$ for cover crop = 3.8; for herbicide level = 4.4; for cover crop within herbicide level interaction = 8.0; for herbicide level within cover crop interaction = 8.7.

Table 2. Soybean weed control as affected by cover crop and herbicide system.

	1995				1996			
	Herbicide Input System				Herbicide Input System			
Cover Crop	High	Low	None	*mean*	High	Low	None	*mean*
	-----weed control (%)-----							
Black oat	95	95	86	*92*	89	86	22	*66*
Fallow	92	85	29	*69*	91	82	16	*63*
Rye	95	95	83	*91*	91	88	58	*79*
Wheat	95	91	61	*82*	93	84	29	*69*
mean	*94*	*92*	*65*		*91*	*85*	*31*	

1995 $LSD_{(0.10)}$ for cover crop = 8; for herbicide level = 8; for cover crop within herbicide level interaction = 12; for herbicide level within cover crop interaction = 11.
1996 $LSD_{(0.10)}$ for cover crop = 4; for herbicide level = 6; for cover crop within herbicide level interaction = 7; for herbicide level within cover crop interaction = 9.

Soybean Yield Response to Tillage and Landscape Position

***J. R. Johnson, K. C. McGregor, and R. F. Cullum**

INTRODUCTION

Crop productivity is slowly lost over time from soil erosion on most southeastern US. fields. Reduction of crop yields may not be recognized until the land is no longer suitable for growing crops. Difficulty of detecting crop productivity losses from soil erosion caused by water is further masked by technological innovation in agricultural research. Current research technologies may temporarily improve crop yields by employing new and innovative production practices at a rate faster than the erosion process is depleting yields. Consequently, the loss of crop productivity caused by soil erosion may be temporarily overcome with soil amendments, improved varieties, tillage practices, and annual management practices to improve seasonal water holding capacity of the soil. In soils with shallow restrictive layers, as in the fragipan soils of the Southeast Region of the U. S., the eventual loss of the shallow top soil layer should result in decreased overall crop yields. This paper reports on effects of landscape position on crop yields and compares No-Till (NT) and Conventional Till (CT) soybean *(Glycine max* [L] Merr.) yields. These results are from part of a larger ongoing study.

Various researchers (McGregor et al., 1992; Mutchler et al., 1985; Mutchler and Greer, 1984; McGregor et al., 1975) reported beneficial soil erosion control and increases in crop yields from established NT systems. Variation in crop yield with depth to a fragipan horizon also has been used to explain the effects of soil erosion on crop productivity (McGregor et al., 1992; Frye et al., 1983). Water stress became the limiting factor to satisfactory crop yields in soils with shallow restrictive layers such as fragipans.

Field slopes, another major factor in crop productivity, generally are nonuniform. Slopes, however, consist of many small uniform planes of short length along the slope. Nonuniformity of the overall slopes results in nonuniform erosion occurring along the length of the slope. Nonuniformity of the slopes results in nonuniform soil depths, organic matter, CEC, and pH across the slope due to past erosion and sediment deposits within the field. Yet, slopes are treated uniformly with the applications of soil amendments.

MATERIALS AND METHODS

This report expands the earlier study by McGregor et al. (1992) by extending the analysis of four paired plots to include slope position within the larger and ongoing study. The experimental area described by McGregor et al. (1992) was located on the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station near Holly Springs, Mississippi. The area consisted of paired plots (12 pairs) with the randomized treatments on a Loring silt loam (Typic Fragiudalf) on slopes ranging from 2 to 5%. Past erosion along the slope from this experimental area had caused variation in fragipan depth. Even though the site was considered unusable for crop yield studies, this area was appropriate for evaluating crop productivity from soil erosion on shallow fragipan soils. No-till soybean was grown on one plot of each pair and CT soybean was grown on the other plot from 1983 to 1996. Depth to a fragipan layer varied from about 12 to 18 in. Each of the 24 plots was 150 ft in length and 18 A in width with 3-ft-wide rows in an up-and-downhill direction. Row lengths were divided into 25-ft increments downslope (referred to position A through position F with position A at the apex of the slope, Figure 1). Soybean was harvested from the two middle rows of each plot in 25-ft segments with a plot combine to provide soybean yields. Harvested grain was moisture tested and adjusted to 14% moisture for yield weights.

Corn *(Zea mays* L.) silage had been grown on the site for the previous 20 yr prior to plot establishment in 1983. A fescue *(Festuca arundinancea)* waterway was established at the base of the plot area to trap sediments leaving the area. Due to row orientation, plot rows in the CT enhanced erosion down the slope. All plots were tilled in 1983 preceding planting of continuous soybeans; however, only the CT treatment received two more cultivations for weed control during the growing season of 1983. Tillage sequence preceding planting in 1983 consisted of disking, field cultivation, moldboard plowing, disking, and field cultivation to smooth out any soil and topographical differences left over from previous farming and erosion. After 1983, tillage for CT plots consisted of disking, chiseling, disking, and field

[1]J.R. Johnson, [2]K.C. McGregor, and [2]R.F. Cullum. [1]Agronomy Dept., Mississippi Agri. and Forestry Exp. Sta., Mississippi State University, Holly Springs, MS., [2]Agricultural Engineer, USDA-ARS, National Sedimentation Laboratory, Oxford, MS. Manuscript received 19 March 1997. * Correspongding author.

cultivation preceding planting, and then followed with *two* cultivations for weed control during the growing season. During 1984 through 1989, fertilizer was incorporated with a double-disk opener on both NT and CT plots at planting time at rates recommended by the Mississippi Agricultural and Forestry Experiment Station. Starting in 1990, fertilizer was broadcast at planting time on the soil surface **on** both NT and CT plots. Preemergence herbicides in the CT were sprayed at planting. No fall plowing or tillage implements were used in the CT after the plots were harvested.

No additional tillage was done on plots designated as NT after 1983 except for some areas used for simulated rainfall experiments. During the 1987 and 1996 years, positions E and F on two of the replications in the subset of this study were tilled for these simulated rainfall experiments and thus, no yield data were obtained. One replication of yield data was missing from positions A, B, and C in 1990. These exceptions do not affect the general outcome of the study. Roundup was sprayed on the NT each year in mid-April. Fertilizers in the NT were surface broadcast after the initial burndown and before planting. Preemergence herbicides for the NT were the same as in the CT. In the NT plots, an additional application of Roundup was made at planting to bumdown any emerged weeds since the mid-April burndown. Postemergence herbicides were used if needed to control weeds and grasses. Soybean varieties were rotated annually to avoid cyst nematodes, root diseases, and other pests which could hinder the long-term aspect of the study. In all tillage systems, soybean was planted in May each year. Due to the establishment of the NT system in 1983, the yield data from 1983 did not represent NT systems and was not included with the reported 13-yr period of study.

Crop yield as affected by landscape position for 4 paired plots of a larger experiment (12 reps) were analyzed with a randomized complete block design. Trends were examined to relate the effect of slope position to soybean yield as affected by tillage system.

RESULTS AND DISCUSSION

Average soybean yields for each year are presented in Figure 2. Conventional-till soybean yields were 23 and 3% greater than NT yields during 1984 and 1985, respectively. No-till soybean yields were 5, 17, 82, 29, 50, 35, 43, 20, 119, 36, and 64% greater than CT soybean yields during 1986 through 1996, respectively. During the last 11 yr, NT soybean yields averaged 42% greater than CT soybean yields. Yields after 2 to 3 yr of continuous NT monocropping of soybean were equivalent or exceeded those of continuous CT monocropping soybean system, as was reported in the larger experiment by McGregor et al. (1992) and Johnson et al. (1995).

Significantly higher yields, as influenced by tillage, were detected in years 1988, 1990, 1991, 1992, 1994 and 1996 (Figure 2). These yield measurements showed that erosion influence on yields would gradually progress over time and measurable yield differences between NT and CT systems would increase in frequency with time.

Mutchler et al. (1985) demonstrated that a NT system for soybeans was successful in reducing runoff and soil erosion. Decreased runoff down the slope should result in more water available for the NT system thereby increasing plant growth. An increase in plant growth could mean more cover for the soils, higher yields, and more residue returned to the soil, which could reduce evaporation in future years. The process thus feeds on itself from year to year unless interrupted. This process could account for NT surpassing CT in yields during the third year. Possibly after 2 or 3 yr, increased residue levels in the NT system resulted in moisture being available at crucial times in the NT system to advance yields over the CT system.

Although poor soybean yields from both NT and CT were produced during several years, the sustained trend for lower yields from CT as compared to NT indicated an adverse effect of excessive erosion and tillage **on** crop productivity. Continued erosion of the soil overlying a fragipan soil creates an environment where crop yields cannot be maintained even under optimum growing conditions. With proper management, acceptable NT crop yields may be produced indefinitely.

A separation of means using LSD at the 0.05 probability level was conducted for tillage, slope position, and tillage and slope position interaction (Table 1). Slope position influenced soybean yields in 9 out of 13 yr (Table 1) as found by comparing differences of the average soybean yield with their LSD value for the slope position factor. Yields in the CT were severely impacted in the 75 to 125 ft range (position C and D) after 6-41 of continuous tillage. Due to the significant difference of soybean yield in the tillage and position interaction (Table 1, section of the tillage system by position interaction), an analysis was conducted that compared the average soybean yield at various slope positions along the crop row for each tillage system to the average yield at the apex or position A of the plot (Table 2). Except for position F, yields were generally less for landscape positions below the apex for both NT and CT systems

Positions A, D, and F were plotted for each tillage system (Figure 3). Soybean yields were reduced at position D and were predominantly increased at position F for each tillage system as displayed in Figure 3. Reduction of soybean yield at position D was more pronounced in the CT system, probably due to more eroding soil associated with this system as compared to the NT system. Increase in yield found at position F was probably a result of sediment deposition in both NT and CT systems At this point, differences occurring in yields due to tillage and slope position were a result of soil erosion depleting yields in the CT and yields being slightly enhancedin the NT. Possibly during tillage of the CT, fragipan clays were mixed with topsoils at the D position producing AL toxicity, reduced aeration, and increased bulk density which can reduce yields and water holding capacity.

CONCLUSIONS

Slope position influenced soybean yields in 9 out of 13 yr. After 7-yr of continuous tillage systems, yields were severely impacted in the 75 to 125 ft range of CT plots each year. Yields in the range of 125 to 175 ft down slope were not impacted in the CT plots. Apparently sedimentation was taking place in this area of the lower slope. Yields in the NT were not as pronounced as in the CT plots by slope positions which indicated the soil stability along the slope in NT plots where erosion is not taking place and affecting yields. Also, NT soybean gave higher yields in 11 out of 13 yr when compared to CT soybean.

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Table 1. Table of means for soybean yields (bu/a) as affected by tillage, location, and tillage by location interactions.

Tillage System	Position	Years 1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
CT[†]		37	41	18	24	17	17	6	23	23	21	16	14	11
NT[†]		30	40	19	28	31	22	9	31	33	25	35	19	18
LSD (0.05)		4.5	2.5	2.4	5.9	6.7	4.5	1.5	4.7	5.0	4.3	9.4	8.0	5.6
	A[‡]	42	41	20	27	26	17	8	32	34	23	29	17	17
	B[‡]	35	40	19	25	26	19	7	27	31	24	23	17	15
	C[‡]	30	39	16	27	25	21	7	24	24	21	21	13	11
	D[‡]	24	40	19	26	20	18	7	21	22	20	20	13	8
	E[‡]	31	42	18	26	21	17	7	25	25	22	27	17	14
	F[‡]	41	42	17	27	24	23	9	32	30	28	32	21	19
LSD (0.05)		5.1	3.8	3.8	3.6	3.0	5.2	2.3	5.4	5.5	3.7	6.8	2.5	5.1
CT[£]	A	45	42	20	25	19	17	6	28	27	23	20	16	13
CT[£]	B	38	40	19	23	20	16	4	24	28	23	15	15	9
CT[£]	C	34	41	17	25	18	18	6	20	18	18	9	10	7
CT[£]	D	30	38	17	22	12	16	5	14	12	14	7	8	3
CT[£]	E	34	43	17	25	15	14	6	22	24	21	19	13	11
CT[£]	F	43	43	17	24	17	19	8	29	29	29	26	19	20
NT[£]	A	40	39	21	29	34	17	9	35	40	24	39	19	22
NT[£]	B	33	40	19	27	33	21	10	31	35	26	30	19	22
NT[£]	C	26	38	15	30	32	24	9	28	30	25	34	16	15
NT[£]	D	18	41	22	30	29	21	8	28	32	27	32	18	12
NT[£]	E	28	40	19	27	27	20	8	28	27	23	36	20	17
NT[£]	F	39	40	16	29	32	28	11	36	31	28	39	24	18
LSD (0.05)		6.5	3.7	5.1	3.8	3.5	5.2	1.8	7.7	7.8	4.5	9.8	3.7	5.3
C.V. %		12.8	6.1	18.6	9.3	9.9	18.0	16.0	19.1	18.8	12.8	25.8	14.9	21.0

Notes: CT = Conventional-till NT = No-till A B C D E F are positions along slope of plot.
LSD = least significant difference (bu/A) at the 0.05 level of probability
C.V. % = coefficient of variation in percent

† Average yield across all positions and reps

‡ Average yield across all tillages and reps

£ Average yield across all reps

Table 2 Soybean yields as percent of yields from location A at various locations along the slope of the soybean row for comparison to the apex of the plot.

Tillage	Yield Ratio	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
CT	AIA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CT	B/A	83.8	95.3	92.5	91.1	106.8	94.2	66.7	85.0	102.8	101.1	75.6	92.3	70.6
CT	CIA	76.5	96.4	85.0	97.0	94.6	102.9	91.7	71.7	65.1	79.1	46.2	61.5	54.8
CT	DIA	65.9	90.5	83.8	85.1	64.9	91.3	87.5	48.7	45.0	61.5	35.9	49.2	26.5
CT	H A	76.0	101.8	85.0	98.3	78.4	78.3	100.0	77.0	86.2	92.3	94.9	81.5	85.3
CT	F/A	95.0	101.8	85.0	96.3	90.5	107.2	129.2	102.7	104.6	127.5	130.8	115.4	159.0
NT	AIA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
NT	B/A	82.4	103.2	92.8	94.7	97.0	121.7	105.6	87.9	87.4	108.5	78.6	104.1	98.9
NT	*CIA*	65.4	96.2	73.5	103.5	96.3	137.7	94.4	78.6	75.5	105.3	87.7	85.1	70.7
NT	DIA	44.0	105.1	103.6	106.1	85.8	118.8	88.9	80.0	81.1	112.8	83.1	94.6	54.6
NT	H A	71.1	102.6	89.2	94.1	79.1	115.9	88.9	80.7	68.6	98.9	93.5	106.8	77.6
NT	F/A	96.9	103.2	77.1	102.9	94.0	162.3	116.7	102.1	78.6	118.1	101.3	128.4	82.2

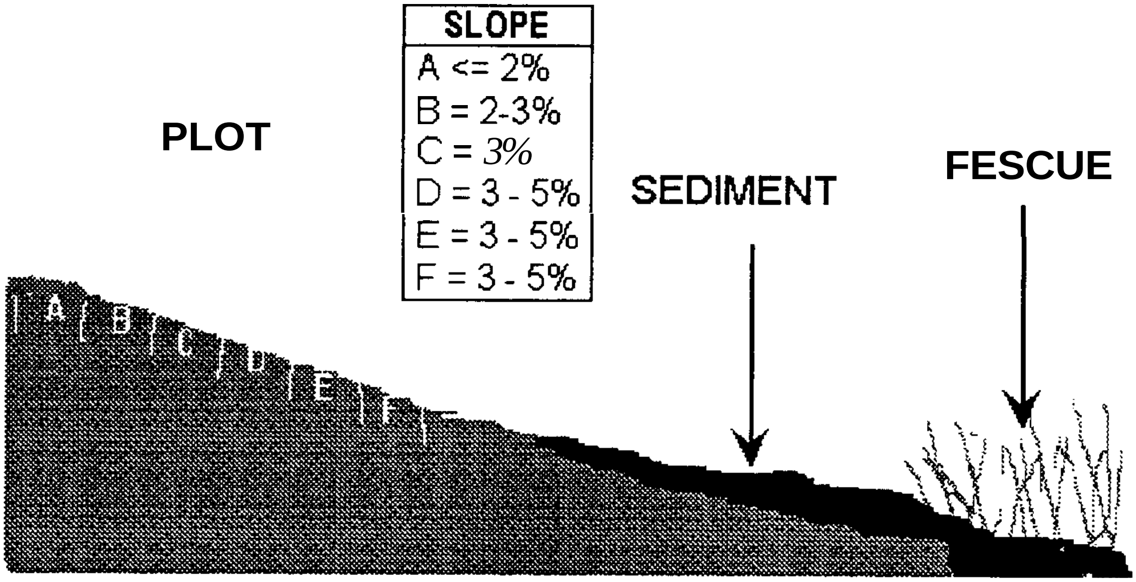

Figure 1. Topographic layout of slope and position configuration of A, B, C, D, E, and F.

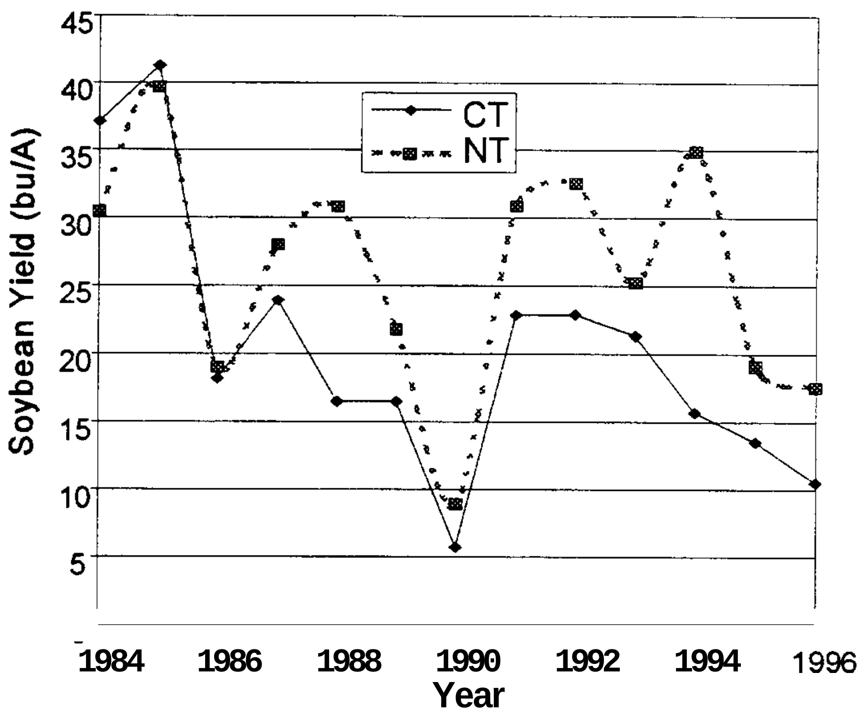

Figure 2. Average soybean yields for each year from NT and CT productivity plots

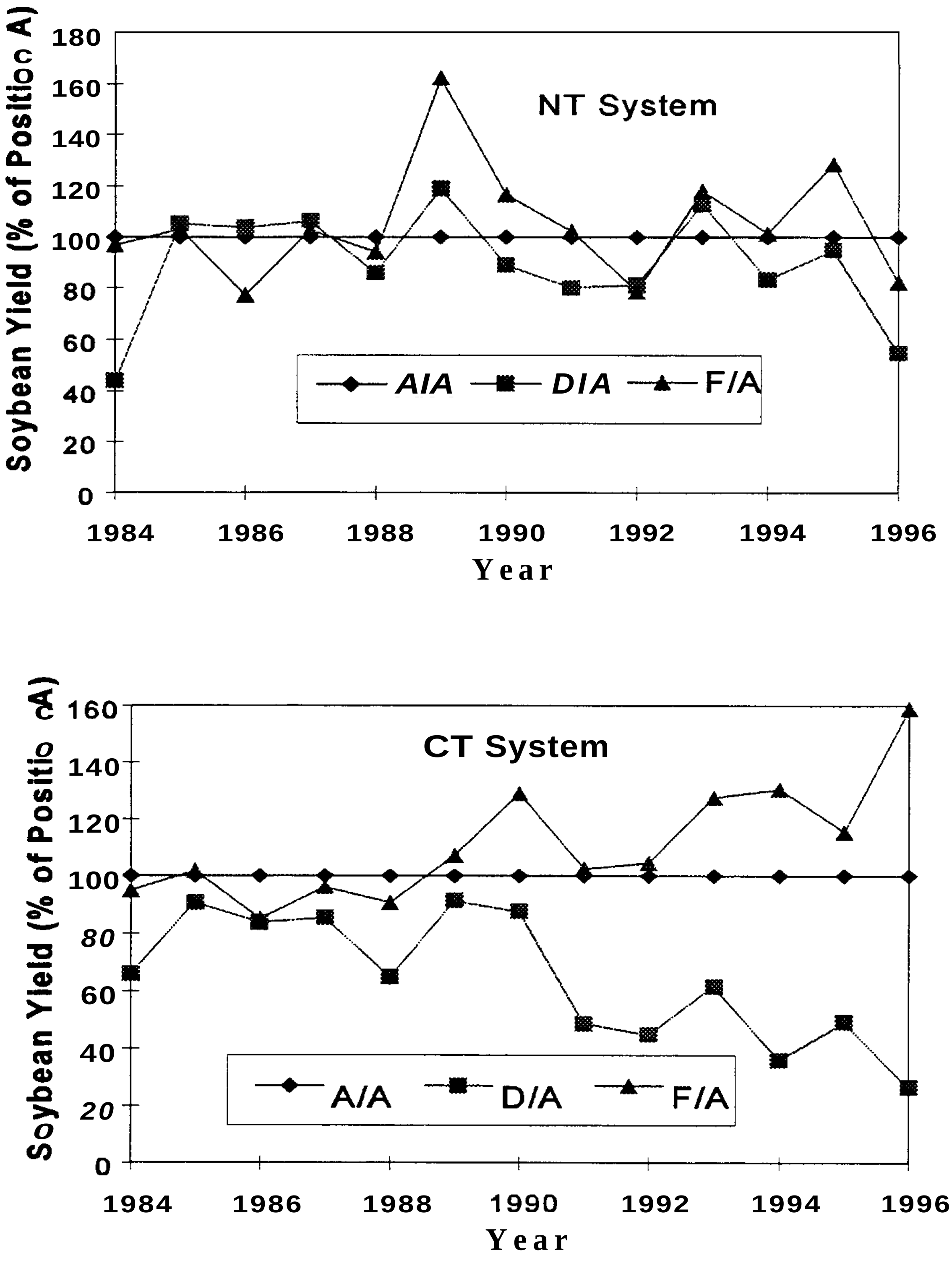

Figure 3. Average yield at various positions along slope of the soybean row compared to the average yield at position A for each tillage system.

Timing of Deep Tillage for Wheat-Soybean Double Crop in the SE Coastal Plain

***W.J. Busscher, P.J. Bauer, J.R Frederick**

ABSTRACT

Deep tillage disrupts subsoil hardpans that reform annually in many southeastern Coastal Plain soils. Generally, producers deep till annually, even when double-cropping. Our purpose was to find out whether fall tillage, spring tillage, or both would increase yield within a wheat *(Triticum aestivum)*-soybean(*G1ycine max)* double-cropping system. We planted eight treatments in four replicates. Treatments were surface tillage (disked and not disked) and deep tillage (not deep tilled, paratilled before wheat planting, before soybean planting, and before both). Disked plots that were not paratilled had a pan at the 4-to 6-in depth, just below the disked zone. AU non-deep-tilled treatments had a at 8 to 12-in depths. Treatments that had been deep-tilled most recently had lower mean profde cone indices. Within the range of soil strengths measured, wheat yield decreased approximately 2.5 bu/a for each atmosphere of increase in mean profde cone index measured at the beginning of the growing season. Soybean yields decreased between 1.6 and 2.7 bu/a for each atmosphere of increase on mean profde cone index. Deep tillage at the beginning of the season improved yields for both wheat and soybean.

INTRODUCTION

Many Coastal Plain soils require deep tillage to disrupt root-restricting subsoil hardpans. Annual subsoiling is currently recommended either prior to spnng planting (Threadgill, 1982; Busscher et al., 1986) or prior to fall planting (Porter and Khalilian, 1995). Double-cropped wheat and soybean have become popular in South Carolina, with acreages ranging from 200,000 to 250,000 in the past 4yr, with reduced surface tillage increasing from 24% to 46% of this acreage. Because planting early increases yield, soybean are planted as soon after wheat harvest as possible. To accomodate early spring planting, some fanners subsoil in the fall. Others believe that they need to subsoil twice, before planting both soybean and wheat.

We believed that the frequency and timing of subsoil tillage would affect crop production and soil strength. The purpose of this study was to determine whether subsoiling in the spring, in the fall, or both gave the greatest improvement in soybean and wheat yield and the greatest reduction in soil cone index.

METHODS

Wheat-soybean double-cropped plots were established in the fall of 1993 at the Pee Dee Research and Education Center near Florence, SC. We grew winter wheat cultivar Northrup King Coker 9134, a soft red winter wheat, and Haygood soybean, a Maturity Group VII cultivar. The soil was a Rains (typic Paleaquult) that had a hardpan below the plow layer. In the summer of 1993, the field had been planted in soybean.

We established two surface tillage and four deep tillage treatments. Surface tillage treatments were either not disked or disked twice before planting. Deep tillage treatments included no paratilling and paratilling at soybean planting, at wheat planting, and at both soybean and wheat planting. The eight treatments were arranged in a randomized complete block design and replicated four times. Each plot was 10 ft wide and 50 ft long.

Surface tillage, deep tillage, and planting were done in separate operations. We used the same wheel tracks as much as possible for all these operations and for harvesting. Surface tillage was done with a 10-ft-wide Tufline[1] disk (Tufline Mfg. Co., Columbus, GA) pulled by a John Deere 4230 (Deere and Co., Moline, IL) 100 HP tractor with wheels on 64-in centers. A four-shank paratill (Tye Co., Lockney, TX) was used to deep till to approximately 16 in. Shanks were spaced 26 in apart The paratill was pulled with a *Case* 2670 (now Case-M, Racine, WI) 220 *HP,* 4-wheel-drive tractor with dual wheels on 75-in and 122-in centers.

Both wheat and soybean were drilled with a 10-ft-wide John Deere 750 No-till Planter pulled by a Massey Ferguson 398 (Massey Ferguson, Inc., Des

W.J. Busscher, P.J. Bauer, and J.R. Frederick. USDA-ARS, Coastal Plain Research Center and Clemson University, Florence, SC. Manuscript received 25 March 1997. * Corresponding author.

[1]Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agric. and does not imply its approval to the exculsion of other products or vendors that may also be suitable.

Moines, IA) 80 HP tractor with wheels on 75-in centers. Wheat was drilled in mid-November at a rate of 20 seeds/ft. Soybean were drilled in late May or early June at a rate of 4 seeds/ft in 7.5-in-wide rows and harvested in early November.

Data for wheat and soybean yield were taken from six 39-in sections of row where whole-plant samples were harvested from each plot. Wheat plots were subsequently cleaned with an Allis Chalmers (now Deutz-Allis, Norcross, GA) F3 Gleaner with a 13-ft header. The harvester wheels were on 8-ft centers. Soybean plots were cleaned with an IH 1420 axial flow combine (now Case-IH Racine, WI) with wheels on 7.5-ft centers and a 13-ft header. Yield data were corrected to 13% moisture for both wheat and soybean.

Phosphorous and K were preplant broadcast for both wheat and soybean following Clemson University soil test recommendations Ammonium nitrate was broadcast on all wheat plots at a rate of 30 lb N/a immediately after planting and 50 lb N/a side-dressed in late February to early March (the stem erect wheat gowth stage). Fertilizer was applied with a 10-ft-wide Gandy spreader (Gandy Co., Owatonna, MN) pulled by the Massey Ferguson 298 tractor.

Non-disked plots were sprayed with Roundup (glyphosate) at a rate of 1.0 lb a.i./a before wheat planting or Bronco (alachlor plus glyphosate) at a rate of 3.5 lb a.i./a before soybean planting. Lasso (alachlor) preemergence was applied to disked plots at a rate of 2.3 lb a.i./a before soybean emergence.

To control annual broad leaves and nutsedge, Classic (chlorimuron) was applied to all plots at 0.012 lb a.i./a at 21 days after soybean planting. To control annual grasses Poast Plus (sethoxydim) was applied to all plots at 0.19 lb a.i. /a at 30 d after soybean planting.

Soil strength was measured with a 0.5-in-diameter cone-tipped penetrometer (Carter, 1967) within two weeks of planting. Strength was measured from the middle of the plot outward at intervals of 3.75 in to a distance of 30 in (approximately the distance between paratill shanks and to a depth of 22 in. Data were digitized into the computer and log transformed before analysis according to the recommendation of Cassel and Nelson (1979). Data for all positions across the plot and depth were combined to produce cross-sectional contours of soil cone indices using the method of Busscher et al. (1986).

We analyzed data using ANOVA in SAS (SAS Institute, 1990) and the least square mean separation procedure. Cone index data were analyzed using a split-split-plot randomized complete block design. The first split was on position across the row and the second on depth. The 5% level of significance was used

RESULTS

General

Wheat was planted three times and soybean three times. Cone index data were not taken at the beginning of the first wheat planting because timing of tillage for wheat or soybean or both had to be established. For the following, spring refers to operations done in association with soybean, fall refers to wheat, and season refers to both.

Cone index

Over the course of the experiment, mean profile soil cone indices were 0.6 atm higher for disked than for nonn-disked treatments (Table 1). On a season by season basis, only the spring 1994 and spring 1996 readings had higher cone indices for the disked than non-disked treatments. For the other data sets these readings were not significantly different. Water contents might account for the differences in strength because wetter soils have lower cone indices, all other things being equal. However, water contents for the disked (11.8% on a dry weight basis) and non-disked (12%) treatments were not significantly different. Water content differences within season (data not shown) were also not significant.

Cone indices for the different seasons were significantly different, with spring having higher values than fall (Table 1). These values were in approximately the reverse order of the water contents (fall 1994 at 13.1%, fall 1995 at 12.4%, spring 1995 at 12.3%, spring 19% at 11.8%, and spring 1994 at 9.9%, with an LSD of 0.2%). Differences could be at least partly due to the water content at the time of measurement.

Generally, the more recent or more frequently deep-tilled treatment had the lower cone index (Table 2). Over the course of the experiment, the treatment that was paratilled at the beginning of both seasons had the lowest soil strength. It had cone indices as low as the fall tillage in fall and the spring tillage in spring. Except for fall 1995, it did not have cone indices lower than the most recently tilled treatments. If treatment analyses were altered to look at more recent and less recent tillage instead of fall and spring, the treatment with no deep tillage had a mean cone index of 17.1 atm. The treatment with last season's deep tillage had a mean cone index of 12.8 aim. The more recently tilled treatment had a mean cone index of 9.8 atm. The treatment tilled both seasons had a mean cone index of 9.24 atm (LSD = 0.78 atm at 5% level). For this analysis, water contents were not significantly different and were not a complicating factor. Cone indices followed the order tilled in both seasons =

more recent tillage <last season's tillage <no tillage.

Averaged over all treatments, cone index increased with depth, with each 2-in-depth interval having a higher cone index than the one above it, through the top 22 in. However, when treatments with no deep tillage were analyzed done, the zone of highest strength was at the 8- to 12-in depth. This was the hardpan that was the reason for deep tillage in the first place. Cone indices in this pan were 29 to 31 atm, 4 atm higher than the zones immediately above and below it (Fig. 1).

Cone indices varied significantly with position across the row. For all treatments, cone indices were higher by an average of 1.4 atm below the wheel-track (position=30 in, Fig. 1) than the non-wheel-track (position=0 in). Differences among positions were more significant for the deep-tilled treatments than the non-deep-tilled treatments.

The surface tillage x depth interaction was significant for both the wheat and soybean planting. This was a result of disking. The top 4 in of the disked treatment had a lower cone index than the non-disked treatment because of the disruption of the disk. Below that, the disked treatment had higher cone indices. This can be seen in Fig. 1 by a tillage pan near the surface of the treatment with no deep tillage. There was no pan contours are further apart) for the non-disked treatments with no deep tillage (data not shown).

Yield

Generally, yield decreased with an increase in cone index. No significant relationship could be found when data from all seasons were analyzed together. However, when we analyzed data on a season-by-season basis, we found a decrease of yield with an increase of mean profile cone index, with r^2 ranging between 0.52 and 0.84 (Fig. 2). Within the range of cone indices measured and based on the slopes of these linear regressions, yields were reduced 2.6 and 2.3 bu/a for every atmosphere increase in mean profile strength for wheat in 1994 and 1995, respectively, and 2.3, 1.6, and 2.7 bu/a for soybean in 1994, 1995, and 1996, respectively.

CONCLUSIONS

Plots that were disked had a pan just below the disked zone. The pan was broken up during deep tillage. The lowest cone indices were recorded for the treatments that were tilled most recently.

Yields were correlated with mean profile cone indices. Reductions in wheat yield were about 2.5 bu/a for each atmosphere of increased mean profile cone index within the range of soil strengths measured here. For soybean, the decrease in yield ranged between 1.6 and 2.7 bu/a.

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Table 1. **Mean surface tillage profile cone indices averaged over four treatments and four replicates.**			
Season	Surface tillage treatment		
	Disked	Non-disked	Mean
	----- Atm -----		
Spring 1994	15.1a*	13.9b	14.5a**
Fall 1994	11.0a	10.3a	10.6e
Spring 1995	12.6a	12.4a	12.5b
Fall 1995	11.0a	11.0a	11.0d
Spring 1996	12.0a	10.6b	11.3c
Mean	12.2a	11.6b	

Table 2. Mean treatment profile cone indices averaged over four replicates each of disked and non-disked plots.

Season	Timing of tillage			
	Both	Spring	Fall	None
	----- Atm -----			
spring 1994	10.9c*	11.3c	16.8b	21.0a
Fall 1994	9.1b	9.5b	9.9b	14.7a
spring 1995	8.9c	8.7c	15.4b	20.0a
Fall 1995	84d	11.8b	9.9c	14.8a
Spring 1996	9.0c	9.3c	11.8b	16.1a
Mean	9.2d	10.0c	12.5b	17.1a

* Means within rows with the same letter are not significantly different by the LSD test at 5%.

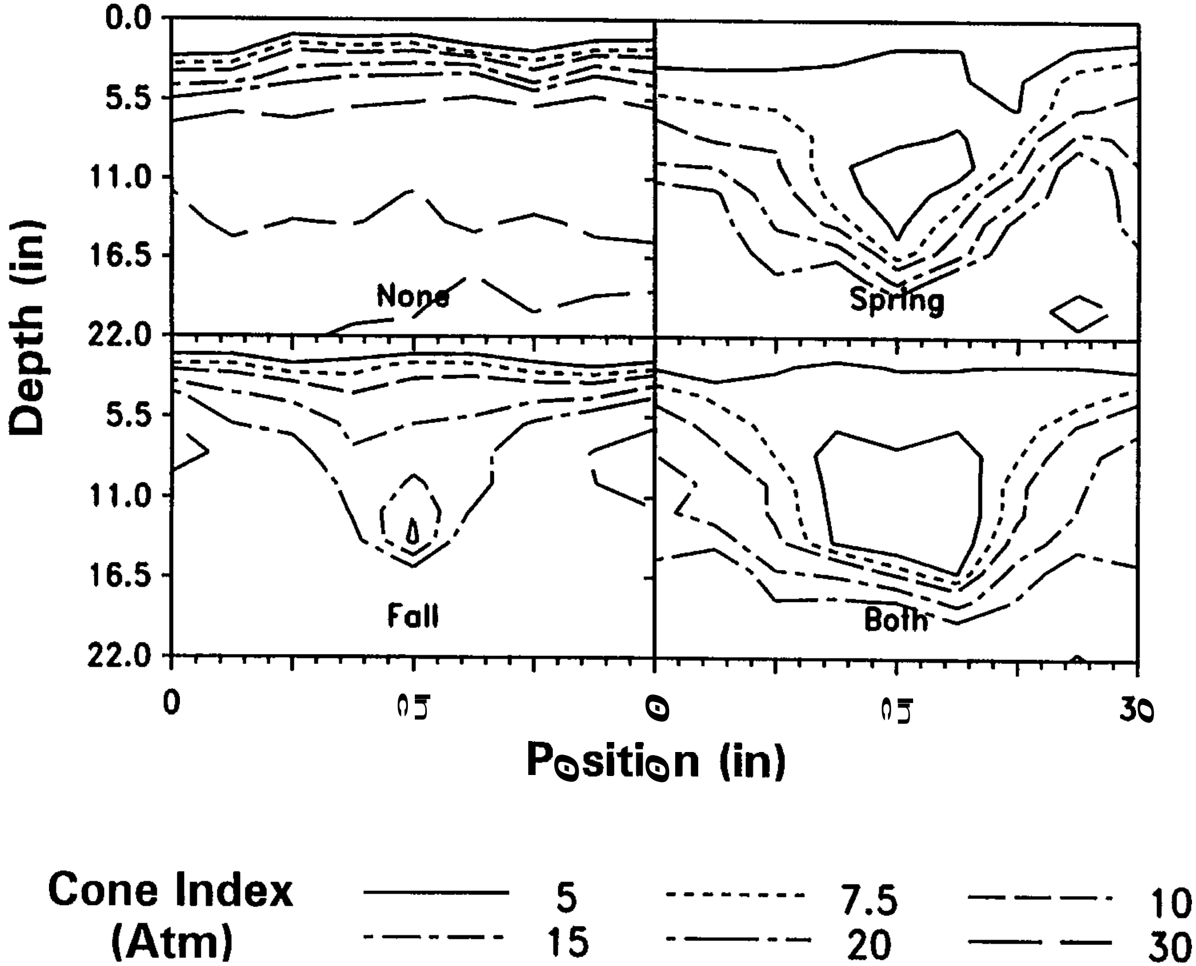

Figure 1. Soil strength contours for the spring 1995 soybean planting disked. The time of deep tillage is listed as none, spring, fall or both (spring and fall).

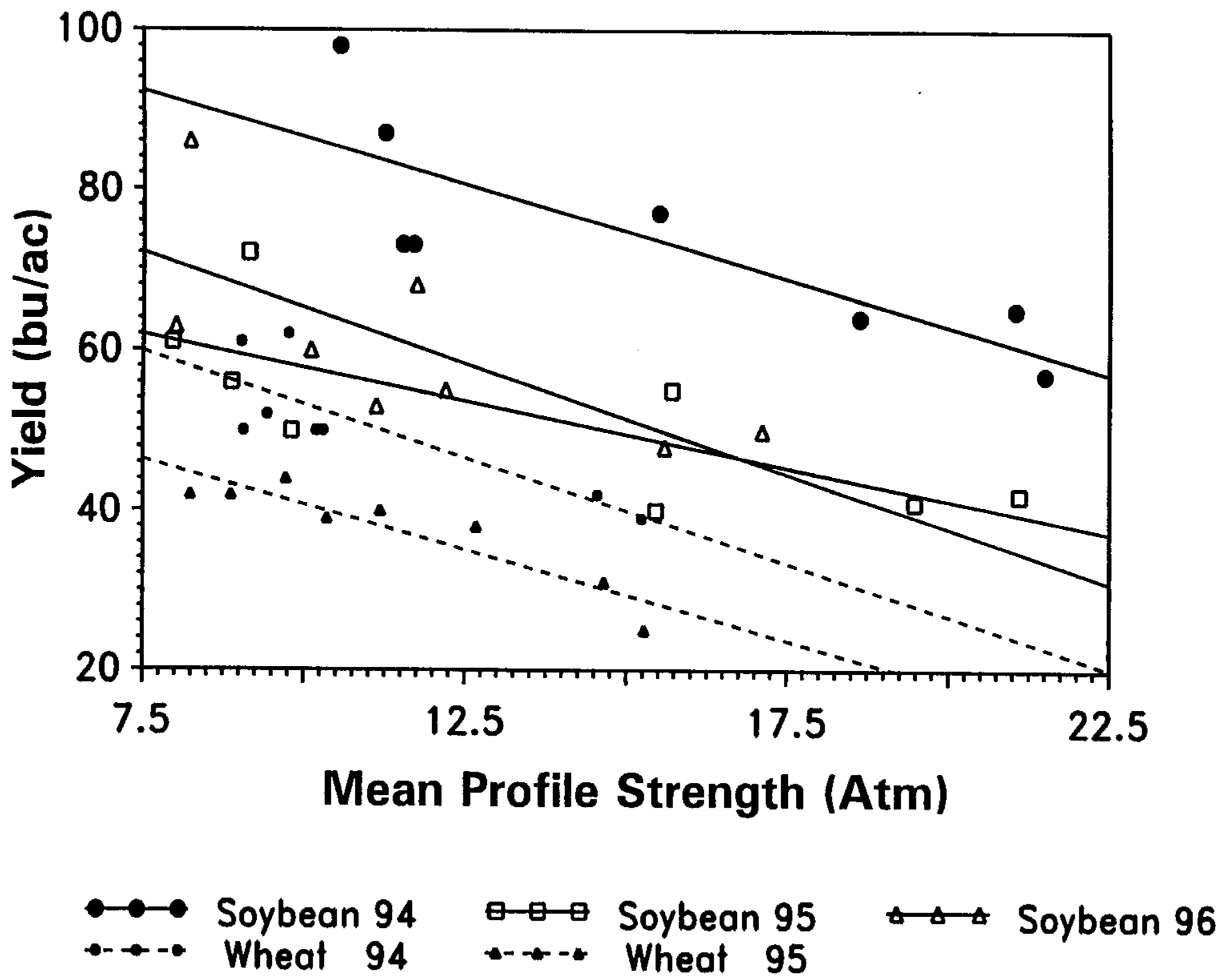

Figure 2. Yield variation with cone index analyzed ∞ a season-by-season basis.

An Economic and Agronomic Evaluation of Selected Wheat Planting Methods in Arkansas

*T.C. Keisling, C.R Dillon, M.D. Oxner, and P.A. Counce

ABSTRACT

The four most commonly used methods of seeding wheat *(Triticum aestivum)* in the lower Mississippi River Valley are conventionally drilled into prepared seedbed (DP), broadcast incorporated (BI), drilled no-till (DN), and broadcast unincorporated (BU). The objective of this study was to determine the effects of the above wheat seeding methods on net returns, yields, yield components, and stand establishment. Experiments were conducted at four locations over a period from 1992 to 1995. Grain yields were adjusted to a constant 13 % moisture content. Yield components of culms per plant, kernels per spike, and kernel weight were analyzed. Percent residue measurements were taken to characterize the effects of residue on stand. An enterprise budget technique was used to estimate expenses associated with each production strategy. BI and DP yields were rather similar and were higher to those of the other two alternatives. No-till and broadcast unincorporated resulted in about a 17% and 24% reduction in yield compared to BI, respectively. DN, while yielding slightly less than DP and BI, also had more stable yields than DP or BU. Thus, BU displays characteristics of a high-risk planting method. Net returns ranged from -$31.31 to $84.18/a. BI had the highest average net returns followed by DP. Moreover, results were mixed with DP, BI, and BU, each being the most profitable in two of six experiments. DP was consistently the most profitable at one site while BI was otherwise most profitable in 1993-1994 and BU in1994-1995. The economics of production indicates that total expenses are similar for DP, DN, and BI except for varied seeding rates. Therefore, yield is directly proportional to net returns in those cases.

INTRODUCTION

In 1994, there were 880,000 a of wheat *(Triticum aestivum* L.) harvested in Arkansas with a value of over $129.5 million at the farm level (Anon., 1994a). Wheat accounted for about 11% of the 1994 harvested acreage in Arkansas. Its importance as a field crop is evidenced by its fifth rank in terms of harvested acreage and value of production. Management is an important factor in wheat production (Beurlin et al., 1991(. Arkansas farmers are constantly searching for more efficient and profitable wheat production practices.

The four most commonly used methods of seeding wheat in the lower Mississippi River Valley are conventionally drilled into prepared seedbed (DP), broadcast incorporated (BI), drilled no-till (DN), and broadcast unincorporated (BU). Wheat is typically conventionally drilled into a prepared seedbed (DP). This method is the most time-consuming because of the number and nature of required field operations. BI has recently increased in popularity as a planting method because it requires less time than DP since seed is usually mixed and spread with fertilizer. Another planting method that is gaining popularity is DN. This practice is thought to be relatively fast because no mechanical seedbed preparation is involved. BU is the least popular wheat planting method. This method is typically implemented through the use of an airplane. BU requires the least time and equipment of the four methods. Although farmers have sporadically used BU for many years, they have usually discontinued the practice after only one or two crops because of inconsistent stand establishment and yields.

The planting method with the greatest expected net returns or yield is not always the method a farmer uses. Each planting method may have certain advantages in various situations. For example, if the window for planting wheat is narrowing, a producer may choose to finish planting the wheat by BU because of the speed at which the method is performed in terms of acres planted per day. Generally, Arkansas farmers will choose between DP and BI. DP is also the most precise method of planting because of accurate seed placement and metering. BI wheat is widely used because of reduced labor, number of field trips, planting speed, and timeliness of completing the planting operation.

Previous research has demonstrated the benefits of BI seeding including improved labor distribution, timeliness and reduced labor requirements (Collins and

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[1]T.C. Keisling, [2]C.R. Dillon, [2]M.D. Oxner, and 1P.A. Counce[1] Agronomy Dept., University of Arkansas at Northeast Research and Extension Center, Keiser, AR. and [2]Agricultural Economics Dept., University of Arkansas, Fayetteville, AR. Manuscript received 10 April 1997. *Corresponding author.

Fowler, 1992). Nonetheless, poor stand establishment has been the primary problem associated with BI seeding of wheat in research studies in Canada (Collins and Fowler, 1992; Barnett and Comeau, 1980) and in Germany (Heymann and Bemhardt, 1973). While Shah et al. (1994) examined the effects of many alternative production practices on wheat yield and yield components, the tillage and planting methods have focused on factors influencing morphological development and anatomical features of wheat (e.g - Huang and Taylor, 1993) and the impact of management on soft red winter wheat production (e.g. - Beuerlein et al., 1991) while soil science studies have investigated infiltration characteristics of different tillage methods (Christensen et al., 1994). Economic analysis of alternative tillage techniques on wheat production has provided mixed results. A 10-yr Oklahoma study of six tillage methods indicated a disk system had the greatest net returns while no-till was the least economical method (Epplin et al., 1994). Comparison across planting dates for two Oklahoma counties also provides evidence of the economic desirability of conventional tillage over no-till (Epplin et al., 1991). Reduced tillage has been shown to outperform either conventional tillage or no-till methods on Colorado winter wheat (Halvorson et al., 1994). Whole farm analysis for Texas High Plains wheat, corn *(Zea mays* L.) and grain sorghum *(Sorghum bicolor* [L.] Moench) production did indicate some no-till wheat production would maximize profits, especially under irrigated conditions; sensitivity analysis results display a greater proportion of conventional tillage to no-till for the dryland wheat acreage (Harman et al., 1985).

The objective of this study was to determine the effects of the above alternative wheat seeding methods on net returns, yields, yield components, and stand establishment. The ultimate purpose of this study is to provide information useful for wheat production management decisions.

MATERIALS AND METHODS

This research study entails both an agronomic and an economic component. A discussion of agronomic materials and methods including general factors, planting, harvesting, yield components and crop stand issues is followed by a discussion of the economic analytical techniques employed.

Agronomic

General

Experiments were conducted at four locations in Arkansas over a period from the fall of 1992 to the summer of 1995 (Table 1) on planting methods for soft red winter wheat. Agronomic factors such as planting date, seeding rate, stand sampling date, wheat seed variety, fertilization rate, fertilization, and harvest information are included in Table 2. Soybeans *(Glycine max* [L.] Merr.) were the crop grown prior to wheat for all experiments.

Planting

The four methods of planting employed were: 1) broadcast incorporated (BI), 2) drilled into a prepared seedbed (DP), 3) drilled into a no-till seedbed (DN), and 4) broadcast unincorporated over undisturbed soil (BU). The various seeding applications are outlined in Table 2. Specific techniques for implementing each treatment are given in Table 3. Preparation of seedbeds consisted of disking followed by a do-all operation to smooth the seedbed and to incorporate seeds in the broadcast incorporated treatment. Where the disk was used a tandem disk was operated at a depth of three to five in. at five to six miles p a hr. This disk was equipped with disk blades on 9-in. spacing. The following do-all operation pulverized clods, and in the same motion, mixed the soil in the top 2-in. of the seedbed while smoothing it out. The drill mechanically placed seeds one to two in. deep and pressed the soil firmly around the seeds. Two large scale farm experiments were done to check the validity of plot simulations for commercial equipment. In these experiments, commercial fertilizer applicators were used to broadcast the seed (Table 1). A ground-driven, twin spinner, fertilizer distributor, commonly called a "fertilizer buggy" and loaned by fertilizer dealers to growers, was used in one test. The other test used a truck equipped with ground radar and a pneumatic delivery system through individual, evenly spaced tubes, commonly called an "air flow" truck, for BI and an airplane for BU.

Weed Control

Herbicide treatments followed Arkansas Cooperative Extension Service recommendations. Weed pressures tended to be the same across wheat planting methods at a given location and year. As a result, the herbicide applied was the same for all planting methods at a location and year. Consequently, Harmony was applied at 0.5 oz at the Marianna CBES in both 1993 and 1994. At the Keiser NEREC (1994 and 1995) and the Keiser farm field, 1.5 pt of 2,4-D was applied. The Marianna farm field required no herbicide.

Harvesting

A swath from the center of each plot was harvested. The swath width is indicated in Table 2. A commercial combine was used on the farm fields. The Cotton Branch Experiment Station (CBES) and Northeast Research and Extension Center (NEREC) tests were harvested using a plot combine.

The wheat grain moisture contents were determined either by an individual plot sample or by composites from each treatment. Grain yields were adjusted to a constant 13 % moisture content. Dockage from foreign material was determined from the experiment harvested by a commercial combine.

Yield Components

Yield components of culms per plan< kernels per spike, and kemel weight were determined. Plants for analysis were selected by randomly locating a site in each plot A straight line was then made from the site, and the first 10 plants (20 plants for NEREC 1994-95) intersected by the line were subsequently analyzed. Culms were determined by visual inspection. Grain from all plants was combined and weighed. A 10-g (0.35 oz) subsample was counted to determine seed weight and for calculating seed per culm. Other details are shown in Table 3.

Crop Stand Versus Percent Residue Cover

During the course of the study, the stand was noted to be critical in determining yield. Percent residue measurements were taken to characterize the effects of residue on stand. Measurements were made to determine the percent cover of residue on broadcast unincorporated treatments at the Keiser farm field. The percent residue cover was determined with the standard Soil Conservation Service method using a 25-ft rope (Soil Survey Staff, 1992). The associated stand of wheat was determined at each residue check point using a one inch by two inch rectangle centered on the residue check point The long axis was perpendicular to the row. The 25 measurements so obtained were summed and then converted to plants per acre. Data was summarized by averaging all data within 2.5% residue cover intervals. Both percent ground cover and stand were averaged to give a single data point for the above intervals.

Economic

An enterprise budget method was used to estimate expenses associated with each production strategy. Managers of farm businesses frequently must estimate costs and returns. In some cases, it may be necessary to estimate costs and returns for one part of the business (Boehlje and Eidman, 1984). An enterprise budget was used rather than a whole farm budget because the study consisted only of wheat production. The Mississippi State Budget Generator (MSBG) computer program (Spurlock, 1992) was used to compile economic information from the four different planting strategies. Gross income was calculated by multiplying total yield by the 1985-1994 seasonal price average of $3.12/bu (Anon., 1994a). Total costs are a sum of the direct and fixed costs. Direct costs included seed, fertilizer, fuel, and herbicides. Also included in direct costs are custom work, labor, repairs, and maintenance, and interest on operating capital. Diesel fuel, operator labor, and repairs and maintenance requirements are presented in Table 5. Custom work included, as relevant, charges for applications of herbicide and fertilizer as well as custom hauling. Input prices are from Arkansas enterprise budgets (Anon., 1994b). Fixed costs included cost of depreciation, taxes, insurance, and interest on capital investment for equipment. Expenses were generated by MSBG and reflect the actual cost for each of the individual treatments.

RESULTS AND DISCUSSION

Yield

Yield results are presented in Table 5. The analysis of variance indicated a complex relation between seedbed and location as well as seedbed and year (both at the 5 % level). The year effect can be observed from the Marianna data (CBES, experiments 1 and 2) and Keiser data (NEREC, experiments 3 and 4) noting that the relative order of treatment effect does not remain the same from year to year. Yields resulting from planting methods, year and locale were aggregated over the composite data, and the overall mean was analyzed to provide insights to yield level expectations. The broadcast incorporated and conventionally drilled yields were equivalent and were superior to those of the other two tests. No-till and broadcast unincorporated resulted in about a 17% and 24% reduction in yield, respectively.

Yield Components

Selected yield component results are shown in Tables 4 and 5. Yield components such as plants/a, culms/plant, kernels/culm and kernel weight are included in these tables. Stand varied dramatically according to the different planting methods employed and varied more so than any other yield component analyzed. In most instances where there was a significant stand reduction, yield was directly affected. The culms per plant at harvest were the same across a given year throughout the different planting methods except for two experiments. Kernels/culm and weight/kernel observations are consistent across all planting methods in a given year at a given location strengthening the observation that the primary yield component to affect yield is stand. In the BU, increasing surface residue from the previous crop resulted in increased stands (Figure 1). The seeds that were lodged against surface residue survived whereas the unprotected seeds either had erratic emergence and were subsequently desiccated or eaten by pests. As a result, it *can* be hypothesized that increasing crop residue to 25% ground cover may be more important than increasing seeding rate for improving stand under the BU method. Increasing the seeding rate of the DN would probably improve the stand, but there was also a yield loss resulting from fewer kernels per culm that still would not be overcome. It has been observed (Cartwright, 1996a; 1996b) that wheat is more susceptible to freeze damage in no-till situations due to planting the wheat too shallow or planting in a seedbed with excessively thick (1 in. to 2 in.) residue.

Economic Analysis

Results for estimated expenses are shown in Table 7. Direct expenses varied from one planting strategy to another due to different levels of custom application work, field operations and seeding rates. Average direct expenses per acre across experiments ranged from a high of $76.81 for BI to a low of $72.33 for DN. The labor required at planting time for each planting method is given in hr/a **as** follows: BI, 0.15 hr/a; DP, 0.30 hr/a DN, 0.37 hr/a and BU, 0 hr/a. BU requires no labor at planting because the procedure is custom hired DN had the highest labor requirements because of the use of a narrow width drill whose operating speed is required to be 4.1 mph or less. DP required about 20% less labor than DN while BI required about 60% less labor than DN.

Fixed costs will be greater on the enterprise which requires the higher capital expenditures and are therefore afunction of the machinery complement required. This machinery complement included a 25-ft combine for all systems, 200 HP tractor (DP, BI, DN), 32-ft light cut disk (DP, BI), triple K (DP, BI), conventional grain drill (DP) and no-till drill (DN), depending on the wheat planting method. As for the fixed *costs* associated with all the planting methods, DP and DN fixed *costs* were about the same at about $14.40/a. BI was the third highest at $11.78/afollowed by BU at $7.1/a. Fixed expense reduction was due to the reduction in use of equipment at planting time; BU takes the fewest hips across the field with the farmer's personal equipment.

Expected total expenses per acre for all methods varied from a low of $80.43 to a high of $88.36, a range of only $7.93. Total expenses for BU are the lowest of all four planting methods except when seeding rate is altered (the fifth experiment).

Gross income is a direct function of yield. The total income varied from a high of $179.09 to a low of $60.53 (Table 8). On average, total income results from highest to lowest strategies are BI, DP, DN, and BU for all locations and years with total income paralleling mean yield results.

Net returns to land, risk, overhead labor and management ranged from -$31.31 to $84.18/a. BI had the highest average net returns followed by DP. Moreover, results were mixed with DP, BI, and BU each being the most profitable in two of six experiments DP was most profitable at CBES while BI was otherwise profitable in 1993-1994 and BU in 1994-1995. DN had about half the net returns of BI on average. BU experienced a loss two out of six times and had net returns about **35%** of those for BI.

CONCLUSIONS

Agronomically, the yield of wheat grown with DN or BU methods varies considerably across years. There is a stand loss with both systems. The stand loss from BU is related to crop residue on the soil surface and probably cannot be improved by increasing the seeding rate. The DN stand probably could be improved by increasing seed rate; however, the smaller number of kernels per culm would still reduce yields of both DN and BU. The economics of production indicates that total expenses are similar for DP, DN, and BI except for varied seeding rates. Therefore, yield is directly proportional to net returns in those cases. DP and BI yields seemed similar and were consistently the highest. DN, while yielding slightly less than DP and BI, also had more stable yields than DP or BU. Yields for BU were erratic. The yields ranged from being equivalent to the best for some locations and years, to being as low as 44% of the best. Thus, BU displays characteristics of a high-risk planting method.

From a whole farm management standpoint, a farmer will choose the method which best utilizes available labor and equipment for maximizing net returns. Typically during the window for planting wheat, labor and equipment are primarily being utilized for harvest of other crops. During this time, a shortage of labor and equipment often exists. Consequently, a farmer may choose BI because of the speed at which the crop *can* be planted Without sacrificing net returns. If time and equipment are not a constraining factor, a farmer may choose DP and still expect the same net return as if choosing BI. However, the competition for labor during this wheat planting window suggests that further analysis under a whole farm framework would be appropriate.

If conditions become worse (usually due to prolonged rains) and the planting window narrows, a farmer may be forced to use the more risky BU and chance sacrificing yield to get crops planted. The farmer may also choose this method if there is no equipment available to plant the crop.

For crop production in row crops, labor savings as well as speed of operation are usually considered benefits of no-till. The results of this study show that no-till drilling of wheat requires more labor, money, and time than any other planting method. The reasons for this are the equipment size and cost combined with operating speed. BU, the other no-till planting method, had the highest direct cost mainly because of the money spent for custom planting. Thus, BU displays some tendency of greater risk than other planting methods.

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Table 1 . Experimental Loeation and Soil Series for Each Site

		Location		
Experiment'	Year	Nearest Town	Field Description	Soil Series
1	1992-93	Marianna'	CBES'	Calloway-Loring-Hemy silt loam
2	1993-94	Marianna'	CBES	Calloway-Loring-Hemy silt loam
3	1993-94	Keiser'	NEREC[§]	Sharkey silty clay
4	1994-95	Keiser'	NEREC	Sharkey silty clay
5	1993-94	Marianna	Farm field	Newellton silty clay
6	1994-95	Keiser	Farm field	Sharkey silty clay and Steel loamy sand

'The above experiments were performed in the following locations: 1) 1992-93 CBES; 2) 1993-94 CBES; 3) 1993-94 NEREC; 4) 1994-95 NEREC; 5) 1993-94 Oxner Farm; and 6) 1994-95 Goble Farm. Wheat followed soybeans in all cases

'Plots were at the same location in consecutive years.

[§]CBES refers to the Cotton Branch Experiment Station and NEREC refers to the Northeast Research and Extension Center.

Table 2. Agronomic Factors for All Experiments

	Planting			Fertilizer		Plot		Stand
Experiment[†]	Date	Variety[‡]	Rate (lb/a)	Date	Amount (lb/a)	L.x W. (ft. x ft.)	Harvest Swath (ft.)	Date Counted
1	11/16/92	Cardinal	90	2/23/93	100-0-0[§]	12.7*100	5	---
2	11/9/93	Cardinal	90	2/28/94	100-0-0	12.7*100	5	3/11/94
3	10/7/93	Madison	90	2/28/94	60-0-0	12.7*100	5	3/16/94
				3/22/94	60-0-0			
4	11/5/94	Madison	90	4/17/95	75-0-0	12.7*100	5	---
5	10/7/93	Cardinal	90 to 180[¶]	2/25/95	46-0-0	60*420	26	6/18/94
				3/10/95	46-0-0			
6	11/16/94	Madison	90	2/25/95	46-0-0	38*1142	20.42	11/21/94
				3/10/95	46-0-0			

[†]The above experiments were performed in the following locations: 1) 1992-93 Cotton Branch Experiment Station; 2) 1993-94 Cotton Branch Experiment Station; 3) 1993-94 Northeast Research and Extension Center; 4) 1994-95 Northeast Research and Extension Center; 5) 1993-94 Oxner Farm; and 6) 1994-95 Goble Farm.

[‡]Soft red winter wheat.

[§]$N-P_2O_5-K_2O$.

[#]Dates not recorded, estimates used are given.

[¶]Varied according to the recommendations of the Delta Agricultural Digest (1994). Drilled seeded in a prepared seedbed was at 90 lbs./a, drilled into a no-till seedbed was at 90 lbs./a, and broadcast incorporated and broadcast unincorporated was at 180 lb/a.

Table 3. Methods of Seeding and How Accomplished in Each Experiment

	Seeding Methods			
Methods of planting	Marianna (CBES)	Marianna (farm field)	Keiser (farm field)	Keiser (NEREC)
DP (i.e. drilled into prepared seedbed)	conventional grain drill	JD750 no-till drill	JD750 no-till drill	JD750 no-till drill
DN (i.e. drilled into no-till seedbed)	conventional grain drill	JD750 no-till drill	JD750 no-till drill	JD750 no-till drill
BI (i.e. broadcast incorporated)	simulated' airflow	fertilizer buggy	airflow	simulated' airflow
BU (i.e. broadcast unincorporated)	simulated' airplane	simulated' airplane	airplane	simulated' airplane

'Simulated by driving across **the** plots with grain drill raised sufficiently to meter seeds without **the** openers touching the soil.

‡Simulated by driving across the plots with a fertilizer buggy.

Note: These treatments were simulated either because it was impractical to have plots large enough to accomodate the swath width of fertilizer buggies (25 ft.), air flow trucks (60 **ft.**) **or** air planes (60 **ft.**) *or* the characteristics related to their operation. These implements have characteristic application patterns that have been document many times and usually if set and operated proplery have a coefficient of uniformity greater than 85%. The manner in which we simulated these implements placed the *seed* on **the** soil surface with a uniformity coefficient that would exceed 90%. This same procedure or similiar simulations has been used for decades in soil testing 7 research. The authors **feel** that these procedures were close enough to mimicking **the** implements actually used that methods would give the **same** results.

Table 4. Diesel, Operator Labor and Repairs and Maintenance Requirements

	Drilled		Broadcast	
Input	Prepared Seedbed	No-till Seedbed	Incorporated	Unincorporated
Diesel (gal/a)	4.1757	3.8193	3.3177	1.7469
Operator Labor (hrs/a)	0.4352	0.5040	0.2857	0.1429
Repairs and Maintenance (%/a)	5.49	5.47	4.01	2.18

Table 5. Yield and Plant Density for Selected Experiments

	Drilled		Broadcast	
Exp No.[†]	Prepared Seedbed	No-till Seedbed	Incorporated	Unincorporated
		Yield (bu/a)		
1	37 6a[‡]	24.9b	34.5a	19.4c
2	54 9a	43.4ab	44.8ab	37.1b
3	18 2a	18.9a	22.8a	10.0b
4	26 2a	26.8a	37.5a	37.7a
5	46 9a	31.5b	42.2a	29.8b
6	32 7a	34.6a	33.0a	35.6a
Mean	34.8a	29.0b	35.1a	26.8b
		Relative percent of maximum yield		
Mean	99	83	100	76
		Plant density (plants/a * 0.001)		
1	---	---	---	---
2	232a	211a	200a	127b
3'	334b	345b	526a	171c
4	784a	632c	697b	610c
5[§]	1071a	1059a	1061a	747b
6[¶]	76a	72a	81a	80a

Note: Numbers in **same** row followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test. [†]The above experiments were performed in the following locations: 1) 1992-93 CBES; 2) 1993-94 CBES; 3) 1993-94 NEREC; 4) 1994-95 NEREC; 5) 1993-94 Oxner Farm; and 6) 1994-95 Goble Farm. [‡]Plants may have had culms at **counting** time. [§]Heads per a, not individual plants. 'Stand was taken prior to culming negating comparisons to other experiments.

Table 6. Yield Components (Culms and Kernels) From all Locations and All Years

	Drilled		Broadcast	
Exp. No.[†]	Prepared seedbed	No-till Seedbed	Incorporated	Unincorporated
	Culms/plant at harvest			
1	---	---	---	---
2	3.7a	4.6a	4.3a	3.7a
3	4.5b	6.7a	4.9ab	5.5ab
4	6.9a	7.5a	6.5a	6.7a
5	3.6a	2.1a	2.3a	2.3a
6	4.1a	3.2b	3.9a	4.1a
Mean	5.1a	5.9a	5.3a	4.9a
	Kernels/culm			
	---	---	---	---
2	31.9a	28.8a	35.9a	29.5a
3	18.0a	22.8a	25.1a	21.7a
4	15.7a	13.7a	13.1a	15.5a
5	21.9a	14.5a	19.5a	20.2a
6	21.3a	13.8b	20.0a	18.2ab
Mean	24.9ab	20.3c	25.3a	21.9c

Note: Numbers in same row followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range **test.**

[†]The above experiments were performed in the following locations: 1) 1992-93 CBES; 2) 1993-94 CBES; 3) 1993-94 NEREC; **4)** 1994-95 NEREC; 5) 1993-94 Oxner Farm; and ***6)*** 1994-95 Goble Farm.

Table 7. Total Expenses (TEXP), Fixed Expenses (FEXP), and Direct Expenses (DEXP) in Dollars per Acre for Various Wheat Planting Methods

	Drill						Broadcast					
	Prepared seedbed			No-till seedbed			Incorporated			Unincorporated		
Exp. No.'	TEXP	FEXP	DEXP‡	TEXP	FEXP	DEXP	TEXP	FEXP	DEXP	TEXP	FEXP	DEXP
1	97.18	14.39	77.39	89.91	14.41	75.50	90.41	11.28	79.12	79.29	7.61	71.68
2	94.90	14.39	80.51	92.93	14.41	78.52	90.85	11.28	79.56	82.20	7.61	74.58
3	96.94	14.39	82.55	97.32	14.41	82.91	96.24	11.28	84.95	94.65	7.61	87.04
4	77.48	14.39	63.09	77.70	14.41	63.29	77.04	11.28	65.76	69.64	7.61	62.03
5	78.24	14.39	63.85	76.70	14.41	62.29	90.69	11.28	79.40	80.52	7.61	72.91
6	85.44	14.39	71.05	85.88	14.41	71.47	83.32	11.28	72.04	76.26	7.61	68.65
Mean	88.36	14.39	73.07	86.74	14.41	72.33	88.09	11.28	76.81	80.43	7.61	72.82

'The above experiments were performed in the following locations: 1) 1992-93 Cotton Branch Experiment Station; 2) 1993-94 Cotton Branch Experiment Station; 3) 1993-94 Northeast Research and Extension Center; 4) 1994-95 Northeast Research and Extension Center; 5) 1993-94 Oxner Farm; and 6) 1994-95 Goble Farm.

‡Direct expense includes labor charges of $2.72, $3.11, $1.85, and $1.03 for drilled into a prepared seedbed, no-till drilled, Broadcast incorporated, and broadcast unincorporated, respectively.

Table 8. Total Income (TINC) and Net Returns (NRET)[†] for Various Wheat Planting Methods in Dollars per Acre

	Drill				Broadcast			
	Prepared seedbed		No-till seedbed		Incorporated		Unincorporated	
Exp. No.[†]	TINC	NRET	TINC	NRET	TINC	NRET	TINC	NRET
1	117.31	25.53	77.69	-12.22	107.64	17.23	60.53	-18.77
2	179.09	84.18	137.59	44.66	141.96	51.11	117.94	35.74
3	115.13	18.19	120.12	22.80	144.46	48.22	63.34	-31.31
4	82.06	4.58	83.93	6.23	116.69	39.64	117.62	47.99
5	131.66	53.42	98.59	21.89	146.64	55.95	92.98	12.45
6	101.71	16.27	107.95	22.07	102.96	19.64	110.76	34.50
Mean	121.16	33.70	104.31	17.57	126.73	38.63	93.86	13.43

[†]Net returns are calculated as total income less total specified expenses and represent net returns to land, **risk,** overhead labor and management.
'The above experiments were performed in the following locations: 1) 1992-93 Cotton Branch Experiment Station; 2) 1993-94 Cotton Branch Experiment Station; 3) 1993-94 Northeast Research and Extension Center; 4) 1994-95 Northeast Research and Extension Center; 5) 1993-94 Oxner Farm; and 6) 1994-95 Goble Farm.

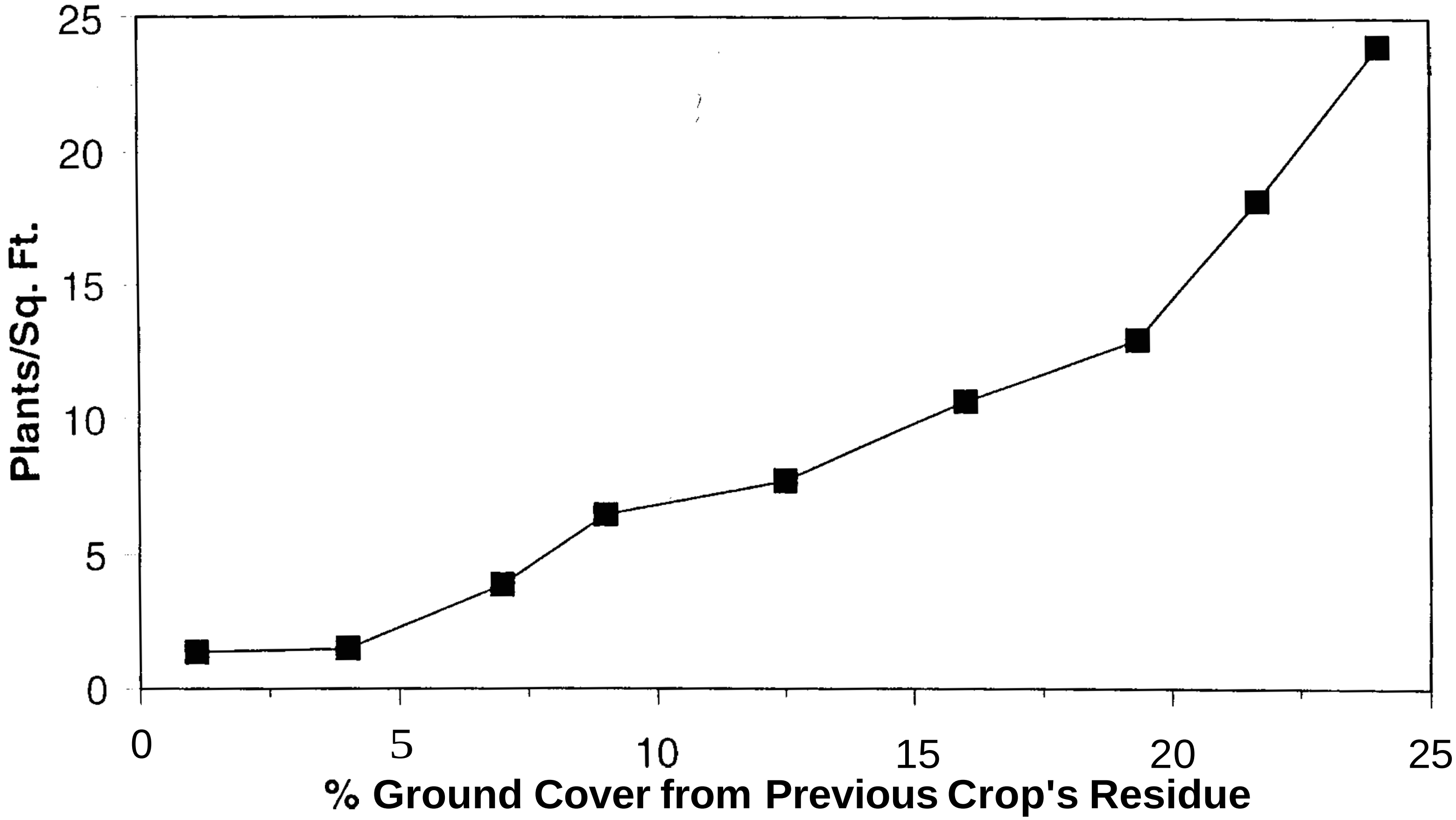

Fig. 1. Plant establishment as related to percent of cover from the previously grown crops.

Establishing the Value of the Phosphorus and Potassium Contained in Poultry Litter for a No-Till Corn and Soybean Rotation

J. H. Grove

INTRODUCTION

With the growth of the poultry industry in Kentucky, more litter/waste has become available to our grain producers. The poultry litter is a source of nutrients, especially N, P, and K. It is also a source of organic matter, which can be. beneficial in other ways (increased soil water holding capacity, formation and maintenance of good soil structure). Much of the plant nutrition contained in poultry litter is in the organic fraction of the waste. Nutrients contained in organic compounds must first be mineralized before they are made available, resulting in slower release of these nutrients.

The nutritional value of one ton of poultry litter can vary considerably. If one assumes a typical moisture content of 40%, and that the remaining dry material averages 3% N, 2% P, and 3% K, then that ton of litter is worth about $24 at today's fertilizer prices. About $10 of that value is in the N. Another large part of that value, $9, is in the P content If all the P and K contained in that ton of litter were available in the first year of application, then the P and K removed by the harvest of 160 bu of corn *(Zea mays* L.) grain could be provided by that ton of litter.

It is unlikely, however, that all the nutrients contained in the litter will be available in the fust year. And though the question of N residuality from poultry waste applications has been well examined, the issue of P and K residuality has not. This is particularly true for no-tillage production systems where the litter will lie on the soil surface. Will fertilizer P and K still be needed to get no-till corn and soybean *(Glycine max* [L.] Merr.) off to a good start albeit at reduced rates, when litter has been applied? How long will litter derived P and K continue to be made available? The lack of incorporation in no-tillage limits nutrient fixation deeper in the soil, but may also slow microbial mineralization of both N and P. How long will it take the grain producer to recover that $24 value in nutrients?

Phosphorus may be of particular importance, as some states use P loading in setting waste loading rate standards. Nutrient management plans will need to be developed and soil testing will be an important part of those plans. How/when will soil test values reflect litter nutrient additions to the surface of no-till soils? Will the test's predictive relationship of the soil's ability to supply P (and K) be changed, and if so, how?

J. H. Grove, Department of Agronomy, University of Kentucky, Lexington, KY. Manuscript received 10 April 1997.

MATERIALS AND METHODS

To answer the questions posed above, a field experiment of common design was conducted at each of two locations. The first site was on a Pope silt loam (coarse-loamy, *mixed,* mesic Fluventic Dystrochrept) and the second location was on a Tilsit silt loam (fine-silty, mixed, Typic Fragiudult). Plot size was 30 A by 12 ft (4 rows) on the Pope soil and 35 A by 12 A on the Tilsit soil. Seven fertilizer P and K treatments, involving combinations of four different rates of each nutrient, in the presence and absence of poultry litter, were used at each location (Table 1). Somewhat greater rates of nutrients were used on the Pope silt loam because of the historically greater yield potential at this location.

Litter and fertilizer were applied prior to corn planting in 1995. Amendments were not repeated in 1996. Soil samples (0- to 3- in depth increment) were taken prior to amendment in 1995 and prior to planting in 19% and subjected to Mehlich III extraction for P and K Corn and soybean were planted in middle to late May of each year. Ear leaf samples were taken at silking and topmost trifoliate leaf samples were taken at first flowering. Grain samples were taken at harvest. Corn was hand harvested from 20 feet of each of the two center rows of each plot. Corn yields were corrected to a uniform 15.5% moisture content after determining the moisture content and shelling fraction from ears sampled from each plot Soybean was harvested with a small plot combine from 20 (Pope) or 25 (Tilsit) feet of the center two rows of each plot. Soybean yields were corrected to a uniform 13.5% moisture.

RESULTS AND DISCUSSION

Potassium in litter was readily available to corn in the first year. There was a strong interaction between the litter and fertilizer K on **corn** ear leaf K (Fig. 1a), and litter amendment more positively affected ear leaf K at the lower rates of fertilizer K addition. A similar, but stronger interaction was observed on corn grain yield (Fig. 1b), where there was no response to fertilizer K in the presence of litter.

The pattern of response observed for soybean trifoliate leaf K (Fig. 1c) was similar to that observed for corn ear leaf K. Soybean yields rose with fertilizer K addition, both in the absence and presence of litter, and there was a consistently greater yield where litter had been applied the previous year (Fig. 1d). The greater responsiveness of soybean to fertilizer K in the presence of litter may reflect removal of K by the prior corn crop (avg. of 27 lb K_2O/a), or the greater responsiveness of this legume species to adverse K nutrition.

Phosphorus in poultry litter was not as readily available to corn as K the first year. Litter amendment again more positively influenced ear leaf P at lower rates of fertilizer addition (Fig. 2a), but the interaction was not as strong as that observed on ear leaf K (Fig. 1a). Fertilizer P additions raised corn grain yields, both in the absence and presence of poultry litter (Fig. 2b). This suggests that the P contained in the litter was not as available as that derived from the fertilizer. This was likely due to the fact that a portion of the litter P is contained in organic compounds that are insoluble and must be mineralized to be made available to the corn crop.

Phosphorus concentrations in trifoliate leaves taken from the second year's soybean crop responded positively to fertilizer P, regardless of litter amendment (Fig. 2c). That leaf P response was somewhat less positive where litter was used. Soybean yields rose with both litter and fertilizer P amendments, but there was no interaction between the two experimental factors (Fig. 2d). Fertilizer P was beneficial to soybean yield without regard to litter amendment, and litter application raised soybean yield without regard to fertilizer P application rate. The results suggest that the litter provided some benefit to the soybean crop beyond additional P nutrition, a result not observed in the first year's corn crop. Another possibility is that the rather large amount of P removed by the corn crop (avg. of 37 lb P_2O_5/a) diminished readily available P reserves in all treatments, causing soybean to rely on relatively more uniform, and less available, soil P fractions.

Relating crop yield to soil test measures of soil P and K provides another way of assessing the relative availability of litter and fertilizer sources of these nutrients. Corn (Fig. 3a) and soybean (Fig. 3b) yield responses to soil test K suggest little difference in K availability from the two sources. Although only data from the Tilsit soil are shown, the other location responded similarly. Litter application raised soil test K values at the end of the first season across both locations, by an average of 14 lb K/a.

Corn yield response to soil test P (Fig. 3c) *suggests* that the crop "sees" litter-derived P to about the same extent that the litter changes soil test measures of available soil P. This does not appear to be the case with soybean (Fig. 3d). At both locations, there was a significantly greater yield response to fertilizer P in the presence of litter. This response was above and beyond that expected from the change in soil test P alone. Litter application raised soil test P values at the end of the season across both locations, by an average of 3.2 lb P/a.

CONCLUSIONS

These preliminary data suggest that poultry litter will provide considerable quantities of plant-available P and K to the crop in the first year after application. Litter K appears to be fully available the first year, while only about 75% of the litter P is available in that season. To the extent that litter P and K were not removed by corn in the first season, they were available to the following soybean crop. At these modest rates of litter application, the row-crop producer will recover most of the P and K value in the litter in this 2-yr year rotation on this and similar soils. Litter amendment does not reduce the ability of the Mehlich III extraction procedure to predict soil P and K availability.

Table 1. Poultry litter and fertilizer P and K rates used in the two field experiments.

Litter			Fertilizer	
N	P_2O_5	K_2O	P_2O_5	K_2O
lb/a				
Pope silt loam				
0	0	0	0	54
61	69	55	23	54
			46	54
			69	54
			69	36
			69	18
			69	0
Tilsit silt loam				
0	0	0	0	36
52	53	41	17	36
			34	36
			52	36
			52	24
			52	12
			52	0

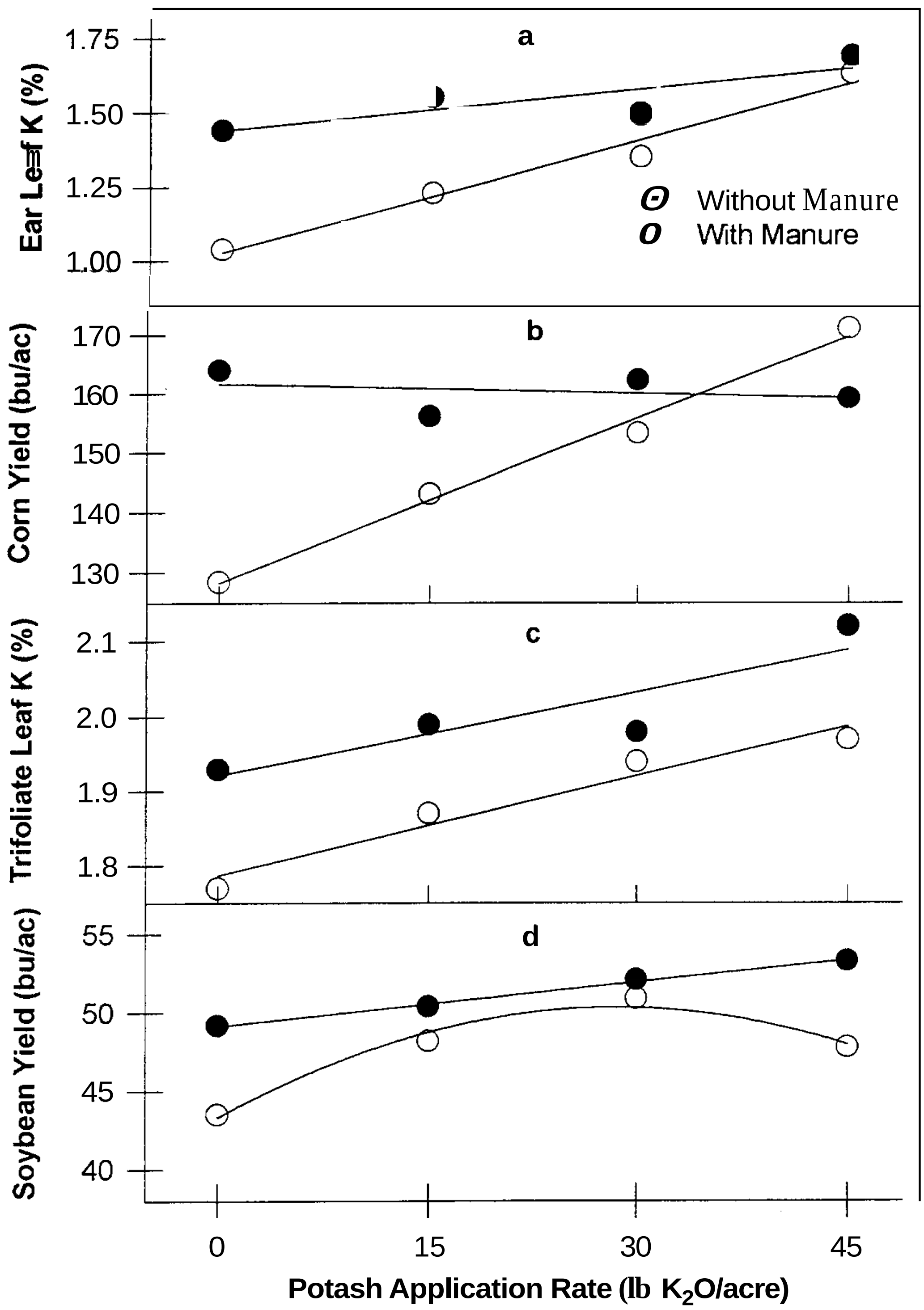

Figure 1. Leaf tissue and grain yield responses of corn and soybean to potash in the absence and presence of poultry litter (ave. of two locations).

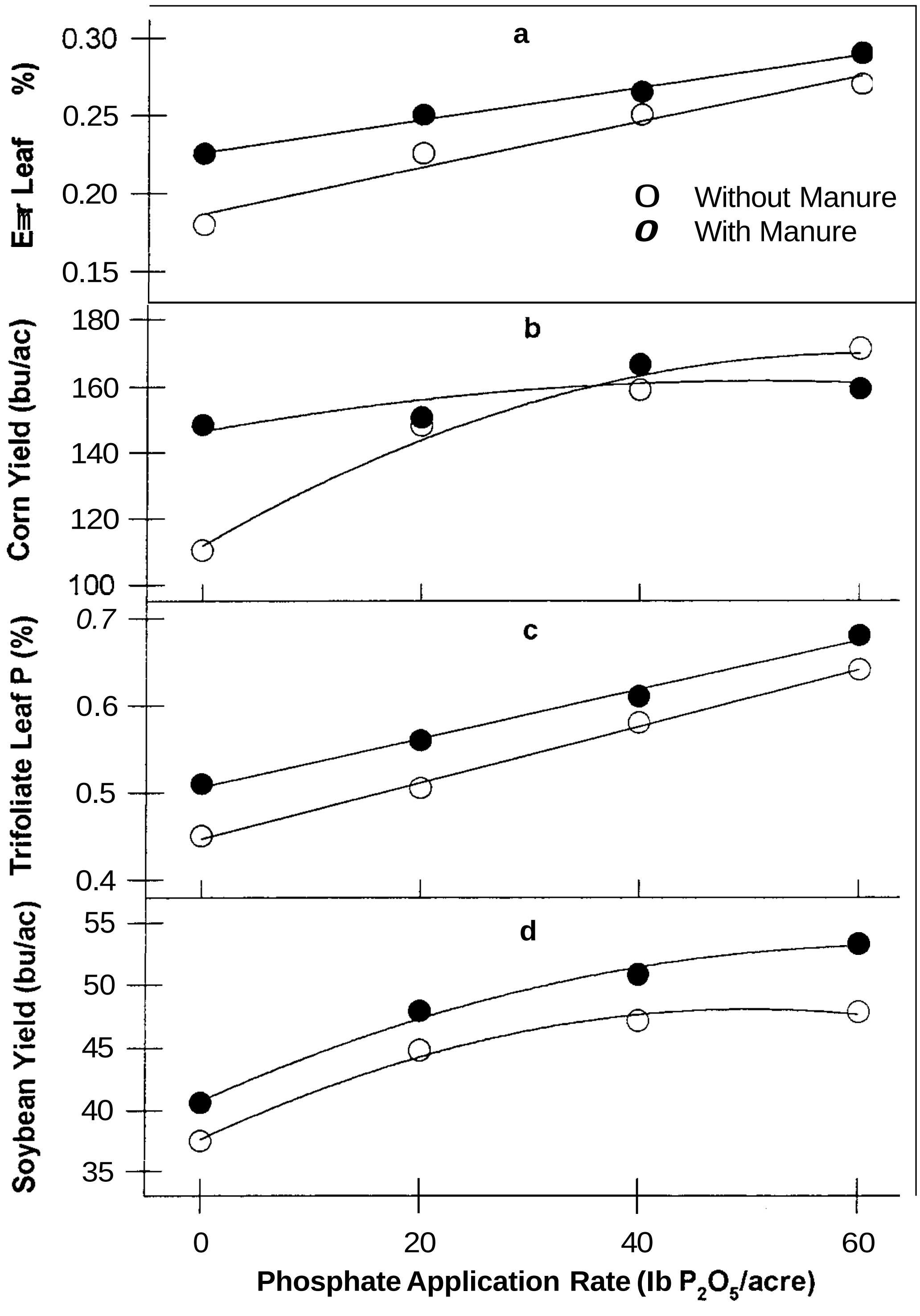

Figure 2. Leaf tissue and grain yield responses of corn and soybean to phosphate in the absence and presence of poultry litter (ave. of two locations).

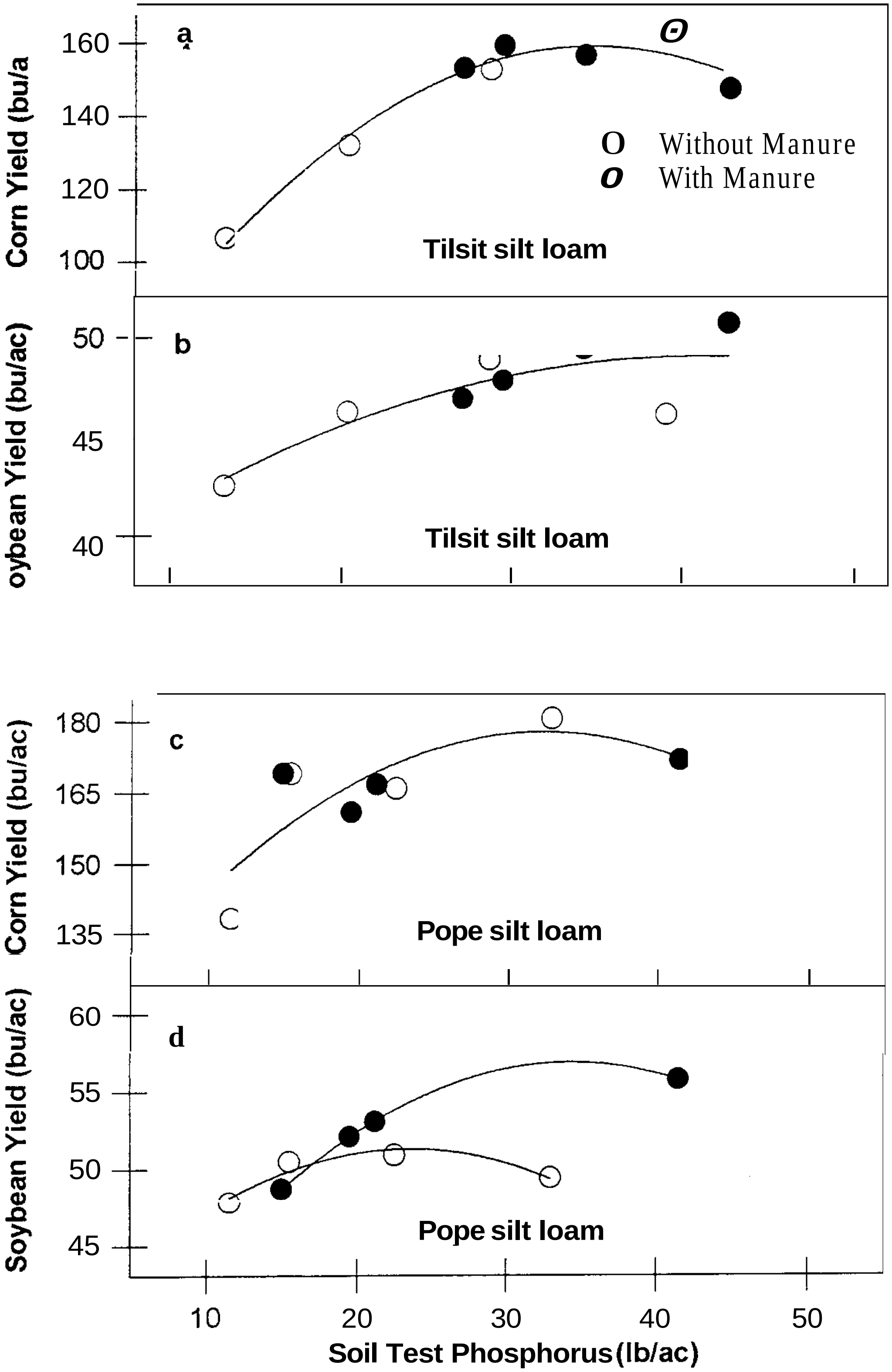

Figure 3. Grain yield responses of corn and soybean to soil test potassium and phosphorus for selected soils in the absence and presence of poultry litter.

Application of Unprocessed Urban Plant Debris Directly to Land

***Gerald Kidder, Marvin F. Weaver, David O'Keefe, and Richard Vories**

ABSTRACT

Urban plant debris (UPD) was taken directly from yard trash collection routes in Alachua County, Florida, and applied at rates of approximately 200 tons/a to a field that is in a watermelon *[Citrullus lanatus* (Thunb.) Matsum. and Nakai]-livestock-forage rotation. Applying unsorted UPD to land without any sorting, grinding, or composting is an uncommon means of handling this portion of the urban waste stream. Because of the unique nature of this approach to UPD utilization, observations made at the field site during the 1.5 yr following initial application were documented. Three forage crops have been produced since initial incorporation of the UPD material The presence of large woody debris 1.5 yr after UPD application would likely interfere with planting of watermelon. However, the farmer anticipates planting melons 2.5 yr after UPD application. About 9 mo after UPD application, decomposing yardwaste supplied enough N and other nutrients to produce a 2.5-ton dry weight sorghum-sudangrass (Sorghum *bicolor* x *Sorghum vulgare sudanense)* forage crop. However, there were indications that N mineralization during the winter was not sufficient for maximum growth of rye *(Secale cereale).* Soil fertility tests after UPD application showed high to very high P, K, and Mg and adequate Ca, Zn, Mn, and Cu levels. Application of unprocessed UPD directly to land appears to be a viable management option. It utilizes an urban waste material as a resource in agricultural production and provides an environmentally sound alternative to disposal methods.

[1]G. Kidder, [2]M.F. Weaver, [3]D. O'Keefe and [4]R. Vories. [1]Soil and Water Science Dept., IFAS, Univ. of Florida, Gainesville, FL., [2]Gilchrist County Extension Service, IFAS, Univ. of Florida, Trenton, FL., [3]Full Circle Solutions, Inc., Gainesville, FL., and [4]Boone Waste Industries, Inc., Gainesville, FL. Manuscript received 2 April 1997. *Corresponding author.

Use of Dairy Manure Effluet in a Rhizoma (Perennial) Peanut Based Cropping System for Nutient Recovery and Water Quality Enhancement

***E. C. French, K. R. Woodard, D.A. Graeb, G. M. Prine, and H. H. Van Horn**

INTRODUCTION

Development of appropriate crop management programs for dairy effluent sprayfields is needed to efficientlyuse the available nutrients and avoid possible ground water contamination. The most desirable design for any cropping system is one that meets environmental demands by maximizing nutrient uptake by the crops while meeting the needs of dairy producers. Several cropping *systems* using traditional crops have been suggested for use under sprayfields. Rhizoma (perennial) peanut *(Arachis glabrata* Benth.), a relatively new crop to Florida is currently being examined for use in effluent sprayfields. Perennial peanut is a legume that produces a high quality forage which can be used in a dairy cow rations as a source of protein, fiber, and other nutrients. A perennial peanut sod based system in a dairy effluent sprayfield may also have the potential of continuous nutrient recovery over an entire year in addition to the production of a high quality forage. Being a legume, perennial peanut is normally grown with no applied N fertilizer,but when N is made available, perennial peanut will take it up from the soil and manure effluent. Perennial peanut produces a dense underground rhizome/root system which can intercept applied nutrients.

CROPPING SYSTEMS

Considering the advantages and potential inherent to perennial peanut, research was designed and conducted to examine perennial peanut as a component in cropping systems managed in a dairy effluent sprayfield setting as compared to a conventional crop rotation of corn *(Zea mays* L.)-sorghum *(Sorghum bicolor* L.)-rye *(Secale cereale* L.) . Three 12-mo cropping rotations were compared for their yield potential of high quality forage and ability to prevent groundwater contamination (Fig. 1). The year-round systems consisted of (1) corn, forage sorghum, and winter rye; C-FS-R, (2) perennial peanut and rye; PP-R, and (3) corn (planted directly into a perennial peanut *sod),* perennial peanut, and rye, C-PP-R.

Before the initiation of this study, the N uptake was estimated to be 440 lb/a/yrfor the C-FS-R system, 428 lb for the PP-R, and 440 for the C-PP-R. These estimates were based on previously reported *dry* matter yields and forage N percentages of the individual crops grown in North-Central Florida.

EXPERIMENTAL METHODS

A waste effluent-cropping systems study was conducted at the University of Florida's Dairy Research Unit near Hague, Florida. All annual crops were planted using no-tillage equipment.Rye was planted on all plots in December, 1992. The study began in March, 1993 with the corn planting, continued through two 12-mo cycles, and ended with rye harvest in late March, 1995.

In the C-FS-R system, corn was no-till planted into rye stubble and harvested in July. Forage sorghum was then no-till planted into existing corn stubble. Following sorghum harvest, rye was planted for the winter season using a no-till grain drill. For the C-PP-R rotation, corn was no-till planted into an established perennial peanut sod in March. At that time, the growth of perennial peanut was somewhat slow due to cool night temperatures, which allows corn a slight head start. After the corn canopy developed overhead, growth of the perennial peanut was suppressed. After corn harvest, the perennial peanut recovered and its growth phase began. After it was harvested in late fall, rye was overseeded with a no-till grain drill. For the PP-R system the perennial peanut was harvested three times during the warm-growing season. Rye was overseeded into the peanut sod in late fall for the cool season crop.

Within each cropping system there were three N treatments (Table 1). They consisted of a (1) control where plots received dairy waste effluent irrigation during a 12-month period at an annual input of 360 lb N/a, (2) low N treatment where plots received waste effluent (same as control) and from ammonium nitrate, 130 lb N/a during corn season, 60 lb N during forage sorghum, and 40 lb during rye, and (3) high N treatment where plots received effluent and 230 lb N/a during corn, 120 during forage sorghum, and 80 during rye. The corn, forage sorghum, and rye received the N during early vegetative

[1]E.C. French, [1]K.R.Woodard, [2]D.A. Graetz, [1]G.M. Prine and [3]H.H. VanHorn.[1]Agronomy Dept., [2]Soil and Water Dept., and [3]Dairy and Poultry Sci. Dept., University of Florida, Gainesville, FL. Manuscript received 1 April 1997. * Corresponding author.

growth. For the aforementioned rates on corn and forage sorghum, N was split applied. Crops growing in the other two cropping *systems* were fertilized with ammonium nitrate at the same time and N rate as those in the C-FS-R system.

DRY MATTER YIELD

Perennial Peanut -Rye System

The dry matter (DM) yield (2-yr average) of perennial peanut in the control treatment of the PP-R rotation was 6.2 ton/a (Table 2). Converting to 12% moisture forage, a hay yield of over 7 ton was obtained. This is one of the highest seasonal yield we have ever recorded for perennial peanut in north-central Florida. It appears that DM yield was suppressed slightly at the high N rate. The average DM yield of perennial peanut in the high N treatment was 8% lower from that of the control (effluent only) The overall average DM yield for the PP-R rotation was 7.9 ton/a/yr.

Corn-Perennial Peanut-Rye and Corn-Forage Sorghum-Rye Systems

Forage DM yield did not differ between the corn planted into rye stubble (C-FS-R) and that planted into perennial peanut sod (C-PP-R). Adding more N from ammonium nitrate to corn plots receiving effluent increased forage DM yield by 1.2 ton/a or less (Tables 3 and 4). These results show that the corn was close to reaching its full production potential with effluent N only (effluent N was applied at 195 lb/a during corn season).

Perennial peanut forage between corn rows in the C-PP-R system was harvested at the same time as the corn. Mean DM yield was only 0.5ton/a in 1993 and0.7 toda in 1994 (not shown). Forage yield tended to be slightly higher in control plots compared to low N and high N plots, likely due to more shading at the higher N rates. The perennial peanut forage between corn rows will be difficult for the producer to harvest and because of the light yield, may not be feasible. Perhaps the best practice would be to mow the perennial peanut and existing corn stubble as low as possible, thus allowing a new peanut crop to emerge uniformly. Following the corn, perennial peanut produced an average DM yield of over 2 ton/a, equivalent to a single cutting of perennial peanut in the PP-R system.

Across all N treatments, the annual DM yield was greater in the C-FS-R system than the C-PP-R rotation The main difference being the higher DM yield of the forage sorghum which was more than double that of the p. peanut. The annual DM yield of the C-PP-R system was 77 to 85% of the yield of the C-FS-R system while the DM production of the PP-R rotation was 48 to 58% of the C-FS-R.

NITROGEN REMOVAL

Perennial Peanut - Rye System

Mean N removal in 1993 from the three harvests of perennial peanut was 326 lb/a for the control treatment (Table *5)*. Nitrogen removal increased by less than 20 lb/a with additional fertilizer N, a very small increase considering that during the growth cycle of the peanut in 1993, an additional 350 lb N/a was applied to the high N plots. This small increment is a result of a slight increase in N percentage in forage with the higher N rates and not a yield increase. The rye following perennial peanut removed an average of 52 lb N/a for the control. Removal increased to 81 lb/a for the high N treatment, due mainly to an increase in yield.

Corn-Perennial Peanut-Rye and Corn-Forage Sorghum-Rye Systems

No substantial differences in N removal occurred between the corn planted into rye compared to perennial peanut sod (Tables 6 and 7). As with the PP-R *system,* large increases in N removal did not occur with additional fertilizer N being applied. Nitrogen removal increased less than 40 lb in high N plots, although an additional 230 lb of fertilizer N was applied during the corn season.

If the perennial peanut forage between corn rows could be removed, then approximately 30 lb N/a could be added to each of the total means in Table 6, resulting in an advantage of the C-PP-R system over C-FS-R. Nitrogen removal by the perennial peanut following corn decreased slightly over N treatments, due mostly to a small yield decline, while removal by forage sorghum (following corn) increased, due mainly to increase in N percentage in forage in 1993. Nitrogen percentage in forage sorghum was 1.0 for the control, 1.1 for the low N and 1.3 for the high N. In the C-FS-R and C-PP-R systems, N removal by the rye increased across N treatments, due mainly to increased DM yield.

In all cropping systems, N removal increased only slightly with increased loading rate of N (Table 8). These results indicate that the crops in the control plots of all systems were close to their maximum potential and efficiency for removing N from the soil. The largest increase of N removal across N treatments occurred in the C-FS-R system (117 lb N/a). The highest N removal within all three N loading rates occurred with the PP-R rotation. This result seems inconsistent because it had the lowest annual DM yield. The reason for the higher values of the PP-R plots is because the N percentages of the perennial peanut forage [crude protein (CP) as well] were 250% higher than those of the corn and forage sorghum (Table 9). The range of N percentages of perennial peanut was 2.4 to 3.5 (15 to 22% CP) compared to 0.9 to 1.4 (6 to 9% CP) for corn and forage sorghum. The high N percentages in perennial peanut forage not only compensated for the lower DM yields but resulted in the highest N removal.

PHOSPHORUS REMOVAL

Phosphorus removal did not follow the same trend as N (Table 10). Although P levels were generally higher in perennial peanut forage (0.24 to 0.36%) than corn and forage sorghum (0.16 to 0.28%), they were not high enough to offset the much lower DM yield of the peanut. Therefore, higher P removal averages were recorded for the corn and forage sorghum (50 to 59 lb and corn and perennial peanut (56 lb). Average annual P removed by the perennial peanut was 36 lb/a.

CONCLUSIONS

Most of the forage production potential and nitrogen removal capacity of the three cropping *systems* was achieved with the control (effluent) N loading rate of 360 lb N/a/yr. Substantial increases in either component did not occur with the low N rate (effluent plus 230 lb fertilizer N/a) being applied The optimum annual loading N rate in terms of DM yield and N removal is likely a level between the control and low N rate.

The lowest annual DM yield was obtained from the PP-R system. Since the forage N percentage (and crude protein as well) was about 250% greater in perennial peanut than in corn and forage sorghum; however, the PP-R system attained the higher N removal values. The C-FS-R and C-PP-R systems were superior to the PP-R rotation in P removal. Though P levels in perennial peanut forage were generally higher than those in corn and forage sorghum they were not high enough to compensate for the much lower annual DM yields of the PP-R *system.* Therefore, these results suggest that if N pollution is the major concern in a particular area, then the PP-R would be a good choice since it performed as well or better than the C-FS-R and C-PP-R systems. However, if P is the major concern, the C-FS-R and C-PP-R ***systems*** would be better choices.

ACKNOWLEDGEMENTS

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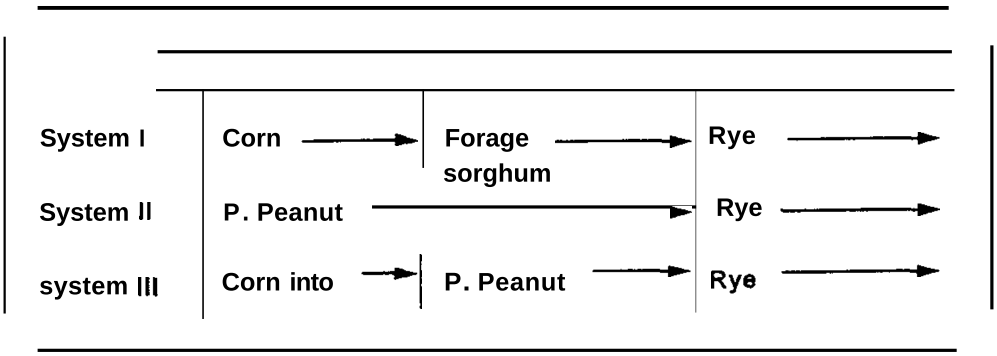

Corn and forage sorghum harvested for silage while the rye and perennial peanut are harvested as hay or silage.

Fig 1. Year-round cropping systems that utilize plant nutrients contained in dairy waste irrigation effluent.

Table 1. Nitrogen applied to all cropping systems during corn, forage sorghum, and rye growing cycles at the Dairy Research Unit near Hague, Florida during 1993-94

Crop	N treatment	N applied
		(lb/a)
Corn	Control (effl only)	195
	Low N	195+130=325
	High N	195+230=425
Forage sorghum	Control (effl only)	70
	Low N	70+60=130
	High N	70+120=190
Winter rye	Control (effl only)	95
	Low N	95+40=135
	High N	95+80=175
Total N	Control (effl only)	360
	Low N	590
	High N	790

Table 2. Dry matter yield (2 yr average) of perennial peanut and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

Nitrogen treatment	Perennial peanut					
	Harvest number					
	1st	2nd	3rd	Sub total	Rye	Total yield
	ton/a					
Control (Effl. only)	**2.0**	2.3	1.9	6.2	1.8	8.0
Low N (Effl+0.5 N)†	1.9	2.3	1.8	6.0	2.1	8.1
High N (Effl+full N)‡	1.7	2.2	1.8	5.7	**2.0**	7.7

† For Low-N treatment, 130 lb N/a **was** applied to these plots during the corn cycle, 60 lb during the forage sorghum cycle, and 40 lb during **the** rye **phase** in each 12-mo period.
‡ For High-N treatment, 230 lb N/a was applied during the corn cycle, 120 lb during the sorghum cycle and 80 lb during the rye in each 12-mo period.

Table 3. Dry matter yield (2 yr average) of corn, perennial peanut (following corn), and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

Nitrogen treatment	Corn	Perennial peanut	Rye	Total yield
	ton/a			
Control (Effl. only)	7.7	2.2	1.8	11.7
Low N (Effl+0.5 N)†	8.7	2.1	2.0	12.8
High N (Effl+full N)‡	8.5	1.9	2.0	12.4

† In the Low-N treatment 130 lb N/a was applied to the corn, 60 lb N to the perennial peanut (during forage sorghum cycle), and 40 lb N to rye in each 12-mo period.
‡ In the High-N treatment, 230 lb N was applied to the corn, 120 lb to the perennial peanut, and 80 lb to rye in each 12-mo period.

Table 4. Dry matter yield (2 yr average) of corn, forage sorghum, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94 and 1994-95.

Nitrogen treatment	Corn	Forage sorghum	Rye	Total yield
	ton/a			
Control (Effl. only)	7.7	4.6	1.4	13.7
Low N (Effl+0.5 N)†	8.2	5.2	1.9	15.3
High N (Effl+full N)‡	8.9	5.3	2.0	16.2

† In the Low-N treatment 130 lb N/a was applied to corn, 60 lb N to forage sorghum, and 40 lb N to rye during both 12-mo cycles.
‡ In the High-N treatment, 230 lb N was applied to the corn, 120 lb to forage sorghum, and 80 lb to rye during both 12-1110 cycles.

Table 5. Annual nitrogen removal by perennial peanut and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

Nitrogen† treatment	Perennial peanut				Rye	Total yield
	Harvest number					
	1st	2nd	3rd	Sub total		
	ton/a					
Control (Effl. only)	125	116	85	326	52	378
Low N (Effl+0.5 N)	126	130	87	343	71	414
High N (Effl+full N)	120	133	92	345	81	426

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1

Table 6. Annual nitrogen removal by corn, perennial peanut, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

Nitrogen† treatment	Corn	Perennial peanut	Rye	Total
	lb N/a			
Control (Effl. only)	186	100	57	343
Low N (Effl+0.5 N)	205	98	77	380
High N (Effl+full N)	212	86	91	389

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1.

Table 7. Annual nitrogen removal by corn, forage sorghum, and winter rye grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

Nitrogen? treatment	Corn	Forage sorghum	Rye	Total
	------------	------------ lb N/a	------------	------------
Control (Effl. only)	178	80	29	287
Low N (Effl+0.5 N)	198	111	44	353
High N (Effl+full N)	214	129	61	404

† For applied N rates from waste effluent and ammonium nitrate (34-0-0) refer to Table 1.

Table 8. Annual nitrogen removed by three year-round cropping systems conducted under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993-94.

	Cropping systems			
Nitrogen treatment	*Corn* F.sorghum Rye	Corn P.peanut Rye	P.peanut (3 harvests) Rye	Annual N applied
	------------	------------ lb N/a	------------	------------
Control (Effl. only)	287	343	378	360
Low N (Effl+.05 N)	353	380	414	590
High N (Effl+full N)	404	389	426	790

Table 9. Range of crude protein, N, and P percentages of dry matter in forage crops grown under dairy waste effluent irrigation at the Dairy Research Unit near Hague, Florida during 1993-94

Crop	Crude protein	N	P
	%		
Corn	6-8	1.0-1.3	0.18-0.27
Forage sorghum	6-9	0.9-1.4	0.16-0.28
Perennial peanut	15-22	2.4-3.5	0.24-0.36
Rye	12-19	1.9-3.0	------

Table 10. Total phosphorus removed by corn and forage sorghum, corn and perennial peanut, and perennial peanut grown under waste effluent irrigation at the Dairy Research Unit near Hague, Florida, during 1993.

Nitrogen treatment	Corn F.sorghum	Corn P.peanut	P.peanut (3 harvests)
	lb P/a		
Control (Effl. only)	59	56	36
Low N (Effl+0.5 N)	55	56	36
High N (Effl+ full N)	50	56	35

† The only source of applied phosphorus on all plots during the study period was dairy waste effluent

Effects of Farm Management on Soil Quality

*E.E. Huntley, M.E. Collins, and M.E. Swisher

ABSTRACT

The objectives of the study were: 1)to determine the effects of different farm management systems on soil quality and to 2)relate the ratio of product output and energy input to the efficiency and viability of the management systems. Soil quality of two farm management systems, conventional and organic, were compared in terms of productivity and sustainability. Farming systems were also compared to native control and pasture plots to determine potential levels of soil quality of the studied soils. Soil properties measured included bulk density, moisture content at field capacity, percent organic C, and microbial biomass C. Results showed statistical differences in soil properties over time and depth of sampling. The product output and energy input ratio for organically farmed watermelon *(Citrullus lanatus)* plots was higher than the ratio for conventionally farmed watermelon plots. The productivity ratio was lower for organically farmed peanut *(Arachis hypogaea)* plots than for conventionally farmed peanut plots.

INTRODUCTION

Soil quality of a specific managed area may indicate sustainability of that managed area. Smith (1993) stated that soil quality is the most important factor for sustaining the global biosphere. Too often however, soils have been overlooked when measuring the "health" of a farming system (Rapport, 1996). This is especially critical for the fragile soil ecosystems in Florida, where management recommendations from studies of other regions cannot be applied The quality and quantity of inputs used to sustain many Florida agricultural soils are worth investigating to determine the environmental, social, and economic cost effects of farm management.

MATERIALS AND METHODS

Physical, chemical, and biological properties were used to quantfy soil quality. These properties were represented by bulk density (BD), moisture content at field capacity (%MC), percent organic C, and microbial biomass C (MBC). Samples were taken from six different sites including a control plot under natural vegetation, pasture of bahiagrass *(Paspalum notatum* Flugge.) (P), organic watermelon *(Citrullus lanatus* [Thumbs.] Mansf.) plot (OW), conventional watermelon plot (CW), organic peanut *(Arachis hypogaea* L.) plot (OP), and conventional peanut plot (CP). Samples were taken from each plot four times within a growing season of each crop. Control and pasture plots were sampled twice, at the beginning and end of the *study.*

Energy analysis was completed for representative areas of watermelon and peanut production in the organic and conventional fanning system. Information concerning all inputs used were gathered from farmer interviews. Energy analysis was used to measure energy efficiency and productivity by calculating the following ratio (Fluck, 1996):

$$\text{Energy Productivity} = \frac{\text{Total Outuut (lb/a)}}{\text{Total Energy (million Btu)}} = \text{lb/million Btu/a}$$

RESULTS AND DISCUSSION

Results were interpreted by investigating how properties changed over individual times within each farmed plot. Soil morphological properties confirmed that studied soils were uniform in characteristics and could be compared in reference to management effects. Bulk density showed least change among soil properties measured. Percent moisture content, % OC, and MBC showed most variability over time.

Soil Properties

Percent Moisture Content. Increases in %MC were greater in the OP and CP plots than in OW and CW plots. Hudson (1994) suggested that as organic matter increased, volume of water held by soil at field capacity also increased. However the design of this study did not confirm that %MC was affected by %OC. Samples for %MC were taken from undisturbed cores. Percent OC did not necessarily represent the %OC within those cores

[1]E.E. Huntley, [1]M.E. Collins, and [2]M.E. Swisher. [1]Soil and Water Science Dept., and [2]Family, Youth and Community Sciences Dept., University of Florida, IFAS, Gainesville, FL. Manuscript received 18 April 1997. *Corresponding author.

Percent Organic Carbon. Changes in %OC at 0 to 15 cm soil depth are recorded in Figures 1 and 2. Increase in %OC at the second sampling time in OW most likely reflected the addition of 4 ton/a of chicken manure. The %OC in CW was lower than that in OW at all sampling times. This was attributed to both inherent soil conditions and effect of black plastic mulch on decomposition rate of % OC. At the final sampling time, in both OP and CP plots, an increase in %OC was recorded. Having been cultivated for 2-yr, this result was unexpected. The increase may have been due to decomposition of bahiagass lignin root system and peanut plant residue after harvest. Decomposition of ryegrass (Lolium spp.) in the OP plot also may have contributed to the increase in %OC.

Microbial Biomass Carbon. Three flushes of growth were observed in MBC (Figure **3).** These were recorded at March sampling time for the OW plot and March and May sampling times for the CW plot. The increase in growth was typical of MBC *after* addition of organic amendments. The addition of manure provided a C substrate which contributed to MBC for the OW plot at March sampling time. Data of MBC recorded at March and May sampling times for the CW plot were attributed to the use of black plastic mulch and fertigation which created good conditions, including C, energy, and moisture sources, and heat. The fresh bahiagrass most likely provided a C source. Fertigation provided energy and moisture sources. The plastic helped to heat the soil.

Statistical Analysis. The means of soil properties, over time and depth of sampling, were compared to see if differences in soil properties occurred due to farm management Statistical differences were not shown between BD. Statistical differences were shown between %OC means and between %MC means. The mean % OC, through time and depth, of the OW plot was recorded at 0.88% while the mean %OC for CW was 0.49%. The % MC mean, through time and depth, at 1.0 bar of the OW plot was 11.6% and the % MC mean of the CW plot was 8.6%. These results confirmed that management did effect soil properties over the short term. The higher means %OC and %MC of OW and OP plots gave evidence that the organic systems more positively influenced these factors that contribute to soil quality.

Energy Analysis

As expected, the lower energy input systems (OW and OP) were the lower yielding systems (Table 1). The total energy used in OW was 65% less than in CW. Yield in OW was 56% lower than yield of CW. Total energy used in OP was 49% less than in CP production. Yield in OP was 71% less than in CP. In terms of energy efficiency, OW energy productivity was 83% higher than energy productivity in CW. Energy productivity of CP system was 77% greater than energy productivity in the OP system.

Quantities of individual inputs were ranked in order of greatest to least amounts of energy used (Table 2). In the OW and CW plots, the highest energy inputs directly effected crop and soil properties. Nitrogen, applied to the soil through manure, contributed to the largest amount of energy used in OW. Plastic mulch and drip irrigation most greatly effected soil properties in CW. Microbial flush and decline in organic C reflected the influence of black plastic mulch. In the OP and CP plots, diesel, an input which does not directly effect crop and soil conditions, was reported as the highest energy input. This difference in direct and indirect inputs reflects the particular requirements for the two different crops, watermelon and peanut. Furthermore, diesel was used most in OP and CP during land preparation and production and reflected use of equipment for cultivation in OP production and application of amendments and pesticides in CP production.

CONCLUSIONS

The organic and conventional farm management practices studies affected soil properties. For example, organic materials in manure, bahiagrass, and ryegrass, improved %OC. Soil quality seemed to be most affected by the practice of bahiagrass rotation that was shared by both systems. Crop yield was more effected by other practices used in the conventional system than measured soil properties were effected. Continued emphasis on balancing the most efficient inputs used to enhance soil quality is needed on sandy soils.

Agriculture makes a demand on an ecosystem to produce energy in the form of food. Management is needed to replace that amount of energy taken away in crop yield. Cassman and Harwood (1995) stated that as soil quality decreases, greater inputs and management skills are necessary to counter the reduction in nutrients the crop obtains fiom soil resources. In systems with limiting environmental conditions, such as sandy, low-fertility soils, significant gains in efficiency in input use are needed to maintain or increase productivity and yields. One way to determine effects of energy on soil quality and effects of input changes on yield may be to calculate a ratio between a measured soil property and energyinput. Given the results that lower input systems were lower yielding systems but not necessarily less energy efficient systems, further investigations of the relationship between yield, soil quality, and energy efficiency are needed.

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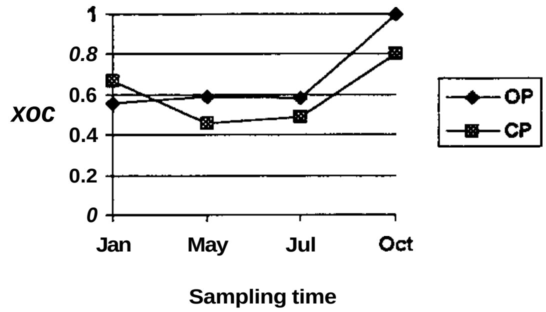

Figure 2. Percent organic carbon (%OC) of OP and CP plots at four sampling times at 0 to 15 cm.

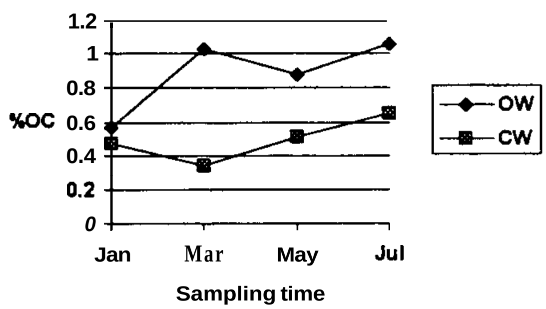

Figure 1. Percent organic carbon (%OC) of OW and CW plots at four sampling times at 0 to 15 cm.

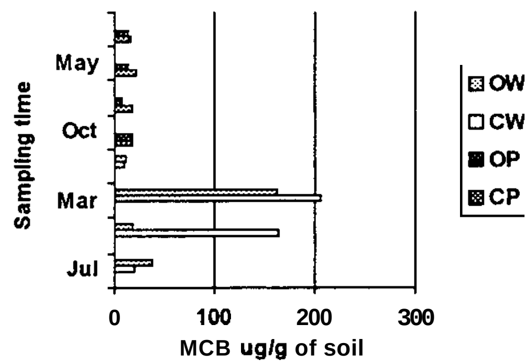

Figure 3. Microbial biomass carbon (MBC) of OW and CW at four sampling times at 0 to 15 cm.

Table 1. Energy inputs, total energy, yield and energy productivity in OW, CW, OP, CP fields[1].

	OW	CW	OP[2]	CP
Land preparation inputs (million Btu/a)	9.91	34.22	2.81	6.19
Planting inputs (million Btu/a)	0.88	9.73	1.93	2.97
Production inputs (million Btu/a)	**2.06**	7.76	1.44	3.52
Harvest (million Btu/a)	5.53	2.46	1.41	2.04
Other costs (million Btu/a)	1.33	2.34	1.06	1.97
Miscellaneous (million Btu/a)	0.48	2.13	0.18	0.79
Total energy (million Btu/a)	20.19	58.74	8.84	17.48
Yield (lb/a)	13000	30000	1200	4200
Energy productivity (lb/million Btu/a)	643.88	510.73	135.75	240.27

[1] OW = organic watermelon, CW = conventional watermelon, OP = organic peanut, and CP = conventional peanut plots.
[2] No peanut crop was harvested for OP in 1996. Yield and harvest energy used were recorded for OP was from 1995.
[3] Other *costs* include energy terms of variable and fixed costs of equipment less fuel costs.
[4] Miscellaneous items include lubricants used in equipment operation.

Table 2. Ranking of amounts of energy used in OW, CW, OP, and CP production'.

Ranking[2]	OW	CW	OP	CP
	Input/Energy (10^6 Btu/a)			
1	N/ 6.55	Plastic Mulch/ 12.72	Diesel/ 4.08	Diesel/ 6.44
2	Diesel/ 5.44	Drip tube/ 12.72	Rye seed/ 1.32	Equipment.' 1.97
3	Labor/ 3.37	Seedlings/ 7.40	Peanut seed/ 1.32	Lime and Gypsum/ 1.56
4	Crates/ 2.02	Diesel/ 6.62	Equipment/ 1.06	Peanut seed/ 1.32
5	Equipment.' 1.33	N/ 4.32	Labor/ 0.65	Nematicide/ 1.10
6	Miscellaneousl0.48	Irrigation diesel/ 2.75	Gasoline/ 0.23	Insecticide/ 1.00
7	Gasoline/ 0.46	Equipment/ 2.33	Miscellaneous/ 0.19	N/ 0.82
8	PI 0.300	Labor/ 2.22	N/A	Miscellaneous/ 0.79
9	W 0.24	Miscellaneousl2.13	N/A	Labor/ 0.48
10	*Seed/* 0.017	Gasoline/ 2.90	N/A	Gasoline/ 1.23
11	N/A	P/ 1.09	N/A	K/ 0.44
12	N/A	Fungicide/ 1.06	N/A	P/ 0.37
13	N/A	K/ 0.92	N/A	Fungicide/ 0.33
14	N/A	Lime/ 0.89	N/A	Herbicide/ 0.22
15	N/A	Crated 0.46	N/A	**Minor nutrients/** 0.14
16	N/A	N/A	N/A	N fixing bacteria/ 0.012
17	N/A	N/A	N/A	Epsom salts/ 0.0022

[1] OW = organic watermelon, CW = conventional watermelon, OP = organic peanut, and CP = conventional peanut plots.
[2] Rankings are from 1 = greatest amount of energy to 17 = least amount of energy.

Reducing Surface Disturbance with No-Till and Low-Till Systems for Cotton in the Mid-South

***Gordon R. Tupper and Harold R. Hurst**

INTRODUCTION

Producers are trying to reduce input costs and soil erosion while improving water quality eliminating trips across the field. In-row subsoil tillage with the Paratill may be a possible solution. The Paratill is a deep tillage tool with high horsepower requirements that reduces soil surface disturbance. A lower draft deep-tillage tool, with reduced soil surface disturbance, was deslgned by Tupper in 1993 (Tupper, 1994). This deep-tillage tool, referred to as the low-till parabolic subsoiler, utilizes a straight parabolic-shaped shank positioned at a 28^{o} angle from the vertical (away from the center of the subsoiler) to reduce the amount of soil surface disturbance. This angle allows the shank to run in fractured soil, even under less than ideal soil moisture (wetter) conditions, thus reducing draft requirements. The leading edge of the shank was cut at a 45" angle, providing a sharp edge to reduce soil lift and further reduce draft requirements. With the use of the low-till parabolic subsoiler, deep subsoil tillage can be accomplished with minimum surface disturbance followed by no addtional tillage after planting. Other studies have shown increased yield responses with deep-band K. In-row subsoiling and deep-band K with minimum soil disturbance can reduce tillage trips and soil erosion, enhance water infiltration, maintain yields, and improve economic returns. Mid-South cotton *(Gossypium hirsutum* L.) producers have expressed a great interest in this system.

Summarizing 2 yr of research with subsoil tillage equipment, Tupper (1977) reported increased lint yield, a reduced power requirement, and a 43.4% reduction in wheel slippage with the parabolic design as compared to the conventional straight shank design. Smith and Williford (1988) reported that the parabolic subsoiler designed by Tupper required 30.2% less fuel per acre than the conventional subsoiler while worlung an average of 0.8 in deeper. The low-till shank pulls easier than the conventional parabolic shank, thus increased fuel efficiency should be realized with the low-till design.

Low soil test K in the subsoil can be corrected with deep banding fertilizer K directly under the drill row (Tupper, 1992, Tupper et al., 1992 a,b). In several studies across the Delta, soil test K levels were significantly correlated to lint yields at three soil sample depths (0 to 6 in., 6 to 12 in., and 12 to 18 in.) in non-irrigated solid planting, and in irrigated solid and skip-row plantings (Tupper, 1992). Lint yields have been improved the most when deep banding on soils which are low in soil test K, have desirable pH (6.0 - 6.8), and produce a deep root system. In order to get K into the subsoil, an applicator for deep banding low concentrations of dry material was designed and built at Stoneville, MS, during 1985 (Tupper and Pringle, 1986). This equipment was designed and built to provide an economical yet practical means of supplying K to the subsoil. By combining this technology with low-till parabolic subsoiler design, it should be possible to provide K to the subsoil with only minimal soil surface disturbance. This research project should provide producers with answers to help in the decision making of selecting tillage practices and provide solutions to several unanswered questions. Our objectives were to: 1) develop new production systems with the low-till parabolic subsoiler with minimum surface disturbance, improve soil potassium levels, and maintain or improve lint yields with increased economic returns, 2) compare the new production system to a no-till system and a conventional tillage system for cotton *(Gossypium hirsutum* L.) production with the low-till parabolic subsoiler, and 3) determine the changes in cost and returns with in-row-direction limited soil disturbance deep tillage systems.

MATERIALS *AND* METHODS

A dryland experiment was initiated in 1994 on Bosket very fine sandy loam and Souva silt loam soil at the Delta Research and Extension Center. The experiment was designed in a randomized complete block with 12 treatments replicated four times. The main

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[1]G. R. Tupper and [2]H. R. Hurst, [1]Agricultural Engineering, and [2]Plant Physiology, Delta Research and Extension Center, Mississippi State University, Stoneville, Mississippi. Manuscript received 3 March 1997. *Corresponding author.

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(controlling) treatments were: 1) no-till, 2) low-till parabolic subsoiler in-row direction with a light do-all to smooth the drill area, and 3) low-till parabolic subsoiler, hip, seedbed conditioner, and cultivate. The four other factorial treatments were: 1) check – no K, 2) 100 lb K_2O/a surface broadcast, 3) 150 lb K_2O/a deep band (applied to surface in no-till plots), and 4) 100 lb K_2O/a surface broadcast plus 150 lb K_2O/a deep band (applied to surface in no-till plots). Plots consisted of four 40-in rows, 95 ft. long.

Initially, soil samples were taken from 0- to 6-in and 6- to 15-in deep in the drill. Soil test recommendations suggested 80lb K_2O/a for the 0- to 6-in soil sample depth (topsoil) and 120 lb K_2O/a for the 6- to 15-in soil sample depth (subsoil). Applications were increased by 25% for both samples (100 lb of K_2O/a and 150 lb K_2O/a) and applied as single and combination treatments. The surface 100 lb K_2O/a treatment was broadcast applied and the deep 150 lb K_2O/a treatment was banded 6- to 15-in deep in the dnll row with a continuous band 9 in tall and 2 in wide. All no-till K treatments were surface broadcast in order to maintain its no-till status as a treatment.

A solid planting pattern was used with 'DES 119' variety planted in 1994, 1995, and 'SG 125' variety in 19%. The eight deep tillage treatments were subsoiled 23 September 1993, 3 November 1994, and 13 October 1995, respectively, for the 1994, 1995, and 1996 crops. The potassium treatments were applied 23 September 1993, 23 March 1995, and 26 February 1996, for the three crop years, respectively. Weeds were controlled as needed for each tillage system. A number of weed counts were made. during the experiment, but are not reported in this paper. Insects were controlled as needed during each growing season.

After defoliation, two center rows of each plot were spindle picked twice for yield determination. Representative samples of seed cotton (replications combined) were taken from each treatment at both first and second harvest and ginned to determine the lint percents used for calculating lint yield of each plot. A small scale ginning system (20 saw gin with the USDA recommended ginning practices) was provided by the USDA Ginning Laboratory at Stoneville. Data were subjected to analysis of variance and a 5% level of significance was chosen to separate means using Fisher's Protected LSD procedures.

RESULTS AND DISCUSSION

Lint yield data for 1994, 1995, 1996, and the 3-year average are given in Table 1. In 1994, in the treatment average the two highest K treatments (150 and 250) were higher in lint yield than the check (0). Five of six treatments at these K levels were sigruficantly higher than the conventional cultivated check treatment. Good rainfall throughout the 1994 growing season provided a good water supply for the no-till treatments.

In 1995, the deep band treatments (150) were the best treatments because of the late drought and the development of deeper root systems were able to hold up these treatments much longer into the drought before wilting began in the heat of the day. In both tillage systems, the deep 150 lb K_2O/a treatment produced sigruficantly more lint than the check (0) treatment. On the average, 150 lb K_2O/a also produced more lint than the check (0) treatment. In the treatment means, both tillage systems produced more lint than the no-till system. Conventional tillage produced more lint (84 lb/a, 10.8%) than the no-till on the average in 1995.

In 1996, only one treatment produced more lint yield than the no-till check (0) treatment. The low-till subsoiler, seedbed conditioner, with deep band 150 lb K_2O/a treatment produced a significantly higher lint yield. The 150 lb K_2O/a treatment produced more lint than the nc-till check (0). Conventional tillage produced more lint (100 lb/a, 10.8%) than no-till, on the average, in 1996.

In the 3-41 average, surface treatments of 100, 150, and 250 lb K_2O/a did not improve no-till lint yields over the check (0) or conventional tillage check (0) treatments. However, with the low-till subsoiler, seedbed conditioner with the deep band 150 lb K_2O/a treatment increased lint yield over the no-till and conventional tillage check (0). Overall, the 150 and 250 lb/a rates of K improved lint yield over the check (0). The 3-yr averages for tillage systems were not shown because of the significant interaction with year.

Figure 1 shows the percent residue cover the day after the stalks were shredded. Counts were made on 6-inch intervals over a 50 A chain stretched from row middle across four rows to row middle. Before any tillage treatments were performed, treatments were virtually alike in residue coverage. Figure 2 shows the percent residue after weathering up to 4 April, subsoiling, deep fertilizer applications, and hipping had been done in the low-till and conventional tillage treatments. Figure 3 shows the percent residue coverage the day after planting. The low-till treatments were lightly seedbed conditioned and conventional tillage treatments were seedbed conditioned. The low-till system at that point averaged 13% residue cover as compared to 27% for no-till and 4% for conventional tillage. Even though the low-till treatments do not maintain the higher levels of residue coverage that the no-till treatments maintained, they had two to three times more residue cover than conventional tillage and yields were considerably higher when 150 lb K_2O/a was deep band than in the no-till treatment when 150 lb K_2O/a was surface broadcast. Figure 4 graphs the 3-yr average lint yield, illustrating the average yields for the study.

CONCLUSIONS

The low-till subsoiler, seedbed conditioner treatment with deep band 150 lb K2O/a may be a good alternative system rather than no-till in the Mississippi Delta on relatively flat sandy loam soil types. Additional research is being done at this time to combine the low-till parabolic subsoiler and the deep band *dry* materials applicator into one piece of equipment. Additional work will be done to look at the economics of the new tillage system which is not complete at this time.

ACKNOWLEDGMENTS

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Table 1. 1. Effect of tillage system, potassium rate, and placement on lint yield, Stoneville, MS, 1994, 1995, 1996, and 3-year average (1994-1996).

Tillage system	K Rate	K Placement	Lint yield 1994	Lint yield 1995	Lint yield 1996	Lint yield 3-yr Avg
	(lb K_2O/A)		----------------(lb/A)----------------			
No-till	0	--	1021	799	923	914
	100	Surface	1025	772	900	899
	150	Surface[1/]	1081	761	932	924
	250	Surface[1/]	1093	779	948	940
Low-till	0	--	928	746	866	847
(Low-till Sub and	100	Surface	1027	854	1003	961
Seedbed	150	Deepband	1098	890	1068	1019
Conditioner)	250	Split[2/]	1099	834	1005	979
Conventional	0	--	946	793	1002	914
(Low-till Sub, Hip,	100	Surface	1013	848	1033	965
Seedbed Conditioner	150	Deepband	996	928	1047	991
& cultivate)	250	Split[2/]	1069	878	1018	988
LSD (5%)			114	99	137	100
	Treatment means					
Tillage system						
No-till			1055	778	925	--[3/]
Low-till Sub., Seedbed Conditioner			1038	831	985	--
Low-till Sub., Hip, Seedbed Conditioner. Cultivate			1006	862	1025	--
LSD (5%)			57	49	69	
Potassium system						
	0	--	965	779	930	891
	100	Surface	1021	825	978	942
	150	Deepband	1058	860	1015	978
	250	Split	1087	830	990	969
LSD (5%)			66	57	79	58

[1/]No-till required all K to be surface applied.
[2/]Split: 100 lb K_2O/A surface, 150 lb K_2O/A deep band
[3/]Interaction significant at the 0.01% level.

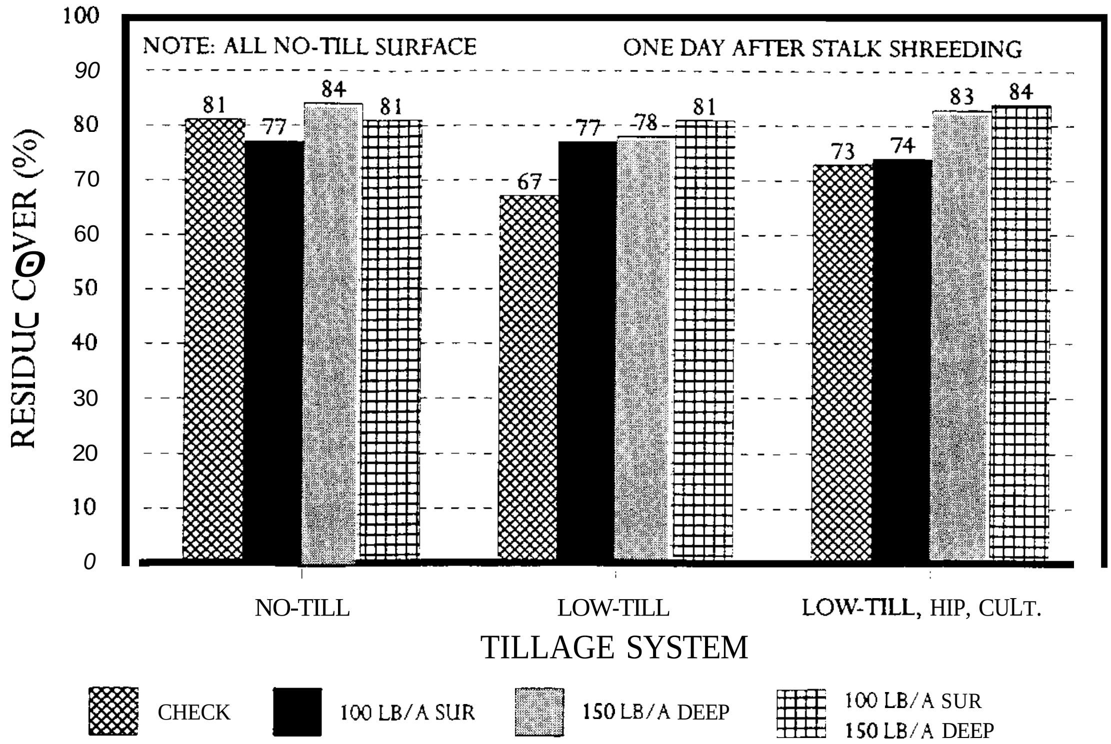

Figure 1. Effect of tillage, potassium rate and placement on surface residue, 10/12/1995

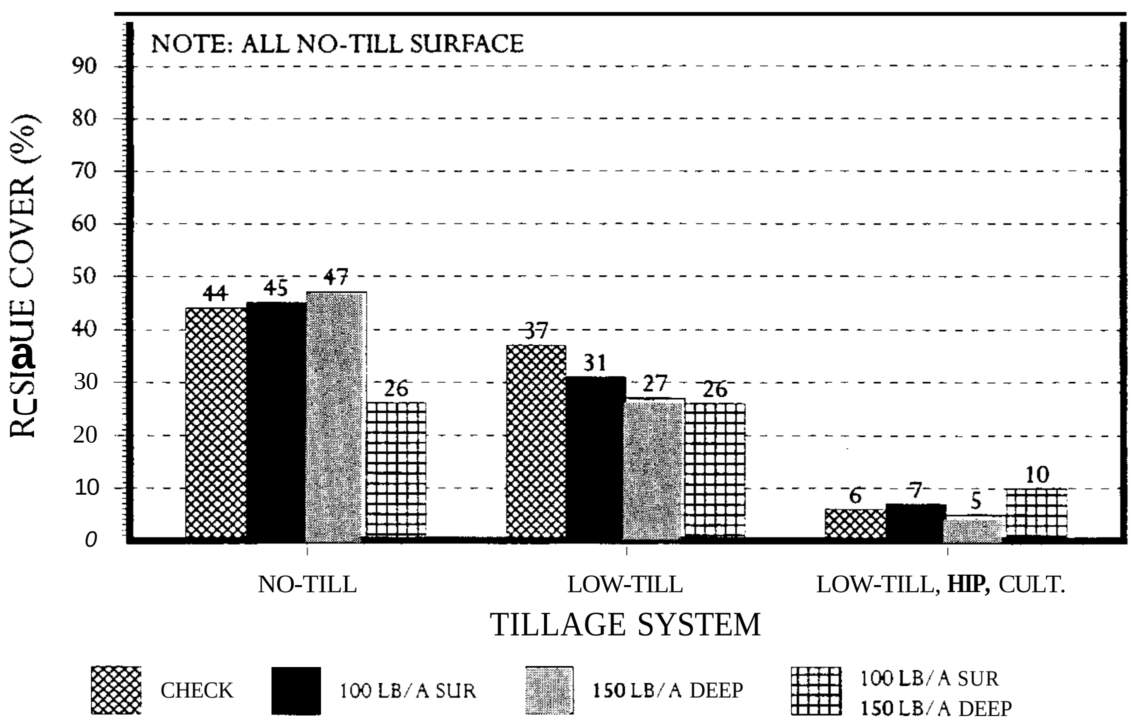

Figure 2. Effect of tillage, potassium rate and placement **on** surface residue, 4/4/1996

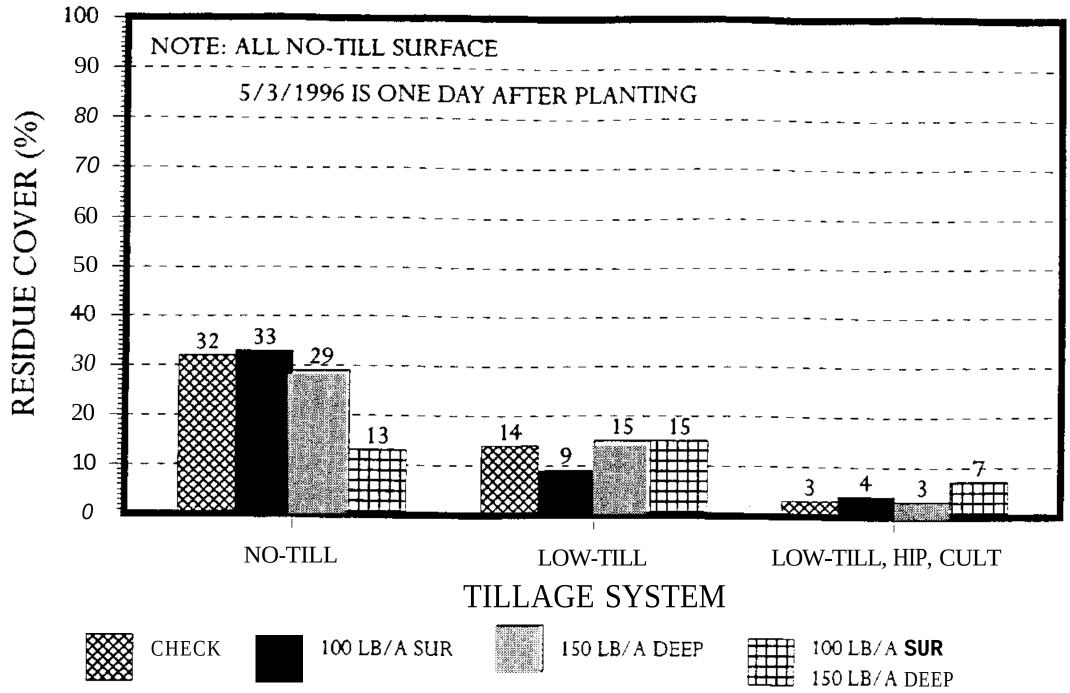

Figure 3. Effect of tillage, potassium rate and placement on surface residue, 5/3/1996

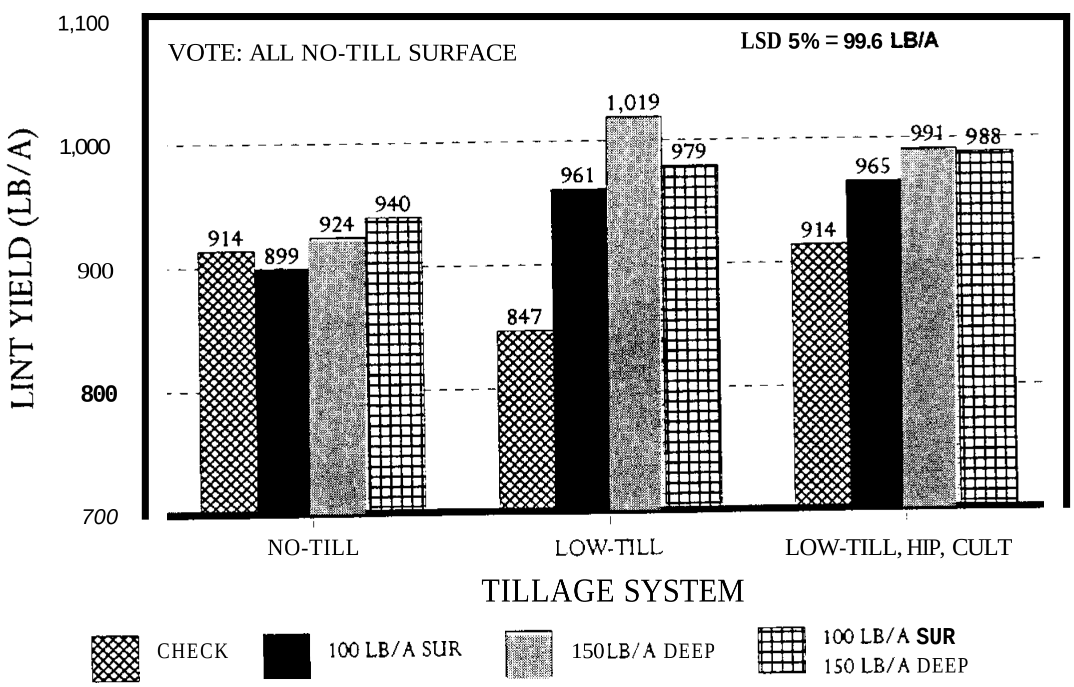

Figure 4. Effect of tillage, potassium rate and placement on lint yield, 3-yr average (1994-1996)

Nitrogen Management For No-Tillage Cotton

***J.J. Varco, J.M. Thompson, and S. R. Spurlock**

INTRODUCTION

No-tillage production is becoming a more accepted practice, as evidenced by producer interest and adoption of this technology. In Mississippi in 1989, there were 1183 a of no-tillage cotton *(Gossypium hirsutum)* and 27,000 a in 1991. Adoption of no-tillage and conservation tillage practices has prompted many questions regarding the application and placement of fertilizer, especially with respect to N. For com *(Zea mays),* dissimilar trends in grain yield response to applied fertilizer N between no-tillage and conventional tillage systems have been found by different researchers (Moschler and Martens, 1975; Blevins et al., 1980; Meisinger et al., 1985). In general, conventional tillage corn out yields no-tillage corn at low N rates, while the opposite is true at higher rates. Published N effects on modem cotton cultivars have been with conventional tillage systems (Phillips et al., 1987; McConnell et d., 1989). Little work has been done on N source and placement effects on no-tillage cotton yield. In conventional tillage, producers typically knife into the soil either urea-ammonium nitrate (UAN) solutions or anhydrous NH_3 but with the adoption of no-tillage techniques, many are dribbling N solutions on the soil surface. Volatile losses of ammonia can be high when urea containing fertilizers are placed on the soil surface (Termans, 1979). The objectives of this study were to determine the effects of tillage and fertilizer N rate, placement, and sources on cotton yield and N recovery.

MATERIALS AND METHODS

This research was conducted at the Plant Science Research Center at Mississippi State University from 1991 through 1996. The soil at the site is a Marietta fine sandy loam (fine-loamy, mixed, thermic, siliceous Aquic Fluventic Eutrochept). Fertilizer treatments were as follows: ammonium nitrate broadcast, UAN 32% N subsurface banded, UAN 32% N surface dribbled, and urea broadcast. All sources were applied at rates of 40, 80, 120, and 160 lb N/a with half the rate applied at planting and the other applied at early squaring. A check without N fertilizer was also included to estimate soil N availability. Subsurface banded UAN was placed approximately 6-in. to one side of the row at 4-in. depth at planting and a 9-in. spacing at the same depth when side-dressed at early square. Treatments were arranged using a randomized block design involving four replications. Plot size was 12.7 ft. wide by 30 ft. long with four rows at a spacing of 38 in. Insect, disease and weed control practices were according to current recommendations. Cotton variety 'DES 119' was used 1991 through 1994, and 'Suregrow 125' was used in 1995 and 1996. Cotton was harvested using a mechanical spindle type picker and subsamples of seedcotton were ginned to determine lint yield. Total N uptake for the years 1991 through 1995 was determined on whole plant samples obtained from 3.28 ft. of row at early boll opening.

J.J. Varco, J.M. Thompson, and S.R. Spurlock. Mississippi State University, Plant and Soil Sciences Dept., Mississippi State, MS. Manuscript received 31 March 1997. * Corresponding author.

RESULTS AND DISCUSSION

Lint yield response to N fertilization methods averaged across all years is shown (Fig. 1). Similar results were obtained up to 40 lb N/a, but at 80 lb N/a and greater trend differences were evident. Maximum predicted lint yield with ammonium nitrate was at 1150 lb/a at a rate of 123 lb N/a. With banded UAN, maximum yield was lower at 1100 lb/a as well as the required N rate of 103 Ib/a. Maximum yield for UAN dribbled was similar to UAN banded, but it required 126 lb N/a. A lint yield of 1173 lb/a was predicted with urea, but the N rate of 176 lb/a necessary to produce this yield was greater than the maximum N rate evaluated in this study.

Average fertilizer N recoveries using the difference method and the non-fertilized check as the baseline plant N uptake are shown in Table 1. For all treatments, it appears that N recovery reaches a maximum near 80 lb N/a and then begins to decrease at higher rates. Nitrogen recovery across rates was greatest for ammonium nitrate, although at 40 lb N/a it was similar to UAN banded and urea broadcast. There appeared to be greater N loss by ammonia volatilization with UAN dribbled at lower rates than for UAN banded, but not at the two greater N rates evaluated in this study. Overall, the lowest N recovery values were obtained with UAN dribbled even when compared to urea broadcast. It is apparent that N loss, most likely through ammonia volatilization, resulted in lower plant N recoveries for urea-based fertilizers, which is in agreement with Terman (1979).

CONCLUSIONS

Broadcast ammonium nitrate appears to be a sound method of applying fertilizer N when switching to no-till or conservation tillage systems. Urea-ammonium nitrate solutions should be placed subsurface in reduced tillage systems to prevent volatile N losses.

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Table 1. Average fertilizer N source, rate, and placement effects for the years 1991 through 1995 on apparent fertilizer N recovery by no-tillage cotton.

N rate (lb/A)	Fertilizer N sources/Placement				
	Ammonium nitrate	UAN Band	UAN Dribbled	Urea	Mean
	------ N recovery, % ------				
40	47	49	31	53	45
80	72	55	43	48	55
120	56	39	39	49	46
160	53	35	33	43	41
Mean	57	45	37	48	
$LSD_{(0.05)} = 9.6$					

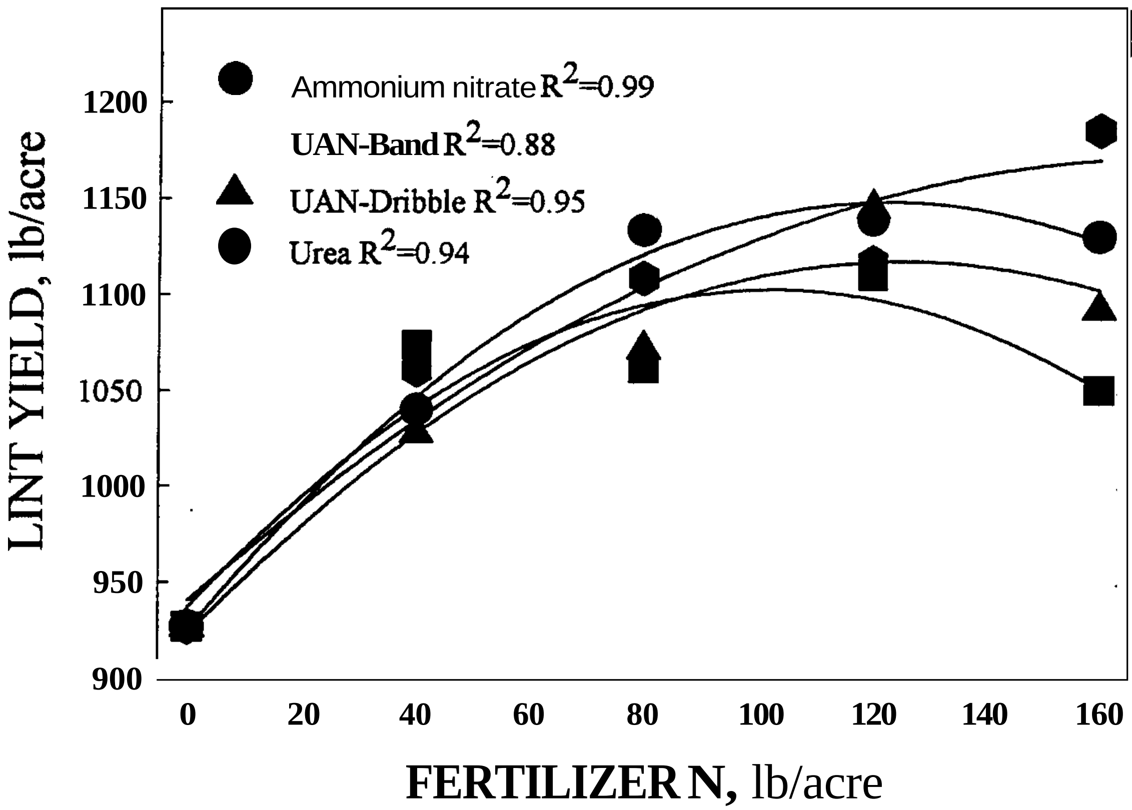

Fig. 1. Fertilizer N source, rate, and placement effects on lint yield averaged across 1991 through1996.

Influence of Starter Fertilizer on Strip - Till Cotton

***P. J. Wiatrak, D. L. Wright, J. A. Pudelko, and B. Kidd**

ABSTRACT

This research was conducted during 1995 and 1996 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located at the North Florida Research and Education Center (NFREC), Quincy, FL The objective of this research was to evaluate the influence of starter fertilizer on different varieties of cotton planted in strip tillage. Cotton *(Gossypium hirsutum)* was planted after winter wheat *(Triticum aestivum).* The emergence was significantly higher on cotton with the starter fertilizer application when compared to cotton with no fertilizer application for Deitapine DP 5409 (54.5 and 48.5 %, respectively) and Deltapine 5415 DP (61.1 and 46.3 %, respectively) in 1995, and for Deltapine DP 5409 (37.3 and 33.8%, respectively) in 1996. The cotton emergence was significantly higher for Stoneville St 474, Deltapine DP 51, Deltapine DP 5690, and Deltapine Acala 90 (62.5, 61.9, 61.2, and 60.1 YO, respectively) in 1995, and for Deltapine DP 20, Deltapine DP 51, Deltapine DP 5409, Deltapine DP 5490, and Suregrow SG 501 (38.8, 37.5, 35.6, 35.3, 35.5 %, respectively) in 1996. The yields of cotton were significantly different in 1995 and 1996. In 1995 a significantly higher lint yields were obtained from Suregrow SG501, Deltapine DP 20, and BXN 57 (618.5, 615.2, and 531.6 lb/a, respectively) The difference for starter vs. no-starter was not significant for any of the varieties. In 1996 significantly higher yields were obtained from KC 311, Suregrow SG501, and Stoneville ST474 (778.3, 756.5, 683.1 lb/a, respectively). The starter fertilizer did not influence significantly the cotton yields except for Stoneville ST 453 where the lint yield was higher on the treatments with no starter fertiier when compared to the treatments with the starter application (581.3 and 476.6 lb/a, respectively). In a 2-yr period the significantly higher lint cotton yields were received from Suregrow SG 501 and DP 20 (687.5 and 606.3 lb/a, respectively). Generally, starter fertilizer application did not increase yields, but in a few cases decreased the yields of cotton.

[1]P.J. Wiatrak, 1D.L. Wright, [2]J.A. Pudelko and [1]B. Kidd. [1]North Florida Research and Education Center, University of Florida, Quincy, FL. and [2]Agric. Univ. of Poznan, Plant and Soil Cultivation Dept., Mazowiecka, Poznan, Poland. Manscript received 11 March **1997.** *Corresponding author.

INTRODUCTION

Torbert and Reeves (1991) have shown that in years of below-normal rainfall during the growing season, strip tillage was found to maintain the highest seed cotton *(Gossypium hirsutum* L.) yield. Fertilizer N application had no effect on cotton yields in an extremely dry growing season indicating that the beneficial effect of fertilizer N may be limited under these conditions.

In 1990 and 1991 increasing N application increased cotton biomass and decreased lint percentage (Torbert and Reeves, 1994). In the dry year of 1990, no-traffic decreased seed cotton yield from 1500 to 1360 kg/ha (1335 to 1210 lb/a), while tillage had no significant effects on cotton yield components. Above-normal rainfall in 1991 resulted in the strip-till with no-traffic treatment having the highest seed cotton yield of 2749 kg/ha (2447 lb/a) and the greatest fertilizer N uptake efficiency (35%). Results indicate that the effects of traffic on N uptake efficiency may be reduced with conservation tillage systems and that higher fertilizer N application rates may not be needed for conservation tillage practices such as strip-till in Coastal Plain soils.

According to Howard and Hutchinson (1993), yields response to starter fertilizer applied to cotton in Tennessee (Loring soil) and Louisiana (Gigger soil) was inconsistent. Compared with broadcast fertilization at 80-40-60 lb/a of N-P-K, cotton yields were increased in only three of eight experiments from 1991-1992. In-furrow applications of starter fertilizer (11-37-0) at 3.0 and 4.5 gal/ausually reduced cotton stands and reduced yields in several instances.

Touchton et al. (1986) reported starter applications increased no-tillage cotton yields 2 out of **3** yr and conventional tillage yields in one out of 3 yr in north Alabama. Yields of cotton were increased by banding 23-23-8 lb/a (N-P-K, respectively) when cotton was subjected to moisture stress during flowering and fruiting, but were not increased by banding either 23-0-0 or 23-23-0 lb/a (N-P-K, respectively).

Banding 150 lb/a of either 10-34-0 or 11-37-0 (N-P-K, respectively) to conventional planted cotton in

Mississippi increased an average lint yield from 17 of 18 locations over a 3-yr period (Funderburg, 1988).

MATERIALS AND METHODS

The experiment was conducted in 1995 and 1996 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center, Quincy, FL.

Treatments in 1995

On 15 May, a Brown Ro-till planter was used to strip rows prior to planting cotton. On 16 May, the study was broadcast sprayed with Prowl @ 2 1/3 pt/a + Cotoran @ 1 1/2 qt/a + Gramoxone @ 1 pt/a in order to control weeds. Fertilizer was applied (broadcast application) at 500 lb/a of 5-10-15. A Cone Planter was used to plant cotton in 6-ft-wide and 23-ft-long plots with 3 ft of space between rows on 17 May. On 18 May, 400 lb/a of 3-9-18 starter fertilizer was applied over the cotton rows. Cotton was direct-sprayed between rows with Cotoran @ 1 pt/a + MSMA @ 1 pt/a using a Redball Hooded sprayer on 2 June. On 27 June, cotton was sidedressed with 70 lb N/a of 34-0-0 fertilizer with a FP row fertilizer applicator. Cotton was direct-sprayed (between rows) with Bladex @ 1 qt/a + MSMA @ 2 pt/a + Induce @ 2 qt/100 gal H_2O on 28 June. Asana (insecticide) was broadcast applied on cotton at 6 oz/a to control the bollworm eggs on 11 July. The Spra-Coupe sprayer was used to broadcast spray Baythroid 2 (insecticide) @ 2 oz/a + Pix (growth regulator) @ 4 oz/a to control the bollworm eggs and the plant's height on 14 July, Baythroid 2 @ 2 oz/a + Pix @ 8 oz/a on 26 July, Baythroid 2 @ 2 oz/a *on* 27 July and 4 Aug., and Prep @ 1% pt/a +Harvade @ 8 oz/a +Crop Oil @ 1 pt/a on 26 Sept. The Hi-boy sprayer was used to defoliate cotton with Dropp @ 1/8 lb/a + Harvade @ 8 oz/a on 13 Oct. and Harvade @ 8 oz/a+ Dropp @ 1/8 lbs/a + Prep @ 1 1/2 pt/a + Gramoxone @ 1/2 pt/a + Crop Oil @ 1 pt/a on 8 Nov. Cotton was harvested with a modified International **Cotton** Picker on 14-16 Nov.

Treatments in 1996

On 11 April, 300 lb/a of 5-10-15 fertilizer was broadcast and the study was sprayed with Roundup Ultra @ 1.5 pt/a. On 12 April, the Brown Ro-till planter was used to prepare the rows for planting cotton. The cotton variety trial was planted following wheat with the Cone Planter in 23-ft-long plots and 3-ft row spacing with the Thimet 20 G (insecticide) applied in furro @ 5 oz/100 ft. of row on 18 April. The same day, the starter fertilizer was applied over the row at 100 lb/a of 5-10-15. On 19 April, Cotoran @ **3** pt/a +Prowl @ 1.8 pt/a +Zorial @ 1.75 lb/a was broadcast before cotton emerged in order to control weeds. The experiment was sprayed on 10 May with Staple @ 1.5 oz/a + Fusillade @ 1 pt/a + Induce @ 1 qt/a to control the weeds. On 10 June, 70 lb. N/a (34-0-0 fertilizer) was sidedressed on all cotton varieties. Cotton was post-direct sprayed with Cotoran @ 1 qt/a + Bueno 6 @ 1 qt/a with a Red-ball Hooded Sprayer. Karate was broadcast on cotton to control the Bollworms population on 10 July (4 oz/a), 2 and 23 Aug. (6 and 4 oz/a respectively). On 19 Aug. all varieties were sprayed with Pix @ 12 oz/a (Growth Regulator) to control the plant's height. Cotton was defoliated with Folex 1% pt/a + Prep @ 1 1/2 pt/a + Induce @ **1** pt/20 gal H_2O on 19 Sept. and with Roundup @ 1 pt/a + Prep 1 pt/a on 11 Oct. On 21-25 Oct. cotton was harvested with a modified International Cotton Picker.

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

Cotton emergence was sigmficantly lower in 1996 when cornpared to 1995 (33.6 and 56.3 %, respectively) (Table 1). The emergence was significantly higher on cotton with the starter fertilizer application when compared to cotton with no fertilizer application for Deltapine DP 5409 (54.5 and 48.5 %, respectively) and Deltapine 5415 DP (61.1 and 46.3 % respectively) in 1995, and for Deltapine DP 5409 (37.3 and 33.8 %, respectively) in 1996. It was significantly lower with the starter fertilizer than with no starter fertilizer application for KC 311 cotton (62.1 and 53.0 %, respectively). Cotton emergence was significantly higher for Stoneville ST 474, Deltapine DP 51, Deltapine DP 5690, and Deltapine Acala 90 (62.5, 61.9, 61.2, and 60.1 %, respectively) in 1995, and for Deltapine DP 20, Deltapine DP 51, Deltapine DP 5409, Deltapine DP 5490, and Suregrow SG501(38.8, 37.5, 35.6, 35.3, 35.5 %, respectively).

There was a significant difference in lint yields for 1995 and 1996 and for a starter vs. no starter fertilizer applications (Table 2). In 1995, significantly higher lint yields were obtained from Suregrow SG 501, Deltapine DP 20, and BXN 57 (618.5, 615.2, and 531.6 lb/a, respectively) (Table 2). The difference for starter vs. no-starter was not significant for any of the varieties. In 1996, significantly higher yields were obtained from KC 311, Suregrow SG 501, and Stoneville ST 474 (778.3, 756.5, 683.1 lb/A, respectively) (Table 2). Generally, the starter fertilizer did not significantly influence cotton yields except for Stoneville ST 453 where the lint cotton yields were higher on the treatments with no starter fertilizer when compared to the treatments with the starter application (581.3 and 476.6 lb/a, respectively).

Over the 2-yr period highest lint yields were received from Suregrow SG 501 and DP 20 (687.5 and 606.3 lb/a, respectively). Generally, starter fertilizer did not increase yields or emergence, but in a few cases, it decreased the yields of cotton.

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Table 1. The emergence of State Cotton Trial with and without Starter at NFREC, Quincy, FL in 1995 and 1996.

Cotton Variety	Percent emergence in 1995				Percent emergence in 1996				Mean
	No starter	Starter	Mean	LSD (0.05)	No starter	Starter	Mean	LSD (0.05)	
Calgene BXN 57	50.8	58.9	54.8	NS	30.8	32.2	31.5	NS	43.2
Deltapine DP 20	54.0	59.9	56.9	NS	38.8	38.8	38.8	NS	47.9
Deltapine DP ---51	62.6	61.3	61.9	NS	38.7	36.3	37.5	NS	49.7
Deltapine DP 5409	48.5	54.5	51.5	2.83	33.8	37.3	35.6	2.44	43.5
Deltapine DP 5415	46.3	61.1	53.7	12.65	34.6	32.1	33.3	NS	43.5
Deltapine DP 5690	56.8	65.6	61.2	NS	35.5	35.2	35.3	NS	48.3
Deltapine ACALA 90	57.8	62.5	60.1	NS	34.7	33.0	33.8	NS	47.0
KC 311	62.1	53.0	57.6	8.68	30.1	31.4	30.7	NS	44.1
Stoneville ST 453	56.1	52.8	54.4	NS	26.3	26.9	26.6	NS	40.5
Stoneville ST 474	62.4	62.6	62.5	NS	31.3	30.9	31.0	NS	46.8
Suregrow SG 1001	54.5	57.5	56.0	NS	34.9	32.9	33.9	NS	45.0
Suregrow SG 501	44.4	44.6	44.5	NS	36.0	35.0	35.5	NS	40.0
Mean	**54.7**	**57.9**	**56.3**	**NS**	**33.8**	**33.5**	**33.6**	**NS**	**44.9**
$LSD_{(0.05)}$	-	-	7.88	-	-	-	2.96	-	1.71

$LSD_{(0.05)}$ for Year = 1.71
$LSD_{(0.05)}$ for Variety = 4.20
$LSD_{(0.05)}$ for Starter = NS
$LSD_{(0.05)}$ for Year x Variety = 5.94
$LSD_{(0.05)}$ for Year x Starter = 2.42
$LSD_{(0.05)}$ for Year x Variety x Starter = NS

Table 2 The lint cotton yield of State Cotton Trial with and without Starter at NFREC, Quincy, FL in 1995 and 1996.

Cotton Variety	Lint cotton yield (lbs/a) in 1995				Lint cotton yield (lbs/a) in 1996				Mean (lbs/a)
	No starter	Starter	Mean	LSD (0.05)	No starter	Starter	Mean	LSD (0.05)	
Calgene BXN 57	501.5	561.7	531.6	NS	614.5	585.5	600.0	NS	565.8
Deltapine DP 20	595.1	635.3	615.2	NS	600.1	594.8	597.5	NS	606.3
Deltapine DP 51	407.9	441.4	424.6	NS	714.2	641.7	678.0	NS	551.3
Deltapine DP 5409	394.5	441.3	417.9	NS	612.1	546.0	579.1	NS	498.5
Deltapine DP 5415	321.0	240.7	280.8	NS	752.0	601.8	676.9	NS	478.9
Deltapine DP 5690	374.5	374.5	374.5	NS	591.1	661.6	626.4	NS	500.4
Deltapine ACALA 90	247.4	240.7	244.0	NS	646.2	661.1	653.7	NS	448.8
KC 311	334.4	294.2	314.3	NS	804.9	751.6	778.3	NS	546.3
Stoneville ST 453	508.2	414.6	461.4	NS	581.3	476.6	529.0	24.4	495.2
Stoneville ST 474	367.8	394.5	381.1	NS	687.5	678.6	683.1	NS	532.1
Suregrow SG 1001	401.2	381.1	391.2	NS	662.8	627.5	645.2	NS	518.2
Suregrow SG 501	608.5	628.6	618.5	NS	788.8	724.2	756.5	NS	687.5
Mean	**421.8**	**420.7**	**421.3**	**NS**	**669.6**	**629.3**	**649.2**	**39.6**	**534.6**
$LSD_{(0.05)}$	-	-	131.2	-	-	-	97.1	-	81.9

$LSD_{(0.05)}$ for Year = 33.4
$LSD_{(0.05)}$ for Variety = 81.9
$LSD_{(0.05)}$ for Starter = NS
$LSD_{(0.05)}$ for Year x Variety = NS
$LSD_{(0.05)}$ for Year x Starter = NS
$LSD_{(0.05)}$ for Year x Variety x Starter = NS

Strip-Till Versus Conventional Tillage on Yield and Petiole-Sap Nitrate of Cotton and Soil Nitrate

***F. M. Rhoads, D. L. Wright, P. J. Wiatrak, and S. T. Reed**

INTRODUCTION

A conservation compliance plan must exist on highly erodible land if a producer wishes to receive USDA benefits. This requirement was stated in the Food Security Act of the 1985 Farm Bill and must have been fully emplemented by I January 1995 (Bogusch and Supak,1995). There has been a rapid growth of interest and acreage of cotton *(Gossypium hirsutum* L.) in conservation tillage in the Southeast (York, 1995). About 10% of the cotton acreage in the Southeast was either in no-till or strip-till systems in 1995 and further increases are expected. There are benefits of omsewation tillage, even where conservation compliance is not a concern. Examples include reduced number of trips over the field, and more efficient use of time, labor, and equipment in the overall farm operation. Furthermore, cover crop residue has value in conserving soil moisture and improving water quality. Sand blasting of seedling cotton on sandy soils can be avoided by planting into cover crop mulch. Since climate, growing conditions, and soils are different in each cotton growing region, research must be conducted in each region to measure cotton response to different types of conservation tillage. The objective of this research was to determine yield, N requirements, and N movement in soil for strip-tilled versus conventional-tilled cotton

MATERIALS AND METHODS

A cotton production test with ' NuCotn 33B' was initiated in the spring of 1996 on Dothan sandy loam (fine, loamy, siliceous, thermic, Plinthic Kandiudult) located on the University of Florida, North Florida Research and Education Center near Quincy, Florida. Tillage treatments were strip-till and conventional-till. Nitrogen rates were 0, 60, 120, and 180 lb/a. After harvesting, three winter cropping systems were superimposed over tillage and N treatments as follows:

[1]F.M. Rhoads, [1]D.L. Wright, [1]P.J. Wiatrak, and [2]S.T. Reed, 1University of Florida, NorthFl. Research and Education Center, Quincy, FL. and [2]Florida A & M University, College of Engineering Sciences, Technology and Agriculture, Tallahasse, FL. Manuscript received 16 April 1997. * Corresponding author. Florida Agric. Exp. Stn. Journal Series No. R-05707.

fallow, legume cover crop, and wheat *(Triticum aestivum* L.) cover crop. The experimental design was a split-split plot with four replications. Main plots were tillage treatments, subplots were winter cropping systems, and sub-sub plots were N application rates. Cotton plots consisted of six rows 3 ft wide and 25 ft long. Cotton fiber yield was determined as 38% of seed plus fiber yield.

Petiole-sap nitrate was monitored weekly, starting at first bloom appearance, by collecting 15 petioles at the fourth leafposition from the top. Nitrate concentration was determined with a portable nitrate meter (Cardy Nutrient Meters).

All plots were sampled to a depth of 4 ft to determine soil nitrate levels at different depths (0 to 1, 1 to 2, 2 to 3, and 3 to 4 ft) before fertilizer was applied in the spring and the influence of fertilizer on nitrate after harvest. Soil sample extracts were analyzed for nitrate after shaking soil with calcium sulfate solution, filtering, adding powder containing Cd to a 5 mL aliquot and measuring transmittance at 425 microns. All data were analyzed for statistical significance using a desk-top computer with a MSTAT-C statistics package (Freed et al., 1989).

RESULTS AND DISCUSSION

Tillage main effect did not influence yield of cotton in 1996. Fiber yield was 1139 lb/a with ship-till and 1027 lb/a with conventional-till, which were not significantly different at (P=0.26). However, strip-till produced a significantly (alpha=0.05) greater yield than conventional-till with 180 lb of fertilizer N/a (Table 1.). There were no differences in yield between tillage treatments at other fertilizer N rates. Equal or better yields with strip-till compared to conventional-till would allow cotton producers in North Florida to comply with conservation rules of the USDA without incurring costly yield losses. Also, the benefits of conservation tillage such as increased efficiency in farm operations and water use, along with seedling protection with cover crop mulch, could make conservation tillage more economical than conventional tillage.

Tillage did not influence nitrate-N concentration of cotton-petiole sap (Table 2); petiole-sap nitrate-N levels were proportional to fertilizer N rates for the first three wk of blooming. After three wk, there were no differences in petiole-sap nitrate-N levels between the rates of 0 and 60 lb N/a. The petiole-sap nitrate-N level of the 180 lb N rate remained significantly higher than other treatments during the 7-wk sampling period. Petiole-sap nitrate-N levels for the 120 lb N/a rate were not significant from the *zero* rate at the 6- and 7- wk sample dates. Since there was no significant difference in yield between the 60 and 120 lb N rates, data in Table 2 suggest that petiole-sap nitrate-N level of cotton is important only during the first and second wk of blooming and that critical values were 1500 ppm the first wk and 500 ppm the second wk.

Soil nitrate-N levels were significantly higher with conventional-till at 120 and 180 lb of N/a than with strip-till (Table 3). However, tillage did not influence soil nitrate-N levels with soil depth. Soil samples taken in the spring before fertilizer was applied contained between 43 and 51 lb of nitrate-N/a in the top four ft of the profile (Table 4), while fall samples contained between 115 and 154 lb of nitrate -N/a. The 0 and 60 lb fertilizer N rates each contained 115 lb of nitrate-N/a in the soil profile, while there was about a 20 lb/a increase of *soil* nitrate-N per 60 lb of fertilizer N between the 60 and 180 lb N rates. This suggests that the 120 and 180 lb N rates were excessive, supplying more N than the plants could utilize. The absence of a significant yield increase between the 60 and 120 lb N rates support the possibility of excessive N. Excessive nitrate-N in the 120 and 180 lb N plots accumulated in the 2- to 4- ft depth range, with peak levels between the 2- and 3-ft depths (Table 4).

CONCLUSIONS

Strip-till did not reduce yield or influence mole-sap nitrate-N levels of cotton. Petiole-sap nitrate-N levels of cotton appeared to be most critical during the first two wk of blooming. Conventional-till plots appeared to accumulate more soil nitrate-N at the 120 and 180 lb N rates than strip-till plots. The 120 and 180 lb N rates appeared to be excessive in this experiment as shown by nitrate-N accumulation below the 2-ft soil depth.

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Table 1. Yield of cotton fiber with two tillage systems and four N rates.

Fertilizer-N Rate	Tillage	
	strip-till	Conventional-till
	lb/a	
0	766	758
60	1188	998
120	1156	1183
180	1445	1170
$LSD_{0.05}$	192	

Table 2. Nitrate-N concentration in petiole sap of cotton at seven sample dates with four fertilizer-N rates and two tillage systems.

Week of Bloom	Fertilizer-N Rate (lb/a)				Tillage		
	0	60	120	180	strip	Conv.	$LSD_{0.05}$
	ppm						
1	140	1626	2021	2264	1497	1529	277
2	130	570	1440	1569	916	939	177
3	151	318	1349	1790	945	859	197
4	165	194	1039	1596	752	746	223
5	201	207	734	1575	642	717	319
6	245	237	361	1315	426	654	424
7	282	305	305	852	435	428	161

Table 3. Soil nitrate-N levels at four fertilizer-N rates and four soil depths with two tillage systems.

Fertilizer-N Rate	Tillage		Soil Depth	Tillage	
	strip	Conventional		strip	Conventional
lb/a	----------------ppm--------------------		-- ft --	----------------ppm---------------------	
0	7.3	7.0	0-1	8.1	8.9
60	6.8	7.6	1-2	7.7	8.1
120	7.8	9.0	2-3	7.7	8.6
180	9.0	10.1	3-4	1.4	8.1
$LSD_{0.05}$	1.04			1.04	

Table 4. Soil nitrate-N levels at spring and fall sample dates, with four fertilizer-N rates and four sample depths.

Fertilizer N-rate	Sample Date		Soil Depth	Fertilizer-N Rate (lb/a)			
	Spring	Fall		0	60	120	180
---------------lb/a------------------------			--ft--	-------------------------ppm---------------------------------			
0	51†	115†	0-1	8.1‡	8.3‡	8.4‡	9.2‡
60	46	115	1-2	7.0	7.3	8.0	9.2
120	50	134	2-3	6.7	6.5	8.8	10.7
180	43	154	3-4	7.0	6.7	8.2	9.1
$LSD_{0.05}$	7.2	13			1.5		

†Multiply lb/a by 0.0625 to convert to ppm in top four ft of soil.
#Multiply ppm by 4 to convert to lb/a in a one A layer of soil.

Cover Crops and Tillage Practices for Cotton Production on Alluvial Soils in Northeast Louisiana

***E. M. Holman, A. B. Coco, and R. L. Hutchinson**

INTRODUCTION

Advances in equipment and herbicide technology have contributed greatly to the increase in producer acceptance of reduced tillage practices. The development of reduced tillage systems that include the use of pre-emerge and post-emerge herbicides in lieu of pre-plant soil incorporated herbicides has greatly reduced the need for spring tillage (Crawford, 1992; Reynolds, 1990). These effective herbicide schemes have, in many cases, made practices such as no-tillage and stale-seedbed possible. These reduced tillage practices have greatly enhanced the opportunities to produce cotton on clay soils in the Mid-South (Boquet and Coco, 1993), and have provided a method for environmental compliance on highly erodible soils (Valco and McClelland, 1995). Reduced soil erosion (Hutchinson, et al., 1991), increased soil organic matter (Boquet and Coco, 1993), and reduced soil moisture evaporation (Wilhelm et al., 1986) are just some of the documented benefits from minimum tillage. Reduced or conservation tillage has also, in many instances, lead to lower equipment and fuel costs resulting from savings in time and labor. In addition, cover crops have been found to be an important component of conservation tillage systems (Hutchinson et al., 1991; Ebelharet al., 1984).

However, questions remain on the importance of deep tillage in relation to reduced tillage practices on some of the common alluvial soil types in the Mid-South. Therefore, a study was initiated in the fall of 1995 to investigate the interaction between deep tillage and various other conservation tillage practices.

MATERIALS AND METHODS

A field study was initiated in the fall of 1995 on a Commerce silt loam (fine-silty, mixed, nonacid, thermic Aeric Fluvaquent) and on a Sharkey clay (very-fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts) at the Northeast Research Station near St. Joseph LA. Tillage treatments included conventional tillage (CT), Fall bedded (FB) and no-tillage (NT). The NT treatments were split for in-season cultivation. Cover crop treatments were native vegetation, hairy vetch *(Vicia villosa* L.), and wheat *(Triticum aestivum* L.). Thus, eight treatments were designed to compare these various conservatino tillage practices (Table 1). The experimental design was a randomized complete block with four replications. Plot size was eight (40 in. row spacing) rows wide by 65 ft long.

In the fall of 1995, the cover crops were planted, the CT treatments were subsoiled, and the FB treatments were re-hipped and rolled. In the spring of 1996, the wheat plots on both soil types received 30 lb N/a as ammonium nitrate. On 4 March, the CT treatments were disked, and were tilled with a field cultivator and hipped on 12 April. Both tests were planted with Sure-Grow 501 seed on May 7 with a John Deere model 7300 series planter equipped with ripple coulters, conventional hoppers, and granular infurrow applicators. At planting, all plots received Temik 15G + Terraclor TSX (0.5 lb + 1.0 lb ai/a). Although the planter was equipped with ripple coulters, in many places on the silt loam, the coulters did not cut through the thick mat of vetch, but only pressed it into the seed furrow. As a result, the stand of cotton *(Gossypium hirsutum* L.) in the vetch plots on silt loam was inadequate, therefore they were replanted on 21 May.

Herbicide applications included Roundup Ultra at 1.0 lb ai/a as a burndown to all cover crops in early April followed by Gramoxone at 1.0 lb ai/a 14 days later. All plots received Cotoran and Prowl, (1.2 lb + 1.0 lb ai/a) preemerge, Staple broadcast at 1.5 oz ai/a , Cotoran + MSMA (0.5 lb + 1.0 lb) ai/a post-directed, and Bladex + MSMA (0.7 lb + 2.0 lb ai/a) at layby.

The cotton planted in the vetch plots on the silt loam received 60 lb N/a while all other plots received 90 lb N/a Cotton planted in the vetch plots on clay received 90 lb N/a while all other plots received 120 lb N/a. Insect control and other agronomic practices followed Louisiana Extension Service recommendations.

The silt loam test was defoliated on 1 October and the center four rows of each plot were harvested on 10 October with a spindle picker adapted for small plot harvest. The clay test was defoliated on 26 September and the Center four rows of each plot were harvested on 7 October.

E.M. Holman, A.B. Coco, and R.L. Hutchinson. Louisiana State University Agricultural Center, Northeast Research Station, St Joseph LA. Manuscript received 21 March 1997. * Corresponding author.

RESULTS AND DISCUSSION

On the silt loam, there were no differences in biomass production between the wheat and vetch cover crops prior to herbicide application (data not shown). The cotton in the no-till vetch plots was significantly later than the other treatments in maturity due to replanting. This was evidenced by the shorter plant height and lower number of nodes measured on 24 June (Table 1). The delay in maturity was also evident in the nodes above white flower counts, with the vetch plots averaging 7.4 and 5.5 at the last two sample dates compared to 6.0 and 4.3 for all the other treatments. This may also account for the lower seedcotton yield produced in the no-till vetch plots. Among the no-tillage plots, there were no significant differences due to cultivation.

The. CT treatment was subsoiled in the row with a Paratill in the fall. Cotton has been shown to respond to subsoiling on this soil type (Crawford 1978), and in this experiment the CT treatment resulted in significantly more seedcotton than any of the no-tillage treatments (Table 1). This may reinforce the hypothesis that annual fall subsoiling is needed on this soil type, however the CT treatment was not significantly different (at P=0.05 level) than the FB treatment, which was not subsoiled. Therefore, the yield increase associated with CT may be partially related to other factors.

On the Sharkey clay, the FB treatment resulted in significantly more seedcotton than all the other treatments (Table 2). The plants in the FB treatment were also taller and had more main stem nodes by 24 June than the plants in the other treatments, with 9.1 nodes and 12.0 in. in height compared to averages of 8.3 nodes and 8.7 in. for the other treatments. This could possibly be due to a higher soil temperature early in the season which resulted in more rapid early growth. There were no differences in yield with respect to cover crop or in-season cultivation among the six no-till treatments. There were also no significant differences with respect to crop maturity as measured by nodes above white flower counts.

PRELIMINARY CONCLUSIONS

On the Commerce silt loam, it appears from the first year results that annual fall subsoiling may be an important factor in the success of any reduced tillage system. In order to further investigate the effect of deep tillage on the growth and development of cotton in reduced tillage systems, all of the treatments on both soil types were split for in-row subsoiling with a Paratill in the 1996. On the Sharkey clay, the fall bedded tillage system was superior, possible due to a higher early growth rate.

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Table 1. Growth and yield of cotton grown on Commerce silt loam under various tillage and cover crop regimes.

Tillage	Cover Crop	Cultivation	Seedcotton Yield	Main-Stem Nodes'	Plant Height'	Node Above White Flower — Sample dates —		
			lb/a	#	in.	July 8	July 15	July 29
None	None	No	3303	11.7	20.5	7.74	6.34	4.19
None	Wheat	No	3145	11.7	18.6	7.65	5.95	4.10
None	Vetch	No	2666	9.0	11.4	--	7.41	5.67
None	None	Yes	3445	12.2	20.0	7.40	5.85	4.45
None	Wheat	Yes	3128	11.5	18.0	7.84	6.39	4.45
None	Vetch	Yes	2598	8.9	12.2	--	7.45	5.30
Conventional	None	Yes	3857	12.2	23.7	7.30	6.04	4.39
Fall bedded	None	Yes	3563	11.8	20.9	7.21	5.93	4.44
LSD (0.05)			323	0.56	1.19	0.24	0.30	0.28
C.V. *(Yo)*			6.8	8.9	11.5	10.4	15.2	19.7

† Number of main-stem nodes counted on June 24,1996.

‡ Plant height **was** also measured on June 24,1996.

Table 2. Growth and yield of cotton grown on Sharkey clay under various tillage and cover crop regimes.

Tillage	Cover Crop	Cultivation	Seedcotton Yield	Main-stem Nodes	Plant Height	Node Above White **Flower** — Sample dates —		
			lb/a	#	in.	July 8	July 22	July 26
None	None	No	2553	8.4	9.0	6.10	4.90	4.41
None	Wheat	No	1754	7.3	7.5	5.56	4.88	4.44
None	Vetch	No	2129	8.6	8.3	6.30	4.70	4.31
None	None	Yes	2552	8.5	9.5	6.09	4.89	4.16
None	Wheat	Yes	2029	8.0	8.1	5.76	4.61	4.05
None	Vetch	Yes	1992	8.8	8.5	6.25	4.97	4.86
conventional'	None	Yes	2541	8.7	10.0	6.11	5.14	4.16
Fall bedded'	None	Yes	2994	9.1	12.0	6.19	4.66	3.64
LSD (0.05) =			419	0.49	0.97	0.25	0.29	0.29
C.V. *(Yo)* =			6.8	10.3	18.8	13.1	19.0	22.2

† The Conventional tillage consisted of Spring tillage and rebedding.

‡ The Fall bedded tillage consisted of Fall rebedding and rolling.

Cover Crops for Weed Control in Conservation-Tilled Cotton

***M. G. Patterson, D. W. Reeves, and B. E. Gamble**

INTRODUCTION

The use of cover crops in conservation tillage offers many advantages, one of which is to control weeds. In southern Brazil, black oat *(Avena strigosa* Schreb.) is the predominant cover crop on millions of acres of conservation - tilled soybean *[Glycine max* (L.) Merr.] due in part to its weed suppressive capabilities. We initiated a field study in 1995 to determine the suitability of black oat as a cover crop for conservation-tilled cotton *(Gossypium hirsutum* L.) using the Brazilian system of managing cover crops. The Brazilian system is based on terminating the cover crops during early reproductive growth by treating with a herbicide and mechanically rolling the covers to form a dense mat of residue on the soil surface. We wantedto compare the Brazilian system using black *oat* and two common cover crops used in the southeastern USA, i.e., rye *(Secale cereale* L.) and wheat *(Triticum aestivum* L.). Results reported here are for the first 2-yrs of the study (1995 and 1996).

MATERIALS AND METHODS

The *study* site was a Dothan fine sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudult) in southeastern Alabama It had been in conservation tillage (strip-tilled) for the previous 8 yr and had a high population of Palmer Amaranth *(Amaranthus palmer;* S. Watts.). Cotton was grown in a strip-plot design of four replications. Horizontal plots were winter covers of black oat, rye, wheat, or fallow. Dominant winter weeds in the fallow system were cutleaf evening primrose *[Oenothera laciniota* Hill] and chickweed *[Stellaria media* (L.) Vill.]. The cover crops were sown in November of 1994, 1995, and 1996. Cover crops were terminated with an application of glyphosate (1.0 lb a.i./a) 3 wk prior to planting DPL 5690 cotton in early May each year. Within 3 d following glyphosate application, the covers were rolled with a modified stalk chopper to lay all residue flat on the soil surface. Cotton wasplanted in 36-in row widths with a John Deere MaxiMerge® planter equipped with Martin@ row cleaners and Accra-Plant@retrofit seeding disk openers.

Vertical plots were herbicide input levels: none, low, or high. The low herbicide input level consisted of a preemergence application of pendimethalin (1.0 lb a.i./a) + fluometuron (1.5 lb a.i./a). For the high input level, additional applications of fluometuron (1.0 lb a.i./a) + DSMA (1.5 lb a.il/a) early post-direct and lactofen (0.2 lb a.i./a) + cyanazine (0.75 lb a.i./a) late post-direct were made. In 1995, because the site has a well developed hardpan, the cotton was in-row subsoiled with a narrow parabolic subsoiler equipped with pneumatic tires to close the subsoil channel with minimal disturbance of the residue. In 1996, the area was paratilled 2 wk prior to planting. In both years, residue disturbance was minimal and residue formed a dense mat over the soil surface.

Weed control was determined by visual ratings (0 to 100 % control scale) early in the season (approximately 30 days after planting) and late in the season at 51 and 80 days after planting, respectively, in 1995 and 1996. In 1995, we also determined weed biomass and control ratings for grasses (primarily large crabgrass *[Digitaria sanguinalis* (L.) Scop.] and Texas panicum *[Panicum texanum* Buckl.]) and sedges *[Cyperus esculentus* L. and *C. rotundus* L.], sicklepod *(Cassia obtusifolia* L.), and Palmer amaranth. We then determined Pearson correlation coefficients between visual ratings and weed biomass to measure the validity of visual ratings. Correlation coefficients ranged from 0.77 to 0.94 and in 1996 we only used visual ratings to measure weed control. Late season weed control ratings in Table 2 are averaged over all dominant weed species.

Recommended practices were used for insect control. Seed cotton yield was determined by machine harvesting the middle two rows of each 30-A long plot.

RESULTS AND DISCUSSION

In 1995, residue production was similar for all winter cereal covers, averaging 4665 lb dry mater/a. Winter weeds produced 1260 lb *dry* matter/a in fallow plots. The severe winter of 1996 resulted in differences in residue production by the covers. Dry matter averaged 5580, 3900, 1175, and 780 lb/a for rye, wheat, black oat, and winter fallow, respectively, in 1996.

Although there were significant cover x herbicide input level interactions, no cover crop was economically

[1]M.G. Patterson, [2]D.W. Reeves, and [1]B.E. Gamble, [1]Alabama Agricultural Experiment Station, Auburn University, and [2]USDA-ARS National Soil Dynamics Laboratory, Auburn, AL. Namuscript received 14 March 1997. *Corresponding author.

effective in controlling weeds without a herbicide program (Table 1). Without herbicide, black oat gave more effective weed control (based on visual ratings and weed biomass than rye (35% control vs. 25% control) in 1995 but in 1996, rye gave greater control than black oat (54% control vs. 18% control) due to severe winter kill of black oat. Weed control following wheat and winter fallow were similar both years, averaging 14% and 19% in 1995 and 1996, respectively.

Averaged across winter covers, seed cotton yields were 3449 and 2925 lb/a with the high herbicide input system vs. the low input *system* in 1995. Without herbicide, there were no harvestable yields. Seed cotton yields with the low input system following black oat (3242 lb/a) were comparable to those following winter fallow (3267 lb/a) and the high input system (Table 2).

In 1996, yields averaged 428, 1475, and 2892 lb seed cotton/a with no, low, and high herbicide input programs, respectively. Winter covers also affected seed cotton yields in 1996, averaging 820, 1292, 1520, and 2759 lb/a for fallow, black oat, wheat, and rye, respectively. Maximum yield occurred with the high herbicide input system and a rye cover crop (3691 lb/a). Within the low herbicide input program, yields averaged 393, 1029, 1380, and 3098 lb seed cotton/a following covers of winter fallow, black oat, wheat, and rye, respectively.

Preliminary results indicate: 1) rye and black oat are more effective cover crops than wheat for weed control in conservation cotton, but inferior cold tolerance of black oat compared to rye may limit its zone of adaptation, 2) a strong yield benefit for planting conservation tilled cotton using the Brazilian management system, i.e., cover crops grown to produce large amounts (>4,000 lb/a) of residue rolled to form a dense mat on the soil surface.

Table. 1. Seed cotton yields as affected by cover crop and herbicide system.

	1995				1996			
	Herbicide Input System				Herbicide Input System			
Cover Crop	High	Low	None	*Mean*	High	Low	None	*Mean*
	seed cotton (lb/a)							
Black oat	3424	3242	---†	***3334***	2826	1029	24	***1293***
Fallow	3267	2686	---	***2977***	2069	393	0	***821***
Rye	3557	2989	---	***3273***	3691	3098	1489	***2759***
Wheat	3545	2783	---	***3164***	2983	1380	200	***1521***
Mean	***3449***	***2925***	---		***2892***	***1475***	***428***	

1995 $LSD_{(0.10)}$ for cover crop = ns ***(P50.20);*** for herbicide level = 421 ; for cover crop withm herbicide level interaction = ns *(P≤0.24)*; for herbicide level within cover crop interaction = ns *(P≤0.24)*.
1996 $LSD_{(0.10)}$ for cover crop = 362; for herbicide level = 434; for cover crop withm herbicide level interaction = ns *(P≤0.23)*; for herbicide level withm cover crop interaction = ns *(P≤0.23)*.

†No harvestable yield.
‡Calculated for High and Low level of herbicide only.

Table 2. Cotton weed control as affected by cover crop and herbicide system.

	1995				1996			
	Herbicide Input System				Herbicide Input System			
Cover Crop	High	Low	None	*Mean*	High	Low	None	*Mean*
	weed control (%)							
Black oat	95	91	35	*74*	78	55	18	*50*
Fallow	94	86	13	*64*	72	43	22	*45*
Rye	94	89	26	*70*	91	82	54	*76*
Wheat	94	87	14	***65***	82	43	20	***51***
Mean	***94***	***88***	***22***		***81***	***58***	***28***	

1995 $LSD_{(0.10)}$ for cover ***crop = 6;*** for herbicide level = 4; for cover crop withm herbicide level interaction = 8; for herbicide level withm cover **crop** interaction = 7.
19% $LSD_{(0.10)}$ for cover crop = 8; for herbicide level = 10; for cover crop withm herbicide level interaction = ns *(P≤0.18)*; for herbicide level within cover crop interaction = ns ***(P≤0.18).***

Tillage and Cover Crops Affect Cotton Growth and Yield and Soil Organic Matter

*D. J. Boquet, R. L. Hutchinson, W. J. Thomas, and R.E.A. Brown

ABSTRACT

The loess soils in the mid-Southern USA are easily eroded, drought prone, and have low organic matter and poor physical structure Without irrigation, crop yields are low. Conservation tillage and winter cover crops can reduce erosion and increase soil organic matter, thereby improving the soil's physical structure. This study was conducted to determine the effects of tillage intensity and cover crops on cotton *(Gossypium hirsutum)* growth, yield, and soil organic matter. A field experiment was conducted from 1987 through 1996 on Gigger silt loam (fine-silty, mixed, thermic Typic Fragidaulf) with three tillage systems and four winter cover crops. Tillage systems were conventional-till (CT), ridge-till (RT), and no-till (NT), Winter cover crops were native vegetation, crimson clover *(Trifolium incarnatum)*, hairy vetch *(Vicia villosa)*, and wheat *Triticum aestivum)*. At 30 d after planting, cotton plants in NT were 9 to 33% taller with 12 to 21% more nodes than in CT and RT systems. Plant growth rate in CT was reduced compared with NT and RT as shown by 15% smaller nodes after white flower (NAWF) and 30% shorter terminal internode length (TIL) in July. From 1991through 1993, NT cotton yielded 829 lb lint/a. which was 18% higher than RT and 6% higher than CT. Cotton following crimson clover consistently yielded 10 to 20% less than cotton following vetch or wheat. From 1994 through 1996, NT cotton yielded 979 Ibs lint per acre, which was 16% higher than RT and 6% higber than CT. Per acre lint yield following wheat was 981 lb; following vetch; 924 lb and following native vegetation, 938 lb. After 6-yr of conservation tillage, soil organic matter had more than doubled in all treatments from an initial value of 0.5%. due to a reduction in tillage intensity. After 10-yr, NT and wheat plots had the highest levels of soil organic matter. Adoption of NT practices and winter cover crops in the Macon Ridge area of Louisiana would increase yields of cotton while minimizing soil erosion.

D.J. Boquet, R.L. Hutchinson, W.J. Thomas, and R.E.A. Brown. Louisiana State University Agricultural Center, Winnsboro, and St. Joseph, LA. Manuscript received 3 March 1997. *Corresponding author.

INTRODUCTION

Cotton *(Gossypium hirsutum* L.) is grown extensively in the Macon Ridge Area of Louisiana. This region has undulating topography and loess soils that are classified as highly erodible (Martin, et al., 1981). Soil erosion has already reduced the productivity of these soils and threatens to further reduce long-term productivity Conservation tillage systems that maximize surface residue are among the most effective and economical practices for reducing soil erosion on erodible cropland (Hutchinson, 1993). In addition to crop residue, cover crop mulches are also effective for erosion control and to conserve soil water for crop use (Unger and Weise, 1979). The objectives of this study were to: 1) determine the growth and yield responses of cotton to conservation tillage practices and winter cover crops and 2) determine the effects of tillage and winter cover crops on soil organic matter.

MATERIALS AND METHODS

A field study was conducted from 1987 through 19% at the Macon Ridge Research Station in Winnsboro on a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragiudalf). The site chosen for the experiment was on a field with a 1.6% slope that had experienced considerable erosion. Four cover crops (winter wheat *(Triticum aestivum* L.), hairy vetch *(Vicia villosa* L.), crimson clover *(Trifolium incarnatum* L.), and native vegetation) were evaluatd across three tillage systems of conventional-till (CT), ridge-till (RT), and no-till (NT). The experimental design was a factorial arrangement of tillage and cover crops in a randomized complete block with four replications. Plots were eight rows (40-in. spacing), 50 ft in length. All treatments have been miantained in the same location since 1987. The test was not irrigated.

The crimson clover (15 lb/a), hairy vetch (25 lb/a), and wheat (90 lb/a) were broadcast seeded into the standing cotton stalks between mid-October and early-November each year. The cotton stalks were shredded with a rotary mower after the cover crops were seeded.

The CT treatments were disked twice in early

April and twice again in late April each year. Following the final disking, the CT plots were bedded with disk hippers. A reel and harrow bed conditioner was used for final seedbed preparation. Fall tillage was not used in this study, although this was a common practice for many years on this field and on farms in the area at the time this study was initiated.

The NT and RT wheat and native vegetation treatments received a burndown application of glyphosphate (Roundup) at 1.0 lb ai/a in early April and paraquat dichloride (Gramoxone Extra) at 0.5 lb ai/a in late April. The NT and RT crimson clover and hairy vetch treatments received bumdown applications of paraquat dichloride (Gramoxone Extra) at 0.5 lb ai/a in early April and again in late April.

No seedbed preparation was used in the NT plots, however, ripple coulters were mounted ahead of each planter unit for planting the NT treatments. In the RT plots, a modified Buffalo® row cleaner was used to clear the residue and approximately one inch of soil from the top of the beds prior to planting. Cotton was planted in all plots in early May with in-furrow treatments of aldicarb (Temik) at 0.5 lb ai/a and pentachloronitrobenzene + 5-ethoxy-3-(trichloromethyl)-1,2,4 thiadiazole (Terrachlor Super X) at 1.0 + 0.25 lb ai/a.

Preemerge weed control in all plots consisted of a broadcast application of pendimethalin (Prowl) at 1.0 lb ai/a plus fluometruon (Cotoran) at 1.2 lb ai/a. All CT and RT treatments were cultivated twice and received banded post-emergence applications of fluometuron (Cotoran) plus MSMA (0.6 + 1.0 lb ai/a) and prometryn (Caparol) plus MSMA (0.31 + 1.0 lb ai/a). Ridging wings were attached to the cultivator to rebuild the beds in the RT plots at the last cultivation. From 1987 through 1993, postemergence weed control in NT plots was the same as for CT and RT. From 1994 through 1996, the NT plots were not cultivated but received a post-directed application of fluometuron (Cotoran) plus MSMA (0.6 + 1.0 lb ai/a) followed by broadcast application of prometryn (Caparol) plus MSMA (0.62 + 2.0 lb ai/a) applied beneath the cotton plants. All plots received a layby application of cyanazine (Bladex) at 1.1 lb ai/a plus MSMA (1.65 lb ai/a).

In late May each yr, all plots received 70 lb N/a as 32% UAN solution either as a dnbble band approximately 10 in. from the drill, or as a knifed application approximately 3 in. deep and 10 in. from the drill. An additional 30 lb N/a was sidedress applied to wheat and native vegetative plots in June. The test was checked twice weekly for insects and appropriate insecticide applications made whenever any pest insect populations reached threshold numbers. The entire test was defoliated in late-August or early-September each year, usually with thidiazuron (Dropp) at 0.05 lb ai/a plus tribuphos (Def) at 0.6 lb ai/a.

A spindle picker was used to harvest the four center rows of each plot. Boll samples were hand picked from border rows and laboratory-ginned to provide a lint percentage. The lint percent was used to calculate the lint yield by multiplying machine-picked seedcotton yields by the laboratory-derived lint percentages. Ten plants per plot were measured for plant height and number of mainstem nodes. From 1994 through 1996, plant measurements were expanded to include nodes above white flower (NAWF), and terminal internode length (TIL) (the average internode length above the NAWF) at several dates during the cotton growing season. Soil samples were collected from each plot *after* harvest and analyzed for nutrients and organic matter content by the Louisiana State University Agronomy Department Soils Laboratory.

All data were analyzed using the ANOVA or GLM procedures of SAS (SAS Institute, 1989). The protected LSD (P=0.05) test was used for mean separation.

RESULTS AND DISCUSSION

Plant Growth

Plant height and number of mainstem nodes were significantly affected by tillage but not by cover crops or tillage x cover crop interaction, when averaged across years (Tables 1 and 2). At 30 d after planting (DAP), cotton plants were taller and had more nodes in NT than in RT and CT systems. At early-and mid-bloom dates, NAWF was significantly affected by tillage and cover, but not by tillage x cover crop interactions. Plant growth rate in CT was reduced compared with NT and RT as shown by the smaller NAWF at 5 July and 18 July and TIL at 18 July.

Yield

In the initial year of the study (1987), yields in NT were significantly higher than in RT treatments but were not different from CT (Tables 3 and 4). Cotton following hairy vetch or wheat cover crops yielded significantly higher than when following crimson clover or native vegetation. From 1988 through 1990, lint yield was not affected by tillage system. Cotton following wheat was higher yielding than when following other cover crops. During the 1991 through 1993 and 1994 through 1996 periods, tillage had an effect on lint yield with NT yielding higher than CT or RT. Cover crops also affected lint yield during this period, as yields of cotton following crimson clover were consistently lower than for cotton following vetch or native cover. During the 1991-1993 period, cotton following wheat and hairy vetch yielded similarly, but during the next three years, cotton following wheat was higher-yielding than cotton following any other cover crop.

From 1994 through 1996, NT cotton yielded significantly higher than cotton planted with other tillage systems. Cotton following the wheat cover crop yielded significantly higher than cotton following vetch or native cover crops (Table 4). The tillage by cover crop interaction for lint yield was not significant throughout the study. The advantage of the wheat cover crops is probably related to the protection provided seedling cotton from rapid temperature changes and to water conservation (Unger and Weise, 1979). The consistent reduction in yield of cotton following Crimson clover was possibly caused by allelopathic effects of the clover on cotton (Bradow, 1991) although this did not evidence itself in any of the measured plant growth parameters.

Soil Organic Matter

The initial soil organic matter levels for the test area averaged less than 0.5%. Within four yr, organic matter had almost doubled in each treatment because of the reduction in tillage intensity for all treatments (Tables 5 and 6). This included the CT treatment, as tillage (especially fall tillage) in this treatment was reduced from that occurring prior to initiation of the study in 1987. From 1988 through 1996, NT cotton plots increased soil organic matter more rapidly than CT or RT (Table 5). The greatest benefit in conserving organic matter was with NT where no cover crop was planted. Planting winter cover crops increased soil organic matter but this effect was not as large as the tillage effect

CONCLUSIONS

Cotton plant height, number of mainstem nodes, and NAWF were higher in NT than in CT. Lint yield of cotton was increased by NT treatments and/or by using wheat as a winter cover crop. Soil organic matter content was increased primarily by reduction in tillage intensity and secondarily by growing a winter cover crop. Adoption of NT practices and winter cover crops in the Macon Ridge Area of Louisiana would increase. yields of cotton while minimizing soil erosion.

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Table 1. Tillage and cover crop effects on cotton plant growth on a Gigger silt loam - Winnsboro, LA.

	Plant Height 30 DAP[1] 1994-96	Nodes 30 DAP 1994-96	NAWF[2] 7/5/96	NAWF[2] 7/18/96	Terminal Internode Leneth 7/5/96	Terminal Internode Leneth 7/18/96
	--inches--	-number-	---------number-------		----------inches--------	
			Tillage means across cover crops			
Conventional-Till	11	7.6	6.6	3.3	2.6	1.5
Ridge-Till	9	7.0	7.2	4.6	2.4	1.8
No-Till	12	8.5	7.6	4.3	2.7	1.7
			Cover crop means across tillage systems			
No Cover Crop	10	7.4	7.3	4.2	2.6	1.7
Crimson Clover	11	7.7	6.9	3.9	2.6	1.6
Hairy Vetch	11	7.9	7.2	4.1	2.5	1.7
Wheat	11	7.1	7.1	4.1	2.6	1.7
LSD (0.05) Tillage	1	0.3	0.3	0.3	0.1	0.1
LSD (0.05) Cov Crop	NS	NS	0.3	0.4	0.1	0.1
C.V. (%)	9	5	6	9	4	5

'DAP = days after planting
[2]NAWP = nodes above white flower

Table 2. Tillage and cover crop effects on cotton plant growth on a Gigger silt loam - Winnsboro, LA.

	Plant Height 30 DAP' 1994-96	Nodes 30 DAP 1994-96	NAWF[2] 7/5/96	NAWF[2] 7/18/96	Terminal Internode Leneth 7/5/96	Terminal Internode Leneth 7/18/96
	--inches--	-number-	---------number---------		---------inches---------	
			Conventional-Till			
No Cover Crop	11	7.5	6.6	3.4	2.7	1.5
Crimson Clover	11	7.9	6.4	2.9	2.5	1.4
Hairy Vetch	11	7.7	6.6	3.3	2.6	1.4
Wheat	10	7.2	6.6	3.5	2.6	1.6
			Ridge-Till			
No Cover Crop	9	6.7	7.6	4.6	2.5	1.8
Crimson Clover	9	7.1	6.8	4.5	2.5	1.6
Hairy Vetch	9	7.0	7.3	4.8	2.3	1.8
Wheat	9	7.0	7.2	4.5	2.6	1.8
			No-Till			
No Cover Crop	11	7.9	7.6	4.5	2.7	1.7
Crimson Clover	12	8.2	7.4	4.2	2.7	1.7
Hairy Vetch	13	8.9	7.8	4.3	2.6	1.7
Wheat	14	8.8	7.6	4.3	2.7	1.8
LSD (0.05) Tillage x Cov	1.4	0.6	0.6	0.5	0.2	0.2
C.V. (%)	9	5	6	9	4	5

'DAP = days after planting
[2]NAWF = nodes above white flower

Table 3. Tillage and cover crop effects on cotton lint yield on a Gigger silt loam - Winnsboro, LA.

	Lint Yield			
	1987	1988-90	1991-93	1994-96
	------------------------------------lb/a------------------------------------			
	Tillaee means across cover crops			
Conventional-Till	654	671	779	921
Ridge-Till	624	602	703	844
No-Till	674	604	829	979
	Cover crop means across tillage systems			
No Cover Crop	597	593	767	938
Crimson Clover	628	590	711	815
Hairy Vetch	700	627	801	924
Wheat	678	693	802	981
LSD (0.05) Tillage	39	45	37	35
LSD (0.05) Cov Crop	46	52	42	41
C.V. (%)				

Table 4. Tillage and cover crop effects on cotton lint yield on a Gigger silt loam - Winnsboro, LA.

	Lint Yield			
	1987	1988-90	1991-93	1994-96
	lb/a------------------------------------			
	Conventional-Till			
No Cover Crop	641	667	781	957
Crimson Clover	643	677	731	842
Hairy Vetch	698	656	794	927
Wheat	634	684	811	958
	Ridge-Till			
No Cover Crop	564	527	718	871
Crimson Clover	581	553	605	727
Hairy Vetch	684	624	732	849
Wheat	667	706	756	928
	No-Till			
No Cover Crop	581	586	802	987
Crimson Clover	657	540	798	875
Hairy Vetch	719	601	877	997
Wheat	733	689	838	1056
LSD (0.05) Till x Cov Crop	78	82	61	59
C.V. (%)	8	16	6	5

Table 5. Tillage and cover crop effects on organic matter content of a Gigger silt loam - Wmnsboro, LA.

	Lint Yield			
		0-6" Depth		0-3" Depth
	1987	1988-91	1992-95	1992-96
	----------	---------- %	----------	----------
		Conventional-Till		
No Cover Crop	0.47	0.83	1.14	1.22
Crimson Clover	0.44	0.78	1.21	1.36
Hairy Vetch	0.50	0.91	1.21	1.33
Wheat	0.46	0.86	1.30	1.42
		Ridge-Till		
No Cover Crop	0.48	0.80	1.08	1.34
Crimson Clover	0.53	0.90	1.18	1.49
Hairy Vetch	0.50	0.92	1.20	1.51
Wheat	0.57	0.98	1.27	1.58
		No-Till		
No Cover Crop	0.54	0.99	1.20	1.65
Crimson Clover	0.48	0.99	1.23	1.65
Hairy Vetch	0.46	0.97	1.27	1.67
Wheat	0.49	1.00	1.26	1.61
LSD (0.05) Till x Cov Crop	NS	0.14	0.11	0.25
C.V. (%)				

Table 6. Tillage and cover crop effects on organic matter content of a Gigger silt loam - Winnsboro, LA.

	Organic Matter			
		0-6" Depth		0-3" Depth
	1987	1988-91	1992-95	1992-96
	----------	---------- %	----------	----------
		Tillage means across cover crops		
Conventional-Till	0.46	0.84	1.22	1.33
Ridge-Till	0.52	0.90	1.19	1.48
No-Till	0.49	0.98	1.24	1.65
		Cover crop means across tillage systems		
No Cover Crop	0.50	0.87	1.14	1.41
Crimson Clover	0.48	0.89	1.21	1.50
Hairy Vetch	0.49	0.93	1.23	1.50
Wheat	0.50	0.94	1.25	1.54
LSD (0.05) Tillage	NS	0.07	NS	0.11
LSD (0.05) Cov Crop	NS	NS	0.07	NS
C.V. (%)	16	11	7	12

Winter Crop Effect on Double-Cropped Cotton Grown With and Without Irrigation

*Philip J. Bauer and James R. Frederick

ABSTRACT

Flax *(Linum usitatissum)* is a potential winter crop for production in the southeastern USA. Both the seed and the straw of flax are harvested; thus, fewresidues are left after flax harvest to protect the soil surface. Our objective was to compare conservation tillage cotton *(Gossypium hirsutum)* production following flax to production following winter wheat *(Triticum aestivum)*, with and without supplemental irrigation. Adjacent irrigated and rainfed experiments were conducted on a Goldsboro sandy loam soil. Wheat and flax were planted in November 1992 and 1994. Spring N rate treatments applied to the winter crop were 0. 20, 40, and 60 lb N/ a. Cotton was planted immediately after winter crop harvest in June 1993 and 1995. Supplemental irrigation was applied with a traveling gun system to the irrigated study when tensiometers at the 9-in. depth in the irrigated plots reached -30 centibars. Rainfed cotton yields averaged 557 lb lint/a, and neither year nor winter crop had a significant impact on yield. Irrigated cotton yield was greater in 1994 (893 lb lint/a) than in 1996 (617 lb lint/a). In the irrigated experiment, cotton following wheat yielded 84 lb lint/a more than cotton following flax. Innovative production strategies are needed to improve the yield of double-cropped cotton produced with conservation tillage, especially when it is double-cropped with low residue crops like flax.

INTRODUCTION

The long growing season and mild winters in the southeastern USA allow growers to produce two crops per year in the same field. Currently, much of the soybean *(Glycine max* [L.] Merr.) production in the area is grown following winter wheat *(Triticum aestivum* L.) harvest. The development of double-crop systems for cotton *(Gossypium hirsutum* L.) would allow growers more flexibility in matching cropping systems with economic situations. Low yields (Baker, 1987; Hunt et al., 1997; Smith and Varvil, 1982) and even crop failures (Hunt et al., 1997) have resulted when cotton was double-cropped with wheat.

In full-season production, adequate residue cover reduces some of the risks involved in cotton production with conservation tillage on sandy Coastal Plains soils (Bauer and Busscher, 1996). Since wheat is the major winter crop in the region, adequate surface residues for no-till double-cropped cotton production are obtained from the straw left after wheat harvest. An alternative winter crop, flax *(lilum usitatissimum* L.), is currently being evaluated in the area. Since both the seed and the straw are removed at harvest, there are no residues remaining on the soil surface following flax harvest. Information is needed on using conservation tillage when double-cropping cotton with low residue winter crops like flax.

One of the benefits of adequate residue cover in conservation tillage production is increased rainfall infiltration. Supplemental irrigation may negate this benefit by providing adequate soil water through the season, and irrigation may be necessary for cotton double-cropped with low residue winter crops. Our objective was to determine the effect of winter cash crop on double-cropped cotton lint yield when cotton was grown with and without supplemental irrigation.

MATERIALS AND METHODS

The experiment was conducted at Clemson University's Pee Dee Research and Education Center near Florence, SC. Treatments were winter cash crop (flax or wheat) and spring N rate. Wheat (cv. NK Coker 9835) and flax (cv. Natasja) were planted in the fall of 1992 and 1994. Seeding rates were 90 lb/a for the wheat and 100 lb/a for the flax. At planting, 20 lb N/a was broadcast applied to both crops. The following spring, N was applied at rates of 0, 20, 40, or 60 lb/a. Each irrigated and rainfed experiments were conducted simultaneously and adjacent to one another. Soil water levels were monitored with tensiometers that were placed 9-in deep, and a traveling gun irrigation system was used to apply water to the irrigated study when tensiometers averaged -30 centibars. Wheat was planted on 19

[1]P.J. Baur, and [2]J. R. Frederick. [1]USDA-ARS Coastal Plaine Soil, Water and Plant Research Center, Florence SC. and [2]Clemson University, Florence, SC. Manuscript received 24 March. *Corresponding author.

November 1992 and 20 November 1994. Flax was planted on 3 November both yr. Experimental design for both studies (irrigated and rainfed) was randomized complete block with treatments in a split-plot arrangement. Winter crops were the whole plots, and spring N levels applied to the winter crops were the subplots. There were four replicates in each study each yr.

After winter crop harvest, cotton (cv. Stoneville 453) was planted after in-row subsoiling on 11 June 1993 and 31 May 1995. Subplot size was four 38-in.-wide cotton rows that were 30 ft long. At planting, all cotton plots received 40 lb N/a. Another 40 lb N/a application was made approximately one mo after planting. Three tensiometers were placed to a depth of 9 in. in each subplot of the irrigated study. Supplemental water was applied when tensiometers averaged -30 centibars. Weeds were controlled with a combination of herbicieds and handweeding. Plots were scouted regularly, and insecticides were applied at recommended rates when insect pest thresholds were reached.

A two-row spindle picker was used to harvest the cotton twice in 1993 (16 Nov. and 30 Nov.) and once in 1995 (13 Nov.). At harvest, a grab sample from the harvest bags was collected for ginning to determine lint percent.

All data were subjected to analysis of variance. Linear, quadratic, and deviation from quadratic single degree-of-freedom contrasts were made for the N analysis of the winter crops. Years were analyzed separately for the winter crop yields. For cotton yield, data were combined over yr.

RESULTS AND DISCUSSION

The seed yield responses to N of the wheat and flax and the straw yield response to N of the flax are shown in Table 1. Seed yield increased linearly with N rate for both crops under rainfed and irrigated conditions both years. There were no differences between N rates for flax straw yield under rainfed conditions in 1995. Flax straw yield increased with increasing N levels under rainfed conditions in 1993 and under irrigated conditions both years.

Rainfall during the growing season in 1993 was about one-half the amount received in 1995. In 1993, 12.8 in. of precipitation fell between planting and the end of Sept. In 1995, 24.1 in. of precipitation fell during the same time period. Irrigation was applied eight times in 1993 total 9 in. applied). Application dates ranged from 18 June to 13 Sept. In 1995, there was adequate rainfall early and late in the season, but from late July through Aug., rain was scarce and temperatures were high. Six water applications (9 in. applied) were made from 17 July to 25 Aug.

Cotton lint yields were greater in 1993 than in 1995 in the irrigated experiment (Table 2). In the rainfed experiment, yields did not differ between years. Even though N fertilization had a large impact on the winter crops the amount of N applied to the winter crops had no impact on cotton yield in either yr of the study. Averaged over both yr of the study, cotton following wheat had higher yield than cotton following flax ($P<0.10$) when irrigated (Table 2). In the rainfed experiment, cotton yield following the two winter crops did not differ when averaged over the 2 yr.

Yields in this study were not very high with irrigation in 1995 or without irrigation in both yr, suggesting that innovative production strategies are needed to improve the yield of double- cropped cotton produced with conservation tillage. Since cotton yields following wheat were higher than those following flax when irrigation was supplied, there is an apparent need for new strategies for those winter crops that produce or leave few residues on the soil surface. The ability to successfully produce a summer crop following flax would be an important, positive factor in the adoption of flax as a winter cash crop.

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Table 1. Wheat and flax seed yield and flax straw yield response to N fertilizer.

		Rainfed			Irrigated		
		Seed		Straw	Seed		Straw
Year	N	Wheat	Flax	Flax	Wheat	Flax	Flax
	lb/a	--------- bu/a --------		ton/a	---------- bu/a --------		ton/a
1993	20	40.5	7.1	0.72	41.0	11.6	1.00
	40	53.9	11.3	1.01	57.0	15.4	1.29
	60	64.4	17.2	1.40	77.4	20.0	1.52
	80	70.9	17.9	1.32	87.7	24.0	1.64
	Contrast'	L**	L**	L**	L**	L**	L**
1995	20	42.7	8.7	0.73	51.2	12.3	1.00
	40	48.6	11.2	0.85	59.9	16.3	1.25
	60	51.0	11.7	0.84	67.1	21.2	1.37
	80	55.1	12.3	0.81	71.6	24.6	1.41
	Contrast	L**	L**	NS	L**	L**	L**,Q*

t L= linear, Q=quadratic

*,** indicates contrast significant at P=0.05, 0.01, respectively

Table 2. Effect of winter cash cmp on double-cropped cotton yield under irrigated and rainfed conditions in 1993 and 1995.

	Rainfed			Imgated		
Winter Crop	1993	1995	Mean	1993	1995	Mean
	------------ lb/a ------------					
Flax	584	495	539	846	580	713
Wheat	663	485	574	940	654	797†
Mean	623	490		893**	617	

† indicates cotton yield following wheat was greater than yield following flax at $P \leq 0.10$.

** indicates yield in 1993 higher than 1995 at $P \leq 0.01$

Management of Reniform Nematodes in Strip Till Cotton Treated with Temik 15G and Telone II, Including Use of Telone II at Planting

***J.R Rich, S.K. Barber, RA. Kinloch and D.L. Wright**

INTRODUCTION

Conservation tillage systems have been shown to have little short- to medium-term impact on plant-parasitic nematode populations (Dickson and Gallaher, 1989; McSorley and Gallaher, 1994). Effects of long-term conservation tillage systems where organic matter may be accumulated have not been studied extensively. These tillage systems, however, may impact nematode development and management due to weed growth and reduced efficacy of nematicides. Many weeds serve as hosts of the plant-parasitic nematodes and can increase populations before, during, and after the crop cycle. Good agronomic practices in any tillage system generally reduce this potential problem. The action of nematicides, however, may be influenced by tillage systems due to increased organic matter and its sorptive potential (Smelt and Leistra, 1992).

The objectives of the present studies, using strip tillage, were to determine: 1) relative efficacy and effective rates of two commonly used nematicides, Temik 15G, and Telone 11, and 2) a preliminary test of at planting Telone II applications in cotton *(Gossypium hirsutum* L.).

MATERIALS AND METHODS

Test 1

A field trial was conducted on a fine sand soil (80% sand, 8% silt, 12% clay) infested with the reniform nematode *(Rotylenchulus reniformis* Linford and Oliveira). The test site was at the IFAS North Florida Research and Education Center, Quincy, FL. The field was previously planted to soybean *(Glycine max* [L.] Merr.) and weed fallowed over the winter. Soil was prepared by subsoiling and striptilling to 18 in. wide one wk prior to nematicide application. Telone II treatments were made on 22 April with a single in the row chisel to 10 in deep and immediately after application, rows were rototilled to seal the fumigant. Temik 15G and Thimet 15G were applied infurrow at planting on 8 May 1995 with a Gandy applicator. Thimet 15G was applied to the control and Telone I1 plots at planting to reduce thrips damage *(Frankliniella* spp.), since Temik has activity on these pests. Cotton cv. 'Chembrand 407' was planted 2-3 in. apart in the 36 inch-wide-rows. Plots were 2 rows wide x 25 ft. long, and the experiment was placed in a randomized complete block design containing six replications.

Cotton was managed utilizing normal cultural practices and irrigated as needed. The crop was harvested by hand from all plants in the two-row plots on 15 December 1995. Lint yield of cotton was calculated by multiplying seed cotton yield by 0.40, and yield was converted to lb lint/a. Cotton stalk weight was taken from 3 ft. of each plot row and converted to lb./a. Six soil cores (1 in. diam., 10 in. deep) were taken from each plot on 20 December 1995, combined and a 100-cm^3 soil sample was processed by the centrifugation-sugar flotation technique (Jenkins, 1964) and nematodes counted Data were analysed using ANOVA and Fisher's LSD test (F< 0.05).

Test 2

Soil in a site adjacent to test 1, grown previously in cotton, was subsoiled and strip tilled to 18 in. wide one wk prior to Telone I1 treatment. Preplant application rates of Telone I1 were made with a single in the row chisel to 10 in. on 9 May . At planting applications of Telone I1 or Furadan were made at planting on 22 May, and cotton' DP 5415' was planted as in test 1. Similar plot sizes and replications were used as in test 1. Cotton was observed for phytotoxicity and on 1 July, plants were counted from 3 ft of each plot row. Additionally, heights of 10 plants were measured from each plot

RESULTS AND DISCUSSION

Cotton yield was increased by all Telone I1 treatments with the 6.0 gal/a producing highest yield (Table 1). With the exception of Telone II at 1.5 gal/a, both yield and stalk weights were hgher using Telone II compared to Temik 15G treatments. All Telone I1 treatments produced significantly higher stalk weights than the control. The Temik treatment of 12 lb/a

J.R. Rich, S.K. Barber, R.A. Kinloch, and D.L. Wright. Univ. of Florida, North Florida REC, Quincy, FL. Manuscript received 21 April 1997. * Corresponding author.

produced both lowest lintyield and stalk weights of all the chemical treatments. The number of reniform nematodes were high at the end of the season and did not differ among treatments and the control.

Telone II at 3 to 6 gal/a appeared to be optimal rates under conditions of this test (Table 2), and these rates are similar to those recommended in conventional systems (Dunn, 1996) Nematode numbers were initially low at the beginning of this test, thus yield increase due to chemical treatment was less than if higher initial populations were present. Higher stalk weights in the Telone I1 test complimented field observations that this chemical stimulated vegetative growth of cotton. This may have reduced lint yield, and application of a growih regulator would have been useful in the Telone I1 treatments.

Data from the 9 and 12 lb/a rates of Temik 15G may be confounded due to early season stunting. At high use rates, a modified in-furrow application is necessary to avoid phytotoxicity in cotton. The study did not include Telone II plus Temik 15 G treatment, but low rates of each in combination may be useful to include in further tests.

No phytotoxicity of cotton was observed among preplant or at planting treatments of Telone 11, Furadan, or the control. Plant stand did not differ among treatments and plant heights were similar. The data, however, are preliminary and growersare not encouraged to utilize the practice. Heavier soil types, cool soils, and excessive moisture can result in increased fumigant retention which can result in plant injury.

CONCLUSIONS

Under normal conditions in north Florida, use and rates of nematicides in reduced tillage systems should be similar to conventional tillage. Data from this test indicated nematicide efficacy and use rates at comparable levels to conventional tillage. A possible exception in either system would be presence of large quantities of organic matter that would prevent proper movement of nematicides.

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Table 1. Yield and stalk weight of cotton cv. Chembrand 407 and number of reniform nematode juveniles at harvest in a field nematicide test, 1995.'

Treatment'	Lint yield (lb/a)	stalk wt. (lb/a)	No. nematodes/ 100 cm^3 soil
Telone II 6.0 gal	599	6490	5369
Telone II 4.5 gal	565	6006	4507
Telone II 3.0 lb	564	6236	4452
Temik 15 G 3.0 lb	550	5397	4763
Temik 15 G 9.0 lb	549	5312	4348
Temik 15 G 6.0 lb	517	4985	4607
Telone II 1.5 gal	516	6152	4073
Temik 15 G 12.0 lb	514	4922	5411
Control (Thimet 15G)	460	4518	3781
LSD ($P \leq 0.05$)	180	1557	2148

[1] Data are an average of six replicates.
[2] Application of Telone II was by single chisel injection to 12 in. deep. Temik 15G and Thimet 15G applications were made in-furrow at planting. Thimet 15G was applied to the control and Telone II treatments.

Table 2. Plant stand and height of cotton 40 days after at-planting treatment with three Telone II rates.'

Treatment	Rate (gal/a)	Plant stand	Plant height (in.)
Control	--	13	10.6
Telone II	1.5	13	11.4
Telone II	3.0	12	11.0
Telone II	4.5	13	11.7
Telone II	1.5	12	11.3
Telone II	3.0	11	10.7
Telone II	4.5	12	10.3
Furadan	0.25	11	11.7
Furadan	0.50	12	12.1
Furadan	0.75	12	10.9

[1] Data are average of 6 ft. of row in each plot.

No-Till Cotton: Redvine Control on Clay Soil

Harold R. Hurst

INTRODUCTION

Redvine [*Brunnichia ovata* (Walt.) Shinners] a perennial vining weed that is difficult to control. It is a member of the buckwheat family, distributed in the United States from Florida to Texas and north to Kentucky, Missouri, and Oklahoma (Shaw and Mack, 1991). Redvine is prevalent on low-lymg clay soils and is a common perennial plant in the Mississippi Delta. In a 1984 Mississippi Delta survey, redvine was the most frequentof six perennial weeds, occupyingmore than 1% area in 43% of cotton *(Gossypium hirsutum* L.) and 31% of soybean *(Glycine max* [L.] Merr.) fields (Elmore, 1984). The recent increased interest in reduced tillage can provide an opportunity for increased redvine infestation if it is not controlled (Hurst, 1995). This is especially relevant on the clay soils where redvine has an adaptative advantage. The objective of this experiment was to evaluate the use of herbicides applied alone and in sequential combinations for controlling redvine in no-till cotton.

MATERIALS AND METHODS

Cotton ('DES 119' in 1995, 'SG 125' in 1996) was planted 10 April and replanted 28 April 1995 and 29 April 1996 on a Sharkey clay (7% sand, 26% silt, 73% clay, 1.9% organic matter, 6.5 pH) with a natural population of redvine. In 1995, the 28 April replanting was made on the old row without destroying plants from the original planting. A randomized block design with four replications was used. Individual plots were four rows 40 in. wide by 80 ft. long. All data were obtained from the two center rows and analyzed using Analysis of Variance. Treatment means were separated with Duncan's Multiple Range Test at P=0.05. All herbicide applications were made with a tractor-mounted spray system using 4-row equipment in 10 [all Roundup D-Pak" (glyphosate) applications] or 20 gal total volume/a (all other broadcast applications). Redvine control was evaluated by visual estimates of foliar injury, control estimates (0 = no injury or control, 100 = complete control) and plant stem counts at the soil level (number of plants/40 in. wide by 80 ft long in each plot). Cotton response was measured by stand counts on one row per plot, visual estimates of foliar injury, and mechanical harvest (2-row plot harvester). Insects were controlled according to normal procedures for this area. Granular Terrachlor Super X" witlDi-Syston® (14.6 G at 9 lb/a) was used in-furrow at planting because of the Command® (clomazone) treatments requiring Di-Syston for cotton injury safening. The only soil surface disturbance was made about one month before planting with the application of 150 lb N/a as 32% urea/ammonium nitrate solution with knives 1 to 2 in. deep and 10 in. to each side of the drill. Herbicide treatments and application dates for controlling redvine are listed in Table 1.

Herbicides were broadcast applied to the entire area for the control of annual winter and summer weeds. These were Goal 1.6E® (oxyfluorfen) 0.25 lb ai/a on 2 November 1994 and 23 October 1995; Gramoxone Extra" 2.5E (paraquat) 0.94 Ib ai/a on 30 March 1995; Cotoran 4L® or 85DF (fluometuron) 1.75 lb ai/a = Zorial 80DF® (norflurazon) 1.6 lb ai/a + Bladex 4L® or Cy-Pro 4L® (cyanazine) 1.2 lb ai/a preemergence at planting on 12 April 1995 and 30 April 1996 (Zorial omitted on spring-applied Command treatments); and Bladex 4L or Cy-Pro 4L 1.0 lb ai/a + Goal 1.6E 0.25 lb ai/a Post-DIR layby on 13 July 1995 and 1 July 1996. A 20-in. wide band of Staple 85SP® (pyrithiobac) at 0.047 and 0.063 lb ai/a was applied over the row on 16 May 1995 and 6 June 1996, respectively. Bladex 4L or Cy-Pro 4L 1.0 lb ai/a + Bueno 6 6E® (MSMA) 1.5 lb ai/a was applied to a 20-in area between the cotton rows on 6 June 1995 and 6 June 1996. Cotton-Pro 4L® (prometryn) 0.5 lb ai/a + Select 2E® (clethodim) 0.094 lb ai/a was applied broadcast Post-DIR 19 June 1995. Hooded sprayer treatments were made with a Red Ball" unit to a 34-in. wide area between rows in 14 gal total volume/a. Induce" surfactant at 1% volume/volume (v/v) was used with Roundup D-Pak and either Latron AG-98®, Activate Plus", X-77®, or Surf Aid" surfactant at 0.5% v/v was used with other applications. No surfactant was added to Banvel alone or Clarity® (dicamba) treatments. No in-season cultivation was used except on the cultivated control which was cultivated on 12 May, 30 May, and 19 June 1995, and 6 May, 7 June, and 18 June 1996 leaving a 12-in undisturbed band centered on the row. The hand weeded control was hoed on 24 May, 8 June, 30 June, and 20 July I995 and on 6 June, 28 June, and 24 July 1996.

H.R. Hurst, Mississippi State University, Delta Research and Extension Center, Stoneville, MS. Manscript received 11 March 1997.

RESULTS AND DISCUSSION

Injury to existing redvine plants was evaluated in early- to mid-season (Table 2). These values represent redvine plant injury resulting from treatments applied the previous fall and/or those applied before at, or soon after planting. Treatments with Roundup or Banvel applied in the fall had the greatest foliar injury ratings the following spring and early summer. With some treatments without follow-up in-season application, values declined in 1995 after early-season.

Redvine plant counts were 28% lower in 1995 and 49% lower in 19% than original counts in 1994 when averaged over all treatments (data not shown). In the weedy check treatment 1 with a high count of 228 redvlne plants, the relative values were an increase of 1% in 1995 followed by a decrease of 36% in 1996 (Table 3). For the weedy check treatment 15 with a lower count of 108 redvine plants, the relative values were similar to the original for both 1995 and 1996. Counting error probably could account for the 1994-1995 difference but the 1995-1996 change was too great for counting error alone when the identical area was counted each year. Continued use of herbicides for annual weed control and the mid-season weather conditions of 1995 (very dry) and 1996 (wet) allowed redvine plants to compete without much hindrance in 1995 (roots are very deep) while in 1996 cotton plants provided more competition. Also redvine population is very unpredictable (Hurst, 1995). Herbicide treatments with low original redvine counts (treatments 2, 6, 7, 10) maintained the original control. Treatments 8, 10, and 11 had low original counts and continued to reduce the redvine population over the two years (Table 3).

Cotton stand was not affected by any treatment either year. The stand ranged from a low of 36,100 plants per acre in 1995 to a high of 49,400 in 1996.

Cotton injury in 1995 was not different for any treatment (Table 4). Minimal foliar symptoms were observed on plants in treatments 8 and 10 after Clarity was applied but were considered to be of no great concern at the time. In 1996, cotton injury symptoms were more severe especially with treatments 8 and 10. A 2.3-in. rain occurred two d after applying Clarity on 17 June. Severe dicamba (from Clarity) injury symptoms were present at the 28 June rating date and was even more severe by 22 July. Injury to cotton from other treatments was the result of redvine competition stunting plants.

The seed cotton yields from this clay soil site are considered to be good with these treatments maintaining a very high level of redvine control. Yields in 1995 were low with Clarity in treatments 8 and 10 in 1995 without much evidence of plant injury when compared with the hand weeded treatment. The 1995 season was virtually without rain after 5 July . In 1996, rainfall was greater than normal in July and August resulting in a drastic yield effect from Clarity applied in-season. Apparently, Clarity was absorbed by the cotton roots. The greater rainfall in 1996 also resulted in greater redvine growth which reduced yield in the weedy check treatment when compared to the hand-weed treatment. When compared with the hand-weeded control, only treatments 4, 8, and 10 produced lower yields in 1995. In 1996, treatments 8 and 10 also were lower in yield than the hand-weed control.

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Table 1. Herbicide treatments and application for controlling redvine in no-till cotton on clay, Delta Research and Extension Center, Stoneville, MS, 1995-96.

Trt. No.	Herbicide[1/]	Rate/a	Application Type	Application Date(s)
		(lb a.i.)		(mo/day/yr)
1.	None	--	--	--
2.	Banvel 4S	2.0	Broadcast	10/4/94, 9/13/95
3.	Banvel 4S(94), SGF (95)	1.0	Broadcast	1014194,9113195
	Banvel SGF	1.0	Broadcast2	1111194,9128195
4.	Command 3ME	1.0	Broadcast	4112195,4130196
	Roundup D-Pak	1.0	Band[3/]	6/21/95, 6/17/96
5.	Command 3ME	1.0	Broadcast	10/4/94, 9/13/95
	Command 3ME	1.0	Broadcast	411 2195,4130196
6.	Roundup D-Pak	2.0	Broadcast	10/4/94, 9/13/95
	Roundup D-Pak	1.0	Band?'	6121195,6111196
7.	Banvel SGF	2.0	Broadcast	1014194,9/1 3195
	Command 3ME	1.0	Broadcast	411 2195,4130196
8.	Clarity	I.0	Band[3/]	7110195,6111196
9.	Roundup D-Pak	1.0	Band?'	6/21/95, 6/17/96
10.	Banvel SGF	1.0	Broadcast	3/23/95, 4/8/96
	Clarity	I.0	Band[3/]	7/10/95, 6/17/96
11.	Banvel SGF	2.0	Broadcast	1014194,9113195
	Roundup D-Pak	1.0	Band?'	6/21/95, 6/17/96
12.	Banvel SGF	2.0	Broadcast	10/4/94, 9/13/95
13.	None	--	Cultivate[4/]	5112 + 5130 + 6119195, 5/6 + 6/7 + 6/18/96
14.	None	--	Hoe	5/24 + 618 + 6/30 + 1120195, 6/6 + 6128 + 1124196
15.	None	--	--	--

Fall applications made 2 to 3 d after harvest (stalks standing):

[1/] Added Induce surfactant to Roundup at 1.0% vlv in 10 GPA, others in 20 GPA.

[2/] Harvest plus 2 wk; 7 d prior to stalk destruction.

[3/] 34-in. area between rows with hooded sprayer in 14 GPA.

[4/] 12-in. band centered on row undisturbed.

Table 2. Redvine foliar injury from treatments applied to no-till cotton on clay, 1995-96, Delta Research and Extension Center, Stoneville, MS.

Trt. No.	Estimated redvine plant injury (0-100)[1/2/]					
	1995			1996		
	May 15	June 2	July 12	April 30	May 6	May 22
	(%)					
1.	9 d	Od	1 e	o c	35 d	28 de
2.	78 ab	75 ab	50 cd	99 a	100 a	100 a
3.	86 ab	71 abc	63 hc	100 a	100 a	94 ab
4.	59 bc	31 bcd	78 abc	45 b	80 abc	60 bcd
5.	65 bc	26 bcd	5 e	55 b	75 bc	49 cde
6.	98 a	48 bcd	86 abc	95 a	89 ab	69 a-d
7.	93 a	25 bcd	63 bc	100 a	96 a	97 ab
8.	38 cd	16 cd	45 cd	10 c	38 d	13 e
9.	14 d	Od	14 ahc	o c	34 d	14 e
10.	20 d	I d	58 bcd	100 a	98 a	56 bcd
11.	98 a	71 abc	90 ab	100 a	100 a	78 abc
12.	94 a	71 ab	19 de	100 a	95 ab	76 abc
13.	23 d	9 d	4 e	o c	26 d	5 e
14.	13 d	100 a	100 a	19 c	48 cd	30 de
15.	29 d	I d	3 e	o c	26 d	10 e

[1/]0 = no foliar injury, 100 = complete foliar removal.
[2/]A common letter in the same column indicates menas are not different according to DMRT at $P \leq 0.05$

Table 3. Redvine population at harvest from herbicide treatments applied to no-till cotton on clay. Delta Research and Extension Center, Stoneville, MS, 1994-96.

Trt.	Redvine population’’			Plants in 1996 as % of	
No.	7 October 1994	I September 1995	2 October 1996	1995	1994
	---(plants/267 ft^2)---				
1.	228.0 ah	3.08 ab	146.3 a	63.4	64.1
2.	7.5 b	1.5 h	2.5 b	166.7	33.3
3.	298.5 a	55.8 ah	52.0 ab	93.3	17.4
4.	207.0 ab	258.3 a	120.3 ab	48.8	58.1
5.	242.3 ab	148.9 ah	96.3 ah	64.6	39.7
6.	21.8 ab	16.5 h	28.0 ab	169.7	128.7
7.	5.3 h	9.5 b	4.3 h	44.7	81.0
8.	27.5 ab	7.0 h	7.5 h	107.1	27.3
9.	233.5 ah	135.5 ab	125.8 ah	92.8	5.9
10.	20.3 ab	7.3 h	11.8 ab	162.1	58.0
11.	6.3 b	3.2 b	0.3 h	7.7	4.0
12.	109.0 ah	94.3 ab	63.8 ah	67.6	58.5
13.	48.8 ab	110.5 ah	80.3 ah	72.6	53.9
14.	20.8 ab	14.0 h	15.0 ah	107.1	72.3
15.	108.0 ab	111.3 ab	103.0 ab	92.6	95.4

[1/]A common letter in the same column indicates means are not different according to DMRT at $P \leq 0.05$.

Table 4. Cotton response to herbicides applied for controlling redvine in no-till cotton on clay, Delta Research and Extension Center, Stoneville, MS, 1995-96.

Trt. No.	Estimated cotton injury (0-100%)[1/] 1995 July 14	1995 July 24	1996 June 28	1996 July 22	Seed cotton yield 1995	Seed cotton yield 1996
	(%)				(lb/a)	
1.	14 a	18 a	16 b	41 b	1488 bc	1131 c
2.	0 a	0 a	0 c	0 c	1812 a	1916 a
3.	0 a	0 a	0 c	0 c	1682 ab	1845 ab
4.	13 a	14 a	13 bc	15 c	1381 cd	1487 b
5.	0 a	0 a	4 bc	13 c	1590 abc	1720 ab
6.	0 a	0 a	0 c	0 c	1841 a	1829 ab
7.	0 a	0 a	0 c	0 c	1739 ab	1912 a
8.	8 a	10 a	45 a	81 a	1176 de	303 d
9.	0 a	1 a	3 bc	15 c	1636 abc	1696 ab
10.	6 a	14 a	39 a	76 a	989 e	588 d
11.	0 a	0 a	0 c	0 c	1742 ab	1867 ab
12.	0 a	0 a	0 c	0 c	1727 ab	1821 ab
13.	0 a	0 a	8 bc	10 c	1713 ab	1689 ab
14.	0 a	0 a	0 c	0 c	1744 ab	1850 ab
15.	0 a	0 a	1 c	14 c	1746 ab	1701 ab

[1/] A common letter in the same column indicates means are not different according to DMRT at $P \leq 0.05$

Weed Management in No-Till Roundup Tolerant Soybean and Cotton

Barry J. Brecke

INTRODUCTION

Conservation tillage is not a new concept in row-crop agriculture. Benefits associated with cover crops and reduced tillage are well documented and include decreased soil erosion, enhanced soil moisture, and reduced equipment, energy, and labor input. (Gallaher, 1977; Hayes, 1982; Young, 1982; Papendick, 1987; Teasdale, 1993). However, even though cover crops can offer some suppression of weed growth (Barnes, 1983; Lodhi, 1987), inadequate weed management systems have been a barrier to further adoption of conservation tillage practices (Yenish, 1996; Gebhardt, 1985).

With the recent introduction of genetically altered crops which can tolerate postemergence over-the-top application of Roundup (glyphosate), new systems are now available for weed management in no-till soybeans *(Glycine max* L.) and cotton *(Gossypium hirsutum* L.). The objective of this research was to evaluate several soybean and cotton weed management programs which include Roundup postemergence as a component in a no-till cropping system.

MATERIALS AND METHODS

General Procedures

Studies were conducted at the University of Florida, West Florida Research and Center near Jay, FL, to evaluate weed management in Roundup tolerant soybean and cotton. The soil in the study area was a Red Bay sandy loam (fine loamy, siliceous, thermic Rhodic Paleudults) with pH 5.5 and 2% organic matter. A wheat *(Triticum aestivum* L.) cover crop was killed with an application of Roundup (1 lb/a) 2 wk prior to planting. Crops were planted at the rate of 5 seeds/ft in rows spaced 30 in apart into the killed cover crop with an in-row subsoil no-till planter.

Soybean

'Hartz 6686' soybean (Roundup tolerant) was planted in 1995 and 1996 during late May. Herbicides were applied with a tractor-mounted boom sprayer using air as a propellent and 10004 flat fan nozzles operated at 20 psi to deliver 20 g/a spray solution. Herbicide treatments included Roundup at 0.5, 0.75, and 1.0 lb/a applied early postemergence (EF) over the top of soybean 6 to 8 in and weeds 1 to 4 in tall and postemergence POST) to soybean 10 to 12 in and weeds 4 to 8 in tall. Sequential applications of Roundup EP followed by Roundup late postemergence (LP) to soybeans 20 to 24 in and weeds 3 to 12 in tall were also evaluated. The standard treatment of Treflan (trifluralin) plus Sencor (metribuzin) preplant incorporated (PPI) followed by Classic (chlorimuron) LP was included for comparison.

Cotton

'Coker 312' cotton (Roundup tolerant) was planted on 20 May 1996, using the procedures described above. Preemergence (PRE) and postemergence over-the-top treatments were applied with the same equipment and settings as for soybean. Early postemergence applications were made to cotton 5 to 8 in (3 to 4 leaf) and weeds 1 to 6 in tall. Directed postemergence (DP) treatments were applied to cotton 10 to 15 in and weeds 4 to 10 in tall. The applicator used for DP treatments consisted of 11002 flat fan nozzles mounted on skids (two per skid) using CO_2 as a propellant and operated at 25 psi to deliver 20 gal/a. The nozzles were adjusted so that the spray was directed toward the base of the cotton plants to minimize contact with the crop foliage.

Herbicide treatments evaluated in cotton included Roundup applied at 1 lb/a EP over the top or DP, a sequential application of EP followed by DP, Roundup EP followed by Bladex (cyanazine) at 0.75 lb/a plus MSMA at 2 lb/a DP, Prowl 0.75 lb/a PRE followed by Roundup EP, Prowl PRE followed by the Roundup sequential EP and DP and Prowl plus Cotoran (fluometuron) 1.5 lb/a PRE followed by Roundup EP. The standard treatments of Prowl plus Cotoran PRE and Prowl plus Cotoran followed by Bladex plus MSMA DP were included for comparison.

Data collected included visual weed control ratings during August using a scale of 0 to 100 where 0 = no weed control and 100 represents complete control of the species evaluated. Crop yield was determined by harvesting the center two rows of each plot with standard commercial harvesting equipment.

Plots were four rows by 25 ft, and treatments were replicated three times in a randomized complete block

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B.J. Brecke. West Florida Research and Education Center, University of Florida, Jay, FL. Manuscript received 4 April 1997.

experimental design. Data was subjected to analysis of variance, and Fisher's Protected LSD test was used for mean separation.

RESULTS AND DISCUSSION

Soybean

Roundup-applied EP provided good to excellent control of sicklepod *(Cassia obtusifolia* L.) and morningglory *(Ipomoea* spp.) species in 1995 (Table 1). However, Roundup provided no better than 85% control of Florida pusley *(Richardia scabra* L.) regardless of rate applied EP. When application was delayed to POST, sicklepod control declined significantly for all rates tested Control did improve, however, as the POST rate increased from 0.50 to 1.0 lb/a. Roundup applied as a sequential application EP followed by LP provided excellent (95 to 100%) control of all species evaluated and was comparable to the standard herbicide program of Treflan plus Sencor PPI followed by Classic LP. Soybean yield reflected control of sicklepod and was reduced when sicklepod was not adequately controlled.

In 1996, a single application of Roundup at 0.75 lb/a EP provided 90 to 100% control of all weed species evaluated (Table 2). Unlike 1995, there was no advantage to a sequential application in 1996. Weather conditions were more suitable for soybean growth in 1996 than in 1995 and resulted in a more competitive crop. In addition, the level of weed infestation was less in 19%. The more vigorous crop growth provided better competition for late-season weeds than during the previous season and, combined with the lower weed density, required only early-season weed control with herbicides for excellent season-long weed management and soybean yield.

Cotton

Roundup has a narrower window for over-the-top application in cotton than in soybean. In cotton, over-the-top application cannot be made after the four-leaf stage or unacceptable crop damage may occur. After the four-leaf sage. Roundup can be applied as a DP treatment without causing injury to Roundup tolerant cotton. In 1996, a single application of Roundup EP provided 80% control of purple nutsedge *(Cyperus rotundus* L.) and Florida beggarweed *(Desmodium tortuosum* [Sw] DC.) and 90% control of Florida pusley and smallflower momingglory *(Jaquemontia tamnifolia)* (Table 3). When application was delayed to DP, however, control of all species evaluated was less than acceptable. A sequential application of Roundup EP followed by Roundup DP provided excellent control of all species including the perennial purple nutsedge while Roundup EP followed by Bladex plus MSMA DP provided good purple nutsedge control and excellent control of the broadleaf species evaluated. Both of these treatments controlled purple nutsedge better than standard Prowl plus Cotoran PRE followed by Bladex plus MSMA DP. Cotton yield reflected the level of weed control observed and was lowest for Roundup DP alone and Prowl plus Cotoran PRE alone, treatments which provided only 65% or less control of the species evaluated.

CONCLUSION

Roundup has the potential to be an important component of weed management systems for both no-till soybeans and no-till cotton. Sequential applications of Roundup EP followed by LP over the top in soybeans or EP over the top followed by DP in cotton provided excellent control of problem annual weed species such as Florida pusley, sicklepod, Florida beggarweed, morningglory, and common cocklebur *(Xanthium Pensylvanicum* Wallr.). The cotton system also provided excellent control of the perennial species purple nutsedge, a troublesome weed in many crops. These Roundup systems provide control comparable to or better than the standard programs for soybean and cotton.

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Table 1. Weed management in no-till Roundup tolerant soybean, 1995, WFREC, Jay, FL

Treatment	Rate	Applic.[b]	Weed control[a] Fl. pusley	Sicklepod	Morningglory	Soybean yield
	lb/a		%			bu/a
Roundup	0.50	EP	85	90	100	45
Roundup	0.75	EP	80	90	100	40
Roundup	1.00	EP	80	85	100	40
Roundup	0.50	POST	80	55	100	35
Roundup	0.75	POST	85	70	100	40
Roundup	1.00	POST	90	80	100	45
Roundup+ R'up	0.5 + 0.25	EP + LP	95	100	100	40
Roundup+ R'up	0.75 + 0.25	EP + LP	100	100	100	45
Roundup+ Rup	0.5 + 0.5	EP + LP	95	100	100	45
Treflan + Sencor + Classic	0.5 +0.5 +0.008	PPI + PPI +LP	100	100	100	40
Untreated			0	0	0	25
$LSD_{0.05}$			8	10	5	7

[a] Fl. Pusley = Florida pusley; Morningglory = mixture of pitted and tall morningglory.
[b] Application timings: PPI = Preplant Incorporated, EP = Early Postemergence, POST = Postemergence; LP = Late Postemergence.

Table 2. Weed management in no-till Roundup tolerant soybean, 1996, WFREC, Jay, FL

Treatment	Rate	Applic.[b]	Weed control[a]				Soybean
			Sicklepod	Fl. beg.	Cockle.	Smflwr.	yield
	lb/a		%				bu/a
Roundup	0.75	EP	100	100	100	90	50
Roundup	1.00	EP	95	100	100	90	55
Roundup	1.50	EP	95	100	100	100	55
Roundup + Rup	0.75 + 0.50	EP + LP	100	100	100	100	50
Roundup+ R'up	0.75 + 0.75	EP + LP	100	100	100	100	55
Treflan + Sencor + Classic	0.5 + 0.38 + 0.008	PPI + PPI +LP	100	95	100	90	50
Untreated			0	0	0	0	20
$LSD_{0.05}$			10	5	5	5	10

[a] Fl. beg = Florida beggarweed; Cockle. = common cocklebur; Smflwr. = smallflower morningglory.
[b] Application timings: PPI = Preplant Incorporated; EP = Early Postmergence, LP = Late Postemergence.

Table 3. Weed management in no-ti Roundup tolerant cotton, 1996, WFREC, Jay, F L

Treatment	Rate	Applic.[b]	Weed control[a] P. nut.	Fl. beg.	Fl. pusley	Smflwr.	Cotton yield
	lbla		%				lint/a
Roundup	1.0	EP	80	80	90	90	1070
Roundup	1.0	DP	60	55	50	50	450
Roundup + R'up	1.0 + 1.0	EP + DP	90	95	100	100	1100
Roundup + Bladex + MSMA	1.0 + 0.75 + 2.0	EP + DP + DP	85	100	100	95	1100
Prowl + R'up	0.75 + 1.0	PRE + EP	80	95	100	75	1010
Prowl + Rup + R'up	0.75 + 1.0 + 1.0	PRE + EP +DP	95	100	100	80	1100
Prowl + Cotoran	0.75 + 1.5	PRE + PRE	0	65	60	65	900
Prowl + Cotoran + R'up	0.75 + 1.5 + 1.0	PRE + PRE + EP	80	100	100	100	1060
Prowl + Cotoran + Bladex + MSMA	0.75 + 1.5 + 0.75 + 2.0	PRE + PRE + DP + DP	70	100	100	100	1100
Untreated			0	0	0	0	200
$LSD_{0.05}$			15	15	15	15	190

[a] P. nut =purple nutsedge; Fl. beg = Florida beggarweed; Fl. Pusley = Florida pusley; Smflwr. = smallflower morningglory.
[b] Application timings: PRE = preemergence; EP = Early Postemergence; DP = directed postemergence.

Corn Forage Yield and Cost of Silage Production from Use of Yard Waste as Compost

***P.E. Hildebrand, R.N. Gallaher, and R. McSorley**

ABSTRACT

Urban plant debris or urban yard waste is an increasing problem for urban areas whose sanitary landfills are overflowing with these organic materials which can be processed into yard waste compost (YWC) for beneficial application to agricultural land. The objective of this paper is to report corn *(Zea mays)* forage yield and silage production costs from application of YWC to farm land in Alachua County, Florida Two adjacent experiments received large amounts of YWC for no-tillage corn. Both experiments had control treatments with either no YWC applied or applied only the first year (1992) of the 5-yr study. Both experiments were in randomized complete block designs with five replications. In this analysis, replications and years are considered as environments. In all environments, the use of YWC increased yield and decreased cost of forage.

INTRODUCTION

Application of urban plant debris to agricultural land can improve soil properties and result in increased crop yield (Gallaher and McSorley, 1994; Gallaher and McSorley, 1995; Gallaher and McSorley, 1996; Kidder, 1993; Kluchinski et al. 1993). Urban plant debris can be applied in the fresh form (Kluchinskiet al., 1993) or after it has been processed as yard waste compost (YWC) (Gallaher and McSorley, 1994; Gallaher and McSorley, 1995, McSorley and Gallaher, 1995; Kluchinski et al., 1993). While many questions remain regarding the application of urban plant debris to agricultural land, most information to date is positive. The objective of this research was to evaluate corn forage yield and cost of production from application of YWC to farm land in Alachua County, Florida.

[1]P.E. Hildebrand,[2] R.N. Gallaher, and [3]R. McSorley, [1]Food and Resource Economics Department, *Agronomy Department, and [2]Entomology and Nematology Department, IFAS, University of Florida, Gainesville, FL. Manuscript received 15 March 1997. *Corresponding author.

MATERIALS AND METHODS

Two adjacent experiments were conducted on a Bonneau fine sand for 5-yr. on the Haufler Brothers Farm, Gainesville, Florida, from 1992 to 1996. Three treatments of < 5 cm particle size, 4- to 6-mo-old YWC were as follows for experiment one: Treatment one had no YWC applied in 1992, had 120 tons/a YWC applied evenly over the soil surface for a mulch followed by a planting of in-row subsoil no-tillage corn in 1993 and again in 1994 (0-m-m). This YWC mulch was incorporated following corn *(Zea mays* L.) silage harvest each yr. No YWC was applied in 1995 or 1996. Total YWC for treatment one was 240 ton/a over the 5-yr. Treatment two was the same as for treatment one except that the YWC was incorporated prior to planting *corn* each time in 1993 and 1994 (0-i-i). Treatment three received no YWC any yr and was the control treatment (0-0-0). Adjacent to experiment one was experiment two, which used the same YWC type and source with the same three treatments as used in experiment one with the following exception. All three treatments received 120 ton/a that was incorporated in 1992 (i-m-m, i-i-i, and i-0-0). Treatments i-m-m and i-i-i received a total of 360 toda of YWC over the 3-41. Further illustration of the treatments has been reported before (Gallaher and McSorley, 1996). Corn forage yield was obtained from guarded plots each year by weighmg whole plants from each plot in the field, weighmg a subsample in the field, and weighmg subsamples for dry matter following complete drying at 70^{o} C. Corn forage yield was adjusted to 30% dry matter to coincide with yield calculations usedby the cooperating farmer in his silage marketing operation.

All inputs except YWC were the same for all treatments. Beginning in 1994 weed control included residual herbicides as well as mechanical cultivator. This provided relatively weed free conditions compared to 1992 and 1993. Further, more adapted corn hybrids were used in 1995 and 1996. These changes likely account for greater yields compared to earlier yr. Those treatments with YWC required spreading and the incorporated YWC required an extra operation. The YWC was provided free of cost for the experiment and is not costed in this analysis. Purchase and transportation costs ultimately would need to be added if this becomes standard practice in the future.

Adaptability Analysis (Hildebrand and Russell, 19%) was used to ascertain the effect of the treatments in the different environments represented by blocks and years.

RESULTS AND DISCUSSION

In 1993, rains were poor so yields overall were low, but the effects of the added YWC were dramatic (Figure 1). Yields over all environments more than doubled with the addition of YWC (either 0-i or 0-m) over no compost (0-0). Best yields were achieved with the addition of YWC both yr (1992 and 1993) as in treatments i-i and i-m. The treatment with incorporated YWC in 1992 and non-incorporated mulch (i-m) in 1993 achieved the best yields.

Yields generally increased each year of the experiment owing to improved weed control and improved, more adapted cultivars, but the effect of the treatments remained consistent (Figure 2). The best yield consistently was i-m-m-0-0, closely followed by i-i-i-0-0. Any YWC was better than none, but the effect of the YWC incorporated only in 1992 (i-0-0-0-0) disappeared in the best environment by 1996.

Preliminary cost estimates were taken from Hewitt (1997). Costs that did not vary among treatments were estimated at $160/a. Excluding cost of YWC and its transport, treatment costs are estimated at $10 for the control, S25.60 for the incorporated treatments and $7.30 for the mulch treatments. Based on these estimates, the YWC treatments reduced cost of silage production by at least half in 1993 (Figure 3). The two treatments with mulch in that dry year (i-m and 0-m) were the lowest cost, largely because there is no cost of incorporation prior to planting. Again, because of improved practices each year, costs continued to decline as the environment for producing the corn improved (Figure 4). If the cost of YWC and its transport to the field is as much as $2/ton, then the advantages of the YWC essentially disappear (Figure 5), and costs would exceed the price of the silage at the pit, $35/tan.

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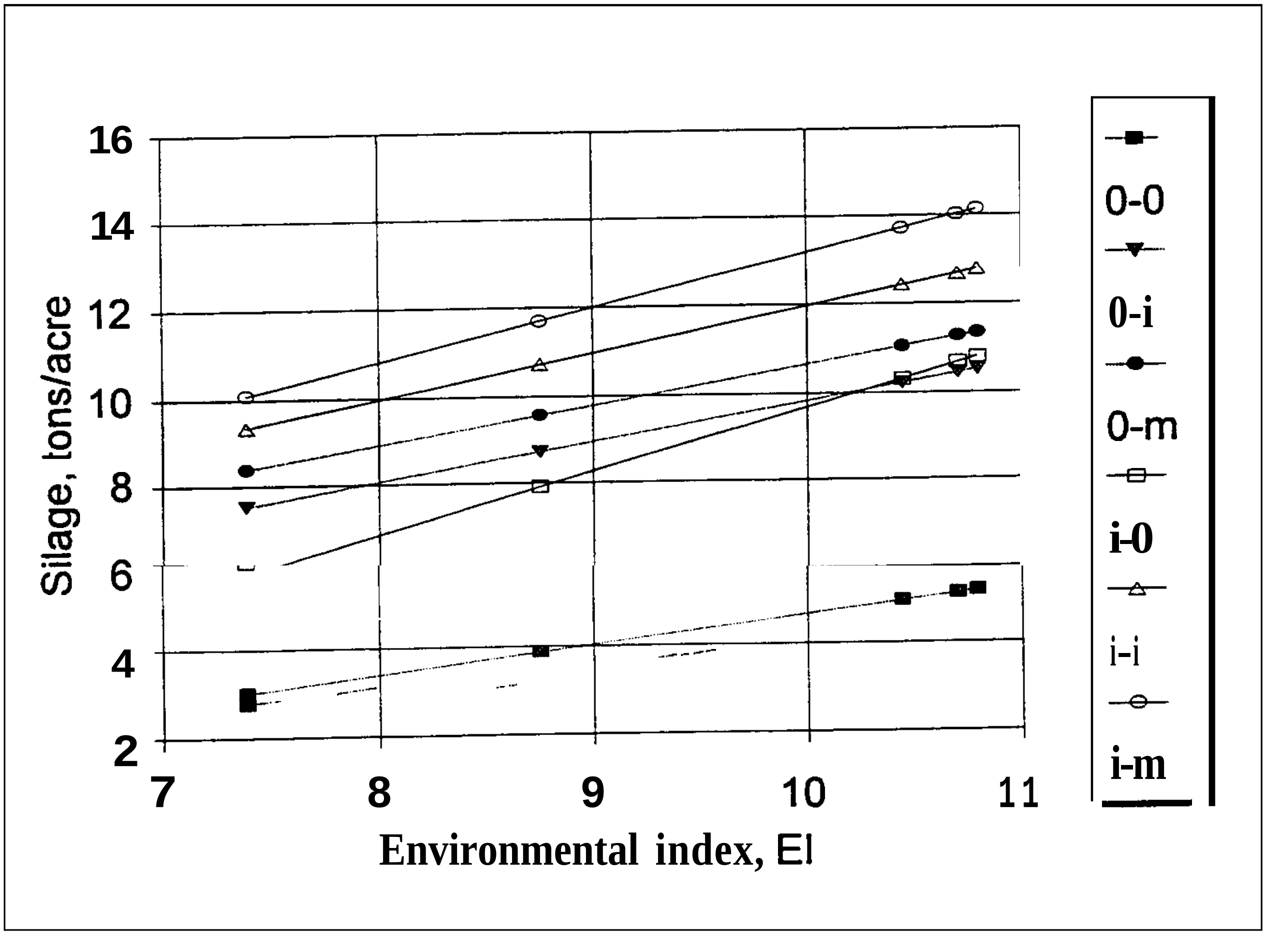

Fig. 1. Corn silage yield related to environmental index based on replications as influenced by yard waste compost treatment, 1993. *0* is no compost, *i* is incorporated compost and *m* is mulched compost.

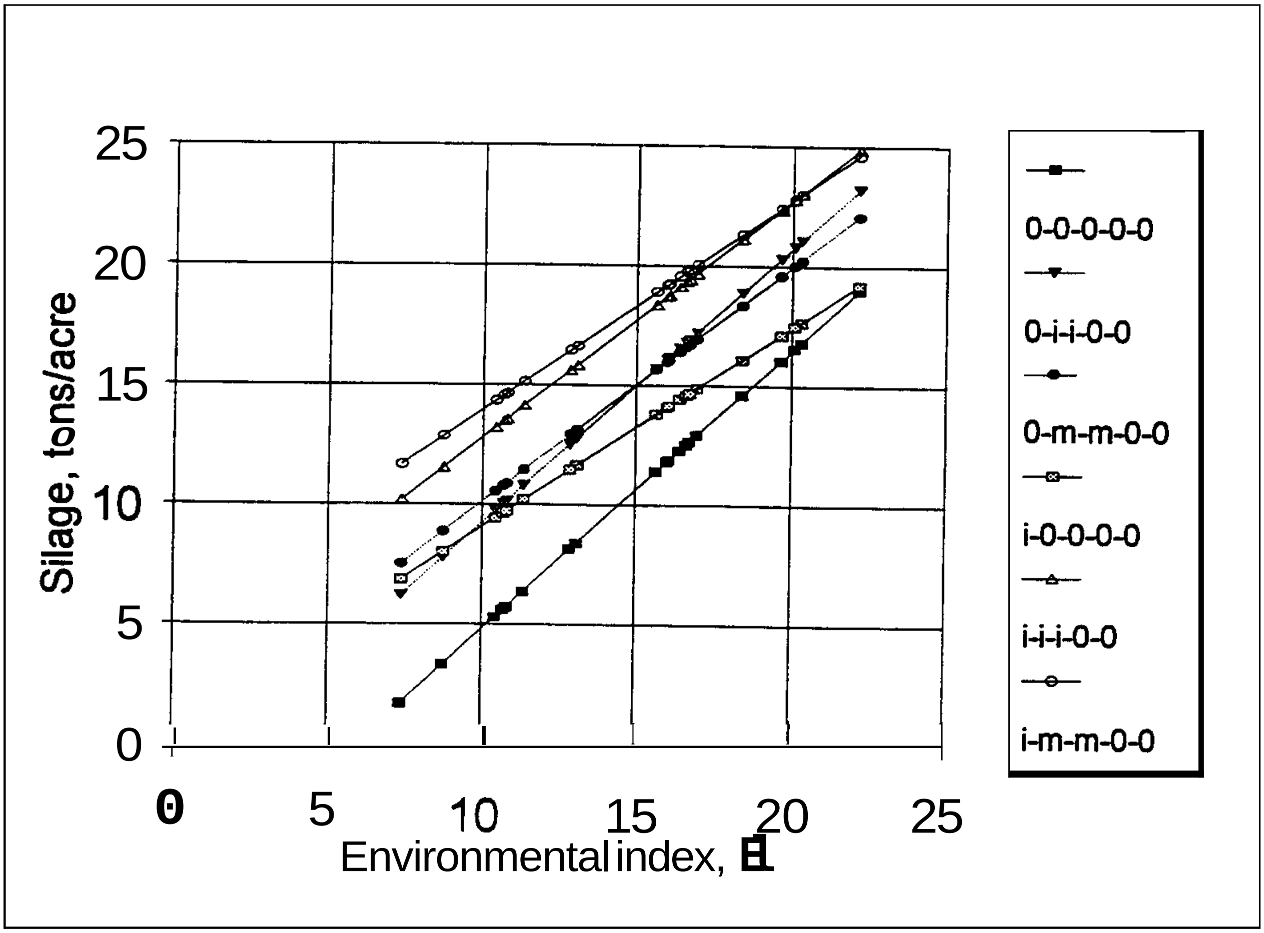

Fig. 2. Corn silage yield related to environmental index based on replications and years, as influenced by yard waste compost treatment, 1993-1996. ***0*** **is no compost,** ***i*** **is incorporated compost and** ***m*** **is mulched compost.**

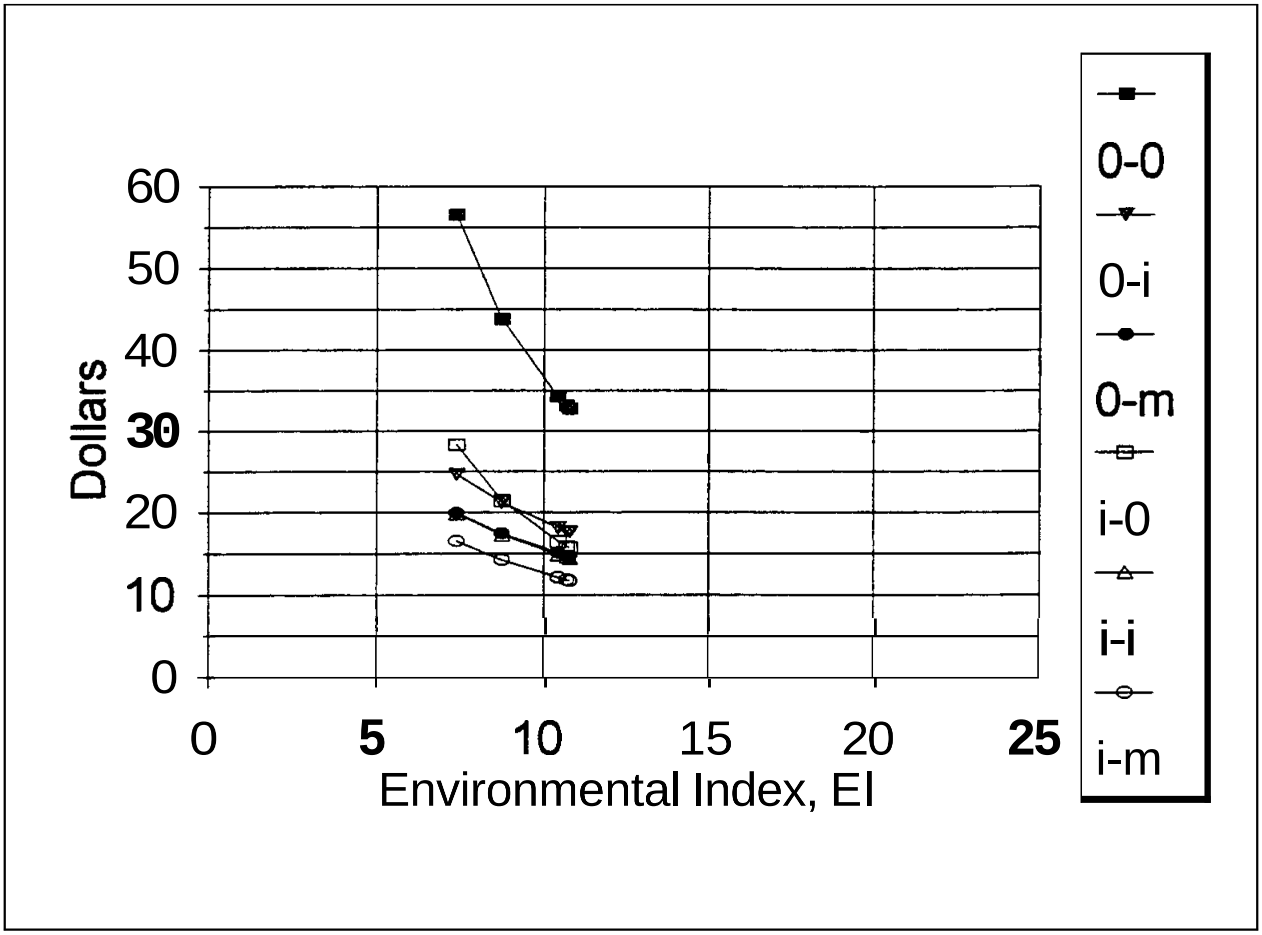

Fig. 3. Cost/ton of corn silage related to environmental index based on replications, as influenced by yard waste compost treatment, 1993. ***0*** **is no compost,** ***i*** **is incorporated compost and** ***m*** **is mulched compost.**

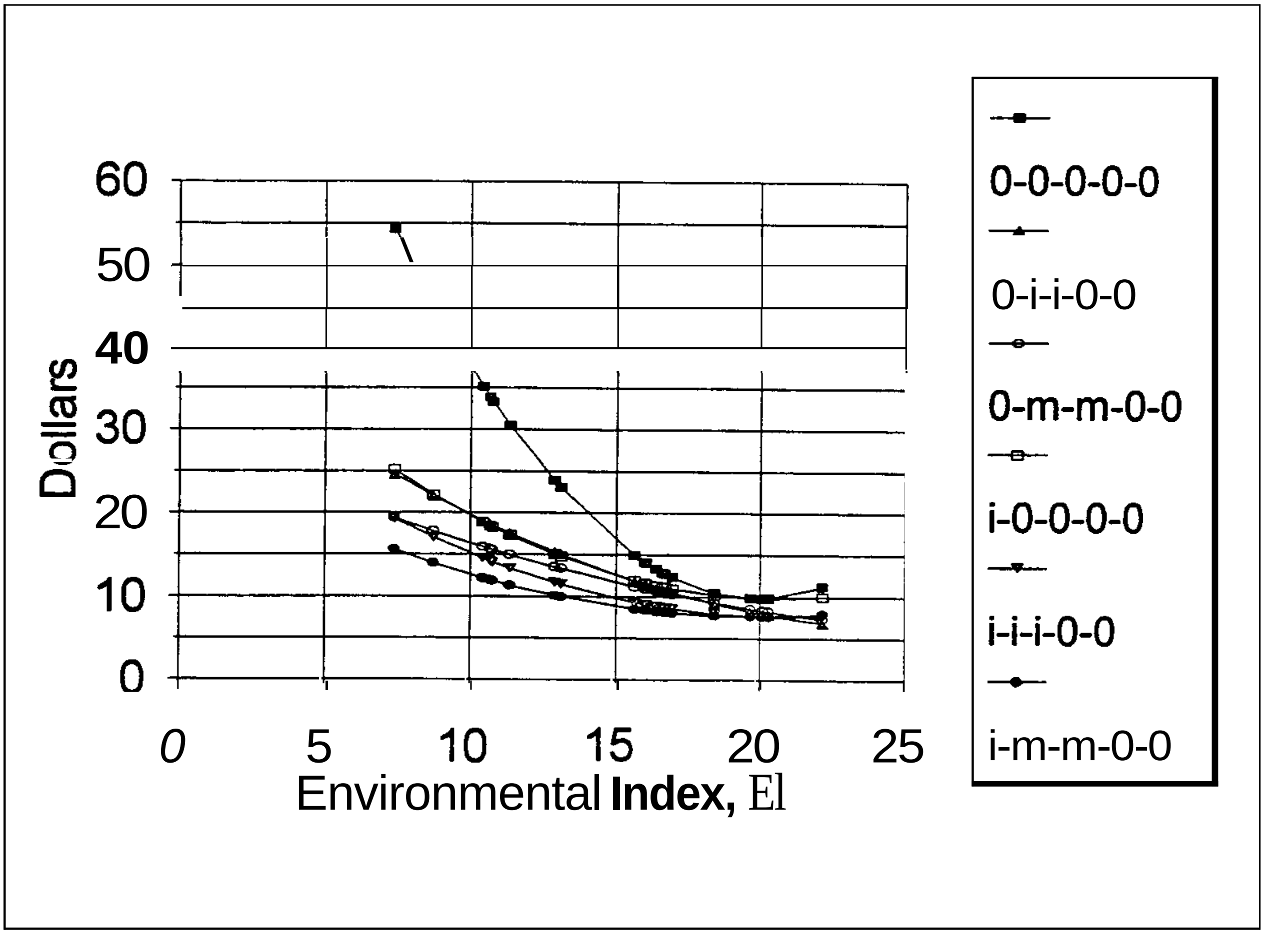

Fig. 4. Cost/ton of corn silage related to environmental index based on replications and years, as influenced by yard waste compost treatment, 1993-1996. 0 is no compost, *i* is incorporated compost and *m* is mulched compost.

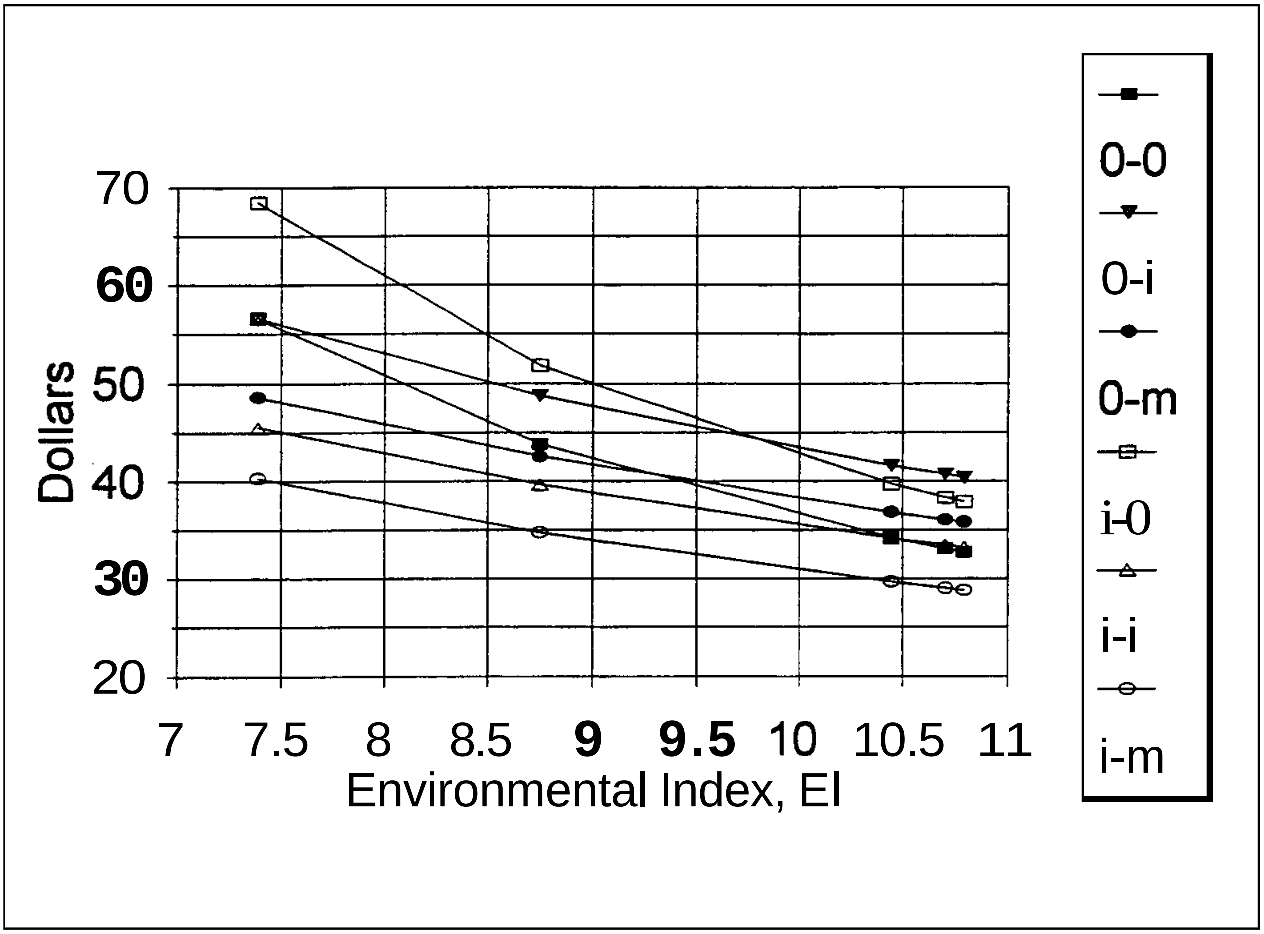

Fig. 5. Cost/ton of corn silage related to environmental index based on replications, as influenced by yard waste compost treatment with compost priced at $2/ton, 1993. 0 is no compost, i is incorporated compost and m is mulched compost.

Weed Control for Corn Planted into Sod

***M. L. Broome and G. B. Triplett**

INTRODUCTION

Tilling permanent vegetation initiates processes that degrade soil resources and make sustainable production difficult. Erosion is increased asmuch as 100 times and continued cropping causes soil organic matter to decline. This, in turn reduces soil structural stability and rainfall infiltration, increases runoff, and accelerates erosion Erosion and organic matter loss are less intense in the Midwest than in the Midsouth where the thermic climate accelerates organic decomposition and intense rainstorms increase erosion.

While growing annual crops, no-tillage systems reduce soil erosion by 90 to 99%, closer to the geologic rate than the losses from tilled agriculture. Organic debris from the crop, weed growth or a cover crop protect the soil from raindrop impact and slow the overland flow of runoff. Even with no cover, untilled soil resists erosion more strongly than recently tilled soil (Van Doren et al., 1984). Bruce et al. (1995) reported that crop yields increased with continued no-tillage. They attributed this to increased organic matter in the soil surface, which improved rainfall infiltration and water available for the crop. Several years were required to restore productivity on a site degraded by tilled annual cropping. One tillage cycle destroyed the benefits derived from several years of no-tillage.

Several million acres of hghly erodible cropland were enrolled in the CRP (Conservation Reserve Program) in the Midsouth during the 1980s. These contracts are maturing, and commodity price levels common in 19% could accelerate conversion of this land to annual cropping. Development of *systems* for no-tillage planting into sod would preserve soil benefits accumulated during the CRP years and increase sustainability while producing annual crops.

Some of the first successful no-tillage reported involved corn planted into sod killed with herbicides (Davidson and Barrons, 1954; Moody et al., 1961; Triplett et al., 1964). The introduction of atrazine in 1959 facilitated the subsequent development of no-tillage production systems. High atrazine rates control cool season perennial grasses found in the Midwest with or without contact herbicides. Despite the obvious benefits, such systems have not been widely developed for use in the Midsouth. Atrazine does not control warm season perennial grasses common in the Midsouth, such as johnsongrass *(Sorghum halepense* [L.] Pers.), bermudagrass *(Cynodon dactylon* [L.] Pers.), broomsedge *(Andropogon virginicus* L.), and *Paspalum* sp., and no other suitable herbicides have been available to control all of these grasses except johnsongrass, which can be controlled effectively with nicosulfuron and primisulturon. A recently published survey of vegetation present on CRP' sites in Kentucky Martin et al., 1996) found vegetation similar to the lower Midsouth.

Williams and Wicks (1978) listed bermudagrass and johnsongrass as major detriments to reduced tillage with herbicides available at that time. Timely corn *(Zea mays* L.) planting into dormant sod compounds the problem because preemergence applications of herbicides, active solely through foliar uptake, are ineffective. Vegetation control is essential for no-tillage production of any crop.

Herbicides are becoming available for no-tillage planting into sod. Products that control perennial vegetation, and transgenic corn hybrids that tolerate pre- and postemergence applications of these herbicides, have been developed. Triplett et al. (1964) stated that herbicides for no-tillage must: 1) control vegetation present, 2) prevent growth of weeds from seed, 3) not injure the crop, 4) not injure succeeding crops, and 5) be economical. Objectives of this study were to evaluate various herbicide combinations and rates for control of untilled perennial vegetation as a means of producing *corn*, to meet the first four requirements listed above.

MATERIALS AND METHODS

Corn was planted into untilled sod in 1995 and 1996 at the Mississippi Agricultural and Forestry Experiment Station's North Mississippi Branch, Holly Springs, Black Belt Branch, Brooksville; and Coastal Plain Branch, Newton. Soils at these respective sites were Grenada silt loam (fine-silty, mixed, thermic Glossic Fragiudalfs) with a 2-5% slope; Brooksville silty clay fine, montmorillonitic, thermic Agric Chromuderts) with a 1 to 3% slope; and Prentiss fine sandy loam (coarse loamy siliceous, thermic Glossic Fragiudults) with a 2-5% slope. Plant species identified on the various sites are

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M.L. Broome and G.B. Triplett. Mississippi State University, Mississippi State, MS. Manuscript received 20 March 1997. *Corresponding author.

listed in Table 1.

Both discrete rate and logarithmic (variable) rate applications were made to evaluate herbicides. Both methods were used on plots 10 ft x 30 ft arranged in randomized complete block designs with three replications. The center two rows of each 4-row plot were sprayed using a CO_2-pressurized backpack sprayer and hand-heldboom.Allherbicides were applied in 17.7 gal/a at 30 psi. In the logarithrmc study, herbicide rate was reduced 50% for each 5 ft of plot length sprayed. Logarithmic applications provide a continuum of rates that range from no effect on vegetation to complete control. Herbicide rate required for control was determined by measuring from the point spraying began to the point of 90% control. This distance was used to calculate. the rate. A 4-row planter was used to plant into a predominantly bermudagrass sod at Newton; Holly Springs, bermudagrass and broomsedge; and Brooksville, fescue *(Festuca arundinacea)* and dallisgrass *(Paspalum dilatatum)*. At Brooksville, logarithrmc rate studies were located in fescue sod and in broomsedge, late boneset, and johnsongrass, vegetation common on CRP sites. Various treatments (Table 3) were planted to Pioneer hybrid 3165, Pioneer hybrid 3245IR (imidazolinone resistant) and Dekalb hybrid 689 Liberty Link (glufosinate-ammonium resistant) hybrids, as appropriate, at 25,000 seeds/a.

In the discrete rate plots, PRE (treatments) were applied at planting as dormancy of warm season perennial species was ending 22 March to 10 April , and POST applications were made to active vegetative growth 21-28 DAP (d after planting) depending on growing conditions. The first logarithrmc rate applications were made when warm season perennials were dormant and at succeeding 14-d intervals until full vegetative growth occurred. All plots received broadcast fertilizer according to soil test recommendations. Additional N was applied sidedress at 8-10 leaf stage. Weed control ratings were recorded approximately 56 DAP for both discrete and logarithmic rate applications. Data were subjected to statistical analysis and means were separated by LSD at the 0.05 probability level.

RESULTS *AND* DISCUSSION

In preliminary results from the 1995 logarithrmc rate studies, several herbicides applied separately failed to control warm season perennial grasses at the highest rates used These herbicides included atrazine, paraquat, and cyanazine, which were eliminated from the 1996 logarithmic trials. Corn hybrids resistant to imidazolinone herbicides were included at all locations, and imazapyr and imazethapyr applied alone in the logarithmic study controlled perennial grasses (Table 1) at 0.5 lb a.i./arate except for imazethapyr on broomsedge. Imazapyr also gave excellent control of these grasses when applied three and five weeks after planting, while imazethapyr showed very low weed control at 0.5 lb ai./a. In 1996, logarithmic applications were made at 2-wk intervals on three dates, beginning in March when warm season perennials were dormant and ending in mid-April when these perennials were actively growing. Lower herbicide rates were required for control with successively later treatment dates (Table 2).

In preliminary results from discrete rate plots at Brooksville, atrazine tank mixed with paraquat or glufosinate provided 90% control of fescue, but paraquat alone was ineffective (less than 30% control, see Table 3). Also, an understory of bermudagrass, dallisgrass, and broomsedge present in the fescue sward was not controlled and developed rapidly, competing with the growing crop. Treatments containing imazapyr provided 90% control of bermudagrass, johnsongrass (data not shown) and broomsedge. Atrazine combined with either paraquat or glyphosate PRE did not control bermudagrass or johnsongrass at any of the three locations. Cool season species present on the sites were controlled readily with most herbicides used and were not competitive with the crop. Imazapyr provided season long (120 d) control (90%) of both perennial and summer annual species even at our lower rates.

Seven herbicide combinations provided 90% control, or greater, of one or more warm season perennial grasses (Table 3). All of these included imazapyr or imazethapyr or glufosinate, either alone or combined with other herbicides. In 1996, a mixture of imazapyr and imazethapyr identified as X-996 became available. X-996 failed to control perennial grasses at rates used but did control many other species at all locations.

In the discrete rate plots at Holly Springs, vegetation control with glyphosate PRE and glufosinate POST was excellent early but was unsatisfactory at 56 DAP except on broomsedge. Neither herbicide has soil residual activity, and weeds included both summer annuals and perennials that recovered from the initial application. For effective weed control with non-residual herbicides, correct timing of application was critical. Successful herbicide systems included an application at planting that suppressed the perennial grasses before the POST applications were made. Corn hybrids, those resistant to either imidazolinone or glufosinate, provided crop safety for postemergence application of effective herbicides. We observed no crop injury to resistant hybrids at any herbicide rate used.

At the Newton location, on a mostly

bermudagrass site, control with a combination paraquat plus atrazine PRE and imazapyr POST provided excellent control (90%). No other herbicide combinations were effective. Neither glyphosate nor paraquat applied postemergence with a hooded sprayer were effective for control of bermudagrass.

Warm season annuals posed a problem at all locations (see Table 1) when no soil residual herbicides were used or POST applications were not correctly timed. However, the use of imazapyr or imazethapyr PRE gave excellent control of the warm season annuals. Glyphosate PRE + glufosinate POST failed to give 90% control of these warm season annuals due to no soil residual activity and warm season annuals emerged after their use.

Cotton *(Gossypium hirsutum* L.) was planted in 1996 at one location following application of imazapyr at 0.5 and 1.0 lb ai./A in 1995. There were no crop injury symptoms observed at either rate. Triplett (1985) reported less soil residual carryover of atrazine and simazine applied to sod than when applied to tilled soil. Thus, these imidazolinone herbicides may be acting similarly.

Results from these preliminary trials indicate that with new technology available, methods of producing corn in untilled sod comprised of perennial species common in the Midsouth is possible. Additional work will be needed to verify these results at other locations, and to investigate other candidate herbicides as to rates and time of application for most effective control.

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Table 1. Species present on one or more of the three study sites.

Warm Season Grasses
Bennudagrass *Cynodon dactylon* L. Pers.
Broomsedge *Andropogon virginicus* L.
Johnsongrass *Sorghum halepense* L. Pers.
Dallisgrass *Paspalum dilatatum* Poir.

Broadleaf
Late. boneset *Eupatorium serotinum* Michx.
Wild carrot *Daucus carota* L.
White health aster *Aster pilosus* Willd.
Bullthistle *Cirsium vulgare* (Savi) Tenore
Milkweed *Asclepias syiaca* L.
Horsenettle *Solanum carolinense* L.
Curly dock *Rumex crispus* L.

Cool Season Grass
Fescue *Festuca arundinacea* Schreb

Winter Annuals
Chickweed mousear *Cerastium vulgatum* L.
Carolina geranium *Geranium carolinianum* L.
Henbit *Lamium amplexicaule* L.
Little barley *Hordeum pusillum* Nutt
Hairy vetch *Vicia villosa* Roth
Ryegrass *Lolium* sp.

Warm Season Annuals
Yellow foxtail *Setariaglauca* L. Beauv.
Crabgrass, southern *Digitaria ciliaris* (Retz.) Keol
Broadleaf signalgrass *Brachiaria platyphylla* Griseb

Table 2. Minimum rate of herbicide required for 90% bermudagrass control Herbicide applied with indeterminate logarithmic sprayer in 17.7 gal/a spray volume.

Treatment Herbicide	Initial Rate	Application Date and Weed Growth Stage		
		15 March Dormant	1 April Early Vegetative	15 April Vegetative
	lb ai/a	--------Herbicide Rate (lb ai/a) --------		
Imazapyr	0.5	>0.5	0.19	0.04
Imazethapyr	*0.25*	>0.25	0.21	0.13
Glufosinate	0.84	>0.84	>0.84	0.57
x-9%	*0.22*	>0.22	>0.22	0.18
LSD(0.05)			0.01s	0.056

Table 3. Effect of PRE and POST herbicide treatments on broomsedge, bermudagrass, and fescue at three locations. Ratings 56 DAP.

	Treatment Herbicide	Rate	Broomsedge 1995	Broomsedge 1996	Bermudagrass 1995	Bermudagrass 1996	Fescue 1995	Fescue 1996
		lb ai/a			% Control[1]			
1	Paraquat+atrazine PRE +	0.5+1.0	54bc	---[2]	---	---	90a	---
	a imazapyr PRE	0.5	---	98a	---	96a	---	---
	b imazapyr POST	0.25	---	---	93a	---	---	---
	c paraquat POST*	0.6	---	---	23d	---	85a	---
	d glufosinate POST	0.75	---	---	---	40c	---	---
	e glyphosate POST*	0.6	---	---	53bc	---	---	---
	f imazethapyr POST	0.125	53bc	---	---	---	88a	---
2	Glyphosate+atrazine PRE +	I 25+1.0	53bc	---	23d	---	50b	---
	a imazapyr PRE	0 5	---	96ab	---	96a	---	93ab
	b paraquat POST*	0 6	70ab	---	17d	---	---	---
	c glyphosate POST*	0 6	---	---	50c	---	---	---
	d sethoxydin POST	0 2	---	---	53bc	---	---	77d
	e imazethapyr POST	0 125	---	---	33d	---	---	90ab
3	Glufosinate+atrazine PRE +	.2+1.0	84bc	---	20d	---	90a	---
	a glyphosate POST*	0.6	---	---	67bc	---	---	---
	b glufosinate POST	0.375	---	---	---	80b	---	92ab
4	Paraquat PRE +	0.5	---	---	---	---	28cd	---
	a cyanazine PRE	2.0	25d	---	---	---	28cd	---
	b imazapyr PRE	0.5	---	---	---	---	---	95a
	c imazapyr POST	0.5	---	---	---	---	---	93ab
	d glufosinate POST	0.75	---	90b	---	---	---	87bc
5	Glyphosate PRE +	1.25	---	---	---	---	---	---
	a cyanazine PRE	2.0	53bc	---	---	---	---	---
	b imazapyr PRE	0.5	---	95ab	---	90a	---	---
	c imazethapyr POST	0.5	---	50d	---	37c	---	---
	d glufosinate POST	0.4	---	90b	---	80b	---	---
	e X-9% POST	0.1	---	78c	---	33cd	---	---
6	Glufosinate PRE	0.15	---	90b	---	37c	---	---
		LSD(.05)	25	6.0	16.5	6.9	12	6.7

[1] % control based on a visual rating on a scale of 0 = no control up to 100 = complete control
[2] Species not present or no treatment applied
*Hooded sprayer
Means followed by same letter do not significantly differ (P = .05 Duncan's MRT)

Influence of Conservation Tillage Practices on Grain Yield and Nitrogen Status of Corn Grown on an Alluvial Clay in Louisiana

***H.J. Mascagni, Jr., R.L. Hutchinson, B.R. Leonard, and D.R. Burns**

INTRODUCTION

Corn *(Zea mays* L.) acreage has increased dramatically in Louisiana in recent years. Research is being conducted to better define production practices that will maximize grain yield and profitability. Rainy wet periods during late winter/early spring often delays corn planting, particularly on the more poorly-drained clay soils. Delayed planting may result in decreased yield potential, as well as lower grain prices, increased conflict with management of other crops, and higher risk from tropical storms. According to Mascagni and Boquet (1996), optimal corn planting dates range from mid-March to mid-April in north Louisiana.

Recent govemment policies involving soil conservation have increased the need for research evaluating minimum-tillage systems. One of the principal advantages of no-till (NT) systems is more timely planting, especially on the pmrly drained, clayey soils (Boquet and Coco, 1993). Herbek et al. (1986) found a tendency for corn grain yield to increase as planting date increased from late April to mid-May for the NT sysem on a poorly drained soil, while for the conventional-tillage (CT) plots, grain yields decreased with delayed planting date. Although limited tillage research on corn has been conducted in Louisiana, no-till or minimum tillage production systems for cotton *(Gossypiurn hirsutum* L.) have shown promise, when compared to the more traditional tillage practices on alluvial clays of the Mississippi River (Boquet and Coco, 1993; Crawford, 1992; Reynolds, 1990).

The inclusion of winter cover crops in combination with conservation tillage has been found to be an important component of minimum-tillage systems. The use of these systems may reduce soil erosion, especially on the sloping silt loams of the Macon Ridge (Hutchinson et al., 1991); increase soil organic matter (Boquet and Coco, 1993); reduce soil moisture evaporation (Wilhelm et al., 1986); and modify soil temperature (Wilhelm et al., 1986). The use of a leguminous cover crop, i.e. crimson clover *(Trifolium incarnatum* L.), contributes biologically fixed N (Ebelhar et al., 1984), thus reducing the N fertilizer requirement and the potential of polluting ground water with nitrate-N.

Information is needed for corn production systems that will enhance profitability and protect the environment from unnecessary pollution of soil and water. Objective of these experiments was to evaluate the influence of tillage systems, cover crops, and N rate on corn grain yield and N uptake on an alluvial clay soil.

MATERIALS AND METHODS

Field experiments were conducted from 1994 to 1996 to evaluate the effects of tillage systems, cover crops, and N rate on corn grown on a Sharkey clay (very-fine montmorillonitic, nonacid, thermic Vertic Haplaquepts) at the Northeast Research Station near St. Joseph, LA. Tillage treatments were CT and NT. Cover crop treatments were native vegetation, crimson clover (‘Tibbee’ in 1994 and 1995 and ’Robin’ in 1996) and wheat *(Triticum aestivum* L.) (‘Florida 303’ in 1994 and 1995 and ’Buckshot 2368’ in 1996). Nitrogen rates evaluated were SO, 100, 150, and 200 lb N/a.

The experimental design was a randomized complete block with a split-plot arrangement of treatments having four replications. Tillage treatments were main plots and cover crops and N rates were factorially arranged as split plots. Plots were four rows wide (40-in. row width) and ranged from 28 to 50 A. long.

Conventional-till consisted of double-disking, bedding, and a bed smoothing operation just before planting. No-till consisted of no spring primary tillage operations. Beds were rehipped and smoothed (rolled) for planting in the fall.

Cover crops (crimson clover and wheat) were hand broadcast in 1994 and drill planted in

H.J. Mascagni, Jr., R.L. Hutchinson, B.R. Leonard, and D.R. Burns. Louisiana State University Agricultural Center, Northeast Research Station, St. Joseph, LA. Manuscript received 21 March 1997.
* Corresponding author.

1995 and 19%. Seeding rates were 25 lb/a for crimson clover and 120 lb/a for wheat when broadcast and 15 lb/a for crimson clover and 90 lb/a for wheat when drilled. In 1994, beds were smoothed (rolled) immediately after seeding the cover crops.

Cover crops were burned back in early spring each year. In 1994, *two* burndown applications of 0.6 lb ai/a of paraquat plus 0.25% surfactant were applied in early to late March across all cover crop treatments. A similar rate of paraquat was applied with pre-emerge treatments. In 1995 and 1996, 0.6 lb ai/a of paraquat plus 0.5% surfactant was applied **on** the crimson clover and native vegetation and 1.0 lb ai/a of glyphosphate plus 0.5% surfactant was applied on the wheat cover crop in early to mid-March. A second application of 0.6 lb ai/a of paraquat was applied about a week later. A similar rate of paraquat was also applied with pre-emerge treatments.

Pre-emerge treatments consisted of labelled rates of alachlor or metolachlor and atrazine at each location. Post-emerge applications were 1.5 lb ai/a of linuron and 1.0 lb ai/a of atrazine plus 0.25% surfactant in 1994. In 1995, 1.0 lb ai/a of linuron and 1.0 lb ai/a of atrazine plus 0.5% surfactant was applied at layby. Insecticide treatment was 1 lb ai/a of carbofuran applied in-how in all tests.

Corn ('Pioneer hybrid 3165') was planted at about 27,000 seeds/a using a John Deere 7100 or 7300 planter. Ripple coulters, if needed were mounted on the planter for no-till planting. Planting date was 4 April in 1995, however, planting dates were different for tillage treatments in 1994 and 1996 due to inclement weather affecting the CT seedbed preparation. Planting dates were 21 March for NT and 11 April for CT in 1994 and 4 April for NT and 12 April for CT in 19%.

Nitrogen treatments were broadcast at about the four-leaf growth stage. The N source was ammonium nitrate. Whole above-ground plant samples were collected from each plot at the early silk growth stage in 1994 and 1995, and grain samples were collected from each plot in 1996. Plant and grain samples were dried, ground, and analyzed for N using Kjeldahl procedures. Nitrogen uptake was determined by multiplying the *dry* weight by plant or grain N concentration.

Corn was harvested from two center rows of each four-row plot. Grain yields were adjusted to 15.5% grain moisture. Analyses of variance of yield data were conducted using GLM prccedures of SAS. The LSD Cp4.05) was calculated for mean separation.

RESULTS AND DISCUSSION

Rainfall was well distributed at St. Joseph in 1994 and 1996, with June rainfall below the long-term mean in 1995 (2.3 in.). Averaged across all treatments grain yields ranged from 89 bu/a in 1996 to 138 bu/a in 1994 (Table 1).

Grain yields were not significantly affected by tillage treatment in any year (Table 1). Averaged across years, grain yield was 117 bu/a for the NT treatment and 114 bu/a for the CT treatment. There was a relatively large difference between tillage treatments in 19%. Mean grain yield for NT was 97 bu/a compared to 81 bu/a for CT. The lack of statistical significance (P=0.11) between tillage treatments was probably due to a high CV (19%). Although tillage treatments were confounded by planting date in 1994 and 1996, the delayed planting for the CT treatment was considered part of the treatment effect. Planting date for each of the tillage treatments were within the recommended planting window for north Louisiana (15 March to 15 April).

Grain yields were influenced by cover crop treatments each year (Table 1). Highest grain yields occurred when corn followed crimson clover and native vegetation. Grain yields were severely reduced by the wheat cover crop regardless of tillage treatment. Grain yields following wheat decreased 35% in 1994, 27% in 1995, and 23% in 1996 when compared to the other cover crop treatments. Averaged across years, grain yields for corn following wheat were decreased 30%. Although plant populations were decreased approximately 10% following wheat, this would not account for the large difference in grain yield among cover crops.

Grain yields continued to increase as N rates increased each year (Table 1). There appeared *to* be a linear yield increase up to 200 lb N/a on this clay soil. There were no significant cover crop X N rate interactions for grain yield, which indicates that the grain yield response to N rate was similar among cover crops. At an equivalent yield level, corn following wheat would require a higher N rate than for corn following crimson clover or native vegetation.

Mean N uptake for whole-plant (at early silk) in 1994 and 1995 and seed in 1996 was highest when corn followed crimson clover or native vegetation (Table 2). Similar to grain yield response, there were no significant cover crop X N rate interactions for N uptake. Nitrogen uptake increased as N rate increased each year.

The lack of a significant cover crop X N rate interaction for grain yield and N uptake indicates that crimson clover did not contribute significant amounts of plant-available N during the growing season. This was due in part to the slow growth of crimson clover in these experiments, resulting in relatively low biomass production. The N equivalent averaged less than 40 lb N/a at burndown (data not shown). Similarly, the lack of a significant cover crop **X** N rate interaction for grain yield and N uptake indicates that the reduced corn grain yield following wheat probably was not due to N fertilizer immobilization. Other factors that might influence the cover crop effect on grain yield include alleopathic effects and immobilization of the native soil N by the wheat plant.

CONCLUSIONS

Data in this 3-yr study indicate that minimum tillage systems may be equivalent to the traditional tillage systems on the alluvial clay soils in northeast Louisiana. More timely planting is better assured by using a NT management system. There was little agronomic benefit from cover crops evaluated in these studies. Crimson clover did not produce enough available plant N to influence the N fertilizer efficiency. Grain yields were reduced significantly following wheat as a cover crop. The mechanism causing this yield reduction is not clear and needs to be determined.

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Table 1. Influence of tillage, cover crop, and N rate on corn grain yield on Sharkey clay at St. Joseph, LA, for three years.

Treatment	1994	1995	1996	Mean
	---------------	bu/a	---------------	
Tillage				
No-till	136	119	97	117
Conventional	140	120	81	114
LSD(0.05)	NS[1]	NS	NS	NS
Cover Crops				
Native	155	131	94	127
wheat	102	95	74	90
Crimson Clover	157	131	98	129
LSD(0.05)	7	7	7	**4**
N rate, lb/a				
50	83	78	43	**68**
100	130	106	77	104
150	162	136	101	133
200	178	157	133	156
LSD(0.05)	8	9	8	9

[1]Non-significant at the 0.05 probability level.

Table 2. Influence of tillage, cover crop, and N rate on N uptake[1] on Sharkey clay at St. Joseph, LA, for three years.

Treatment	1994	1995	1996
	--------	lb N/a	--------
Tillage			
No-till	122.8	107.1	43.3
Conventional	135.6	114.1	35.5
LSD(0.05)	NS[2]	NS	NS
Cover Crops			
Native	141.3	121.0	41.5
Wheat	106.8	86.8	32.3
Crimson Clover	139.4	124.2	44.1
LSD(0.05)	13.9	17.1	3.8
N rate, lb/a			
50	84.1	76.3	18.8
100	126.4	91.9	33.5
150	141.4	124.0	43.6
200	164.7	149.0	61.3
LSD(0.05)	16.1	19.7	4.4

[1]In 1994 and 1995, whole-plant N uptake at silking was measured. In 1996, *seed* N uptake was measured.
[2]Non-significant at the 0.05 probability level.

Tillage and Soil Insecticide Effects on Dryland Corn Yields

***J.E. Matocha, S.G. Vacek, and F.L. Hopper**

INTRODUCTION

Conservation tillage programs are important even on nonerodible soils. Definitive research in conservation tillage in the southwest had not been initiated extensively until the 1980s. Compliance with soil erosion guidelines, economic factors including rising inputs *costs* for equipment, fuel, labor, other variable costs, and uncertain market prices are strong incentives to develop and adapt Conservation tillage systems. Earlier reports have described conservation tillage systems that appeared suitable for southern Texas (Matocha, 1993; Matocha et al., 1991; Salinas-Garciaetal. 1997).

The specific objectives of this study were: 1) to compare alternative tillage systems including two forms of conservation tillage on plant rooting and grain yields and 2) to determine the need for soil insecticides with conservation tillage.

MATERIALS AND METHODS

The long-term dryland study was conducted from 1980 through 1995 on an Orelia sandy clay loam (hyperthermic Typic Ochraqualf) located at the Texas Agricultural Experiment Station farm at Corpus Christi A randomized complete block design with eight tillage treatments as major plots and three principal crops, grain sorghum *(Sorghum bicolor* [L] Moench), corn *(Zea **mays*** L.), and cotton *(Gosypium hirsutum* L.) as sub or split-plots were each studied in four replications. Tillage treatment response data reported in this paper are for corn as the indicator crop and include: 1) conventional (CT), 2) minimum tillage (MT), 3) no-till (NT), and deep tillage (12-inch depth) using 4) moldboard (MB) and 5) chisel (CH) plows. The conventional system includes some 10-12 tillage operations including planting and cultivating. Maximum tillage depth in the CT system was 6 in., while tillage depth in the MT treatment was maintained at 3 in.

Further description of MT and CT tillage systems is given in Table 1. Secondary tillage was performed using bedder sweeps. Atrazine, paraquat, and sometimes glyphosate were used in the NT and MT plots.

J.E. Matocha, S.G. Vacek, and F.L. Hopper. Texas A & M University, Agricultural Research and Extension Center, Corpus Christi, TX. Manuscript received 7 April 1997. * Corresponding author.

Atrazine was also used in the CT, MB, and CH tillage systems as post-plant spray. Carbofuran (Furadan) was used in the seedrow at planting at a rate of 1.0 lb a.i./a for control of soilborne insects in 1983, 1985, and 1989. Terbufos (Counta) was used in 1991, 1993, and 1994 at label recommended rate of 1.0 lb a.i./a. In the years indicated, both soil insecticides were compared with untreated checks in split-plot design. Corn was rotated with cotton in four-year cycles with corn and cotton initiated in 1979 in split plots, corn was moved to cotton plots in 1983 and continued through 1986 followed by cotton for four years. In 1987, corn again followed cotton for a four-year project. In 1991, corn was again moved to the cotton side of the plots and continued through 1995.

Soil cores were extracted using a four-inch-diameter probe at selected depths to 24-in. at the silking stage of growth. Cores were centered directly over individual corn plants. Root mass determinations were made using a root washer and analytical balance.

RESULTS AND DISCUSSION

Tillage effects

Early plant growth. Plant growth as well as final grain yields fluctuated with season and precipitation during the growing period. In seasons with below long-term average precipitation (Table 2), plant growth was suppressed by deep primary tillage methods that caused the greatest disturbance of soil particles (12-in. moldboard vs no-till). On the other hand, if precipitation was not limiting, growth very little difference was observed among the five primary tillage systems. Growth of no-till corn was significantly less due to grassy-weed competition. Present herbicide technology using over-the-top sprays with sulfanyl urea compounds was not available during earlier years of the study, and when it later became available, the proximity of sorghum and cotton prevented its use.

Grain yields. Grain yields were variable with crop year and precipitation occurring during the period of April-June. However, April-June precipitation did not correlate highly with final grain yields. Yield data describing tillage depth effect for 16 of the 17 yr of the study are presented in Figure 1. Data for the first yr, 1979, are not shown Grain yields ranged from a low of 1020 to a high

6100 lb/a. In general, yields fluctuated with precipitation during the growing season with some exceptions. The no-till treatment represented the zero tillage depth. Data show that in nine of the 16 yr, sufficient positive yield response was measured to offset the cost of chisel sweep tillage at six-in depth. However, yield response to chisel sweep plowing at 12-in depth was sufficient to more than offset tillage costs in only two of the 16 yr of the study Complete inversion of the soil as is the case with moldboard plowing caused even more substantial reduction in crop yields in certain seasons with subaverage precipitation during the fall months. These data followed normal expectation for dryland farming since tillage methods that cause the greatest and deepest disruption of soil physical properties should affect plant available soil moisture (Cripps and Matocha, 1987).

Yield data averaged for seven relatively wet and five relatively dry seasons show no difference due to method of tillage at both 6-in. and 12-in. plowing depths (Figures 2-3). Yields increased approximately 50%, 60%, and 53% due to increased precipitation for CH, MB, and CT tillage *systems*, respectively, when tillage was performed to a depth of 6 in. (Figure 2).

Increasing tillage depth to 12 in. with either the CH or MB plow (Figure 3) resulted in increased averaged yields in the wet seasons by 68% and 76%, respectively, over the dry seasons while the CT system produced 53% higher yields. These yield increases of approximately 19% with 12 in tillage depth over 6-in. depth (CT) are probably due to increased rainfall harvesting and water retention in the profile. These data also show an approximate average 300 lb/a or 9% yield reduction due to deep tillage with either MB or CH plows in the dry seasons.

Yield data for five individual tillage systems are presented for four yr with high precipitation during the growing season (ppt. 150% above average) in Figure 4. Yields from MT treatment substantially exceeded from the CT yields in one of the four yr (1981) and those from NT in four or five yr. Average MT yields for these wet yr were 101% of those for the CT system while average MB yields were slightly higher, at 103% of CT. The slight increase in yield due to MB plowing to 12-in depth would not be economically justifiable.

Variable but nonsignificant response to tillage method was measured during the four seasons when April-June precipitation was less than 50% of average (Figure 5). Yields during these dry periods were less than 50% of those observed for the periods when soil moisture was adequate (Figure 4). In three of the four dry yr, 1984, 1988, and 1990, corn grown with the MT system produced 600-700 lb/a more grain than corn grown with NT. In 1984, MT corn produced substantially more grain that corn grown with the CT system. Corn yields with MT averaged for the four dry seasons were 110% of those for the CT system.

Plant rooting. Root data showed that MB tillage produced corn with slightly higher root weights than NT corn and significantly greater rooting in the surface 6 in. than MT, CT, and CH systems (Figure 6). However, these differences became less pronounced with soil depth. At the 6- to 12-in. depth, only the CT systems produced significantly greater rooting than the NT and MT systems. At the 12-to 18-in. soil depth, corn showed significantly greater root weights when grown in the CH system compared to MB. No treatment effect on rooting was apparent at soil depths below 18 in.

Soil insecticide effects

Corn grain yields comparing effects of soil insecticides for four separate tillage systems are shown for 6 yr in Figures 7-8 . Furadan was used in the first three yr while Counter was applied in the second three yr of insecticide use. Data for 1983, which was the first yr of *corn* following cotton in the four yr rotation, show only limited response to Furadan application in the seed row. Yields were limited due to subaverage rainfall during the growing season. Both conservation tillage systems produced yields equal to CT. Likewise, in 1985, the third yr of continuous corn, with average rainfall, yield data indicated no response to soil insecticide regardless of the tillage system used in seedbed preparation. In fact, a slight yield depression was evident in the conservation tillage treatments which was not expected. Similar data for the fourth yr of continuous corn is not available since soil insecticide was not used. Perhaps some response to soil insecticide could have occurred in the fourth yr.

Data for 1989, the third yr of continuous corn following the second cycle of cotton, show a trend of yield enhancement due to insecticide in all tillage treatments with the largest yield increase with NT. Generally, little or no yield enhancement is expected during the first yr or two following rotation with crops such as cotton or soybean.

Response data to tillage and soil insecticide using Counter are presented in Figure 8 for three yr in the latter part of the study. Rainfall during these three seasons was generally adequate to excessive as shown in Table 2. The data show in paired comparisons the application of Counter at recommended rate produced no significant increase in grain yields regardless of tillage system. However, small increases due to insecticide use occurred, but generally ranged from minus 190 lb/a to positive 770 lb/a outside of the conservation tillage treatments. Within the two conservation tillage treatments, yield influence ranged from a low of 230 (NT) to a high of 660 lb/a (MT). The higher response was measured during the fourth yr of continuous corn.

CONCLUSIONS

Grain yields were highly variable with yr and precipitation during the 15 growing seasons. Method of primary tillage usually has little or no effect on final grain yields except in droughty seasons when yield reductions were associated with deep primary tillage with either moldboard or chisel plows. A minimum tillage system developed for southern Texas produced 110% of the CT system corn yields in seasons with subaverage precipitation and 101% with above average precipitation. Plant rooting in the surface 6 in was most intense for NT and MB systems and highest with CT in the 6- to 12-in soil layer. Small and inconsistent responses in final grain yields to both Furadan and Counter soil insecticides suggest their use in CT and MB tillage systems would not be economically feasible. However, data for NT and MT suggest a possible economic response.

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Table 1. Description of conventional and minimum tillage systems.

Conventional (10-11 tillage trips)	Minimum Till (5 tillage trips)
1. Shred and disc corn stalks	1. Disc corn stalk
2. Middlebuster corn rows	2. Root plow corn row and form slight bed over row
3. Rebed with middlebuster plow	3. Spray atrazine or paraquat as needed for fall-winter weed control
4. Plow middles between beds using busters and sweeps run through beds to control weeds, 2-4 times during fall and winter depending upon rainfall.	4. Knife in fluid fertilizer
5. Knife in fluid fertilizer	*5. Plant using JD Model 6100 planter
6. Plant using sweep-type planter (JD Model 6100)	6. Cultivate once
7. Cultivate twice	*No-till was planted with JD Maxi emerge

Table 2. Monthly rainfall in inches at Corpus Christi, TX, 1980-1995 and long-term average (LTA).

	LTA	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95
January	1.71	1.64	1.66	0.13	0.35	6.32	2.40	1.41	1.85	0.81	1.72	0.44	1.78	3.03	0.40	0.79	0.63
February	1.96	0.79	1.80	8.36	2.00	0.26	3.20	1.54	3.82	1.20	1.87	2.23	1.43	3.40	1.58	0.85	2.38
March	0.94	0.32	1.63	0.22	2.18	0.09	1.93	0.50	0.19	0.92	0.40	2.46	0.91	4.11	2.76	2.23	3.51
April	1.72	0.06	1.46	0.79	0.00	0.00	2.63	0.80	0.76	0.69	2.68	4.53	3.23	2.29	2.13	2.26	0.3
May	3.33	2.28	7.45	1.73	3.25	1.32	3.76	3.80	3.13	1.10	0.00	0.75	3.59	7.67	6.80	1.55	3.18
June	3.09	0.00	2.27	0.30	2.13	0.41	4.23	3.27	7.93	0.66	3.10	0.43	8.56	2.26	8.49	3.20	2.25
Total March-June	9.37	2.66	12.81	3.04	7.56	1.82	12.55	8.37	12.01	3.37	6.18	8.17	16.29	16.33	20.18	9.24	8.97

Table 3. Effect of tillage system on early growth of corn for growing seasons with different precipitation patterns (values followed by the same letter within columns do not differ significantly).

System	Below Average Precipitation	Above Average Precioitation
No-Till	2811a	4390 c
Min. Till	2242ab	5824ab
Conventional	2806ab	5723ab
Moldboard -12-inch	1848 b	5286 b
Chisel - 12-inch	1928ab	5421 b

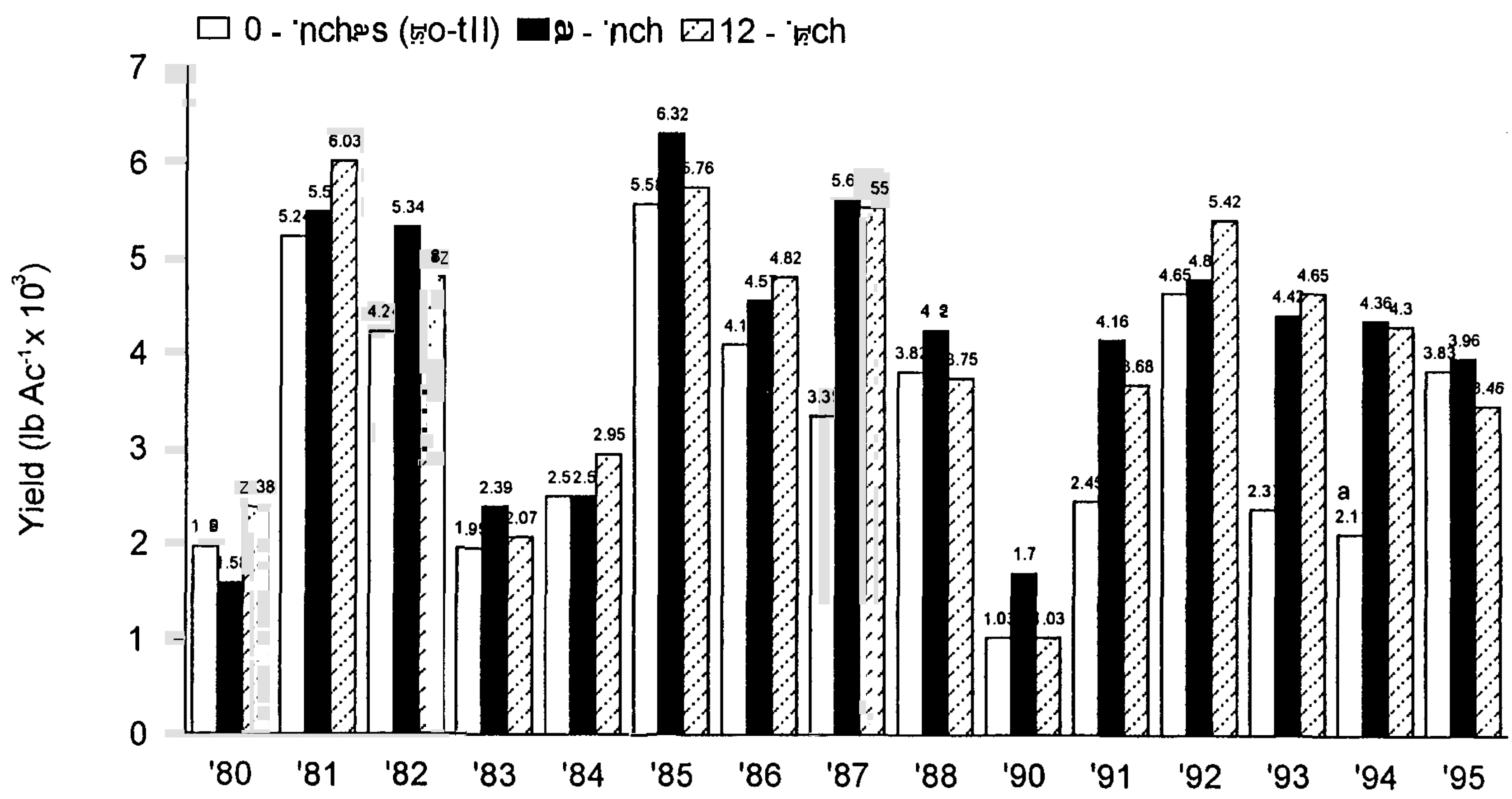

Figure 1. Influence of plowing depth on grain yield of corn over 16 seasons (chisel sweep used in 6 and 12 -inch depths).

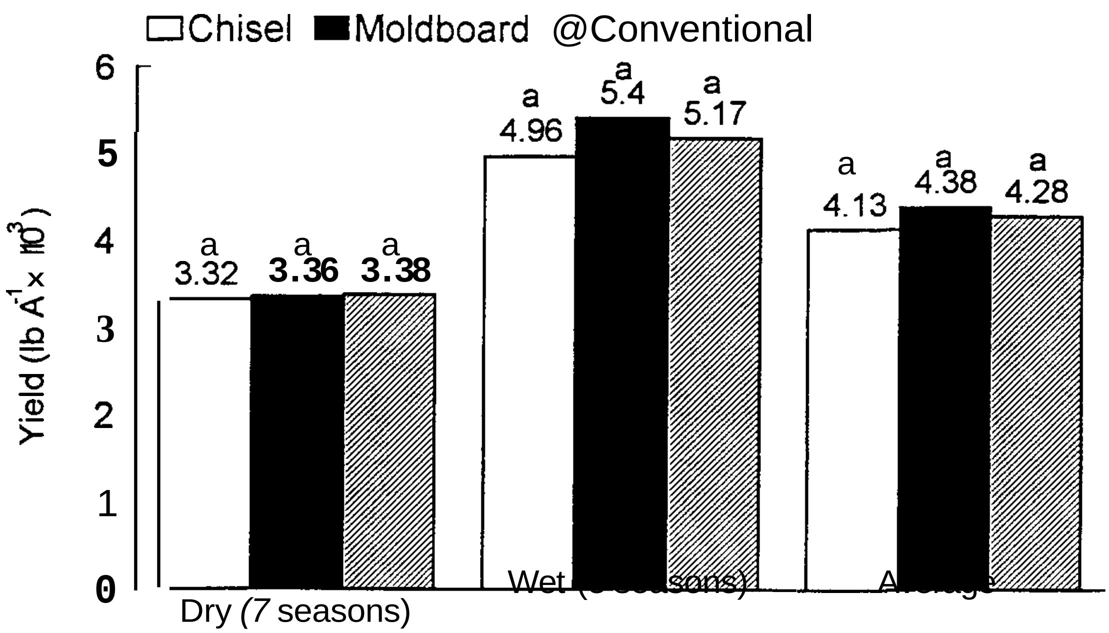

Figure 2. Effect of primary tillage methods and precipitation on corn yields. Values followed by the same letter within seasons are not significant at 0.05 (6-Inch tillage depth, chisel & moldboard).

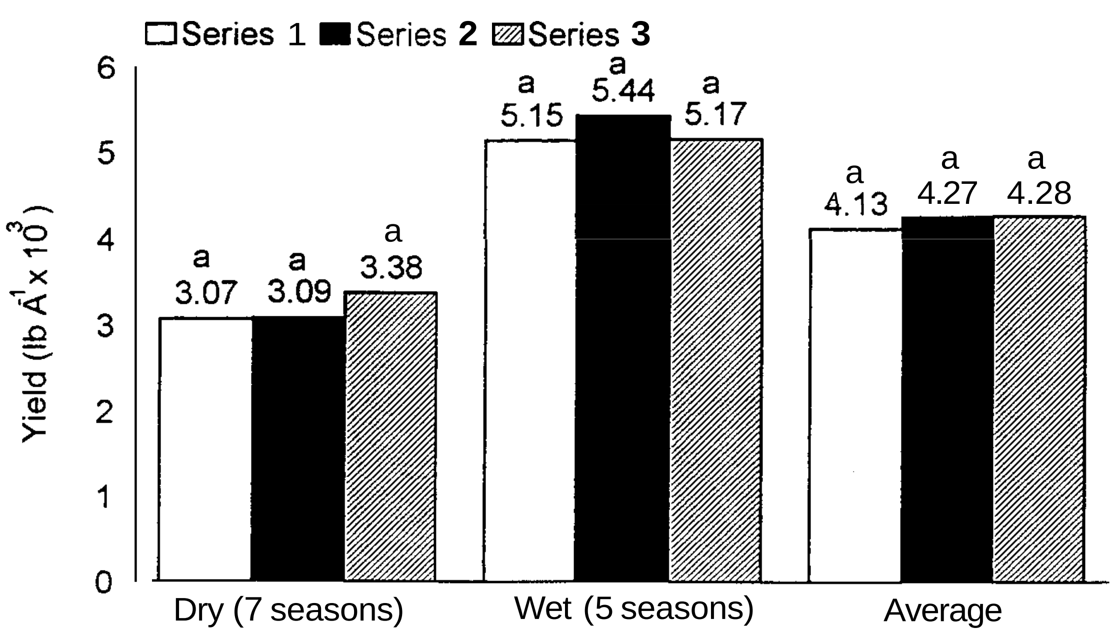

Figure 3. Effect of primary tillage methods and precipitation on corn yields. Values followed by the same letter within seasons are not significant at 0.05 (12-inch tillage depth, chisel & moldboard).

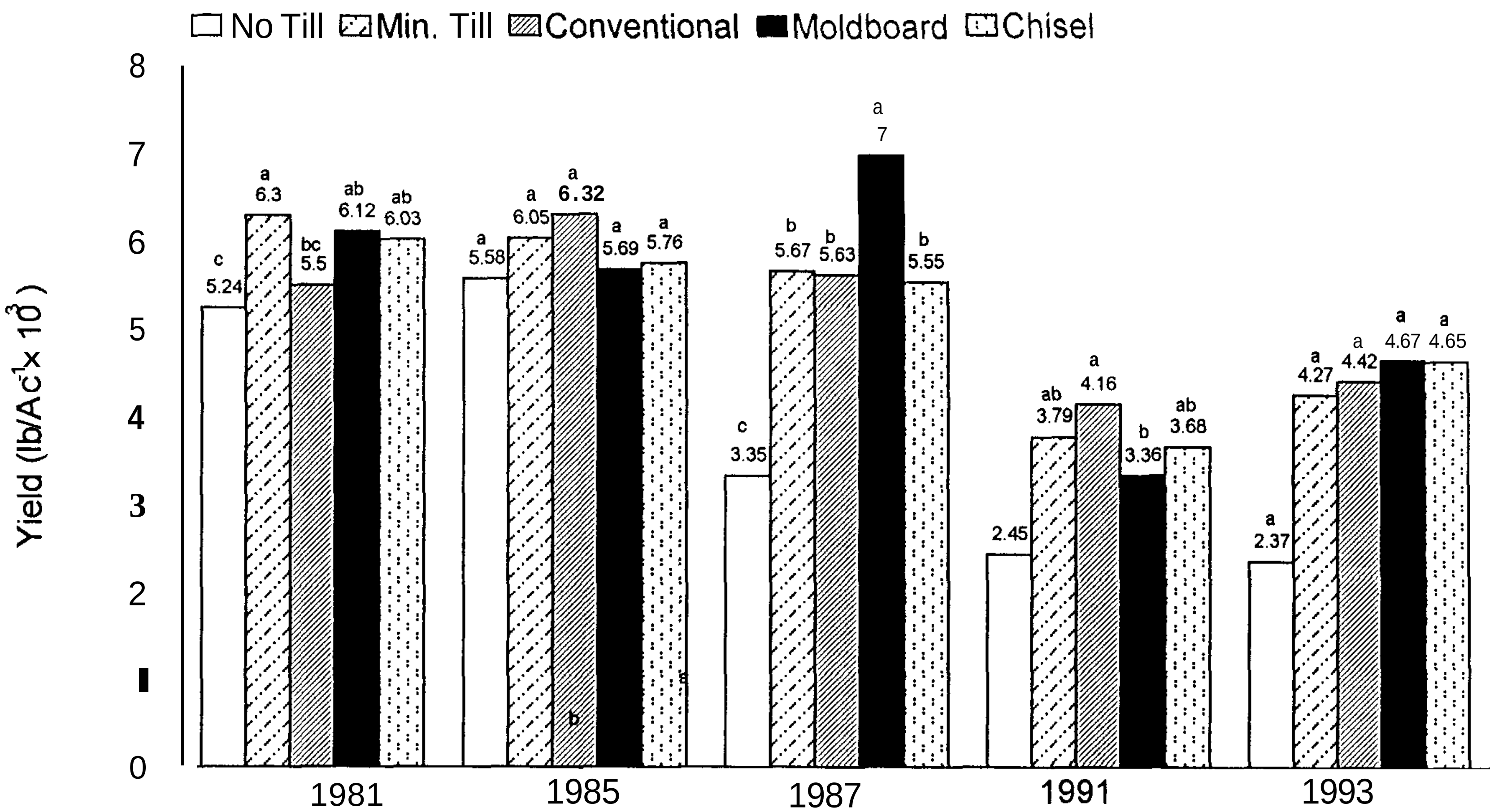

Figure 4. Effect of long-term tillage systems on grain yields with precipitation 150 percent of average. Moldboard and chisel plow at 12-inch depth. Values followed by the same letter within seasons are not significant at 0.05.

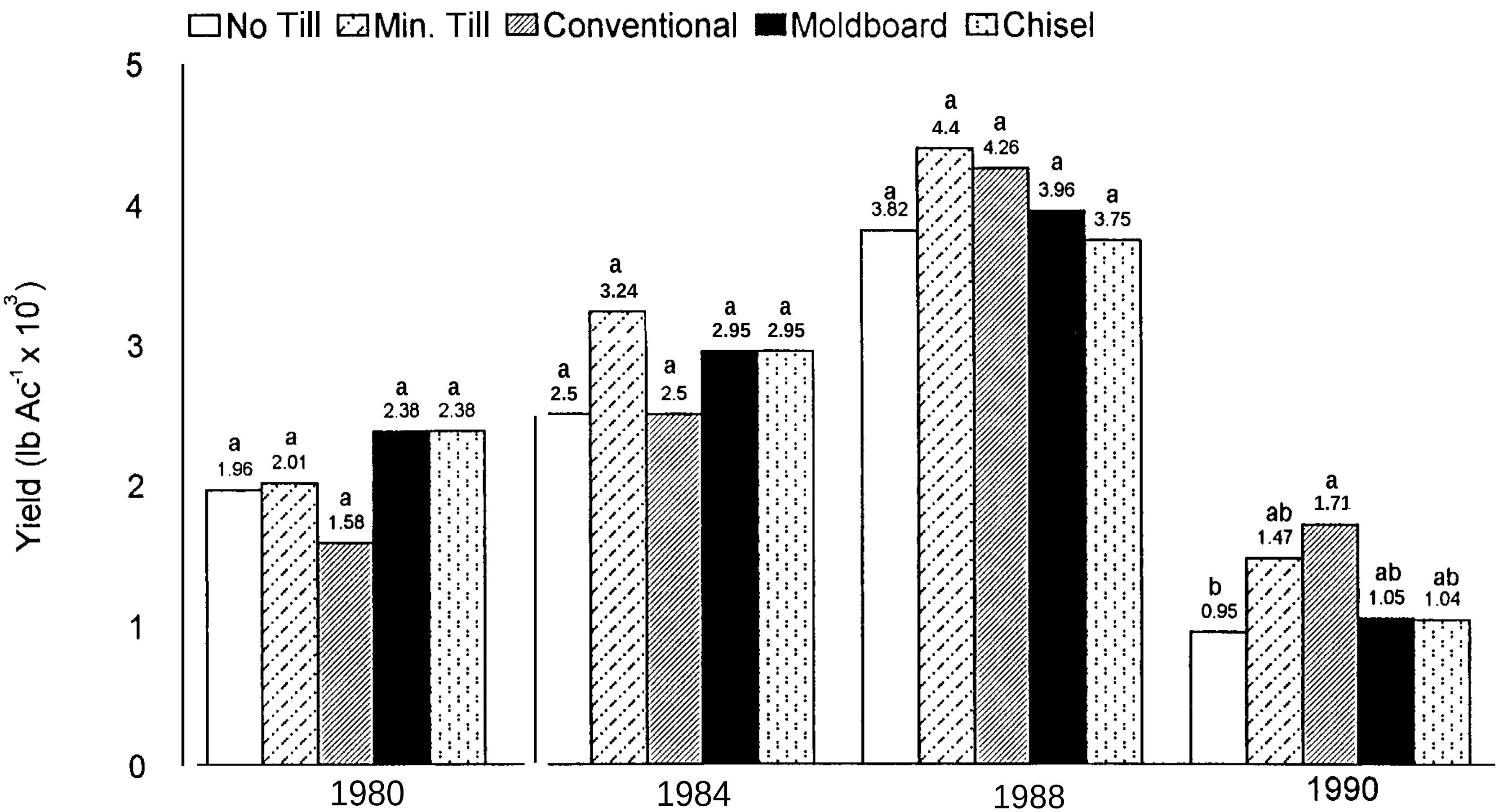

Figure 5. Effect of long-term tillage systems on grain yields with precipitation less than 50 percent of average. Moldboard and chisel plow at 12-inch depth. Values followed by same letter within seasons are not significant at 0.05.

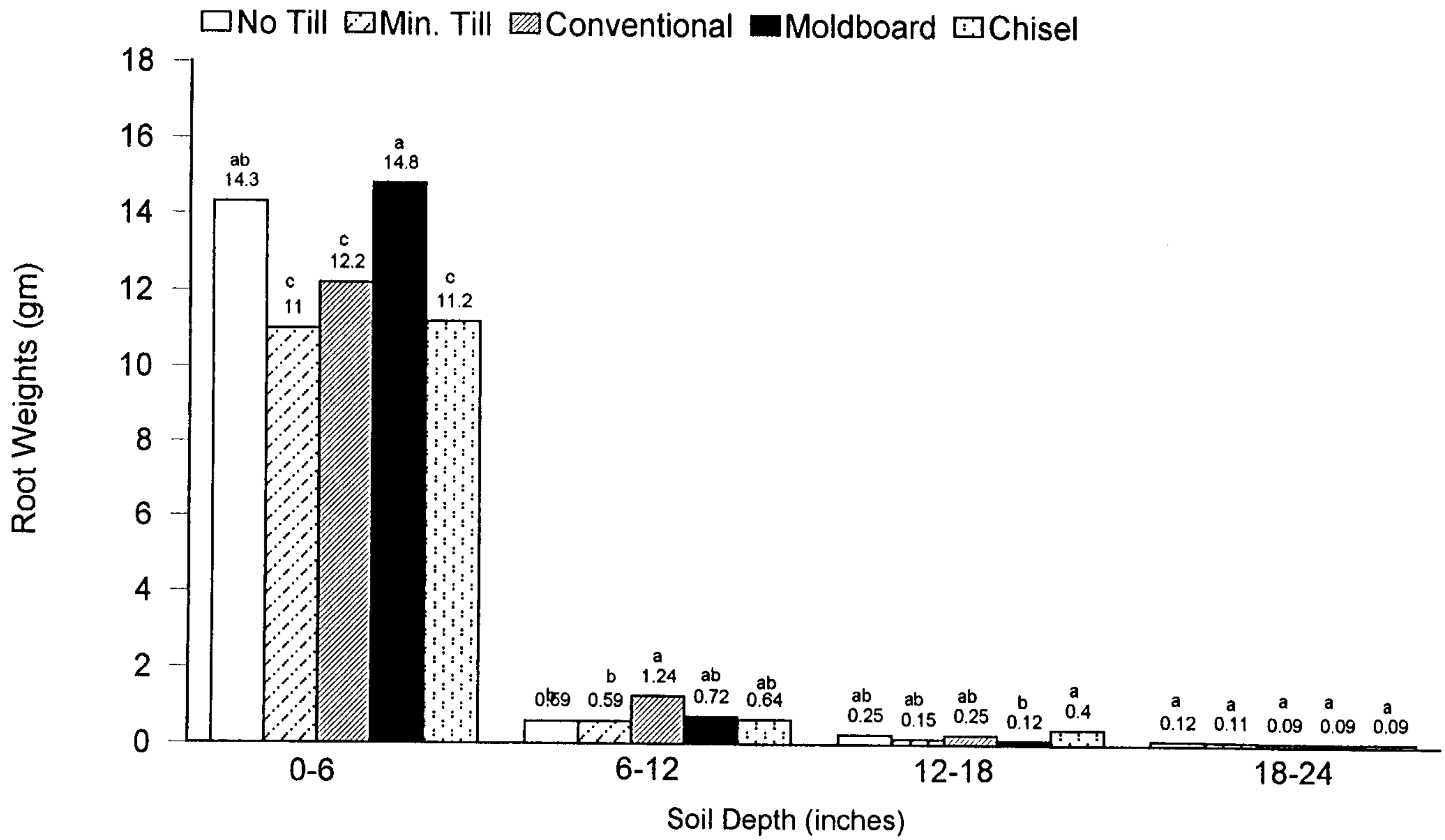

Figure 6. Plant root weights as affected by tillage systems at various soil depths.

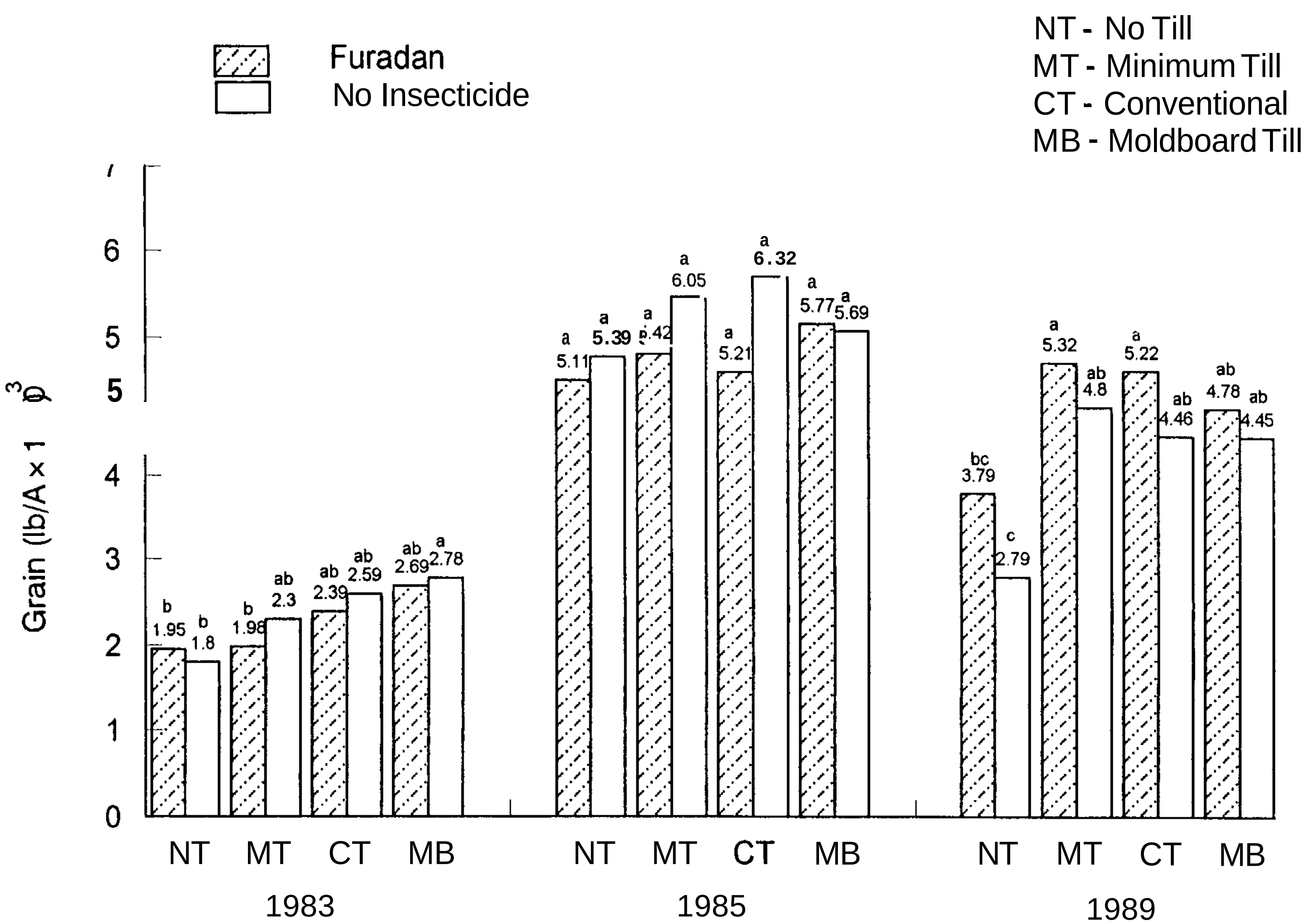

Figure 7. Influence of tillage systems and soil insecticide on grain yields of corn (T-3). Values followed by the same letter within season are not significant at 0.05 level.

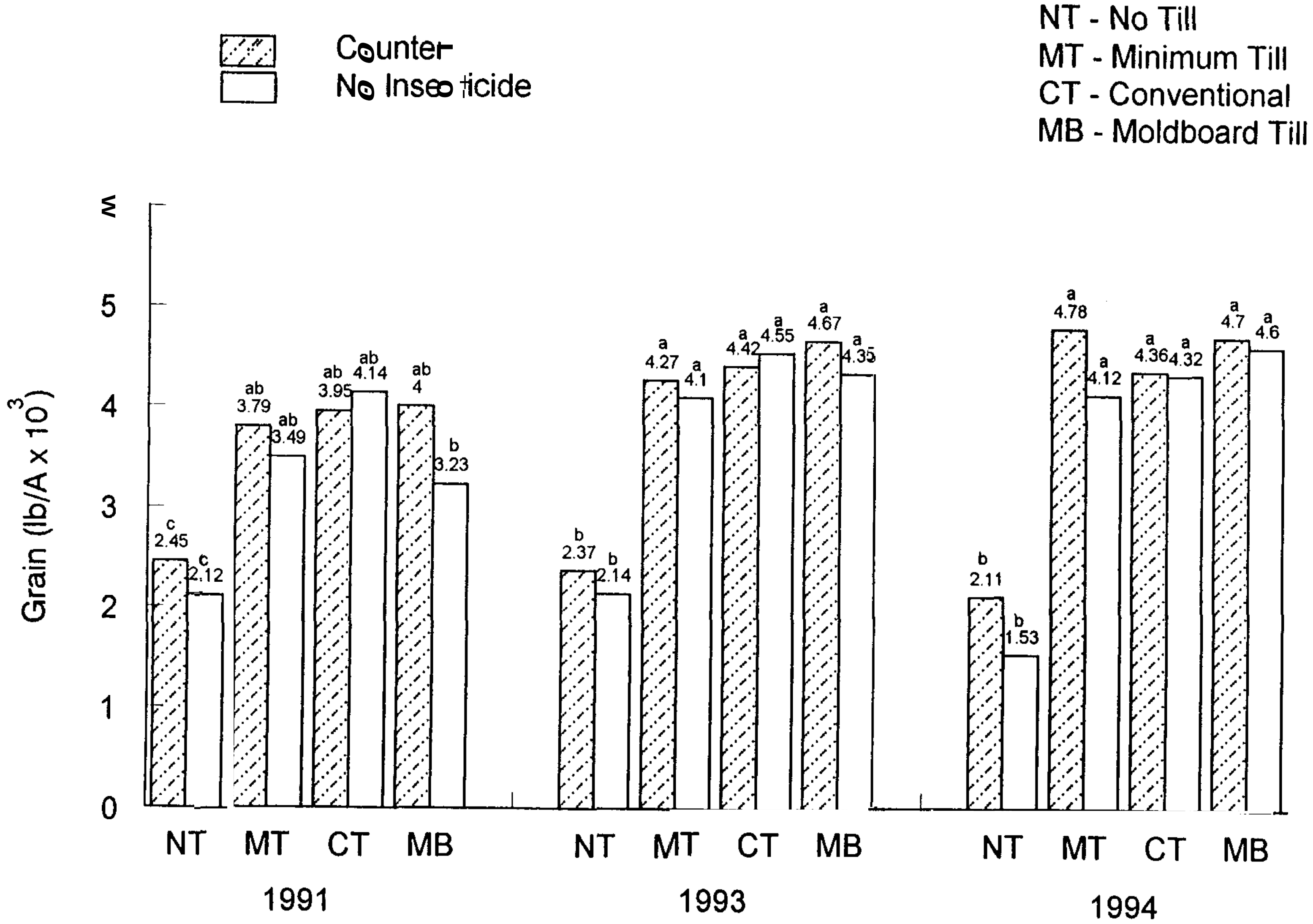

Figure 8. Influence of tillage systems and soil insecticide on grain yields of corn (T-3). Values followed by the same letter within season are not significant at 0.05 level.

Research Techniques Using Precision Agriculture Technology

Roberto Barbosa, John Wilkerson, William Hart, Paul Denton, Roland Roberts, *Don Tyler, and Don Howard

INTRODUCTION

Burdened by high production costs and increased environmental concerns, today's farmers are looking for new technologies that can help optimize their production Efficiency. Site-specific fanning is a technique to describe what some are calling the next major revolution in production agriculture which has the potential to address many of these concerns. An experiment was conducted in 1995 to document site-specific yield response of corn *(Zea mays* L.) For different application rates of N fertilizer within soils with varying yield potentials. To accomplish this task, new technologies such as Global Positioning System (GPS), Geographic Information Systems (GIS), grain yield monitoring and variable rate control were integrated into an overall system. A 22-a no-till production corn field located in Milan, Tennessee was selected for this study. Prior to planting an extensive soil survey was conducted and the field was classified based on varying levels of yield potential. Five different application rates of N were applied on the field using a variable rate applicator controlled by a laptop PC with control information being received in real-time from a GPS receiver and digital application map. Soil nutrient samples, leaf N samples, and plant population samples were collected through the season.

MATERIALS AND METHODS

The experiment was conducted at the University of Tennessee Milan Experiment Station. The test field had a total area of 22.5 a and had been continuously used for agricultural research. In the past 10 yr it has been in a corn/wheat *(Triticum aestivum* L.)/soybean *(Glycine max* [L.] Merr.) No-till rotation. In February 1993, 2,204 lb/a of lime were applied to the field test. On 15 March 1995, 80 lb/a of P_2O_5 and K_2O were applied in the field. Corn was planted on 5 April 1995. The cultivar used was 'FFR-943' with a population of 25,000 plants/a.

[1]R. Barbosa, [1]J. Wilkerson, [1]W. Hart, [1]P. Denton, [1]R. Roberts, [2]D. Tyler, and [2]D. Howard. [1]University of Tennessee, Knoxville, TN. and [2]West Tennessee Experiment Station, University of Tennessee, Jackson, TN. Manuscript received 29 April 1997. *Corresponding author.

Variable rates of liquid N fertilizer were the only treatments applied to the field. Five discrete rates were randomly applied using GPS and variable rate technology. Corn yield was recorded using a yield monitor and GPS equipment. All field data were later analyzed usinga GIS package for analysis of the effect of the various N. rates on corn yield by soil groups. Soils were mapped based on landscape features with a resulting variably sized grid pattern that averaged about 0.4 a. Properties expected to affect yields such as depth to fragipan percent slope, soil drainage, etc. were noted. Mapping units delineated are shown in Table 1

Fertilizer Application

A mixture of urea and ammonium nitrate, containing 32% N, was used as the N fertilizer source in the application. Based on an estimate that used 1.2 to 1.3 lb of N to produce one bu of grain corn and on the yield goal for each class of soils, five different rates were chosen: 0 lb N/a, 90 lb N/a, 120 lb N/a, 150 lb N/a, and 180 lb N/a. After calibrating the applicator based on a speed of 5.8 mph, row spacing of 30 in. and pressure of 40 PSI, the actual rates applied were: 0 lb N/a, 84 lb N/a, 127 lb N/a, 143 lb N/a. And 181 Ib N/a.

A fertilizer applicator was adapted, capable of delivering five discrete rates through the combination of three different orifices. The applicator consisted of centrifugal pump with a maximum pressure output of 100 PSI and maximum flow of 90 GPM; a 200-gal tank, three pressure compensating solenoid values that controlled each of the three orifices; line strainers; pressure regulators, and five 20-in bubble coulters. The orifices were mounted in each row directly behind the coulters. The applicator was equipped with five coulter units. The desired rates were achieved through orifice combinations.

To expose all groups of soils to every N rate, the fertilizer was applied according to the following pattern; the field was divided into 22 strips parallel from north to south. Each strip had a width of 90 A. The applicator, equipped with a laptop, a single-board computer, and a GPS system, changed the rates every time it crossed the lines separating each sub-area.

The applicator was controlled by a laptop computer interfaced with a single-board computer (SBC). The laptop computer and the GPS receiver were located inside the tractor's cab. The laptop received information about the geographic position of the sprayer, looked up the desired application rate at that location, and sent the rate information to the SBC. The SBC calculated what orifice combination produced the desired rate and sent an electrical signal to the solenoid valves to open or close the required orifices. The laptop computer recorded each field position during the application, along with the rate applied. The files were later used to create maps of application in the area using GIS.

Yield Data Collection

The corn was harvested on 12 September 1995. A John Deere combine model 4425 with a four-row corn header was used in the harvest. A yield monitor and GPS receiver were used to record the corn yield and its geographic position. Data from the GPS receiver and yield monitor were recorded every second by the laptop PC. A program written in C-language captured the incoming data from both devices and stored it into ASCII format.

Yield Analysis

Yields were separated by Nrate, soil series, soil mapping unit, and previous yield potential grouping. Interactions between rates and series, rates and slope, rates and depth to fragipan, series and slope, series and depth, and slope and depth we found to be significant ($P<0.05$). This indicated the complexity of landscape-soil relationships to yield. Yield results were predicted correctly at each N rate from 84 to 181 lb/a when separated using criteria for potential yield soil groups in Table 2 compared to measured yield (Table 3). A preliminary economics analysis was performed to determine most profitable rate of N relative to yield measured for the mapping units.

CONCLUSIONS

Variable rate application of N in corn based on yield potential shows promise as a method for maximizing profit potential within a field. The variable rate applicator used in this research proved to be an effective system for varying liquid N at predetermined discrete rates. The commercially-available yield monitor proved to be an accurate method of documenting yield variability. The yield monitor was calibrated to an accuracy of 1.8%. The GPS receivers provided a very reliable system for geo-referencing data acquisition within the test field. With a local base station and real-time radio links for GPS, positional accuracy was maintained at one meter or better 95% of the time. The GIS proved to be an effective and essential tool for managing all geographically related information within the field.

Table 1. Soil types identified in the test area.

Soil Unit	Description
LoA0	Loring series, 0-2% slope, fiagipan at or greater than 36 in.
LoA2	Loring series, 0-2% slope, fiagipan between 20-30 in
LoA3	Loring series, 0-2% slope, fiagipan between 12-20 in.
LoB0	Loring series, 2-5% slope, fragipan at or greater than 36 in
LoB	Loring series, 2-5% slope, fragipan between 30-36 in.
LoB2	Loring series, 2-5% slope, fragipan betweenn 20-36 in.
LoB3	Loring series, 2-5% slope, fragipan between 12-20 in.
LoB4	Loring series, 2-5% slope, fiagipan between 12-20 in.
LxC	Lexington series, 5-8% slope
LoC2	Loring series, 5-8% slope, fragipan between 20-30 in.
LoC3	Loring series, 5-8% slope, fiagipan between 12-20 in.
GrA	Grenada series, 0-2% slope, fragipan between 30-36 in
HeA2	Henry series, 0-2% slope, fragipan between 20-30 in.
PrB3	Providence series, 2-5% slope, fragipan between 12-20 in.
PrC4	Providence series, 5-8% slope, fragipan between 0-12 in.
CoA	Collins series, 0-2% slope

Table 2. Soil groups created based on projected yield potential.

Group	Yield Potential	Definition
	---------- bu/a----------	
High	140	Moderately well-drained soils with at least 36 in. of depth to the fragipan and less than 5% slope. Units in this group: LoA0, GrA, LoB0, LoB.
Good	120	Soils with 2 to 5% slope and depth to the fragipan between 20 and 30 in. Soils with 0 to 2% slope and depth to the fragipan of 12 to 20 in. Deep soils (no fragipan) on 5 to 8% slope. Units in this group: LoA2, HeA2, LoA3, LoB2, LxC.
Fair	90	Soils with a combination of slope between 2 to 5% and 12 to 20 in. of depth to the fragipan. Soils on 5 to 8% slope depth to a fragipan between 20 and 30 in. Units in this group: LoB3, PrB3, LoC2.
Poor	70	Soils with a depth to the fragipan less than 12 in. Soils with depth to the fragipan between 12 to 20 in. and slope between 5 to 8%. Units in this group: LoB4, LoC3, PrC4.
Bottomland	*	Units in this group: CoA, FaA

*This part of the field was used to calibrate the yield monitor and not used to compute yields.

Table 3. Yield results by group of soils within nitrogen rates.

		Rates (lb N/a)				
		0*	84	127	143	181
HIGH	Yield (bu/a)	107.6	177.3	170.7	108.3	183.8
	Area (a)	0.6	1.9	1.7	1.9	1.7
GOOD	Yield (bu/a)	88.2	169.7	162.7	176.8	175.1
	Area (a)	0.6	0.8	0.9	1.1	1.2
FAIR	Yield (bu/a)	97.1	164.3	163.2	172.1	166.0
	Area (a)	0.2	1.2	0.9	0.5	0.8
POOR	Yield (bu/a)	132.4	161.1	148.1	163.4	161.8
	Area (a)	0.2	0.6	0.5	0.4	0.8

*Insufficient data at the 0 rate on *certain* soil mapping units.

Effect of Low-Input Techniques on Tropical Corn Production on Small-Scale Farms

***C.S. Gardner, C.H. McGowan, R L. Carter, C. L. Brasher and G. L. Queeley**

INTRODUCTION

Small-scale farms, although declining in numbers, still remain very important components of the U.S. economy. Small-scale farms are defined on the basis of family farms with acreage ranging from 1 to 40 a or the family being dependent on the farm for a major portion of its income; the family has established commodity mixes and limited resources such as land, capital, and labor; the family members provide most or all the labor and management input; or the farm has gross annual income equal to or less than $10,000 (McGowan, 1987 a,b,; Ward, 1989). According to H. W. Kerr (1991), "for over 100 yr the small farm sector has richly contributed to the varied landscape and economic stability of the U.S." The decline in numbers among small-scale farmers has been largely due to poor profitability of many traditional enterprises in which they engage. To remain profitable, the small-scale farmer will of necessity have to adopt alternative production methods which are less costly, produce non-traditional "specialty crops" which carry a high market value, or develop value added products from their enterprise. For example, in field corn *(Zea mays* L.), alternative production technologies such as ridge planting have resulted in up to 50% reduced input of fertilizers and pesticides (McDermott, 1990).

This study evaluated intercropping and reduced inputs of herbicides and fertilizers as alternative low-input techniques for producing tropical corn on small-scale farms in north Florida. Intercropping is a form of mixed cropping whereby two or more crops are grown simultaneously on the same unit land area during all or part of the life cycle of the respective crops (Mullen, 1995). Intercropping systems have been traditionally practiced by small farmers in many developing countries and have become an area for research focus in the U.S. (Calavan and Weil, 1988). The Farming Systems Research and Extension (FSR/E) approach (Hildebrand and Poey, 1995: Byerlee et al., 1982) was used in carrying out the study. In the FSRE methodology, development techniques for adoption by small-scale farms requires the participation of the farmers themselves in all steps of the project, such as planning, implementation, evaluation, and dissemination of results.

Florida bas an extended warm crop growing season (March to mid-November) which is conducive for production of many tropical crops. Hiebsch, et al. (1995) stated that long warm seasons which cannot adequately support two sole crops may be more productive when fully utilized by intercrops. Intercropping involving a cereal and a legume may lead to increased total productivity per unit land area when the yield of the cereal is added to that of the legume intercrop. There is also the added benefit of environmental and economic sustainability obtainable from this practice (Fortin and Edwards, 1995; Calavan and Weil, 1988).

The objective of this research was to determine the optimal yields of non-irrigated tropical corn grown with reduced input of fertilizer and herbicides or grown with cowpea *(Vigna unguiculata* [L.] Walp.) as an intercrop on small-scale farms in north Florida.

MATERIALS AND METHODS

On-farm demonstration research was carried out in Gulf and Jackson counties in north Florida. This was supported by on-station research at the Florida A&M University farm at Quincy, in Gadsden County. The on-farm research was conducted with the participation of small-scale farmers in each of the counties. The soil type in Gulf and Jackson counties was very sandy, while the soil at the Gadsden county location had a high clay content. The research study was conducted in 1992, 1993, and 1994. The Gadsden county component was in 1993 and 1994. At the county level, extension personnel were instrumental in selecting the farmers and monitoring the study throughout its duration.

Pioneer Brand hybrid 3192 tropical corn was planted in the plots in May to June of each year. A plant density of approximately 18,000 to 22,000 plants/a was desired.

A randomized complete block design with two replications and six treatments was used to evaluate the techniques. Plot size was 130 A x 40 ft. The six treatments were as follows: 1) corn only - no fertilizer or herbicide applied, 2) corn intercropped with cowpea - no

C.S. Gardner, C.H. McGowan, R.L. Carter, C.L. Brasher, and G.L. Queeley. Division of Agricultural Sciences, Florida A&M University, Tallahassee, FL. Manscript received 7 May 1997. * Corresponding author.

fertilizer or herbicide; 3) corn + atrazine at 2 lb a.i./a, 70 lb/a of a 5-10-15 mixed fertilizer and 40 lb/a of ammonium nitrate (NH_4NO_3); 4) corn intercropped with cowpea and 2O lb/a of NH_4NO_3 plus 35 lb/a of a 5-10-15 mixed fertilizer, 5) corn + 35 lb/a of a 5-10-15 mixed fertilizer and 40 lb/a of NH_4NO_3; 6) corn intercopped with cowpea plus 20 lb/a of NH_4NO_3 35 lb/a of a 5-10-15 mixed fertilizer.

Harvesting of the corn was done whenever the grains were field-dried to approximately 13 % moisture content. The cowpea crop was harvested when the pods were mature green, approximately 8 wk after planting. In the third yr, 1994, the cowpea was not harvested due to labor shortage.

For the sole crop corn, sample data were collected from a 65 sq ft area for determination of dry matter yield and other parameters. However, for the intercrop corn, the sample area was doubled since the cowpea occupied a 36-in-wide section in those rows. Cowpea was sample harvested over the same area as the corn. Field data collected on corn yield and other parameters were as follows. Plant height was calculated as the distance from soil level to the base of the last true leaves at the top of the plant. Ear height was determined by measuring the distance from the base of the plant to the point of stalk attachment of the first mature ear (cob) on the plant. Plant population was determined by counting the number of plants in the harvested area of each treatment. Row and grain number per ear were determined by manual counting of 10 cobs from each treatment. Ear weight was calculated as the total weight of the harvested cobs from the individual treatments, while grain yield was calculated as the total weight of the shelled grain of 20 ears from each treatment. All parameters were extrapolated to determine their values on a per-a basis.

RESULTS AND DISCUSSION

Analysis of variance showed significant yr and location effects for grain yield and other parameters ($P \leq 0.05$). Therefore, the data were further analyzed on the basis of individual yr. Tables 1 through 3 show the yield parameters for tropical *corn* produced in Jackson County. In 1992, the 687 lb/a grain yield of sole crop **corn** without herbicide or fertilizer was not significantly $P \leq 0.05$) different from the grain yield of the corn intercropped with cowpea (Table 1), However, when the pod yield of the cowpea is added, the total yield from the intercropped treatments would be increased up to 1,267 lb/a. For that particular yr, higher grain yield (>1,780 lb/a) was obtained from the sole crop corn to which the 70 lb/a of 5-10-15 mixed fertilizer plus 45 kg/ha of NH_4NO_3 was applied (treatment 5). The yield pattern for the second yr (1993) in this county was similar to that of the first yr (Table 2). In that yr highest corn grain yield (1,242 lb/a) was obtained from the sole plot corn to which herbicide and fertilizers (treatment 3) were applied. However, in the third yr of the study, both the sole crop corn and the corn intercropped with cowpea and which received no fertilizer or herbicide application gave grain yields which were not significantly diffferent ($P < 0.05$) from the other treatments (Table 3). The yields realized in sole corn treatment may have been due to the increased plant density (over 32,793 plants/a) or a change in location within the same county. This change came about because the first farmer participant was unable to cooperate the third yr of the project. Although not measured, it seemed as if the natural fertility of this soil was greater than that of the previous location.

Tables 4 through 6 shows the responses for the Gulf County study. Here again in 1992 (Table 4), sole crop corn which received the high level of 5-10-15 and NH_4NO_3 (70 lb/a and 40 lb/a, respectively, treatment 3) gave the highest grain yield (6,007 lb/a). Yields from the plots to which no fertilizers or herbicide was applied (treatments 1 and 2), were not significantly different ($P \leq 0.05$) from the plots having the cowpea intercrop (1,121 lb/a to 2,424 lb/a). In 1993 (Table 5), the sole crop corn which received no fertilizers or herbicide application (treatment 1) gave the highest grain yield of over 3,560 lb/a. Over the two yr, the yield difference realized from the corn component in the intercrop treatments would be partially compensated for by the total yield/a (corn grain yield and cowpea pod yield).

Table 6 shows the response for Gulf County in 1994. Highest corn grain yields were obtained from the sole crop corn to which fertilizer and herbicides were applied (1,538 lb/a and 1,357 lb/a, treatments 3 and 5). These yields were significant when compared to yields from the intercropped plots or those not treated with herbicide or fertilizers.

Tables 7 and 8 shows the response from the on-station study carried out on the university's farm. In both yr., the sole crop corn which received no herbicides or fertilizers yielded as much as those plots which received these chemicals. The high clay content of the soil at this location and hence a high level of inherent natural fertility (determined by soil test) may partially account for this. Also, at this location, the corn was planted on an area previously planted with winter legume cover crops. Although cowpea was planted in the intercrop plots, it was not harvested in either yr because of labor problems. The corn grain yields obtained from the intercropped treatments was similar in trend to those at the county level although numerically greater.

Total productivity (TP) is equal to the yield of the main crop (in this study, tropical corn) plus the yield of the intercrop (Fortin and Edwards, 1995). It is expected that TP will result in increased yields per unit land area which would be greater than those in the monoculture crop. This outcome was realized at Jackson County in the 1992 study (Table 1) where TP= 1,266 lb/a (treatment 2) vs 687 lb/a (treatment l), and in 1993 Table 2) when TP= 1,166 lb/a (treatment 6) vs 767 lb/a (treatment 5).

At the Gulf County location in 1992, TP resulted in increased yields but these were not greater than those of the comparable intercrop (Table 4.). However, in the 1993 study, TP was greater when the sole crop with pesticide and fertilizer (treatment 3) was compared (not statistically) to the intercrop receiving the same application (treatment 4).

CONCLUSION

Under rainfed cropping systems in north Florida, low input technique of intercropping tropical corn with cowpea may lead to increased yield outcome for small-scale farmers. Potentially, the intercrop may ensure some returns for the farmer, thus guarding against risk of total loss, if the corn crop fails to return marketable yields. However, when grown in this manner, there may be competition between crop species for light and nutrients which may result in overall low yields among the crop species. The latter will be exacerbated under poor soil fertility conditions. The yields which were obtained in Jackson and Gulf counties seemed to point in this direction. On the other hand, adequate soil fertility conditions may lead to increased yields as evidenced from the Gadsden County studies. Reducing the amount of fertilizer applied for tropical corn on sandy and largely infertile soils may also result in low uneconomic grain yields. Except the Gulf County in 1993, treatments 1 and 2, and Gadsden County in 1994, treatment 3 corn grain yields were at or slightly below state average (2,670 lb/a). Additional studies on row spacing (between and intra) as well as timing methods of applying fertilizer needs to be carried out to further examine these techniques.

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Table 1. Mean yield components of tropical corn grown at Jackson County, Florida, 1992

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Ear ht	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	687b	0.12a	352b	17431a	5.9b	1520b	9.0a	24.0a	52.8c	22152a	10.5a
Corn-cowpea intercrop (no chemical treatment)	543b (1266)	0.09a	447ab	8534b	6.7ab	941b	12.0a	25.6a	61.4abc	9079b	11.0a
Sole crop corn (Pesticide and fertilizer)	2185a	0.10a	506a	15252a	7.1a	3039a	13.0a	39.8a	63.8ab	19610a	11.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	869b (1236)	0.07a	535a	7082 b	7.5a	1412b	14.0a	25.6a	63.0abc	9442 b	11.0a
Sole crop corn (Fertilizer)	1809a	0.15a	539a	15979a	7.5a	3184a	13.0a	26.0a	67.3a	19247a	11.0a
Corn-cowpea intercrop (Fertilizer)	561b (928)	0.04a	534a	7445b	7.5a	1048a	12.0a	24.0a	56.3bc	7626b	11.0a
R^2	0.81	0.001	0.84	0.35	0.32	0.82	0.55	20.1	30.7	0.39	0.45

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 2. Mean yield components of tropical corn grown at Jackson County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	203c	0.03cd	215b	9805b	4.3c	724c	12.0a	56.3d	14526a	3.0c
Corn-cowpea intercrop (no chemical treatment)	192c (373)	0.06bcd	384a	4358c	5.9b	615c	13.0a	59.1cd	4721b	6.5b
Sole crop corn (Pesticide and fertilizer)	1242a	0.01d	474a	13799ab	7.1a	3329a	13.0a	75.6a	15252a	11.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	306c (1 121)	0.14ab	482a	4721c	7.5a	1416c	13.0a	67.3b	4721b	10.0a
Sole crop corn (Fertilizer)	767b	0.17a	436a	14526a	6.7ab	2352b	12.0a	66.9b	15615a	9.0a
Corn-cowpea intercrop (Fertilizer)	352c (1 166)	0.12abc	464a	4721c	7.5a	1121c	12.0a	63.8bc	5084b	9.5a
R^2	0.82	0.002	**0.88**	0.37	0.38	0.86	0.50	36.6	0.38	0.93

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test,
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 3. Mean yield components of tropical corn grown at Jackson County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	904ab	0.12a	333a	26873ab	5.1b	2533b	12.0a	29.9a	59.8a	33047a	10.5b
Corn-cowpea intercrop (no chemical treatment)	904ab	0.15a	329a	24876ab	5.5b	3257ab	13.0a	32.3a	63.8a	26692ab	11.0ab
Sole crop corn (Pesticide and fertilizer)	1356ab	0.09a	361a	31958a	5.9ab	5066ab	13.0a	31.1a	67.3a	34862a	12.0ab
Corn-cowpea intercrop (Pesticide and fertilizer)	678ab	0.03a	419a	20155ab	5.9ab	3257ab	12.0a	31.1a	63.8a	18702b	12.5ab
Sole crop corn (Fertilizer)	1538a	0.08a	437a	33410a	6.3a	5789a	13.0a	35.8a	70.9a	37041a	13.0a
Corn-cowpea intercrop (Fertilizer)	633b	0.07a	413a	16342b	6.3a	2352b	13.0a	29.9a	63.8a	163421,	12.0ab
R^2	0.59	0.001	0.65	0.29	0.30	0.63	0.18	15.8	16.9	0.33	0.63

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 4. Mean yield components of tropical corn grown at Gulf County, Florida, 1992

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	2424bc	0.09a	402b	24694a	5.9ab	4849b	12.0ab	24.0b	56.3ab	25057a	13.0a
Corn-cowpea intercrop (no chemical treatment)	1121c (1845)	0.09a	341b	9079c	5.5b	1701b	12.0b	20.5b	49.2b	11802c	13.0a
Sole crop corn (Pesticide and fertilizer)	6007a	0.15a	612a	23605a	8.3a	11217a	14.0a	32.3a	70.9a	25057a	13.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	2351bc (3164)	0.04a	507a	12529c	7.9a	4252b	13.0ab	25.2ab	61.0ab	12166c	14.0a
Sole crop corn (Fertilizer)	3437b	0.11a	454ab	18158b	7.1ab	4668b	13.0ab	25.2ab	56.3ab	21789c	13.0a
Corn-cowpea intercrop (Fertilizer)	2352bc (2720)	0.13a	475ab	10713c	7.1ab	3980b	12.0ab	25.2ab	57.5ab	11984c	13.0a
R^2	0.80	.001	0.71	0.39	0.28	0.78	0.61	28.3	26.0	0.40	0.45

Means within columns followed by the same letter arc not significantly different at the 0.05 probability **level** according to Duncan's New Multiple Range Test,
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 5. Mean yield components of tropical corn grown at Gulf County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	3618ab	0.15a	206a	11621cb	4.3a	619bc	11.0ab	53.9a	14526a	9.5a
Corn-cowpea intercrop (no chemical treatment)	181b (362)	0.07a	184a	6900c	4.3a	351c	11.0a	50.4a	7989b	8.5a
Sole crop corn (Pesticide and fertilizer)	1016a	0.11a	394a	13800ab	6.3a	1899a	13.0a	55.1a	16705a	11.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	471ab (1285)	0.13a	339a	6537c	5.5a	816abc	12.0a	63.0a	7263b	12.0a
Sole crop corn (Fertilizer)	702ab	0.13a	314a	17068a	5.5a	1566ab	13.0a	63.0a	18887a	10.0a
Corn-cowpea intercrop (Fertilizer)	362ab (1177)	0.11a	317a	7445c	5.5a	758abc	12.0a	56.3a	7445b	9.0a
R^2	0.59	0.001	0.55	0.36	0.19	0.67	0.49	15.0	0.36	0.35

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.
+ = Total yield (grain yield of corn + pod yield of cowpea.

Table 6. Mean yield components of tropical corn grown at Gulf County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Ear ht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn (no chemical treatment)	680bc	0.07a	222ab	22878ab	4.7c	19721a	12.0a	35.8ab	68.5bc	22878a	12.5a
Corn-cowpea intercrop (no chemical treatment)	159c	0.15a	124b	7989b	4.3c	271a	12.0a	24.0b	58.7c	159784a	12.5a
Sole crop corn (Pesticide and fertilizer)	1538a	0.11a	456a	33773a	7.1a	4342a	14.0a	72.1a	96.1a	33773a	12.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	588c	0.09a	327ab	14345ab	7.5a	1538a	13.0a	37.4ab	72.1bc	14345a	12.0a
Sole crop corn (Fertilizer)	1357ab	0.09a	368ab	27236ab	6.7b	37091a	13.0a	39.8ab	76.8b	27236a	12.5a
Corn-cowpea intercrop (Fertilizer)	498c	0.04a	278ab	12529ab	5.9b	1130a	12.0a	38.6ab	75.6b	12529a	11.0a
R^2	0.76	0.0006	0.70	0.28	0.37	0.45	0.33	25.6	35.0	0.25	0.35

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 7. Mean yield components of tropical corn grown at Gulf County, Florida, 1993

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Ear wt.	Rows/ ear	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	No	%
Sole crop corn (no chemical treatment)	2034a	0.11a	400a	12347a	6.3b	3347a	13.0bc	75.6ab	17068a	12.0a
Corn-cowpea intercrop (no chemical treatment)	814a	0.11a	393a	6537b	7.1ab	1356a	12.0bc	70.9b	6356b	12.5a
Sole crop corn (Pesticide and fertilizer)	1943a	0.15a	511a	11984a	8.7a	3167a	12.0bc	90.2a	12710a	12.0a
Corn-cowpea intercrop (Pesticide and fertilizer)	995a	0.11a	471a	6214b	7.9ab	1650a	14.0a	80.3ab	6537b	12.0a
Sole crop corn (Fertilizer)	1624a	0.18a	340a	12347a	5.9a	2826a	12.0a	78.0ab	14889a	12.0a
Corn-cowpea intercrop (Fertilizer)	860a	0.66a	404a	4903b	7.1ab	1107a	13.0ab	73.2ab	6537b	13.0a
R^2	0.59	0.0006	0.52	0.33	0.30	0.6l	0.82	23.6	0.37	0.41

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 8. Mean yield components of tropical corn grown at Gulf County, Florida, 1994

Treatment	Grain Yld	100 gr. wt.	Grains/ ear	Ears/ a	Ear length	Earwt.	Rows/ ear	Earht.	Plant ht	Plants/ a	Moisture
	lb/a	oz	No	No	in	lb/a	No	in	in	No	%
Sole crop corn **(no** chemical treatment)	2533ab	0.07a	558a	30868ab	7.9a	7237a	14.0a	38.6a	79.1a	50841a	13.0a
Corn-cowpea intercrop (no chemical treatment)	1131b	0.09a	379a	13800c	7.1a	3889a	12.0a	35.8a	75.6a	20518b	12.5a
Sole crop corn (Pesticide and fertilizer)	2895a	0.09a	564a	33047a	8.7a	11579a	13.0a	42.1a	100.8a	45757a	12.5a
Corn-cowpea intercrop (Pesticide and fertilizer)	1312ab	0.04a	579a	20518abc	9.1a	5789a	13.0a	34.7a	80.3a	21971b	13.0a
Sole crop corn (Fertilizer)	2442ab	0.09a	479a	31314ab	8.3a	1086a	12.0a	43.3a	89.0a	4540a	13.0a
Corn-cowpea intercrop (Fertilizer)	1583ab	0.11a	583a	8832bc	9.1a	6513a	13.0a	48.0a	92.5a	22334b	13.0a
R^2	0.59	0.0004	0.52	0.32	0.22	0.41	0.40	14.8	18.5	0.38	0.40

Means within columns followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's New Multiple Range Test,

Corn Performance Trials in Quincy and Gainesville, Florida

RL. Stanley and *R.N. Gallaher

INTRODUCTION

Corn *(Zea mays* L.) is an important agronomic crop in Florida, being produced for use as grain and silage in livestock rations. From 1985 to 1995 corn acreage in Florida decreased from 240,000 to 60,000 a. Average yield during the same period increased from 65 to 90 bu/a In 1996, corn acreage increased to 100,000 a.

Commercial corn hybrids are evaluated at various University of Florida, Inst. Food & Agr. Sci. (IFAS) locations in the state to aid producers in selecting varieties to plant. A small effort has also been underway for several years by IFAS, to develop subtropical hybrids adapted to cropping systems and environmental conditions in Florida. This report summarizes some of the results of corn performance trials conducted at the North Florida Research and Education Center (NFREC), Quincy and on the Florida Experiment Station and commercial farms near Gainesville, Florida.

MATERIALS AND METHODS

Performance Trials at Quincy

The NFREC test site was turned with a moldboard plow in late February 1996. Immediately prior to planting 1000 Ib/a of 5-10-15 (N-P_2O_5-K_2O) and Sutan:Aatrex at 3 Ib/a a i : l lb/a a.i., were incorporated. Following planting Counter[R] 15G was banded over the row at 15 lb/a. Additional nutrients were applied in 2 applications to give a total of 300-200-300 lb N-P_2O_5-K_2O/a. Plots were machine planted at about 1.5X the desired population in early April for spring plantings and hand thinned after emergence to a final population of 30,000 plants/a. Soil type was Norfolk loamy fine sand. Overhead sprinklers were used as needed to maintain optimum soil moisture conditions for corn production. Corn was harvested in early September with grain yields reported at 15.5% moisture. This same management is typical for other years for early planted corn experiments at Quincy.

Tropical corn tests were planted in early June each year with the same herbicide and insecticide practices. Total nutrients were 200-100-200 lb N-P_2O_5-K_2O/a applied half preplant and half when about knee high Corn was harvested in late October and grain yield reported at 15.5% moisture andforage yield reported at 70 % moisture.

[1]R.L. Stanley and R.N. Gallaher, University of Florida, Institute of Food and Agricultural Sciences, 'North Florida REC, Quincy, FL and 'Agronomy Department, Gainesville, FL. Manuscript received 5 April 1997. *Corresponding author.

Performance Trials at Gainesville

Commercial hybrids and IFAS experimental subtropical hybrids and open pollinated entries were tested from 1991 to 1996 at various dates and locations around Gainesville, Florida. Overhead sprinkler irrigated tests at the Green Acres Agronomy Field Laboratory were at 30,000 plants/a. Trials on farms were planted to 26,000 plants/a if irrigated and 22,000 plants/a if unirrigated. Fertility management was based on IFAS soil test recommendations. Early tests were planted in early to mid March, mid planting dates were late May and late planting dates were early to mid July. Labeled rates of Atrazine and Dual were used preemergence as well as cultivation when needed in conventional tillage plantings. Counter was used for May and July planted corn at labeled rates. Lannate was also used for foliar feeding insects in split applications at labeled rates for July planted corn and as needed for May planted corn. Some trials were planted by hand, but most were planted with John Deere Flexi 71 planters attached to a Brown-Harden row-till (strip-till) two row planter. Grain yields were adjusted to 15.5 % moisture and forage 70 % moisture.

RESULTS AND DISCUSSION

Performance Trials at Quincy

Table 1 shows performance of temperate hybrids at the NFREC test site. Average production for 2 and 3 yr is included for those that were tested in those years, since performance for more than one yr should be considered when selecting hybrids for planting. Grain quality rating and number of days from planting to silking are included in Table 1. Data are averages of four replications and no other ANOVA mean separation is given However, the average yield ranged from a high of almost 194 bu/a to a low of 124 bu/a. Most of these hybrids had very good to average grain quality. Good management and hybrid selection should make for reasonably good corn grain yields in north Florida.

The long growing season in Florida allows time to grow two or more crops on the same land in the same year (Bustillo and Gallaher, 1989; Edme, 1994; Overman and Gallaher, 1989). Many multiple cropping systems are possible which included corn as a second or summer crop. For example, thousands of acres of vegetables and small grain are grown each year in the late winter and early spring. If corn cultivars were available and adapted to late planting, there is plenty of frost free time to plant and grow corn as a second crop in these. double cropping systems (Edme, 1994). Since this potential exists, there is a need to evaluate available germplasm that may have some disease and insect resistance or tolerance that has limited photoperiod sensitivity and is competitive with other crops like soybean *(Glycine max* [L.] Merr) and grain sorghum *(Sorghum bicolor* [L.] Moench). Past history indicate that tropical/subtropical corn may be the proper choice for such late plantings. These tropical and subtropical corn hybrids can be planted later than temperate hybrids and fit better into some double cropping systems Table 2 shows performance of some tropical and subtropical hybrids at NFREC, Quincy, Florida. Pioneer brand hybrid X304C is the standard tropical corn hybrid from which all others can be judged. Data in 1995 from Quincy, revealed that Florida subtropical Experimental hybrid 'Howard IIIST was quite competitive not only with Pioneer Brand hybrid X304C but with all commercial and experimental hybrids tested (Stanley, 1996). Reasonable grain and forage yields can be expected with the proper choice and management of tropical/subtropical corn planted in the Quincy, Florida area in early June (Table 2). Highest average yield for corn for forage was with Florida Experimental subtropical hybrid Howard IIIST in 1995 at Quincy (Table 2) (Stanley, 1996).

Performance Trials at Gainesville

The evaluation of several Florida subtropical experimental hybrids planted in mid-march, 1996 at Gainesville, Florida showed that both Howard IIIST and 'Howard IIST' would be very competitive for both grain and forage yield (Table 3). Both of these hybrids far surpassed the yield of Pioneer brand hybrid X304C. These data would indicate that Howard IIST and Howard IIIST subtropical corn hybrids produce yields that may be competitive with those often reported by temperate hybrids when planted in early spring. Several on-farm and experiment station experiments in the Gainesville, Florida area consistently show that the above mentioned Howard hybrids out yielded Pioneer brand hybrid X304C (data not shown). Several recent unreported experiments have shown that both Howard IIST and Howard IIIST have significantly less root-knot nematode infestation compared to Pioneer Brand hybrid X304C.

Both of the Howard hybrids are earlier maturing than Pioneer Brand hybrid X304C. Howard IIIST and Howard IIST are earlier to silking than Pioneer Brand hybrid X304C by 11 and 6 d, respectively (Table 3). Early maturity is an important consideration for late planted corn. Early maturity should speed up vegetative development and allow more time for development of grain during the fall when both light and heat units available for grain filling is steadily decreasing (Bustillo and Gallaher, 1989). Experiments have shown that, in general, temperate hybrids outyield tropical hybrids when planted early in the spring (Edme, 1994). This is not always the case (Table 4). Under good management both Pioneer Brand hybrid X304C and Florida Experimental hybrid Howard IIIST were among the top yielding hybrids in a mid-March planting (Table 4). Temperate hybrid Pioneer Brand 3320 had the greatest drop in yield due to planting date (Table 4) which has typically been found for most temperate hybrids tested over the years. The data in table 2 suggest that the hybrid of choice over all three planting dates of mid-March, mid-May and mid-July would be Florida experimental hybrid Howard IIIST when planted under high yielding irrigated conditions. Under good management but without irrigation, both Howard IIIST and Pioneer Brand hybrid X304C were equal in yield and both would be the choice to plant at any of the early to late planting dates among the hybrids tested.

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Table 1. Performance of corn hybrids at NFREC Quincy, Florida

Company or Brand Name	Variety	1996	2-Yr Avg.	3-Yr Avg.	Grain Quality	Days to Silking
		---------- Bu/a @ 15.5% Moisture ----------				
Pioneer	3146	193.7	179.8	156.9	2.00	64.7
Cargill	8325	193.1			2.25	64.0
Pioneer	3245	192.8	185.8	158.3	2.25	64.0
Pioneer	3163	191.2	163.3	152.7	3.00	64.2
Hyperformer	9919	184.2			3.00	64.5
Pioneer	3223	183.5			2.25	65.2
DeKalb	DK 714	178.1			2.00	63.5
Northrup King	N 7931	177.3			2.50	61.7
DeKalb	DK 706	176.0			2.00	63.7
Pioneer	3085	174.7	170.0	149.2	2.00	66.2
Cargill	X9513	171.5			2.50	65.0
Northrup King	N 8811	168.6	180.0	153.5	1.75	64.5
Cargill	8527A	168.3			2.00	64.5
Hyperformer	9845	167.2			2.00	63.7
DeKalb	DK 687	166.9			1.75	64.7
Pioneer	3154	163.6	164.8	144.1	2.00	62.7
DeKalb	DK 683	162.6	176.2	167.0	2.00	64.7
Hyperformer	9977	159.2			2.25	65.0
Northrup King	N 8655	158.5			2.00	64.7
AgraTech	AT 888	156.0			2.25	64.5
Pioneer	3167	152.5	148.6	137.7	2.00	66.5
Northrup King	McNair 508	141.5	133.4	124.7	1.75	72.0
FL Exp	Howard IIST	124.1			1.75	72.2
FL Exp	Howard IIIST	123.6			2.00	66.2

Grain Quality: 1 = Excellent, 5 - Poor; Days to silking is days from planting to 50 % showing; FL Exp = Florida Experimental subtropical hybrids 1996 information: Planted 9 April 1996; 30,000 plants/a in 36-in rows; Norfolk loamy fine sand; 300-200-300 lb $N\text{-}P_2O_5\text{-}K_2O$/a; optimum irrigation; harvested 9 September 1996.

Table 2. Yield of tropical/subtropical hybrids at NFREC, Quincy, Florida

Company or Brand Name	Variety	1996	2-Yr Avg.	3-47 Avg.	Forage 1995	Forage 2-47 Avg.
		Bu/a @ 15.5% Moisture			Ton/a @ 70 % Moisture	
Zeneca	8452	105.8	92.0	92.2	16.7	16.7
Pioneer	X304C	92.6	89.5	74.6	16.6	17.5
FL Exp	16-91XF21	92.1				
FL Exp	Howard IIIST	88.4	85.4		17.6	
Zeneca	8392	87.1	99.2	92.9	15.9	15.5
Zeneca	8455	87.1	84.5		16.6	
FL Exp	BM33X5Y53	87.1				
FL Exp	SY20XBY31	86.0				
Zeneca	8501	85.0	82.1		15.6	
Pioneer	3098	80.9	75.0	69.1	15.3	15.8
FL Exp	Howard IIST	79.2				
Zeneca	8568	76.4	84.6	89.4	14.5	15.3
FL Exp	BM4XSW41	76.1				
Zeneca	8202	75.6	71.9	67.5	16.6	
FL Exp	BY12X5Y20	73.7				
FL Exp	FLSTOP	70.3	56.8		16.6	
FL Exp	BM5XSY56	69.0	60.8			

19% information: Planted 6 June 19%; 22,000 plants/a in 36-in rows; Norfolk loamy fine sand; 200-100-200 lb/a N-P_2O_5-K_2O/a; **partial** irrigation; Harvested 25 October 1996.

Table 3. Yield and other variables for subtropical/tropical exoerimental corn test. Gainesville. Florida, 1996.

Hybrid/ Cultivar	Grain	Forage	Plant	Ear	Stalk	Final Plants	Final Ears	Initial Flower
	bu/a 15.5%DM	Ton/a 30% DM	Lb/a DM	Lb/a DM	Lb/a DM	Per 50 sq ft	Per 50 sq ft	Days
Howard IIST	193	38.6	23171	11895	1 1276	34.8	34.2	79
Howard IIIST	188	29.7	17844	10589	7254	38.0	39.8	74
SY20 X BY31	178	29.6	17756	10408	7348	37.6	38.2	75
BY32 X SW3	168	28.9	17347	10197	7150	30.8	33.0	79
BY8 X SM2	167	29.7	17790	9880	7910	39.0	36.8	71
16(91) X F21	158	26.0	15578	9349	6228	34.2	36.2	85
K61 X 29	156	27.4	16466	9569	6897	29.8	29.6	79
BM4 X SW41	154	29.2	17518	9469	8049	37.2	38.2	78
44(92) X 16(91)	150	31.7	19004	9474	9530	34.8	34.4	80
20 X 8(95)	147	24.6	14736	8489	6247	32.4	33.8	76
BY12 X SW20	147	24.5	14680	8381	6299	30.8	29.0	78
BM33 X SY53	146	26.9	16139	8741	7398	36.4	35.4	86
BM5 X SY56	145	27.7	16620	8705	7915	32.8	32.0	80
SY43 X BM4	142	31.0	18619	8753	9866	36.4	35.2	74
Pioneer X304C	138	23.9	14321	8188	6134	31.4	30.8	85
FLASTOP	113	23.1	13893	7243	6650	27.0	24.6	78
LSD =	29	5.3	3184	1738	2332	4.3	3.8	
CV =	14.7	14.8	14.8	14.7	24.1	9.9	8.8	

1996information: Green Acres Agronomy Research Field Laboratory; randomized complete block-5 replications; planted 2 1 March 1996; 34,500 plants/a in 30-in rows; Kendrick sand; 280-20-140 lb/a N-P_2O_5-K_2O/a; optimum irrigation; Harvested 15 July 1996.

Table 4. Planting date and water management on yield of temperate and tropical corn hybrids, Gainesville, FL

Hybrid	Hybrid Type	Planting Period	Yield Irrigated	Yield Nonirrigated	Yield Loss Irrigated	Yield Loss Nonirrigated
			bu/a	bu/a	%	%
Pioneer 3165	Temperate	Mid March	188.6 a	136.2 a	100	100
Howard IIIST	Sub Tropical	Mid March	176.7 ab	140.4 a	100	100
Pioneer X304C	Tropical	Mid March	175.5 ab	140.3 a	100	100
Pioneer 3320	Temperate	Mid March	171.7 b	130.2 a	100	100
Pioneer 3394	Temperate	Mid March	169.2 b	139.9 a	100	100
Pioneer 3165	Temperate	Mid May	131.8 a	101.3 b	70	74
Howard IIIST	Sub Tropical	Mid May	120.4 ab	116.0 a	68	83
Pioneer X304C	Tropical	Mid May	101.4 bc	119.0 a	58	85
Pioneer 3320	Temperate	Mid May	93.4 c	97.0 c	54	75
Pioneer 3394	Temperate	Mid May	113.0 b	110.8 ab	67	79
Pioneer 3165	Temperate	Mid July	59.5 c	54.6 b	32	40
Howard IIIST	Sub Tropical	Mid July	101.0 a	80.2 a	57	57
Pioneer X304C	Tropical	Mid July	84.5 b	83.1 a	48	59
Pioneer 3320	Temperate	Mid July	36.5 d	41.1 c	21	32
Pioneer 3394	Temperate	Mid July	68.3 c	63.4 b	40	45

Values in columns among the five hybrids within a irrigation treatment and date not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test.

APPENDIX

Past Conferences, Coordinators, and Proceedings

Year	Location	Coordinator	Proceedings
1978	Griffin, GA.	Joe Touchton Agronomy Department University of Georgia 1109 Experiment Street Griffin, GA. 30223-1797	Touchton, J.T., and D.G. Cummins (eds.). 1978. Proc. First Annual Southeastern No-Till Systems Conference. Special Public. No. 5 Univ. of Georgia, College of Agr. Exp. Stn., Experiment, GA.
1979	Lexington, KY.	Shirley Phillips Agronomy Department University of Kentucky Lexington, KY. 40546	No Proceedings Published.
1980	Gainesville, FL.	Raymond N. Gallaher Agronomy Department University of Florida Gainesville, FL. 32611	Gallaher, R.N. (ed.). 1980. Proc. 3rd Annual No-Tillage Systems Conference. Inst. of Food and Agr. Sci., Univ. of Florida, Gainesville, FL.
1981	Raleigh, NC.	Worshum/Wagger/Lewis Soil Science Department North Carolina State Univ Raleigh, NC. 27650	Lewis, W.M. (ed.). 1981. No-Till Crop Production Systems in North Carolina -- Corn, Soybeans, Sorghum, and Forages. North Carolina Agr. Extension Serv., Raleigh, NC.
1982	Florence. SC.	Jim Palmer Agronomy Department Clemson University Clemson, SC. 29634	Palmer, J.H., and E.C. Murdock (eds.). 1982. Proc. 5th Annual Southeastern No-Till Systems Conference. Agronomy and Soils Extension Series No.4. Clemson University, Clemson, SC.

1983	Milan, TN.	Ashburn/McCutchen University of Tennessee West TN Ag. Exp. Stn. Jackson, TN.	Jared, J., F. Tompkins, and R. Miles (eds.). 1983. Proc. 6th Annual Southeastern No-Till Systems Conference. Univ. of Tennessee Inst. of Agriculture, Knoxville, TN.
1984	Dothan, AL.	Joe Touchton Agronomy Department Auburn University Auburn, AL. 38301	Touchton, J.T., and R.E. Stevens (eds.). 1984. Proc. 7th Annual Southeast No-Tillage Systems Conference. Alabama Agr. Exp. Stn., Auburn Univ., Auburn, AL.
1985	Griffin, GA.	W.L. Hargrove Agronomy Department University of Georgia 1109 Experiment Station Griffin, GA. 30223-1797	Hargrove, W.L., F.C. Boswell, and G.W. Langdale (eds.). 1985 Proc. 1985 Southern Region No-Tillage Conference. Univ. of Georgia, Athens, GA.
1986	Lexington, KY.	Phillips/Wells Agronomy Department University of Kentucky Lexington, KY, 40546	Phillips, R.E. (ed.). 1986. Proc. Southern Region No-Tillage Conference. Southern Region Series Bulletin 319. Kentucky Agr. Exp. Stn., University of Kentucky, Lexington, KY.
1987	College Station, TX.	Tom Gerik Blackland Research Center Temple, TX. 76501	Gerik, T.J., and B.L. Harris. (eds.). 1987. Proc. Southern Region No-Tillage Conference. Texas Agr. Exp. Stn., Texas A & M Univ. System, College Station, TX.
1988	Tupelo, MS.	Normie Buehring Mississippi State University Northeast Miss. Branch Stn. Verona, MS. 38879	Hairston, J.E. (ed.). 1988, Proc. 1988 Southern Conservation Tillage Conference. Special Bulletin 88-1. Mississippi Agr. and Forestry Exp. Stn., Mississippi State Univ., Mississippi State, MS.

1989	Tallahassee, FL.	David Wright University of Florida N. Florida Res. & Educ. Ctr. Route **3** Box 4370 Quincy, FL. 32351	Teare, I.D. (ed.). 1989. Proc. 1989 Southern Conservation Tillage Conference. Special Bulletin 89-1. Inst. of Food and Agr. Sci., Univ. of Florida, Gainesville, FL.
1990	Raleigh, NC	M.G. Wagger North Carolina State Univ. Raleigh, NC. 27650	Mueller, J.P., and M.G. Wagger (eds.). 1990. Proc. 1990 Southern Region Conservation Tillage Conference. NCSU Special Bulletin 90-1. North Carolina State University, Raleigh, NC.
1991	N. Little Rock, AR.	Chapman/Keisling University of Arkansas Soil Testing & Research Lab. P.O. Drawer 767 Marianna, AR. 72360	Keisling, T.C. (ed.). 1991. Proc. 1991 Southern Conservation Tillage Conference. Univ. of Arkansas Special Report 148. Arkansas Agr. Exp. Stn., Fayetteville, AR.
1992	Jackson, TN.	Bradley/Mullen University of Tennessee P.O. Box 1071 Knoxville, TN. 37901	Mullen, M.D., and B.N. Duck (eds.). 1992. Proc. 1992 Southern Conservation Tillage Conference. Special Public. 92-01 Univ. of Tennessee, Tennessee Agr. Exp. Stn., Knoxville, TN.
1993	Monroe, LA.	Pat Bollich Louisiana State University LA. Ag. Exp.. Stn. P.O. Box 1429 Crowley, LA.70527-4129	Bollich, P.K. (ed.). 1993. Proc. 1993 Southern Conservation Tillage Conference for Sustainable Agriculture. Louisiana Agr Exp. Stn. Ms. No. 93-86-7122. Louisiana State Univ., Baton Rouge, LA.
1994	Columbia, SC.	W.J. Busscher/P.J. Bauer USDA-ARS Coastal Plains Research Ctr. Florence, SC.29501-1241	Bauer, P.J., and W.J. Busscher(eds.).1994. Proc. 1994 Southern Conservation Tillage Conference for Sustainable Agriculture, USDA-ARS Coastal Plains Soil, Water, and Plant Research Florence, SC.

1995	Jackson, MS.	Normie Buehring Mississippi State Univ. Northeast Miss. Branch Stn. Verona, MS. 38879	Kingery, W.L., and N. Buehring (eds.). 1995. Proc. 1995 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Bulletin 88-7. Mississippi Agr. and Forestry Exp. Stn., Mississippi State Univ., Mississippi State, MS.
1996	Jackson, TN.	Denton/Hodges/Tyler Univ. of Tennessee Plant Soil Sci. Dept. Knoxville, TN.37901	Denton, P., N. Eash, J. Hodges, III and D. Tyler (eds.). 1996. Proc. 19th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Public. 96-07. Univ. of Tennessee Agr. Exp. Stn., Knoxville, TN.
1997	Gainesville, FL.	R. Gallaher/D.Wright Univ. of Florida Agronomy Dept.	Gallaher, R.N., and R. McSorley. 1997. Proc. 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, Cooperative Extension Service, IFAS, University of Florida, Gainesville, FL.

Editorial Comments

Abbreviations Used in Proceedings:

a - acre(s)
bu - bushel(s)
d - days(s)
ft - foot (feet)
in - inch(es)
lb - pound(s)
lb/a - pounds per acre
mo - month(s)
wk - weeks
yr - year(s)

Examples of Literature Citations:

Journal Articles:
Wilson, D.O., and W.L. Hargrove. 1986. Release of nitrogen from crimson clover under two tillage systems. Soil Sci. Am. J. 50:1251-1254.

Book
Hesse, P.R. 1092. A Textbook of Soil Chemical Analysis. Chemical Publishing Co., New York, NY.

Chapter in Book
Midmore, D.J. 1991. Potato production in the tropics. pp. 728-793. *In* P.H. Harris (ed.). The Potato Crop, 2nd edition. Chapman and Hall, London.

Chapter in Edited Proceedings:
McSorley, R., and R.N. Gallaher. 1994. Effect of long-term rotation and tillage programs on plant-parasitic nematodes. pp. 23-26. *In* P.J. Bauer and W.J. Busscher (eds.). Proc. 1994 Southern Conservation Tillage Conference for Sustainable Agriculture. USDA-ARS Coastal Plains Soil, Water, and Plant Research Center, Florence, SC.

Chapter in Proceedings (no editor):
Crawford, S.H., and R.K. Collins. 1991. Preplant weed control options for fallow bed cotton. p. 267. *In* Proc. 1991 Beltwide Cotton Prod. Res. Conf. National Cotton Council, Memphis, TN.

Statistical Software (with authors)
Freed, R., S.P. Eisensmith, S. Goetz, D. Reicosky, V.W. Snail, and P. Wohlberg. 1987. User's Guide to MSTAT (version 4.0). Michigan State University, East Lansing, MI.

Statistical Software (no author)

Anonymous. 1988. SAS/STAT User's Guide, Version 6.03. SAS Institute, Cary, NC.

or

SAS Institute. 1988. SAS/STAT User's Guide, Version 6.03. SAS Institute, Cary, NC

Agricultural Statistics:

Anonymous. 1996. Virginia Agricultural Statistics. Bulletin No. 68. Virginia Agric. Statistics Serv., Richmond, VA.

Thesis:

Tindall, T.T. 1991. Potato available nitrogen from barley/legume underseedings and reduced tillage/ridge potatoes. M.S. Thesis. University of Maine, Orono, ME.

Experiment Station Publication:

Baldwin, R.E., J.F. Derr, H.E. Holt, C.R. O'Dell, S.B. Sterrett, H.L. Warren, and H.P. Wilson. 1995. Commercial vegetable production recommendations. Virginia Cooperative Extension Serv., Publication No. 456-420. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Experiment Station Annual Report:

Reynolds, D. 1990. Evaluation of burndown and residual herbicides for soybeans planted into a stale seedbed. pp.341-347. *In* Northeast Res. Stn. Ann. Prog. Rep. Louisiana Agr. Exp. Stn., Baton Rouge, LA.

Experiment Station Mimeo (notes, etc.):

Mehlich, A. 1953. Determination of P, Ca, Mg, K, Na, and NH_4. North Carolina Soil Test Division (Mimeo, 1953). North Carolina State Univ., Raleigh, NC.

1997 Southern Conservation Tillage Conference Regional Steering Committee

ALABAMA:

Dr. Wayne Reeves
USDA-ARS National Soil Dynamics Laboratoxy
P.O. Box 3439
Auburn, AL 36831-3439
Phone (334) 844-4741 ext. 138
Fax 334-887-8597

ARKANSAS:

Dr. Stan Chapman
Extension Soils Specialist
Post Ofice Box 391
Little Rock, AR 72203
Phone (501) 671-2168
Fax 501-671-2297

Dr. Teny Keisling
Northeast **Res.** Center
Post **Ofice** Box 48
Keiser, AR 72351
Phone (501) 272-4683
Fax 501-526-2582

Mr. Tom L. Riley, Jr.
Extension Specialist
Environmental Policy & Section Leader
Post Office Box 391
Little Rock, AR 72201
Phone (501) 671-2080

FLORIDA:

Dr. Raymond N. Gallaher
Agronomy Department
University **of** Florida
Gainesville, FL. 32611
Phone (352) 392-2325
Fax 352-392-9082

Dr. David Wright
NFREC
University **of** Florida
Quincy, FL
Phone (904) 875-71 19
Fax 904-875-7148

Dr. Robert McSorley
Entomology & Nematology
University of Florida
Gainesville, FL 3261 1
Phone (352) 392-1901 ext. 137
Fax 352-392-0190

GEORGIA:

Dr. Dan McCracken
University of Georgia
Georgia Experiment Station
Griffin, **GA** 30223-1797
Phone (770)228-7306
Fax 770-229-3215

Dr. Jim E. Hook
Crop and **Soil** Sci. Dept.
College of Agnculture and
Environmental Science
Tifton, **GA.**

KENTUCKY:

Dr. John Grove
University of Kentucky
122 Ag. Science North
Lexington, KY 40546-0091
Phone (606) 257-5852
Fax 606-257-2185

Dr. J. D. Green
University of Kentucky
N- 106B Ag. Sci. North
Lexington, KY 40546

LOUISIANA:

Dr. Pat Bollich
Rice Research Station
Louisana State University
Post Office Box 1429
Crowley, LA 70527
Phone (318) 788-7531
Fax 318-788-7553

MISSISSIPPI:

Dr. N.W. Buehring
MississippiState University
Post Office Box 456
Verona, MS 38879
Phone (601) 566-2201
Fax 601-566-2257

Dr. Jac J. Varco
Plant and Soil Sci. Dept.
Mississippi State Univ.
Mississippi State, MS 39762
Phone (601) 325-2737
Fax 601-325-8742

Dr. J. R. Johnson
N. Mississippi Exp. Stn.
42 MAFES Circle
Holly Springs, MS 39635
Phone (601) 252-4321
Fax 601-252-5680

NORTH CAROLINA:

Dr. Larry King
NC State University
Soil Sci. Department
Box7619
Raleigh, NC 27695-7619
Phone (919) 515-2645
Fax 919-515-2167

Dr. George Naderman
NC State University
Soil Sci. Department
Box7619
Raleigh, NC 27695-7619
Phone (919) 515-7193
Fax 919-515-7494

OKLAHOMA:

Dr. Jim Steigler
Agriculture Hall
Oklahoma State University
Stillwater, OK 74078-0507
Phone (405) 744-6421
Fax 405-744-5269

SOUTH CAROLINA:

Dr. Philip J. Bauer
USDA-ARS
Coastal Plains Research Ctr.
Florence, SC 29501-1241
Phone (803) 669-5203 ext.7250
Fax 803-622-3110

Dr. Jim Palmer
Clemson University
Agronomy & Soils Dept.
Clemson, SC 29634-0359
Phone (864) 656-3519
Fax 864-656-3443

Dr. Dan O. Ezell
Clemson University
103 Barre Hall
Clemson, SC 29634-0310
Phone (864) 656-3382
Fax 864-656-0765

Dr. Warren Busscher
USDA-ARS
Coastal Plains Res. Ctr.
Florence, SC 29501-1241
Phone (803) 669-5203
Fax 803-669-6970

TENNESSEE

Dr. Paul Denton
University of Tennnessee
Extension Plant and Soil Sci.
Knoxville, TN 37901-1071
Phone (423) 974-7208

Dr. John Hodges, III
University of Tennessee
124 Brehm Animal Sci. Bldg.
Knoxville, TN 37901-1071
Phone (423) 974-1000
Fax 423-974-9462

Dr. Bob Duck
Plant and Soil Science Dept.
Univ. of Tennessee at Martin
Martin, TN 38238
Phone (901) 587-7000

Dr. John I. Sewell
TN Agric. Exp. Station
University of Tennessee
Post Office Box 1071
Knoxville, TN 37901-1071
Phone (423) 974-7105
Fax 423-974-6479

Dr. Don Tyler
605 Airways Boulevard
University of Tennessee
Jackson, TN 38301-3201
Phone (901) 424-1643
Fax 901-425-4760

TEXAS:

Dr. Henry C. Bogusch
USDA-NRCS
810 Hyde Park
Cleburne, TX 76031

Dr. Cloice Coffman
366 Heep Center
Texas A & M Univ.
College Station, TX 77343
Phone (409) 845-0877
Fax 409-845-0604

Dr. John E. Matocha
Texas A & M Univ.
Res. & Ext. Center
Corpus Christi, TX 78406-9704
Phone (512) 265-9201
Fax 512-265-9434

Dr. Wayne Keeling
Texas A & M Univ.
Research & Ext. Center
Route 3, Box 219
Lubbock, TX 79401
Phone (806) 746-6101

Dr. James Supak
Texas A & M Univ.
Soils/Crop Sci. Dept.
Room 434
College Station, TX 77343
Phone (409) 845-4008
Fax 409-845-0456

VIRGINIA

Dr. Ron Morse
Virginia Tech. Hort. Dept.
306-C Saunders Hall
Blacksburg, VA 24061-0327
Phone (540) 231-6724
Fax 540-231-3083

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20th **Annual**
Southern Conservation Tillage Conference for Sustainable Agriculture

"PARTNERS FOR A WHOLESOME FOOD SUPPLY"

The continuing purpose of this annual conference is to promote the exchange of information pertaining to conservation tillage management, equipment, pest control, crop improvement, and multiple cropping systems among farmers, educators, researchers, agribusiness, government agencies, and farm groups for greater sustainable agriculture. The conference will include:

- Invited speakers among the ***'partners who are involved in production of a wholesome food supply"***
- Volunteer papers (oral and/or poster) on all aspects of soil and crop management as related to conservation tillage
- Tours and demonstrations at research fields and three local farms

Conference Coordinators: Dr. Raymond N. Gallaher and Dr. David L. Wright

Program Chairman: Dr. Raymond N. Gallaher
University of Florida
Institute of Food and Agricultural Sciences
P.O. Box 110730, Wallace Bldg. 631
Gainesviile, FL 32611-0730
Phone: (352) 392-2325 / Fax: (352) 392-9082
Email: mg@gnv.ifas.ufl.edu

Program Committee: Dr. Raymond N. Gallaher, Dr. David L. Wright, Mr. Daniel L. Polk, Dr. E. Ben Whitty, Dr. Carrol G. Chambliss, Dr. Robert McSorley, Mr. Winston D. Tooke, Mr. Pat Cockrell, Dr. Edwin C. French, and Dr. Kenneth H. Quesenberry

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Administrative Advisors: Dr. James L. App, Dr. Everett R. Emino, and Dr. Joseph C. Joyce

Program

Tuesdav, 24 June 1997

8:00am ***Registration*** (to 5:00pm) *(Conference Center Lobby)*

8:00am ***Posters and Display Set-up*** (to 12:00pm) *(DeSoto Room)*

Invited Speaker Forum:
Partnership in Production of a Wholesome Food Supply
(San Marcos Ballroom)

Moderator: **Dr. Jerry M. Bennett**

1:00pm Welcome - **Dr. Elizabeth D. (Betty) Capaldi**

1:05pm *Role of IFAS* - **Dr. Joseph C. (Joe) Joyce**

1:25pm *Role of USDA-NRCS* - **Mr. Niles Glasgow**

1:45pm *Role of Florida Farm Bureau Federation* - **Mr. Pat Cockrell**

2:05pm *Role of Soil and Water Conservation of the Office of Agricultural Water Policy* - **Mr. David Vogel**

2:25pm *Role of Water Management Districts* - **Mr. Jerry Scarborough**

2:45pm *Role of Industry in Conservation Tillage and Sustainable Agriculture* - **Dr. Robert G. (Bob) Palmer**

3:05pm ***View Posters/Refreshment Break*** *(DeSoto Room, See pp 6-7 for listings)*

Moderator: **Dr. Randall B. Brown**

3:20pm *Practice of Conservation Tillage* - **Dr. Larry Hawf**

3:40pm *Practice of Sustainable Agriculture* - **Dr. E.T. York**

4:00pm *Recycling Urban and Agricultural Organics in Fields and Forests* - **Dr. Wayne H. Smith**

4:20pm *Use of Animal Manure in Production of Wholesome Food* - Dr. Harold H. (Jack) Van Horn, Jr. and **Patrick W. Joyce**

4:40pm *Organic Farming Practices* - **Dr. James J. (Jim) Ferguson** and Mr. Marty Mesh

5:00pm ***Final Comments***

5:05pm ***Poster Presentations, Displays, and Reception*** (to 7:00pm) *(DeSoto Room, See pp 6-7 for listings)*

7:00pm ***Steering Committee and Guest Dinner and Business Meeting*** (to 8:30pm) *(Granada Room)*

Wednesday, 25 June 1997

Comment: This day is dedicated to voluntary oral and poster presentations by participants, especially from the South. Historically, a wide range of topics are covered related to the success of conservation tillage including: pest management (weeds, nematodes, insects, diseases), cropping systems, soil properties, fertilization, new crops and/ or new cultivar releases, equipment, etc., University research and extension experts, USDA staff, farmers, industry representatives, and others participate in the program to provide a broad spectrum of updated information which involves many of the partners in the production of a wholesome food supply.

7:30am ***Registration*** *(Conference Center Lobby)*

8:00am ***Morning Refreshments*** *(DeSoto Room)*

Oral and Poster Presentations:
Partnership in Information Exchange
(San Marcos Ballroom)

Moderator: **Dr. David L. Wright**

8:20am ***Welcome*** - **Dr. Christine Taylor Stephens**

8:30am KEYNOTE SPEAKER - *Evolving Communication to Inform and Educate* - Ricky W. Telg and **Larry J. Connor**

9:00am *Converting CRP* to *Cropland in Oklahoma* - **Jim Stiegler**

9:15am *Nitrogen Fertilization of No-Tillage Corn Using Precision Farming Technology* - R. Barbosa, J. Wilkinson, W. Hart, **D. D. Tyler**, P. Denton, and J. Bradley

9:30am *Obstacles* to *Sod-Seeding Winter Annual Forages in Mississippi* - **David J. Lang**, R. Elmore, and B. Johnson

9:45am *Telogia Creek Conservation Tillage Project* - **Ben F. Castro**, Bobby R. Durden, Henry G. Grant, Joel C. Love, and F. Johnson

10:00am **_View Posters/ Refreshment Break_** *(DeSoto Room, See* *pp. 6-7 for listings)*

10:45am *Cover Crop and Herbicide Burndown Effects on No-Till, Water-Seeded Rice* - **Patrick Bollich**

11:00am *Methods for Managing Nematodes in Sustainable Agriculture* - **Robert McSorley** and Raymond N. Gallaher

11:15am *Weed Control for Corn Planted into Sod* - **Malcome L. Broome** and Grover B. Triplett

11:30am *Value of Roundup Ready Technology in One-Pass Planted Soybeans* - **David L. Wright,** Pawel **J.** Wiatrak, B. J. Kidd, and *J.* Prihota

11:45am *Questions for Morning Speakers*

12:00pm ***Lunch*** *(on your own)*

<u>Moderator</u>: **Dr. Robert McSorley**

1:00pm *Economic and Agronomic Evaluation of Selected Wheat Planting Methods in Arkansas* - **Terry C. Keisling,** Carl Dillon, Michael Oxner, and Paul Counce

1:15pm *Corn Forage Yield and Cost of Silage Production from Use of Yard Waste Compost* - **Peter E. Hildebrand,** Raymond N. Gallaher, and Robert McSorley

1:30pm *Effect of Low Input Technology on Tropical Corn Production in Small-Scale Farming Systems* - **Cassel** *S.* **Gardner,** C. H. McGowan, R. Carter, C. Brasher, and G. Quelley

1:45pm *Tillage Effects on Cotton and Peanut Double Cropped after Small Grain* - James E. Hook, C. **C.** Dowler, **A.** W. Johnson, and H. S. Sumner

2:00pm *Reducing Surface Disturbance with No-Till and Low-till Systems for Cotton in the Mid-South* - Gordon R. Tupper and Harold R. Hurst

2:15pm *Influence of Starter Fertilizer on Strip-Till Cotton* - **Pawel J. Wiatrak,** David L. Wright, **J. A.** Pudelko, and Brian Kidd

2:30pm *View Posters/Refreshment Break (DeSoto Room, See* *pp. 6-7 for **listings)***

3:00pm *Strip-Till Versus Conventional Tillage on Yield and Petiole-Sap Nitrate of Cotton and Soil Nitrate* - **Fredrich M. Rhoads,** David L. Wright, **Pawel** J. Wiatrak, and S. Reed

3:15pm *Cover Crops and Tillage Practices for Cotton Production on Alluvial Soils in Northeast Louisiana* - **Merritt Holman, A.** B. Coco, and R.L. Hutchinson

3:30pm *Nitrogen Management For No-Tillage Cotton* - **Jac J. Varco,** John M. Thompson, and Stan R. Spurlock

3:45pm *Use of New Genotypes of Small Grain and Soybean in Conservation Tillage Systems* - **Ronald** *D.* **Barnett, Ann** R. Blount, and David L. Wright

4:00pm *Wheat Residue in Arkansas Double-Cropped Soybeans* - **Caleb Oriade,** Carl Dillion, and Terry C. Keisling

4:15pm *No-Till Production of Irish Potato on Raised Beds* - **Ronald Morse**

4:30pm *Question **for** Afternoon Speakers*

5:00pm *Adjourn*

5:00pm *Removal **of** Posters and Displays.* (<u>Please Note</u>: All posters and displays must be removed by 10:00 pm.)

Posters

1. *Cover Crops for Weed Control in Conservation-Tilled Cotton* - **M. G. Patterson,** Wayne Reeves, and B. E. Gamble
2. *Cover Crops for Weed Control in Conservation-Tilled Soybeans* - **Wayne Reeves, M.** G. Patterson, and B. E. Gamble
3. *Tillage and Cover Crops Affecting Cotton Growth and Yield and Soil Organic Matter* - **Donald J. Boquet,** R. **L.** Hutchinson, W. J. Thomas, and R. **E.** Brown
4. *Winter Crop Effect on Double-Cropped Cotton Grown With and Without Irrigation* - **Phil J. Bauer** and J. R. Frederick
5. *Use of Temik I5G and Telone 11 to Manage Reniform Nematodes in Strip Till Cotton* - **Jimmy R. Rich,** R. **A.** Kinloch, S. K. Barber, and D. L. Wright
6. *Tillage and Soil Insecticide Effects on Dryland Corn Yields* - **John E. Matocha,** S. G. Vacek, and F. L. Hopper
7. *No-Till Cotton: Redvine Control on Clay Soil* - **Harold R. Hurst**
8. *Soybean Yield Response to Tillage and Landscape Position* - **Joseph R. Johnson,** K. C. McGregor, and R. **F.** Cullum
9. *Timing of Deep-Tillage for Wheat-Soybean Double Crop in the SE Coastal Plain* - **W. J. Busscher, P.** J. Bauer, and J. R. Frederick
10. *Alternative Arkansas Rotation and Tillage Practices* - **Carl Dillon,** T. C. Keisling, Bob Riggs, and L. R. Oliver
11. *Influence of Conservation Tillage Practices on Grain Yield and Nitrogen Status of Corn Grown on an Alluvial Clay in Louisiana* - **H. J. "Rich" Mascagni,** R. **L.** Hutchinson, B. R. Leonard, and D. R. Bums
12. *Effect of Cover Crops as a Nutrient Source for Tropical Corn on Small Farms* - **C. S. Gardner,** C. H. McGowan, R. Carter, and H. Grant
13. *Lupin Hay as an Organic Fertilizer for Production of 'WhiteAcre' Cowpea* - **C. E. Wieland,** J. **A.** Widmann, and R. N. Gallaher
14. *Assessment of Soil Incorporated Crimson Clover Hay as an Organic Fertilizer Source in the Production of Bush Bean* - **B. L. Wade, S.** J. Rymph, and R. N. Gallaher
15. *Effects of Farm Management on Soil Quality* - **E. Huntley, M.** E. Swisher, and M. Collins
16. *Establishing the Value of the Phosphorus and Potassium Contained in Poultry Litter for a No-tiII Corn and Soybean Rotation* - **J. H. Grove**
17. *Application of Unprocessed Urban Plant Debris to Farm Land* - **G. Kidder, M.** F. Weaver, D. O'Keefe, and R. W. Vories
18. *Use of Dairy Manure Effluent in a Rhizoma (Perennial) Peanut Based Cropping System for Nutrient Recovety and Water Quality Enhancement* - **E. C. French,** K. R. Woodard, D. **A.** Graetz, G. M. Prine, and H. H. (Jack) Van Horn
19. *Nematode Population Levels on Vegetable Crops Following Two Winter Cover Crops* - **Robert McSorley** and R. N. Gallaher ***(Poster will be on display at Green Acres Agronomy Research Field Laboratory)***

Thursdav, 26 June 1997

Experiment Station and Farm Tours:
Partnership in Production and Use of New Knowledge

Locations: Green Acres Agronomy Research Field Laboratory, 12 miles west of Gainesville, Institute of Food and Agricultural Sciences, University of Florida, and farms in Alachua and Gilchrist Counties

Coordinator: *Dr.* **Raymond N. Gallaher**

7:00am *Morning Refreshments (Conference* **Center** *Lobby)*

7:30am *Load Busses*

7:40am *Depart for Green Acres Agronomy Research Field Laboratory*

8:00am *Arrive Green Acres Agronomy Research Field Laboratory*

8:10am *Welcome - Dr.* **Richard** *L. Jones*

8:15am *Begin tours of research and demonstrations,* Green Acres Agronomy Research Field Laboratory

Featured: Plant breeding for conservation tillage cropping systems-new varieties of oat, *rye,* red clover. crimson clover, soybean, and subtropical corn hybrids; Organic farming systems with use of yard waste compost, cover crops, organic sources of fertilizers, and conservation tillage planting of vegetables; Conservation tillage systems for summer row crops using best management practices for cover crop and weed control and nitrogen fertilization; Conservation tillage plantings **of** cotton, corn, soybean, etc.; Pest management in conservation tillage systems; Roundup ready crops under conservation tillage management; Chemical weed control management.

Green Acres Presentations

No-Tillage Corn Performance Trials Planted into Chemically Killed Rye - R. L. Stanley and R. N. Gallaher

No-Tillage Forage Sorghum Performance Trial into Rye; and High Population No-tillage Drilled Corn for Grazing - C. G. Chambliss, W. Webb, R. (Bob) Palmer, D. R. Rau, and R. N. Gallaher

No-Tillage Tobacco Fertilizer N and Weed Control Trials - E. B. Whitty and R. N. Gallaher

*Weed Management and No-Tillage Roundup-Ready Soybean and Cotton, Liberty Link Corn, and No-Tillage Peanut (Discussion and demonstration on latest spray application technology by W.L. Currey and **T.** Paulk) - B.* J. Brecke, W. H. Currey, T. Paulk, and R. N. Gallaher

No-Tillage Long-Juvenile Trait Soybean Double-Cropped After Florida's Newly Released Oat and Rye Varieties - R. *D.* Bamett, **Ann** R. Blount, and R. N. Gallaher

No-Tillage Roundup-Ready Cotton Varieties Following Winter Cover Crops of Wheat, Rye, Oat, and Lupin - D. L. Wright and R. N. Gallaher

Demonstration of No-Tillage and Weed Control for Corn Following Florida's Newly Released Crimson Clover and Red Clover Varieties, and Discussion on New Peanut Cultivars for Animal Grazing - K. H. Quesenberry, D. S. Wofford, and R. N. Gallaher

Best Management Practices (Tillage and N Fertilization) for Florida's Experimental Subtropical Corn vs. Commercial Tropical Corn Following Winter Cover Crops of Vetch, Rye, Lupin, and Crimson Clover Rotated into Old Long Term Winter Cover Crop Planted Areas four areas) - R. N. Gallaher, R. McSorley, and P. Hildebrand

Nematode Population Levels on Vegetable Crops Following Two Winter Cover Crops - R. McSorley and R. N. Gallaher

Organic Versus Chemical No-tillage Sweet Corn into Crimson Clover - R. *N.* Gallaher and R. McSorley

*No-Tillage Sweet Corn Following Long-Term Yard Waste Compost Treatments. Area is Planted to Chemically **Killed** Winter Lupin Prior to Planting Sweet Corn* - R. N. Gallaher and R. McSorley

No-Tillage Vegetables (Okra, Bushbean, Cowpea, Squash) into Rye - R. N. Gallaher, C.E. Wieland, B.L. Wade, R. McSorley, C. Greg Davis, and R. Morse

Weed Control in No-Tillage Sweet Corn into Rye (21 years of continuous no-tillage in this area) - *S. L.* Brooks, Gary Kennedy, and R. N. Gallaher

Sweet Corn Hybrid and Carbofiran Experiment Under No-Tillage into Crop of Lupin - *C. G.* Davis, **O.** Dunn, and R. N. Gallaher

Tillage, N Fertility, Weed Control, and Variety on Yield of Roundup-Ready Cotton (21 years of continuous no-tillage) - R. N. Gallaher and D. L. Wright

11:45am ***Fish Fry at Green Acres Agronomy Field Research Laboratory***

1:00pm ***Busses Depart for Farm Tours***

2:00pm ***Arrive at North Florida Holstein, Gilchrist County***

Featured: On-farm demonstrations, research and practices using perennial peanut, conservation tillage, and use of dairy waste

2:45pm ***Depart North Florida Holstein, Gilchrist County***

3:00pm ***Arrive at Mr. Craig Watson's Farm***

Featured: On-farm use of untreated yard trash in a commercial organic farming operation.

3:30pm ***Depart Mr. Craig Watson's Farm***

4:00pm ***Arrive at Haufler Brothers Farm***

Featured: Residual impact of application of large quantities of yard waste compost for improved soil quality and corn silage yield

4:20pm ***Depart Haufler Brothers Farm***

4:30pm ***Arrive at Haufler Brothers Silage Storage Location***

Featured: Farm crops and equipment for growing and harvesting silage and bunker type silage storage facilities

5:00pm ***Depar! Haufler Brothers Silage Siorage Location***

5:30pm ***Arrive Cecil B. Webb Livestock Pavilion*** for barbecue dinner prepared by Poultry Science Club, University of Florida. Entertainment by the *Crosswinds Band.*

7:30pm ***Depart for hotel and conference adjourns***

We would like to acknowledge the following for their participation and contributions to the farm tours:

Green **Acres** tour and **fish** frv: Gordon Prine, Ken Quesenberry, Ben Whitty, Carrol Chambliss, David Wofford, Barry Brecke, David Wright, Ronald Bamett, Robert Stanley, Peter Hildebrand, Cindy Wieland, Jorge Widmann, Brett Wade, **Stuart** Rymph, Roy and Myrt Arnett, W.H. Currey, Greg Davis, ***Gary*** Kennedy, Shane Brooks, Ord Dunn, Robert Palmer, Donald Rau, Gary Gibson, Larry Hawf, Elzie McCord, Larry Spooner, Drew Rush, Roebie Burriss, Todd Faulk, Ken Muzyk, Ty Paulk, Kent Taylor, Howard Palmer, Jim Chichester, Walter Davis, Leroy **Polk,** James J. (Jim) Ferfuson, Richard **A.** (Rick) Hill, Marty Mesh, David L. Moon, Harry C. Wood, Eddie L. (Pete) Brown, Jr., Ronald T. (Tom) Cutler, Carl Sheffield and Lawrence Crawford.

North Florida Holstein: Donald Bennick, Marvin Weaver, Edwin French, Kenny Woodard, G.M. Prine, Donald Graetz, and Harold (Jack) Van Horn, Jr.

Mr. Craig Watson's Farm: Craig Watson, Marvin Weaver, Gerald Kidder, D. O'Keefe, and R.W. Vories

Haufler Brothers Farm, Equipment and Silage Storage: Dale Haufler, Donald Haufler, Raymond Gallaher, Robert McSorley, William Brown, and Peter Hildebrand

Speakers, Presenters, Authors, and Field Tour and Other Contributors

Buddy Adamson, Executive Director, Alabama Cotton Commission, Montgomery, AL

James L. App, Assistant Dean, Office of Dean for Extension, IFAS, University of Florida, Gainesville, FL

Roy and **Myrt Arnett,** Suwannee, FL

S. K. Barber, North Florida Research and Education Center, IFAS, University of Florida, Quincy, FL

R. Barbosa. Institute of Agriculture, University *of* Tennessee. Jackson, TN

Ronald D. (Ron) Barnett, Professor, North Florida Research and Education Center: IFAS, University of Florida. Quincy?FL

Philip J. Bauer, USDA-ARS, Coastal Plains Soil, Water, and Plant Research Center, Florence, SC

Jerry M. Bennett, Chairman, Department of Agronomy, IFAS, University of Florida, Gainesville, FL

Donald (Don) Bennick Farmer, North Florida Holsteins, Gilchrist County, FL

Ann Blount, North Florida Research and Education Center-Quincy, IFAS, University of Florida, Quincy, FL

Patrick Bollich, Agricultural Center-Rice Research Station, Louisiana State University, Crowley, LA

Donald J. Bouquet, Northeast Research Station, Louisiana State University Agricultural Center, St. Joseph, LA.

J. Bradley, Institute of Agriculture, University of Tennessee, Jackson, TN

C. Brasher, College of Engineering Science Technology and Agriculture, Tallahassee, FL

Barry J. Brecke, Associate Professor, West Florida Research and Education Center-Jay, Department of Agronomy, IFAS, University of Florida, Jay, FL

Shane L. Brooks, NOVARTIS (Ciba-Geigy), Ocala, FL

Malcome L. Broome, Mississippi State University, Mississippi State. MS

Eddie L. (Pete) Brown, Jr., Agricultural Assistant, IFAS, University of Florida, Gainesville, Fl

R. E. Brown, Macon Ridge Research Station, Louisiana State University Agricultural Center, Winnsboro. LA

Randall B. Brown, Chairman, Department of Soil and Water Science, IFAS, University of Florida, Gainesville, FL

William F. (Bill) Brown, Director, Alachua County Extension Service, IFAS, University of Florida. Gainesville, FL

D. R. Burns, Northeast Research Station, Louisiana State University Agricultural Center, St. Joseph, LA

Roebie Burriss, Pioneer Hi-Bred International, Inc., Leesburg, GA

Warren J. Busscher, USDA-ARS, Coastal Plains Soil, Water, and Plant Research Center, Florence, SC

Elizabeth D. (Betty) Capaldi, Provost and Vice President, Academic Affairs, University of Florida, Gainesville, FL

Roy Lee Carter, Director, Gulf Country Extension Service, IFAS, University of Florida, Quincy, FL

Ben F. Castro, Gadsden County Extension Service, IFAS, University of Florida, Quincy, FL

Carrol *G*. Chambliss, Associate Professor, Department of Agronomy, IFAS, University of Florida, Gainesville. FL

James R Chichester, Chemist, IFAS, University of Florida, Gainesville, FL

Pat Cockrell, Director. Agricultural Policy, Florida Farm Bureau Federation, Gainesville, FL

A. B. Coco, Northeast Research Station, Agricultural Center, Louisiana State University, St. Joseph, LA

Mary E. Collins, Professor, Soil and Water Science Department, IFAS, University of Florida, Gainesville, FL

Larry J. Connor, Dean, Academic **Programs,** IFAS, University of Florida, Gainesville, FL

Paul Counce, University of Arkansas, Keiser, AR

Lawrence F. Crawford, Senior Agricultural Assistant, IFAS, University of Florida, Gainesville, FL

R F. Cullum, Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, Holly Springs, MS

W. L. Currey, Weed Systems Equipment, Keystone Heights, FL

Ronald T. (Tom) Cutler, Agricultural Assistanf IFAS, University of Florida, Gainesville, FL

C. Greg Davis, Asgrow Vegetable Seed Co., Alachua, FL

Walter Davis, Agricultural Assistant, IFAS, University of Florida, Gainesville, FL

Paul Denton, Institute of Agriculture, University of Tennessee, Knoxville. TN

Carl Dillion, University of Arkansas, Fayetteville, AR

C. C. Dowler, Weed Scientist, USDA-ARS, Nematode Weed and Crop Unif Coastal Plains Experiment Station, Tifton, GA

Ord Dunn, FMC Corp., Atlanta, GA

B. R. Durden, Gadsden County Extension Service, IFAS, University *of* Florida, Quincy, FL

R. Elmore, Coastal Plain Branch Experiment Station , Mississippi State University, Newton, MS

Everett R. Emino, Assistant Dean, Office of Dean for Research, IFAS, University of Florida, Gainesville, FL

Todd Faulk, Spraying Systems Co., Atlanta, GA

James J. (Jim) Ferguson, Associate Professor, Department of Horticultural Sciences, IFAS, University of Florida, Gainesville, FL
J. R. Frederick, Pee Dee Research and Education Center, Clemson University, Florence, SC
John J. Frederick, Biologist, Department of Entomology and Nematology, IFAS, University of Florida, Gainesville, FL
Edwin C. (Tito) French III, Associate Professor, Department of Agronomy, IFAS, University of Florida. Gainesville, FL
Tom **Fulmer,** Enviro-Comp Services, Inc., Jacksonville, **FL**
Raymond N. Gallaher, Professor, Department of Agronomy, IFAS, University of Florida, Gainesville, FL
Wanda E. Gallaher, Independent Contractor, Gainesville, FL
B. E. Gamble, USDA-ARS NDSL and Agronomy and Soils Department, Auburn University, Auburn, AL
Cassel S. Gardner, Assistant Professor, Center for Cooperative Agricultural Programs, Florida A & M University, Tallahassee, FL
W. Gary Gibson, Representative, ZENECA Professional Products. Vero Beach, FL
Niles Glasgow, Director, USDA-Natural Resource Conservation Service, Gainesville, FL
Donald A. Graetz, Professor, Department of Soil and Water Science, IFAS, University of Florida, Gainesville, FL
Henry G. Grant, Director, Gadsden County Extension Service, IFAS, University of Florida, Quincy, FL
J. H. Grove, Agronomy Department, University of Kentucky, Lexington, KY
W. Hart, Institute of Agriculture, University of Tennessee, Jackson, TN
Dale Haufler, Farmer, Haufler Brothers Farm, Alachua County, FL
Donald Haufler, Farmer, Haufler Brothers Farm, Alachua County, FL
Larry Hawf, Regional Representative, Monsanto Chemical Co., Sasser, GA
Denny Hebner, Fleischer Mfg. Inc. /Buffalo Farm Equipment, Monistown, TN
Peter E. Hildebrand. Professor, Department of Food and Resource Economics, IFAS, University of Florida, Gainesville, FL
Richard (Rick) A. Hill, Lab Technician, IFAS, University of Florida, Gainesville, FL
iMerritt Holman, Northeast Research Station. Agricultural Center, Louisiana State University, St. Joseph. LA
James E. (Jim) Hook, Professor, Crop and Soil Science Department, College of Agriculture and Environmental Science, Tifton, GA
F. L. Hooper, Agricultural Research and Extension Center, Texas A & M University, Corpus Christi, TX
Ellen E. Huntley, Graduate Student, Soil and Water Science Department, IFAS, University of Florida, Gainesville, FL
Harold R. Hnrst, Plant Physiologist, Delta Research and Extension Center, Mississippi State University, Stoneville. MS
R. L. Hutchinson, Agricultural Center Northeast Research Station, Louisiana State University, Winnsboro, LA
Gay M. Jividen, Senior Director, Cotton Inc., Raliegh, NC
A. W. Johnson, Nematologist, USDA-ARS, Nematode Weed and Crop Unit, Coastal Plains Experiment Station. Tifion, GA
B. Johnson, Coastal Plain Branch Experiment Station , Mississippi State University, Newton, MS
F. **Johnson,** USDA Natural Resource Conservation Service (NRCS), Quincy, FL
Joseph R Johnson, North Mississippi Branch Experiment Station, Mississippi State University, Holly Springs, MS
Richard L. Jones, Dean and Director, Office of Dean for Research, IFAS, University of Florida, Gainesville, **FL**
Joseph C. (Joe) Joyce, Associate Vice President, Office of Vice President for Agriculture and Natural Resources. IFAS, University of Florida, Gainesville, FL
Patrick W. Joyce, Extension Agent II, Duval County Extension Office, Dairy & Livestock, IFAS, University of Florida, Jacksonville, FL
Terry C. Keisling, Professor, NEREC, University of Arkansas, Keiser, AR
Gary Kennedy, NOVARTIS (Ciba-Geigy), Ocala, FL
Brian T. Kidd, Senior Biologist, North Florida Research and Education Center-Quincy, IFAS, University of Florida, Quincy. FL
Gerald (Jerry) Kidder, Professor, Department of Soil and Water Science, IFAS, University of Florida, Gainesville, FL
Lee Kimbrough, Fleischer Mfg. Inc. /Buffalo Farm Equipment, Momstown, TN
R. A. Kinloch, Associate Professor, North Florida Research and Education Center, IFAS, University of Florida, Quincy, FL
David J. Lang, Mississippi State and Coastal Plain Branch Experimental Station, Newton, MS
Lisa A. Lanza, Certified Independent Organic Inspector, Clearwater, **FL**
B. R. Leonard, Macon Ridge Research Station, Louisiana State University Agricultural Center, Winnsboro, LA
Joel C. Love, Florida Department of Agriculture and Consumer Services-Bureau of Agriculture Water Policy, Live *Oak,* FL
Elzie McCord, E.I. DuPont De Nemours & Co., Sarasota, FL
C. H. McGowan, Associate Professor, Center for Cooperative Agricultural Programs, Florida A & M University, Tallahassee, FL
K. C. MeGregor, USDA-ARS, National Sedimentation Laboratory, Oxford, **MS**
Robert (Bob) McSorley, Professor, Department of Entomology and Nematology, IFAS, University of Florida, Gainesville, FL
H. J. "Rich" Mascagni, Jr., Northeast Research Station, Louisiana State University Agricultural Center, St. Joseph. **LA**
John E. Matocha, Agricultural Research and Extension Center, Texas **A** & M University, Corpus Christi, TX

Marty Mesh, Coordinator, Florida Organic Growers and Consumers, Gainesville, FL

David L. Moon, Senior Lab Technician, IFAS, University of Florida, Gainesville, FL

Ronald Morse, Department of Horticulture, Virginia Tech Agricultural Experiment Station, Blacksburg, VA

Ken Muzyk, American Cyanamid Co., Brandon, FL

Maylon Nicholson, Kelly Mfg. Co., Tifton, GA

D. O'Keefe, President, Full Circle Solutions, Gainesville, FL

L. R. Oliver, University of Arkansas, Fayetteville, AR

Caleb Oriade, University of Arkansas, Keiser, AR

Michael Oxner, University of Arkansas, Keiser, AR

Howard C. Palmer, Lab Technician, IFAS, University of Florida, Gainesville, FL

Robert G. (Bob) Palmer, Pioneer Hi-Bred International, Inc., Huntsville, AL

M. G. Patterson, USDA-ARS NSDL and Agronomy and Soils Department, Auburn University, Auburn, AL

Ty Paulk, Weed Systems Equipment, Keystone Heights, FL

Daniel L. Polk, Coordinator, Department of Agronomy, IFAS, University of Florida, Gainesville. FL

Don J. Porter, Representative, ZENECA Ag Products, Vero Beach, FL

J. Prihota, North Florida Research and Education Center-Quincy, IFAS, University of Florida, Quincy, FL

Gordon M. Prine, Professor, Department of Agronomy, IFAS, University of Florida, Gainesville FL

J. A. Pudelko, Visiting Research Scientist [from Agriculture University, Institute of Soil Cultivation and Plant Production, Mazowiecka, Poznan, Poland], North Florida Research and Education Center-Quincy, IFAS, University of Florida, Quincy, FL

G. Quelley, Center for Cooperative Agricultural Programs, Florida A & M University, Tallahassee, FL

Kenneth H. (Ken) Quesenberry, Professor, Department of Agronomy, IFAS, University of Florida, Gainesville, FL

Donald R Rau, TERRA Industries, Alachua, FL

S. Reed, Center for Cooperative Agricultural Programs, Florida A & M University, Tallahassee, FL

Wayne Reeves, USDA-ARS NSDL and Agronomy and Soils Department, Auburn University, Auburn, AL

Fredrick M. Rhoads, Professor, North Florida Research and Education Center-Quincy, IFAS, University of Florida. Quincy, FL

Jimmy R Rich, Professor, North Florida Research and Education Center, IFAS, University of Florida, Quincy, FL

Dave Richey, Fleischer Mfg. Inc. /Buffalo Farm Equipment, Momstown, TN

Bob Riggs, NEREC, University of Arkansas, Keiser, AR

Drew Rush, Delta and Pineland Co., Brewton, AL

Stuart J. Rymph, Graduate Student, Department of Agronomy, IFAS, University of Florida, Gainesville, FL

Nancy Sanders, Secretary, Department of Entomology and Nematology, IFAS, University of Florida, Gainesville, FL

Jerry Scarborough, Director, Suwannee River Water Management District, Live Oak, FL

Carl Shefield, Heavy Equipment Operator, IFAS, University of Florida, Gainesville, FL

Aziz Shiralipour, Assistant Scientist, Center for Biomass Programs, IFAS, University of Florida, Gainesville, FL

Wayne H. Smith, Director, School of Forest Resources and Conservation, IFAS, University of Florida, Gainesville, FL

Larry Spooner, Paymaster Seeds. Stuttgart, AR

Stan R. Spurlock, Mississippi State University, Mississippi State, MS

Robert L. (Bob) Stanley, Jr., Associate Professor, North Florida Research and Education Center-Quincy, IFAS, University of Florida, Quincy, FL

Christine Taylor Stephens, Dean and Director, Office of Dean for Extension, IFAS, University of Florida. Gainesville, FL

Jim Stiegler, Agronomy Department, College of Agricultural and Environmental Sciences, Oklahoma State University, Stillwater, OK

H. S. Surnner, Agricultural Engineer, USDA-ARS, IBPMRL, Coastal Plains Experiment Station, Tifton, GA

Marilyn E. Swisher, Associate Professor, Home Economics Department, IFAS, University of Florida, Gainesville, FL

Kent Taylor, AgrEvo USA, Tifton, GA

Ricky W. Telg, Assistant Professor, Department of Agricultural Education and Communication, IFAS, University of Florida, Gainesville, FL

W. J. Thomas, Northeast Research Station, Louisiana State University Agricultural Center, St. Joseph, LA.

John M. **Thompson,** Mississippi State University, Mississippi State, MS

Winston D. Tooke, USDA Natural Resources Conservation Service, Gainesville, FL

Grover B. Triplett, Mississippi State University, Mississippi State, MS

Gordon R Tupper, Delta Research and Extension Center, Mississippi State University, Stoneville, MS

D. D. Tyler, Institute of Agriculture, University of Tennessee, Jackson and Knoxville, TN

Noble R. Usherwood, Vice President, Potash and Phosphate Institute, Norcross, GA
S. G. Vacek, Agricultural Research and Extension Center, Texas A & M University, Corpus Christi, TX
Harold H. (Jack) Van Horn, Jr., Professor, Department of Dairy and Poultry Science, IFAS, University of Florida, Gainesville, FL
Jac J. Varco, Plant and Soil Sciences Department, Mississippi State University, Mississippi State, MS
David Vogel, Administrator, Soil and Water Conservation, Florida Department of Agriculture and Consumer Services, Tallahassee, FL
RW. Vories, Chief Financial Officer, Boone Waste Industries, Gainesville, FL
Brett L. Wade, Graduate student, Department of Agronomy, IFAS, University of Florida, Gainesville, FL
Craig Watson, Owner, Craig Watson's Farm, Giichrist County, FL
Marvin F. Weaver, County Extension Director and Extension Agent IV, Gilchrist County, IFAS, University of Florida, Trenton, FL
Wilbur Webb, DeKalb Seed Co., Tifton, GA
E. Ben Whitty, Professor, Department of Agronomy, IFAS, University of Florida, Gainesville, FL
P. J. Wiatrak, OPS Professional, North Florida Research and Education Center-Quincy, IFAS, University of Florida ,Quincy, FL
J. Wilkinson, Institute of Agriculture, University of Tennessee, Knoxville, TN
Jorge A. Widmann, Graduate Student, Department of Environmental Horticulture, IFAS, University of Florida, Gainesville. FL
Cindy E. Wieland. Graduate Student, , Department of Environmental Horticulture, IFAS, University of Florida, Gainesville, FL
David S. Wofford, Associate Professor, Department of Agronomy, IFAS, University of Florida, Gainesville, FL
Harry C. Wood, Senior Lab Technician, IFAS, University of Florida, Gainesville. FL
Keony R. Woodard, Post Doctoral Associate, Department of Agronomy, IFAS, University of Florida, Gainesville, FL
David L. Wright, Professor of Agronomy, North Florida Research and Education Center-Quincy, IFAS, University of Florida. Quincy, FL
E.T. York, Distinguished Service Professor Emeritus, IFAS, University of Florida, Gainesville, FL

Continuing Education Units

Continuing Education Units (CEUs) for Florida State Pesticide Applicator License re-certification and Certified Crop Advisers (CCA) certification will be offered for attending this conference. If you would like approval for CEUs, **you** must present your pesticide licenses and/or **your CCA** certification number along with your social security number at the conference registration area.

Florida State Pesticide Applicator CEUs

Participants who attend the conference may earn up to a total of **9** CEUs to apply towards their Florida State Pesticide Applicator License re-certification. The CEUs available are listed below. Please note that participants cannot exceed the daily total of CEUs approved.

Tuesday, **24** June (Total CEUs approved - **4)**

Private Applicator Agricultural	**4**
AgRowCrop	**4**

Wednesday, **25** June (Total CEUs approved - 2)

Private Applicator Agricultural	**2**
AgRowCrop	**2**
Demo/Research	2

Thursday, **26** June (Total approved - **3)**
(note: signature for approval will be given upon completion of the tours)

Private Applicator Agricultural	**3**
AgRowCrop	**3**
Demo/Research	**3**

Ms. Pam Houmere, a representative from the Florida Department of Agriculture and Consumer Services will be available at the conference registration area from 11:00 am-5:00 pm, Tuesday, June **24,** and from 8:00 am-5:00 pm, Wednesday, June 25. She will approve CEUs and be able to answer questions regarding CEUs and licensing. Should you need assistance prior to the conference, you may contact her at **904-488-6838.**

Certified Crop Advisers CEUs

Participants may earn up to a total of 14 CEUs to apply towards their Certified Crop Advisers (CCA) certification. CCA CEUs are applicable for the Southeastern states of ***Florida, Georgia, Alabama, South Carolina,*** and ***North Carolina.*** Participants will be required to sign out at the end of each day in order to receive the CEUs requested. The CEUs available are listed below. Please note that participants cannot exceed the daily total of CEUs approved. Should you have any questions regarding CCA CEUs, you may contact Andy LaVigne, Executive Director of the Florida Fertilizer and Agrichemical Association at (941) 293-4827.

Tuesday, 24 June (Total approved - 2.5)

Soil Fertility	.5
Soil and Water	.5
Crop Production	1.5

Wednesday, 25 June (Total approved - 6.0)

Soil Fertility	.5
Pest Management	1.0
Crop Production	4.5

Thursday, 26 June (Total approved - 5.5)

Pest Management	1.5
Crop Production	4.0

Conference Registration

The registration fee includes a proceedings, the Tuesday evening reception, Thursday's tour with a fish **fry** luncheon, the Thursday evening barbecue with entertainment, and daily refreshment breaks.

Regular Registration Fee	$130.00
Student Registration Fee	$40.00
Farmer Registration Fee	$25.00

To register, complete and return the enclosed registration form with payment. If you require additional information, contact the registration department at the Office of Conferences (352) 392-5930. Requests for refunds will be honored if written notice of cancellation is received **by** the Office of Conferences on or before June 1, 1997. A $10.00 processing fee will be deducted from all refunds. *Sorry,* no refunds will be honored after June 1, 1997.

In compliance with ADA requirements, participants with special needs can be reasonably accommodated by contacting the Office of Conferences at least 10 working days prior to the conference. We can be reached by phone at (352) 392-5930, by ***fax*** at (352) 392-9734, or by calling 1-800-955-8771 (TDD).

Hotel Accommodations

The conference will be held at the Holiday Inn West located at 7417 NW 8th Avenue, Gainesville, FL 32605. A block of rooms has been reserved at the hotel for conference participants at a special rate of $69 plus 9% tax for up to two people per room, $73 plus 9% tax for three people per room and $83 plus 9% tax for four people per room. For reservations, call the hotel's national number at 800-HOLIDAY or call directly at 1-800- 551-8206 or (352) 332-7500. **Be sure to state that you are with the Annual Conservation Tillage Conference when you call. Reservations should be made by June 1, 1997.** After this date, reservations and the special rate will be subject to availability.

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