PRESENTATION SUMMARIES

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OVERVIEW AND IMPACTS OF PSA PROGRAMS IN SUSTAINABLE AGRICULTURE, FORESTRY AND HORTICULTURE

Resources for Clemson Sustainable Agriculture Programs

Jim Fischer, Dean and Director, Agriculture and Forestry Research

This presentation is available as a PowerPoint slide show via a link on our web page: http://www.clemson.edu/sustainableag/saconfppt.htm.

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Agriculture, Horticulture and Forest Industries in South Carolina – Growth and Economic Trends

Todd Davis, Assistant Professor and Extension Economist, Agricultural & Applied Economics

Overview

The agricultural, forestry, and horticultural industries play an important part in South Carolina's economic health. Agriculture and forestry comprise about 17% of the state's economic product, and 460,000 (22%) of the state's full and part-time jobs. South Carolina agriculture and forestry industries generated $35.7 billion in gross sales in 2001, which was 22.1% of the state's total sales for the year (*South Carolina Agriculture & Forestry Overview*, 2001).

Economic Trends

In 1992, tobacco generated the largest agricultural cash receipts, $190 million, in the state (Table 1). However, cash receipts for tobacco have been declining due to reduced tobacco quotas. A bright spot in South Carolina agriculture has been the broiler and nursery industries. The broiler industry has generated the largest agricultural cash receipts since 1994. Cash receipts for broiler production increased 157% from $136 million in 1992 to over $350 million in 2001. Similarly, the nursery industry has grown dramatically since 1992. Cash receipts for nursery crops increased 132% from $120 million in 1992 to over $280 million in 2001 (Table 1). Nursery crops now generate the second largest amount of agricultural cash receipts in South Carolina.

Cotton production generated cash receipts of $146 million in 1996. However, Table 1 illustrates the cyclical nature of cotton prices, as the 2001 cash receipts were $94 million. Similarly, receipts from cattle production were depressed in 1996, but have increased to $135 million in 2001 (Table 1). Cotton and cattle are still an important part of the state's agricultural economy.

Payments received from the government are a large component of farm profitability. In 1996, South Carolina producers received $43 million in payments from the government. Government
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payments have increased 295% to $170 million in 2001. Government payments represent the third largest agricultural cash receipt for 2001.
Table 1. Cash Receipts from Farm Marketing and Government

Payments (Million Dollars)

	1992	1996	2001
Broilers	$136	$307	$350
Cattle and Calves	113	75	135
Cotton	75	146	94
Nursery	120	165	280
Tobacco	190	215	150
Govt. Payments	73	43	170

Land Use
Of the 19.9 million acres of land in South Carolina, 4.7 million acres are farmed, 12.4 million acres are in forests, and 2.8 million acres are in urban, residential, or industrial use. An important issue in South Carolina agriculture is the transition of land out of agricultural production to urban use. From 1982 – 1992, 40,000 acres per year transitioned out of agriculture into urban use. This rate increased to over 100,000 acres per year from 1992 to 1997 (*South Carolina Agriculture & Forestry Overview*, 2001).

Forestry
Forestry is the third largest manufacturing industry in the state, employing 26,000 people, and forestry products are valued at $7.5 billion per year (*South Carolina Agriculture & Forestry Overview*, 2001). Other economic benefits of forests are watershed protection, wildlife habitat, recreation, and aesthetic qualities. A by-product of forests is the income generated by hunting. Hunting generates $658 million per year in economic activity (*South Carolina Agriculture & Forestry Overview*, 2001).

The trend in South Carolina for the past 15 years is the divesting of large land holdings by forest companies. Pension funds and partnerships are purchasing much of these large acreages. Industry consolidation and present tax laws have been a major force in this trend, and this trend is expected to continue (USDA Forest Service).

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Row Crops

Ben U. Kittrell, Director, Pee Dee Research and Education Center

For a crop culture to be economically viable, supply must be great enough to support an active market but not so great as to bury consumers under an avalanche of surplus, smothering prices and profits. On the other side of the equation, demand must be sufficiently vigorous to ensure a reliable and satisfactory rate of return. The theory of comparative advantage suggests that production in a given place tends to specialize in activities that the environment and resources will support and that provide the greatest rates of return. In agriculture, therefore, the profitability of a given crop must be as great as any other that could be produced with the means at hand. When a commodity no longer answers this requirement, effort, acreage and capital shift to one that will. (Long Green by Eldred Prince Jr. University of Georgia Press 2000 p.1.)

A brief history of South Carolina may help us understand the crops we grow and our focus on sustainable agriculture today. It may also show us how “true” the economic theory mentioned previously has been and why it will continue to be. I must apologize if I sound like an economist!

When this country was being settled, the Carolinas - North and South - were an experiment financed by a group of Englishmen known as the Lords Proprietors. These men, hoping to reap profits from this venture, expected the new settlers to produce silk, citrus, olives and wine. None of these crops proved to
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be successful; however, they did find that the area around Charleston produced excellent watermelons, pumpkins, potatoes and tobacco. Since tobacco already had an established market from the successful Virginia colony, Jamestown, the Carolina settlers began to grow tobacco as their first "money crop". In order to compete with Virginia tobacco, the Proprietors convinced the King to forgo the taxes for seven years. When the Virginia growers realized that tobacco shipped from Charleston had no tax imposed, they brought Virginia tobacco to Charleston to be shipped to England. Overproduction and an unhappy King caused the Carolina growers to look for another enterprise.

With the fresh water flowing from the rivers into the tidal marshes in the Charleston area, the possibility of rice production was examined. The entire rice culture was imported from the coast of Africa along with the knowledge and expertise to build rice fields and flood gates, and of course, enough slave labor to develop the enterprise. Soon rice became the "money crop" and tobacco was left to those in Virginia and North Carolina. When the South Carolina Governor became concerned that the black population was becoming too large, he offered free land to those from the north and from other countries to settle the "backwoods" area of South Carolina. Some settlers came with tobacco seeds and found that they could grow tobacco on these small farms without slave labor. Since rice was confined to the tidal areas, it could not expand. As a result, tobacco once again became the "money crop" beyond the coastal area.

Long-fiber cotton was being grown along the coast, but could not be produced outside of that climate. Short-fiber cotton was much better adapted to most of the land area in South Carolina as well as all southern states. However, unlike the long-fiber cotton seed, the lint was very difficult to separate from the seed of short-fiber cotton, which seriously limited the acres that could be planted the next year. With the invention of the cotton gin, this obstacle was removed. The demand for cotton soared as a result of the industrial revolution and the increase in cotton mills in Great Britain. Cotton truly became King throughout the state, especially in the upstate where it was said that the hills were white with cotton with no trees growing in the way.

With King Cotton at the throne, the plantation owners became rich with their slave labor and vast land holdings. Beautiful homes were built and these agricultural leaders enjoyed a social life that was unsurpassed. During the early 1800's, South Carolina was a leading state economically, socially and politically. Unfortunately, a lack of knowledge and minimal regard for the land resulted in the loss of precious topsoil on the hilly slopes, causing cotton yields to diminish. Competition with other southern states that produced cotton, low prices due to oversupply and the eventual freeing of the slaves left the state with a very depressed agriculture. Growers began wondering if another crop was needed as their "money crop."

Several agricultural leaders around the Great Pee Dee River experimented with tobacco as an optional crop. They were aware of the tobacco culture in the Piedmont area of North Carolina. Individuals from North Carolina were hired to come south to teach growers the art of tobacco culture. Also during this time the Land Grant System was established to experiment and to instruct growers in Ascientific farming@. A more diversified agriculture was developed with emphasis placed on reduced soil erosion, improved varieties in several crops, improved yield per acre and a better standard of living. This increase in agricultural productivity allowed more of the population to be displaced to the growing industrial sector of the economy.

World War I resulted in bringing the world closer together with a greater dependence upon each other and more knowledge of what other

countries were doing and producing. The introduction of cigarette smoking and the use of tobacco throughout the world increased the demand for tobacco. South Carolina joined with North Carolina and Virginia growers to satisfy this increased demand. Tobacco in South Carolina once again became the main "money crop." Cotton, plagued by the boll weevil, was relegated to second place.

What can we say about crop sustainability? The only crop that has not survived those early beginnings in South Carolina is rice. We continue to have a diverse row crop agriculture that is suited to our environment. We have cotton, tobacco, peanuts, corn, soybeans, and wheat. Today, most growers would say that tobacco and cotton are their "money crops," with a limited number having peanuts. With the Boll Weevil Eradication Program, cotton has made a good comeback in the state; however, it has lagged behind states like Georgia and North Carolina in cotton acreage increases. At present, cotton prices are very low and growing cotton is only profitable with government support. Tobacco still remains South Carolina's most profitable crop but acreage has declined drastically in the last few years since health concerns have reduced demand domestically. Export demand continues to increase but the present tobacco program continues to keep our prices high, giving foreign production a competitive advantage. The recent movement to contract marketing has clouded the future direction of this crop in South Carolina. However, with the great advances in mechanization and our ability to produce a better quality leaf, we may still have a competitive advantage over other countries if the present control program is discontinued and demand continues throughout the world.

Numerous research projects that contribute to the sustainability of these crops continue to be conducted by Clemson scientists. There is some commonality among the objectives of these projects, including:

1. Conservation tillage to control soil erosion, improve water quality, improve soil structure and organic matter (or carbon sequestration) and for its impact on yield, nematodes, insects and weeds;
2. Pest control for insects, diseases and weeds utilizing fewer chemicals, better use of economic threshold limits, proper scouting techniques, biological control, and transgenics;
3. Row spacing with narrow rows and planting more crops with a grain drill, - especially when used in conjunction with transgenics and conservation tillage methods;
4. Management techniques for new transgenic varieties to avoid possible pest resistance;
5. Adaptation to precision farming techniques that utilize yield monitors and greater precision of applications of fertilizer and pesticides.

Some have defined sustainability as economically profitable, environmentally friendly and socially accepted. The concept of a "money crop" as has been used throughout this presentation has resulted in a monocrop philosophy in the past and has affected the degree of sustainability by ignoring the many other factors that are important to sustaining an agricultural industry. Those growers that tried to follow that system are no longer viable farmers. We must adopt a philosophy of cropping systems that will give some degree of economic credit to those parts of the system that are not as profitable but certainly will contribute to the entire system. This will include, but is not limited to such practices as crop rotation, crop residue, organic matter, better soil health and carbon credits. Many growers have now found a demand for other parts of their total farm. Wildlife and the sale of hunting rights has become a new enterprise and must be protected if it is to be made a viable part of the sustained

farming system. In addition, as our state has become more urbanized, agricultural tourism has become more popular and opportunities are increasing.

Will South Carolina agriculture be sustainable? If our land is more valuable for non-farm uses, will we eventually see it grow up (as an economist put it) in pine trees and trailer houses?

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Animals - Beef and Related Forages

Steve Meadows, Director, Edisto Research & Education Center, Blackville, SC

The Beef and Forage research/extension component at the Edisto Research and Education Center is undergoing dramatic change. There is one major project that is out for review that will focus on AIntegrated Resource Management.@ This project will evaluate the genetic makeup of the herd from conception to consumption. There will be a total of 120 cows on this project comprised of Angus, Gelbvieh, Simmental and Charolais breeding. The brood cows will be F1 crosses representing 50% British breeding and 50% Continental breeding. Resulting steer mates will be fed out and carcass evaluation conducted. All pre and post weaning variables will be measured. This project will run for 5 years and we plan to renew for an additional 5 years.

A current project entitled ABreeding to optimize maternal performance and reproduction of beef cows in the Southern region@ is in its final year. This study focuses on the milk EPDs (expected progeny difference) for 50 Angus cows that are divided into control, high and low EPD ranges for the breed. These cows are milked at 45 days postpartum and every 30 days thereafter until weaning. Milk weights were compared to milk EPD to evaluate relationship of EPD to weaning weight of calf.

There are currently three forage research/extension projects being conducted at the Edisto REC. The first project is the evaluation of brome grass varieties and their possible use in the Coastal Plains of South Carolina. This is a joint project with USDA to evaluate these particular varieties. Additional work is being done with Switch grass that will also evaluate varietal adaptation as well as management techniques. The third component of the forage program is the evaluation of the new MAX Q fescue in the coastal plains. These plots were planted in the fall of 2001, due to drought they got off to a late start but are progressing.

Beef cattle breeding research at the Simpson station is part of the S-277 project that was referenced earlier. Again, this project evaluated milk production as related to EPD and its effect on reproduction. Body condition scores were taken and data analyzed. This project is in its final year as well. Termination scheduled for fall of 2002. The breed make-up of this group is primarily Simmental breeding.

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Animals – Dairy

Jean Bertrand, Professor, Animal and Veterinary Science

Research programs in Sustainable Agriculture in Dairy are being conducted by three professors in the Animal and Veterinary Science Department - Dr. Jean Bertrand, Dr. Tom Jenkins and Dr. Annel Green. Areas of research include:

1. Animal waste management (Greene, Bertrand)
   A. Animal Waste Treatment

Dr. Greene has developed several methods of treating animal waste to reduce odors, destroy bacteria and to reduce the environmental impact of animal waste. In these processes animal waste is treated to reduce bacterial content, color, odor, biochemical oxygen demand and chemical

oxygen demand. One U.S. patent has been granted on a portion of the animal waste treatment process and four additional patent applications are under submission. Additional technologies developed include methods of rapidly making alternative fuels from animal waste. We also have devised a process that will allow us to develop cooperative agreements between animal farmers and horticultural interests so that each agricultural segment can derive financial benefit and solve critical problems. The overall goal of our project is to develop methods by which the farmer can solve the animal waste problem while making a profit from value added products derived from the waste.

B. Reducing phosphorus in manure through dietary manipulations

Excess phosphorus is excreted in the manure of dairy cattle. Even when cows are fed the recommended levels of phosphorus, a large amount is excreted in the manure. Dr. Bertrand has investigated possible ways to reduce the output of phosphorus in manure by evaluating methods of altering the diet to improve the absorption of phosphorus from the gastro-intestinal tract. In particular, she has evaluated reducing dietary phosphorus and increasing dietary vitamin D as a possible means of increasing phosphorus absorption and thereby decreasing its excretion.

2. Use of forages for grazing (Bertrand, Jenkins).

Dr. Bertrand has been conducting research for eight years on the use of pasture by dairy cows as a means of improving the sustainability and profitability of dairy farms. One of the most exciting recent developments in agriculture is the discovery that milk from cows that graze contains significantly higher levels of a compound shown to have potent cancer-fighting properties. This compound is commonly called conjugated linoleic acid or "CLA". Grazing is a management practice recognized as contributing to the goals of the sustainable agriculture movement, and this discovery offers the exciting possibility of opening new and unique markets for dairy farmers that graze.

The main objective of this research is to gain knowledge that will enhance the ability of dairy farmers that graze to increase the CLA content of their milk. Current research includes building a database of information on the fatty acid and nutrient content of different forages that are grazed and the milk CLA response to different forages. In the future, we wish to investigate the synergistic components present in the rumen (pH, presence of starch, etc.) that enhance or diminish the production of CLA when pasture is fed.

3. Enhance the health of dairy products (Jenkins).

The objective of this research is to modify the type and amount of fat in meat and milk to further enhance the contribution of animal products to healthful diets. Diet-conscious consumers continue to make food selections that are driven by concerns about fat content and quality. Preference is usually given to foods that are low in fat, cholesterol, and saturated fatty acids. While the relationship between saturated fatty acid intake and human health risks are unresolved, medical and nutritional advice to consumers is to limit their intake of saturated fatty acids from dairy products and red meat. The challenge in ruminant species is to prevent biohydrogenation so that unsaturated fatty acids in the diet will not be converted to saturated fatty acids that are deposited in body tissues. Fatty acyl amides were recently developed (Patent No. 5,547,686) as a feed supplement for ruminant rations to avoid biohydrogenation and increase the content of unsaturated fatty acids in meat and milk. Also, conjugated linoleic acids (CLA), which are intermediates in ruminal biohydro-genation, have been identified as potent anticarcinogens found naturally in meat and

milk. Studies are being initiated to enhance CLA.

4. Improve animal productive efficiency (Jenkins, Bertrand).

A. Utilize fat energy in ruminant diets to maximize animal productive efficiency under stressful situations (Jenkins).

Adding fat to ruminant diets has been one approach to reducing the severity of some stressors associated with high levels of production. Potential benefits of fat include its high energy density and energetic efficiency which may reduce the incidence of metabolic disorders, alleviate heat stress, and improve reproductive performance. The challenge has been to overcome the limitations associated with feeding high levels of fat to ruminants which include inhibition of microbial fermentation in the rumen and impaired intestinal fatty acid digestibility. Progress has included knowledge of how fatty acids can be chemically modified to reduce their antimicrobial effects, quantitation of the kinetics of lipid transformations in the rumen, and the factors that reduce fatty acid digestion post-ruminally.

B. Improve animal productive efficiency by regulating cellular metabolism in ruminant species via control of fatty acids that act as regulators of cell function and tissue metabolism (Jenkins).

Regulatory effects of lipids on cellular metabolism are based on their roles as regulators of membrane structure and fluidity, as ligands for cell-surface receptors, as anchors for membrane associated proteins, and as second messengers. The most attention has been given to unsaturated fatty acids because they are parent compounds to the biologically potent eicosenoids and prostaglandins. The challenge in ruminant species is to prevent biohydrogenation so that unsaturated fatty acids in the diet will not be converted to saturated fatty acids by ruminal microbes. Progress has been made in limiting biohydrogenation by the discovery that amides of unsaturated fatty acids resist hydrogenation by ruminal microbes. Present and future studies feeding fatty acyl amides to ruminants will examine hormonal and metabolic effects of elevated unsaturated fatty acids in ruminant tissues.

C. Evaluate the nutrient content and digestibility of traditional versus genetically modified whole cottonseed.

Whole cottonseed (WCS) is a very popular feed for dairy cattle and is uniquely high in fiber, energy (from fat), and protein. Recent genetic modifications have produced cotton plants more resistant to pests and herbicides. One of the most popular genetic modifications includes the introduction of a gene that controls the major lepidopteran insect pests of cotton. This is commonly referred to as the “Bt” gene. The other popular genetic modification is the inclusion of a gene which gives tolerance to nonselective herbicides such as glyphosate. This cotton is commonly known as the “Roundup Ready®.” While these genetic modifications offer advantages to the cotton grower, it is unknown how the modifications have altered the characteristics of the seed and its use as an animal feed. Extension agents have reported that some dairy producers have discontinued using WCS because they perceive it to be less digestible than it once was and are asking if the genetic modifications have caused the seed to be less digestible. Therefore, studies are being conducted to determine if the nutrient content, gossypol, and *in vitro* digestibility of genetically modified WCS differs from traditional varieties.

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Animals – Poultry

Peter Skewes, Professor, Animal and Veterinary Science

Unlike many other components of animal agriculture, poultry interests have evolved into two totally separate stakeholder groups. One
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group is the commercial poultry industry that is dedicated to the production of poultry products for human consumption. The other group includes hobby, recreational use, and small flock owners. Obviously the needs and programs for each segment are very different.

Commercial poultry/food production
The stakeholders in this group include both large agribusiness corporations and large contract farms.

Examples of programs with these stakeholders include waste management certification and research to alter nutrient profiles of manure.

Hobby, recreational, show, and small flock
The stakeholders in this group include people with small numbers of birds that produce little or no food products. Most are interested in showing their poultry or producing gamebirds to meet the needs of hunting preserves. Many do not derive significant profit from their poultry activities.

Examples of current programs with these clientele include small flock certification programs, National Poultry Improvement Plan certification, gamebird programs, and many youth programs including the very popular pullet chain. Although there are no specific "sustainable objectives for these activities, the majority of these people incorporate relatively "sustainable" practices in the management of their poultry.

Resources committed to poultry and sustainable agriculture
Currently in the Animal and Veterinary Sciences Department at Clemson University there are 0.5 FTE dedicated to poultry extension programs and approximately 2 FTEs dedicated to poultry research. Of this, approximately 0.5 of the extension/research activity can be tied to sustainable agriculture. There are also numerous individuals in Agriculture and Biological Engineering, Agricultural Economics, Food Science, and county offices that contribute to extension/research related to poultry.

Future trends
Both stakeholder groups are growing. The commercial poultry industry is being challenged in relation to practices involving waste management, air quality, animal welfare, and food safety. There will be increasing pressure on these issues that will result in more stringent legislation.

New initiatives
The most exciting activity related to sustainable poultry production is the development of free-range poultry production unit. This unit will be created by current students in the AVS 402 Poultry Management Class during the Spring 2002 semester. Additionally, there are plans for a cage-free egg production facility. Both facilities will be used for, teaching, demonstration, and research activities.

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Animals – The Changing Swine Industry

J. Albrecht and *J. McConnell*, Professors, Animal and Veterinary Science

Change continues to be the hallmark of swine production in S.C. Economic and environmental pressures have remained key forces in reducing the state's swine population and the people population associated with swine production. The number of farms with swine in 1980 was near 22,000 with a population of 419,000 swine; today, the farm population is near 175 while the swine population is estimated to be 300,000 head.

Trends that continue in the industry include fewer producers but larger farms with greater outputs, a reduction in processing facilities for pork, increasing restaurant demand for pork and a gradual increase in consumer pork demand. Profits per farm unit have not increased
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significantly since 1980, while costs of production and costs of living have increased. Hence, the survivors have been those who have increased the size of their units to sustainable levels.

Technology adoption has been a key in helping farmers survive. Artificial insemination makes the best genetics available to all and at reasonable prices. The readily available and superior genetics have increased carcass muscling and quality while reducing the fat content. Consistency in product quality has become more commonplace with better genetics and nutrient partitioning agents such as ractopamine. Phosphorus levels in diets have been reduced through the use of the enzyme phytase so that swine wastes are less problematic than before. Gene altered feedstuffs will alleviate many waste management problems in the future.

Small-scale swine herds can continue to exist. Emphasis must be directed to carcass acceptability and niche markets will be important for small farm survival.

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Animals – Animal Waste Management
John Chastain, Associate Professor, Agricultural and Biological Engineering

This presentation is available as a PowerPoint slide show via a link on our web page: http://www.clemson.edu/sustainableag/saconfppt.htm.

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Fruit Production
Desmond Layne, Assistant Professor, Horticulture

Industry Size (US and SC):

- Fruit and nut crops, including berry and tree fruits, are the sixth largest agricultural segment in all U.S. agricultural production.
- They comprise 6 % of American agricultural sales with total value approaching $13 billion. Of 25,207 fruit and nut farms, 2,941 (12 %) had sales over $1 million in 1997.
- Fruit and nut crops are one of the top 5 commodities in 10 states.
- Total sales from SC fruit and nut production exceeded $37 million in 2000.

- Peach is by far the most important fruit crop in SC, comprising 17,000 acres of production with a farm value approaching $30 – 40 million per year. Apple production is declining while production of strawberries, blueberries, brambles and grapes continues to increase in SC.
- South Carolina ranks second only to California in U.S. peach production.
- There are several thousand SC jobs in fruit and nut crops. Many of these are contract labor (i.e., H2A Guest Worker program, etc.); however, numerous individuals are involved in retail marketing as well.

Mission:
The overall mission of the Fruit Team is to improve the profitability of the fruit industries through development of sustainable, low risk, highly efficient and cost-effective technology that increases economic development and avoids degradation of the environment.

Goals:

- Develop interdisciplinary research and extension programs to enhance understanding of the science associated with fruit production and to convey this knowledge to the SC grower.
- Discover and develop profitable production techniques for fruit crops.
- Improve the yield, quality and post-harvest shelf life of fruit crops through

cultural manipulation integrated with appropriate postharvest management practices.
- Develop pest management practices and production strategies that reduce chemical inputs and runoff, protect the environment, promote sustainability, enhance yield and quality, and ultimately provide consumers with a residue-free product.

Team Members and Expertise:
- Bert Abbott, Professor, peach genome research/teaching
- Felix Barron, Associate Professor, Food Science & Human Nutrition
- Roy Dodd, Professor, Agricultural & Biological Engineering
- Roger Francis, County Extension Agent, small fruit and vegetable production
- Clyde Gorsuch, Professor, fruit entomology extension/research**
- Keith Hall, County Extension Agent, fruit production and others
- Greg Henderson, County Extension Agent, fruit production and livestock**
- Howard Hiller, County Extension Agent, fruit production and others
- Danny Howard, County Extension Agent home horticulture
- Libby Hoyle, Professor, Food Science and Safety
- Dan Kluepfel, Associate Professor, soil microbiology research/teaching
- Desmond Layne, Assistant Professor, Tree fruit research/extension**
- Dale Linvill, Professor, Agricultural Meteorology
- Tony Melton, County Extension Agent, vegetable and fruit production and others
- Wayne Mitchem, Regional Extension Specialist, weed control in fruit crops**
- Henry Nunnery, County Extension Agent, fruit production and others
- Tom Owino, Assistant Professor, Agricultural & Biological Engineering
- David Parker, County Extension Agent, fruit production and others
- Jim Rathwell, Professor, agricultural economics
- Gregory Reighard, Professor, Tree fruit research and education**
- James Rushing, Associate Professor, vegetable, fruit and medicinal plants postharvest extension/research; food safety issues
- Guido Schnabel, Assistant Professor, fruit research/extension**
- Simon Scott, Professor, fruit crop virology**
- Powell Smith, County Extension Agent, vegetable and fruit production
- Peter Vergano, Professor, packaging science
- Christina Wells, Assistant Professor, root physiology research/teaching
- Bob Williamson, Professor, Agricultural Engineering
- Joey Williamson, Multicounty Extension Agent, fruit production and others

** faculty with primary responsibility in fruit crops

Research Emphasis Areas (selected – not all inclusive):
- Peach rootstock evaluation and development (Reighard et al.)
- Peach bloom delay and flower thinning studies (Reighard et al.)
- IPM peach research (Schnabel, Gorsuch and Reighard)
- Bacterial spot modeling (Schnabel, Miller, Linvill, and Brannen)
- Peach genome project (Abbott, Reighard and others)
- New tree growth form types and management (Reighard)

- New fruit and nut crops for South Carolina (Reighard)
- Peach systems trial (Layne)
- Modeling peach feeder root production for proper timing of fertilizer application (Wells and Layne)
- Root studies related to peach replant problems (Wells and Reighard)
- Peach cultivar and advanced selection evaluation and web site (Layne)
- Oak root rot disease management (Schnabel and Layne)
- Peach scab management and alternative spray programs (Schnabel and Layne)
- Blossom rot and brown rot management and disease resistance monitoring (Schnabel)
- Strawberry crown rot management and inoculum source identification (Schnabel, Layne, Jeffers and Huang)
- Strawberry cultivar evaluation for coastal production (Hassel and Dufault)
- Forcing fall/winter strawberries with row covers for early coastal production (Dufault, Hassell, Shepard, Ward and Phillips)

Extension Outreach:
- EPA Administrators Tour (June 25-26, 2001)
- Peach web site (http://www.clemson.edu/hort/peach/peachhome.htm)
- Southeastern Regional Peach Newsletter (http://resources.caes.uga.edu/publications/newsletters/SRPN)
- Small Fruit News (http://128.192.110.100/SFC_News/SmallFruitNews.htm)

On-Farm Demonstration Trials:
- Peach orchard floor weed management trial (Henderson and Mitchem)
- Methyl bromide alternatives for strawberries (Henderson and Smith)
- IPM for insect/mite control in strawberries (Smith)
- Conventional fertility program vs. programmed release fertilizer (Smith)
- Peach variety and advanced selection testing (Layne)

External Funding Sources:
- USDA/SR – IPM
- USDA/NRI
- USDA/CAR
- South Carolina Peach Council
- Clemson University IPM Program

Service Activities Linked to Clemson University PSA Goals:
- Leadership at Industry educational events focusing on Agrisystems Productivity/Profitability (SC Peach Council)

Downsizing/Elimination of Programs:
- None

Interaction with Centers and Collegiate Institutes:
- Genomics Institute (CUGI)

Resources Needed to Achieve Goals:
- Research – Tree Fruit Entomology (Main campus)
- Teaching - Postharvest Management and Postharvest Physiology (Main campus or through distance education by Rushing).
- Teaching – Fruit Crops (Main campus by Layne, offered annually beginning 2003)
- Graduate student assistantship stipends
- Regional extension agent with small fruit responsibilities

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Vegetables and Niche Market Plants

Merle Shepard, Professor, Entomology, and Director, Coastal REC, Charleston, SC
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The Coastal Research and Education Center (CREC), located in one of the most active vegetable production areas in South Carolina, has served for many years to enhance the industry's growth. The CREC's responsibilities include research to increase production and postharvest technology for the vegetable industry in the state and dissemination of information through extension activities. In cooperation with the Clemson Extension Service, local problem-solving and grower educational programs receive major emphasis. With the population increasing in the U.S. and more rapidly in the "Sunbelt", the South Carolina vegetable industry can capture a greater share of the market by utilizing innovative production and postharvest methodology and effective pest management systems with biological control and alternatives to chemical pesticides as the core. The CREC also provides instruction and practical experience to graduate students in all areas of vegetable sciences and coordinates its programs with those of the U.S. Department of Agriculture Vegetable Laboratory.

The primary mission of the Coastal Research and Education Center (CREC) is to develop efficient and economical systems for vegetable and medicinal plant production in South Carolina. A primary goal is to become a center of excellence for vegetable research. The team that focuses its efforts on accomplishing this goal consists of a horticulturist, a postharvest physiologist, a plant pathologist, two entomologists and an extension horticulturist.

The CREC in its 70-year life span has developed many significant vegetable varieties that today remain standards in commercial production and in breeding programs. Also, the CREC was instrumental in developing production practices and guidelines specific to South Carolina that were nonexistent before.

The first multiple disease resistant cucumber varieties, such as “Ashley” and “Polaris” were developed at the CREC along with pickling cucumbers such as "Chipper", "Galaxy", and "Sumter". At one point, 80% and 50% of the world and U.S. slicer cucumber production, respectively, were varieties that originated from CREC breeding programs. "Marion" tomato is one of the last open-pollinated varieties to be developed before the advent of jointless, hybrid varieties with multiple resistance to four diseases and displaying heat tolerance. Other contributions include "Marketmore" cucumber, "Blondie" and "Burgundy" okra, "Parris Island" lettuce, "Cherokee" wax beans, "Ranger" squash and several downy mildew resistant cabbage breeding lines, such as "Carolina Seven".

Origination of new varieties has been only a part of the CREC's role. Responding quickly to industry needs has become a CREC tradition. Research on cultural practices contributed significantly to improving the efficiency of commercial production. Guidelines for producing fresh market tomatoes using mulch, stakes, and pruning were developed at the CREC and are still in use today throughout the Southeast. Postharvest programs solved problems associated with high decay rates in fresh market tomatoes through water quality management. This approach has been successfully applied to other fruits and vegetables. When food borne illnesses (salmonellosis) were linked to South Carolina tomatoes, a Hazard Analysis Critical Points program was developed and implemented. This has served as a model plan for the fresh fruit and vegetable handlers throughout South Carolina. A management system for the diamondback moth of cole crops has recently been developed, implemented by one of many competent county agents in the state. A method has been worked out at CREC whereby the disease, gummy stem blight, *Didymella bryoniae,* can be detected on the cotyledons of cucurbits. The primers will be licensed to a commercial company to develop an assay for *D. bryoniae*-infected seed. Resistance to the fungicide benomyl by the gummy stem

blight fungus, *D. bryoniae*, was first discovered by scientists at CREC. These techniques are being used in several other states to survey for benomyl-resistance. SC Melcast was implemented at CREC whereby growers can phone in and receive information, based on current weather conditions, on when to apply fungicides. Many of the disease, insect control, herbicide, and fertilizer recommendations for vegetable production in South Carolina were developed by CREC scientists as well as various rotation schemes for alternating vegetable crops with agronomic crops.

Major emphasis from CREC entomologists and the plant pathologist is placed on developing alternatives to commercial chemical pesticides and defining the role of predators and parasitoids as part of IPM in vegetables and medicinal plants. Outreach activities emphasize the development of IPM Ambassadors in middle schools in Charleston County, as well as increased participation in IPM by limited resource farmers.

Summary of Ongoing Projects/Activities by Faculty of CREC

Robert Dufault – Horticulture

- Cultural practices for alternative vegetable crops such as romaine lettuce, broccoli, bell peppers, cauliflower and cantaloupe for South Carolina
- Forcing strawberry production for winter production using row covers
- Forcing asparagus production for winter production using row covers
- Medicinal plant production
- Efficiency of cover crops for removing deeply-leached nitrates

Richard L. Hassell – Extension Specialist (Horticulture)

- Extension Specialist
- Cultivar evaluation to improve commercial recommendations on established crops (such as watermelon and tomato) and alternative crops (such as medicinal plants, leeks, leaf lettuce, strawberries, endive, cantaloupe, and cilantro)
- Melon and medicinal plant seed germination physiology

Anthony P. Keinath – Plant Pathology

- Biology, epidemiology and management of cucurbit and tomato diseases
- Medicinal plant pest management
- Biological control and management of soil borne plant pathogens for sustainable crop production

Gloria S. McCutcheon - Entomology

- Biological control of selected arthropod pests and weeds
- Biological control of insect pests in medicinal plants
- Response of pest and beneficial insects to cover crops in collard
- Impact of red imported fire ant on arthropods in brassica crops
- Role of nectar-producing flowers in sustaining the parasitoid complex in collard
- IPM School Ambassador Project

James W. Rushing – Postharvest Physiology

- Leads effort on medicinal plants
- New effort on low chill fruit
- Food safety, including in-service training for implementing good agricultural practices
- Extension specialist in postharvest management

B. Merle Shepard – Director and Entomology

- Pest control alternatives, including botanical materials and insect microbials
- Integrated pest management (IPM) on cowpea in Ghana
- Impact of red imported fire ant on biodiversity in non-cultivated “edge habitats”
- IPM on medicinal plants

- Biological control of leafminers in the U.S. and Indonesia
- New rice varieties and niche markets for 'Carolina Gold'

Future research and extension activities will continue to provide support for the existing vegetable industry as it shifts from the coastal to inland areas of the state. In addition, other niche market crops will be explored. These will include expanding the effort on medicinal plants, edible soybean, specialty rices and others. Identification of new markets will become a priority.

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Greenhouse/Nursery Ornamentals, Landscape and Turf

Mary Haque, Alumni Distinguished Professor, Horticulture

As a landscape architect with a 100% teaching appointment in the Department of Horticulture at Clemson University, I try to incorporate sustainability issues into all aspects of my work including teaching, research, and service. I teach my landscape design students to design for water conservation, energy efficiency, wildlife habitat, biodiversity, and efficient maintenance to reduce the need for watering, mowing, weeding, pruning, and spraying. Most of my work is interdisciplinary in nature and involves the collaboration of many colleagues, students, institutions, and organizations that have partnered on sustainability projects over the past five years.

Sustainability in Teaching and Advising

Courses Incorporating Sustainability
Problems in Landscape Design--HORT 461/661
Landscape Appreciation--HORT 208
Landscape Design--HORT 308
Honors Research-Agric. H491
Landscape Implementation-- HORT 400
Special Problems in Horticulture--HORT 408
University Success Skills-CU 101

Community Service Projects
I will often offer students extra credit for participating in community service projects and will meet them on project sites with landscape professionals outside of class. Examples include the Demonstration Xeriscape Garden and Foothills Perennial Garden in the SC Botanical Garden, The Hwy. 123 Tree Planting Projects, the Sams/Shanklin Park Project, and the Habitat for Humanity Project.

Field trips
I took a team of students to the "Greenprints 2000 Conference" in Atlanta, GA, February 6-8, 2000, and took another team of students to "ALCA Career Days" (Associated Landscape Contractors of America) to study and compete.

Student-developed web sites and electronic student portfolios
http://virtual.clemson.edu/groups/hort/HORT400/HORT400.htm

http://virtual.clemson.edu/groups/hort/course/HTML_SUS_land_pres/HTML%20Presentation%20folder/sld001.htm

Service
Design or supervise designs for sustainable landscape projects including residential, business, institutional, recreational and urban restoration related projects across the state and internationally.

Lecture on sustainability at meetings sponsored by industry, professional, civic, and higher education groups around the state.

Work with the CU Service Learning Collaborative, the National Wildlife Federation, Habitat for Humanity International, the Sustainable Universities Initiative, and other
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organizations to provide landscape design services for low-income families and for K-12 schoolyard habitats around the state of South Carolina.

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Forestry and Natural Resources

Pat Layton, Professor and Chair, Forest Resources

This presentation is available as a PowerPoint slide show via a link on our web page: http://www.clemson.edu/sustainableag/saconfppt.htm.

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CROSS-CUTTING PROGRAMS

Water Quality and Agriculture

John Hayes, Professor, Agricultural Engineering and Associate Dean for Environmental Conservation

Agriculture and water quality are closely intertwined since the largest contributor to non-point source pollution continues to be sediment, and since chemicals such as those applied in agriculture are often of concern to water quality. In addition, recent news events have thrust water quality issues involving waste management into the forefront because of bacteria concerns. Issues about the rural/urban fringe have become valid and politically hot topics and are expected to continue to be of major concern in the next few years. It is interesting to note that much of the technology being applied to water quality in urban areas actually originated from developments for agriculture. As a consequence, current and anticipated water quality projects will have significant relevance to both areas. This presentation focuses on projects having both agricultural and water quality emphases and provides a brief introduction to what the projects involve and their impacts. They range from projects that are developing conservation systems to improving waste management to evaluating the impacts of agriculture in receiving waters downstream. Many other projects taking place at Clemson either have water quality as a minor role or are not directly related to agriculture. Such projects will not be discussed herein in the interest of brevity.

Projects

Environmental and economical benefits of new crop production technologies to southeastern farmers

This project is focused on continued development of research data sets quantifying the yield enhancement, input requirements, soil quality improvements, and environmental impacts of new cropping practices, precision farming technologies, transgenic varieties, and systems that integrate the three. A split landscape study examines the decreases in erosion, water and chemical runoff, and leaching and increases in grower profitability that can be obtained when growers adopt new production practices and technologies. Traditional practices are used on one side of the split landscape field and innovative practices on the other side. On the innovative side of the field, practices centering on conservation tillage, narrow row widths, broadcast deep tillage, precision nutrient application, transgenic varieties, and environmentally friendly herbicides are used. The innovative set of management practices we are developing for crop production on the Coastal Plain are dramatically reducing the amount of water, sediment, and nutrients that move off site during rainfall events. Besides conserving and protecting natural resources, these practices may also be of value in reducing problems associated with pollutants in runoff water originating from animal waste.

Tobacco and Peanut Cropping Systems

This project seeks to determine the effects of cropping systems on soil, water and environmental quality. These studies have shown that reduced tillage in peanuts does not impact

yield or quality and is more cost effective and environmentally friendly. Therefore, growers are currently adopting reduced tillage technology for peanut production. However, these studies have also shown that reduced tillage has a negative impact on yield and quality when used for tobacco and is currently not recommended for use in tobacco production.

Cover crops for removal of deeply-leached nitrates & implications in IPM systems
The project is surveying nitrate leaching on commercial production operations and fields at Coastal REC; identifying efficient nitrogen-scavenging cover crops that effectively remove deeply leached nitrates and recycle them for vegetable crops grown in rotation; and determining if fertilizer nitrate and pesticides are reaching the water table from normal level of commonly used pesticides in the soil in the shallow subsurface usage and monitor concentrations over the growing season. Vegetable crops utilize far less nitrogen than applied, and a major portion of the nitrogen leaches or runs off. In the most serious situation, nitrates may move into the groundwater and pollute drinking water and/or wetlands. One strategy that will reduce nitrate leaching is to use deep-rooted annual cover crops that siphon soil nitrates from the subsoils to the plow layer and fix nitrogen into vegetation.

Natural biogeochemical filters as BMPs for row crop agriculture
The project utilizes natural biogeochemical filters to develop low cost, low maintenance BMPs to improve water quality in the South Carolina coastal plain. Results of this work will facilitate the development of a tile drain system with built-in denitrification activity. This system will result in fewer nitrates being exported from farms in coastal plains.

Sound hog lagoon effluent applications for loblolly pine, longleaf pine and sweetgum at planting
This project seeks to determine sound application rates of hog lagoon effluent to loblolly, long leaf and sycamore at planting that does not degrade water quality. Soil samples are being taken every October and December to observe the changes in N, P, K, Mg, Mn, Cu, and Zn in the top 24 inches. Groundwater monitoring well samples are being taken every quarter. Results to date indicate that the groundwater is not being impacted by applications of 50 and 100 lb PAN/ac. The results from this project should provide the required information to allow livestock producers to establish new forest stands for pulp production and provide a new use for manure nutrients.

Sustainable & environmental impacts of animal waste utilization in beef cattle systems
The project evaluates the sustainability of systems utilizing animal waste and municipal/industrial nitrogen-based sludge compared to conventional commercial fertilizer-based systems and measures the buildup of nitrogen and phosphorus in the soil, the movement of these elements from the treated areas and the level of concentration in nearby water sources. Techniques have proven effective in increasing both the pH and magnesium levels of soils. This could result in a savings from the application of lime of approximately nine dollars per acre per year.

Electromagnetic terrain conductivity in quantifying the groundwater impact of animal waste
This project will determine if electromagnetic survey (EM) can be used to detect the impact upon local groundwater quality of hog lagoon effluent and turkey litter application to recently planted and established tree stands in three major South Carolina physiographic regions. Deep EM terrain conductivity measurement shows a strong correlation to total soil phosphorus transport to surface water. Deep EM terrain conductivity measurement shows a strong correlation to total averaged ion transport from soils to surface

water. Terrain conductivity appears to be a useful tool to predict potential phosphorus loading to surface streams from enriched fields. EM offers the potential to serve as a rapid and reasonably accurate tool to assess the eutrophication potential of a particular watershed, and further, to assist in locating the source of phosphorus loading to the surface water of an agricultural watershed.

Integrated waste management systems for intensive aquaculture production facilities
The project is developing an integrated waste treatment and water recovery system for application to intensive aquaculture production facilities. The major system components will include a series of subsurface drain lines which will continuously remove ammonia nitrogen from the algal enriched sediment layer and deliver it to a high rate denitrification reactor being developed. The automated sump will remove fish waste to an existing anaerobic digester. The treated water will be returned to the aquaculture unit reducing the requirement for water makeup, and eliminating the need for water or waste discharge to the environment. Aquaculture operations are considered to be concentrated animal feeding operations by the federal government and are currently regulated. The development of the aquaculture industry will require technology to effectively treat the waste produced in the culture system. This technology has the potential for turning water bodies polluted by nutrients into sources of energy while at the same time reducing the levels of nutrients.

Risk characterization and risk mitigation strategies for water quality
The project seeks to model wetlands to evaluate treatment performance for individual materials and mixtures (waste streams); conduct field "potency" experiments using the mobile model stream system to measure the effects of individual materials (pesticides, surfactants, etc.) and mixtures or waste streams (wastewater from swine production facility, etc.); and conduct field testing and demonstrations of constructed wetland treatment performance for individual materials (pesticides, surfactants, etc.). This project has developed model aquatic systems that will be used to characterize potential risks of elements, compounds, mixtures and biota that may enter watersheds as a result of their utilization in production of food, fiber and construction materials. Further, this project has also developed novel systems or reactors that can be utilized to mitigate risks that may impinge on aquatic systems from point and non-point sources of these materials.

Physiological and reproductive effects of cropland production chemicals on aquatic invertebrates
The project evaluates potential effects of cropland production chemicals on sensitive aquatic invertebrates, especially those which may be used for human consumption. This research can help us evaluate the safety of agrochemicals used in aquaculture or near wetlands and estuaries in terms of toxicity to sensitive larval invertebrates, such as shrimp and crayfish.

Watershed modeling to characterize nutrient fate and transport in two SC coastal plain basins
The project is developing and testing a GIS-based water quality model for a sub-basin within two watersheds to include an estimate of yearly nitrogen, phosphorus, and carbon balances and their possible impacts. It will be necessary to characterize it on the basis of land use, soil type, topography, and other pertinent features necessary to evaluate utility of the GIS-based water quality model outside the research watershed. Previous results of this research effort have allowed us to focus on nitrate problems in the Coastal Plain. The implications of this are significant since occurrence of noxious algal blooms in coastal waters are becoming more widespread and nitrogen is being implicated. Our research will facilitate better nitrogen management in the upper reaches of coastal watersheds had lead to significant reductions in

available nitrogen in estuarine and near-coastal waters.

Develop and assess precision farming technology and its economic and environmental impacts

The project is focused on developing precision farming technology. One potential advantage of precision farming is the reduction in chemical applications. This project will provide the opportunity for South Carolina farmers to focus on enhancing crop production while protecting environmental quality. Spatial-based information will enable growers to apply inputs (pesticides, nutrients, irrigation, etc.) only to locations and in the amounts needed in the field. The environmental benefits are obvious in that fewer pesticides are introduced into the soil, ground water, streams and lakes.

Future Plans

Limited resources, particularly ones targeted to agriculture, require that we look for collaborations and external funding in order to continue and expand current efforts. For example, the Changing Land Use and the Environment (CLUE) project seeks to relate land use to downstream environmental impacts so that intelligent selection of Best Management Practices can be accomplished. This has led to a NSF Biocomplexity Planning Project that is bringing together a large multi-disciplinary team to focus on what drives land use decisions and how this process can be improved. Another new project is looking at development and implementation of Total Maximum Daily Loads (TMDLs) from agriculture. These and other projects in the future will involve more collaborations and multi-disciplinary activity. Facilities are generally in place, but lack of sufficient human resources has limited our ability to take advantage of the opportunities. Identification of additional persons with relevant interests and getting them involved is a priority in order to overcome this situation and overcome the problem of limited operating funds.

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Agroecology Program

Jim Frederick, Associate Professor, Crop and Soil Environmental Science, Pee Dee REC, Florence, SC

An endowment was established in the fall of 1997 to support long-term agroecology research pertaining to the economic, environmental, and ecological effects of agricultural practices on the Southeastern Coastal Plain. With these funds, a long-term, split-landscape study was initiated in 1998 to examine the sustainability of both traditional and more innovative cropping systems with respect to site-specific crop productivity, changes in soil quality, and potential environmental impacts. In addition, a number of shorter-term experiments were initiated to develop and evaluate new cropping practices and technologies for use in the split landscape study, to generate publications, and to serve as a basis for obtaining extramural funding. As a result of this research, new cropping systems have been developed for corn, soybean, wheat, and cotton which center on production practices such as conservation tillage, narrow row widths, broad-cast deep tillage, transgenic varieties, and precision nutrient application. Compared to traditional practices, crop yields of corn, cotton, and soybean have been 10 to 20% higher (or more) with these new cropping systems. Wheat yields have been the same or slightly less with the new cropping system, although production practices have recently been found that can potentially improve wheat yield when the new system is used. Data indicate that the new cropping systems have little effect on soil bacteria populations and have the same or fewer pest problems. Deep tillage was found to be very important when narrow rows and/or conservation tillage were used. In fact, for narrow-row culture, a close negative correlation was found between grain yield and the degree of soil compaction for all crops examined.
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Substantially less water, sediment, and agrochemical runoff occurred with the new cropping systems than with the traditional cropping systems. Using the new cropping systems also resulted in improvements in soil quality, but the improvements primarily occurred only in the top inch of soil. Research results to date indicate that the new cropping systems we developed are superior to traditional cropping systems with respect to higher yields, less pesticide use, improved soil quality, and less potential environmental impact. Now that research data sets are available, an economic analysis of the benefits of new technologies and cropping practices is being initiated. As a result of the endowment fund, several unique outreach activities were initiated, including the Agroecology Newsletter, the New Technologies and Cropping Practices education session at the Annual Ag EXPO, the Annual Cropping Systems Field Day, the Agroecology web page, the Agroecology Advisory Panel, and an undergraduate internship program.

Project Description

Many of the economic and environmental problems associated with row crop production on the southeastern Coastal Plain can be attributed to the low organic matter and sandy nature of the region's soils. Soil quality is further diminished by the intensive tillage practices used by a majority of the area's farmers. The rise in tourism centered on the Coastal Plain's water bodies and the continued increase of urban sprawl into rural areas have resulted in the demand for more environmentally sustainable farming practices. Thus, alternative production practices are needed that will improve both crop productivity and environmental conservation.

Conservation tillage (leaving plant residues on the soil surface) has been proposed as a means to improve soil quality, increase crop productivity, reduce wind and soil erosion, and decrease water runoff from agricultural fields. It is felt that the benefits from conservation tillage could be enhanced if other environmentally friendly production practices were integrated into conservation-tillage systems. Practices that could potentially be a part of these systems on the Coastal Plain include bioengineered pest- and herbicide-tolerant varieties, precision-farming practices and technologies, cover crops, narrow row widths, and broad-cast deep tillage. In 1998, scientists from Clemson University and the USDA-ARS initiated a broad-based agroecology program focused on developing integrated cropping systems and determining their impacts on the agroecosystem. Both basic and applied research studies are being conducted to expand our understanding of the interaction of plant, soil, pest, and climatic factors that affect crop productivity and ecological sustainability. Crops being emphasized are corn, wheat, soybean, and cotton. Soil fertility levels; beneficial and pest insect populations; soil compaction; weed and nematode populations; water, nutrient, sediment, and pesticide runoff and leaching; yield and quality; grower profitability; soil organic matter levels; and soil microorganism populations are being examined in relation to these new cropping practices.

Research Projects in Progress:

- Improvements in water quality with innovative cropping practices.
- Tillage systems for soybean grown with narrow row widths.
- Residue and site-specific management for optimum cotton lint yield and quality.
- Site-specific management of no-till soybean.
- Effects of tillage systems on fire ants.
- Timing of deep tillage for no-till winter wheat production.
- No-till system effects on soil nutrient, physical, and microbial properties.
- New weed-control systems for narrow row corn.
- Integrating molecular identification and precision farming

technologies for nematode control in cotton and soybean.
- Variety development for no-till, narrow row soybean.

Structure of Agroecology Program
The overall structure of the Agroecology Program was developed to obtain a balanced integration of research, education, and extension and so that the research and outreach activities would be multi-commodity and multi-disciplinary in nature. A series of short-term research studies (2-5 years) are being conducted to develop information on best management practices and technologies for several crops so that this information could be used in a long-term split landscape study. To provide a focus for the overall project, developing information to be used in the split landscape study was used as one of the criteria to determine whether a given experiment should be a part of the project. Other criteria included group evaluation as to the merit of the proposed research and whether there would be attempts to obtain outside funding through competitive grant programs.

The split landscape study is funded primarily out of the Pee Dee Agroecology Endowment fund. The project was initiated to be long-term in nature (5 to 10 years), with years to be used as replications in the statistical analyses of the data. The focus of this study is to monitor the effects of traditional and innovative cropping systems on soil quality, water quality, site-specific productivity, and pest populations. Practices used with the Innovative cropping system include site-specific phosphorus fertilizer application and pest management, conservation tillage, narrow row spacings, broadcast deep tillage, and the use of genetically modified varieties. The split landscape field also serves as a focal point for outreach activities. Growers prefer to see new concepts tested on a large field basis (relative to small plots), which is more representative of their own production conditions. When problems arise in this study, follow-up studies are to be conducted using replicated field plots. Research results are communicated to both the agricultural community and the general public.

New partnerships and collaborative opportunities have been highly encouraged. The project has had an open door policy since its inception if scientists want to participate in the project. One uniqueness of the project is each scientist can spend as much time on the project as he/she deems appropriate. The project was designed so that it would only be one component of each scientist□s individual program and hopefully compliment their personal research. The only expectation was that each scientist would fulfill his/her commitments in a timely fashion. By bringing scientists from various disciplines, agencies, and locations together, it is hoped that research programming will be enhanced, leading to greater national recognition and more opportunities for grant funding.

Goals 0f Agroecology Project
Research at the Pee Dee Research and Education Center has traditionally been applied and very commodity oriented. An important goal of the Agroecology Program is to develop multi-disciplinary and multi-commodity research and outreach programs oriented towards issues that are regional, national, and global in nature. It was felt such a program would provide balance to the commodity-based programs on-going at the Pee Dee Center. The overall objective of the Agroecology Program is to develop more profitable and environmentally friendly cropping systems centered upon conservation tillage.

Issues that are being addressed in the Agroecology Program include:

I. Farm Profitability - in a global economy, it is necessary that new methods are discovered to increase yields and lower input costs so that our growers can remain sustainable. The scientists= vision

is the greatest advances will occur through the development of new cropping systems (integrated sets of cropping practices).

II. Integrated Pest Management - new practices are needed that will reduce grower reliance on chemical pesticides and give them alternative methods of pest control.

III. Provide Water Quality Protection - information is needed related to the potential impact of current production practices on our water resources and to what extent new technologies and practices can reduce the potential for negative impact on water quality. It is important that new cropping practices and systems be developed that can reduce total daily maximum loads (TDML) of pollutants entering our bodies of water.

IV. Improve Soil Health - determine how production practices can be used to enhance the quality of our Coastal Plain soils. We also desire to obtain a better understanding of how conservation-tillage systems can be optimized to sequester carbon in the air in the form of plant residues to help reduce the rise in air CO_2 concentration and global warming.

V. Integrate new technologies - examine how precision farming technologies can be used to enhance the economic and environmental sustainability of Southeastern cropping systems. Also, identify how cropping systems and practices can be manipulated to maximize the benefits of genetically modified crops.

VI. Work closely with scientists and personnel from other government agencies, private industry, and other academic institutions.

VII. Become more of a part of the ›One Clemson University System‹ - to extend our project beyond the confines of the Pee Dee region and utilize the expertise of scientists from throughout the Clemson system and other universities.

Agroecology Scientists

- Phil Bauer, Cotton Production and Physiology, USDA-ARS
- William Bowerman, Wildlife Toxicologist, Clemson University
- Warren Busscher, Soil Physicist, USDA-ARS
- Bruce Fortnum, Plant Pathologist, Clemson University
- Jim Frederick, Grain Crop Production and Physiology, Clemson University
- Dewitt Gooden, Agronomist, Clemson University
- John Hayes, Agricultural Engineer, Clemson University
- Steve Klaine, Environmental Toxicologist, Clemson University
- Don Manley, Entomologist, Clemson University
- Gloria McCutcheon, Entomologist, Clemson University
- Jason Norsworthy, Weed Scientist, Clemson Unversity
- Jeff Novak, Soil Scientist, USDA-ARS
- Chris Robinson, Agricultural Economist, Clemson University
- Sue Robinson, GIS/GPS Specialist, Clemson University
- Emerson Shipe, Soybean Geneticist, Clemson University
- Horace Skipper, Soil Microbiologist, Clemson University

Summer Internship Program With Francis Marion University

The summer internship program was established to give college students hands-on experience in multidisciplinary research and outreach activities. The program is primarily aimed at undergraduate students in their junior or senior year of study and has been conducted in collaboration with Francis Marion University. The program is based out of Clemson University=s Pee Dee Research and Education Center located near Florence, SC. As part of the program, the interns gain valuable experience in many aspects of agricultural research and assist scientists with research experiments, preparing for field days and scientific meetings, and writing proposals and publications. Students meet with the Agroecology scientists to discuss career opportunities within many agricultural disciplines. The interns work both independently and as part of a broad-based team. If desired, each intern can also work on a research project in an area of his/her interest. Discussions have been held regarding establishing a joint M.S. degree program between Francis Marion and Clemson University in the area of ecological sciences.

Advisory Panel
The Agroecology Advisory Panel meets annually to review and discuss the accomplishments of the program scientists and provide input for future research and outreach projects. The Advisory Panel also aids in the dissemination of information and helps identify where future partnerships can be established.

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Precision Agriculture

Ahmad Khalilian, Professor, Edisto REC, Blackville, SC

Introduction
Crops in the Southeastern United States are generally produced in fields known to have a high degree of variability in soil type, topography, soil moisture and other major factors that affect crop production. Precision agriculture is a promising management tool that can enable the development of an agricultural system to effectively manage fields to account for this variability, to optimize profit, and reduce environmental impact. Precision agriculture refers to a set of technologies and management practices, which encourage intensive management of field crop production for increased profitability and reduced environmental impact. The cornerstones of precision agriculture technology include the Global Positioning System (GPS), Geographic Information Systems (GIS), and variable rate equipment and controllers.

The Precision Agriculture Challenge
Precision agriculture hardware development is relatively more advanced than the knowledge base necessary to successfully implement its use. Technologies, which are applicable today, are often confused with technologies that will become feasible only through the application of further research and development. Planning of agricultural operations will become increasingly mapped based, which will require a new management perspective. An increasingly competitive marketplace will compound the above-mentioned challenges.

Clemson University is actively seeking internal and external partners in order to address the challenges accompanied with the adaptation of precision agriculture. CU is looking at precision agriculture as it applies to field crops, orchard, and the turf industry. Work is being conducted on the Research and Education Centers, producers' fields and manufacturers' research facilities. Many components of this work will provide a solid knowledge base on which precision-farming technology can move forward to provide the expected benefits.

Impact
Precision agriculture will provide the opportunity for South Carolina farmers to focus
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on enhancing crop production while protecting environment quality. Spatial-based information will enable growers to apply inputs (pesticides, nutrients, irrigation, etc.) only to locations and in the amounts needed in the field. The environmental benefits are obvious in that fewer pesticides are introduced into the soil, ground water, streams and lakes.

The potential impact to producers is reduced pesticide and nutrient use and thereby reduced input costs. Producers also benefit by the increasing availability of better, and timely information about their crops for decision-making. They will be able to denote problem areas in a field before problems become visible and before it is too late to take corrective action. The impact to consumers is a cleaner environment and continued supply of good quality food at a reasonable cost. There are no known negative impacts to the environment, to producers, or to consumers. The ultimate outcome of the adoption of precision agriculture will be to enhance the competitive position of South Carolina Agriculture and improve stewardship of the environment.

Goals

Investigate the steps necessary for successful implementation of precision agriculture technologies in South Carolina. This includes discovery and development of new techniques/technologies, developing management strategies for adaptation of existing on- the-shelf-components, and modification of systems to fit South Carolina conditions**,** and transferring the knowledge to Ag related industries**.** These activities are driven by a need for an economically competitive agriculture existing in harmony with the environment.

Scientists

Fifteen scientists from five departments at Clemson University are involved in this project. We are working with six scientists from the university of Arkansas and the University of Missouri on a USDA (IFAFS) funded project - "Site-specific detection and control of crop nematodes". Also, six scientists from Clemson University are members of a regional project (S-138 precision agriculture) involving 14 states.

Research

Site Specific Detection and Control of Nematodes in Cotton

The overall objective of this work is to develop and test concepts and technologies for site-specific detection and control of plant-parasitic nematodes with the aim of optimizing farm profit while minimizing the effect of production practices on the environment. Nematodes cause over $250 million in yield losses to cotton in the United States each year. Farmers usually apply one rate of a nematicide across an entire field to protect their crop from these nematodes. However, nematodes are not uniformly distributed within fields, and there may be substantial acreage in most fields where nematodes are either not present, or are not an economic concern. Applying a nematicide at one rate over the entire field can be both costly and environmentally questionable. Use of soil electrical conductivity to predict soil texture was very successful as was the subsequent use of soil texture to predict the distribution of Columbia lance, spiral, and ring nematodes in a field. The Veris model 3100 Electrical Conductivity Mapping System provided readings from 0.31 to 3.90 mS/M in a ten-acre loamy sand field in Barnwell County, South Carolina. These ratings were able to predict percentage clay in a soil sample with a linear model having a correlation coefficient of 0.915 and predict percentage sand in a field with a correlation coefficient of 0.912. When broken down into four electrical conductivity ranges (0.0 to 1.0, 1.1 to 2.0, 2.1 to 3.0, and 3.1 to 4.0) they showed distinct distribution patterns for Columbia lance, spiral, and ring nematodes. Recovery at planting and at harvest of Columbia lance nematode decreased as soil electrical conductivity increased. An increase of nine percent in clay content of the soil resulted in a 57% reduction in nematode

population density. In South Carolina 64% less aldicarb was required per acre in areas treated with the variable-rate nematicide application compared to uniform application rate without affecting cotton yields where Columbia lance nematodes were present. In Missouri, grid sampling for nematodes indicated that 69% of a test field had a root-knot nematode population density below the damage threshold, therefore no aldicarb was used. Using soil electrical conductivity to predict the distribution of soil textures and nematodes with in a field is achievable in a sandy or loamy sand soil type. This will allow placement of nematicides in portions of the field with soil textures that have the highest probability of containing significant levels of specific nematode species, which are being targeted for control.

Improved Sensor Mounting Technology for Cotton Yield Monitors

The foundation of precision agriculture is based on the ability to continuously monitor yield at harvest. Yield monitoring combined with the ability to establish a geographic reference for these data allows the producer to construct yields maps and track field performance from year to year. Two commercially available cotton yield monitors (Micro-Trak inc. and Agriplan inc.) were tested for three years at research centers and growers' fields. These cotton yield-monitoring systems are similar in design but exhibit some differences. Both systems utilize an infrared sensor method to measure cotton flow. Field trials in 1997 and 1998 showed that the Micro-Trak and Agriplan units would accurately predict cotton weight when they remain clean and free from obstruction. Results also showed that sensors to become dirty and obstructed very quickly under normal field harvesting conditions. As the sensing units became dirty, measurement errors reached up to 107%. Even with cleaning before each load, errors greater than 5% were evident in data. Therefore, a positive air pressure mounting technique was developed by Agricultural and Biological Engineers at Clemson University to completely enclose the existing sensor effectively sealing it from environmental contamination. The AirBox was pressurized by the picker fan, which forced air across the sensor eyes. A John Deere 2-row picker was equipped with the latest versions of the both Agriplan and Micro-Trak sensors using the AirBox mounting technique. The yield monitors were tested in two 10-acre fields at the Edisto REC and a 15-acre field on a grower farm. The yield monitors were cleaned and calibrated prior to data collection. Sensors for both Micro-Trak and Agriplan stayed clean during the test. Measurement errors for Agriplan unit were less than 5% in all three fields. Six yield measurements out of 25 had errors in excess of 5% for the Micro-Track system. The positive air pressure and isolation from dirt, dust, and lint contamination kept the sensing units clean over 25 harvested loads. During 1999, Micro-Trak sensors with Air-Box mounting systems were evaluated on the Bozard Farms in Cameron, South Carolina. Sensing units were installed on two chutes of a Case-IH 5-row picker model # 2055. Eight basket loads of cotton were monitored in a 50-acre field. Average error for the loads was less than 1%. However, error ranged from –12% to 7%. Since the sensing units stayed clean during the test, the variation in yield measurements could be because only two out of five rows of cotton were monitored. In addition, sensor calibration was based on a single basket load. Calibrating the sensors utilizing several basket loads could reduce measurement errors. The Agriplan system was more accurate in detecting cotton yield levels than was the Micro-Track system especially in smaller fields. In 1999, the Agriplan Inc. adopted the positive air pressure technology to keep the sensing units clean and currently the system is commercially available. Yield maps were successfully produced with both yield-monitoring systems using global positioning systems (GPS) and geographic information systems (GIS).

Spatial Accuracy Evaluation of Cotton Yield Monitors

Four sensors of the new AgLeader Technology cotton yield-monitor and four sensors of the Agriplan Inc. were installed on both the front and rear chutes of a John Deere spindle-picker in year 2000. Two pickers were used, one for plot work and one for large scale testing. Tests were conducted to evaluate the performance of these cotton yield monitors under grower's field environments, and to determine the spatial accuracy of the individual yield data. For spatial accuracy test, 160 plots ranging from 35 to 60 ft were utilized. Yield data were recorded in one-second intervals, which included 8 to 14 data points per test plot. Seed cotton yields were measured using sacking attachment and the yield monitors from 2 rows plots. The mean error from first field (64 plots) was 0.85% for AgLeader and 1.7% for Agriplan. Measurement errors ranged from –7.6 to 7.4% for AgLeader and from –16.9 to 18% for Agriplan. 70% of the test runs for AgLeader and 65% for Agriplan had errors less than 5%. In another field (96 plots), 80% of the data for AgLeader had errors less than 5% with mean error of 0.4% ranging from –8 to 9.3%. Errors for Agriplan in the same field ranged from –20 to 34% with only 30% of runs with less than 5% error. The AgLeader system was more accurate in detecting individual yield data points within a small area than was the Agriplan system. In addition, the yield monitors were tested in three 15-acre fields at the Edisto REC and a 15-acre field on a growers' field, near Elko, SC, to evaluate the performance of the yield monitors under large field environment. A Trimble Ag132 GPS receiver was connected to the yield monitors for developing yield maps to determine spatial variability of cotton yield within a given area. The yield monitors were calibrated prior to data collection using four basket loads. The sensors were inspected routinely during the harvest and were cleaned as needed. In growers' field, all measurement errors for both yield-mapping systems were less than 5%. Errors for the AgLeader ranged from –2.9 to 2.8%. Yield maps were successfully produced with both yield monitors using global positioning systems (GPS) and geographic information systems (GIS). The yield maps were similar for this field. Similar results were obtained in other fields. Measurement errors in both fields for the AgLeader unit were less than 5%. For the Agriplan system, 84% of the basket loads had error less than 5%. The measurement errors ranged from 6.8 to 6.9%. The flush mounting techniques for the AgLeader sensors eliminated the need for manual cleaning. The Agriplan yield monitor required sensor cleaning on daily bases. With proper maintenance both sensors can accurately predict seed cotton yields within an acceptable level. The AgLeader system is more users friendly than the Agriplan mapping system.

Controlling Tillage Depth Based on Geo-Referenced Soil Compaction Data to Enhance Crop Yield and Conserve Energy

Soil compaction limits root penetration below the plowing depth, reduces yields, and makes plants more susceptible to drought stress. Soil compaction management in the mid-south and southeastern U.S. relies heavily on the use of annual deep tillage, usually to a uniform depth (14 to 16 in.) at a cost of approximately $12 per acre. This practice improves yields in soils of the coastal plain, which are subject to the formation of tillage pans. There are several drawbacks to this approach to manage soil compaction. Farmers do not usually know if annual subsoiling is required, where it is required in a field, nor the required depth of subsoiling. In addition, there is a great amount of variability in depth and thickness of hardpan layers. Applying uniform-depth tillage over the entire field may be either too shallow or too deep and can be costly.

An instrumented shank was designed and built to measure mechanical impedance of soil at multiple depths over the entire top 18 in. Of soil profile while moving through the soil. GPS-based equipment was developed and tested for

controlling the tillage depth "on-the-go" to match soil physical parameters. An electro-hydraulic actuator and proportional directional control valves were used to move the gage wheels on a four-row subsoiler-bedder upward or downward to control the tillage depth.
Tests were conducted for the two years on a coastal plain soil to compare variable-depth tillage with the constant-depth tillage and no-till system in terms of energy requirements and effects on soil parameters and crop responses. Intensive geo-referenced soil compaction data was collected using a GPS based tractor mounted, hydraulically operated penetrometer system. Maps showing the depth and thickness of the hardpan were produced using GIS system. Yield maps from previous years, soil electrical conductivity map, and soil compaction map was used to divide the test field into four different management zones. In each area, five replications of the following treatments were applied: 1) constant depth tillage (17 inches); 2) variable depth tillage; and 3) no-till. Variable depth tillage was applied according to application maps generated from soil compaction data. The depth of tillage within a single plot was constant and was calculated using the average predicted hardpan depth for that particular plot. Cotton was planted and crop responses in terms of root weight and length at various depths, plant height and population, and yield were determined. Plant tissues (30 leaves/plot) were collected and analyzed for nutrient.

It was possible to determine the optimum tillage depth using a cone penetrometer, electrical conductivity meter or the instrumented shank. Also, it is possible to control the tillage depth "on-the-go" to match soil physical parameters. Variation in the predicted tillage depths to eliminate the hardpan layer ranged from 10 to 17 inches. Based on penetrometer data, approximately 75% of the test area required tillage operations shallower than the recommended tillage depth for coastal plain soils. There was a strong positive correlation between EC readings and seed cotton yield. Also, the predicted tillage depths were inversely correlated to the soil electrical conductivity. Taproot length was significantly shorter in the no-till plots compared to conventional and variable depth plots. There was no statistically difference in taproot length between conventional and variable depth plots. Soil texture was found to override the effects of deep tillage operation. For sections of the field with high clay contents and depth to B-horizon less than 13 in., there were no differences in yield between variable depth tillage, no-till, and conventional tillage operations. In the sandier part of the field with depth to clay layer more than 13 in., there was a significant difference in yield between no-till and the other two tillage treatments. The energy savings of 42.8% and fuel saving of 28.4% were achieved by variable-depth tillage as compared to uniform-depth tillage.

Remote Sensing and Aerial Photography
Most management tools of precision agriculture technology, e.g., grid soil sampling, give more complete field data but the extra costs and labor inputs to implement them often deter farmers from adopting this new technology. The use of aerial photography, which gives a quick assessment of an entire field, is an attractive alternative to detailed ground-level field scouting.

Insect and disease stresses in cotton, especially due to cotton nematodes, are being studied using low-level and high-level aerial photography using color and near-infrared cameras. For low-level aerial photography, a radio-controlled model airplane was designed and fabricated in-house. The model airplane has a hollow camera compartment that can accommodate any one of three available cameras. Electronic shutter release is connected to a radio-controlled relay, which can be activated remotely from the ground. The cameras are also fitted with a Viewfinder Video Tap (Nikon VVT, SkyEye

Corporation, Wellesley, MA), and a video transmitter (Model AAR05 Airborne Video System, Wireless Video Cameras, Rancho Santa Margarita, CA) so that the optical viewfinder image of the camera can be seen from the ground. The model airplane can be used for aerial photography up to 600 feet high. For high-level aerial photography, commercial Cessna 172 and 182 airplanes are available at Oconee and Aiken Airports in South Carolina. A commercially available tilt-and-pan camera attachment (Strut Mount, SkyEye Corporation, Wellesley, MA) is attached to the Cessna wing strut. A two-camera rack was fabricated and connected to the Strut Mount so that both color and infrared pictures can be taken at the same time. Electronic shutter release cable and a video cable from VVT unit is extended from the camera rack to inside the cabin. The tilt-and-pan angle of the cameras can also be adjusted from inside the cabin using a joystick control of the SkyEye Strut Mount unit. The images can be taken from 1,000 feet high to over 3,000 feet high.

With the aid of a GPS unit, ground-level field scouting was used to map sicklepod (*Senna obtusifolia)* infestations in a 1996 soybean field. Areas of significant sicklepod infestations were mapped again at the end of the following corn season (1997) via color infrared aerial photography. The maps were used jointly to determine areas that would require control of sicklepod with glyphosate during the third year's (1998) soybean crop. Strips, 18.3 m wide, which passed through infestation and non-infestation regions, were used for three treatments of broadcast, spot and no herbicide applications. Assessment of sicklepod control was made with aerial color visible spectrum and color infrared photos at crop maturity and was confirmed with ground-level observations. There were no advantages from using color infrared photos instead of color visible spectrum photos. Results from the 1998 data show that aerial photography, when supplemented with minimal ground-level confirmation, is an effective tool for remote field scouting for sicklepod weeds. Spot treatment for sicklepod was shown to be a viable and significant cost saving method of weed control. The estimated herbicide cost to broadcast treat the entire region of the field used for this study would have been $112.70. The cost to spot treat within the field study area would have been $24.50. The resulting savings are $88.20 or 78%.

The turfgrass plants on golf courses are subjected to tremendous growth stress due to the frequent and extremely low-height mowing practice. Application rate of the nutrients, especially nitrogen (N) is kept high to alleviate the plant stress and maintain the quality. The application of the fertilizers is usually done according to a time schedule and/or visual examination of the turfgrass plants based on the experience of the superintendent without knowing the optimum required rate. This application generally results in over-fertilization. Surface and groundwater pollution due to the intense application of chemicals, particularly nitrogen, on golf courses has become an important issue in last two decades. The application rate of nutrients is usually determined by applying either soil sample or plant tissue analysis. However, these techniques require many samples leading to excessive labor, time, and cost. Another disadvantage of these practices is that it may take several days to obtain the lab results. Turfgrass clipping samples of two different species were obtained from a commercial golf course and their reflectance was measured using a dual type spectroradiometer under artificial illumination three hours and 51 hours after mowing. For the creeping bentgrass, the reflectance values in green band (520-580 nm) and the NIR band (770-1050 nm) increased as the nitrogen content increased. For the hybrid Bermudagrass + perennial ryegrass blend, no general trend was observed. Four wavelength bands at 550, 680, 770 and 810 nm were selected to develop and compare several regression models with varying

number of independent variables. All models performed well (R^2>0.87) and predicted the nitrogen content within ±1.0% for creeping bentgrass-clipping samples. A discrimination analysis showed that the regression model with a single wavelength variable performed as well as the models with a greater number of wavelength variables.

Grants For the Last 5 Years
This project has generated over $1,400,000 in grants and unrestricted gifts for the past five years. Included in these are national (USDA), Ag industry, national and state grower organizations, and Clemson University grants.

Teaching and Graduate Students
Precision Agriculture courses AGM 473 (Junior or senior standing) and AGM 771(Graduate level) are offered under Selected Topics in the Department of Agricultural & Biological Engineering. Four graduate students Deepesh Mathur (MS), Serap Gorucu (PhD), Muharrem Keskin (PhD), and Zhisheng Qing (PhD) are currently working on precision-agriculture related projects in the Ag & Bio Engineering Department.

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Agri-Tourism – The Interface of Tourism and Agriculture

Dr. Ken Backman & *Bill Norman*, Director, Recreation, Travel and Tourism Institute

Background
South Carolina's agriculture industry is facing a multitude of problems that are affecting their long-term sustainability. Specifically, suppressed prices due to increased competition from foreign producers, the increasing cost of land due to suburban growth and changes in the food distribution systems have forced farmers and other agricultural businesses to seek out methods to increase the return on their investment. One potential solution is embracing the concept of agricultural tourism or "agri-tourism."

Agri-tourism
According to the University of California, Davis's Small Farm Center, agricultural tourism is the act of visiting a working farm or any agricultural, horticultural or agribusiness operation for the purpose of enjoyment, education, or active involvement in the activities of the farm or operation. Agri-tourism can be defined as the marketing of local agricultural products, lifestyles, culture and landscape to tourists. It represents the interface between sustainable agriculture and sustainable tourism. The result is an improved quality of life in rural America, increased business development, job opportunities for farm and non-farm workers, cultural and historical preservation and greater appreciation of our agricultural traditions and natural resources.

Agri-tourism is bringing new markets (tourists) to producers and agricultural retail establishments, selling agricultural products to tourists who visit an area primarily for other purposes and using and developing agriculturally-related facilities and activities to attract visitors. Components of the agri-tourism system include working farms, landowners (forestry), living history farms, farm markets, roadside stands and markets, u-picks, community festivals, farm vacations, bed and breakfasts, wineries, food processing plants, corn mazes, agricultural historical sites and museums, specialty foods and restaurants and the recreational use of private agricultural lands.

Benefits of Agri-tourism
The benefits of agri-tourism include linking agricultural producers and sellers to a growing segment of travelers who are seeking authentic and educational experiences, developing new markets for agricultural products, providing farmers an expanded market for their products, and the development of new "value-added"
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products which result in increased revenues and employment. The anticipated results of agri-tourism are maximizing the use of agricultural and human resources, increased cash flow during important times of the year, visitors learning how agriculture contributes to society's need for food and fiber, community economic diversification strategy, economic impact to community and survival of the family farm.

Successful Agri-tourism

While there is great potential in agri-tourism, there are issues facing agri-tourism businesses (farm and non-farm). They include customers demanding quality products, services and recreation opportunities that have not been traditionally offered by farmers, a lack of information about the agri-tourists (e.g., barriers to purchase products), lack of research on the economic feasibility of new agri-tourism products, strategies and marketing efforts and being caught in the middle between agriculture and tourism.

To be successful, farm and non-farm business must recognize the importance of providing recreational experiences--not just farm products. They need to provide the traveling public with value-added products for which they are willing to pay more. At the same time, consumers are increasingly relying on brand names in their decision- making and that branding will be important to the success of agri-tourism in South Carolina. They must know their travel segments, are they independent travelers or traveling with a group, and are they an en route stop or a destination area. They also must realize that agri-tourism is a niche market within the big picture of tourism and that to be successful they will need critical mass and that they should not go it alone.

Recommendation

It is our recommendation that successful agri-tourism in South Carolina requires new partnerships. This includes agricultural businesses working together cooperatively marketing their region and products, the development of routes linking farms and roadside stands, and the forming of associations. Agricultural and tourism businesses need to work together to joint market and advertise and develop travel packages. Agricultural businesses also need to join local, regional and state tourism organizations to identify potential funding and tourism marketing dollars. Finally, we think that agricultural and tourism businesses need to work with colleges and universities to conduct research and educational programming.

Clemson University Sustainable Ag-Tourism Project

Clemson University Public Service Activity (PSA) has recently approved the Clemson University Sustainable Ag-Tourism Project. The project will be a collaborative effort coordinated from the Department of Parks, Recreation and Tourism Management. Based on a review of the agricultural tourism research literature and university reports and publications, the objectives of this five year program are: 1) to conduct a comprehensive statewide market research study of ag-tourists in South Carolina, 2) to conduct a study on the factors or barriers that may constrain ag-tourism business, 3) to conduct an economic impact study of selected agri-tourism venues and events and 4) to conduct a series of new product development research studies for South Carolina agricultural products and experiences desired by ag-tourists.

The benefits of a research program that examines the agriculture and tourism relationship in South Carolina include filling the void in detailed marketing information about ag-tourists that currently exists in agri-tourism projects throughout the United States. It provides an estimate of the economic impact of agri-tourism in South Carolina and a template that could be used throughout the state. It can assist farmers, agricultural producers and rural community leaders to a growing segment of travelers who

are seeking authentic culture as an educational component of family vacations. It provides farmers and the agriculture industry with market research data that allow them to expand market for traditional agricultural products. It provides farmers and the agriculture industry with market research data that will allow them to develop new value added products. It can lead to additional income and employment for farmers and agricultural producers and rural communities, making them more economically viable. It can provide opportunities for the traveling public to purchase fresh, locally grown produce and products. Travelers will learn how agriculture contributes to society's needs for food and fiber. It can contribute to the sustainability of rural life (economically and socially) through sustainable agriculture, cultural and historic preservation, and natural resource protection.

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IPM/Sustainable Agriculture Programs
Geoff Zehnder, Professor, Entomology, and Coordinator, IPM and Sustainable Agriculture Programs

This presentation is available as a PowerPoint slide show via a link on our web page: http://www.clemson.edu/sustainableag/saconfppt.htm.

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