ENHANCING COTTON PRODUCTION BY INCORPORATING SOD INTO TRADITIONAL ROW CROPPING SEQUENCES IN VIRGINIA: ANOMALY OR REALITY?

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INTRODUCTION

In southeastern Virginia, production of cotton and Virginia-type peanuts has been important to the economic base throughout the past century. Peanut and cotton complement each other well in rotation because they host relatively few common pests. For this reason many peanut producers throughout the U.S. peanut producing region are also cotton producers.

Following the loss of the quota program (2001), peanut acreage in southeastern Virginia has declined from 75,000 acres (30,300 ha) in 2001 to 15,000 acres (6000 ha) in 2006 (NASS, 2006a). Disease control comprises a large portion of the input costs associated with peanut production in southeastern Virginia due to the high incidence of soilborne disease associated with past short rotation intervals, i.e. one or 2 years between peanut crops. Sclerotinia blight (*Sclerotinia minor)* occurs frequently in the Mid-Atlantic States and is an expensive disease to control.

Cotton acreage in Virginia has ranged from 110,000 acres (44,500 ha) and 90,000 (40,400 ha) acres between 2000 and 2006 (NASS, 2006b). The cotton industry is characterized by volatile prices, uncertain government support programs, and increasing input costs including fuel, machinery and fertilizers. In the past several years, producers have had to utilize government price supports due to low cotton prices. Without government price supports, cotton production with current land and input costs would have produced negative economic results during recent years. These price supports are currently being scrutinized by the World Trade Organization, and many economists believe may be reduced in the 2008 farm bill (personal communication, Roberts 2007).

Development and adoption of a more environmentally and economically sustainable cotton and peanut production system is needed for Southeastern Virginia. Such systems will reduce dependency on government support payments and enable farmers in this region to be more economically competitive. Farming systems with lower economic risks, higher yield potential and more environmentally favorable practices need to be developed and their benefits demonstrated to gain widespread acceptance.

The Natural Resources and Conservation Service (NRCS) and the Farm Service Agency have initiated the Conservation Reserve Program (CRP) which offers incentives to producers adopting systems that offer environmental benefits such as soil stabilization (Farm Service Agency, 2005, Lawrence Personal Communication, 2007) and provide an opportunity for growers to transition to new cropping systems. The integration of perennial grass crops into the peanut/cotton rotation in Florida and Alabama has demonstrated potential to improve soil quality, decrease overall pesticide inputs, reduce nitrate leaching, and reduce financial risks without sacrificing profitability (Katsvairo et al., 2006). The potential benefits and feasibility of integrating perennial grass crop production into row crop systems in southeastern Virginia needs to be examined for enhancing the sustainability of cotton and peanut production.

University and USDA researchers in other states (Florida, South Carolina, Alabama, and Georgia) have similar projects underway and have demonstrated significant yield, economic, and environmental benefits of incorporating perennial grass crops into a traditional peanut/cotton rotation (Wright et al., 2002). Most recent efforts in the southeastern US have utilized bahiagrass as the grass crop in the rotation to be baled and sold, or for cattle grazing. Producers in South American countries such as Brazil, Argentina, and Uruguay have made extensive use of perennial grass based rotations for row crop production for many years. In the absence of a government price support program, 52% of farms in Uruguay utilize such systems (Prechac et al., 2002).

This project was initiated to examine the impact of incorporating perennial grasses into traditional row crop rotations in southeastern Virginia. This presentation reports cotton growth development, yield, and quality when produced following traditional row crops, tall fescue, and orchardgrass. Additionally, it reports the results from producer survey conducted to assess the potential for incorporating perennial grasses into traditional row crop sequences in Virginia.

MATERIALS AND METHODS

The study is being conducted at the Tidewater Agricultural Research and Extension Center. Eight crop rotations (see below) were selected for study and are shown in Table 1. The rotations are arranged in a Randomized Complete Block Design with four replications. Plots are 8-rows (7.38 m, 24 ft) wide by 12.3 m (40 ft) long. Thirty foot alleyways will be established between blocks for maneuvering equipment. The experiment is located on a Nansemond fine loamy sand soil series (Coarse-Loamy, Siliceous, Subactive, Thermic Aquic Hapludults).

Table 1. Eight crop rotations selected for study and the sequence of crops in each rotation for the years 2003-2007.

Rotation	2003	2004	2005	2006	2007
1	Peanut	Cotton	Cotton	Cotton	Cotton
2	Peanut	Cotton	Corn	Cotton	Peanut
3	Peanut	Cotton	Peanut	Cotton	Peanut
4	Peanut	Tall fescue	Tall fescue	Cotton	Peanut
5	Peanut	Orchardgrass	Orchardgrass	Cotton	Peanut
6	Peanut	Tall fescue	Tall fescue	Tall fescue	Peanut
7	Peanut	Orchardgrass	Orchardgrass	Orchardgrass	Peanut
8	Peanut	soybean	Cotton	Cotton	Peanut

*follow all row crops after 2005 with wheat cover after row crop harvest and until spring planting

Grass plots were all established in the early spring of 2004 and row crops were planted according to recommendations. In each row crop planting, extension recommendations were followed with respect to fertility, seed rate, variety, disease, and pest control.

Weeds in row crop plots, including those following perennial grass, are burnt down with a standard herbicide application approximately 1 month prior to planting. Cotton, corn, and soybean are strip-till planted and peanut plots are moldboard plowed in the spring followed by land conditioning. Plots will be kept weed free to eliminate competition effects and non-uniform plant response.

Sod plots were be fertilized three times annually a Gandy broadcast spreader and granular fertilizer (15-5-20) at a rate of 666 1b/acre with applications typically made three times annually. Applications were made prior to seeding and following each harvest if grass was still growing vigorously. If cutting was made in late fall no fertilizer was applied. This particular fertilizer analysis is recommended for top hay and pasture production by Virginia Cooperative Extension. The cotton, peanut, soybean, and corn crops will receive lime and fertilizer applications based on soil tests taken prior to planting in April.

In 2006, cotton will be harvested and subsamples of seedcotton from each plot ginned for lint percentage and high volume instrumentation (HVI) quality determinations. Various measurements of plant growth and maturity including nodes above cracked boll, nodes above white flower, and plant height will be monitored in cotton plots. Nutrient status of cotton plants will be monitored via tissue sampling of leaves and petioles.

At three Virginia Cooperative Extension producer meetings in 2006, surveys were completed by producers in attendance. These surveys requested information on acres planted to peanut and cotton in 2006, accessibility to forage harvesting equipment and markets, and interest in implementing rotations that incorporate perennial grasses if economically viable.

RESULTS AND DISCUSSION

All cotton had emerged by 1 week after planting (18 May). Emergence was non-uniform due to difficulties achieving uniform planting depth as well as a lack of moisture following planting. Therefore, two rows from all plots with similar plant populations were used for in-season measurements, yield, and quality. Adjacent rows were manually reseeded where necessary two weeks after planting to provide uniform competition.

Height (Table 1)

First measurements of plant height occurred on 13 June, 2006 with 10 plants from the harvest rows chosen at random. On this date, cotton plants in rotations fescue-fescue-cotton (f-f-ct) and orchardgrass-orchardgrass-cotton (o-o-ct) were significantly taller than all other treatments except continuous cotton. Continuous cotton (ct-ct-ct) was not significantly different from cotton-corn-cotton (ct-c-ct) or soybean-cotton-cotton (s-ct-ct). Rotations ct-c-ct and s-ct-ct were not significantly different from the cotton-peanut-cotton (ct-p-ct) rotation.

On 28 June, the trend of taller plants in the f-f-ct and o-o-ct rotations continued with plant height being significantly greater than any conventional rotation (ct-ct-ct, ct-p-ct, ct-c-ct, and s-ct-ct) but with no significance between the two perennial grass rotations. There were no significant differences in plant height in any of the conventional rotations.

On the 20 July, the f-f-ct continued to be significantly taller than all other plots except o-o-ct, however the latter was statistically similar to ct-ct-ct. Continuous cotton was not statistically different from any other conventional rotations.

Measurements on 27 July once again showed statistically greater heights in the f-f-ct rotation. Fescue-

fescue-cotton was not statistically different from o-o-ct, and o-o-ct was not statistically greater than either continuous cotton or ct-p-ct. Soybean-cotton-cotton and ct-c-ct were the shortest and statistically the same but not significant from ct-ct-ct or ct-p-ct.

The final measurement of plant height taken the 9 August again showed the greatest height from f-f-ct but not statistically different than that of o-o-ct or ct-p-ct. Orchardgrass-orchardgrass-cotton and ct-p-ct were also statistically the same as continuous cotton. The four conventional rotations were statistically the same.

Nodes and NAWF (Table 2)

Counts of nodes above the cotyledon were begun on the 28 June. On this date the f-f-ct rotation was statistically greater in number of nodes compared to any other rotation averaging around 1 full node more. No other plots were statistically different. The second count of total nodes was conducted one month later on the 27 July. On this date rotations f-f-ct and o-o-ct had the greatest total nodes averaged across ten plants. Continuous cotton was statistically the same as both of the rotations containing perennial grass but also statistically the same as all other conventional rotations. Nodes above white flower (NAWF) were taken in late July and early August to assess possible differences in time to reach physiological cutout. On the 27 July all plots had statistically the same NAWF with means ranging between 6.1 and 6.5 nodes, indicating similar progression to maturity among treatments. On the 9 August NAWF again was statistically the same among treatments with means ranging between 2.8 and 3.4 nodes indicating that plants had reached physiological cutout (NAWF=5) just prior to the sampling date.

Leaf and petiole sampling for nutrient status (Tables 3 & 4 respectively)

On August 9, 2006 20 leaves and petioles were sampled and separated from each plot to be analyzed for nutrient concentrations. Nutrients measured include nitrogen (N), sulfur (S), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na). Among all rotations N, Mg, Ca, and Na concentrations in the leaf and petiole samples were statistically the same.

Leaf S concentration was statistically greatest in rotations ct-p-ct, f-f-ct, and o-o-ct. Continuous cotton was statistically equal to both the latter three rotations as well as the s-ct-ct rotation. Soybean-cotton-cotton was also statistically the same as c-ct-ct which had the lowest leaf concentrations. Petiole samples reflected similar S concentrations as the leaf samples. Continuous cotton, ct-p-ct, f-f-ct, and o-o-ct were statistically the same and had the highest concentrations of S. Cotton-corn-cotton and s-ct-ct were statistically the same with the lowest concentrations.

Phosphorous was found to be the in the highest concentration in leaf samples in the f-f-ct rotation. Orchardgrass-orchardgrass-cotton, ct-ct-ct, and ct-c-ct were statistically the same with slightly lower leaf phosphorous concentrations than f-f-ct rotation. Cotton-peanut-cotton and s-ct-ct were lowest and statistically the same for leaf phosphorous. The latter two rotations were also statistically the same as ct-ct-ct and ct-c-ct. Fescue-cotton-cotton also had the highest mean petiole P concentration and was statistically equal to o-o-ct. Orchardgrass-orchardgrass-cotton was statistically the same as continuous cotton and ct-c-ct which had the next highest petiole P concentrations. The lowest petiole P concentrations were again found in ct-p-ct and s-ct-ct which were statistically equal to each other as well as continuous cotton and ct-c-ct.

Leaf potassium concentrations showed an opposite trend compared to all other nutrients which had shown differences between treatments. The highest concentrations of K were found in continuous cotton, ct-c-ct, ct-p-ct, and s-ct-ct which were all statistically equal. Cotton-peanut-cotton was statistically the same as o-o-ct which had the next highest concentrations of leaf K. Fescue-cotton-cotton had the lowest leaf K concentration and was statistically the same as o-o-ct. Petiole potassium concentrations on the other hand showed no statistical difference between the rotations.

Leaf area index (Table 5)
Measurement of Leaf Area Index (LAI) was collected on the 18th of August, 2006. Measurements were made in two locations of each treatment between the two rows designated for harvesting. Treatments ct-p-ct, f-ct-ct, and o-o-ct were statistically similar. Treatments o-o-ct and ct-p-ct were statistically similar as treatments ct-ct-ct and s-ct-ct. Treatments ct-ct-ct, ct-c-ct, ct-p-ct, and s-ct-ct were also statistically similar. Data from leaf area index is shown in table 4.

Lint yield (Table 6) and fiber properties
Cotton following the two year perennial grass treatments (f-f-ct or o-o-ct) yielded significantly greater lint than any other rotation. The yields of cotton in treatments following two years of either perennial grass were insignificant between the grasses. Yields of the remaining four treatments (ct-ct-ct, ct-c-ct, ct-p-ct, and s-ct-ct) were insignificant between these treatments. Data for yield and % lint can be found in table 5 and figure 2.

There were no differences in the micronaire, fiber length, strength, and uniformity of lint.

Producer Survey
The producer survey represented 31 producers. Sixty five percent of the producers planted cotton in 2006, 90% planted peanut, and 61% planted both peanut and cotton. The percentage of total acres in Virginia represented for cotton and peanut were 10 and 18 percent respectively. The percentage of producers that had livestock was 49 and the percentage of producers that produced hay crops was 39. Of the producers surveyed, 68% indicated they would have an interest in incorporating perennial grasses into their current rotations if it is feasible.

CONCLUSION

Based on the producer survey, there appears to be an interest in incorporating perennial grasses into current crop rotations in Virginia. This may be due to the number of producers (49%) that are currently involved in livestock and/or forage production in addition to producing row crops. The economic feasibility of incorporating fescue and orchardgrass into rotations has not been determined and is certain to vary with each producer. Government incentives for conservation efforts, labor and producer time constraints, access to hay markets on and off producer farms, and availability of hay/pasture equipment are just a few of numerous factors that will influence the feasibility.

As measured by plant height and LAI, cotton growth following perennial grasses was enhanced relative to following other row crops utilized in this study. Earlier canopy closure, as measured by LAI, reduces the sunlight reaching the ground in row middles, reducing the window of time when many weeds will germinate and thus reducing the need for late season herbicide applications and/or plant competition. The economics of cotton production following perennial grasses was enhanced in 2006 due to increased cotton lint yields. This study does not conclude that this yield enhancement will occur every year and the underlying factors supporting it are currently being investigated. Also, the question remains of whether the increase in lint yield in one season will offset possible income reductions while the land is planted to perennial grasses. As previously mentioned, the inherent challenge in determining the economics is accounting for the variability in government programs, commodity prices, land rental vs. ownership, and individual farming enterprises.

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	Plant Height (inches)				
Treatment	**13-Jun-06**	**28-Jun-06**	**20-Jul-06**	**27-Jul-06**	**9-Aug-06**
Ct-Ct-Ct-Ct	**5.9 ab**	**7.8 b**	**19.1 bc**	**22.1 bc**	**25.3 bc**
Ct-C-Ct-P	**5.5 bc**	**7.7 b**	**17.7 c**	**20.3 c**	**21.6 c**
Ct-P-Ct-P	**5.2 c**	**7.6 b**	**18.7 c**	**21.9 bc**	**26 abc**
F-F-Ct-P	**6.3 a**	**9.7 a**	**22.7 a**	**26.7 a**	**30.3 a**
O-O-Ct-P	**6.1 a**	**9.1 a**	**21.3 ab**	**25 ab**	**29.6 ab**
S-Ct-Ct-P	**5.5 bc**	**7.9 b**	**18.6 c**	**20.7 c**	**23.4 c**

Table 1: Cotton heights in inches
Means followed by the same letter do not significantly differ (P=0.05, LSD)

	Avg. Nodes per 10 plants			Nodes Above White Flower	
Treatment	**28-Jun-06**	**27-Jul-06**	**9-Aug-06**	**27-Jul-06**	**9-Aug-06**
Ct-Ct-Ct-Ct	**7.1 b**	**13.7 ab**	**14.2 b**	**6.5 a**	**3.8 a**
Ct-C-Ct-P	**7.2 b**	**13.2 b**	**13.2 c**	**6.1a**	**3.4 a**
Ct-P-Ct-P	**7.3 b**	**13.1 b**	**14.3 ab**	**6.4 a**	**4.0 a**
F-F-Ct-P	**8.1 a**	**14.3 a**	**15.3 a**	**6.4 a**	**4.8 a**
O-O-Ct-P	**7.4 b**	**14 a**	**14.7 ab**	**6.5 a**	**4.1 a**
S-Ct-Ct-P	**7.1 b**	**13.1 b**	**13.8 bc**	**6.1 a**	**3.5 a**

Table 2: Mean nodes per 10 plants and mean NAWF
Means followed by the same letter do not significantly differ (P=0.05, LSD)

	Leaf Tissue Analysis by %						
Treatment	**Nitrogen**	**Sulfur**	**Phosphorous**	**Potassium**	**Magnesium**	**Calcium**	**Sodium**
Ct-Ct-Ct-Ct	**4.395 a**	**0.608 ab**	**0.325 bc**	**2.175 a**	**0.548 a**	**2.638 a**	**0.038 a**
Ct-C-Ct-P	**4.665 a**	**0.378 c**	**0.353 bc**	**2.035 a**	**0.58 a**	**2.718 a**	**0.038 a**
Ct-P-Ct-P	**4.379 a**	**0.73 a**	**0.318 c**	**1.893 ab**	**0.555 a**	**2.68 a**	**0.043 a**
F-F-Ct-P	**4.367 a**	**0.67 a**	**0.44 a**	**1.54 c**	**0.535 a**	**2.333 a**	**0.035 a**
O-O-Ct-P	**4.360 a**	**0.655 a**	**0.378 b**	**1.713 bc**	**0.555 a**	**2.550 a**	**0.035 a**
S-Ct-Ct-P	**4.524 a**	**0.468 bc**	**0.3 c**	**2.035 a**	**0.555 a**	**2.623 a**	**0.035 a**

Table 3. Analysis of leaf tissue for nutrient content. 20 leaves analyzed per plot..
Means followed by the same letter do not significantly differ (P=0.05, LSD)

	Petiole Tissue Analysis by %						
Treatment	**Nitrogen**	**Sulfur**	**Phosphorous**	**Pottasium**	**Magnesium**	**Calcium**	**Sodium**
Ct-Ct-Ct-Ct	**2.053 a**	**0.24 a**	**0.275 bc**	**6.663 a**	**0.705 a**	**1.980 a**	**0.033 a**
Ct-C-Ct-P	**1.928 a**	**0.125 b**	**0.263 bc**	**5.003 a**	**0.725 a**	**1.883 a**	**0.028 a**
Ct-P-Ct-P	**2.057 a**	**0.240 a**	**0.243 c**	**6.045 a**	**0.753 a**	**2.153 a**	**0.028 a**
F-F-Ct-P	**1.853 a**	**0.260 a**	**0.390 a**	**5.985 a**	**0.708 a**	**1.993 a**	**0.030 a**
O-O-Ct-P	**2.108 a**	**0.235 a**	**0.323 ab**	**6.705 a**	**0.725 a**	**2.070 a**	**0.030 a**
S-Ct-Ct-P	**1.809 a**	**0.158 b**	**0.210 c**	**5.875 a**	**0.705 a**	**1.853 a**	**0.030 a**

Table 4: Analysis of petiole tissue for nutrient content. 20 petioles analyzed per plot.
Means followed by the same letter do not significantly differ (P=0.05, LSD)

Leaf Area Index	
Treatment	**LAI**
Ct-Ct-Ct	**1.56 bc**

Ct-C-Ct	**1.20 c**
Ct-P-Ct	**1.84 abc**
F-F-Ct	**2.20 a**
O-O-Ct	**1.97 ab**
S-Ct-C	**1.35 bc**

Table 5: Leaf Area Index measured August 18th, 2006.
Means followed by the same letter do not significantly differ (P=0.05, LSD).

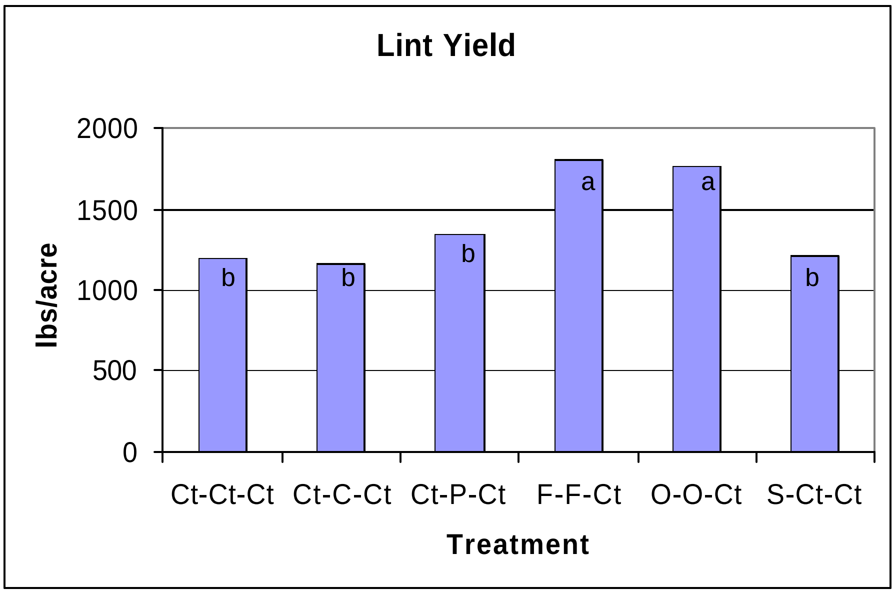

Figure 1: Lint yield of treatments in lbs/acre.
Bars labeled with the same letter do not significantly differ. (P=0.05, LSD)