A Multi-State Project to Sustain Peanut and Cotton Yields by Incorporating Cattle in a Sod Based Rotation

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ABSTRACT

The number of commercial farms in the southeastern United States is decreasing at an alarming rate. Escalating costs of production, reductions in the value of commodities, and stagnant yields have caused many in the farm community to sell out or plant pines on land previously in row crops. Main production limitations in the Southeast are infertile, compacted, droughty soils and pests. The primary objective of this project is to develop an economically and environmentally sustainable sod based- row crop production system appropriate for the biological and social conditions of the southeastern United States. Bahia or bermuda sod can add organic matter to infertile soils for better nutrient and water holding capacity. Bahiagrass also reduces nematode populations, and both bahia and bermuda can reduce other pests. Grass roots grow through the compacted soil layer, allowing subsequent row crop roots to penetrate the compacted layer for access to deeper water and nutrients. When following bahia or bermuda grass, root growth of row crops is often 10 times deeper than in conventional cropping systems. Most growers agree that sod based rotations with bahia or bermuda grass will increase yield of crops by 50-100%. When economic analyses are done on cotton and peanut in a sod based rotation (bahia-bahia-peanut-cotton), profits are about twice as great as in a conventional peanut-cotton-cotton or peanut-cotton rotation. Income is further increased and diversified if cattle are pastured on the Bahiagrass.

KEYWORDS

Integrated pest management, conservation tillage, bahiagrass, southeastern United States

INTRODUCTION

The number of commercial farms in the southeastern United States is decreasing at an alarming rate. There are many reasons for this including droughts and low prices, but the ultimate problem is that there has been little or no incentive for the industry to develop and utilize a farming system that reduces costs and dramatically increases yield even in drought years. Escalating costs of production, reductions in the value of commodities, and stagnant yields have caused many in the farm community to sell out or plant pines on land previously in row crops. The primary objective of this project is to develop an economically and environmentally sustainable sod-based row crop production system appropriate for the biological and social conditions of the southeastern United States This project will deliver a viable production system for small farms in the 100 to 800 acre range, and will obtain higher yields at less cost. These farms include family farms as well as a large number of minority and presently under funded farmers.

Main production limitations in the Southeast are infertile, compacted, droughty soils and pests. There is a low cost way to markedly reduce the impact of each of these limitations, and that is using a sod based rotation of bahia or bermuda grass in the cropping system. Bahia or bermuda grass adds organic matter to infertile soils for better nutrient and water holding capacity, while grass roots grow through the compacted soil layer allowing subsequent row crop roots to move through the compacted layer for access to more water and nutrients. Bahiagrass also reduces nematode populations, even after only one year (Norden, *et al.*, 1977, Rodrígues-Kábana, *et al.*, 1988). Water in the soil profile is conserved and utilized by subsequent crops, since rooting of row crops is often 10 times deeper following bahia or bermuda grass than in conventional cropping systems. Long and Elkins (1983) found that cotton following 3 years of continuous bahiagrass sod rooted more deeply than that planted in continuous cotton, allowing the cotton in the bahiagrass-cotton rotation to extract water and nutrients from lower soil depths. This could result in as little as 1/10th the current water use for irrigation, alleviating

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some of the water problems currently being debated in Tri-state water talks. They reported a reduced amount of N, K, and Ca in the soil solution at the lower depths and an increase in K and Ca in the cotton plants. Especially significant in considering the potential for nitrate leaching, is the fact that they found that NO_3-N in the soil solution 66 inches deep was only 10 ppm in plots following bahiagrass, but 40 ppm in plots under continuous cotton (100 lbs N acre-1 was applied to the crop).

The increases in water and nutrient extraction and deep root growth in crops following bahiagrass sod is attributed to the effect that the deep penetrating roots of the grass have on soil structure, especially soil pore size. Long and Elkins (1983) found a seven fold increase in pore sizes greater than 0.04 Perennial Forage in Rotation with Row Crops in the Southeast inches in the dense soil layer below the plow depth. They concluded that bahiagrass roots had penetrated the dense soil layer and that after the decay of the roots, pores were left that were large enough for the cotton roots to grow through. They also reported an increase in water and nutrient extraction at greater soil depths.

We expect that the need for irrigation will be reduced several ways. First, the bahiagrass will not need as much irrigation as the row crops (10 inches *vs.* 20 inches), and half of the land will be in bahiagrass. Second, the increased water infiltration will reduce the need for irrigation in row crops. Third, the increased root depth and density will make the row crops more efficient at extracting deeper water. Finally, the rotation may increase organic matter, which has many positive impacts on farming systems (Reeves, 1977).

Most growers agree that sod based rotations with bahia or bermuda grass will increase yield of crops by 50-100%. State average yield of peanut in the Southeast is about 2,500 pounds per acre, but yields after bahiagrass are often 3,500-4,500 lbs per acre. When economic analyses are done on cotton and peanut in a sod based rotation, profits are about two times greater as in a conventional peanut-cotton-cotton rotation.

Crop rotation has been a viable means of pest control since agriculture began. Although experience and research data show that the yield of cotton and peanuts can be increased significantly when rotated with other row crops, we also know that sod based rotations can often increase yields even further. When combined with advances in minimum till technology, we feel it is now possible to develop an economic and environmentally sustainable row crop rotation system for farmers in the Southeast while reducing equipment costs, labor, and pesticide use.

Primary considerations for a successful rotation must include the reduction of costs of inputs (both economically and environmentally), the increase or at least maintenance of the soil health, and an increase in the economic output of the acreage farmed, even in the global economy. The cropping systems and farming practices developed must have a high degree of sustainability to be effective. This project will address these needs from several fronts, including adaptation of modern IPM practices, utilization of the most advanced genetics available, precision planting equipment, precision agriculture tools, minimum or no-tillage systems and, most importantly, the introduction of sod based rotations to give dramatic yield increases and improved economics of production.

Although growers and scientists realize the merits of a sod based cropping system, no practical steps have been brought forward to implement it. A business model is currently being delivered to growers and scientists to better define the advantages of the system along with conservation tillage aspects of crop production. This project will verify the model. The concept will be taken to farms for further verification and promotion. We expect this system to add $100-200 per acre profit to the 3 million acres of cotton and peanut being grown in Florida, Alabama and Georgia. This increased profit will result from less inputs and higher yield on smaller acreage of row crops. After considering the multiplier effect, the total impact resulting from this rotation is expected to infuse 3-6 billion more dollars into the rural economy.

The yield benefits of several years of bahia or bermuda grass on cotton and peanut as well as other row crops cannot be matched by increased use of fertilizer or pesticides. Better soil health and water quality are by- products of this sod based rotation system and will be verified in this project. This joint (Florida, Alabama, and Georgia) project will simulate the production environment of integrated systems, monitoring yield, pests, and soil quality factors such as organic matter and carbon sequestering, compaction, water quality, and nutrient movement.

Peanuts and cotton are major cash crops for the southeastern region of the United States. Yields of most row crops have remained level for the past 25 years because of poor rotations and use of inputs such as irrigation and pesticides which help keep yields high even under unfavorable production conditions. Both are dependent in large part upon government support programs that change regularly, with the present Farm Bill expiring in 2002. The future value of the peanut and cotton crops in the Southeast will be affected as the support programs are revised and as a result of direct competition from imports and shifting production areas within the United States, especially with more peanuts in Texas. The domestic price of peanut and cotton may be forced downward to international price levels. The expected shift in the price of peanuts will force surviving farmers to adopt a more economical system of farming. To do that with sustainable practice requires a whole farm systems level approach.

The major objectives of the this project are:

1. Develop and compare the economic and environmental benefits of conventional and sod based farming systems using conservation tillage systems,
2. Quantify the positive impact that sod based rotations have on soil health, pest reduction, and sustainable farm production, and
3. Refine and promote production practices in a sod based rotation which results in significant yield increases associated with decreased inputs.

MATERIALS AND METHODS

Field Plots

The specific objectives will be met through the establishment at five sites (one each in Alabama and Georgia and three in Florida) of a 4 year rotation experiment. At each site a conventional peanut-cotton-cotton (Florida and Georgia) or peanut-cotton (Alabama) rotation will be compared to a bahia-bahia-peanut-cotton rotation. Farm sized plots (40 acres) will be used to best simulate the production environment, especially yield and insect, nematode, disease, and weed interactions. This will also provide an excellent teaching environment for demonstration of the equipment, crops, and production practices. The crop management will be conservation tillage systems utilizing the most advanced strip till equipment, genetics, and farming and animal production practices. Best management practices appropriate for each site will be used during the cropping season, but treatments in each trial will be consistent. Detailed data will be taken on all farming practices as well as crop performance and economic costs. There will be a core data set consisting of abiotic, biotic, and economic factors that will be consistent across all systems.

Two sites will harvest the bahiagrass as hay. At the Quincy, Florida and the Tifton, Georgia site, a 1/4 acre replicated plot field design will be used. The cropping sequences will be conventional peanut-cotton-cotton compared to bahia-bahia-peanut-cotton-winter wheat. Each will be grown under full conservation tillage systems. At Quincy, plots will be split for irrigated and nonirrigated trials. At Tifton, all plots will be irrigated. Bahiagrass and conventional systems were established at these locations in 1999, and 2002 will be the first planting of peanuts after 2 years of rotation.

Three sites will harvest the bahiagrass by grazing cattle. All will be under irrigation. At Headland, Alabama a 50 acre site will be established with 2 replicated plots of the bahia-bahia-peanut-cotton rotation and two plots with a conventional peanut-cotton-peanut-cotton rotation. A stocker operation will be used to graze the sod and winter cover crops of wheat and/or oats that will be used for winter grazing. At Marianna, Florida two (one at the North Florida Research and Education Center and one on a commercial farm) 120 acre sites under center pivot irrigation will be divided into 40 acre plots and planted to the bahia-bahia-peanut-cotton rotation. Both sites will use a cow-calf operation on the second year of bahiagrass.

All pests will be managed with standard IPM practices, genetically resistant varieties where available, and biological and cultural controls. We will use Bt and herbicide resistant varieties whenever possible.

Plant Data

Data collection will be consistent at each site. Microclimate data, management practices and costs, crop data, and pest data (including control strategies) will be recorded for each system. Nematodes will be monitored with preplanting and post harvest soil samples for each crop. Insects in cotton will be monitored weekly until the pinhead square stage and then twice weekly, examining 10 plants per plot. On peanuts, the foliage feeding insects will be sampled weekly with a beat-cloth technique. Root-peg-pod feeding insects will be monitored by digging 5 plants and examining the pegs, pods, and roots. Wheat will be scouted weekly for aphids and disease.

Disease assessment and pathogen population monitoring will be done on a regular basis in each of the crops. In cotton, boll rot and hard lock will be quantified in each system as it is anticipated that the taller plants in the sod based system may lead to a denser canopy, resulting in higher humidity and possibly increased boll rot. Seedling stands will also be examined for damping off diseases by determining the incidence of damping off and the pathogen responsible. In peanuts, plants will be examined weekly for early and late leaf spot, Tomato Spotted Wilt (TSW), Sclerotinia, and Cylindrocladium Black Rot (CBR) by examining 10 consecutive plants at 4 different sites in each plot. Yield of cotton and peanuts will be collected and analyzed for quantity and quality. Specific harvest dates will depend upon the growing conditions, but harvest will be done at the optimum time. Bahiagrass hay will also be harvested and quantified.

Market prices at harvest will be used to determine economic returns. Extension Enterprise Budgets will be modified to account for limitations associated with the experimental design (i.e. plots smaller than production fields) so that the economic data can be extrapolated to real farm conditions.

Dry matter samples of total biomass for each crop, including bahiagrass cuttings, will be collected and analyzed for C and N in order to calculate inputs of C and N to the soil.

Soil Data

A consistent core set of data to determine the impact of cropping and tillage systems will be collected at all sites. Baseline soil quality data (physical and chemical) will be collected before starting the experiment in 2002 and at the end of the experiment in 2004/2005. Data collected will include wet aggregate stability determinations (0-2 inch depth), water infiltration, total soil carbon and total N at depths of 0-2, 2-6, and 6-12 inches. Particulate and mineral-associated C, which represents the transient and resistant soil C pools, respectively, will be determined following the techniques of Camberdella and Elliott (1992). Soil microbial biomass will be determined at the same time as C and N by the fumigation method (Jensen *et al*., 1996). Soil pH will be determined using a 1:1 soil/water ratio. For non-sod crops, bulk density measurements to a 4-inch depth immediately after planting will be taken within the row using the core method (Blake and Hartge, 1986).

Animal Data

Animal data will include the costs and returns associated with the animal production aspect of the study. Weight gain, herd health, and costs associated with the animals will be analyzed. Weight gain and reproduction efficiency will be recorded for each herd.

RESULTS AND DISCUSSION

The economics of rotation to a non cash crop are confounding. Although income is lost because of the reduction in area of the most economically important crop, expenses are reduced if the rotation crop requires fewer inputs and also results in the need for fewer inputs for the cash crops. For example, in our proposed rotation system, we assume that in a 200 acre farm in the bahiagrass rotation, there would be 100 acres of bahiagrass (50 acres one year old and 50 acres 2 years old), 50 acres of cotton, and 50 acres of peanuts. We expect the increase in yield in the peanuts and cotton to be 50% following the bahiagrass, and that the bahiagrass sod would produce about 5 tons per acre of hay the second year to be sold for $2.50 per 50 lb square bale. We also assume that the farm has 40 tons of quota peanut that would sell for $618 per ton and the additional at $300 per ton. The cost of establishing, maintaining and harvesting the bahiagrass is estimated at $210 per acre and the cost of producing the peanuts and cotton is estimated at $370 per acre. These are estimates based on average year expenses and returns. When returns and expenses are totaled, the farm practicing the bahiagrass rotation realizes an average profit of $35,500/year whereas the farm with no bahiagrass realizes less than $15,700 profit per year (Table 1). A 200 acre farm grazing cattle on the bahiagrass can realize a profit of nearly $45,000. The major factors in increased profit are a reduction in production costs of the crops (nearly $7,000) and the sale of the bahiagrass as hay or the cattle operation.

Obviously a critical aspect of this system is the increase in yield as a result of the bahiagrass; however, the grower community has experienced such increases in yields for years. They will pay a premium to rent land in bahiagrass, and regularly the top state peanut producer from Alabama, Georgia, or Florida reports they followed bahiagrass. This study will document the growers' experiences and determine the mechanisms responsible for the increase. At present, growers search to rent land in bahiagrass rather than integrating it into their own farm.

Another critical aspect of the economics of the project is the potential income generated from the bahiagrass sod. In the present economics model, the sod is harvested for hay as either 1,000 lb roles or 50 lb square bales, and marketed as such. Presently, the large roles sell for about $25, whereas the square bales sell for $2.50. Thus, the economics obviously favors the square bales; however, more work is required and a market for the bales must be available. In this study we will also develop information on the feasibility, including labor demands and economics, of putting cattle on the 2 year old bahiagrass and possibly in the late summer and fall on the 1 year bahiagrass. We have had a lot of interest in this information, as many of the small row crop farmers in the southeastern United States also have small herds (less than 100 head) of cattle. The Florida site will conduct the study as a cow-calf operation, whereas the Alabama site will begin with a stocker operation. We expect that the addition of the cattle may affect the nutrient status of the soil, but that the larger benefits of the sod rotation will not be affected. Other sites at Florida and Georgia will not have cattle and the sod will be harvested as hay.

The major changes in pesticide use, other than the reduction in area of both peanuts and cotton, is the need to kill the bahiagrass in the fall of its second year (we will use glyphosate at 1 qt per acre) and a reduction in peanut leafspot sprays from 6 to 3. We also anticipate a reduction in the need for nematicides, but expect about 50% of the farms will still use aldicarb or thimet to control thrips on cotton. However, those that use a peanut variety resistant to tomato spotted wilt virus (which is vectored by thrips and the reason they must be controlled) will not need aldicarb, as the bahiagrass will eliminate the need to control the nematodes.

The cost for pesticides for growing conventional peanuts and cotton are calculated to be $141 per acre and $37 per acre, respectively. In the conventional farming system with 200 acres in a 3 year rotation, any given year will have 66 acres in peanuts and 134 acres in cotton for a total farm cost of $14,256.

In the bahiagrass rotation, the cost for pesticides for bahiagrass is $7.50 per acre or $375 on the 50 acres to kill it with glyphosate in the fall before peanuts. No other pesticides will be needed for bahiagrass. For the peanuts in rotation, the pesticide cost is reduced to $95 per acre because of the reduction in leafspot sprays and aldicarb application. In the cotton the cost per acre remains the same, $37 per acre. In the bahiagrass rotation, the annual cost for pesticides in the 50 acres of peanuts will be $4,756 and in the cotton, $1,325. In sum, the total cost for pesticides in the grass rotation will be $6,600, as compared to $14,250 in the conventional farming system, a reduction in costs of over $7,500.

Crop rotation has been a viable means of pest control since agriculture began. When combined with advances in IPM and minimum till technology, we feel it is now possible to develop an economic and environmentally sustainable row crop rotation system for farmers in the Southeast while reducing pesticide use, equipment costs, and labor. The systems approach used in this project will help assure that the delivered information will be appropriate for rapid implementation and adoption by the grower community.

This project directly addresses the plight of small row crop farmers in the Southeast. By integrating sod based rotations on small farms, it will be possible to stop the economic and environmental decline ruining many individual farmers and small rural communities. The proposed farming system will increase farm profitability, increase soil health, decrease the need for some inputs (including water and pesticides) and diversify the economic base of the small farm. This is a multi-state (Alabama, Georgia, Florida), multi-institutional (Auburn University, University of Georgia, University of Florida, and the United States Department of Agriculture), and multi-disciplinary (agronomy, entomology, soil science, weed science, plant pathology, nematology, animal science, economics) project that effectively integrates agricultural research, extension and education. The major impact will be directed to the small and mid-sized farms in the southeastern United States, but the principals and practices developed will be largely scale neutral and will apply to row crop production world wide, especially in areas where soil conservation is critical and farm resources are low. The delivery of an effective row crop production system that is economically and ecologically viable and competitive with world market prices will have a tremendously positive impact on the many rural farm-based communities in the Southeast.

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Table 1. Income and expenses associated with a bahiagrass sod rotation and traditional peanut- cotton rotation. This model and the assumptions within it can found at http://nfrec.ifas.ufl.edu/Marois/Index.html.

Crop	Yield	Acres	Costs	Revenue	Profit
Conventional rotation (peanut-cotton-cotton)					
Cotton	650 lbs	134	49574	59228	9654
Peanut	2500 lbs	66	30995	37030	6035
	Total	200	80569	96258	15689
Bahiagrass rotation (bahia-bahia-peanut-cotton)					
Cotton	975 lbs	50	20204	33150	12946
Peanut	3750 lbs	50	24826	40405	15579
Bahia 1-yr	2 tons	50	10572	10000	-572
Bahia 2-yr	5 tons	50	17401	25000	7599
	Total	200	73003	108555	35552
Bahiagrass rotation with cattle					
Cotton	975 lbs	50	20204	33150	12946
Peanut	3750 lbs	50	24826	40405	15579
Bahia 1-yr	2 tons	50	10572	10000	-572
Cattle	68 calves	50	27794	44681	16887
	Total	200	83397	128236	44840

Table 2. Pesticide use and costs in conventional and bahiagrass rotations. This model assumes a 200-acre farm with conventional rotation of cotton-cotton-peanuts and the bahiagrass rotation phase of a bahiagrass-bahiagrass-peanuts-cotton rotation.

	Conventional Peanuts Size = 66 acres			Bahiagrass Rotation Peanuts Size = 50 acres		
Product	Rate/ acre	Cost/ acre	Total cost	Rate/ acre	Cost/ acre	Total cost
Glyphosate	1 pt	3.75	248	2 pt	7.50	375
2-4-D	1 pt	1.50	99	0 pt	0.00	0
Dinitroanaline	2 pt	5.00	330	1 qt	5.00	250
Paraquat	10 oz	2.25	149	10 oz	2.25	113
Bentazon	13 oz	6.00	396	13 oz	6.00	300
2-4-D Butryl	1 pt	4.38	289	1 pt	4.38	219
Chlorimuron	0.5 oz	2.50	165	0.5 oz	2.50	125
Chlorothalonil	4 x 1.5 pt	30.00	1980	2 x 1.5 pt	30.00	1500
Azoxystrobin	2 x 3 pt	75.00	4950	3 pt	37.50	1875
Aldicarb	3.5 lb	10.50	693	0 lb	0.00	0
	Total	141	9298	Total	95	4756
	Conventional Peanuts Size = 134 acres			Bahiagrass Rotation Peanuts Size = 50 acres		
Glyphosate	4 pt	15.00	2010	4 pt	15.00	750
2-4-D	1 pt	1.50	201	1 pt	1.50	75
Aldicarb	3.5 lb	10.50	1407	3.5 lb	10.50	525
Orthene	2 pt	10.00	1340	2 pt	10.00	500
	Total	37.00	4958	Total	37.00	1850

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