ECONOMICS OF SOD-BASED ROTATION

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Abstract

Development of farming systems that reduce input costs and increase yield is critical for the survival of row crop farmers in the southeastern United States. The potential economics of a 4-year rotation utilizing two years of Bahiagrass followed by 2 years of cotton or 2 years of Bahiagrass followed by peanuts and then cotton were examined. Costs and yield data were obtained from interviews with farmers, extension specialists, and researchers. Assuming an increase of 50% yield (from 650 lbs of seed cotton per acre to 975 lbs per acre), we would expect profits on a 200 acre farm to increase from about $7,000 per year in a continuous cotton program to over $22,000 per year in the sod-based rotation if the sod is not utilized, and over $33,000 per year if the grass is harvested and sold in square bales.

Introduction

The number of farms in the Southeast continues to decline. For example, in Jackson County, Florida, the number of farms has gone from more than 4000 farms in the mid 1980s to less than 800 today. Although some of this reduction is due to consolidation into larger farming operations, there is also a significant decline in row crop acreage as land is converted to other uses, especially to silviculture. For farms to survive in the Southeast, a viable cropping system must be developed that incorporates economically and biologically sustainable practices that are now feasible utilizing modern technology and information. To accomplish this, yields must improve dramatically while reducing or maintaining the costs of production, allowing small farms to successfully compete in the depressed national and international markets.

The overall goal of this project is to develop an economically and environmentally sustainable sod-based row crop production system appropriate for the biological and social conditions found in the southeastern United States. This project will deliver a viable production system for small farms in the 100 to 400 acre range. The first objective, reported here, is to develop a preliminary farm management model to determine what aspects of the rotation are biologically and economically feasible. Other objectives include a) quantification of the impact that sod-based rotations have on soil health, pest reduction, and sustainable farm production and b) development of production practices in a sod-based rotation which results in significant yield increases associated with decreased inputs through integrated pest management and conservation tillage practices.

Discussion

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.

The use of sod-based rotations is a critical facet of this research and affects the farming system in several areas. Perhaps the most important aspect is that of improving yield while improving soil health (Reeves, 1997). Much of the farmland in the Southeast suffers from a hardpan starting at 6 to 8 inch depth and continuing to 12 to 14 inches (Kashirad, et. al., 1967; Campbell, et. al., 1974). This has a dramatic effect on crop management. Even with irrigation, it is very difficult to effectively manage water stress because the hard pan prevents deep penetration of plant roots. Under these conditions, water has to be applied frequently, increasing labor and equipment costs and decreasing water use efficiency. Elkins, et. al., (1977) calculated that given an evapotranspiration rate of 0.17 inches of water per day, with available water of 1 inch per foot of soil, and plant rooting depth of 6 inches, plants will experience water stress after only 3 days without rainfall. However, if the rooting depth is 5 ft deep, the plant would not experience water stress until 30 days after rainfall (Table 1). This table may actually underestimate the value of the deeper rooting systems because many soils in the Southeast have increased water holding capacities at deeper depths.

Using weather data from Ward, et. al., (1959), Elkins, et. al., (1977) determined that for the average Coastal Plain Soil - (for the most part a coarse-textured sandy soil with low water holding capacity), a crop with a rooting depth of 12 inches will experience 60 drought days during May through August in 5 out of 10 years. However, if rooting depth were 60 inches, the crop would experience only 11 drought days from May through August.

Water extraction is not the only factor dramatically affected by root depth. Nutrient extraction is also greatly enhanced when rooting depths are increased. This not only increases the use efficiency of fertilizers applied, but also decreases the potential for contamination of groundwater with nitrates and other farm chemicals. Long, et. al., (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 Bahia-cotton rotation to extract water and nutrients from lower soil depths. This resulted in 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. They reported a 25% increase in yield of seed cotton (1500 lb/acre vs 1900 lb/acre) in the cotton plots that followed 3 years of Bahiagrass. There was a continued trend toward higher yields after 5 years of Bahiagrass sod, but this was not statistically significant. They also found that the cotton following Bahiagrass sod had a 40 fold increase in the number of roots at the 24 inch depth. Elkins, et. al., (1977), reported an increase from an average of 1 bale of cotton per acre in continuous cotton to 2 bales/acre in cotton following Bahiagrass.

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. Again, Long, et. al., (1983) found a seven fold increase in pore sizes greater than 0.25 nches in the dense soil layer below the plow depth. They concluded that the dense soil layer had been penetrated by the Bahiagrass roots 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. Especially significant, in considering the potential for nitrate leaching, is the fact that they found that NO_3-N in the soil solution at 65 inches depth was only 10 ppm in plots following Bahiagrass, but 40 ppm in plots under continuous cotton (100 lb of N/acre was applied to the crop).

There is extensive literature on the potential benefits of Bahiagrass sod for controlling nematodes. Norden, et. al., (1977), reported that the greatest change in reducing nematodes was realized after only one year of Bahiagrass sod, and although peanut yields and quality increased with increasing years in sod (up to 7 years), the greatest increase in yield was after only one year. Dickson and Hewlett (1989) reported in Florida that population levels of the nematode *Meloidogyne arenaria* were reduced during the early part of the growing season, but returned to high levels in peanuts following one year of Bahiagrass. Still, they reported a yield increase of 2.3 fold in peanuts following Bahiagrass (1,500 lb/acre vs 650

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lb/acre) with no nematicides applied, and a 3.4 fold increase (2,210 lb/acre) in yield in peanuts following Bahiagrass and also treated with 1,3-dichloropropene. Rodrigues-Kabana, et. al., (1988), reported that *M. arenaria* populations remained low during the entire growing season in Alabama, reducing populations by 41% in peanuts following only one year of Bahiagrass as compared to plots in continuous peanuts. They also reported an increase in peanut yield of 27% in plots following one year of Bahiagrass.

From the above, it is obvious that the use of Bahiagrass in rotation with row crops has numerous advantages for increasing yield. However, the Bahiagrass pasture also may benefit from rotation. There is evidence that permanent grass pastures are not as productive as pastures plowed and seeded periodically. For example, by rotation with row crops, there is the opportunity to control weeds that may have invaded the pasture and replant new or different varieties of grass.

The economics of rotation to a non cash crop are confounding. Although income is lost because of the reduction in acreage of the crop with the highest return, expenses are reduced if the rotation crop requires fewer inputs. 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), and 100 acres of cotton, or 50 acres of peanuts and 50 acres of cotton (Table 2). We expect the increase in yield in the cotton and peanuts to be 50% following Bahiagrass, and that the Bahiagrass sod would produce about 2 tons of hay/acre the first year and 5 tons of hay/acre the second year to be sold for $2.50 a 50 lb square bale. We also assume that the farm has 40 tons of quota peanut that would sell for $600/ton and the additionals at $330. The cost of establishing, maintaining and harvesting the Bahiagrass is estimated at $180/acre, and the cost of producing the peanuts and cotton is estimated at $400/acre. These are approximations based on average expenses and returns, the actual model provides much more detail. When returns and expenses are totaled (including $30/acre land rent), the farm practicing the Bahiagrass/cotton/cotton rotation realizes an average profit of $33,000/year, whereas the farm with continuous cotton realizes a profit of $7,200 per year (Table 2). The major factors in increased profit are a reduction in production costs of over $13,000 and sale of the Bahiagrass hay. If the hay is not utilized, the annual profit is still increased to $22,000.

Crop rotation has been a viable means of pest control since agriculture began. With the new genetically engineered crop varieties resistant to herbicides, it is now possible to include minimum till practices with effective crop rotations. When combined with recent advances in cotton and peanut production, we feel it is now possible to develop an economically and environmentally sustainable row crop rotation system for farmers in the Southeast while reducing equipment costs, labor, and pesticide use.

Summary

What we have come up with thus far is a sod-based rotation of two years of Bahiagrass and then two years of cotton or two years in a cotton/peanut rotation before going back into Bahiagrass. The grass can be harvested or used directly as pasture.

The grass also has considerable impact on the soil. Two-thirds of the grass biomass is below ground. This tremendous below-ground growth will effectively break up the hardpan, allowing more efficient use of fertilizers and water. These factors will have a significant effect on reducing plant stress, especially during drought conditions.

By decreasing soil compaction problems, the sod-based rotation will affect fertilizer use by decreasing fertilizer runoff and increasing uptake efficiency by the larger root system. Water use will also be more efficient as the roots and the water are able to penetrate deeper into the soil.

Bahiagrass also reduces nematode populations significantly, reducing the need of nematicides in the cotton crop. Furthermore, insect pressure will be affected as the nonhost crops will limit pest buildup. Weed populations will also be affected, both qualitatively and quantitatively, as weed species are forced to shift from a sod competition to a row crop competition. Finally, pathogens will be reduced, especially soil borne pathogens. All of this means there will be an increase in yield even as there is a decrease in inputs, resulting in what may be a viable row-crop production system for the southeastern United States.

The Microsoft® Excel 2000 spreadsheet model used for the above calculations is available for downloading at NFREC.IFAS.UFL.EDU/MAROIS. Understand that this is a work in progress, but it is designed so that information can be easily entered by the user.

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Table 1. Days without plant water stress following rainfall for different rooting depths. (Available water = 1 inch per 12 inches of soil, evapotranspiration of 0.2 inches per day).

Rooting depth (inches)	Days without water stress following rainfall
6	3.0
9	4.5
12	6.0
24	12.0
36	18.0
48	24.0
60	30.0

(From Elkins, et al, 1977)

Table 2. Costs and returns of three different cropping systems.

Crop	Acres	Yield	Cost	Revenue	Profit
Continuous Cotton Planting [a]					
cotton	200	650 lb/acre	$81,200	$ 88,400	$ 7,200
Bahiagrass/Cotton Rotation					
Bahia (1st year)	50	2 ton/acre	$ 9,000	$ 10,000	$ 1,000
Bahia (2nd year)	50	5 ton/acre	$15,000	$ 25,000	$10,000
cotton	100	975 lb/acre	$44,000	$ 66,000	$22,000
			$68,000	$101,000	$33,000
Bahiagrass/Peanut/Cotton Rotation					
Bahiagrass[b] (1st year)	50	2 ton/acre	$ 9,000	$ 10,000	$ 1,000
Bahiagrass (2nd year)	50	5 ton/acre	$15,000	$ 25,000	$10,000
peanut	50	3,750 lb/acre	$26,000	$ 40,000	$14,000
cotton	50	975 lb/acre	$22,000	$ 33,000	$11,000
			$72,000	$108,000	$36,000

[a] It is assumed that both farming systems have 40 tons of quota sold at $600/ton and the additionals are sold at market price of $330/ton.

[b] Hay production is lower during establishment year, as well as fertilizer and production costs.