Perennial Forage in Rotation with Row Crops in the Southeast

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ABSTRACT

The Southeast U. S. farming community has been a region in transition for the last 15 years and has seen a continuous cycle of crops with the highest potential return. Low crop prices, yields, and uncertain weather led growers to change from a wheat/ soybean and corn system to cotton to rotate with peanuts. This required the development of an entire infrastructure system to support cotton along with specialized harvesting equipment. During this transition period, many growers went out of business or much of the farm land was planted to trees for long term investments as jobs were secured off farm. The challenges to agriculture today is to cut production costs while increasing yield to bring profit back to the farm since crop prices for most commodities have fallen by 25% or more during the last 15 years. Good management is required to produce better yields. Research during the last half of the 20th century shows the value of rotating cash crops with sod. By starting out farming with a high proportion of the farm in sod, less initial capitalization is required for small tractors and tillage equipment and yield of crops grown behind sod is often 50% or higher than continuously grown row crops. Research from Auburn, Florida and Georgia has shown the impacts of bahiagrass on pests, water infiltration, rooting depth, and subsequent yield of crops grown after bahiagrass. The main objection from growers is that it can't work in their farming operations. A recently developed business model by the University of Florida shows that it is easily adapted to southern farms with or without livestock and becomes more profitable each year with total profits being 3 or 4 times higher after the system is fully implemented in the 4th year.

KEYWORDS

Sod, perennial pasture, conservation tillage, rotation, soil health.

HISTORY

The Southeast is one of the most diverse crop production areas in the U.S. All of the major crops as well as pasture grasses can be grown, with lower average yields for corn and soybean than in the Midwest while wheat yields are near the national average. Cotton and peanut are traditional row crops for the area and competition comes from other Southern areas or over seas. The fertile soils of the mid west were in native grasses that built up organic matter and improved soil structure for many years prior to plowing and cropping corn and soybean. The Southeast, by contrast, had native forest and small areas that had been cleared by Indians where some grass encroached. As these small patches of bluestem and switch grass were not large enough for many animals, they were soon overgrazed and replaced with broomsedge and other less desirable grasses. Other parts of the U.S. developed livestock production from grasses and legumes introduced from Europe to supply needs of cities in the Northeast and for export. Agriculture in the South was primarily cotton and tobacco with limited livestock production to supply local needs. Soils of the Southeast are generally infertile as compared to much of the U.S. and continuous row cropping further degraded these soils. Improved pastures and beef and dairy production did not begin in the South until the 1930's and 40's, when Dr. Glen Burton and others began breeding and releasing new grass varieties.

The Southeast typically has an average annual rainfall of 48-65 inches per year. Most row crops require about 25 inches of rain or irrigation to produce high yields. However, crops yields are limited each year by periods of insufficient rain for optimum crop growth and yield. It has been reported that Florida has more available groundwater than any other state in the nation, yet crop yields are reduced substantially almost every year from lack of moisture. During the last three years of drought, many counties in high population areas instituted water rationing to prevent the water table from dropping lower and contaminating fresh water with salt water intrusion. Can anything be done to overcome the effects of droughts on crops except to irrigate? It is known that rotation with perennial sod crops will increase organic matter content, water infiltration, improve soil structure, and decrease erosion to a much

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higher level than any of the winter annual cover crops which have been shown to be better than summer annuals. Winter annual cover crops do very little to enhance soil quality because of their short duration and fast degradation. Much of the research data in the 20th century looked at these cover crops as green manure crops that were turned under for nitrogen benefit or nematode suppression. Recent advances with herbicide tolerant crops have allowed crops to be planted directly into the standing cover crops. These winter cover crops seem to be better erosion control inhibitors than for increasing soil health. Perennial grasses in all regions of the U.S. and in other countries have been shown to have a major impact on yield (Rogers and Giddens, 1957). This has also been the testimony from growers in the South who plant after bahiagrass and pay a premium for land coming out of perennial grass sods. Do sod crops make enough difference on following crops to over come drought effects and make this systems approach profitable? There is little current research in literature to show the benefits of a sod based rotation, but available data show that individual crops yields can be increased 50-100%. Many peanut producers use irrigation, but it has often been noted that non-irrigated peanuts after bahiagrass are higher yielding than irrigated peanuts even in drought years. Why have we not developed a cropping system that incorporates the advantages of bahiagrass in a system that equals yields of irrigated crops? I believe that there are many answers to that question, but the main one is that the system has never been put together by researchers to show growers that a sod based system can be used successfully with less risk and higher returns. Since best soil quality is obtained after permanent grass crops, best crop yields are obtained immediately behind these grass sod crops because they are taking advantage of the soil characteristics improved by the sod. Cooper and Morris, 1973, put it in context when they described a wheat- sod based rotation by saying that the primary function of sod is to put “heart back into the land”. Cash crops get the first consideration on farms while the output from animals or hay produced from the sod crop is a by product of sound row cropping. Sod crops cannot be justified solely for their contributions to the following row crops, but they must be considered as they have a much lower cost structure and risk factor than do row crops. Row crops alone carry a much higher cost structure from equipment and yearly input costs than do pastures and require bigger equipment if all acreage is devoted to row crops with none being in sod. Therefore, if sod is a part of a farming operation, it must make a contribution for hay, grazing or in another manner to help pay expenses as land value and crop inputs continue to increase.. Virginia research showed that winter annual cover crops did not contribute to improved water holding capacity while perennial grasses did. Mid west data (Bartholomew, 1957) showed that sod crops were the most effective at maintaining organic matter content of any crop. Many years of research in Europe and long term studies of over 100 years at the Morrow plots in Illinois and the MacGruder plots in Oklahoma have shown that the best soil quality is after many years of perennial grass sod and that soil quality and fertility degrade over many years in continuous crops organic matter leveling out after 70-80 years of degradation, and crop yields being mained by increased inputs. Organic matter content of many of these soils are around 4% when initially taken out of sod crops and degrade to around 1-1.5% at which level a crop rotation of corn- soybean or wheat can maintain (Boman, et. al, 1996). However, these crops cannot increase organic matter content above 1-1.5%.

Legume crops result in temporary increases in soil N but degrade more rapidly than grass crops and in the long term contribute less to soil health than do perennial grasses

Green manure cover crops or those grown for strip tilling into have little influence on soil organic matter but can play a significant role in moderating soil temperature and reducing evaporation and soil erosion, thereby helping to maintain soil quality. Where cover crops are incorporated into the soil, degradation is enhanced and little benefit is derived in the South. Even forest soils lose their supply of organic matter rapidly when cultivated.

At least a century of data shows that soil health is improved by having a sod based cropping system and that following crop yields are improved enough to make this system a must for those desiring to stay in row crop production. A recent economic model using today prices with support from the farm bill shows the profitability of getting back to where we were in a farming system in the last century. So the question that needs to be asked is how we can afford not to look at this sod based system for row crops in the South. The rotation which we propose can be started without diminishing farm profits, and profits at the end of year 4, when the system is fully implemented, can be double or triple those of conventional cropping systems. We have all components of a good farming system with conservation tillage to reduce erosion, fuel use and labor, herbicide resistant crops to make farming more consistent and less expensive and time consuming and sod based rotations to increase yield. This system approach allows for any number of crops and will have to be considered to remain viable in the future as we compete in global markets and under adverse weather conditions. Tri-state work is underway to document and verify that this system can make a significant impact on the farm economy.

IMPACT

Perhaps the most important aspect of the sod based system is improving yield while improving soil health (Reeves, 1997). Much of the farmland in the Southeast suffers from a hardpan layer starting at 6-8 inches depth and continuing 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 the water and 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 1/3 inch of water per day, 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 was 5 feet, 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 30 cm will experience 60 drought days during May through August in 5 out of 10 years. However, if rooting depth were 5 feet deep, the crop would experience only 11 drought days.

Table 1. Days without plant water stress following rainfall for different rooting depths.. The available water was 1 inch per 12 inches of soil, and the evapotranspiration 0.33 inch day^{-1} (after Elkins *et al.*, 1977)

Rooting depth	Days without water stress
---- inch ---	-------- d -------
6	3
9	5
12	6
24	12
36	18
48	24
60	30

Water extraction is not the only factor dramatically affected by rooting 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 bahiagrass-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 33% increase in yield of seed cotton (1420 lbs acre^{-1} vs. 1900) 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 an increase in the number of roots at 24 inches depth. In the continuous cotton, there was an average of 0.5 roots per 10 in^2, whereas in the cotton following sod they reported 20 roots per 10 in^2.

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 1.0 mm 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 67 inches depth was only 10 ppm in plots following Bahiagrass, but 40 ppm in plots under continuous cotton (100 lbs. N ha^{-1} was applied to the crop).

We expect that the need for irrigation will be reduced several ways. First, bahiagrass will not need as much irrigation as the row crops (10 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. Finally, the increased root depth and density will make the row crops more efficient at extracting deeper water. 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 6.6 fold in peanuts following bahiagrass (1,691 lbs. acre^{-1} vs. 737) with no nematocides applied, and a 9.7 fold increase (2,479 lbs. acre^{-1}) in yield in peanuts following Bahiagrass and also treated with 1,3-dichloropropene. Rodriguez-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. After 2 years of bahiagrass, Rodriguez-Kabana *et al.* (1991) found that *M. arenaria* populations were reduced to non-detectable levels and recorded an increase in soybean yields of 114%.

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.

Conservation Tillage

The value of conservation tillage is nearly as important to a sustainable cropping system as is the value of rotation (Reeves, 1994; 1997). In recent years the development of precision planters, subsoilers, and varieties resistant to herbicides has allowed for widespread adaptation of conservation tillage practices. Although no-till practices are being used in many cropping systems, strip till is compatible with cotton and peanut production (Pudelko *et al.* 1997; Pudelko *et al.* 1995) and has been proven over a wide area by growers. At this time our experience with no-till is that seed placement (both spacing and depth) with peanut and cotton, even with the most advanced planters, is still difficult at best

Most of the information on water usage by cover crops is from studies of winter cover crops. Usually there is a significant increase in water efficiency. For example, Lascano *et al.* (1994) reported from Texas that the increased evapotranspiration efficiency in cotton after winter wheat resulted in a 35% increase in lint yield with a reduction in soil water evaporation 40% less in wheat residues than in bare soil. Field water balance studies by Baumhardt *et al.* (1993) related increased soil water content due to increased residue cover from a winter wheat crop to increased rain infiltration. However, cover crops and sod crops must be managed effectively to realize the full benefits of the practice. An important aspect in winter cover crops is to kill the crop early enough and efficiently enough so that it does not compete with water needed for starting the new crop. For example, Baumhardt and Lascano (1999) did not recommend their terminated wheat-cotton system for the Texas South Plans because of the lack of water available for the cotton crop. If the cover crop is not killed, there may be continued competition for water and/or nutrients (Pedrosa De Azevedo *et al.*, 1999). This also can occur when converting from sod to row crop if it is not killed effectively (Wilson and Okigbo, 1982).

Plant Pests

Early and late peanut leaf spot alone account for over $70 acre^{-1} or more of inputs in fungicides. Boll rot in cotton has been identified as a major yield limiting factor, most likely due to high N rates accompanied by high humidity and temperature.

The impact of conservation tillage and rotation practices on plant disease is extremely complex and often very site dependent. Often times, below ground and above ground diseases are affected (Bailey, 1996; Ward *et al.*, 1997). There is also clear evidence that tillage practices affect other control measures, including biological (Kim *et al.*, 1997) and chemical (Wheeler *et al.*, 1997). Several observations indicate that there will be a significant shift in the quality and quantity of the epidemics in each of the crops/cropping systems, however crop rotation may help to ameliorate the potential increase in disease pressure due to the increased survival of pathogens on surface debris (Bockus and Shroyer, 1998). Double row peanuts has been reported to help reduce the negative impact of tomato spotted wilt virus, but can also increase the severity of pod rot pathogens and sclerotinia blight (Hollowell *et al.*, 1998; Butzler *et al.*, 1998). While there have been numerous studies on the impacts of crop rotation and minimum tillage on plant pathosystems, there are still many gaps in our knowledge of how these practices will impact row crop production in the southeastern U.S. For example, the use of minimum till practices was originally thought to possibly increase disease pressure, however experience has shown that some diseases in peanuts are actually reduced (Wiatrak *et al.*, 2000).

A similar situation exists with weeds. Although specific weeds may be better controlled with the integration of herbicide resistant crops, in the longer term the weed populations may shift to other weed species, which could be more or less detrimental than the ones they replaced. Rotation with sod will help ameliorate this (Patterson *et al.*, 1996; Reeves *et al.*, 1996; Reeves *et al.*, 1997).

The impact of the cropping systems on insects should be minimal. The dominant effect will be due to the Bt resistance incorporated into the cotton. One potential impact will be the possible overwintering of insects in plant debris in the conservation tillage plots. However, crop rotation will help minimize the potential damage from insects.

Recent studies have analyzed tillage systems and pesticide use in the Corn Belt (Fuglie, 1999), rotations (Funk *et al.,* 1999), cotton in rotation with soybean under three tillage practices (Stark *et al.*, 1996), and fertilizer rates and yield responses in feed grains (Atwood and Helmers, 1998). Overall, the research implies that such a system should be analyzed within a crop management and economic framework. Fuglie (1999), for example, noted that with no-till herbicide use was about equal to that under conventional tillage, but that insecticide use increased. Funk *et al.* (1999), on the other hand found a trade-off between insecticide and herbicide use, but looked only at corn-soybean rotation and did not include tillage. Atwood and Helmers (1998) discussed the yield and protein content decline of feed grains caused by restricting timing and level of nitrogen applications in order to control nitrate contamination. In 1996, Stark *et al.* summarized results from a 1987-1991 experiment. They found that in terms of yield and net returns, full tillage in a cotton-soybean rotation, each preceded by triticale, gave better results than row-till and no-till systems. In that experiment pest control varied by tillage method and fertility levels were to levels recommended by the Georgia Cooperative Extension Service. The experiment reported by Stark *et al.* is the most complete, but an analysis of a complete system suitable for the Southern Coastal Plain for ultra narrow row cotton is lacking. None of the research, however, analyzed a sod-based rotation with rotation-tillage-pesticide-fertilizer in the system.

Integrated Pest Management

The major changes in pesticide use in a sod based system, 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 and a reduction in peanut leafspot sprays from 6 to 3. A reduction in the need for nematicides would be expected, but about 50% of the farms would 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) 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 \$120 acre^{-1} and \$37, respectively. In the bahiagrass rotation, the cost for pesticides bahiagrass is \$10 per acre to kill it with glyphosate in the fall before peanuts. No other pesticides will be needed for bahiagrass. For peanuts in rotation, the pesticide cost is reduced to \$70 per acre because of the reduction in leafspot sprays and need for aldicarb. In cotton the cost per acre remains the same, \$37 per acre. In this rotation, the annual cost for pesticides is slightly less than half of the conventional system.

Growers know that crops must be rotated to control pest and increase yields. They know, also that sod-based rotations can often increase yields even more, even doubling cotton yields (Elkins *et al.*, 1977). When combined with advances in IPM and minimum till technology, it is possible to develop an economic and environmentally sustainable row crop rotation system for farmers in the Southeast that will allow more profit for farms of all sizes including smaller farms.

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. The cropping systems and farming practices developed must have a high degree of sustainability to be effective. Research projects should encompass multi disciplines and embrace modern IPM practices, recent genetic technology, precision planting equipment, precision agriculture tools, and minimum or no-tillage systems and, most importantly, sod-based rotations for dramatic yield increases.

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