YIELD AND ECONOMICS FOR PEANUT UNDER TWO TILLAGE SYSTEMS AND PERRENIAL GRASS VS. CONVENTIONAL ROTATION

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ABSTRACT

Conservation tillage (CT) and rotations which include perennial grasses in peanut production are advocated for the southeast (SE). Field studies were conducted in Headland, Alabama, from 2003 to 2006 to compare crop yields, production costs, revenue and net economic returns in the conventional peanut-cotton-peanut (P-C-P) vs. bahiagrass-bahiagrass-peanut-cotton (B-B-P-C) rotations and two tillage systems, strip-till vs. conventional tillage. Strip tillage and the B-B-P-C rotation increased yield and economic returns in 2 of 4 years at this site. Both strip tillage and the B-B-P-C rotation had reduced disease incidences in all 4 years but this did not always result in greater yield. There is a need for continued research to test the consistence of positive yield and economic returns across years and sites for peanut produced under strip tillage and in rotation with perennial grasses.

INTRODUCTION

The attractiveness of conservation tillage (CT) has lead to its widespread adoption as a management tool in many cropping systems. A phrase extracted from the Farm Press reads "The melodic Oklahoma wind that "comes roaring down the plains" may play well in the theater but it plays pure havoc on seedling peanuts" (Farm Press, 2001). In the same article, CT is proposed as a solution to reduce wind erosion. In the SE the need to conserve soil moisture is a powerful driving force behind the adoption of conservation tillage. The rising cost of fuel can be expected to exert new importance in adoption of CT in the future. Benefits of CT on soil and plant health, micro and macro fauna, disease management and environmental stewardship, are documented (Linden et al., 1994; Magdoff, and van Es., 2000; Katsvairo et al., 2006a).

It has been three decades since CT was first introduced in peanut production, yet it is not as widely adopted (in peanut) as in cotton, the common rotation crop to peanut in the SE (National Crop Residue Management Survey. 2002.). The major challenges to CT adoption has been the effect on crop yield. To this end, a sizeable amount of literature document greater yield for peanut under conservation tillage (Hartzog et al., 1998; Baldwin and Hook, 1998; Marois and Wright, 2003). Yet about the same quantity of articles reports the exact opposite- a dreaded reduction in yield under CT (Jordan et al., 2001; Grichar, 1998; Brandenburg et al., 1998; Cox and Scholar, 1995). Clearly the effect of CT on peanut productivity tends to be regional and even seasonal.

It is often said that history goes in cycles. Recent times have seen renewed interest in adoption of diversified cropping systems such as intercrops, alley cropping, and rotations with perennial grasses. In the early to mid 1900s, extension in Africa discouraged forms of intercropping in favor of clean row cropping. Intercrops were considered unclean and the common phrase "cleanliness is next to Godliness" drove home the case against this form of diversified cropping. To date, numerous articles credit improved soil and plant health, reductions in plant disease, environmental stewardship and preservation of wildlife and visual aesthetics to rotations with perennial grasses in cropping systems, a form of diversified cropping (Toth, 1998; Ball et al. 1996; Kabana et al., 1988; Tsigbey et al., 2004; Katsvairo et al., 2006b; Franzluebbers and Triplett, 2006; Katsvairo et al., 2007a). More importantly, greater yields are reported when peanut is rotated with perennial grasses (Dickson and Hewitt, 1989; Brenneman et al., 2003; Katsvairo et al., 2007b).

Ultimately, economics determines adoption of cropping systems. A study by Kabana et al (1988) reported that rotating peanut with perennial grasses was as effective as using aldicard to control nematodes. Using partial budgets a study in Florida reported greater economic returns for peanut in rotation with bahiagrass (Katsvairo et al., 2007b). Headland, Alabama is in the vital peanut growing region of the US. Approximately 90% of the peanuts in the US are produced within 100 miles from Headland. Our objectives were 1) to compare peanut yield and disease infestation under conventional tillage and conservation tillage, and 2) to determine economic returns of peanut under the two cropping systems.

MATERIALS AND METHODS

A 4-yr tillage x rotation study was initiated in the summer of 2002 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the Wiregrass Research Station in Headland, Alabama. The experimental site was in peanut and cotton rotation in prior years. The experimental design was randomized complete block design in a split plot treatment arrangement with 4 replications. Main plots consisted of two tillage systems (strip till and moldboard). Subplots consisted of two crop rotations. Crop rotations included a cotton-cotton-peanut rotation, which is the conventional rotation used by growers in the region, and a bahiagrass-bahiagrass-peanut-cotton rotation. Other cultural management practices including pesticides use and harvesting were conducted using the standard extension recommendations from Auburn University. A two-year old bahiagrass sod was used in the rotations to ensure good ground coverage and vigorous growth of the crop.

Costs, revenue, and net returns for the two crop rotations and tillage systems were determined. Costs were developed for a conventional (turned) enterprise production budget separately for each year. Peanut drying and assessment costs were adjusted in accordance with the yields for each individual treatment and energy costs for each year. All other costs such as seed, fertilizer, transport, and other machinery were considered similar across all treatments.

Revenue was calculated for each treatment and rotation. Revenue was calculated as the product of the yield in kg ha^{-1} and the national loan rate for peanut in \$ kg^{-1} for each year. The national loan rates were \$0.391, \$0.372, \$0.392 and \$0.403 for 2006, 2005, 2004 and 2003 respectively. Net returns were calculated as the difference between revenue and total costs.

Yield data were analyzed using SAS general linear models procedures (SAS Institute, 2002). Revenue and production costs were not analyzed statistically since the goal was to determine profitability. The study started in 2002, so the sod rotation in 2003 would have only followed one year of bahiagrass, however in subsequent years the sod rotation follows two years of bahiagrass. Mean separation for main effects and interactions were obtained by Fisher's protected LSD, as described by Little and Hills (1978). Effects were considered significant in all statistical calculations if $P \leq 0.05$.

RESULTS AND DISCUSSION

Average yields varied between the years (Table 1). The years 2003, 2004 had greater average yields 5614 and 6231 kg ha^{-1}, respectively, while yields in 2005 and 2006 averaged 4968 and 5413 respectively. In 2004, peanut in the bahiagrass rotation averaged 700 kg ha^{-1} greater than peanut in the conventional rotation. There were no differences in yield between the rotations systems and furthermore, moldboard tillage resulted in greater yield than strip tillage. By 2006, four years later in the rotation and tillage study, exact opposite results were observed compared to 2004. The conventional rotation yielded over 1000 kg ha^{-1} greater than the bahiagrass rotation, furthermore, moldboard tillage also yielded over 1000 kg ha^{-1} greater than strip tillage. While most studies have shown greater yields in peanut after bahiagrass, inconsistent in peanut yields after bahiagrass have been reported. An earlier study from the same site (Headland, Alabama) showed erratic yields for peanut in rotation with cotton, corn or bahiagrass (Hagan et al. 2003). While a Floridian study reported greater yields in peanut after bahiagrass in two out of three years (Katsvairo et al., 2007) and Brenneman et al. (2003) reported greater yields in peanut after bahiagrass in 5 out of 7 years. The exact reason for the inconsistency in our results is not clear. It is possible that soil compaction could have build up under strip tillage, adversely affecting peanut growth and harvesting. We observed reduced incidences of disease to include tomato wilt spotted virus for peanut in the bahiagrass rotation, however this did not contribute to improved yield for that rotation.

Table 1. Average of yield for two tillage and rotation systems in Alabama

	Strip Till		Moldboard		
Year	B-B-P-C	P-C-P	B-B-P-C	P-C-P	Average
2,003	5,619	5,260	6,084	5,491	5,614
2,004	6,530	5,775	6,665	5,955	6,231
2,005	4,679	4,721	5,472	5,000	4,968
2,006	4,370	5,253	5,273	6,755	5,413
Average	**5,300**	**5,252**	**5,874**	**5,800**	

†Rotations are as follow: B-B-P-C stands for bahiagrass-bahiagrass-peanut-Cotton;

P-C-P stands for peanut-Cotton-Cotton

The effect of tillage on the other hand, was more pronounced than that on crop rotations. The average yield difference over the 4 year period between conventional and strip tillage was 560 kg ha^{-1}. When averaged across years, the conventional tillage yields were greater than their strip till analog, regardless of rotation.

Peanut in the bahiagrass rotation had reduced disease instances compared to peanut in the conventional rotation (data not shown).

Costs increased steadily over the 4 year study period primarily due to the direct and indirect cost of energy. In this regards strip tillage had an advantage over conventional tillage. Strip tilling lowers energy costs by reducing the number of trips across the field. The unit operations and the variable and fixed costs of each operation are shown in Table 2.

Table 2. Machinery and equipment costs for peanut under two tillage systems in 2006

	Conventional Tillage			**Strip Tillage**		
Unit Operation	Times Over	†VC $/Ha	¶FC $/Ha	Times Over	VC $/Ha	FC $/Ha
Strip Till Rig	x	x	x	1	12.67	22.82
Moldboard Plow	1	18.45	23.59	x	x	x
Light Disk	2	13.78	16.06	x	x	x
Fertilize	1	3.88	10.52	1	3.88	10.52
Plant	1	3.19	4.94	1	3.19	4.94
Spray	7	29.91	49.45	8	34.18	56.51
Dig Invert	1	26.87	30.38	1	26.87	30.38
Combine	1	47.35	128.32	1	47.35	128.32
Totals		143.43	263.26		128.14	253.49

†VC stands for variable costs; ¶FC stands for fixed costs

Strip tillage had a $15.29 $ ha^{-1} equipment cost savings over conventional tillage and an overall $25.06 advantage in total costs savings. However the additional cost of $26 ha^{-1} for the use of a burn down herbicide prior to strip till planting negated the strip till equipment advantage.

As expected, revenue followed a similar pattern to yield, being greatest for rotations and tillage systems with the highest yield (Table 3).

Table 3. Comparison of revenue ($/ha) for two tillage systems and rotations in Alabama.

	Strip Till		Turned	
Year	B-B-P-C	P-C-P	B-B-P-C	P-C-P
2,003	2262	2118	2449	2211
2,004	2,557	2,261	2610	2332

2,005	1740	1755	2034	1859
2,006	1706	2051	2059	2638
Average	2066	2046	2288	2260

†Rotations are as follow: B-B-P-C stands for bahiagrass-bahiagrass-peanut-Cotton; P-C-P stands for peanut-Cotton-Cotton

There was a \$24 ha^{-1} difference in revenue generated between peanuts in the bahiagrass and cotton rotations but this was of no practical importance. However, when comparing tillage systems, conventional tillage averaged \$218 ha^{-1} more in revenue than strip tillage.

Projected returns went from strongly positive in 2003 and 2004 (\$300- \$750/ha) in all treatments, to mixed (\$531 – \$-267/ha) in 2005-6. The difference in net returns was due to a combination of decreased yields, increased costs and changes in peanut prices. Peanut prices for 2005-6 were slightly lower than 2003-4, while costs increased steadily from \$1850 to \$2050 ha^{-1}over the 4 year period (Table 4). Also yields between the years 2005-6 yields were 700 – 800 kg ha^{-1} less than 2003-4 (Table 1).

Table 4. Summary of cost, revenue, and net returns for two tillage and rotations systems in Alabama

Year	Rotation	Tillage	Total Costs \$ ha^{-1}	Yield kg ha^{-1}	Market \$/kg^{-1}	Revenue \$ ha^{-1}	Net Returns \$ ha^{-1}
2006	**B-B-P-C**	StripTill	1,973.83	4370	\$0.391	1,706.49	**-267.35**
2006	**P-C-P**	StripTill	2,022.14	5253	\$0.391	2,051.30	**29.16**
2006	**B-B-P-C**	Moldboard	2,025.69	5273	\$0.391	2,059.11	**33.42**
2006	**P-C-P**	Moldboard	2,106.40	6755	\$0.391	2,637.83	**531.42**
2005	**B-B-P-C**	StripTill	1,914.28	4679	\$0.372	1,739.65	**-174.63**
2005	**P-C-P**	StripTill	1,939.19	4720	\$0.372	1,754.90	**-184.29**
2005	**B-B-P-C**	Moldboard	1,957.26	5472	\$0.372	2,034.49	**77.23**
2005	**P-C-P**	Moldboard	1,932.93	5000	\$0.372	1,859.00	**-73.93**
2004	**B-B-P-C**	StripTill	1856.30	6530	\$0.392	2,557.15	**700.85**
2004	**P-C-P**	StripTill	1823.50	5774	\$0.392	2,261.10	**437.60**
2004	**B-B-P-C**	Moldboard	1862.01	6665	\$0.392	2,610.01	**748.01**
2004	**P-C-P**	Moldboard	1891.37	5955	\$0.392	2,331.98	**440.61**
2003	**B-B-P-C**	StripTill	1,807.11	5619	\$0.403	2,262.21	**455.10**
2003	**P-C-P**	StripTill	1823.50	5260	\$0.403	2,117.68	**294.18**
2003	**B-B-P-C**	Moldboard	1,828.61	6084	\$0.403	2,449.42	**620.81**
2003	**P-C-P**	Moldboard	1,803.80	5491	\$0.403	2,210.68	**406.88**

†Rotations are as follow: B-B-P-C stands for bahiagrass-bahiagrass-peanut-Cotton; P-C-P stands for peanut-Cotton-Peanut

When averaged across years, the rotation effect on net return (B-B-P-C net return – P-C-P net return) was only $39 ha^{-1}(data not shown). The tillage effect, on the other hand is substantially greater at $187 ha^{-1}. In Tables 5 and 6 net returns are partitioned by rotation and tillage respectively. Table 5 shows the difference in net returns between conventional and strip tillage for each rotation. The average difference in net return was $191 ha^{-1} for the B-B-P-C rotation and $182 ha^{-1} for the P-C-P rotation. This data suggests there is minimal if any economic value in using the bahiagrass rotation over the conventional cotton rotation.

Table 5. Differences in net returns two tillage systems and two rotations.

Results are shown in $ ha^{-1}

	†B-B-P-C	P-C-P
Year	Moldboard-Strip	Moldboard-Strip
2,003	165.71	112.70
2,004	47.16	3.01
2,005	251.86	110.36
2,006	300.76	502.26
Average	**191.37**	**182.08**

†Rotations are as follow: B-B-P-C stands for bahiagrass-bahiagrass-peanut-cotton; P-C-P stands for peanut-cotton-peanut.

Table 6. Differences in net returns between rotations for the two different tillage systems.

Results are shown in $ ha^{-1}.

	Moldboard	Strip
Year	BBPC-PCC	BBPC-PCC
2,003	213.93	160.92
2,004	307.40	263.25
2,005	151.16	9.66
2,006	-498.01	-296.50
Average - $ ha^{-1}	**43.62**	**34.33**

†Rotations are as follow: B-B-P-C stands for bahiagrass-bahiagrass-peanut-Cotton; P-C-P stands for peanut-Cotton-Cotton

Table 6 shows the difference in net returns between the two rotations for each tillage type. The average difference in net return between the bahia and cotton rotations for conventional tillage was $44 ha^{-1} while for strip tillage it was $34 ha^{-1} indicating little if any economic effect of tillage on peanut production.

The economic returns from this study are not very favorable to cropping peanut in the sod rotation and under strip tillage. The benefits obtained from sod rotation and strip tillage in the good years were negated in other years. Currently less than 2% of the peanuts produced in Georgia are preceded by bahiagrass. There is a need for continued research to achieve consistence in yield and economic benefits of perennial grass rotation in peanut production systems. Also, considerations for livestock should be included in farm systems studies, which add value and reduces risk from having all of the acreages in cash crops.

CONCLUSIONS

Both strip tillage and growing peanut in rotation with bahiagrass increased yield in two years, but both practices reduced yield in the subsequent two years. Peanut in the bahiagrass rotation had reduced incidences of TSW in all years. There is a need to continue research to test the feasibility of growing peanut in rotation with perennial grasses and under reduced tillage under different climatic conditions and also over an extended time period. Strip tillage appeared to reduce equipment operating and fixed cost slightly but the savings were more than offset by an increase in herbicide cost. The type of rotation used overall did not seem to affect yield, revenue or return. Under these circumstances, tillage seemed to be the most important factor in the study, with conventional tillage yielding overall superior than strip tillage both in terms of yield, revenue and net return at this location.

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