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Growth and Yield Responses of Three Peanut Genotypes to Tillage Method and Seed Inoculation in Sod Based Peanut-Cotton Rotations

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ABSTRACT

A field experiment was conducted at the North Florida Research and Education Center, Quincy, FL in 2007 to investigate tillage method (conventional and strip till) and seed inoculation (with and without seed inoculation) effects on peanut growth, yield, and plant tissue mineral nutrient concentrations in a sod-based rotation of bahiagrass-bahiagrass-peanut-cotton using three peanut genotypes (cultivars) of ‘AP-3’, ‘Florida’, and ‘McCloud’. Neither tillage method nor inoculation affected peanut yield or harvest index (HI). Among the three genotypes, Florida had the highest yield ($P < 0.05$), but HI did not differ statistically among the three genotypes. Differences were also detected among peanut genotypes in concentrations of several mineral nutrients in plant tissues. Therefore, using proper peanut cultivar in the sod-based crop rotation may further improve peanut yield and increase profitability in the southeast.

INTRODUCTION

A common crop rotation in the southeast of USA is peanut (*Arachis hypogea* L.) - cotton (*Gossypium hirsutum* L.) – cotton, defined as a conventional cropping system. Insects and diseases are two major factors of limiting peanut yield in the region. Recent studies have shown that when peanuts and cotton rotate with perennial grasses such as bahiagrass (*Paspalum notatum*) in Florida can significantly reduce disease and insect pressure (Dickson and Hewlett, 1989; Johnson et al., 1999; Marois and Wright, 2003a; Wright et al., 2004a), improve crop plant growth and development, and increase crop yield and profitability (Norden et al., 1980; Brenneman et al., 1995; Katsvairo et al., 2006; 2007) compared with conventional cropping systems. The value of bahiagrass in rotation with peanuts is clear in many field experiments (Brenneman et al., 1995; Marois and Wright, 2003b; Wright et al., 2004a; Wright et al., 2004b). However, little is known if different peanut genotypes have the same positive response to the sod based crop rotation. It is well known that legume seed inoculation with N-fixation bacteria can facility nodule formation and plant N fixation, improve both soil quality and plant N status, increase crop yield. There are no reports about if seed inoculation has a positive effect on peanut growth and yield in the sod based rotation systems in the southeast USA. In order to clarify these questions and to make the sod-based crop rotation system more profitable and sustainable, we conducted this experiment in 2007. The specific objective of the study was to investigate interactive effects of tillage method, peanut genotype, and inoculation on peanut growth, yield, and market grade.

MATERIALS AND METHODS

The experiment was conducted in 2007 at Quincy (North Florida Research and Education Center, University of Florida). Soil type of the experimental field is Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudult). The experiment included two tillage methods of conventional till and strip till (main plot), two levels of inoculation (i.e., inoculation and non-inoculation) (sub-plot), and three peanut genotypes (cultivars) of 'AP-3', 'Florida', and 'McCloud'(sub-sub-plot). Bahiagrass was seeded in early May 2005 and killed on 20 April 2007 with 3 qts. of Rundup Weather Max per acre. The two tillage treatments were: (1) Conventional till (disc-harrow & Chisel plow and prepared see bed for planting between 27 April and 4 May) and (2) Strip till using a Brown Ro-Till implement (Brown Manufacturing Co., Ozark, AL) in 7 May, immediately prior to peanut planting. Peanut was seeded with a 2-row planter on 7 May 2007 with a row space of 3 feet and six seeds per foot row. There were 6 rows in each sub-sub-plot. During the growing season, insects and diseases were controlled and irrigation was scheduled using a lateral move irrigation system based on peanut production practices in the region.

When crop reached maturity stage on 9 October 2007, two middle rows in each sub-sub plot were mechanically dogged and reversed. Ten plants were randomly selected from each sub-sub plot immediately after plots were revered. Nuts were separated from the plants by hand. Both nuts and rest plant tissues, a combination of roots, leaves and stems, were placed a forced-air dryer at 118°F for 72 hours and weighed. Harvest index (HI) was calculated by nut dry weight dividing by total dry weight of plants. Fresh weight of pod samples harvested by mechanical picker were weighed and then placed a forced-air dryer at 118°F for 72 hours to ensure for a constant weight. The sample dry weights were determined. Peanut yields were estimated based on pod dry weight in the middle two rows and harvested area. Market pod grading characteristics, including percentages of sound mature kernels (SMK), sound split kernels (SSK), other kernels (OK), hulls, and tobacco spot wilt virus (TSWV) infection, were determined in a commercial peanut quality laboratory.

Experimental design and data analysis

The experiments were a split-split plot design with four replications. The tillage method was main plot, peanut cultivar was sub-plot, and see inoculation was sub-sub-plot. The sub-sub-plot size was 21 feet long and 18 feet wide. Analysis of variance (ANOVA) was carried out using SAS procedures of GLM to determine the main and interactive effects of tillage type, cultivar, and inoculation. When ANOVA test was significant, the Fisher's least significant difference (LSD) tests were used to distinguish the treatment difference at $P = 0.05$ level. Primary ANOVA results indicated that there were no any differences between the two tillage methods in either plant growth or peanut yield. Therefore, data of the two tillage methods were combined for further analysis of variance (Table 1) to simplify data analysis and be easy to make comparison.

RESULTS AND DISSCUSSION

Precipitation

Overall, 2007 was an extremely dry year compared to long-term average of precipitation. Cumulative precipitation (390 mm) during the 2007 growing season from April to September in the experimental location was 371 mm less than the long-term average (761 mm). Water saving irrigation was used during the growing season to eliminate plant water deficit stress. A total of 129 mm water was supplied during the growing season by a lateral move irrigation system.

Peanut Yield and Harvest Index (HI)

Neither tillage method (data not shown) nor inoculation affect peanut yield, but cultivar influenced yield significantly ($P < 0.05$, Table 1). There was no interactive effect on peanut yield between cultivar and inoculation (Table 1). Harvest index (HI) did not differ among the three cultivars and between the two inoculation treatments (Table 1).

Table 1. ANOVA table of peanut yield, harvest index (HI), and mineral nutrient elements in plant tissues (Shoots + roots) at harvest time (note: Nuts are not included in the plant tissue for nutrient determination).

Source	df	Yield	HI	N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
Rep (R)	3	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	*	ns
Cultivar (C)	2	*	ns	ns	ns	*	**	ns	ns	ns	ns	**	*	*
R × C	6	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Inoculate (I)	1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
R × I	3	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
C × I	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

The * and ** indicate there are significant differences at $P \leq 0.05$ and 0.01 levels, respectively.

Peanut yield of each individual treatment is presented in Figure 1. Tillage methods did not affect nut yield with 4297 lb acre^{-1} for conventional tillage and 4372 lbs acre^{-1} for strip till, averaged across inoculations and cultivars (Fig. 1). Results of peanut yield having no response to tillage method in this study are consistent with an earlier report by Zhao et al. (2007) who found that peanut yield did not differ among six tillage treatments in sod-based rotations. Therefore, simplifying tillage method without yield reduction can reduce input cost and increase net economic return.

Inoculation treatment had slightly higher yield than non-inoculation in conventional tillage, but results was reversed in strip till treatment. Averaged across tillage methods and cultivars, peanut yields of the inoculation and non-inoculation treatments were 4371 and 4299 lbs acre^{-1}, respectively. Among the three tested cultivars, Florida had the greatest yield and McCloud lowest yield (Table 2). Yield of Florida was significantly greater than that of McCloud in all the tillage and inoculation treatments ($P < 0.05$). Yield difference was only detected between Florida and AP-3 in the conventional with non-inoculation treatment. Averaged across tillage methods and inoculations, peanut yields of Florida, AP-3, and McCloud were 4668, 4371, and 4335 lbs acre^{-1}, respectively (Table 2).

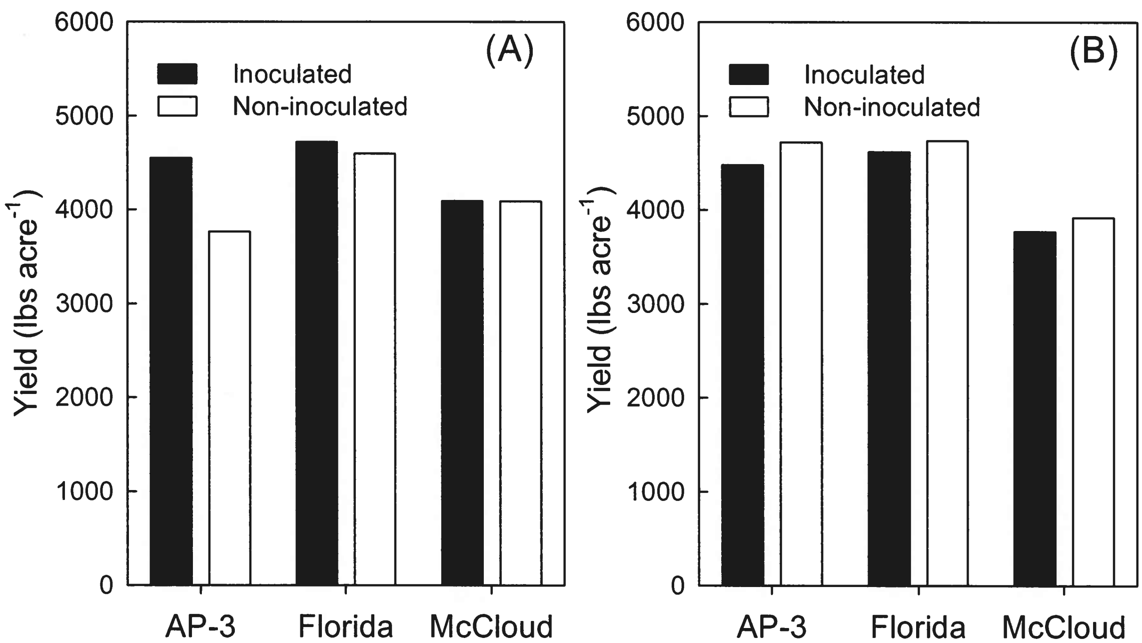

Fig. 1. Peanut yield responses of three peanut cultivars to tillage and inoculation in 2007 at Quincy, Florida. Note: (A) and (B) are the conventional till and strip till, respectively.

Harvest index (HI), defined as the ratio of nut dry weight to total dry weight at harvest time, ranged from 0.482 to 0.554 (Table 2). Any of tillage method, seed inoculation treatment or cultivar did not statistically affect HI. It suggested that peanut yield differences among the three cultivars in the present study were mainly associated with total biomass weight rather than. Our results also indicate that selection of proper cultivars can improve water and nutrient use efficiencies, further increase peanut yield, and enhance profitability of sod-based cropping systems in the southeast.

Table 2. Harvest index (HI) responses of three peanut cultivars to tillage and inoculation in 2007 at Quincy, Florida.

Cultivar	Conventional			Strip till		
	+Inoculation	-Inoculation	Mean	+Inoculation	-Inoculation	Mean
	(ratio of nut DW to total DW)					
AP-3	0.497	0.505	0.501	0.482	0.487	0.485
Florida	0.554	0.552	0.553	0.504	0.529	0.517
McCloud	0.497	0.488	0.493	0.539	0.539	0.539
Mean	0.516	0.515	0.516	0.508	0.518	0.513

Mineral Nutrients

Because either tillage method (data not shown) or seed inoculation (Table 1) did not affect plant tissue mineral element concentrations, data of mineral element concentrations in plant tissues were combined over tillage methods and inoculation treatment to determine cultivar differences in the nutrients. Among the three cultivars, Florida had lowest K, but the greatest Mg, Zn, Mn, and Fe concentrations. Although change patterns of nutrient concentrations among cultivars were not quite clear, it seemed for Florida to have greater micro-nutrient concentrations than other two cultivars (Table 3). More studies are needed to determine if high yield for Florida is associated with greater micro-nutrient concentration in plant tissues.

Table 3. Concentrations of mineral nutrient elements in plant tissues (shoots + roots) at harvest time. Data are means of the two tillage methods and the two inoculation treatment (note: Nuts are not included in the plant tissue for nutrient determination).

Cultivar	N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu
	(% of DW)					(ppm)					
AP-3	1.53	0.13	2.28	0.33	1.16	0.15	19.4	18.7	39.6	538	3.46
Florida	1.49	0.13	2.09	0.42	1.13	0.15	26.7	22.7	54.6	756	3.72
McCloud	1.47	0.15	2.30	0.41	1.11	0.14	27.2	19.8	43.8	627	4.12
$LSD_{0.05}$	ns	0.02	0.02	0.03	ns	ns	ns	3.4	6.6	149	ns

† Means followed by the same letter within a column are not significantly different at $P = 0.05$ level.

Peanut Market Grading

Peanut samples have been sent to a commercial quality test Lab for market grading. Samples are still in process. We will report grading results when they are available.

SUMMARY

Preliminary results of this study indicate that neither tillage method nor seed inoculation statistically affect peanut growth, plant tissue mineral nutrients or nut yield in a sod-based cropping system in the southeast. Cultivar differences in some nutrient elements of peanut plant and nut yield are detected. Cultivar Florida has the highest yield. High yield may be associated with a more total biomass rather than harvest index at harvest time. Therefore, there is potential to simplify tillage method and to select proper peanut cultivar for further enhancing peanut productivity, sustainability, and profitability in sod-based crop rotations. More studies are needed to further conform our findings.

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