BIOMASS PRODUCTION AND NUTRIENT UPTAKE OF RYE FOLLOWING PEANUT RESIDUE

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ABSTRACT

Leguminous crops have been utilized in conservation systems to partially meet N requirements of succeeding summer cash crops. This study assessed the N contribution of peanut (*Arachis hypogaea* L.) residues to a subsequent rye (*Secale cereale* L.) cover crop grown in a conservation system on a Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) at Headland, AL during the 2003-2005 growing seasons. Treatments were arranged in a split plot design, with main plots of peanut residue retained or removed from the soil surface, and subplots as N application rates (0, 30, 60 and 90 lb ac^{-1}) applied in fall. Peanut residue did not affect rye biomass yields, N content, C/N ratio, or N, P, K and Ca uptake. Additional N increased rye biomass, N, P, K, and Ca uptakes, although the highest N rate did not maximize these observed variables. Our results indicate that peanut residue does not contribute significant amounts of N to a rye cover crop grown as part of a conservation system, but retaining peanut residue on the soil surface can improve soil physical properties of the typically degraded southeastern soils.

INTRODUCTION

In the Southeast, legume crop residues have been extensively evaluated in conservation tillage systems to improve crop production and enhance soil physical characteristics (Mitchell and Teel, 1977; Touchton et al., 1984; Hargrove, 1986; Oyer and Touchton, 1990). Typically, legumes are planted after harvest in the fall and terminated in the spring. A summer crop is planted into the residue. A major benefit usually associated with legumes is the potential reduction in N fertilizer expenses for subsequent cash crops.

Nitrogen fixed by legumes in symbiosis with *Rhizobium* bacteria contributes to succeeding non-fixing crops upon decomposition of legume top and root material (Bruulsema and Christie, 1987; Touchton et al., 1984). Winter annual legumes, such as crimson clover (*Trifolium incarnatum* L.) and hairy vetch (*Vicia villosa* Roth.), are utilized as N sources for summer crops (Touchton et al., 1984; Brown et al., 1985; Reeves, 1994). Balkcom and Reeves (2005) also showed how sunn hemp, a summer legume, could be utilized to decrease corn N requirements. In addition, summer cash legumes have also been examined as an N source for subsequent crops. Researchers in the U.S. Corn Belt have found that alfalfa (*Medicago sativa* L.) and soybean (*Glycine max* L.), can decrease the fertilizer N requirements of a succeeding corn (*Zea mays* L.) crop (Bruulsema and Christie, 1987; Bundy et al., 1993; Morris et al., 1993). Although peanut is a legume that is widely grown in the Southeast, no previous research has examined the N contribution of peanut residues to a cover crop utilized in a conservation system. Therefore, our objective was to compare the N response of rye in a conservation tillage system following the removal and retention of peanut residue.

MATERIALS AND METHODS

This experiment was established in October 2002 at the Wiregrass Research and Extension Center in Headland, AL on a Dothan sandy loam. The experimental area rotated to a different location each year to utilize peanut residue from the previous peanut crop, but remained on a Dothan sandy loam. Treatments were arranged with a split-plot structure in a randomized complete block design with four replications. Main plots consisted of the retention or removal of peanut residue from the soil surface following mechanical harvest of peanut pods. Peanut residue was removed by mechanically raking into windrows and baling the peanut residue. The average peanut biomass was estimated by weighing the baled residue. A subsample of the residue was dried at 131°F for 72 h and ground to pass a 2-mm screen with a Wiley mill (Thomas Scientific, Swedesboro, NJ) then further ground to pass a 1-mm screen with a Cyclone grinder (Thomas Scientific, Swedesboro, NJ). The peanut residue was analyzed for total N by dry combustion on a LECO CN-2000 analyzer (Leco Corp., St. Joseph, MI). A rye cover crop was drilled at 90 lb ac^{-1} across the experimental area on 20 November 2002, 30 October 2003, and 15 November 2004. Subplot treatments were N rates (0, 30, 60, and 90 lb N ac^{-1}) hand-applied in the fall, as NH_4NO_3, to the cover crop. Nitrogen was applied to the rye cover crop on 21 November 2002, 14 November 2003, and 3 December 2004. Plot dimensions were 24 ft wide (8-36 in. rows) and 40 ft. long.

Rye biomass production was measured the following spring, prior to termination, on 23 April 2003, 8 April 2004, and 11 April 2005 by cutting all the aboveground biomass at the soil surface randomly from each plot within a 2.7 ft^2 area. Samples were dried at 131°F for 72 h, and weighed to determine total biomass production. A subsample of the dried rye biomass from each plot was ground, and analyzed for total N using procedures described above. An additional 0.5 g subsample was digested in a 70:30 mixture of nitric and perchloric acid overnight (Hue and Evans, 1986) and analyzed for total P, K, and Ca using an inductively coupled argon plasma spectrophotometer (Jarrel-Ash Division/Fisher Scientific Co., Waltham, MA).

All response variables were analyzed using the MIXED procedure (Littell et al., 1996) and the LSMEANS PDIFF option to distinguish between treatment means (SAS Inst., 2001). Data were analyzed with year as a fixed effect in the model, and there were significant year X treatment interactions for all response variables. Therefore, data were analyzed within each year, with data and discussion presented by year. Peanut residue and N rate were also considered as fixed effects, while rep and rep X peanut residue were considered random. Single degree-of-freedom contrasts were used to evaluate linear and quadratic effects of N rates on each response variable. If a single degree-of-freedom contrast indicated a significant linear or quadratic response, the specified regression model was fit with the PROC REG procedure (SAS Institute, 2002). Treatment differences were considered significant if $P \leq 0.10$.

RESULTS AND DISCUSSION

Peanut residue biomass and selected nutrient concentrations are shown in Table 1. Variability in nutrient concentrations existed among years, however in 2005 the K concentration averaged 72% lower than concentrations observed during 2003 and 2004. The N concentration averaged 1.4 % across all three years of the experiment. This N concentration was comparable to that reported by Balkcom et al. (2004) for post-harvest peanut residue. Based on the average residue production and N concentration, peanut residue had a total N accumulation of nearly 41 lb ac^{-1}. Since, this N is bound in the organic form, not all the N would be immediately available for plant uptake. Decomposition of the residue by soil microbes is required and what portion of the N the microbes do not use during the decomposition process will be potentially available for plant uptake and/or N loss pathways (i.e. leaching). Although peanut is a legume, the residue had no effect on any of the measured variables during any year of the experiment (Table 2). The lack of response may be attributed to the C/N ratio of residue, which has been shown to indicate the likelihood of N mineralization. Low ratios (i.e. < 20 to 1) result in net N mineralization, while high ratios (i.e. > 30 to 1) result in net immobilization of N (Tisdale et al., 1993).

All observed variables responded to additional N applied in the fall across all years of the experiment with the exception of N concentration and subsequent C/N ratio during the 2003 crop year (Table 2). The response of additional N was linear for all observed variables, except rye biomass yield and K uptake during the 2004 growing season (Table 3). The linear response would indicate that additional N above 90 lb ac^{-1} could have increased rye biomass and subsequent nutrient uptake. However, it is unrealistic to expect growers to apply high rates of an expensive input, like N, to the cover crop, which will not be harvested for grain. The increased response of rye biomass and N uptake to additional N is obvious, but the increased uptake of P, K, and Ca is also related. As additional N is applied to the rye, growth increases and the subsequent uptake of other nutrients is also increased. Therefore, P, K, and Ca uptakes were increased.

Interactions were observed between peanut residue and N rates during the 2005 growing season for N concentration, C/N ratio, and Ca uptake (Fig. 1). The N concentration and C/N ratio are related due to the relatively constant C concentration of plant tissues. Nitrogen concentrations measured in rye plant tissue following peanut residue were generally higher compared to N concentrations measured following no peanut residue. However, at the 30 lb N ac^{-1} rate, N concentration was lower in the rye following peanut residue compared to no peanut residue. The observed low N concentration observed illustrates why the interaction occurred, but no clear explanation exists why the observed N concentration was so low at that N rate. Calcium uptake increased linearly with N rate following peanut residue, but was more erratic across the N rates following no peanut residue.

CONCLUSIONS

Peanut residue did not contribute significant amounts of N to the rye cover crop based on biomass yield over a 3-yr period. As expected, rye did respond positively to additional N applications, but the linear response to many variables indicates that 90 lb N ac^{-1} may not maximize biomass or the subsequent uptake. Although peanut is a legume, it does not appear to supplement any additional N to a rye cover crop following the harvest of peanut. However, since peanut production in the Southeast is generally on highly weathered Ultisols, retention of peanut residue in the field protects the soil surface from erosion and could increase soil organic matter contents, which will improve soil physical and chemical properties.

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Table 1. Peanut residue yield and selected nutrient (C, N, P, K, and Ca) concentrations measured after peanut harvest at the Wiregrass Research and Extension Center in Headland, AL from 2002-2004.

Peanut crop year	Peanut residue yield	C	N	C/N ratio	P	K	Ca
	lb ac^{-1}	---------%---------			-----------------%-----------------		
2002	2820	42.2	1.7	25.3	0.10	1.2	0.83
2003	2880	44.0	1.1	39.6	0.16	1.3	1.2
2004	3000	36.2	1.4	26.6	0.18	0.35	0.97

Table 2. Analysis of variance probabilities following the removal and retention of peanut residues on the soil surface, subsequent N rates, and the interaction between these effects for rye biomass yield, N concentration, N uptake, C/N ratio, P uptake, K uptake and Ca uptake at the Wiregrass Research and Extension Center in Headland, AL from 2003-2005.

Year	Source	df	Rye biomass yield	N concentration	N uptake	C/N ratio	P uptake	K uptake	Ca uptake
	Residue	1	0.5033	0.1534	0.1774	0.4668	0.4879	0.4399	0.4471
2003	N rate	3	0.0002	0.3671	0.0059	0.4721	0.0032	0.0005	0.0005
	Interaction	3	0.1392	0.3962	0.5378	0.2542	0.1512	0.1461	0.2554
	Residue	1	0.6623	0.1077	0.7657	0.2299	0.8014	0.6284	0.9336
2004	N rate	3	0.0000	0.0008	0.0000	0.0053	0.0000	0.0000	0.0001
	Interaction	3	0.4487	0.3251	0.1607	0.7355	0.7291	0.2000	0.3028
	Residue	1	0.5838	0.3391	0.2182	0.2632	0.6410	0.2841	0.6750
2005	N rate	3	0.0008	0.0257	0.0001	0.0131	0.0097	0.0016	0.0015
	Interaction	3	0.1578	0.0541	0.6557	0.0213	0.6197	0.4204	0.0740

Table 3. Regression equations for rye biomass yield, N uptake, P uptake, K uptake and Ca uptake as a function of fertilizer N rate at the Wiregrass Research and Extension Center in Headland, AL from 2003-2005.

Year	Regression equation	R^2	P > F
Rye biomass yield			
2003	$Y = 2969 + 36.3x$	0.77	0.0039
2004	$Y = 3113 + 108.6x - 0.65x^2$	0.91	0.0022
2005	$Y = 4588 + 66.5x$	0.80	0.0028
N uptake			
2003	$Y = 22.4 + 0.38x$	0.79	0.0033
2004	$Y = 15.7 + 0.50x$	0.91	0.0003
2005	$Y = 30.1 + 0.81x$	0.86	0.0008
P uptake			
2003	$Y = 6.4 + 0.05x$	0.79	0.0033
2004	$Y = 4.8 + 0.06x$	0.96	<0.0001
2005	$Y = 8.7 + 0.11x$	0.87	0.0008
K uptake			
2003	$Y = 9.5 + 0.10x$	0.77	0.0041
2004	$Y = 7.3 + 0.20x - 0.001x^2$	0.88	0.0050
2005	$Y = 14.6 + 0.22x$	0.80	0.0027
Ca uptake			
2003	$Y = 12.0 + 0.17x$	0.81	0.0023
2004	$Y = 7.9 + 0.16x$	0.84	0.0014
2005	$Y = 11.5 + 0.18x$	0.67	0.0128

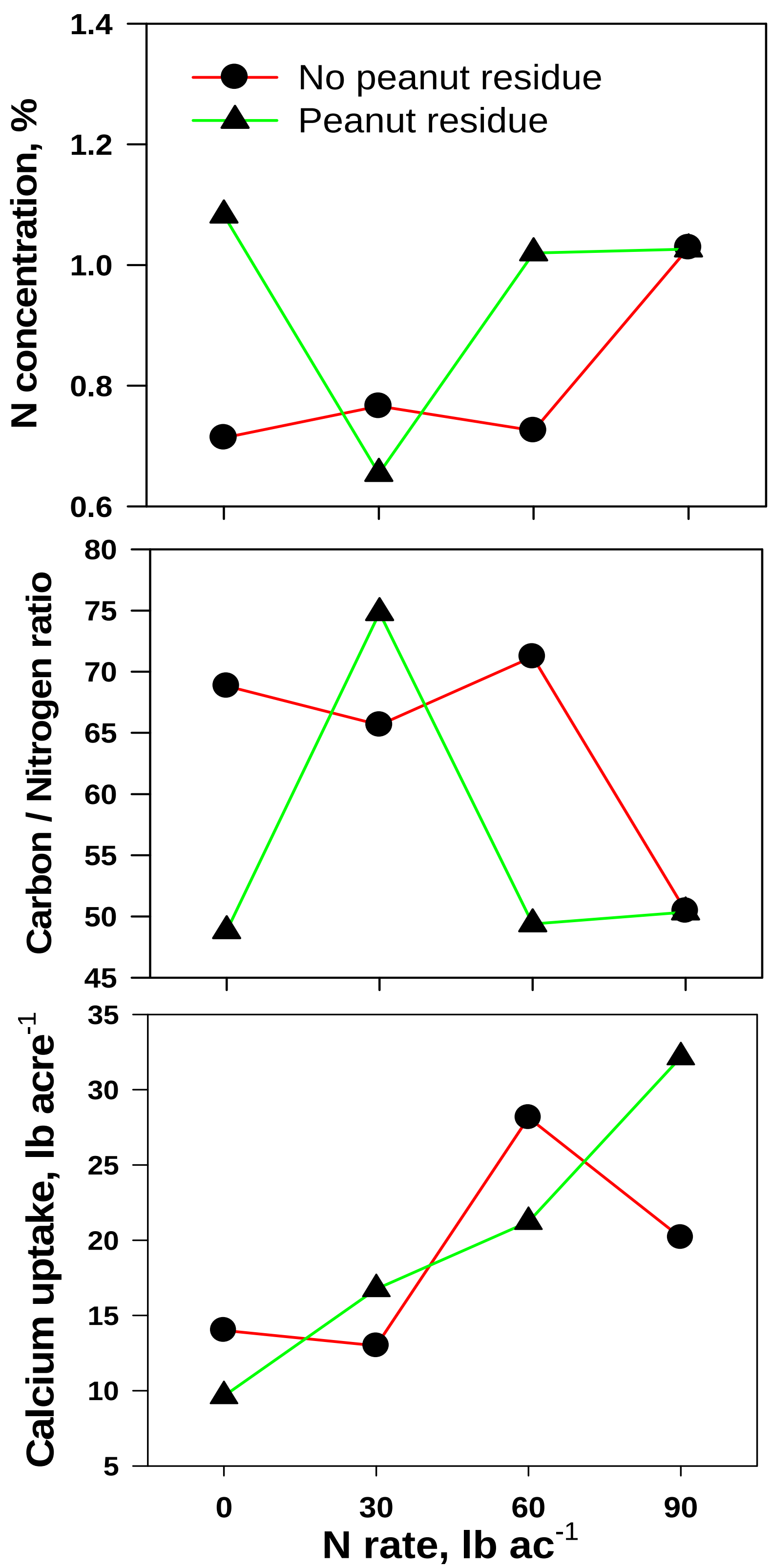

Figure 1. Nitrogen concentration, C/N ratio, and Ca uptake of rye observed following removal and retention of peanut residue during the 2005 crop year at the Wiregrass Research and Extension Center in Headland, AL.