PEANUT RESIDUE AS A NITROGEN SOURCE FOR CONSERVATION TILLAGE RYE AND COTTON

B. Meso*[1], K.S. Balkcom[2], C.W. Wood[1], and J.F. Adams[1]

[1]Department of Agronomy and Soils, Auburn University, Auburn, AL 36849
[2]USDA-ARS Soil Dynamics Research Unit, Auburn, AL 38832

email: mesober@auburn.edu

ABSTRACT

Previous research highlights benefits of utilizing legumes in rotations with non-leguminous crops. Leguminous summer cash crops can contribute nitrogen (N) to succeeding crops. This study assessed the contribution of N from peanut (*Arachis hypogaea* L.) residues to a rye (*Secale cereale* L.) cover crop and subsequent cotton (*Gossypium hirsitum* L.) crop in a conservation system on a Dothan sandy loam (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults). Treatment structure was a split plot in a randomized complete block 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 acre^{-1}). In-season N uptake by rye and cotton differed with N rate. Peanut residue had no effect on rye biomass and N uptake, seed cotton yields, cotton N uptake, or cotton dry weights. Our results indicate that peanut residue does not contribute significant amounts of N to succeeding crops, however, retaining residue on the soil surface provides other benefits to soils in southeastern US.

INTRODUCTION

Management systems that maintain crop residues on the soil surface have several attractive features, including reduced erosion, less on-farm energy use, more available soil water (Unger and McCalla, 1980), and improved soil nutrient status (Kuo et al., 1997). Use of legume crop residues to increase crop production is an old farming practice (Hargrove, 1982). The benefits of legumes are usually associated with N contribution to subsequent 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).

Corn (*Zea mays*) grown without N fertilizer following crimson clover (*Trifolium incarnatum* L.) yielded as much as corn grown following rye with 98 lb N acre^{-1} (Mitchell and Teel, 1977). Bruuselma and Christie (1987) reported 123 lb N acre^{-1} contribution from alfalfa residues that resulted in a 107 bu acre^{-1} corn yield and 124 lb N acre^{-1} contribution from red clover residues that resulted in a 113 bu acre^{-1} corn yield. Hargrove (1986) observed that crimson clover can replace as much as 105 lb acre^{-1} of N fertilizer. Peanut residues were reported to release 37 lb N acre^{-1} to a succeeding maize crop (Mubarak et al., 2002). McDonagh et al. (1993) reported 80% greater corn grain N and 65% higher corn grain dry weight in plots where peanut residue was incorporated compared with plots where it was removed.

Field experiments suggest that yield responses to residues are equivalent to those obtained by application of fertilizer N at a rate equal to two thirds of the N yield of the residues (Groya and Sheaffer, 1985). Yano et al. (1994) reported that peanut residue contributed 11.2% of its total N to a succeeding wheat (*Triticum aestivum* L.) crop upon decomposition. This was comparable with application of 66 lb N acre^{-1} as fertilizer. The objective of our study was to estimate N contributed by peanut residues to a succeeding rye crop and cotton crop in a conservation tillage system.

MATERIALS AND METHODS

This two-year experiment was established in October 2002 at the Wiregrass Research and Extension Center in Headland, AL on a Dothan sandy loam. The experimental design was a split-plot in a randomized complete block (replicated four times). Main plots consisted of retention or removal of peanut residue on the soil surface. Subplot treatments were N rates (0, 30, 60, and 90 lb N acre^{-1}) hand-applied in the fall to the cover crop and again in the spring after cotton planting. The designated rate was applied to the same plot in the fall and spring. The N source was ammonium nitrate. Nitrogen was applied to the rye cover crop on 21 November 2002 and 14 November 2003 and to cotton on 15 May 2003 and on 12 July 2004. Plot dimensions were 24 ft. wide (8-36 in. rows) and 40 ft. long.

Rye was planted (1.5 bu acre^{-1}) on 20 November 2002 and 30 October 2003. Soil samples were collected in the surface 6 in. for initial inorganic N concentrations and soil pH determination. Composite soil samples were taken from each plot by collecting 15 cores randomly and compositing. Selected initial characteristics of soil samples are presented in Table 1.

Rye dry matter production was measured the following spring on 14 March, 28 March, and 23 April in 2003 and on 11 March, 25 March and 8 April in 2004 by hand harvesting a 2.7 ft^2 area selected at random from each plot. These samples were dried at 140 ^{o}F for 24 h, and weighed for dry matter yield. A sub sample was ground to pass a 1.0-mm sieve, and analyzed for total N using a LECO CHN-600 analyzer as described by Hue and Evans (1986). Rye was chemically terminated on 23 April 2003 and 30 April 2004 by mechanically rolling the crop followed by glyphosate application.

Cotton was planted at 3.5 seeds ft^{-1} approximately 3 wk after rye termination. Cotton planted in 2004 was damaged by *Rhizoctonia* and was replanted on 21 June. Prior to fertilizer application, composite soil samples were taken again from each plot using the procedures described above. Seed cotton yield was determined by mechanically harvesting the two center rows of each plot. Samples were collected two times during the growing season (i.e. first square and mid-bloom). A sample of 50 fully opened cotton leaves were randomly picked per plot and bulked for leaf N analysis. Petioles were separated from leaves. All above ground plant parts were removed from a 3.28 ft randomly selected strip within each plot to determine whole plant dry matter production. All plant tissue samples were dried at 65 ^{o}C for 24 hours, ground to pass a 39 mil (1.0 mm) sieve and analyzed for N and C using a LECO CHN-600 analyzer. Whole plant dry weights were recorded for dry matter determination. Chlorophyll meter readings were taken on 30 randomly selected leaves per plot using a chlorophyll meter (SPAD 502, Minolta Co. Ltd).

All data were analyzed using the PROC MIXED procedure of the Statistical Analyses System (SAS Inst., 2001). Treatments were considered significant if P>F was less than or equal to 0.05

RESULTS AND DISCUSSION

Peanut residue biomass collected during the 2003-2004 growing season was 2816 lb acre^{-1} at harvest. Nitrogen concentration in peanut residue averaged 1.5%, comparable to that reported by Mubarak et al. (2003) and Balkcom et al. (2004). Peanut total N accumulation averaged 42 lbs acre^{-1}. This N accumulation was comparable to values reported by Yano et al. (1994) but less than those reported by McDonagh et al. (1993). Okito et al. (2004) reported an average peanut N accumulation of 36 lb acre^{-1} at harvest.

The effects of peanut residue and N rate on rye biomass and N uptake are shown in Table 2. Maximum rye biomass production was measured for the highest fertilizer N rate applied for all three sample times during both growing seasons. Peanut residue had no effect on rye biomass production. Research conducted in Brazil by Okito et al. (2004), reported higher corn yields when corn followed peanuts with residues retained in the field, however, background soil N was low compared to observed N concentrations at our site (Table 1).

Nitrogen uptake in rye was also affected by N rate at all sampling times with the greatest uptake measured following the highest N rate (Table 2). An interaction (P=0.0248) was observed between residue and N rate in the first year at the first sample time (Table 2). Rye N uptake owing to peanut residue retention and application of 30 lb N acre^{-1} was 80% higher than when residue was removed, however, at higher N rates (60 and 90 lb N acre^{-1}) no effects were observed (Fig. 1).

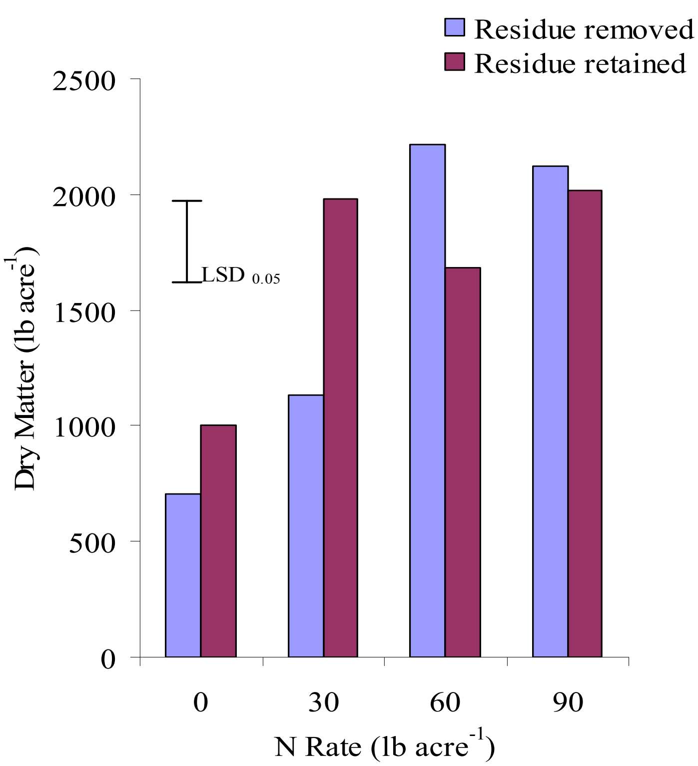

Figure 1. Rye biomass measured on 11 March 2004 following removal and retention of peanut residue and application of nitrogen (N) fertilizer at different rates.

Seed cotton yields did not respond to peanut residue during either year, but there was a response to applied N during the second year (Table 3). In the 2003-2004 growing season, seed cotton yield following an application of 90 lb N $acre^{-1}$ was double the yield measured with no N applied. Seed cotton yields also increased with each increasing N rate.

The effect of peanut residue and N rate on cotton dry weights and N uptake during the 2003-2004 growing season are shown in Table 4. Peanut residue had no effect on dry weights or N uptake at either growth stage. The highest cotton dry weights followed the 90 lb N $acre^{-1}$ application for both growth stages, which also corresponded to the highest N uptakes observed for both growth stages.

CONCLUSION

Rye biomass yield, N uptake and cotton dry biomass, N uptake and seed yield (in 2003-2004 experiment) responded to applied N. Peanut residues did not contribute significant amounts of N to the rye cover crop or subsequent cotton crop. However, maintaining residue in the field could help increase organic matter contents over time, which can provide positive benefits for these soils.

REFERENCES

Balkcom, K.S., C.W. Wood, J.F. Adams, and B.H. Wood. 2004. Composition and decomposition of peanut residues. Peanut Sci. (in press).

Bruulsema, T.W. and B.R. Christie. 1987. Nitrogen contribution to succeeding corn from alfalfa and red clover. Agron. J. 79: 96-100.

Groya, F.L. and C.C. Sheaffer. 1985. Nitrogen from forage legumes: Harvest and tillage effects. Agron. J. 77:105-109.

Hargrove, W.L. (ed.). 1982. Proceedings of the minisymposium on legume cover crops for conservation tillage production systems. University of Georgia, College of Agriculture. Spec. Pub. 19. University of Georgia, Athens, GA.

Hargrove, W.L. 1986. Winter legumes as a nitrogen source for no-till grain sorghum. Agron. J. 78:70-74.

Hue, N.V., and C.E. Evans. 1986. Procedures used for soil and plant analysis by Auburn University Soil Testing Laboratories. Alabama Agric. Exp. Station Department Series 106.

Kuo, S., U.M. Sainju, and E.J. Jellum. 1997. Winter cover cropping influence on nitrogen in soil. Soil Sci. Am. J. 61:1392-1399.

McDonagh, J.F., B. Toomsan, V. Limpinuntana, and K.E. Giller. 1993. Estimates of the residual nitrogen benefit of groundnut to maize in northeast Thailand. Plant and Soil 154 (2):267-277.

Mitchell, W.H., and M.R. Teel. 1977. Winter annual cover crops for no tillage corn production. Agron. J. 69:569-573.

Mubarak A.R., A.B. Rosenani, A.R. Anuar, and S. Zauyah. 2002. Decomposition and nutrient release of maize stover and groundnut haulm under tropical field conditions of Malaysia. Commun. Soil Sci. Plant Anal. 33 (3&4): 609-622.

Okito A., B.R. Alves, S. Urquiga, and R.M. Boddey. 2004. Nitrogen fixation by groundnut and velvet bean and residual benefit to a subsequent maize crop. Pesq. Agropec. Bras. Brasilia 39, 12 (2):1183-1190.

SAS Institute, 2001. The SAS system for Windows. Release 8.02. SAS Inst., Cary NC.
Touchton, J.T., D.H. Rickerl, R.H. Walker, and C.E Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil Till. Res. 4:391-401.
Unger, P.W., and T.M. McCalla. 1980. Conservation tillage systems. Adv. Agron. 33:1-58.
Yano K, H. Daimon, and H. Mimoto. 1994. Effect of Sunn-hemp and peanut incorporated as green manure on growth and nitrogen uptake of the succeeding wheat. Japanese J. Crop Sci. 63(1):137–143.

Table 1. Background soil pH, NO_3-N and NH_4-N (composite of 15 individual cores) prior to rye and cotton establishment.

Year	pH	NO_3-N		NH_4-N	
		Rye	Cotton	Rye	Cotton
		----------------lb acre^{-1}--------------------			
2002	5.5	0.6	2.3	25.6	5.0
2003	6.1	0.2	20.5	5.5	9.8

Table 2. Rye dry weight and N uptake measured following removal or retention of peanut residue and application of nitrogen (N) fertilizer rates on three dates during 2003 and 2004.

	Dry biomass						N uptake					
	2003			2004			2003			2004		
Treatment	14 March	28 March	23 April	11 March	25 March	28 April	14 March	28 March	23 April	11 March	25 March	28 April
Residue treatment	--lb $acre^{-1}$--											
Residue removed	1540	3600	4700	2050	3720	4430	32	46	34	43	47	41
Residue retained	1660	3200	4290	2420	4040	4520	34	52	43	36	48	43
N rate, lb $acre^{-1}$												
0	1780	1780	1050	1930	1050	2160	18	25	22	28	23	22
30	3220	3220	1920	3230	1920	4310	28	36	32	34	36	38
60	4220	4260	2500	4440	2500	5120	40	60	47	35	56	50
90	4500	4500	3580	5910	3580	6140	46	75	54	62	76	59
	Analysis of Variance (P>F)											
Residue treatment	0.2944	0.2944	0.2667	0.0615	0.3993	0.8374	0.4747	0.3965	0.2562	0.2945	0.7316	0.7881
N rate, lb $acre^{-1}$	0.0004	0.0004	0.0002	<0.0001	<0.0001	0.0002	<0.0001	0.0012	0.0072	0.0136	<0.0001	0.0009
Residue x N rate	0.4559	0.4559	0.1392	0.4227	0.9883	0.7718	0.0248	0.4264	0.5404	0.8668	0.9743	0.801

Table 3. Seed cotton yield measured following removal and retention of peanut residue and application of nitrogen (N) fertilizer rates in 2003 and 2004.

Treatment		2003	2004
Residue treatment		-------------lb acre^{-1}---------------	
Residue removed		977	1944
Residue retained		942	2208
N rate, lb acre^{-1}			
Fall	Spring		
0	0	968	1320
30	30	924	2112
60	60	994	2262
90	90	950	2614
		Analysis of Variance (P>F)	
Residue treatment		0.4459	0.1025
N rate, lb acre^{-1}		0.7863	0.0001
Residue x N rate		0.3225	0.5116

Table 4. Cotton dry weights measured following removal and retention of peanut residue and application of nitrogen (N) fertilizer rates in 2004.

		Dry weights		N uptake	
Treatment		First square	Mid-bloom	First square	Mid-bloom
Residue treatment		-------------------lb acre^{-1}---------------------			
Residue emoved		739	2498	27	59
Residue retained		751	2686	27	58
N rate, lb acre^{-1}					
Fall	Spring				
0	0	534	1555	14	27
30	30	724	2658	23	45
60	60	768	2984	31	79
90	90	955	3168	42	84
			Analysis of Variance (P>F)		
Residue treatment		0.8912	0.4534	0.987	0.8693
N rate, lb acre^{-1}		0.0173	0.0009	0.0001	<0.0001
Residue treatment x N rate		0.5246	0.9151	0.7244	0.6665