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The use of cool-season annual legume cover crops in cotton (*Gossypium hirsutum* L.) production as an N source and for erosion control often results in reduced cotton population density. The objective of this study was to determine if genotypic differences exist among available southeastern USA-adapted cotton varieties for performance when grown following green manured annual legumes. In 1988 and 1989, a field experiment was conducted on a Typic Paleudult in which five cultivars were grown following winter fallow or dessicated and disc-incorporated crimson clover (*Trifolium incarnatum* L. 'Tibbe') and vetch (*Vicia villosa* Roth 'Cahaba White'). Nitrogen fertilizer was applied at 95 lb N/acre across the entire experiment. Due to poor establishment of vetch in 1989, data were not used following vetch that year. Population density did not differ among cover crops in 1988. In 1989, a cover crop × cultivar interaction occurred with the cotton cultivar Coker 315 having 30% fewer plants following clover than winter fallow. Total seed-cotton yield was not affected by cover crop treatment either year, but maturity was delayed (measured as percent of total yield in the first harvest) both years in cotton grown following cool-season legumes. The results from this study suggest that when using a cool-season annual legume cover crop as a green manure, cultivar selection criteria do not need to be modified.

THE VALUE of cool-season annual legume cover crops for soil erosion control and as an N source is currently receiving renewed attention. Significant amounts of available N for the following summer crops have been reported for hairy vetch in no-till corn (*Zea mays* L.; Ebelhar et al., 1984) and for crimson clover in no-tillage grain sorghum [*Sorghum bicolor* (L.) Moench] (Hargrove, 1986). Touchton et al. (1984) reported that winter legume mulches provided all the N needs for no-tillage cotton on a sandy soil low in N. A major problem with the use of legume cover crops in cotton cropping systems is reduced cotton population densities (Brown et al., 1985; Grisso et al., 1985; Rickerl et al., 1988; Touchton et al., 1984).

Population density reductions in cotton following winter legume cover crops have been attributed to several factors. Rickerl et al. (1988) found population density reductions to be associated with an increase in *Rhizoctonia solani* in plots that had a winter legume (hairy vetch and crimson clover) under both conventional and reduced tillage. Megie et al. (1967) attributed inhibition of cotton germination and seedling growth to NH_3 toxicity in experiments that included incorporation of alfalfa (*Medicago sativa* L.). Volatile organic compounds from decomposing crimson clover have been shown to reduce cotton seedling root elongation (Bradow and Connick, 1988). Patrick et al. (1963) reported that decomposition products from a number of plant materials (including vetch) were phytotoxic to lettuce (*Lactuca sativa* L.) and spinach (*Spinacea oleracea* L.) seedlings and that seedling roots were especially sensitive.

Cotton cultivars have different levels of tolerance to seedling disease. Genetic variability may also exist for tolerance to other conditions associated with the use of a cool-season annual legume cover crop. This study was conducted to determine if genotypic differences exist among available southeastern USA-adapted cotton varieties for yield and population density when grown following green manured annual legumes.

MATERIALS AND METHODS

The study was conducted at the Clemson University Pee Dee Research and Education Center near Florence, SC, in 1988 and 1989. The soil type was a Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Paleudult). Cover treatments in the experiment were winter fallow, crimson clover ('Tibbee') or vetch ('Cahaba White'). Poor vetch establishment during the winter of 1988–1989 resulted in those plots being discarded in the second year of the study. Two full-season cotton cultivars ('PD-3' and Coker 315) and three short-season cotton cultivars ('McNair 235', 'PD-2', and 'DPL-50') that are adapted to the Southeast were evaluated. Experimental design was randomized split-block in 1988 and randomized complete block in split-plot arrangement in 1989. In 1989, whole plots were winter cover treatment and subplots were cultivars. Subplots were two 90-ft long by 38-in.-wide rows. There were six replicates each year.

High soil P and K levels were maintained each year by broadcast applications of 500 lb/acre of 0–4–8 N–P–K dry fertilizer prior to seeding the legumes. Seeding of the cool-season annual legumes in 1987 was accomplished on 25 October by handspreading 25 lb/acre vetch seed and 20 lb/acre clover seed followed by shallow harrowing to incorporate the seed. In 1988, the same seeding rates were drilled into the plots with a John Deere model 7200 seeder on 7 November. Biomass production in the cool-season annual cover plots was determined by sampling two 10.6-sq-ft areas in each plot on 6 Apr. 1988 and 19 Apr. 1989. Samples were air-dried in a greenhouse and weighed.

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Table 1. Abbreviated analysis of variance of population density, percent first harvest (earliness), and total seed-cotton yield.

Source	Population density	Earliness	Yield
1988			
Cover	NS	*	NS
Variety	**	**	*
Cover × variety	NS	NS	NS
CV (%)	29	5	12
1989			
Cover	NS	**	NS
Variety	**	NS	NS
Cover × variety	*	NS	NS
CV (%)	25	5	12

*, ** Significant at the 0.05 and 0.01 probability level, respectively; NS indicates nonsignificance.

After biomass production samples were taken, all plots were desiccated with paraquat to facilitate soil incorporation of the legumes and then disked twice. Cotton was planted on 9 May 1988 and 25 May 1989 at a seeding rate of approximately 5 seeds/ft of row. At planting, 500 lb/acre of 5-4-8 (N-P-K) fertilizer was banded below and to the side of the seed. A sidedress application of 70 lb N/acre (as NH_4NO_3) was applied at pinhead-square stage each year to all plots. Weeds were controlled with a combination of herbicides, cultivation, and handweeding. Herbicides used at recommended rates were trifluralin, fluometuron, MSMA, and cyanazine. Aldicarb plus pentachloronitrobenzene was applied at planting for early-season disease and insect control and pyrethroid insecticides were used as needed during the season to control *Heliothis* spp. Weekly stand counts from approximately 1 wk after cotton planting through late June in 1988 and early July in 1989 were made. Plants in 6.6 and 30.0 ft of row in 1988 and 1989, respectively, were counted.

Both 90-ft-long rows of each subplot were mechanically harvested with a spindle picker twice each year. First harvests were made on 17 Oct. 1988 and 13 Oct. 1989. Second harvests were made on 1 November both years.

All data collected were subjected to analysis of variance. Years were analyzed separately since two different experimental designs were used. Mean separations were made by calculating a least significant difference when analysis of variance F value was significant at the 0.05 probability level.

RESULTS AND DISCUSSION

Legume cover crop production was good both years (except vetch in 1988–1989). In 1988, the vetch air-dry matter yield was 1429 lb/acre while clover production averaged 2599 lb/acre. In 1989, the clover plots had 3438 lb air-dry matter/acre. Biomass samples were not collected in the fallow plots either year since only limited weed growth occurred.

Population densities were established by the time the first counts were made each year, and there was little change in the number of plants in the plots through late June in 1988 or early July in 1989. The data reported in Tables 1 and 2 were collected at the last counting date each year. Cotton population density was not significantly affected by cover crop treatment in 1988 (Table 1). A cover crop × cultivar interaction occurred in 1989 with Coker 315 having 30% fewer plants in clover cover plots than in the fallow plots (Table 2). No differences between clover and winter fallow treatment for cotton population density were found among the other cultivars in that year. Although plant samples were not taken, substantial amounts of seedling disease were not observed in either year, suggesting that disk incorporation of the cool-season annual covers well before cotton planting diminished the impact of allelochemical components and/or plant pathogen stimulation by the decomposing organic material on cotton population density.

Table 2. Influence of cool-season annual cover crop and cultivar on cotton population density measured on 11 July 1988 and 30 June 1989.

Cultivar	Clover	Vetch	Fallow	Mean
	plants/ft			
1988†				
Coker 315	3.09	4.16	3.74	3.66
DPL-50	4.21	3.64	3.89	3.91
McNair 235	2.60	3.22	3.12	2.98
PD-2	1.47	1.86	1.81	1.71
PD-3	0.85	1.36	1.48	1.23
Mean	2.44	2.85	2.81	
1989‡				
Coker 315	2.42	–	3.48	2.29
DPL-50	2.34	–	2.61	2.47
McNair 235	1.94	–	1.91	1.93
PD-2	1.50	–	1.95	1.73
PD-3	1.76	–	1.52	1.64
Mean	1.99	–	2.29	

† LSD (0.05) value for comparing cultivars in 1988 is 0.37 plants/ft.
‡ LSD (0.05) value for cover crop × cultivar interaction in 1989 is 0.61 plants/ft.

Cultivar difference in plant populations occurred both years (Table 2). Since the planting seed used in this experiment was obtained from different sources, it is not known whether the differences between the cultivars were due to different growing conditions during the production of the seed lots or were genetically determined.

No differences occurred between cover crop treatments for total seed-cotton yield either year (Tables 1 and 3). Seed-cotton yields averaged 1804 and 2106 lb/acre in 1988 and 1989, respectively. Among cultivars, the short season PD-2 variety had less seed-cotton yield than Coker 315, DPL-50, and McNair 235 in 1988, but no differences occurred in 1989.

Although seed-cotton yields did not differ, cotton grown following a green manured annual legume exhibited delayed maturity compared with cotton following winter fallow. The percentage of total seed-cotton harvested in the first picking was less in plots following cool-season legumes compared to fallow (Table 3). Touchton et al. (1984) found delayed maturity in no-till cotton following a clover winter cover crop with applied N levels of 60 lb/acre, but no delay was found in cotton grown following a vetch winter cover crop with the same level of applied N.

It is not clear why maturity was delayed in the cool-season annual legume plots in this study. Since all plots received equal amounts of fertilizer N, the legume plots would have had more soil N. Higher soil N generally decreases the percent of total yield in the first picking be-

Table 3. Influence of cool-season annual cover crop and cultivar on percent of yield in the first harvest (earliness) and total seed-cotton yield in 1988 and 1989.

Variable	Earliness		Seed-cotton yield	
	1988	1989	1988	1989
	%		lb/acre	
Cover crop				
Fallow	81.4	79.8	1748	2089
Clover	72.2	72.4	1745	2122
Vetch	75.0	--	1919	--
LSD (0.05)	5.7	4.3	NS†	NS
Variety				
Coker 315	74.6	74.6	1948	2151
DPL-50	74.9	76.2	1811	2157
McNair 235	80.5	77.4	1954	2123
PD-2	78.7	77.3	1578	1983
PD-3	72.2	75.2	1730	2116
LSD (0.05)	2.6	NS	231	NS

† NS indicates nonsignificant F value from analysis of variance.

cause of increased growth resulting in higher yield at the second harvest, but does not delay fruiting (Joham, 1986). Since the effect of the legume in our study was to reduce cotton yield at the first harvest (with total seed-cotton yields being equal), it is doubtful that the delayed maturity can be totally attributed to the N supply. Plant heights were measured periodically in 1988, but these data (not shown) did not suggest an alteration in seedling growth since no difference between the cotton growing in the fallow and legume plots was found.

INTERPRETIVE SUMMARY

The use of green manure crops for soil improvement is an ancient practice and recommendations for their use in cotton production have been available for many years. For example, Pieters and McKee (1938) stated that a green manure crop should be turned under three weeks before cotton planting to avoid seedling injury by decomposition products. As Stinner and Blair (1990) have pointed out, however, most crop varieties in use at the present time have been developed for high input farming systems. Out intent in conducting this research was to determine if cultivar differences exist among currently available southeastern USA-adapted cultivars in a production system that uses green manured annual legumes.

We found that all five cultivars yielded similarly in conventional winter fallow and in the green manure plots. This suggests that cotton producers and researchers that incorporate winter annual legumes as winter cover crops can use the same cultivar selection criteria (for example, yield potential, pest resistance, and fiber quality characteristics) used in production schemes that do not include green manured annual legumes. Further, these data indicate that cotton breeders need not develop varieties specifically for use following green manure winter annual legume crops.

REFERENCES

Bradow, J.M., and W.J. Connick, Jr. 1988. Inhibition of cotton seedling root growth by rhizosphere volatiles. p. 90–91. *In* J.M. Brown (ed.) Proc. Beltwide Cotton Prod. Res. Conf. New Orleans, LA. 3–8 Jan. National Cotton Council, Memphis, TN.

Brown, S.M., T. Whitwell, J.T. Touchton, and C.H. Burmester. 1985. Conservation tillage systems for cotton production. Soil Sci. Soc. Am. J. 49:1256–1260.

Ebelhar, S.A., W.W. Frye, and R.L. Blevins. 1984. Nitrogen from legume cover crops for no-tillage corn. Agron. J. 76:51–55.

Grisso, R.D., C.E. Johnson, and W.T. Dumas. 1985. Influence of four cover conditions in cotton production. Trans. ASAE. 28:435–438, 440.

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

Joham, H.E. 1986. Effects of nutrient elements on fruiting efficiency. p. 79–90. *In* J.R. Mauney and J. McD. Stewart (ed.) Cotton physiology. The Cotton Foundation, Memphis, TN.

Megie, A.C., R.W. Pearson, and A.E. Hiltbold. 1967. Toxicity of decomposing crop residues to cotton germination and seedling growth. Agron. J. 59:197–199.

Patrick, Z.A., T.A. Toussoun, and W.C. Snyder. 1963. Phytotoxic substances in arable soils associated with decomposition of plant residues. Phytopathology 53:152–161.

Pieters, A.J., and R. McKee. 1938. The use of cover and green-manure crops. p. 431–444. *In* Soils and men. USDA yearbook of agriculture. U.S. Gov. Print. Office, Washington, DC.

Rickerl, D.H., W.B. Gordon, E.A. Curl, and J.T. Touchton. 1988. Winter legume and tillage effects on cotton growth and soil ecology. Soil Tillage Res. 11:63–71.

Stinner, B.R., and J.M. Blair. 1990. Ecological and agronomic characteristics of innovative cropping systems. p. 123–140. *In* C.A. Edwards et al. (ed.) Sustainable agricultural systems. Soil and Water Conserv. Soc., Ankeny, IA.

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 Tillage Res. 4:391–401.