Enhancing Sustainability in Cotton with Reduced Chemical Inputs, Cover Crops, and Conservation Tillage

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ABSTRACT

In the fall of 2000, an on-farm sustainable agricultural research project was established for cotton at two locations in Georgia. The objectives were to (1) develop cover crop systems for conservation tillage cotton that enhance habitat for aboveground beneficial insects, reduce risks of belowground plant parasitism by nematodes, improve nutrient cycling and water availability, and reduce costs of cotton production, and (2) enhance producer understanding of sustainable principles and practices. Cover crop treatments included: (1) no cover crop, (2) cereal rye, (3) legume blend - balansa clover, crimson clover, and hairy vetch mixture, (4) combination of legume blends plus rye, and (5) crimson clover. This paper is a preliminary report on some of the results on insects for the first year of the project. In the cover crops, mean number of pest insects from highest to lowest occurred in the following order: blend < crimson clover < rye < blend+rye. Mean number of predators followed a similar pattern suggesting that more predators occurred when insect pest density was higher. In cotton, mean number of pest insects from highest to lowest occurred in the following order: blend < blend+rye < crimson clover < rye < no cover. Except for the blend and blend+rye treatments, higher numbers of predators occurred where insect pest numbers were highest. Predator numbers were higher in all cover crop treatments compared to the no cover treatment. No differences in cotton yields were detected among treatments. Number of insecticide applications was significantly lower for the crimson clover and rye treatments than for the no cover, blend+rye, and blend treatments. The data suggests that higher predator density resulted in fewer insecticide applications. So, even though differences in yields statistically were not detected among the treatments, the cover crops benefited the growers by reducing insecticide inputs and thus increasing profit.

KEYWORDS

Cover crops, natural enemies, forage legumes, rye

INTRODUCTION

Eradication of the boll weevil in the early 1990's has re-established cotton as a significant component of farm enterprises in Georgia where cotton expanded from 0.3 million acres in 1990 to 1.5 million acres in 1998 (CTIC, 1998). However, during this time, world yield out paced demand with prices falling from near \$1.15 lb^{-1} in 1995 to between 52 and 55 cents currently (Shurley, 1999). Prices more than 75 cents lb^{-1} are needed to provide a profit with current practices, but sustained price increases are not projected for the future; therefore, to remain competitive in a global market production costs must decline.

Benefits of conservation tillage and cover crops have largely been overlooked in cotton production systems, even though these practices can reduce expensive inputs through improved soil water relationships and long-term soil productivity, increased habitat for beneficial insects and greater agroecosystem stability (Altieri, 1994; Reeves, 1994). Today, nearly 75% of US cotton is grown using conventional tillage without cover crops or rotation (Reeves, 1994), and farm expenditures under these practices have increased 14 percent from 1993 to 1998.

A significant amount of research has been conducted on cover crops in conservation tillage systems in the south (Reeves, 1994). Limited research has focused use of cover crops with conservation tillage to enhance beneficial insects (Ruberson *et al*., 1997; Lewis *et al*., 1997) or for adoption in cotton production (Touchton *et al*., 1984; Hargrove, 1986; Daniel *et al*., 1999a & b). Most studies have focused on comparisons among single species of legumes and non-legumes (Reeves, 1994). Only a few studies have addressed mixtures even though they can provide a more

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diverse biological habitat through an extension of availability of nectar and other food sources (Altieri, 1995).

In the fall of 2000, an on-farm sustainable agricultural research project funded by SARE was established for cotton at two locations in Georgia. The objectives were to

1. develop cover crop systems for conservation tillage cotton that enhance habitat for aboveground beneficial insects, reduce risks of belowground plant parasitism by nematodes, improve nutrient cycling and water availability, and reduce costs of cotton production, and
2. enhance producer understanding of sustainable principles and practices through research and outreach components that educate about environmental and economic benefits of sustainable agriculture systems and expand the network of producers who can provide leadership for further adoption and dissemination of information on sustainable production practices. This paper is a preliminary report on some of the results on insects for the first year of the project.

MATERIALS AND METHODS

Cover Crop Treatments

In 2001, studies were conducted on farms near Louisville, GA and Tifton, GA. Only the results of the studies in Tifton will be reported in this paper. The primary on-farm study compared traditional cover crop practices to two diverse cover crop mixtures designed to extend availability of food sources to beneficial insects and increase biomass inputs to improve soil organic matter content. Cover crops in the mixture were chosen based on early, midseason, and late blooming characteristics and their adaptation to the area. Cover crop treatments included: (1) no cover crop-conventional practice where farmers allow weeds to grow during the winter, (2) cereal rye - standard grass cover crop, (3) legume blend - balansa clover, crimson clover, and hairy vetch mixture chosen to extend flowering (early, mid, and late flowering, respectively), (4) combination of legume blend plus rye - combines benefits of legume nectar production and N fixation with enhanced biomass production of rye, and (5) crimson clover – standard legume cover crop. Ten-acre fields were used for each treatment. Fields were chosen to ensure homogenous soil types for all fields within a location.

Cover Crop Management

Cover crops were drill planted in the fall directly into mowed cotton stubble. Cover crops were killed 3 weeks prior to cotton planting by applying glyphosate in 24 inch wide bands leaving 12 inch wide strips of cover crop that grew to maturity providing an insect habitat for a relay of insects from the cover crop to cotton.

Cotton Production

Cotton was planted at 7 to 10 lbs acre^{-1} on all fields using either 4 or 6 row strip-till planters. No nematicide was applied to the fields. In the rye-legume mixture, cotton was planted in killed rye strips. Aboveground insect control relied on beneficial insects, and insecticides were applied only as a last resort for pest control. The number of insecticide applications was recorded. Cotton yield was determined using a mechanical picker. Cotton yield and insecticide application data were analyzed by PROC MIXED COVTEST followed by LSD separation of means (SAS Institute 2000).

Above Ground Insect Dynamics

Insect population density was determined for insect pests and natural enemies. Cover crops and cotton were sampled from the seedling stage until senescence or harvest. Sampling method depended on plant growth stage and species, and biology and behavior of pest and natural enemy species. Techniques included shake cloth samples, sweep net samples, and whole plant samples. This paper reports some of the results from sweep samples. Twenty-one 20-ft sweep samples were obtained each week for each replicate of each treatment. Insect pest and natural enemy density data were analyzed by PROC MIXED COVTEST followed by LSD separation of means (SAS Institute 2000).

Results and Discussion

In the cover crops, mean number of pest insects from highest to lowest occurred in the following order: blend < crimson clover < rye < blend+rye (Table 1). Mean number of predators followed a similar pattern suggesting that more predators occurred when insect pest density was higher.

Table 1. Mean pest insects and predators in cover crops for 20-foot sweeps in the legume blend, crimson clover, legume blend + rye treatments.

	Insect Pests			Predators		
Treatment	Mean		SE	Mean		SE
	-------- count per 20-foot sweep ---------					
Blend	12.25	a†	0.68	7.06	a	0.22
Crimson Clover	7.51	b	0.68	3.85	b	0.22
Rye	6.45	b,c	0.77	1.38	c	0.25
Blend + Rye	4.33	c	0.80	0.87	c	0.24

† Means within a column followed by the same letter do not differ statistically based on $LSD_{0.05}$.

Table 2. Mean pest insects, predators, cotton yields, and insecticide applications in cotton for 20-foot sweeps in legume blend, crimson clover, legume blend + rye, rye, and no cover treatments. The last columns refer to the number of insecticide applications needed as a last resort for pest control.

	Pest insects			Predators			Cotton Yield			No. of applica.		
Treatment	Mean		SE	Mean		SE	Mean		SE	Mean		SE
	-------- count per 20-foot sweep --------						Bales acre^{-1}					
No cover	2.1	c†	0.8	1.1	d	0.4	1.9	a	0.2	1.8	a	0.4
Blend + Rye	2.3	c	1.1	3.4	a,b	0.4	2.4	a	0.2	1.7	a	0.4
Blend	1.9	c	1.0	3.1	c	0.4	2.1	a	0.2	1.3	a,b	0.4
Rye	10.4	a	1.1	4.6	a	0.4	2.1	a	0.2	0.3	b,c	0.4
Crimson Clover	6.4	b	1.1	4.4	bc	0.4	2.4	a	0.2	0.0	c	0.4

† Means within a column followed by the same letter do not differ statistically based on $LSD_{0.05}$.

In cotton, mean number of pest insects from highest to lowest occurred in the following order: blend < blend+rye < crimson clover < rye < no cover (Table 2). Except for the blend and blend+rye treatments, higher numbers of predators occurred where insect pest numbers were highest. Predator numbers were higher in all cover crop treatments compared to the no cover treatment. Interestingly, predator numbers were higher in the blend and blend+rye treatments than in the no cover treatment even though pest numbers were about the same for all three treatments. No differences in cotton yields were detected among treatments. The number of insecticide applications was similar for the no cover, blend+rye, and blend treatments. The number of insecticide applications was significantly lower for the crimson clover and rye treatments than for the no cover, blend+rye, and blend treatments. Except for the blend+rye treatment, the data suggests that higher predator density resulted in fewer insecticide applications. So, even though differences in yields statistically were not detected among the treatments, the cover crops benefited the growers by reducing insecticide inputs and thus increasing profit.

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LITERATURE CITED

Altieri, M.A. 1995. Agroecology, the science of sustainable agriculture. 2nd ed. Westview Press, Boulder CO.

Altieri, M.A. 1994. Biodiversity and pest management in agroecosystems. Food Products Press, New York.

CTIC. 1998. National crop residue management survey. Conservation Technology Information Center, West Lafayette, IN.

Daniel, J.B., A.O. Abaye, M.M. Alley, C.W. Adcock, and J.C. Maitland. 1999a. Winter annual cover crops in a Virginia no-till cotton production system. I. Biomass production, ground cover, and nitrogen assimilation. J. Cotton Science 3:74-83.

Daniel, J.B., A.O. Abaye, M.M. Alley, C.W. Adcock, and J.C. Maitland. 1999b. Winter annual cover crops in a Virginia no-till cotton production system. II. Cover crop and tillage effects on soil moisture, cotton yield, and cotton quality. J. Cotton Sci. 3:84-91.

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

Lewis, W.J., P.B. Haney, R. Reed, and A. Walker. 1997. A total systems approach for sustainable cotton production in Georgia and the southeast: first year results. pp. 1129-1134. *IN* Proc. Beltwide Cotton Prod. Res. Conf. National Cotton Council, Memphis, TN.

Reeves, D.W. 1994. Cover crops and rotations. pp.125-172. *IN* J. L. Hatfield and B. A. Stewart (eds.) Crops Residue Management. Advances in Soil Science. Lewis Publishers, Boca Raton, FL.

Ruberson, J R., S.C. Phatak, and W.J. Lewis. 1997. Insect populations in a cover crop/strip till system. pp. 1121-1124. *IN* Proc. Beltwide Cotton Prod. Res. Conf. National Cotton Council, Memphis, TN.

SAS Institute. 2000. SAS/C online document™, Release 7.0, Cary, NC, SAS Institute, Inc.

Shurley, D. 1999. The US cotton situation and outlook for 1999/2000. Paper presented at the American Agricultural Economics Association, Nashville, TN, August 9, 1999. (Available at www.ces.ugs.edu/agriculture/agecon/outlook/cotton/cotton2000.html)

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.