USE OF LEGUME WINTER COVER CROPS IN COTTON PRODUCTION SYSTEMS

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INTRODUCTION

Cover crops historically were widely grown in the southeastern United States, with an estimated 13 million acres of cover crops grown in this region in 1940 (Rogers and Giddens, 19571. Cover crops were incorporated as green manures prior to planting a summer or cash crop in an effort to maintain soil productivity in the absence of inexpensive inorganic fertilizers. Recently there has been a resurgence in research and interest in winter cover crops, especially legumes lHoyt and Hargrove, 1986; Smith et al., 19871. These crops are being evaluated for their effectiveness in reducing soil erosion and nitrogen contribution to the subsequent cash crop. Estimates of nitrogen (N) contribution from a hairy vetch (Vicia villosa Roth) cover crop for a subsequent cotton (Gossypium hirsutum L.) crop ranged from 6-60 lb N/A (Brown et al., 1985; Melville and Rasbury. 1980; Scott et al., 1990, Touchton et al., 1984). In addition to nitrogen, a number of soil properties are improved by cover crops including increased soil organic matter, saturated hydraulic conductivity, and water infiltration rates (Scott et al., 1990).

Long-term studies have demonstrated the feasibility of a legume cover crop-cotton production system. In a study conducted since 1972 at the Delta Branch Station, Clarkedale, Arkansas, hairy vetch plus rye (Secale cereale L.) or hairy vetch cover crop treatments significantly increased seedcotton yields by 263 and 145 lb/A, respectively, compared with winter fallow (Scott et al., 19901. Annual seedcotton yields in a long-term study (1955-1980) at the Red River Research Station near Bossier City, Louisiana, were 2152 lb/A following hairy vetch compared to 2120 lb/A for cotton monoculture with 60 lb/A of supplemental nitrogen (Dawkins and Paxton, 1983).

One of the concerns with the use of cover crops has involved a perception that pest problems in the cash crop would increase due to the cover crop. However, there is limited data on the impact of cover crops on pest populations and pest damage for the subsequent cash crop. This information is critical for cotton, a crop in which profitability is determined in large part by pest damage and pesticide use. Seven sites were examined for the benefits and risks from pests as a result of the use of winter legume cover crops in cotton production systems as part of a Sustainable Agriculture Research and Education Grant. All sites had the cover crop treatments hairy vetch and winter fallow. Two long-term sites were included; Clarkedale, Arkansas, established in 1972, and Bossier City, Louisiana, established in 1955. Tillage comparisons, conservation vs. conventional, are included at four sites. The entomology sites, Edisto. SC and Foreman, AR ,included two hairy vetch treatments; 1) all of the cover crop incorporated, and 2) strips of hairy vetch allowed to mature. This report will focus on the impact of legume cover crops on seedling diseases of cotton.

MATERIALS AND METHODS

Field sites

Field studies on seedling diseases of cotton were conducted in 1992 and 1993 at 5 locations (Table 1). Timing of some field operations are listed in Table 1. Cotton stands were determined by counting seedlings in two 20 ft sections of row per plot. Sites were managed according to current University Cooperative Extension Service recommendations.

Soil Populations

Soil samples, 0 to 6 in., were taken along diagonals on the bed or within the row at three times; prior to planting cotton, at approximately cotton planting, and 6 weeks postplanting. Samples were refrigerated at 2 to 5 C and mixed thoroughly prior to assaying. Twenty-five grams of soil (oven dry weight1 were suspended in sufficient

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Table 1. Experimental outline for cover crop sites.

Site component	Clarkedale	Rohwer	Lewisville	Bossier City	Springfield
Plot design	Split plot	Split-split-split plot	Split plot	Split plot	Split-split plot
Cover crop treatments	Hairy vetch Winter fallow Hairy vetch +rye Crimson clover + rye	Hairy vetch Winter fallow Rye Wheat Crimson clover	Hairy vetch Common vetch 'Cahaba White' Winter fallow	Hairy vetch Winter fallow	Hairy vetch Common vetch 'Cahaba White' Fallow
Tillage treatments	Conventional Conservation	Conventional Conservation	Conventional Conservation	Conventional	Conventional Conservation
Other treatments		Irrigation +/- "Burndown" +/-		Nitrogen level	Aldicarb +/-
Replications	4	4	4	4	6
Plot size	8 rows x 100 ft	4 rows x 40 ft	6 rows x 50 ft	6 rows x 210 ft	8 rows x 50 ft
Soil type	Dubbs/Dundee silt loam	Hebert silt loam	Caspianna silt loam	Norwood very fine sandy loam	Lucy loamy sand
Cover crop killed	4/8/92 4/14/93	3/16/92 3/28/93	3/27/92 4/7/93	4/16/92 4/21/93	4/28/92 6/21/93
Cotton planted	5/12/92 5/26/93	5/2/92 5/6/93	5/8/92 5/3/93	5/5/92 5/7/93	5/26/92 6/21/93

0.2% water agar to make 250 ml. The sample was shaken on a wrist action shaker for 20 min prior to assaying populations or making additional dilutions. The spread plate method was used for estimating populations of Pythium spp. on P_6ARP (Jeffers and Martin, 1986). Populations of Thielaviopsis basicola were determined by the pour-plate method in TB-CEN (Specht and Griffin, 19851. Soil populations of Rhizoctonia spp. were determined by the soil-pellet method with a multiple-pellet soil sampler (Henis et al., 1978) on Ko and Hora's medium (Ko and Hora, 1971).

Seedling disease and pathogen isolation

Cotton seedling samples were collected approximately three weeks after planting from five random one foot sections of row. Seedlings were rinsed for 45 minutes in running tap water and rated for seedling disease symptoms. The hypocotyl disease severity index was 1=no symptoms, 2=few pinpoint lesions or diffuse discolored areas, 3=distinct nongirdling necrotic lesion, 4=girdling lesion, and 5=seedling dead. The root disease index was 1=no symptoms, 2=1-10% of the root system discolored, 3=11-25% of the root system discolored, 4=26-50% of the root system discolored, and 5>50% of the root system discolored. Seedlings were surface disinfested by immersion for 1.5 min in 0.5% NaClO and plated on water agar (2%). Resulting colonies were transferred to PDA and identified to genus. Seedlings were subsequently transferred to the Thielaviopsis selective medium to determine isolation frequency for T. basicola.

RESULTS AND DISCUSSION

Plant Stand

Cotton plant stands were similar over all winter cover crop treatments for 1992 and 1993. The conservation tillage treatment resulted in lower plant stands compared to conventional tillage at Rohwer in 1992 and Clarkedale in 1992 and 1993 (data not shown).

Soil populations

Differences were observed among treatments for soil populations of selected fungal genera. Pythium populations were significantly greater for the plots containing hairy vetch for most of the sites sampled compared to winter fallow (Table 2). In addition, the other winter cover crops at Clarkedale crimson clover + rye and hairy vetch + rye also increased populations of Pvthium spp. in soil. A rye winter cover crop at Rohwer did not elevate Pythium populations. The elevation of soil populations of Pythium spp. following winter legume cover crops has been reported previously (Rothrock and Hargrove, 1988). Populations of Pythium spp. also were greater under the conventional tillage treatment at Rohwer (Table 2) and Clarkedale (data not shown) than under the conservation tillage treatment.

Thielaviopsis basicola populations were only detected in appreciable numbers at the long-term Clarkedale site. Soil populations were significantly lower following the cover crop treatments hairy vetch and hairy vetch + rye compared to the winter fallow treatment (Table 2). Evidence for the suppression of T. basicola populations from the incorporation of hairy vetch also has been shown in controlled environmental studies (Rothrock and Kendig, 1991).

Soil populations of Rhizoctonia spp. did not differ with cover crop treatment (Table 2) for the at planting sample in 1992 or 1993. Greater populations were found in the conventional tillage treatment at Springfield, SC than the conservation tillage treatment in 1992. Tillage did not significantly influence Rhizoctonia populations at the other sites.

Seedling disease

Seedling diseases were more severe at Clarkedale in 1992 and Lewisville. Seedling disease severity was not consistently influenced by cover crop or tillage treatment. Cotton seedlings showed slightly greater root and hypocotyl disease symptoms in the hairy vetch treatment than the winter fallow or common vetch treatments at Springfield in 1992 (Table 3). However, a rye cover crop increased root disease severity at Rohwer in 1993 and the winter fallow treatment had the greatest root disease severity at Clarkedale in 1993. Conventional tillage decreased root disease severity compared to the conservation tillage treatment at Rohwer in both 1992 and 1993 (Table 3) and Clarkedale in 1993, but increased disease severity at Clarkedale in 1992 (data not shown).

Table 2. Influence of winter cover crop and tillage treatments on soil populations of selected plant pathogenic genera at cotton planting.[y]

	Rhizoctonia spp.		Pythium spp.		Thielaviopsis basicola	
Location/Treatment	1992	1993	1992	1993	1992	1993
Clarkedale, AR						
Cover crop						
Hairy vetch	35.4 a[z]	0 a	864,562 a	562,010 a	5,715 b	5,080 b
Winter fallow	55.8 a	0 a	175,543 c	258,098 c	30,391 a	25,401 a
Rye + crimson clover	19.5 a	8.2 a	762,068 ab	606,463 a	18,235 ab	23,224 a
Rye + hairy vetch	7.7 a	0 a	603,742 b	413,683 b	15,649 b	6,441 b
Lewieville, AR						
Tillage						
Conservation	6.8 a	0 a	107,503 a	184,615 a	0 a	0 a
Conventional	8.2 a	0 a	152,410 a	139,255 a	0 a	0 a
Cover crop						
Hairy vetch	8.6 a	0 a	224.078 a	217.274 a	0 a	0 a
Winter fallow	14.1 a	0 a	64,411 b	102,060 b	0 a	0 a
Common vetch	0 a	0 a	102,060 b	166.471 ab	0 a	0 a
Rohwer, AR						
Tillage						
Conservation	42.6 a	6.4 a	203,213 b	315,706 b	0 a	363 a
Conventional	62.6 a	2.3 a	529,351 a	372,859 a	91 a	816 a
Cover crop						
Hairy vetch	83.5 a	0 a	619,614 a	349.726 a	91 a	91 a
Winter fallow	45.4 a	10.0 a	253,109 b	351,540 a	45 a	181 a
Rye	29.5 a	3.2 a	226,800 b	331,582 a	0 a	953 a
Springfield, SC						
Tillage						
Conservation	28.6 a		59,422 a		0 a	
Conventional	68.9 b		50,803 a		0 a	
Cover crop						
Hairy vetch	74.4 a		92,081 a		0 a	
Winter fallow	40.4 a		35,834 b		0 a	
Common vetch	32.2 a		54,432 b		0 a	
Bossier City, LA						
Cover crop						
Hairy vetch	172.4 a	74.8 a	8,165 a	108,864 a	0 a	0 a
Winter fallow	127.0 a	57.6 a	11,340 a	109.771 a	0 a	0 a

[y] Propagules per lb of soil. Zero = populations below the detectable level.

[z] Means within a column and location and main effect are not significantly different if they are followed by the same letter, LSD ($P = 0.05$).

Table 3. Influence of cover crop and tillage on seedling diseases and isolation frequency of pathogens.

Location/Treatment	Isolation frequency (%)[v] Rhizoctonia solani 1992	1993	Pythium spp. 1992	1993	Thieleviopsis basicola 1992	1993	Diseases severity index Hypocotyl[w] 1992	1993	Root[x] 1992	1993
Clarkedale										
Cover crop										
Hairy vetch	7.8 a[y]	9.0 a	23.6 a	35.0 b	19.2 c	1.0 a	2.4 a	2.0 a	3.0 a	1.5 b
Winter fallow	12.3 a	6.2 a	10.6 ab	30.2 bc	76.0 a	5.8 a	2.3 s	2.2 a	3.2 a	2.1 a
Rye+clover	4.3 a	3.0 a	17.1 ab	66.0 a	58.7 b	5.0 a	2.6 a	2.0 a	3.6 a	1.6 b
Rye+vetch	1.7 a	10.0 s	4.1 b	15.0 c	44.8 b	2.0 e	2.2 a	2.1 a	3.4 a	1.6 b
Lawisville										
Tillage										
Conservation	6.7 a	1.0 b	32.0 a	8.0 a	0 a	0.3 a	2.0 a	2.0 s	2.5 a	3.2 a
Conventional	13.2 a	3.3 a	25.0 a	6.4 a	o s	0.0 e	2.1 a	1.8 a	2.9 a	3.5 a
Cover crop										
Hairy vetch	6.8 a	3.5 s	29.8 e	9.0 a	o s	0.0 a	2.0 a	1.9 a	2.3 a	3.3 a
Winter fallow	9.5 a	3.0 a	23.8 e	4.5 a	0 a	0.5 a	2.1 s	1.9 a	2.9 a	3.4 a
Common vetch	13.5 a	O b	31.9 a	8.0 a	0 a	0.0 a	2.1 e	1.9 a	2.9 e	3.4 a
Rohwer										
Tillage										
Conservation	8.3 a	2.5 b	5.2 a	12.2 a	0 a	1.5 b	1.6 e	2.4 a	2.5 a	2.9 a
Conventional	17.8 a	6.9 a	10.1 a	18.5 a	0 a	11.8 a	1.7 a	2.2 a	1.9 b	2.5 b
Cover crop										
Hairy vetch	18.9 a	7.5 a	13.9 a	10.3 a	o s	10.6 a	1.7 a	2.3 a	2.1 a	2.6 b
Winter fallow	6.5 b	3.2 s	3.6 b	18.0 a	0 a	1.7 e	1.6 a	2.2 a	2.1 a	2.4 b
Rye	13.7 ab	3.2 s	5.3 b	17.8 a	0 a	7.7 a	1.7 a	2.4 a	2.3 a	3.1 a
Springfield										
Tillage										
Conservation	22.9 a		nc[z]		0 a		2.4 a		2.6 a	
Conventional	38.3 a		nc		0 a		2.3 a		2.3 a	
Cover crop										
Hairy vetch	27.1 a		nc		0 a		2.5 a		2.7 a	
Winter fallow	29.2 a		nc		0 a		2.2 b		2.3 b	
Common vetch	35.5 e		nc		0 a		2.2 b		2.3 b	

[v] Isolation frequency is based on seedlings from 5 random 1 ft sections of row, <= 25 plants.
[w] Hypocotyl disease index: 0 = no symptoms, 5 = seedling dead.
[x] Root disease index; 0 = no symptoms, 5 = greater than 50% root discoloration.
[y] Means within a column and location and main effect ara not significantly different if they are followed by the same letter. LSD ($P = 0.05$).
[z] Identification not completed. However, percent isolation was very low at this site.

Isolation frequency of pathogens varied among locations (Table 3). T. basicola was one of the major components of the cotton seedling disease complex at Clarkedale in 1992. The importance of reduced populations of this pathogen following a hairy vetch cover crop was indicated by the low incidence of black root rot, isolation of T. basicola, on cotton for these treatments (Table 3). Differences in isolation frequency of Pythium spp. from cotton seedlings were found among the cover crop treatments in 1992 and 1993, but results were not consistent. A hairy vetch cover crop tended to increase isolation frequency of R. solani at Rohwer in 1992, but hairy vetch did not influence isolation frequency in other years or locations (Table 3). Tillage influenced isolation frequency significantly at three sites. Conservation tillage decreased isolation frequency of Pythium spp. at Clarkedale (data not shown), T. basicola at Clarkedale in 1992 and Rohwer in 1993. and decreased R. solani at Rohwer and Lewisville in 1993 (Table 3).

SUMMARY

These results suggest that winter cover crops influence some cotton seedling diseases to a greater degree than others. Because several pathogens may be responsible for seedling disease, it is important to know which diseases are important in each field. Legume cover crops may reduce seedling disease in situations where T. basicola is an important pathogen. In contrast, when R. solani is an important component of the seedling disease complex, disease severity may increase. The data stress that the impact of cover crops on individual pests and pest damage will have to be understood before integrated crop management systems that include cover crops can be developed. An interdisciplinary team is addressing a number of aspects of the use of cover crops in cotton production, including the impact of cover crops on insects, nematodes. and weeds. Research suggests that the environmental sound production practice of the use of winter legume cover crops does not increase pest problems and may reduce specific problems such as black root rot. Initial results indicate the profitability of the production system varies dramatically over sites.

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