The Influence of Winter Legume Cover Crops on Soilborne Plant Pathogens and Cotton Seedling Diseases

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ABSTRACT

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The influence of winter legume cover crops on soilborne plant pathogens and seedling diseases of cotton was examined at two locations over 2 yr. The Clarkedale site was a long-term cover crop experiment established in 1972. The Lewisville site was established in a production field with a history of cotton monoculture. Soil populations of *Thielaviopsis basicola* and isolation frequency of this pathogen from cotton seedlings were reduced following a hairy vetch cover crop compared with winter fallow at Clarkedale, the only site with moderate to high soil populations of this pathogen. Isolation of *Rhizoctonia solani* from cotton seedlings and soil populations of *Rhizoctonia* spp. at planting were increased following hairy vetch compared with winter fallow at Lewisville. A similar trend was found for *Rhizoctonia* spp. following hairy vetch at Clarkedale. Soil populations of *Pythium* spp. were greater at both locations following a legume cover crop compared with winter fallow; however, no differences among cover crop treatments were found for isolation frequency of this genus from seedlings. The other cover crop treatments (common vetch, hairy vetch plus rye, or crimson clover plus rye) were intermediate between winter fallow and hairy vetch in their influence on pathogen populations and isolation frequency. Bacterial and fungal populations were greater in the cropping system containing a hairy vetch cover crop compared with winter fallow at Clarkedale. The influence of winter legume cover crops on the seedling disease complex depended on the prevalent pathogens at each location. Winter legumes do not appear to increase the risks of cotton seedling diseases sufficiently to deter their use in reducing soil erosion and providing nitrogen to a subsequent cash crop, and can reduce the risk of black root rot.

Additional keywords: *Gossypium hirsutum, Vicia villosa, Chalara elegans, Thanatephorus cucumeris*

Cover crops historically have been important in the southeastern United States. In 1940, an estimated 5.3 million hectares of cover crops were grown in this region (24). 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 inorganic fertilizers. Recently there has been a resurgence in research and interest in winter cover crops, especially legume cover crops (8,28), for their effectiveness in reducing soil erosion and their nitrogen contribution to the subsequent cash crop.

Long-term studies have demonstrated the feasibility of a legume cover crop–cotton (*Gossypium hirsutum* L.) production system. In a study conducted since 1972 at the Delta Branch Station, Clarkedale, AR, cover crop treatments of hairy vetch (*Vicia villosa* Roth) plus rye (*Secale cereale* L.) or hairy vetch alone significantly increased annual seed cotton yields by 295 or 162 kg/ha, respectively, compared with winter fallow (27). Annual seed cotton yields in a long-term study (1955–1980) at the Red River Research Station near Bossier City, LA, were 2,411 kg/ha following hairy vetch compared with 2,375 kg/ha for cotton monoculture with 67 kg/ha of supplemental nitrogen (5). Estimates of nitrogen (N) contribution from a hairy vetch cover crop for a subsequent cotton crop ranged from 7 to 72 kg N/ha (3,18,27,32). In addition, a number of soil properties were improved with the use of cover crops including increased soil organic matter, saturated hydraulic conductivity, and water infiltration rates (27). Reduced cotton stands also have been associated with the use of some winter cover crops (23).

There is limited information 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. Incorporation of either hubam (*Melilotus alba Medik.* var. *annua* H. S. Coe) or indica (*Melilotus indica* (L.) All.) clover cover crops reduced the number of plants killed by Phymatotrichum root rot and increased cotton yields (14). Cover crops also have been used to suppress diseases on other crops (2,7,19). The addition of organic amendments to soil has been shown to suppress pathogens responsible for seedling diseases of cotton (20,33), including *Thielaviopsis basicola* (Berk. & Broome) Ferraris (*Chalara elegans* Nag Raj & Kendrick) (22), *Rhizoctonia solani* Kühn [*Thanatephorus cucumeris* (A. B. Frank) Donk] (15,21), and *Pythium* spp. (12).

This study examined the influence of winter cover crops on soil populations and isolation frequency of cotton seedling pathogens and seedling diseases on cotton. A preliminary report has been published (26).

MATERIALS AND METHODS

Field sites. Field studies were conducted in 1989 and 1990 at two locations in Arkansas. A long-term cover crop site established in 1972 at the Delta Branch Station, Clarkedale, is a Dubbs-Dundee complex fine silty loam. The cover crop treatments were *(1)* hairy vetch, planted since 1972, *(2)* hairy vetch plus rye, planted since 1977, *(3)* crimson clover (*Trifolium incarnatum* L.) plus rye, planted since 1979, and *(4)* winter fallow. They were established by broadcasting seed of the cover crops on 27 October 1988 and 10 October 1989. Aboveground cover crop biomass, 0.84 m^2 per plot, was harvested on 11 April 1989 and 9 April 1990 and fresh weight determined. Cover crops were shredded, incorporated, and rows bedded on 11 April 1989 and 9 April 1990. Plots were fertilized with 59 and 48 kg N/ha in 1989 and 1990, respectively, and 6.4 kg phosphorus and 12.1 kg potassium per hectare in 1990. Plots, 8 rows (1.02 m row spacing) × 30 m in length, were planted on 17 May 1989 and 8 May 1990 with cv. Deltapine 50. Cotton stands were determined on 7 June 1989 and 29 May 1990 by counting seedlings in two 6.1-m sections of row per plot. Four 30-m rows from each plot were mechanically harvested twice for seed cotton yields on 6 and 24 October 1989 and 25 September and 16 October 1990. The experimental design was a randomized complete block with four replications.

The second field site on a Caspianna silt loam was established in 1988 in a grower's field in southwestern Arkansas near Lewisville. This field had a history of cotton monoculture, approximately 10 yr, and a Fusarium wilt-root-knot nematode problem. The experiment was

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a split-plot design with cover crop treatments as the main plots and nitrogen treatments as subplots. The cover crop treatments were *(1)* winter fallow, *(2)* hairy vetch, and *(3)* common vetch (*Vicia sativa* L.) cv. Cahaba white. They were broadcast on 21 November 1988 and 19 October 1989. The four nitrogen treatments were 0, 38, 76, and 114 kg N/ha. Aboveground cover crop biomass, two 0.1 m^2 per plot, was harvested on 13 April 1989 and 13 April 1990 and fresh weight determined. Cover crops were disked under on 11 May 1989 and 13 April 1990 during preparation of the seedbed. Plots, 4 rows (0.97 m row spacing) × 7 m in length, were planted on 12 May 1989 and 8 May 1990 with cv. Stoneville 825. Cotton stands were determined on 1 June 1989 and 6 June 1990 by counting seedlings in two 6.1-m sections of row per plot. Cotton was not harvested at Lewisville because of extensive plant mortality due to Fusarium wilt. Each cover crop treatment was replicated four times. Both sites were managed for insects and weeds according to current University of Arkansas Cooperative Extension Service recommendations (1).

Microbial populations. Soil samples, 15 cm deep, were taken along diagonals on the bed or within the row at three times: *(1)* prior to planting cotton, *(2)* approximately at cotton planting, and *(3)* 6 wk postplanting. Soil samples were taken at Clarkedale on 1 May, 31 May, and 28 June in 1989, and on 10 April, 16 May, and 19 June in 1990. Soil samples were taken at Lewisville on 12 April, 12 May, and 22 June in 1989, and 13 April, 10 May, and 19 June in 1990. Samples were refrigerated at 2–5 C and mixed thoroughly prior to assaying. Twenty-five grams of soil (oven dry weight) were suspended in sufficient 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_5ARP (9), six plates per plot. Ten *Pythium* colonies per plot were selected at random from dilution plates for the at-planting sample for both locations and tested for pathogenicity by a cotton hypocotyl assay (10). A hypocotyl disease rating of >2 was considered a pathogenic reaction (see seedling disease and pathogen isolation). Populations of *Thielaviopsis basicola* were determined by the pour-plate method on TB-CEN (30), 10 plates per plot. Soil populations of *Rhizoctonia* spp. were determined by the soil-pellet method with a multiple-pellet soil sampler (6) on tannic acid-benomyl medium using metalaxyl in place of pyroxyclor (31). A total of 105 pellets per plot were incubated for 48 hr and suspected colonies of *Rhizoctonia* spp. transferred to potato-dextrose agar for identification. Nuclear status of *Rhizoctonia* isolates was determined by staining hyphae with DAPI (4′,6′-diamidino-2-phenylindole) and *R. solani* isolates were identified to anastomosis group (AG) group by pairing isolates with anastomosis testers on cellophane (4). The percentage of pellets from which *Rhizoctonia* spp. grew was recorded and populations were adjusted for multiple colonization as suggested by Sneh et al (29).

Soil populations of bacteria, actinomycetes, and fungi were determined for the at-planting sample for both locations in both years. Ten grams of soil (oven dry weight) were placed in a pharmaceutical bottle and suspended in sufficient water to make 100 ml. Fifteen 2-mm-diameter glass beads were added to the pharmaceutical bottle and the bottles were shaken for 10 min on a wrist action shaker. Ten-fold dilutions were made from the original suspension and populations were assayed by the pour plate method. Fungi were assayed on Martin's rose bengal agar (16), bacteria were assayed on tryptic soy agar containing 3 g tryptic soy broth (17), and actinomycetes were assayed on chitin agar (13).

Seedling disease and pathogen isolation. Cotton seedling samples were collected approximately 3 wk after planting on 8 June 1989 and 29 May 1990 at Clarkedale and 2 June 1989 and 31 May 1990 at Lewisville from five arbitrary 0.3-m sections of yield rows, with the exception of Lewisville in 1990 when additional samples were taken. Seedlings were rinsed for 45 min 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

Table 1. Influence of cover crop treatments on soil populations of specific fungal groups at Clarkedale[x]

	Rhizoctonia spp. (cfu[y]/100 g soil)			*Pythium* spp. (cfu/g soil)				*Thielaviopsis basicola* (cfu/g soil)			
					AT					POST	
Main effect	PRE	AT	POST	PRE	1989	1990	POST	PRE	AT	1989	1990
Year											
1989	16 a[z]	10 a	10 a	758 a			900 a	86.1 a	113.9 a		
1990	7 b	14 a	1 b	508 b			598 b	97.5 a	67.0 b		
Cover crop											
Winter fallow	10 a	12 a	8 a	515 b	456 b	471 c	501 b	125.5 a	131.6 a	275.1 a	90.4 a
Crimson clover + rye	13 a	7 a	3 a	753 a	1,012 a	1,350 b	994 a	96.2 a	64.1 b	236.8 a	52.0 a
Hairy vetch + rye	8 a	9 a	2 a	795 a	1,256 a	1,400 ab	941 a	49.6 b	50.6 b	87.2 b	44.8 a
Hairy vetch	17 a	19 a	4 a	704 a	1,069 a	1,688 a	1,056 a	28.5 b	33.1 b	57.5 b	10.5 a

[x]Samples obtained preplanting (PRE), at-planting (AT), or postplanting (POST).
[y]Colony-forming units.
[z]Means followed by same letter within a column and main effect are not significantly different, LSD ($P = 0.05$).

Table 2. Influence of cover crop treatments on soil populations of specific fungal groups at Lewisville[x]

	Rhizoctonia spp. (cfu[y]/100 g soil)			*Pythium* spp. (cfu/g soil)				*Thielaviopsis basicola* (cfu/g soil)		
						POST				
Main effect	PRE	AT	POST	PRE	AT	1989	1990	PRE	AT	POST
Year										
1989	57 a[z]	53 a	25 a	247 b	610 a			2.0 a	1.5 a	2.4 a
1990	8 b	20 b	7 b	296 a	659 a			3.8 a	4.7 a	2.0 a
Cover crop										
Winter fallow	31 a	23 b	15 a	225 b	365 c	175 c	255 c	4.5 a	3.7 a	2.9 a
Common vetch	38 a	38 ab	15 a	271 ab	627 b	503 b	552 b	1.5 a	1.8 a	1.1 a
Hairy vetch	30 a	48 a	20 a	316 a	911 a	632 a	1,052 a	2.8 a	3.8 a	2.6 a

[x]Samples obtained preplanting (PRE), at-planting (AT), or postplanting (POST).
[y]Colony-forming units.
[z]Means followed by same letter within a column and main effect are not significantly different, LSD ($P = 0.05$).

areas, 3 = distinct 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, blotted dry with paper towels, and plated on water agar (2%). Resulting colonies were transferred to potato-dextrose agar and identified to genus. Seedlings were subsequently transferred to the *Thielaviopsis* selective medium to determine isolation frequency for *T. basicola.*

Statistics. Data were analyzed by the GLM procedure using SAS (SAS Institute Inc., Cary, NC). The Clarkedale site was analyzed as a randomized complete block by year or as a split-plot design over year, with year as the main plot. The Lewisville site was analyzed as a split-plot design, with cover crop treatment as the main plot and nitrogen treatment as the subplot, or as a split-split plot design; with year as the main plot, cover crop treatment as the subplot, and nitrogen as the sub-subplot. If an interaction between year and cover crop was present, the data for each year are presented separately.

RESULTS

Soil populations. No significant differences in soil populations of *R. solani* were observed among cover crop treatments at Clarkedale (Table 1). There was a trend, however, toward increased populations following hairy vetch incorporation for the preplanting and at-planting sample. Forty percent of *Rhizoctonia* isolates from soil at Clarkedale were multinucleate. All multinucleate isolates were *R. solani* AG-4. Soil populations of *R. solani* at Lewisville were lower in 1990 than in 1989 (Table 2). *R. solani* populations at Lewisville were greater following hairy vetch than following winter fallow for the at-planting sample. All *Rhizoctonia* isolates from soil at Lewisville were multinucleate and *R. solani* AG-4.

Soil populations of *Pythium* spp. were greater for all winter cover crops than for winter fallow at Clarkedale (Table 1). In 1990, crimson clover plus rye had lower soil populations of *Pythium* spp. compared with hairy vetch at the time cotton was planted. Pathogenicity assays of randomly selected *Pythium* colonies at Clarkedale indicated a greater percentage of the *Pythium* soil population was pathogenic to cotton following hairy vetch (56%) than following hairy vetch plus rye (41%), winter fallow (37%), or crimson clover plus rye (45%), $P = 0.05$. *Pythium* populations were greater for the hairy vetch treatment than for winter fallow at all sample times at Lewisville (Table 2). *Pythium* soil populations for the common vetch treatment were intermediate between hairy vetch and winter fallow. No differences in the percentage of the *Pythium* soil population that were pathogenic were found at Lewisville; hairy vetch (67%), common vetch (58%), or winter fallow (48%), $P = 0.05$.

Thielaviopsis basicola was one of the major components of the cotton seedling pathogen complex at Clarkedale. Soil populations were lower following the incorporation of the cover crop treatments hairy vetch or hairy vetch plus rye than following the winter fallow treatment at all sampling times, except the postplanting sample in 1990 ($P = 0.08$) (Table 1). Crimson clover plus rye suppressed *T. basicola* populations for the preplanting and the at-planting sample. Soil populations of *T. basicola* were low at Lewisville and were not influenced by cover crop treatment (Table 2).

Bacterial populations in soil were greater at Clarkedale for all winter cover crops than for the winter fallow treatment (Table 3). The hairy vetch cover crop treatment also had higher bacterial populations than crimson clover plus rye or hairy vetch plus rye cover crops. Fungal populations were greater following hairy vetch than winter fallow or hairy vetch plus rye. Soil actinomycete populations were higher in the hairy vetch plus rye cover crop treatment than in the winter fallow or hairy vetch cover crop treatment (Table 3). No difference in actinomycete populations was found between the hairy vetch plus rye and the crimson clover plus rye treatments.

Table 3. Influence of cover crop treatments on soil microbial populations[y]

Location	Main effect	Bacteria (cfu[y] × 10^7/g)	Actinomycetes (cfu × 10^6/g)	Fungi (cfu × 10^5/g)
Clarkedale	Year			
	1989	3.2 a[z]	3.8 a	2.1 a
	1990	4.3 a	3.5 b	1.7 b
	Cover crop			
	Winter fallow	2.8 c	3.5 bc	1.7 c
	Crimson clover + rye	3.8 b	3.9 ab	2.0 ab
	Hairy vetch + rye	3.7 b	4.0 a	1.8 bc
	Hairy vetch	4.8 a	3.1 c	2.2 a
Lewisville	Year			
	1989	3.6 b	2.9 a	1.3 a
	1990	4.8 a	2.7 b	1.3 a
	Cover crop			
	Winter fallow	4.0 a	2.9 a	1.3 a
	Common vetch	4.1 a	2.7 a	1.3 a
	Hairy vetch	4.5 a	2.7 a	1.3 a

[y] Colony-forming units.
[z] Means within column for year or cover crop for each location followed by same letter are not significantly different at $P = 0.05$, LSD.

Table 4. Influence of cover crop treatments on seedling disease symptoms and isolation frequency of seedling disease pathogens at Clarkedale

	Disease severity index						
	Hypocotyl[w]		Root[x]		Isolation frequency (%)[y]		
Main effect	1989	1990	1989	1990	*Rhizoctonia solani*	*Pythium* spp.	*Thielaviopsis basicola*
Year							
1989					8.3 b	80.1 a	16.8 a
1990					24.2 a	21.7 b	21.8 a
Cover crop							
Winter fallow	3.1 a[z]	2.1 a	3.4 a	3.6 a	12.3 a	52.2 a	29.7 a
Crimson clover + rye	3.0 a	2.2 a	3.1 a	3.7 a	19.5 a	56.7 a	13.9 b
Hairy vetch + rye	2.9 a	2.4 a	2.9 a	2.6 b	17.3 a	47.0 a	10.8 bc
Hairy vetch	2.8 a	2.3 a	3.6 a	2.5 b	24.2 a	44.9 a	2.0 c

[w] Hypocotyl disease severity index: 1 = no symptoms, 2 = few pinpoint lesions or diffuse discolored areas, 3 = distinct necrotic lesion, 4 = girdling lesion, and 5 = seedling dead.
[x] Root disease index: 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.
[y] Isolation frequency is based on seedlings from five random 1-ft sections of row, ≤25 plants.
[z] Means within column and main effect followed by same letter are not significantly different, LSD ($P = 0.05$).

Table 5. Influence of cover crop treatments on seedling disease symptoms and isolation frequency of seedling disease pathogens at Lewisville

Main effect	Disease severity index		Isolation frequency (%)[y]		
	Hypocotyl[w]	Root[x]	*Rhizoctonia solani*	*Pythium* spp.	*Thielaviopsis basicola*
Year					
1989	3.3 a[z]	3.0 a	37.8 a	9.5 a	1.8 a
1990	2.6 a	2.0 b	19.4 b	5.6 a	5.7 a
Cover crop					
Winter fallow	2.6 a	2.5 a	20.8 b	6.8 a	6.8 a
Common vetch	3.0 a	2.5 a	28.9 ab	10.6 a	1.6 a
Hairy vetch	3.1 a	2.6 a	36.1 a	5.2 a	2.8 a

[w] Hypocotyl disease severity index: 1 = no symptoms, 2 = few pinpoint lesions or diffuse discolored areas, 3 = distinct necrotic lesion, 4 = girdling lesion, and 5 = seedling dead.
[x] Root disease index: 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.
[y] Isolation frequency is based on seedlings from five random 1-ft sections of row, ≤25 plants.
[z] Means within column and main effect followed by same letter are not significantly different, LSD ($P = 0.05$).

Table 6. Influence of cover crop treatment on cotton stand

Location	Cover crop	Plant stand (plants/m of row)	
		1989	1990
Clarkedale	Winter fallow	17.2 a[z]	11.1 a
	Crimson clover + rye	17.2 a	11.2 a
	Hairy vetch + rye	17.3 a	10.6 a
	Hairy vetch	17.8 a	5.9 b
Lewisville	Winter fallow	8.5 a	0.3 a
	Common vetch	7.8 a	0.8 a
	Hairy vetch	5.9 b	0.7 a

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

Table 7. Influence of cover crop treatments on seed cotton yield at Clarkedale

Main effect	Seed cotton (kg/ha)
Year	
1989	3,083 a[z]
1990	2,205 b
Cover crop	
Winter fallow	2,555 b
Crimson clover + rye	2,696 ab
Hairy vetch + rye	2,787 a
Hairy vetch	2,714 ab

[z] Means within main effect followed by same letter are not significantly different, LSD ($P = 0.05$).

Microbial populations were not influenced by cover crop treatment at Lewisville (Table 3).

Cotton seedling disease. The cover crop treatment did not affect the hypocotyl disease severity index at Clarkedale in either 1989 or 1990 (Table 4). The root disease severity index was lower following hairy vetch or hairy vetch plus rye than following crimson clover plus rye or winter fallow in 1990. No differences in the hypocotyl or root disease severity index were observed at Lewisville (Table 5).

Rhizoctonia solani was isolated more frequently in 1990 than in 1989 and *Pythium* spp. were isolated more frequently in 1989 than in 1990 at Clarkedale (Table 4). No differences in the isolation frequency of *R. solani* or *Pythium* spp. were found for the cover crop treatments. *Thielaviopsis basicola* was isolated from 30% of cotton seedlings in the winter fallow treatment compared with 2% of cotton seedlings following the hairy vetch treatment at Clarkedale (Table 4). *Thielaviopsis basicola* was isolated from 14 and 11% of cotton seedlings following crimson clover plus rye and hairy vetch plus rye, respectively.

Rhizoctonia solani was isolated more frequently in 1989 than in 1990 at Lewisville (Table 5). *Rhizoctonia solani* was isolated from more cotton seedlings following a hairy vetch cover crop than following winter fallow. Cover crop treatments did not influence the isolation frequency of *Pythium* spp. or *T. basicola* from cotton at Lewisville (Table 5).

Crop growth. The aboveground fresh weight of the cover crops at Clarkedale was 11,126, 11,398, and 12,619 kg/ha in 1989 and 9,295, 9,227, and 5,156 kg/ha in 1990 for hairy vetch, hairy vetch plus rye, and crimson clover plus rye treatments, respectively. Fresh weight of the cover crops at Lewisville was 21,583 and 8,790 kg/ha in 1989 and 19,491 and 6,235 kg/ha in 1990 for hairy vetch and common vetch, respectively.

Cotton stands were lower at Lewisville in 1989 and Clarkedale in 1990 following incorporation of a hairy vetch cover crop compared with other cover crop treatments (Table 6). Plant stands for all treatments were low for Lewisville in 1990 as a result of heavy rainfall and soil crusting following planting. Seed cotton yield at Clarkedale was significantly greater following a hairy vetch plus rye cover crop than following the winter fallow treatment (Table 7). Yields following other cover crop treatments were intermediate between hairy vetch plus rye and winter fallow treatments.

DISCUSSION

These results suggest that winter legume cover crops may have a differential effect on certain soilborne pathogens and seedling diseases of cotton. Soil populations of *T. basicola* were reduced in cotton production systems that included winter legume cover crops. The importance of reduced populations of this pathogen in these cropping sequences was indicated by the low frequency of isolation of *T. basicola* from cotton for these treatments in the cover crop study at Clarkedale. Root discoloration also was lower in treatments containing hairy vetch than for the winter fallow treatment in 1990, a year when *Pythium* spp. were a minor component of the disease complex. This data suggests that black root rot symptoms also were decreased following hairy vetch.

In contrast, when *R. solani* was an important component of the seedling disease complex, seedling disease may increase following a hairy vetch winter cover crop. The incidence of seedling disease caused by *R. solani* was increased in the presence of hairy vetch at Lewisville. This coincided with a significant increase in *R. solani* soil populations at planting at Lewisville. A similar trend was observed for soil populations and isolation frequency for *Rhizoctonia* spp. at Clarkedale, although this trend was not significant. In the years when the isolation frequency of *R. solani* was significantly higher, 1989 at Lewisville and 1990 at Clarkedale, cotton stands were significantly lower for the hairy vetch treatment compared with the winter fallow treatment, indicating a role for seedling disease in plant stand establishment. However, the increase in seedling disease caused by *R. solani* apparently was not of greater importance than the overall benefits of the winter cover crop as measured by seed cotton yield. In our study seed cotton yield increased at the Clarkedale site 232 or 159 kg/ha following hairy vetch plus rye or hairy

vetch, respectively, compared with winter fallow. These yield increases are comparable with the yield increases found for these cover crop treatments in earlier studies, 295 or 162 kg/ha for hairy vetch plus rye or hairy vetch cover crop treatments, respectively (27).

Soil populations of *Pythium* spp. increased significantly following incorporation of legume cover crops, but this increase in soil populations did not increase isolation frequency of *Pythium* spp. from cotton seedlings. Previous research with crimson clover and hairy vetch in a winter cover crop-sorghum cropping system demonstrated a similar increase in *Pythium* populations compared with a rye cover crop or no cover crop (25).

The differences in the responses of soil populations or isolation frequencies of the cotton seedling pathogens among the different cover crops at Lewisville is probably due to the lower biomass production of common vetch than hairy vetch. At Clarkedale, the differences in the responses of soil populations or isolation frequencies of the cotton seedling pathogens among the different cover crop treatments was probably influenced by the presence of rye in several cover crop treatments.

Changes in the soil microflora were documented among the cover crop treatments in the long-term study at Clarkedale. Changes in soil physical and chemical properties have been documented previously at this site (27). Bacteria and fungi increased significantly with the incorporation of a hairy vetch cover crop. Research indicates that actinomycetes are less competitive in colonizing new substrates compared with other bacteria or fungi (11). Actinomycetes increased only in cover crop treatments that contained rye. This observation may be explained by actinomycetes being more common in grasslands and being favored in situations requiring the degradation of more complex organic residues (11). These changes in soil microflora are gradual, as no differences in soil microflora were observed among cover crop treatments at Lewisville.

The benefits of legumes used as cover crops for decreasing soil erosion and improving soil fertility levels have been documented. The impact of these cover crops on seedling diseases will differ because several pathogens may be responsible for seedling disease on cotton. The impact of cover crops on other pests and pest damage will have to be examined before sustainable crop management systems can be developed that take advantage of pest-suppressing aspects of cover crops, while minimizing any risks from increased pest damage. In these studies, legume cover crops reduced populations of *T. basicola* and isolation frequency of *T. basicola* on cotton seedlings and may reduce seedling disease in situations where *T. basicola* is an important component of the seedling disease complex.

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