WINTER WEED SUPPRESSION BY WINTER COVER CROPS IN A CONSERVATION-TILLAGE CORN AND COTTON ROTATION

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ABSTRACT

An integral component of a conservation-tillage system in corn (Zea mays L.) and cotton (*Gossypium hirsutum* L.) is the use of a winter cover crop. A field experiment was initiated in 2002 to evaluate winter weed dynamics following various winter cover crops in both continuous cotton and a corn and cotton rotation. Winter cover crops included black oats (*Avena strigosa* Schreb.); two crimson clover entries (*Trifolium incarnatum* L.); two cultivars of forage rape (*Brassica napus* L. var. *napus*), spring and winter; oil radish (*Raphanus sativus* var. *oleiformis Pers.*); three cultivars of turnip (*Brassica rapa* L. *subsp. rapa*); white lupin (*Lupinus albus* L.); and a mixture of black oat and lupin. Two-year conservation-tillage rotational sequences included conventionally tilled continuous corn and cotton winter fallow systems as controls. The 10 conservation-tillage, winter cover-crop systems investigated were three continuous cotton systems that alternated a winter legume (lupin or clover), six cotton-corn systems, where lupin preceded cotton and radish, rape, or turnip preceded corn, and a cotton-corn system that had a lupin-black oat mixture as a winter cover crop every year. Use of lupin or 'AU Robin' clover resulted in weed biomass reduction of up to 80% and 54%, respectively, in weed biomass compared to the fallow system. The highest yielding corn-cotton conservation tillage rotation with a winter cover yielded 200 lbs/acre more that the continuous cotton winter fallow system. Continuous conventional corn with winter fallow yielded 30 bu/acre less than the highest yielding 2-yr, conservation tillage winter crop system.

INTRODUCTION

Winter cover crops utilized in a conservation tillage system increases soil carbon, water infiltration, and availability while reducing soil erosion. Cereal rye (*Secale cereale* L.) and soft red winter wheat (*Triticum aestivum* L.) are the two most common winter cover crops recommended for corn and cotton production in the southeastern U.S. with the addition of vetch and annual clover for corn (Jost et al. 2004; Mask et al. 1994; McCarty et al. 2003; Monks and Patterson 1996). However, alternative cover crops are increasingly being used and developed for use in corn and cotton for reasons including nutrient cycling, pathogen control, and weed suppression. Black oat has recently been introduced in the southeastern U.S. through a joint release between USDA-ARS, Auburn University, and The Institute of Agronomy of Paraná, Brazil, and is currently marketed as "SoilSaver black oat" (Bauer and Reeves 1999). AU Homer is a bitter (high alkaloid) white lupin (*Lupinus albus* L.) developed at Auburn University as a winter cover crop for cotton production systems.

The use of cover crops in conservation tillage offers many advantages, one of which is weed suppression through physical as well as chemical allelopathic effects (Nagabhushana et al. 2001; Phatak 1998). Cover crops contain allelopathic compounds that inhibit weed growth (Akemo et al. 2000; Chase et al. 1991; Perez and Ormeno-Nunez 1991; Yenish et al. 1996). Residues from

Brassica crops have been shown to have biotoxic activity against many soilborne pathogens and pests, including weeds (Chew, 1988; Peterson et al. 2001). However, little research has been conducted evaluating winter weed suppression provided by winter cover crops. Two of the most troublesome southeastern weeds in glyphosate tolerant cotton are cutleaf eveningprimrose [*Oenothera laciniata* (Hill) Cronq.] and glyphosate resistant horseweed (*Conyza canadensis* L.). Winter cover crops that displace troublesome winter weeds may offer growers an alternative control strategy.

Crop rotation is also an important component of cotton production in the Southeast. Because cotton is the main cash row-crop for many growers, much of the acreage is in continuous cotton. Continuous cotton production causes many problems including increased soilborne pathogen populations and an increase in hard to control weeds due to the lack of herbicide chemistry rotation. Rotations with corn are typical, due to the lower production costs, ease of production, and because corn is a non-host to many cotton pathogens.

While some reported research has evaluated weed-suppressive qualities of winter cover crops, few experiments have evaluated winter weed suppression prior to cash crop planting following the use of alternative winter covers in rotation. Therefore, our objective was to evaluate weed dynamics and cash crop yields following various winter cover crops within 10 different conservation-tillage corn-cotton rotations. Weed dynamics following continuous corn and cotton grown in a conventional-tillage winter fallow system were also included.

MATERIALS AND METHODS

An experiment evaluating winter cover crop sequence preceding a 2-yr corn-cotton rotation was established in autumn 2001 at the Field Crops Unit, E.V. Smith Research and Extension Center of the Alabama Agricultural Experiment Station, Shorter, AL. The experimental design was a standard RCB with two replicates. In autumn 2002, the identical experiment was established again, thus ensuring that both phases of the 2-yr rotation could be evaluated each year. Soil at the experimental site is a Compass loamy sand. Winter cover crops included black oats (*Avena strigosa* Schreb.) cv. SoilSaver; crimson clover (*Trifolium incarnatum* L.) cvs. AU Robin and Dixie; two cultivars of forage rape (*Brassica napus* L. var. *napus*), spring (cv. Liforum) and winter (cv. Licapo); oil radish cv. Rufus (*Raphanus sativus* var. *oleiformis Pers.*); cultivars Civastro, Rondo, and Common of turnip (*Brassica rapa* L. *subsp. rapa*); bitter (high alkaloid) white lupin (*Lupinus albus* L.) cv. AU Homer; and a mixture of 80% lupin and 20% black oat by weight. Two-year conservation-tillage rotational sequences included conventionally tilled continuous corn and cotton winter fallow systems as controls (Table 1). The 10 conservation tillage winter cover crop systems investigated were three continuous cotton systems that alternated a winter legume (lupin or clover) with black oats, six cotton-corn systems, where lupin preceded cotton and radish, rape, or turnip preceded corn and black oats preceded cotton, and a cotton-corn system that had a lupin-black oat mixture as a winter cover crop every year.

The seeding rate was 4 lb/ac for all *Brassica* species. Oil radish was seeded at 8 lb/ac, clovers at 20 lb/ac, black oat, lupin, and the mixture at 90 lb/ac. Fifty lb/ac of nitrogen (N) as ammonium nitrate was applied to all non-leguminous cover crops in autumn of 2002 and 2003 after establishment. Cover crops were seeded with a no-till drill in early November of each year and terminated 2 to 3 wk prior to planting corn and cotton in early April and May, respectively.

Covers were terminated each year with an application of glufosinate at 0.46 lb ai/ac utilizing a compressed CO_2 backpack sprayer delivering 15 gal/ac. Additionally, biomass from winter weeds and winter cover crops were measured in all plots immediately before glufosinate application in all years. The aboveground portion of each winter cover crop was clipped from two randomly selected 10.7-ft^2 sections in each plot, dried at 140 F for 72 h, and weighed. Winter weeds were measured similarly in three 10.7-ft^2 sections in each plot, including winter fallow.

Corn hybrids Pioneer 3455LL and Dekalb 6972RR were planted in spring 2003 and 2004, respectively. The cotton cultivars Surgrow 501BGRR and Stoneville 5242BGRR were planted in spring 2003 and 2004, respectively. Corn seed was planted with a six-row planter at a seeding population of 28,000 seed/ac. Cottonseed was planted with a 4-row planter at a seeding population of 80,000 seed/ac. Both planters were a John Deere MaxEmerge®[1] equipped with row cleaners and double-disk openers. Plots were 60 ft long and 30 ft wide, accommodating either 12 rows of corn (30 in row width) or eight rows of cotton (40 in row width). Because the site had a well-developed hardpan each year, the experimental area was in-row sub-soiled prior to planting with a narrow-shanked parabolic subsoiler, equipped with pneumatic tires to close the subsoil channel. Conventional-tillage plots were prepared utilizing a disk harrow and a 14 ft tractor-mounted rototiller. Alabama Cooperative Extension System recommendations were used for insect control and nutrient management. Crops were harvested from the eight center rows for corn and the four center rows for cotton.

Data were analyzed by analysis of variance using mixed model methodology as implemented in SAS Proc Mixed (Littell et al., 1997). Rotation (tillage plus cover crop + cropping sequence) was considered a fixed effect, whereas replicates, years, and their interactions with rotation were considered random effects.

RESULTS AND DISCUSSION

As expected from experience and previous conservation tillage systems research in the southeastern USA, continuous cropping utilizing winter fallow had the lowest cotton and corn yields (Table 1). Using an average 2:1 ratio of seed to fiber, the difference between cotton lint yield between the highest yielding corn-cotton conservation tillage rotation (No. 10) and continuous conventional cotton with winter fallow was over 200 lbs/acre. Continuous conventional corn with winter fallow yielded 30 bu/acre less then the highest yielding 2-yr, conservation tillage winter crop system (No. 12). Research conducted by Raper et al. (2003) and Terra et al. (2005) on Coastal Plain sites in southeastern USA established that it is absolutely essential to include cover crops as an integral part of conservation tillage systems.

The average total combined biomass for winter covers was 928 lbs/acre preceding cotton compared to 447 lbs/acre for the corn phase. The difference is the combined effect of cover crops and delayed termination for cotton (approximately 3 wk) compared to corn.

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[1] Mention of trade names or commercial products in this manuscript is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture.

Cover crop biomass yields ranged from 261 lbs/acre for the oil radish cv. Civastro preceding corn to 1259 lbs/acre for the lupin plus black oat mixture preceding cotton (Table 2). The difference in yield between AU Robin and Dixie is due to the fact that the termination date for cover crops preceding cotton was in late April, which favors the later-maturing cultivar Dixie. AU Robin was specifically developed for early maturity in corn production systems (van Santen et al., 1992). Pure legume cover crops (lupin and crimson clovers) produced significantly more biomass (500 lbs/acre; $P < 0.01$) than rape, turnip, and radish. However, crop yields in general were not related to the amount of biomass produced by the preceding cover crop.

Most cover crop systems had numerically less weed biomass than the fallow system (Table 2), except for the turnip cultivar Rondo preceding corn and two systems that contained lupin preceding cotton. However, two systems that contained lupin resulted in up to 80% reduction in weed biomass compared to the fallow system. The system that contained AU Robin preceding cotton reduced weed biomass 54% compared to winter fallow. The lupin and black oat mixture provided a 40% reduction in weed biomass preceding corn but was less effective preceding cotton. Winter weeds in both years consisted of chicory (*Cichorium intybus* L.), corn spurry (*Spergula arvensis* L.), cudweed (*Gnaphalium* spp.), cutleaf eveningprimrose, knawel (*Scleranthus annuus* L.), and wild radish (*Raphanus raphanistrum* L.).

CONCLUSIONS

It should be emphasized that this experiment is in its early stages. The current consensus is that crop rotation studies don't reach their "equilibrium" before the fifth cropping season. Based on experience in other studies, we can expect that the differences between fallow and rotation treatments most likely will increase.

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Table 1. Tillage, cover crop treatments, and crop yields for the crop rotation study conducted at the Field Crops Unit, E.V. Smith Research and Extension Center of the Alabama Agricultural Experiment Station, Shorter, AL for crop years 2002/3 and 2003/4.

		Rotation				Crop yield					
		Phase 1		Phase 2		Seed cotton			Corn		
No.	Tillage	Autumn	Spring	Autumn	Spring	Yield	Rank	StdErr	Yield	Rank	StdErr
						lbs acre^{-1}			bu acre^{-1}		
1	Conventional	Fallow	Cotton	Fallow	Cotton	2170	10	485			
2	Conventional	Fallow	Corn	Fallow	Corn				83	8	10
3	Subsurface only	Lupin	Cotton	Black oats	Cotton	2389	5	485			
4	Subsurface only	AU Robin	Cotton	Black oats	Cotton	2344	8	485			
5	Subsurface only	Dixie	Cotton	Black oats	Cotton	2261	9	485			
6	Subsurface only	Raddish	Corn	Lupin	Cotton	2722	4	505	97	2	12
7	Subsurface only	Civastro	Corn	Lupin	Cotton	2108	11	505	95	5	12
8	Subsurface only	Licapo	Corn	Lupin	Cotton	2811	2	505	97	3	12
9	Subsurface only	Liforum	Corn	Lupin	Cotton	2378	6	505	92	6	12
10	Subsurface only	L + BO†	Corn	L + BO†	Cotton	2825	1	505	90	7	12
11	Subsurface only	Rondo	Corn	Lupin	Cotton	2369	7	505	96	4	12
12	Subsurface only	Common	Corn	Lupin	Cotton	2745	3	505	113	1	12

† Mixture of 80 % lupin and 20 % black oats by weight.

Table 2. Cover crop and weed biomass yields for the crop rotation study conducted at the Field Crops Unit, E.V. Smith Research and Extension Center of the Alabama Agricultural Experiment Station, Shorter, AL for crop years 2002/3 and 2003/4.

Rotation	Preceding cotton					Preceding corn				
	Cover			Weeds		Cover			Weeds	
No.	Name	Yield	StdErr	Yield	StdErr	Name	Yield	StdErr	Yield	StdErr
1	Fallow	0	291	939	253					
2						Fallow	0	273	995	279
3	Lupin	884	299	721	253					
4	AU Robin	742	291	432	253					
5	Dixie	1085	291	607	292					
6	Lupin	814	335	306	358	Raddish	535	329	680	348
7	Lupin	851	335	1043	358	Civastro	261	329	563	348
8	Lupin	826	335	190	358	Licapo	793	329	449	348
9	Lupin	1027	335	338	417	Liforum	356	329	648	348
10	L + BO†	1259	335	875	358	L + BO†	297	329	387	348
11	Lupin	860	335	531	358	Rondo	430	329	1374	348
12	Lupin	929	335	1029	358	Common	458	368	903	348

† Mixture of 80 % lupin and 20 % black oats by weight.