COVER CROP RESIDUE EFFECTS ON EARLY-SEASON WEED ESTABLISHMENT IN A CONSERVATION-TILLAGE CORN-COTTON ROTATION

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ABSTRACT

Use of winter cover crops is an integral component of conservation systems in corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.). A field experiment was initiated in 2004 to evaluate weed suppression provided by winter cover crops in a conservation-tillage corn and cotton rotation. Rotation for winter cover crops included clover (*Trifolium incarnatum* L.) preceding corn and rye (*Secale cereale* L.) preceding cotton. The covers were planted at five different planting dates based on thirty year average first frost. Termination dates in the spring were 4, 3, 2 and 1 week prior to cash crop planting, based on thirty year average historical soil temperature. It was observed even a week's delay in winter cover crop planting can severely impact the biomass production and thus have a negative bearing on the cover crop benefits. More than ten times difference in cover biomass produced by clover was observed when the covers were planted on the earliest and terminated on last date compared to late planting and early termination. Rye produced almost eight times more biomass in the same comparison. Correspondingly, weed biomass was 556 kg/ha in the treatment with least rye biomass, eight times higher compared to the treatment with greatest rye biomass. Though the difference was only 34 kg/ha in case of clover, it is important to mention that weed populations observed in clover were less than in rye.

INTRODUCTION

Conservation tillage systems are increasingly becoming an integral part of sustainable agriculture. They are primarily used to address concerns about declining water and air quality, soil erosion and soil productivity. An important component of conservation tillage systems in the Southeast is the use of winter cover crops. Cover crop residue provides soil cover, which is critical in reducing erosion, improving infiltration, soil moisture retention and nutrient enhancement (Blevins et al. 1971; Kaspar et al. 2001; Reeves 1997). An important advantage of using cover crops is their ability to suppress weeds through physical as well as chemical allelopathic effects (Nagabhushana et al. 2001; Putnam et al. 1983). Previous research has shown that weed control using cover crops with conservation tillage systems is comparable to chemical control in certain situations (Teasdale and Mohler 1992; Johnson et. al. 1993).

Approximately 90% of the U.S. cotton grown in 2001 received herbicides (Anonymous 2002). Cotton is the main cash row crop for many growers in the Southeast. Practical alternatives to the intensive use of herbicides for controlling weeds in cotton production offer economical as well as environmental benefits. Cereal rye 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 (Mask et al. 1994; McCarty et al. 2003; Monks and Patterson 1996). Crop rotation is also an important component of cotton production in the Southeast as continuous cotton production causes many problems, including increased soil borne 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 lower production costs, ease of production, and because corn is a non-host to many cotton pathogens.

Historically, cover crop planting and termination has occurred at the discretion of growers' schedules and weather conditions. Previous research has shown that a winter cover's planting date and termination date influences both quality and quantity of residue production, and subsequent weed suppression. Therefore, a field study was conducted to determine optimum dates for planting and terminating a winter cover crop to maximize biomass production and early season weed suppression.

MATERIALS AND METHODS

Field experiments were established in 2003 at the Alabama Agricultural Experiment Station's E.V. Smith and Tennessee Valley Research and Extension Centers. In 2004, a similar experiment was also established at the University of Florida's West Florida Education and Research Center. The experimental design was a randomized complete block with three replicates having a split block restriction on randomization. Each plot had four rows of corn or cotton and both phases of the rotation were present each year.

The experiment involved two cover crops, rye preceding cotton and clover preceding corn rotated annually at each site. We examined five different planting dates and four different termination dates. Horizontal strips consisted of five cover planting dates and vertical strips consisted of four cover termination dates. Both covers were established with a no-till drill at 2 and 4 week prior to, 2 and 4 week after, and on the historical average first frost. The rye seeding rate was 100 kg/ha, and 56 kg of nitrogen (N) as ammonium nitrate was applied to rye in fall after establishment. The clover seeding rate was 28 kg/ha.

In the spring, covers were terminated at 4, 3, 2, and 1 week prior to cash crop planting. Clover was terminated using glyphosate (1.12 kg ae/ha) plus 2,4-D amine (0.20 kg ai/ha) at a rate of 140 L/ha. Rye was terminated using glyphosate at 1.12 kg ae/ha and flattened prior to planting with a mechanical roller-crimper to form a dense residue mat on the soil surface. Cover biomass from each plot was measured immediately before termination. The above-ground portion of rye and clover was clipped from one randomly-selected 0.25-m^2 section in each plot, dried and weighed.

The cotton varieties DP 444 BG/RR, ST 5242 BR and DP 555 BRR were planted at E.V. Smith, Tennessee Valley and West Florida, respectively. The corn variety Dekalb 69-72RR was planted at all the locations. Cash crops were planted with a four-row planter equipped with row cleaners and double-disk openers. Since both the E.V. Smith and West Florida sites had a well-developed hardpan, the experimental areas were in-row subsoiled prior to planting with a narrow-shanked parabolic subsoiler, equipped with pneumatic tires to close the subsoil channel. Weed biomass was determined in two 0.25-m^2 sections as described above when cotton reached the 4-leaf and corn reached 8-leaf growth stages. At this stage glyphosate was applied at 1.12 kg ae/ha. Plots were then kept weed-free until harvest utilizing Alabama Cooperative Extension System recommended herbicide applications. Though evaluations also included soil coverage by cover, cash crop stand establishment and height, and cash crop yield, in this paper we are only reporting the weed suppression provided by the two covers. Data were analyzed by analysis of variance using mixed model methodology as implemented in SAS Proc Mixed.

RESULTS AND DISCUSSION

The significance of treatments and treatment combinations can be found in Table 1. Since there was no environment (location and year)*planting date*termination date interaction the data was averaged over locations for studying the effect of planting dates and termination dates on cover and weed biomass (Table 2). As expected, the highest cover crop biomass in both the cases was produced by an earlier planting and later termination date combination.

In rye, the highest biomass of 6745 kg/ha (Table 2) was produced when rye was planted four weeks prior to average first frost and terminated two weeks prior to cotton planting. This was almost eight times more than the least biomass of 795 kg/ha produced for the treatment in which the rye was planted four weeks after average first frost and terminated four weeks before cotton planting. In clover, the highest biomass of 2637 kg/ha (Table 3) was produced when covers were planted two weeks before the average first frost and terminated four weeks prior to corn planting. The least biomass produced was 182 kg/ha by the treatment combination of last planting date and third termination date.

With an increase in the cover biomass the weed biomass decreased in most instances. In cotton, weed biomass (591 kg/ha) was almost ten times higher when the cover biomass was lowest compared to when cover biomass was highest. In corn (Table 3), the weed biomass was not as predictable as in cotton, but it showed a similar trend (i.e. the higher the amount of cover biomass, the lesser the amount of weeds.) The lowest weed biomass observed was 36 kg/ha corresponding to clover biomass of 2453 kg/ha and the highest was 158 kg/ha corresponding to clover biomass of 373 kg/ha. This is probably due to the fact that high cover biomass provides more soil coverage which can negatively impact the weed seed germination and alter other physical conditions required for weed emergence and establishment. Our observations of decrease in weed biomass by corresponding increase in cover crop biomass agree with other research reportings (Teasdale et al. 1991).

When the planting date and termination date effects were studied separately (Tables 4-7) for each environment, general observation showed an earlier planting date always produced more biomass and correspondingly less weed biomass. Similarly, weed biomass decreased with later termination of the cover at all the locations. It was, however, observed that clover provided more effective weed control though it produced less biomass compared to rye irrespective of the year and location.

Conclusions

In general, cover crop biomass increased with earlier planting and later termination, and weed biomass decreased with increasing biomass. Observations indicate that high cover biomass should decrease early season weed interference and allow flexibility of postemergence application timing.

References

Anonymous. 2002. USDA-NASS. Web page:http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0502.pdf. Accessed 05/03/2006.

Blevins, R. L., D. Cook, S. H. Phillips, and R. E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

Kaspar, T. C., J. K. Radke, and J. M. Laflen. 2001. Small grain cover crops and wheel traffic effects on infiltration, runoff, and erosion. J. Soil Water Conserv. 56:160-164.

Johnson, G.A. M.S. Defelice, and Z.R. Helsel. 1993. Cover crop management and weed control in corn. Weed Technol. 7:425-430.

Mask, P.L., J. Everest, C. C. Mitchell, and D. W. Reeves. 1994. Conservation Tillage Corn in Alabama. Alabama Cooperative Extension System publication ANR-811.

McCarty, W. H, A. Blaine, and J. D. Byrd. 2003. Cotton no-till production. Mississippi State University Cooperative Extension Service publication P1695.

Monks, C. D. and M. G. Patterson. 1996. Conservation Tillage Cotton Production Guide. Alabama Cooperative Extension System publication ANR-952.

Nagabhushana, G. G., A. D. Worsham, and J. P. Yenish. 2001. Allelopathic cover crops to reduce herbicide use in sustainable agriculture systems. Allelopathy J. 8:133-146.

Putnam, A.R., J. Defrank, and J.P. Barnes. 1983. Exploitation of allelopathy for weed control in annual and perennial cropping systems. J. of Chem. Ecol. 9:1001-1010.

Reeves, D. W. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res. 43:131-167.

Teasdale, J.R. and C.E. Beste, and W.E. Potts. 1991. Response of weeds to tillage and cover crop residue. Weed Science. 39:195-199.

Teasdale, J.R. and C. Mohler. 1992. Weed suppression by residue from hairy vetch and rye cover crops. Proc. First Int. Weed Control Congress. 2:516-518.

Table 1. Significance (p-values) of environment (Env), planting dates (PD) and termination dates (KD) on various parameters for corn and cotton.

		Cover		Weeds		Stand		Yield	
Effect	df	Corn	Cotton	Corn	Cotton	Corn	Cotton	Corn	Cotton
Env	4	<0.001	<0.001	<0.001	0.003	0.098	<0.001	<0.001	<0.001
PD	4	<0.001	<0.001	> 0.15	<0.001	<0.001	<0.001	> 015	0.011
KD	3	0.015	<0.001	0.094	<0.001	> 0.15	> 0.15	<0.001	0.010
Env*PD	16	<0.001	<0.001	0.088	<0.001	0.133	<0.001	0.007	0.137
Env*KD	12	> 0.15	<0.001	> 0.15	<0.001	0.006	0.127	> 0.15	> 0.15
PD*KD	12	> 0.15	0.003	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15
Env*PD*KD	48	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15	> 0.15

Table 2. Effect of planting dates (PD) and termination dates (KD) on rye and weed biomass (kg/ha) in cotton (SE_{Rye}= 335, SE_{Weeds}= 69).

	PD1		PD2		PD3		PD4		PD5	
	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS
KD1	4043	371	3237	367	2465	553	1516	519	795	556
KD2	5737	149	5045	193	3782	336	2205	303	1190	591
KD3	6745	78	6433	162	4266	257	2403	221	1290	366
KD4	6229	57	6094	67	4655	190	3165	191	2002	293

Table 3. Effect of planting dates (PD) and termination dates (KD) on clover and weed biomass (kg/ha) in corn (SE_{Clover}= 294, SE_{Weeds}= 24).

	PD1		PD2		PD3		PD4		PD5	
	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS
KD1	2364	65	1514	101	518	105	378	84	373	158
KD2	2412	37	2099	91	711	143	205	133	230	98
KD3	2329	40	2018	56	1124	124	473	82	182	93
KD4	2453	36	2637	59	898	95	823	134	522	132

Table 4. Effect of planting dates (PD) on rye and weed biomass (kg/ha) in individual environment in cotton (SE_{Rye}= 454, SE_{Weeds}= 88).

	EVS 2004		EVS2005		TVS2004		TVS2005		JAY2005	
	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS
PD1	5566	316	5331	289	8878	31	5062	133	3605	48
PD2	5053	318	4893	381	7852	54	5232	182	2982	50
PD3	4344	470	2610	440	6584	406	2863	275	2559	80
PD4	2779	474	518	467	4500	250	2129	298	1687	53
PD5	1276	970	213	378	2649	345	913	479	1545	87

Table 5. Effect of planting dates (PD) on clover and weed biomass (kg/ha) in individual environment in corn (SE_{Clover}= 311, SE_{Weeds}= 32).

	EVS 2004		EVS2005		TVS2004		TVS2005		JAY2005	
	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS
PD1	1808	26	4750	62	2861	81	1928	27	601	26
PD2	2135	28	3827	120	1446	109	2462	54	468	72
PD3	1223	83	1061	136	604	155	945	167	230	42
PD4	1321	75	359	90	304	153	263	171	103	53
PD5	914	109	414	115	93	187	121	135	90	55

Table 6. Effect of termination dates (KD) on clover and weed biomass (kg/ha) in individual environment in corn (SE_{Clover}= 271, SE_{Weeds}= 30).

	EVS 2004		EVS2005		TVS2004		TVS2005		JAY2005	
	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS	CLOVER	WEEDS
KD1	1054	72	2162	142	653	131	977	89	300	77
KD2	1691	68	1813	77	832	142	1119	161	201	54
KD3	1315	76	2005	116	1125	143	1464	38	217	23
KD4	1860	40	2348	83	1637	132	1015	157	474	45

Table 7. Effect of termination dates (KD) on rye and weed biomass (kg/ha) in individual environment cotton (SE_{Rye}= 424, SE_{Weeds}= 81).

	EVS 2004		EVS2005		TVS2004		TVS2005		JAY2005	
	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS	RYE	WEEDS
KD1	1837	1061	2282	603	4394	265	1734	345	1809	91
KD2	4659	532	2794	430	5460	165	2693	397	2352	48
KD3	4731	341	3089	389	6421	153	3767	150	3128	51
KD4	3987	104	2686	141	8095	287	4765	201	2613	64

*SE = Standard Error