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INFLUENCES OF WINTER COVER CROP RESIDUES AND TILLAGE ON COTTON LINT YIELD AND QUALITY

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Abstract

The cotton growing in Turkey has monoculture system and any crop is not grown in approximately five months between two cotton growing which caused lower seed cotton yield, poor lint quality and early leaf senescence. The influences of different tillage systems and winter cover crops on cotton lint yield and quality were evaluated in Aegean Region of Turkey during two cotton-growing seasons. In second year compared to the first year, the dry matter yield of cover crop root residues increased by 40% in conventional tillage system and 60% in no tillage system. Similar increases were also determined for residue organic matter yield in soil. Dry matter and organic matter in soil harvest residues were higher in conventional tillage system as compared to no tillage system. Among cover crop treatments common vetch + oat and hairy vetch + oat mixtures provided the highest dry matter and organic matter in soil harvest residues. Cotton lint yield and quality were not affected by cover crop treatments and tillage systems. Also, tillage by cover crop interactions was non-significant for cotton lint yield and quality. During the observations at 50% boll opening period of cotton, it was monitored that leaf senescence decreased under no-tillage cotton production system in both years.

Introduction

Cotton growing area in Aydin is approximately 82,000 hectares. Cotton production in Aydin and Aegean Region has monoculture agricultural system. Sometimes winter wheat + second crop maize and cotton rotation system are applied. In this case, soil is subject to water and wind erosion, and winter weed species use soil nutrition in winter months (November-May period). Daniel (1997) reported that cotton is considered a low residue crop, which may not provide sufficient surface residue to reduce erosion and protect the soil. Surface residue is critical factor in controlling erosion on agricultural land (Hoffmann *et al.*, 1983). Therefore, a suitable winter cover crop system must be developed. It was recommended that the best cover crop for soil conservation and nutrient cycling was grass species (Shipley *et al*., 1992), while legume species for organic fertilizer-N were suitable.

Meisinger *et al*., (1991) and Smart & Bradford (1996) stated that a no tillage system (NT) produced cotton yields comparable to conventional tillage (CT) while providing many environmental benefits protecting soil and maintaining water quality and the use of winter cover crops in a NT cotton production system enhanced soil productivity. Utomo *et al*., (1987), reported that a significant increase of total organic matter in NT system rose thus increasing in soil organic matter improves moisture holding and cation exchange capacity. The cotton yield and quality have economical importance in all production system. It was found that NT can reduce tillage operations by as many as 6 to 8 operations and cotton lint yield under NT was 7% - 24% greater than that under CT (Nyakatawa *et al*., 2000). Boquet *et al*., (1994) found that using cover crop in a NT production system increased cotton lint yield and reduced tillage system had a 50% increase in square and fruit retention. In addition, Bauer & Busscher (1996) found that cotton lint quality was not affected by tillage system and winter cover crop.

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Early leaf senescence reduces seed cotton yield and lint quality in Meander Valley of Aegean region in Turkey. This has occurred especially in the Aegean Region's standard variety Nazilli 84 since 1990. Visible symptoms are traditionally characterized as interveinal and marginal chlorosis of leaf blades progressing to necrosis and finally disintegration of leaf tissue beginning in the mostly older leaves. Kaynak *et al*., (1998) stated that leaf senescence showed severity in cotton-cotton production system and crop rotation delayed early leaf senescence. The purposes of this study were to evaluate the effects of tillage system and winter cover crop on cotton yield, lint quality and leaf senescence and to select the best winter cover crop.

Materials and Methods

This study was conducted during 1997-1998 and 1999-2000 growing seasons at Adnan Menderes University, Research and Applied Fields of Agricultural Faculty in Aydın-Turkey. Aydin Province located in the West of Turkey has typical Mediterranean climatic conditions (latitude 37º44'-37º49' N and longitude 27º44'-27º50' E). In 1998-1999 growing season, the cover crops were not planted due to heavy precipitations especially during November-December, while cotton were planted during April-May period. The soil type at the site was a sandy loam, pH 8.07, lime percentage 1.208%, organic matter 0.945%; P_20_5 2.1-2.2 ppm; K_20 195-205 ppm. The soil status was described as slightly alkaline, low lime and low organic matter content. Before experiment was conducted, soil parameters were analyzed at soil department laboratory of Adnan Menderes University.

According to the meteorological data during the two growing seasons, there was little variation in the average mean daily temperature at cover crops (10.95-11.67ºC) and cotton growing periods (24.50-26.12ºC). However, the second year received less precipitation than first year (477.5 mm – 654.6 mm).

The experimental design was a split plot with four replications. The main plot treatments were two tillage practices (CT and NT) and the sub-plots consisted of cover crops. Plots were 4.2 m wide and 6 m long with 6 rows and 0.7 m between the rows.

The cover crop treatments were common vetch (*Vicia sativa* L.), hairy vetch (*Vicia villosa* Roth. *var. glabrescens*) and their mixtures with oat (*Avena sativa* L.). Seeding rates were 120 kg ha^{-1} for common vetch and hairy vetch, 80 and 40 kg ha^{-1} for the vetch/oat mixture. The cover crops were planted in the fall on 7 November 1997, 11 November 1999. 30 kg ha^{-1} N and 60 kg ha^{-1} P_20_5 was applied as starter pre-emergence fertilizer, which was Di-Ammonium Phosphate (18:46:0). The different tillage systems was applied only for cotton growing. Conventional tillage plots on 15 April and NT plots on 30 April were harvested in both years. Conventional tillage plots were harvested 15 days before NT plots due to the soil tillage (ploughing; 0.2 m depth and two disk harrow) for sowing. After cover crop harvest, cover crop residue samples were taken from 0.4 x 0.3 x 0.25 m soil profile in both tillage systems (Simon & Eich, 1955). When the measurements were made, separate counts were made of old crop residue, residue from weeds and cover crops residues (Denton & Tyler, 1997). In the present cover crop residues were used as harvest residues. The samples were dried at 105ºC for 24 hours and the dry matter yields (kg ha^{-1}) were recorded. The same samples were used for organic matter analysis, according to Walkley-Black procedure (Nelson & Sommers, 1982).

Conventional tillage plots were ploughed and disked, while zero-till, direct seeding, and irrigation after seeding for no-till plots were applied. The both tillage system plots were planted with 6 rows and 0.7 m between the rows on 7 May 1998 and 9 May 2000. Aegean region of Turkey standard cotton variety, Nazilli-84 (*Gossypium hirsutum* L.) was used. Normal cultural practices were applied during vegetation period. Leaf area index (LAI; m^2/m^2) and lint yield (LY; kg/ha) as agronomical characteristics, and fiber length (FL; mm), and fiber fineness (Mic.) using by HVI (High Volume Instruments, motion control 4000), Fiber Strength (pressley) using by Pressley as quality parameters in cotton were measured. In addition, early leaf senescence occurred at beginning of 50% boll retention period (15 July – 15 August) in all Turkey's cotton production areas. In terms of leaf senescence, numbers of plants with early leaf senescence in each plot were observed (LS; %). Data were analyzed using the SPSS (version 9.0). Means were separated by least significant difference (LSD) at 0.05 probability level.

Results and Discussion

Cover crop residue dry matter: In both years, differences between tillage systems were found to be non-significant for dry matter and organic matter yield in harvest residue of cover crops (Table 1). Abaye *et al*., (1995) found that soil samples, obtained a few weeks after cover crops were killed and disked-in, did not differ in soil organic matter. However, the CT method resulted in 28% and 14% higher dry matters yields than that of NT method for first and second years, respectively (Table 1). The cover crops in CT system were harvested 15 day earlier. Thus, it can be said that the latter harvest of cover crops in NT cotton caused lower root biomass and organic matter in soil harvest residues. Also, residue dry matter yield of soil in both tillage systems increased 40-60% in second year compared to the first year.

Table 1. Mean values of dry and organic matter yield in harvest residues in two growing periods.

Tillage system	1997-1998		1999-2000	
	Dry matter yield (kg ha^{-1})	**Organic matter yield (kg ha^{-1})**	**Dry matter yield (kg ha^{-1})**	**Organic matter yield (kg ha^{-1})**
Conventional	2.50	1.52	3.45	1.81
NT	1.78	1.36	3.01	1.42
$LSD_{0.05}$	1.44	0.87	1.77	1.44
Cover crop				
Common vetch	1.44	0.90	2.25	1.28
Hairy vetch	1.20	0.89	3.49	1.71
Com. Vetch + oat	3.35	2.06	4.09	1.76
Hairy vetch + oat	2.42	1.64.	3.34	1.78
Natural cover	2.28	1.72	2.97	1.55
$LSD_{0.05}$	1.14	0.64	1.27	0.62
Harvest time	ns	ns	ns	ns
Cover crop	**	**	*	ns
İnteraction	ns	ns	ns	ns

*, **; Significant at 0.05 and 0.01 probability level, respectively.

Table 2. Mean values of lint yield and quality parameters in two growing periods.

Tillage system	1997-1998				1999-2000			
	LY	**FL**	**FS**	**FF**	**LY**	**FL**	**FS**	**FF**
Conventional	1.17	27.28	90.36	5.27	1.50	28.25	91.0	5.58
NT	1.16	28.03	90.53	5.38	1.37	28.11	89.1	5.53
$LSD_{0.05}$	0.27	2.32	4.62	0.19	0.79	0.68	2.8	0.15
Cover crop								
Common vetch	1.24	27.65	91.35	5.32	1.41	27.42	89.33	5.52
Hairy vetch	1.08	27.47	90.23	5.28	1.66	28.23	90.25	5.60
Com. Vetch + oat	1.11	28.03	91.03	5.43	1.58	28.17	91.17	5.67
Hairy vetch + oat	1.24	27.73	90.97	5.38	1.22	28.55	90.77	5.43
Natural cover	1.14	27.40	88.63	5.20	1.30	28.52	88.65	5.57
$LSD_{0.05}$	0.19	0.75	4.11	0.43	0.62	1.07	4.43	0.24
Harvest time	ns	ns	ns	ns	ns	ns	ns	ns
Cover crop	ns	ns	ns	ns	ns	ns	ns	ns
İnteraction	ns	ns	ns	ns	ns	ns	ns	ns

LY ; Lint yield (t ha^{-1}), FL; Fiber length (mm), FS; Fiber strength (pressley), FF; Fiber fineness (mic.)
*, **; Significant at 0.05 and 0.01 probability level, respectively.

Similar increases were also observed for residue organic matter yield in soil. In both years, CT system had higher organic matter yield in harvest residue of cover crops than that of NT tillage system, and although increase in organic matter yield of harvest residue for CT system was 20% in second year; this increase was not determined in NT tillage system. Smart & Bradford (1996) found that soil organic matter in the NT doubled in only 6 years when compared with the conventional moldboard tillage treatments. In our study organic matter contribution of CT system in both years was higher than that of NT cotton.

The significant differences among dry matter yield in harvest residue of cover crops were found in both years. However, there was only a significant difference among cover crops for organic matter yield in the first year (Table 1). In both years, the highest dry matter yield of harvest residue was obtained from common vetch + oat mixture. Common vetch + oat mixture which was followed by hairy vetch + oat, natural cover in first year and hairy vetch, hairy vetch + oat in the second year. Similar to dry matter yield, common vetch + oat, hairy vetch + oat, natural cover had the highest organic matter yield in first year. Organic matter yields of harvest residue in second yield were similar values for all cover crop combinations except hairy vetch. The results for dry and organic matter yield in harvest residue of cover crops show that root biomass of mixtures had high values. Daniel (1997) revealed that selecting the best crop species for use as a cover crop depends on needs of the agricultural system. In the present study, common and hairy vetch and oat adapted to Aegean Region of Turkey. Thus, these crops or their mixtures with oat can be grown to provide organic matter in harvest residue of cover crops.

Lint yield and quality: In both years, no differences regarding to tillage systems and cover crops for lint yield and quality parameters were observed. The CT system had higher lint yield especially in second year (Table 2). Boquet *et al*., (1997) found that in the initial year of their studies, lint yield of NT tillage system was not different from CT system and the tillage by cover crop interaction for lint yield was non-significant throughout the study. However, Abaye *et al*., (1995) reported that CT increased seed cotton yield and lint yield over the NT which might be due to the higher plant density in

CT. In addition, Boquet *et al*., (2004) found that till x cover crop interactions for cotton lint yield was significant, whereas tillage and cover crop did not appreciably compromise or improve fiber quality. In respect to cover crops, common vetch, hairy vetch + oat for first year, and hairy vetch, common vetch + oat combinations for the second year had higher lint yield values. Similarly, Daniel (1997) found that high cover crop biomass production coupled with and extended cotton growing resulted in higher lint yield for cotton grown following the hairy vetch + rye treatment.

The tillage system and cover crops did not affect cotton lint quality such as fiber length (FL), fiber strength (FS) and fiber fineness (mic.). Similarly, Abaye *et al*., (1995) and Bauer & Busscher (1996) found that fiber quality properties were not affected by cover crops and tillage systems. In addition, Pettigrew & Jones (2001) stated that the delayed blooming period of the NT plants meant that these plants might have encountered slightly different weather during bloom possibly contributing to the yield and fiber quality differences between treatments.

Leaf area index and leaf senescence: The differences among cover crops for LAI were found to be significant in first year, and differences between tillage systems for LS in both years were significant (Table 3). In first year, NT cotton had significantly 55% higher LAI whereas difference between tillage systems in second year was non-significant but CT system had higher LAI. Pettigrew & Jones (2001) stated that NT plants averaged 42% less LAI during prebloom and 27% less LAI at midbloom.

During the last years, leaf senescence or early aging has appeared in most of the cotton growing areas which caused yield losses and poor quality properties. LS was therefore evaluated during 50% boll retention period. NT significantly decreased leaf senescence. It would suggest that decreasing LS level result from soil moisture holding capacity in NT treatment parcels.

Table 3. Mean values of leaf area index and leaf senescence in two growing periods.

Tillage system	1997-1998		1999-2000	
	Leaf area index ($m^2 m^{-2}$)	Leaf senescence (%)	Leaf area index ($m^2 m^{-2}$)	Leaf senescence (%)
Conventional	2.45	14.08	2.54	17.07
NT	3.79	7.14	2.39	11.71
$LSD_{0.05}$	1.44	6.93	0.42	3.54
Cover crop				
Common vetch	3.26	11.36	2.33	11.93
Hairy vetch	2.92	8.25	2.16	17.35
Com. Vetch + oat	3.90	9.12	2.37	13.92
Hairy vetch + oat	3.26	8.17	2.85	12.83
Natural cover	2.26	16.15	2.62	15.92
$LSD_{0.05}$	0.80	8.81	0.66	5.60
Harvest time	ns	*	ns	*
Cover Crop	*	ns	ns	ns
İnteraction	ns	ns	ns	ns

*, **; Significant at 0.05 and 0.01 probability level, respectively.

Due to the high cost of production, cotton sowing areas in Aydin and Aegean Region has been declining. No-till providing farmers with the opportunity to harvest an equal seed cotton yield and fiber quality with reduced inputs in comparison with the conventional system have been used (Yalcın *et al*., 2005; In press). The winter cover crop + cotton production system, leaves more crop residue and provides protection to soil from wind and water erosion, and could be easily applied to monoculture cotton growing areas in western parts of Turkey. Among the cover crops, common vetch or hairy vetch + oat mixtures could be recommended as the most suitable legume/gramineae forage crops. In addition, the decreasing leaf senescence under no-till cotton production system could have positive effect on cotton lint yield and quality for long term periods.

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