TILLAGE AND COVER CROP EFFECTS ON COTTON GROWTH AND DEVELOPMENT ON A LOESSIAL SOIL

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ABSTRACT

Inconsistency in cotton production under conservation tillage systems has been attributed in part to reductions in plant population. This study was conducted to determine what effects conservation tillage systems (no-till and ridge-till) had on growth and development of cotton and what relationship these growth patterns had with economic yield and plant population. Crop growth rate (CGR), leaf area index (LAI), and yield components were analyzed over two years for cv "Stoneville 453" grown on a Gigger silt loam (fine-silty, mixed, thermic Typic Fragiudalf). Across four cover crops, the no-till system (NT) produced greater pre-bloom CGR and LAI than conventional- (CT) or ridge-tillage (RT) in 1991, but not in 1992. Across years and cover crops, NT produced a numerically greater, but not consistently significant, boll weight during the fruiting period compared with CT and RT. The greater boll weight was influenced by a greater weight per boll in the NT system. Correlation of pre-bloom CGR and LAI values with lint yield across all treatments and years was significant (r = .73 to .66). Pre-bloom CGR and LAI was also significantly correlated with plant population, hut r values were lower (.47 to 27). Across cover crops, the NT system used on this soil had the greatest potential as a successful conservation tillage system. It also appeared to be the system most varied in plant population. The RT system generally had lower pre-bloom growth. The reduced performance of this system is less likely attributable to differences in plant population as it is to some undetermined, soil-related factor that apparently begins to occur early in the growth process.

INTRODUCTION

Interest in conservation tillage systems has increased in the last decade because of the need to develop an approved conservation plan on highly erodible crop land, a need to reduce production costs, and the necessity to maintain soil productivity. A major objective of conservation tillage research has been to maintain crop productivity while providing the additional benefits attributed to conservation tillage systems (Touchton and Reeves, 1988). The use of winter cover crops is often an integral part of a conservation tillage system. The type of tillage and/or winter cover crop used may have an effect on subsequent growth and productivity of cotton. These effects, however, are inconsistent (Keeling et al., 1989; Stevens et al., 1992). Reduced plant populations in conservation tillage systems have been implicated as a major factor in reduced productivity (Grisso et al., 1984; Morrison et al., 1985). The recommended plant population in Louisiana is the range of 26,000 to 52,000 plants/A. Alternatively, lower plant populations do not always result in lower yields (Touchton and Reeves, 1988). Moreover, lower yields may not necessarily be due to lower plant populations. In order to better understand how conservation tillage/cover crop systems improve or impair cotton production on any given soil, analyses of crop growth and development should be conducted during the season. Our objectives were to 1) quantify crop growth and development throughout the season for different tillage/cover crop systems and 2) relate these growth quantities to yield and plant population.

MATERIALS AND METHODS

The cotton variety "Stoneville 453" was seeded on 5/14 and 5/4 in 1991 and 1992, respectively, into a Gigger silt loam soil (fine-silty, mixed, thermic Typic Fragiudalf). Tillage treatments consisted of CT, RT, and NT. Cover crops were native winter vegetation (NV), crimson clover (CC), hairy vetch (HV), and winter wheat (WW). Tillage and cover crops were arranged in a complete factorial randomized block experimental design with four replications. Management of cover crops, seeding method, fertilizer and herbicide applications, and harvesting are described by Hutchinson et al. (these proceedings).

Data Collection

Plant population counts were determined approximately 20 days after planting (DAP) on a

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minimum of 15 ft of row adjacent to a border row. Plant samples for growth quantification were taken from 2 ft of the same row at approximately biweekly intervals throughout the season. The number of plants within the 2 ft of row taken as a sample had to correspond to the population determined for individual plots. Leaves were excised and leaf area was determined on all leaves per sample early in the season and for leaves on one-third to one-half of the plants per sample later in the season. The total leaf area of these samples was determined by the specific leaf area method (Wells and Meredith, 1986). Total fruiting structures were counted and bolls were separated by location on the plant. Bolls were grouped according to the node position on a fruiting branch (1, 2, and 3+) and fruit branch location on the main stem (nodes 5-8, 9-12, 13-16, and 17+). All bolls produced on vegetative branches were pooled. Leaves, stems, and fruit structures were dried at 70°C for a minimum of 48 h and weighed. Crop growth rates and LAI were determined by the use of classical formulae (Evans, 1972). Weight per boll was determined within each boll grouping and percent dry matter partitioned into bolls was determined by dividing total boll weight by total above-ground plant weight.

Data analysis

Data were combined across years in a split plot design with years as the main plot. Samples were not taken on exactly the same DAP each year, but seven sampling dates were within 7 d or less of each other and were used for the combined analysis. The following DAP were used for 1991 and 1992, respectively 29, 28; 54, 51; 63, 64;76, 78; 94, 90; 108, 101; and 132, 129. The mean of each group would be used in subsequent results and discussions. Analysis of variance and correlations were determined using the Statistical Analysis System (SAS Institute, Inc., Cary, NC).

RESULTS

Combined across years and treatments, the strongest positive relationships between lint yield and CGR or LAI was prior to blooming (Table 1). Plant population density would be expected to have influenced CGR and LAI values, especially early in the season, but correlations between these parameters were only low to moderate. The correlation between lint yield and population density was also low ($r = 0.20$). Significant differences in CGR and LAI did occur between treatments, primarily early in the season. Major differences occurred due to tillage, but significant tillage by year interactions indicated that growth response to a particular tillage system was not stable. The major differences occurred in the NT system, exceeding both CT and RT in 1991 but not in 1992 (Table 2). The RT system generally had the lowest rate of pre-bloom crop development in both years. Cover crop did influence the growth responses to tillage systems because the tillage by cover crop interaction was significant at the 6% level of probability. In general, cover crops had less effect under CT than under RT and NT where they tended to improve pre-bloom CGR The most consistent tillage/cover crop system in producing high pre-bloom CGR was NT/HV. The NT/WW system was equivalent to NT/HV in crop growth 28 DAP, but by 52 DAP, the former system had grown substantially slower than the latter (data not shown).

The number of squares that had developed by 52 DAP was highly correlated with lint yield ($r = 0.74$). Additional square production did not correlate as well. The response paralleled that found with pre-bloom CGR and LAI values. The RT system remained the most consistent in producing fewer squares, while NT was similar to or above CT responses (Table 2).

As would be expected, r values relating lint yield with yield components (boll numbers, total boll weight, percent dry matter partitioning into bolls, and weight per boll) were high to moderate and statistically significant beginning at the initiation of boll-set. Tbe average r value was 0.55 +/-26 for these yield components with lint yield (data not presented). Plant population had generally low correlations with yield components (average $r = .15 \pm .17$), indicating that plant population did not influence the latter stages of crop development in this study. There was a cover crop-by-year interaction for boll weight. Total boll weight at the end of the season was generally greater in applied cover crops (CC, HV, and WW) in 1991 than 1992, but there was no difference between years with the NV cover (data not presented). Differences in yield components between tillage treatments were generally not significant although total boll weight was numerically greatest for NT across the season (Table 3). A major factor in the greater boll weight for NT treatments was the generally greater weight per boll for position 1 bolls located off main stem nodes 5 - 12 (Table 3). The greatest percentage of bolls was found at these positions and therefore had the greatest influence on total boll weight.

Table 1. Correlation coefficients across years, tillage, and cover crops for CGR and LAI throughout the season with lint yield and plant population.

	Days after Planting	Lint Yield	Plant Population
		------------r------------	
CGR	28	.72*	.47*
	52	.66*	.27*
	64	.06	.22*
	77	.48*	.29*
	92	.12	.10
	104	-.07	-.16
	130	-.42*	-.03
LAI	28	.73*	.45*
	52	.68*	.32*
	64	.34*	.30*
	77	.62*	.46*
	91	.53*	.48*
	104	-.22*	-.13

* Significant at $P \leq .05$.

Table 2. The effect of tillage systems on pre-bloom growth and reproductive development of Stoneville 453; 1991 and 1992.

		Days after Planting				
		28		52		
Tillage	**Year**	CGR†	LAI	CGR‡	LAI	Squares
		$gm^{-2}day^{-1}$	m^2m^{-2}	$gm^{-2}day^{-1}$	m^2m^{-2}	$no.Ac^{-1}x10^{-3}$
Conventional	91	0.20	0.09	4.28	1.39	329.8
	92	0.12	0.05	3.21	0.96	152.2
Ridge	91	0.20	0.09	4.19	1.40	331.4
	92	0.09	0.04	2.38	0.71	109.4
No	91	0.30	0.14	6.94	2.25	460.8
	92	0.09	0.04	3.21	0.94	135.9
LSD 0.05		0.04	0.02	0.98	0.28	72.5

† Determined from 0 to 28 DAP.

‡ Determined from 29 to 52 DAP.

Table 3. Tillage effects on total boll weight produced and weight per boll for Stoneville 453; average of 2 years.

Yield Component	Tillage System	Days After Planting				
		64	77	92	104	130
Boll Weight (g/m^2)	Conv.	1.6	60.1	229.9	307.6	348.2
	Ridge	2.7	61.1	234.0	342.2	356.0
	No	3.2	78.1	259.8	356.6	364.5
	LSD 0.05	NS	NS	NS	NS	NS
Position 1 Bolls, Nodes 5 - 8 (g/boll)	Conv.	0.32	1.82	4.13	5.04	5.06
	Ridge	0.46	1.72	4.10	5.11	5.13
	No	0.43	2.41	4.65	5.63	5.64
	LSD 0.05	NS	0.34	NS	NS	0.36
Position 1 Bolls, Nodes 9 - 12 (g/boll)	Conv.	----	0.78	3.06	4.25	5.27
	Ridge	----	0.83	2.84	4.16	5.08
	No	----	1.10	3.26	4.69	5.42
	LSD 0.05		0.19	NS	NS	NS

DISCUSSION

It is well established that early developmental stages of plant growth provide the future basis for a productive crop by rapidly increasing leaf area and, in the case of cotton, subsequently and concomitantly developing a branch framework for reproductive development (Muramoto et al., 1965; Potter and Jones, 1977; Watson, 1952; Mauney, 1984). The faster the early growth rate, the sooner the crop will develop greater light interception capacity that can lead to greater productivity. The correlation results of pre-bloom CGR and LAI with lint yield support this hypothesis. Depending upon the year, the NTsystem developed equivalent or greater pre-bloom CGR than any other tillage system while RT produced equivalent or lower CGR This occurred even though RT generally had a greater plant population than NT. Square production early in the season, also significantly correlated with lint yield, reflected the early CGR and LAI values in the different tillage systems.

The early, pre-bloom growth and development differences should have perpetuated a greater development of yield components. Although this was true to some extent, other factors (possibly insect damage at sub-economic thresholds, short-term moisture deficits, or other weather related factors) modulated the response. Regardless of these circumstances, NT generally had greater total boll weights, primarily due to greater weight per boll both years. Conversely, RT generally had lower values for these components compared with NT. Yield components were not influenced by plant population, which suggested that it was not a major influence on the positive or negative responses to these conservation tillage systems. Plant populations in this study were generally within the acceptable range and were not considered a limiting factor, especially for CT and RT systems. The NTsystem, however, did tend to have the best overall results when plant population was equivalent to other tillage systems (Hutchinson et al., these proceedings). These data suggest that the NTsystem could be a consistently superior conservation tillage system on this soil if plant populations were near the mid to upper part of the acceptable range. Plant populations that are slightly lower, however, but near the lower end of the acceptable range (26,000 plants/A), are adequate in NT, presumably due to better partitioning of dry matter into bolls in this system. The reason RT did not perform well on this soil was not fully understood, hut generally slower pre-bloom growth suggested that the problem began early in development and was maintained throughout the season.

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