CONSERVATION TILLAGE CAN AFFECT COTTON PLANT STRUCTURE AND YIELD

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Abstract

The adoption of conservation tillage cotton production has been slow in Texas with less than ten percent of the cotton being produced with conservation tillage. A lack of producer understanding of the benefits of conservation tillage has been a major barrier to adoption of the system. This study compared a no-tillage rain-fed cotton production system with a conventional tillage system. Objectives of this study was to determine the effects of no-tillage on soil temperature, soil moisture, plant canopy structure, light interception by the crop canopy, timing of fruit set, and to determine how theses factors affect boll weevil populations, crop yield, and economics of the two production systems. Soil moisture was greater in the no-tillage throughout the first 90 days of crop growth due to the decreased evaporation with the crop residue mulch and the soil not being dried by tillage. The no-tillage cotton went into a reproductive mode earlier and set an average of 5.3 bolls per plant at 80 days after planting (DAP) while the conventional tillage cotton remained vegetative and had set only 2.3 bolls per plant at 80 DAP. The no-tillage cotton had 60% as many squares on the soil surface per week, 55% as many squares infested with weevil larvae and pupae, and 51% as many live weevil produced per week on average for the last 12 weeks of the cotton growing season. The conventional tillage had $49 per acre more input costs attributed to tillage costs. Conservation tillage cotton was produced with lower input costs and had equal or greater economic returns than the conventional moldboard plow tillage system.

Introduction

An obstacle to cotton production with conservation tillage has been the lack of information available to producers on effects of tillage on crop growth, yield and economics of using conservation tillage for South Texas compared with conventional tillage systems. There are many factors which affect crop yield when tillage systems are altered. Retaining crop residue on the soil surface insulates the soil moderating temperature extremes and also reduces evaporative losses of moisture. Each tillage or cultivation pass over the field dries the soil and between 1 and 4 cm of water is lost with each tillage operation. When tillage and cultivation between the crop rows is eliminated much of this soil moisture is retained in the soil profile. When a no-tillage system is compared with conventional tillage many aspects of crop production are affected. Some agronomic aspects of crop production affected by tillage may include weed management, soil moisture and temperatures, crop stress, timing of fruit set and crop maturity. The objectives of this study was to determine the effects of conservation tillage on soil temperatures, soil moisture, plant canopy structure, lint interception and timing of fruit set and how these factors affect crop yield. Results from this study will be used to provide farmers with guidelines for implementing conservation tillage.

Materials and Methods

Cotton plant growth, timing of fruit set, lint yield, and production economics as affected by tillage in a semi-arid subtropical environment were examined. Two fields were selected to compare effects of tillage on cotton. Both fields had grain sorghum as the previous crop. The no-tillage grain sorghum was chemically terminated prior to sorghum harvest and crop residue was left standing until planting of cotton the following year in March. An application of glyphosate was applied once in the fall and again in the spring prior to planting cotton in March. Cotton was planted using no-tillage into existing grain sorghum stubble which exceeded 6700 kg/ha crop residue on the soil surface. An adjacent field was farmed using a conventional moldboard plow and disk system where essentially all of the crop residue (300 kg/ha on surface) was destroyed or removed from the soil surface. The conventional tillage field had the sorghum crop residue mechanically shredded, and the field was disced twice with a heavy tandem disc after sorghum harvest and three more discing operations were performed in the fall to terminate weeds which emerged after each rainfall. Field size was about 10 acres for each field and the two fields were the same soil type, a Willacy fine sand, with organic matter content in the surface 6 inches of less than 0.2%. Cotton variety "Delta Pine & Land Co. 451RR was planted on March 1, 2000 for both fields with the in 30 inch row spacings. Seeding rate, fertilizer, insecticidal applications and other production factors excluding weed management were the same for each paired tillage treatment. The No-tillage cotton received glyphosate, 0.75 lb a.i./acre applied broadcast over the cotton at the four leaf stage of growth and glyphosate was applied as a directed spray inside a hooded sprayer at the same rate about 50 days after planting. Conventional tillage cotton glyphosate applied at the same rate as the no-tillage cotton to the four leaf stage but did not receive the directed spray treatment. The conventional tillage cotton was mechanically cultivated twice to remove weeds from between the crop rows.

Measurements taken throughout the growing season included soil temperatures both in the crop row and between the crop row at 5, 10, 20, and 30 cm depths, soil moisture, cotton leaf stage, plant height, percent canopy coverage of soil, plant populations, cotton squares on the soil surface, number of squares infested with boll weevil larvae or pupae, number of boll weevil which survived each week per acre, number of weevils on cotton plants, sampled from three plants using a beat basket method at ten sites in each field, and from phermone traps placed every 100 feet around the perimeter of each field. Cotton lint yield was calculated by hand harvesting ten representative sub-sample sites each six rows wide by four meters long from each field. Samples were returned to the laboratory, weighed, ginned using a small scale laboratory cotton gin, then each the seed and lint were weighed to determine percent lint content. The weight of the lint from the average of the ten sample sites from each field was used to calculate the yield for each of the two fields.

The costs for the conventional moldboard tillage include shredding stalks, chiseling, two passes with a tandem disc, forming and shaping beds, cultivating weeds from the time beds were formed in the fall until planting in March of the next year, as weeds germinate all winter in a sub-tropical environment, application of pre-plant fertilizer, herbicide, seed, and planting costs. The costs for the conservation tillage included, two applications of herbicide (glyphosate) during the fall and winter to control weeds, application of pre-plant fertilizer, herbicide, seed, and planting costs.

Total production costs included tillage, seed, fertilizer, insecticide, herbicide, labor, post-planting cultivation defoliation, harvest, and associated ginning costs. Net returns were calculated by subtracting the total production and harvest costs, ginning, bags, ties, receiving and storage costs from the gross returns. No costs were included for interest on money borrowed.

Results and Discussion

Soil moisture content in the no-tillage was greater than the conventional tillage at planting time, and remained greater at 60 days after planting. Soil temperatures in the furrow between crop rows were much greater than temperatures in the crop row where crop shading occurred all day. The no-tillage temperatures from 60 to 112 DAP were frequently greater in the no-tillage between the cotton rows due to the differences in plant structure of

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the two tillage systems. The no-tillage was setting squares and bolls early and averaged 5.4 bolls per plant at 80 DAP while the conventional tillage cotton had more moisture stress and had set only 2.3 bolls/plant at 80 DAP. The conventional tillage cotton remained vegetative longer and became to and at 80 DAP. Soil temperatures in the crop row varied between tillage treatments but were not greatly different (Figure 2.) Soil moisture in the no-tillage was greater early in the growing season because tillage had not dried out the soil. Soil temperatures between crop rows were taken within $\pm$ 2.5 hours following solar noon. No-tillage soil temperatures 85 DAP were greater at a 5 cm depth in the furrow than the conventional tillage cotton which had more shading of the soil surface. Although crop residue on the soil surface shaded the soil, the lesser crop canopy in the no-tillage had greater soil temperatures between the rows than the conventional tillage cotton which had rank growth. Conventional tillage cotton had less moisture and greater plant stress due to lack of soil moisture early in the season causing plants to shed squares and bolls.

No-tillage cotton had 52% of the incoming sunlight reach the soil surface at 85 days after planting while the conventional tillage cotton had only 42% reach the soil surface. Increased plant height and leaf number in the conventional tillage provided more light interception and shading of the soil surface. The no-tillage cotton quickly went into a reproductive fruiting mode while the conventional tillage cotton was putting most of it's resources into vegetative growth of stalk and leaves. Conventional tillage cotton had more shed squares on the soil surface, more squares infested with weevils, and produced more live weevils per acre per week than did the no-tillage (Table 1). Boll weevil populations at 60 days after planting were much greater in the conventional tillage than the conservation tillage and populations continued to be greater even at 90 days after planting.

Average cotton lint yields in in the conservation tillage field was 354pounds of lint /acre while the the conventional tillage field was only 206 lbs/acres (Table 1). Squares on the soil surface were greater in the conventional tillage field when the samples were collected near the field edge, field middle, under the plants, or between crop rows. Boll weevil populations were consistently greater in the conventional tillage system throughout the growing season. Regardless where the sampling occurred, on the field edge, field middle, under plants, or between rows the infested squares and live weevil numbers were consistently greater than those populations in the no-tillage. When phermone traps were placed every 100 feet around the perimeter of each of the fields weevil numbers were consistently greater in the traps surrounding the conventional tillage field throughout the growing season.

Production costs from harvesting the previous crop until crop harvest and ginning for both tillage systems are presented in Table 2. Lint yield in the conventional tillage was 206 lbs/acre while the no-tillage had lint yields of 354 lbs/acre. Due to the increased lint to be harvested in the no-tillage the actual production costs were not very different although most of the tillage costs were eliminated in the no-tillage system. Net returns were calculated in Table 3. The net returns for the no-tillage system were $4.45/acre while a net loss of $99/acre was calculated for the conventional tillage system due to increased tillage costs and a lower lint yield.

No-tillage cotton set squares and bolls early in the season and averaged 5 bolls/plt at 80 DAP while conventional tillage had only 2.3 bolls/plt at 80 DAP. The differences in the tillage systems resulted in taller plants in the conventional tillage system with fewer bolls per plant. Boll weevil populations at 60 DAP were much greater in the conventional tillage and populations continued to be greater even at 90 DAP. Boll weevil populations in the conventional tillage were greater with trap counts, beat basket method, and infested squares. Net returns for the no-tillage system were $ 103/acre greater with the no-tillage system primarily due to reduced input costs, higher yields, and lower insect populations.

Table 1. Cotton squares on the soil surface, number of squares infested with weevil pupae or larvae, and number of live weevils produced per acre on average for the last 12 weeks of the growing season in 2000 for no-tillage and conventional tillage cotton, Weslaco, Texas.

	squares on soil surface	infested with boll weevil	live weevils
Total no-till	30,300	22,755	12,716
Conventional	50,681	40,773	24,866

Table 2. Field operations, production costs, and economics of conventional and no-tillage cotton production near Weslaco, TX 2000

Field operations	Conventional Tillage	No-tillage
chisel plow	$ 12.00	--------
disk	2X - $ 22.00	--------
cultivation	2X - $ 15.24	--------
bedding	$ 4.50	--------
planting	$ 12.00	$ 12.00
seed costs	$ 18.00	$ 18.00
hooded sprayer /		
glyphosate + appl.	---------	$ 13.00
Def 1 qt/acre	$ 12.00	$ 12.00
Roundup 1.5 pt./ac		
+ applic. charge	$ 10.50	$ 10.50
Insecticide sprays		
+ appl 7X	$ 80.50	$ 80.50
Lbs lint/acre		
hvst, gin, wrap, class,	**206** lbs/acre	**354** lb/acre
stor., tags $ 0.13 + 0.12	$ 51.5	$ 88.50
Total prod. costs/acre	$238.24	$234.50

Table 3. Net returns for cotton production with conventional tillage and no-tillage cotton near Weslaco, TX, 2000.

Field operations	Conventional Tillage	No-tillage
Seed @ 75, $95/ton	$ 19.57	$ 33.63
Gross returns/ac		
@ $ 0.58/lb lint.	$119.48	$205.32
	$139.05	$238.95
Total prod. costs/acre	$238.24	$234.50
Net returns/acre	$(- 99.19)	$ 4.45

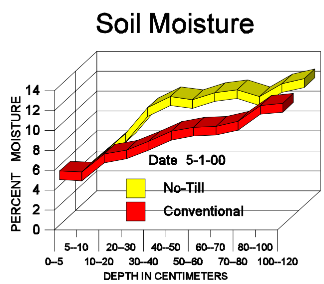

Figure 1. Soil moisture for no-till and conventional tillage cotton at 60 DAP for 0 to 120 cm depth.

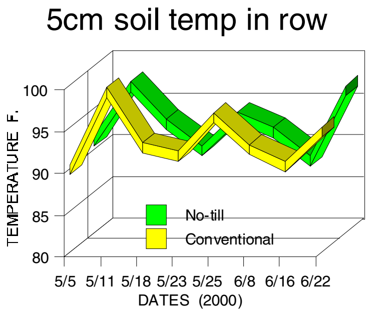

Figure 2. Soil Temperature in the crop row at 5 cm soil depth from 60 DAP to 120 DAP.