The Influence of Tillage on Weed Density, Cotton Growth and Yield

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ABSTRACT

A field experiment was conducted at Larissa, Greece, during 1996, on a clay soil (1% OM), to investigate the effect of three tillage systems (conventional, strip and minimum tillage) on weed emergence, cotton growth and weed-cotton competition. Mouldboard ploughing, followed by chisel ploughing and a single pass with a flexi-tine cultivator prior to cotton sowing constituted the conventional tillage. The strip tillage regime was with a 25-cm deep subsoil treatment at 95-cm intervals, followed by cultivation with a narrow crop cultivator. The minimum tillage treatment plots received a single pass with a flexi-tine cultivator. The combined effect of tillage system x herbicide application (alachlor, prometryne, fluometuron (applied alone), or alachlor EC and alachlor CS in a tank-mix with prometryne or fluometuron, respectively) on weeds and cotton was also examined. The results indicated that both conventional and minimum tillage systems gave taller cotton plants with greater leaf area, wider main stem and higher node number than strip tillage. More weeds were found with conservation tillage (strip and minimum tillage systems) than with conventional tillage. Cotton yield was higher in conventional tillage than conservation tillage systems. Fluometuron treatments produced better weed control and higher cotton yields than the other treatments.

Introduction

Cotton is one of the most important agricultural crops in Greece, occupying 389,833 hectares, 96% of which is irrigated. Cotton was cultivated in 26 counties by 100,400 farmers in 1997 (Hellenic Cotton Board 1996). Interest in conservation tillage production systems has increased (Keeling and Abernathy, 1989) because of rising production costs.

Conservation tillage reduces soil water loss compared to conventional systems, retaining adequate mulch residues on the soil surface (Yoo *et al.*, 1988). Successful weed control in cotton grown under various conservation tillage systems has been reported (Dumas, 1980). Minimum or minimized tillage production systems rely on less soil disturbance for crop seedbed preparation than conventional systems (Robison and Wittmuss, 1973). It is characterized by reduced labour requirements, time savings and crop yields comparable to those of conservation tillage. However in some cases, control of annual weeds with herbicides is inadequate (Brown *et al.*, 1985), cotton plants showing phytotoxic symptoms with increased infestation from perennial weeds (Brown *et al.*, 1987). Reduction of cotton yield was also observed with inadequate early season weed control (Buchanan and Burns, 1970).

Strip or zone tillage is a conservation system that is characterized by soil cultivation in a well-defined zone or strip, equal to the width of the tillage tool, (usually 25-cm). It reduces power requirements, since 25% of the field is tilled (soil cultivation on 25 cm zone at a spacing of 1 m) and fewer passes are required over the field. Strip tillage crop yields were increased by 5 to 200% in coarse-textured soils and by 0 to 6% in fine textured soils, compared to other tillage systems (Carter and Tavernetti, 1968).

In contrast to these results, Johnson (1985), found that soil cultivation increased corn yields, even though the weed density did not justify this treatment. He also found that soil cultivation can provide benefits by being a part of a cost-effective weed control programme, increasing soil moisture and decreasing soil erosion.

The objective of this research was to investigate the combined effect of three tillage systems (conventional, strip and minimum) and nine herbicide treatments on cotton growth (main-stem height, main-stem diameter, number of nodes, and seedcotton yield) and weed control.

Material and Methods

The 1996 experiment was at Larissa, in Central Greece, on a clay soil with 45% clay, 32% silt, 23% sand, 1% organic matter and a pH of 8.0. A randomized complete block split plot design was used with four replications. The three tillage regimes were the main plots with the herbicide treatments as sub-plots. The main plots were 3.8 x 64 m and sub-plots, 3.8x 6 m. Conventional tillage plots were mouldboard ploughed, followed by a chisel ploughing and one flexi-tine cultivator passage prior to planting. Strip tillage plots were sub-soiled every 95cm to a depth of 25-30cm and cultivated with a narrow-crop cultivator. Minimum tillage plots received one passage of flexi-tine cultivator.

Following cultivation, fertilizer (formulated as 12-12-12, N-P_2O_5-K_2O, respectively) at 833 kg/ha was broadcast with a single disc mounted distributor. Cotton cv. Acala-Zeta 2 (*Gossypium hirsutum*) was planted with a Caspardo pneumatic six-row planter at 3.5 cm depth and a seed rate of 24 kg/ha at 95 cm row spacing, to give a stand of approximately 10-14 cotton plants/m row,. A soil pesticide (Thimet) was applied at planting in furrow at 12 kg/ha.

Herbicide application treatments. All herbicides were applied pre-emergence in 300 l/ha of water at 273.57 kPa, using a 4 row hand-held field plot sprayer. The treatments were alachlor [CS] (1.68 kg a.i./ha) + prometryne (1 kg a.i./ha), alachlor [CS] (1.68 kg a.i./ha) + fluometuron (1.5 kg a.i./ha), alachlor [EC] (1.68 kg a.i./ha) + prometryne (1 kg a.i./ha), alachlor [EC] (1.68 kg a.i./ha) + fluometuron (1.5 kg a.i./ha), alachlor [EC] (1.92 kg a.i./ha), prometryne (1.5 kg a.i./ha) and fluometuron (1.65 kg a.i./ha). A weed-free control (weeded manually each week) and a weedy control (weeds left throughout season) treatments were also evaluated. The experimental area was irrigated 12 hours after herbicide application with a travelling sprinkler boom. Foliar insecticides were applied throughout the growing season according to the Hellenic Cotton Board Extension Service recommendations.

Cotton growth sampling procedures. Plant growth was assessed on plants taken from the two middle rows of each plot (11.4 m^2). Seed cotton yield was determined by harvesting the central 2.5-m^2 area of each plot. The growth assessments (cotton plant height, main stem diameter and main stem node number) were made on 3 to 5 representative plants (35 cm length of row) per plot at 3, 5, and 9 weeks after herbicide application (WAA). Leaf area was also measured at 5 and 9 weeks WAA. For each sampling period, one average cotton plant was taken from the cotton plant sample. Leaves and stems were separated and leaf area was measured with a LICOR - 3000A portable area meter. In mid-October, when cotton bolls were fully open. seed cotton was hand-harvested for yield determination.

Weed sampling procedures. The weed infestation in all plots was natural. Weed density of each species was determined on samples from the two central rows of each plot at 3, 5, and 9 WAA, using two quadrants of 50 cm × 50 cm. each. At 10 WAA or 9 weeks after cotton emergence, weeds were removed manually from all plots, except those from the weedy control ones, in order to monitor herbicide and tillage performance and weed-cotton competition.

Analyses of variance were conducted on all data using LSD ($P \geq 0.05$) to separate means.

Results

The weeds found in the experimental area were dominated by *Xanthium strumarium* and *Amaranthus retroflexus*, but other *Amaranthus* spp, *Echinochloa* spp and *Setaria* spp were present. The data presented in Table 1 relate to the final assessment only.

All variables examined were significantly affected by tillage system and herbicide treatments. Weed density and cotton height were also significantly affected by the tillage x herbicide interaction.

There were less weeds in conventional than in strip tillage, and all herbicide treatments reduced weed number relative to the weedy control. *X. strumarium* was controlled partially only with fluometuron treatments. All other weeds were controlled adequately by herbicide treatments. Fluometuron gave good weed control with conventional tillage but it was less effective with strip or minimum tillage.

Plants were taller under conventional and minimum tillage than under strip tillage. The tallest plants were in weed-free control plots and in plots treated with alachlor (EC) + fluometuron. All plots had significantly taller plants than the weedy controls. Plants in plots treated with alachlor (CS) + prometryne were significantly taller under minimum than under strip tillage and were significantly taller in plots treated with alachlor (CS) + fluometuron or fluometuron under conventional and minimum tillage than under strip tillage.

The leaf area was greater in plants grown under conventional and minimum tillage than those under strip tillage. Greater leaf areas were also obtained from plants grown in weed-free control plots. In addition, leaf area of plants grown in alachlor (EC) or (CS) + fluometuron treated plots was greater than in plots treated with prometryne, alachlor (CS) + prometryne, alachlor (EC) or those of the weedy control ones. Plants in plots treated with fluometuron also produced greater leaf area than in plots treated with alachlor (CS) + prometryne, alachlor (EC) or those of the weedy controls.

Cotton plant stem diameter was wider under conventional and minimum till than under strip tillage. With the exception of plots treated with alachlor (CS) + fluometuron, plants in weed free control plots had significantly wider stem diameter than all the other treatments. Plants in plots treated with alachlor (CS) + fluometuron, fluometuron, and alachlor (EC) + fluometuron also had with wider stem diameter than in plots treated with prometryne, alachlor (CS) + prometryne, alachlor (EC) or weedy controls. The stem diameter of plants in weedy controls was narrower than those of all other treatments except those treated with alachlor (EC).

Node numbers were higher on plants grown under conventional and minimum tillage than under strip tillage. High and low node numbers were recorded on plants from weed free and weedy control plots, respectively. In contrast, the node number of plants grown in alachlor (CS) + fluometuron treated plots and in weed-free control plots was not significantly different. Plants in plots treated with alachlor (CS) + fluometuron, fluometuron and alachlor (EC) + fluometuron had significantly more nodes than plants from plots treated with prometryne, alachlor (CS) + prometryne or alachlor (EC).

Seedcotton yield was significantly affected by the tillage system and herbicide treatment. Yields were higher with conventional than minimum or strip tillage. The highest and lowest cotton yields were in weed-free and weedy control plots, respectively. Alachlor (CS) + fluometuron treated plots also yielded significantly more than alachlor (EC) or alachlor (CS) + prometryne treated plots.

Discussion

The larger number of weed seedlings found in the conservation till plots compared to the conventional tilled plots could be due to the higher number of seeds found at or near the soil surface prior to cultivation. In contrast, the smaller number of weed seedlings in the conventional tilled plots may have been the result of freshly shed seeds being buried to a soil depths where germination conditions were unfavourable and some seeds could have fallen into secondary dormancy. These results agree with those reported by Williams *et al.* (1990). The differences in cotton height, leaf area, main stem diameter and node number reduction recorded among the treatments could be due to the different levels of weed density and consequently to the different levels of weed competition. Similar results were found by Burns *et al.* (1971b); Norris *et al.* (1996); Frans *et al.* (1994); Buchanan *et al.* (1970); Burns *et al.* (1971b) and Burns *et al.* (1971a). The higher effect recorded on seedcotton yield due to weed competition compared to the other cotton plant parameters (height, stem diameter, and leaf area) is in agreement with the results reported by Buchanan *et al.* (1970). Seedcotton yield was decreased with increasing weed density under the various tillage regimes. This is in agreement with results found by Buchanan *et al.* (1970) and Chandler *et al.* (1993). The lower weed emergence under minimum tillage compared to strip tillage may be due to reduced soil distrubance in the top eight-cm. soil layer in minimum tillage plots. However, this was not the case with the strip tillage plots. Minimum tillage, according to Mohler (1996), allows weed emergence no deeper than the top 2-3 cm. Higher seedcotton yields and higher values of cotton plant growth parameters were obtained with conventional tillage than with conservation tillage. Cotton yield was also higher in fluometuron treated plots than in other treatments. This may have resulted from better soil conditions for cotton growth in conventional tillage plots and better weed (*X. strumarium* and *Amaranthus* spp) suppression in those treatments. This was also reported by Richburg *et al.* (1994).

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Table 1. Weed density and cotton height, leaf area, yield, main stem diameter and nodes under the tillage regimes and the herbicide treatments at final assessment.

Treatment	Weed Density	Cotton Parameters				
		Height	Leaf area	Main stem		Yield
Tillage Regimes	(number/m^2)	(cm)	(cm^2)	Diameter (mm)	nodes	(kg/ha)
Conventional	25.39 b*	53.65 a	3747.0 a	8.63 a	10.66 a	1332.0 a
Strip	119.50 a	38.19 b	1349.0 b	6.27 b	8.78 b	465.2 b
Minimum	81.17 ab	51.00 a	3197.0 a	8.50 a	10.65 a	759.6 b
LSD	56.86	9.35	1603.0	1.74	1.57	408.8
Weed free control	0.00 c	58.21 a	5335.0 a	10.08 a	12.37 a	1856.0 a
Herbicides						
Weedy control	199.80 a	35.02 d	118.4 d	5.43 f	6.96 e	73.7d
Alachlor(CS) + Prometryne	57.29 b	42.37 c	1226.0 cd	6.76 e	9.17 cd	573.7c
Alachlor(CS) + Fluometuron	35.42 bc	51.44 b	3494.0 b	9.28 ab	11.33 ab	1114.0 b
Alachlor(EC) + Prometryne	50.83 b	49.09 b	1748.0 c	7.93 cd	10.31 bc	657.0 bc
Alachlor(EC) + Fluometuron	46.25 b	52.64 ab	3146.0 b	8.54 bc	10.69 b	838.6 bc
Alachlor(EC)	70.00 b	41.74 c	592.0 cd	6.39 ef	8.95 d	636.8 c
Prometryne	60.21 b	46.97 bc	1250.0 cd	7.21 de	9.41 cd	901.8 bc
Fluometuron	44.21 b	51.05 b	3137.0 b	8.59 bc	11.08 b	1018.0 bc
LSD	38.75	5.817	1358.0	1.14	1.18	473.8

* Means of each column followed by the same letter are not significantly different according to LSD Test.