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Effects of narrow rows and no-tillage on growth parameters, fibre quality and yield components of cotton

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Abstract

This paper focuses on the comparative study of cotton (*Gossypium hirsutum* L.) grown on narrow (75 cm) and conventional (96 cm) row spacing, combined with conventional tillage or no-tillage. The evaluation of these cultural practices was conducted in terms of cotton growth parameters, crop productivity and fibre properties of Celia, one of the most commonly grown cultivars in central Greece. The experimentation showed that cotton grown on narrow-row spacing significantly increased seed-cotton and lint yield by 13.26 and 12.95%, respectively, compared to conventional row spacing. However, there were no significant differences detected between the crop yields of the two tillage practices, even if leaf area index (LAI) was significantly higher in the case of no-tillage. These findings could be potentially useful to the farmers, and the systems of narrow-rows and no-tillage could be viable and profitable for cotton growing in Greece and other Mediterranean-type environments.

Key words: Narrow-row system, no-tillage, cotton yield, leaf area index, fibre properties.

Introduction

Greece is one of the major cotton producer countries in the world, as cotton growing occupies about 400,000 hectares. Approximately, 100,000 rural and 80,000 urban families are involved in cultivation and process of cotton, projecting the economic and social significance of the crop [2]. However, last years selling prices of seed cotton were reduced, while production cost increased, resulting to a lower income for the cotton producers. Therefore, it is crucial to evaluate several production practices, aiming at eliminating production cost and improving crop profitability [18].

Because of its high economic value, cotton is grown in most regions of Greece as a monoculture for more than five years. Consequently, it is important to examine the effects of different cultivation practices in order to avoid risks of soil deterioration in cotton fields and reduce production costs. Reduced tillage cotton yielded either less than or equal to conventional systems [6, 19, 23], even if is usually associated with an improvement in several soil properties [11, 13, 24]. However, in other studies no-tillage cotton yields were significantly higher than in conventionally tilled crops [12, 21]. The prediction of USDA is that by 2010, more than 90% of crop acreage will be grown under conservation tillage systems (reduced or no-tillage), even if they involve difficulties on weed control [10, 14]. It follows that more studies on the effects of reduced tillage systems on cotton growth and yield are required.

Nowadays, there are many projects being conducted in Europe, USA and Australia, in order to evaluate production systems with different row distances: conventional (96 cm) and narrow spacing (75 cm) and consequently to suggest the optimum plant density for each region and variety [4, 16, 22]. In the USA, the narrow row system has been widely adopted by many producers, providing a yield increase up to 25% [1, 7, 8, 27]. Nevertheless, there is also a number of studies on several cotton varieties indicating less favourite and intense results than the above mentioned findings [23, 28], highlighting the importance of additional and extended studies.

In view of these concerns, the aim of this study was the investigation of the effects of two tillage practices (conventional and no-tillage) and two cultural systems (conventional and narrow spacing) on the growth and productivity of cotton crop under Mediterranean environmental conditions.

Materials and Methods

The experiment was conducted during 2003-2004 in Karditsa Prefecture in Central Greece (39°21´N, 21°56´E). A cotton crop (*G. hirsutum* L. cv. Celia) was established in a field of this region on May of 2004. Celia is a widely grown variety of moderate earliness, with big bolls and resistance to several cotton diseases (such as *Fusarium* sp.) The soil was sandy clay loam (24% clay, 41% silt and 35% sand) with pH 7.05, 1.31% organic matter (determined according to Walkley and Black [26]), 0.2% total nitrogen, 9 ppm of available phosphorus (P-Olsen) and a good supply of potassium (116 ppm). Weather conditions during the experiment were more similar to normal conditions prevailing in Central Greece, even relatively drier. The crop before cotton was durum wheat (*Triticum durum* L. cv. Mexicali).

The experiment was set up on an area of 4800 m^2 according to the split plot design with four replicates, two main plots (tillage systems) and two sub-plots (row distances). The area of each plot was 300 m^2.

During the autumn, wheat residues were incorporated. At the end of April the conventional plots were cultivated by chisel at a depth of 25 cm and then plowed again, sprayed with a mixture of two herbicides (Sonalan and Treflan 2 kg ha^{-1}), disked four times and smoothed with a wooden harrow for a proper seedbed preparation. No-tillage plots were sprayed once with Gramoxone (700 kg ha^{-1}) and twice with Roundup (1.1 kg ha^{-1}) for eliminating early weeds. Later, they were disked and harrowed once with a combined disk and wooden harrow, in order to destroy weed residues.

Cotton was planted on 10 May, when the soil temperature at a depth of 20 cm reached 18°C. Seed at rates of 35 and 44 kg ha^{-1} for conventional (96 cm) and narrow rows (75 cm) was used, respectively. Thus, the average number of plants ha^{-1} was 180,000 and 225,000, on conventional and narrow rows, respectively. All plots were fertilized with 400 kg ha^{-1} of NPK (11-15-15) fertilizer, applied before planting. Additionally, on 11 June N (46-0-0) fertilizer (urea) was also applied at a rate of 70 and 90 kg ha^{-1}, for conventional and narrow rows respectively. All treatments received the same number of mechanical hoeings (two), hand hoeings (two) and drip irrigations (six times on 32, 49, 66, 92, 105 and 115 days after planting with a standard dose of about 600 m^3 of water per hectare in each time). Furthermore, applications of the plant growth regulators Pix on 3 August (28 g ha^{-1}), Ethrel (1.5 kg ha^{-1}) and Finish (180 g ha^{-1}) on 4 October were also conducted for plant-growth restriction and earliness. The crop was harvested manually on 17 October (160 days after sowing).

Soil water content was determined gravimetrically at depths of 0-11, 12-20 and 21-30 cm at 150 days after sowing. Leaf area measurement was also taken at 110 days after sowing. Plants were destructively sampled and leaf area was measured using an automatic leaf area meter (Delta–T Devices Ltd, Burwell, Cambridge, UK). The results on a plant basis were converted into LAI by multiplying by the average crop density of each plot. For these measurements, four samplings were taken of each plot.

Yield of seed-cotton was measured at the end of the experimental period, by hand picking plants from 5 m from the central rows of each plot. In order to estimate mean boll weight (MBW), seed-cotton samples were weighed on a laboratory balance and the mean weight of each sample was divided by 50. Lint percentage was obtained as the weight of lint expressed as percentage of the weight of the seed-cotton sample. Lint yield was calculated by multiplying the lint percentage by the seed-cotton weight. Fibre length (2.5% span length, mm), fibre strength (necessary force for breaking the fibre bundle, g tex^{-1}), micronaire and uniformity ratio (%) were determined using the Zellweger Uster Spinlab High Volume Instrument 900 (HVI) (USTER Technologies, Charlotte, Tenessee, USA).

All data were analyzed using the Statgraphics statistical software package (v.5.0, Statistical Graphics Corporation, Englewood Cliffs, NJ, USA). Mean comparison was performed using Duncan's new multiple range test at the 5% level of significance.

Results and Discussion

Soil water content was consistently higher in the no-tillage plots and lower in the conventional tillage plots. This difference can be attributed to the reduction of evaporation losses and the greater size and stability of the soil aggregates [5, 15, 17]. In Table 1 it is also shown that there was a significant effect of the distance between rows on soil water content, as long as narrow rows (75 cm) showed consistently equal or higher values than the conventional rows (96cm).

Table 1. Comparison of alternative tillage practices and row distances of the cotton crop growing in Greece on soil water content.

Tillage practice	Row distance	Soil water content (% $m^3.m^{-3}$) 0-11 cm	12-20 cm	21-30 cm
Conventional tillage	Conventional	27.048 a	22.140 d	20.619 h
	Narrow	25.943 a	24.151 c	21.455 gh
No-tillage	Conventional	24.546 b	20.135 e	20.186 g
	Narrow	27.241 a	22.543 d	23.273 f

Means within the same column that differ significantly using Duncan's new multiple range test at a probability level p<0.05 are noted with different letters.

Measurement of leaf area index (LAI) is critical to understanding many aspects of crop development, growth and management, as long as it is already recognised as a key variable in agricultural modelling [19]. In our study, leaf area index (LAI) exhibited higher values in the no-tillage and lower in the conventional plots for the narrow and the conventional rows. Moreover, it has to be noted that LAI values were significantly higher in the case of the row distance of 75 cm, even if for all the treatments of our experiment LAI values ranged at relatively high levels, indicating the high-yield potential of 'Celia' (Table 2).

Table 2. Effect of alternative tillage practices and row distances of the cotton crop growing in Greece on Leaf Area Index (LAI).

	Leaf area index (LAI) Conventional tillage	No-tillage
Conventional rows (96 cm)	2.66 c	2.95 b
Narrow rows (75 cm)	3.11 b	3.86 a

Means within the same column or row that differ significantly using Duncan's new multiple range test at a probability level p<0.05 are noted with different letters.

Statistical analysis of the data showed significant differences of the yields, especially between conventional and narrow rows (Table 3). Indeed, the narrow-row system on cotton gave significantly higher seed-cotton and lint yield (13.26 and 12.95%, respectively) compared to conventional row system ($p<0.05$), while there were no significant differences between the two tillage practices. These findings are in accordance to the conclusions reported on other varieties in Greece [16], confirming the potential importance of narrow-row cotton. Concerning lint percentage and mean boll weight, no significant differences were detected between the two tillage practices and cultural systems, meaning that the yield differences are related to the higher plant density per hectare of the narrow-row system. MBW and lint yield correlation analysis showed that these two components were not correlated ($r = 0.05$), exactly likewise in other cotton varieties [3]. However, seed-cotton yield and lint yield were closely correlated ($r = 0.99$), while lint percentage was rather slightly and negatively correlated with the above-mentioned yield components ($r = -0.34$ and $r = -0.26$, respectively), confirming that the latter was only a minor factor affecting cotton yield [3].

Fibre quality is mainly determined from its physical properties, namely length, strength, fineness (micronair) and uniformity. However, in our experiment there were not found significant differences in fibre properties between the several treatments (Table 4). Fibre length and other fibre properties depend on many factors, with genotype (cultivar) being the most important one [9]. Indeed, Celia is a variety of high fibre quality, while quality seems not to be significantly affected by the tillage practice or the row

Table 3. Comparison of alternative tillage practices and row distances of the cotton crop growing in Greece on cotton yield (seed-cotton and lint), lint percentage and mean boll weight.

Tillage practice	Row distance	Seed-cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Lint percentage	Mean boll weight (g)
Conventional tillage	Conventional	2998 b	1308 d	43.6 e	6.25 f
	Narrow	3698 a	1600 c	43.3 e	6.34 f
No-tillage	Conventional	3218 b	1380 d	42.9 e	6.59 f
	Narrow	3468 a	1488 cd	42.8 e	6.49 f

Means within the same column that differ significantly using Duncan's new multiple range test at a probability level $p<0.05$ are noted with different letters.

Table 4. Effects of alternative tillage practices and row distances of the cotton crop growing in Greece on fibre quality.

Tillage practice	Row distance	Fibre length (mm)	Fibre strength (g tex^{-1})	Micronaire	Uniformity (%)
Conventional tillage	Conventional	29.42 a	33.7 a	4.32 a	85.8 a
	Narrow	29.50 a	33.6 a	4.43 a	85.7 a
No-tillage	Conventional	29.31 a	33.1 a	4.42 a	85.4 a
	Narrow	29.61 a	33.5 a	4.40 a	86.1 a

Means within the same column that differ significantly using Duncan's new multiple range test at a probability level $p<0.05$ are noted with different letters.

distance of the cotton crop. Additionally, fibre length and strength were slightly correlated ($r = 0.56$, significant at a probability level $p<0.05$), such as in previous similar studies on other cotton varieties [3].

Conclusions

Our findings are in accordance to previous studies on other cotton varieties, indicating the supremacy of cotton yield (seed-cotton and lint) in the narrow-row system. These results are of great importance, as narrow row system can be a viable option (possibly an attractive alternative) to traditional row-cropped cotton. Therefore, it is worthwhile to further investigate and evaluate more cotton varieties for better adaptation to narrow-row system. Moreover, the combination of narrow-rows with no-tillage practice could be viably and successfully applied for cotton, as long as the improved soil, water and plant parameters could achieve the optimum productivity and quality level with the best gross margin and highest profitability.

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