The effect of low irrigation and fertigation on cotton production under Greek conditions

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ABSTRACT

The intensification of cotton cultivation aiming to yield maximization resulted to the overuse of inputs, increase of production cost and environmental pollution. The World Trade Organization imposes the cotton production in a friendly to the environment farming system with low input use and consequently low cost of production and optimization of cotton yield. In the framework of the new agricultural priorities a field experiment was conducted in central Greece for a six years period 1997-2002. In particular, two to three levels of irrigation and one to three nitrogen fertilization levels were evaluated under fertigation and traditional dressing systems, in two main Greek cultivars in a split-split plot design with a minimum of four replications. Drip irrigation was applied in all cases. The results showed that fertigation was beneficial for both varieties, but the yield increase was not always statistically significant. There was also evidence that yield optimization may be obtained with reduced water use but not under a certain critical level. The reduced amount of irrigation, in comparison to the farmer's amount, leaded also to the earliness of maturity of the late cultivar Zeta-2, a fact that is of main importance under unfavorable weather conditions in marginal cotton regions as Greece.

Introduction

The period after World War II was characterized by the maximization of the agricultural production under the pressure of the continuously increasing world population, the food shortage and the increase of profits. Intensive agriculture is characterized by overuse of natural resources, severe environmental problems, high production cost and inferior product quality. High input cost and concerns about environmental protection coupled with the World Trade Organization agreement have imposed the need to produce more sustainable and competitive cotton crops.

In Greece, where cotton is the most dynamic crop, quality improvement and decreased cost of production constitute the main aims of cotton cultivation. Under this priority, the optimization of irrigation and N-fertilization leads to low input sustainable agriculture (Galanopoulou-Sendouca, 1998).

In this study the combined effect of irrigation and nitrogen fertilization was evaluated under fertigation, for first time in Greece and it was compared with the traditional fertilization.

Experimental procedure

A field experiment was conducted, in Thessaly (central Greece), the main cotton region, for six years, 1997-2002. The experimental design was split-split plot with a minimum of four replications. Main plots were two to three levels of irrigation, expressed as percentage of crop evapotranspiration (ETcrop - FAO, 1977) (Table 1). Effective rainfall was taken into consideration for assessing the irrigation treatments. In 1997 and 1998 sub plots were two nitrogen fertilization practices: a) the traditional basic fertilization plus surface dissemination of fertilizer and b) the fertigation with basic fertilization plus fertilization with drip irrigation (Burt, 1995). From 1999 till 2002 the sub plots constituted two to three levels of nitrogen fertilization and sub-sub plots were the two different fertilization practices (Table 2). Two Greek cotton cultivars were evaluated as sub-sub plots in 1997 and 1998 and as sub-sub-sub plots next years. Corina is of medium earliness and Zeta 2 is later in maturity (Galanopoulou-Sendouca, 2002).

During the six years period, weather conditions were normal except May 1999 (intense rainfall during emergence) and the August-September period in 2002 (many rainfalls). Most favorable weather conditions for cotton cultivation prevailed in 2001. Seed sowing was in April. Harvesting included two hand-picking areas per plot.

Lint yield was assessed and the water use efficiency was calculated as ratio of total lint cotton production (g/m^2) to the total water amount (mm) that was applied as irrigation or effective rainfall.

Results

Low irrigation decreased yield significantly only in 1999 and 2001 and the medium level only in 1999 in comparison to high irrigation level (Table 3). Decrease of irrigation increased water use efficiency up to a level of about 35% of ETcrop (Figure 1). However, the correlation of lint yield and irrigation showed that the first picking percentage, maximized at about 50% ETcrop irrigation level (Figure 2). Cultivar yield results were presented in a previous work (Polychronides and Galanopoulou-Sendouca, 2002).

Increase of N fertilization increased yield significantly except 1999, when the medium level did not differ significantly from the high level (Table 3). Fertigation increased lint yield in all cases. This superiority was proved statistically significant in four out of the six years (Table 3).

Discussion/Conclusion

Yield results showed that it is possible to reduce the irrigation water amount, without significant sacri-

fice of yield in most cases. This is in accordance to other results in Greece (Gertsis *et al*., 1997). Significant reduction in yield was noticed in extreme cases (unfavorable or favorable). In 1999 low and medium irrigation decreased yield significantly, probably, due to the delay of emergence that prevented cotton plant to ensure the desirable level of growth before flowering initiation. In 2001, under very favorable weather conditions, low irrigation prohibited cotton crop to express its yield potential, while the medium irrigation proved sufficient and did not differ significantly from high irrigation. This study showed that the optimum irrigation level is about 50% of ETcrop (Figures 1 and 2; Table 3).

Increase of N-fertilization (up to 150-180 kg/ha) increased yield significantly except 1999 when unfavorable conditions optimized the medium level (120 kg/ha). These results are supported also by other studies (Setatou and Simonis, 1994). Fertigation was proved superior in comparison to the traditional practice and increased yield significantly in four out of six years. Also, other researchers report yield increase by fertigation (Janat and Somi, 1998).

References

- Burt, C.M. (1995). Fertigation - The Next Frontier. *Irrigation business and technology,* **4**:16-19.
- FAO, (1977). *Irrigation and drainage*. Paper 24. Rome, pp: 30-66.
- Galanopoulou-Sendouca, S. (1998). Towards a more competitive and sustainable cotton production. *Economy and Environment*. Edited by Joseph N. Lekakis. Kluwer Academic Publishers.16: 112-127.
- Galanopoulou-Sendouca, S. (2002). Industrial plants. Edit Ath. Stamoulis, Athens, Greece, pp: 142-143.
- Gertsis, A.C., Galanopoulou-Sendouca, S., Papathanasiou, G. and Symeonakis, A. (1997). Use of GOSSYM - A cotton growth simulation model - to manage a low input cotton. *Proceedings*: First European Conference for Information Technology in Agriculture. The Royal Veterinary and Agricultural University, Copenhagen, Denmark, 15- 18 June, pp: 359-362.
- Janat, M. and Somi, G. (1998). Comparative Study of nitrogen fertilizer use efficiency of cotton grown under conventional and fertigation practices using ^{15}N methodology. Regional Project RAW/5/002, Syria. First Annual Co-ordination Meeting of RER/5/011. Fertigation For improved crop production and environmental protection. International Atomic Energy Agency's, Vienna, Austria, 21-23 Febr., 2001.
- Polychronides, M.P. and Galanopoulou-Sendouca, S. (2002). Low inputs' cultivation using fertigation in tow cotton varieties. Abstracts of 9th National Conference of Plant Breeding and Genetics. Thessaloniki, 30 Oct.- 1 Nov. (in Greek).
- Setatou, H.B. and Simonis, A.D. (1994). Response of cotton to NPK fertilization – the Greek experience. Proceedings: World Cotton Research Conference-1. Challenging the Future. Brisbane, Australia, 14-17 Febr., pp: 147-151.

Table 1. *Crop evapotranspiration needs (ETcrop) and irrigation levels.*

Year	ETcrop (mm water)	Irrigation level (mm), (% ETcrop)				
		Irr. 1	Irr. 2	Irr. 3	Irr. 4	Irr. 5
1997	580	**----**	**----**	250, (43)	320, (55)	**----**
1998	590	----	200, (34)	266, (45)	----	----
1999	630	126, (20)	200, (32)	280, (44)	----	----
2000	650	----	246, (38)	300, (46)	360, (56)	----
2001	630	**----**	**----**	296, (47)	340, (54)	400, (63)
2002	550	----	----	260, (47)	300, (55)	365, (66)
Mean		126, (20)	215, (35)	274, (45)	330, (55)	383, (65)

Table 2. *Nitrogen fertilization levels and application practices.*

Year	Total N (kg/ha)	Application practices[1, 2, 3]	Nitrogen level		
			Low (kg/ha)	Medium (kg/ha)	High (kg/ha)
1997	160	T = basic + surficial	-----	-----	80+80
		F = basic + fertigation	-----	-----	80+80
1998	120	T = basic + surficial	-----	60+60	-----
		F = basic + fertigation	-----	60+60	-----
1999	60, 120 & 180	T = basic + surficial	30+30	60+60	90+90
		F = basic + fertigation	30+30	60+60	90+90
2000	50, 100 & 150	T = basic + surficial	25+25	50+50	75+75
		F = basic + fertigation	25+25	50+50	75+75
2001 & 2002	100 & 150	T = basic + surficial	-----	50+50	75+75
		F = basic + fertigation	-----	50+50	75+75

[1]: The high level of surficial N-fertilization was applied in tow equal doses.

[2]: The fertigation was distributed in two up to four applications through drip irrigation

[3] T = traditional., F = fertigation.

Table 3. *Lint cotton yield (g/m²) for main factors.*

Factors	Levels	Year*					
		1997	1998	1999	2000	2001	2002
Irrigation (%ETcrop)	Irr. 1 (20)	-	-	67 c	-	-	-
	Irr. 2 (35)	-	125	86 b	151	-	-
	Irr. 3 (45)	169	136	119 a	159	162 b	155
	Irr. 4 (55)	177	-	-	166	173 ab	161
	Irr. 5 (65)	-	-	-	-	182 a	165
LSD $_{0,05}$		Ns	Ns	2,3	Ns	13,1	Ns
Nitrogen fertilization	50-60 kg/ha	-	-	83 b	144 c	-	-
	100-120 ha/ha	-	√	93 a	155 b	160	153
	150-180 ha/ha	√	-	95 a	177 a	184	167
LSD $_{0,05}$		-	-	2,2	7,4	5,3	9,3
Fertilization Practices	Traditional	171	128	87	151	166	153
	Fertigation	175	133	93	166	179	167
LSD $_{0,05}$		Ns	Ns	2,6	4,7	6,5	5,5
CV (%)		10,5	9,4	8,7	13,4	13,8	13,8

* Values followed by the same alphabetical letter in a column do not differ significantly.

Ns = Not significant.

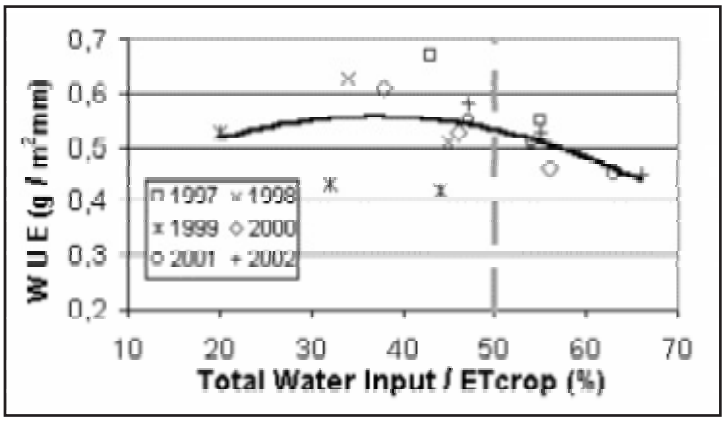

Figure 1.
Curve of water use efficiency in irrigation levels.

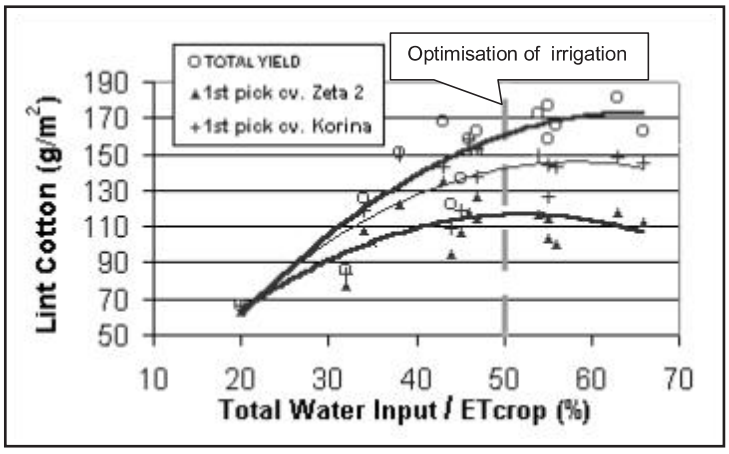

Figure 2.
Curves of first harvest of cv. Zeta 2, cv. Korina and total yield in irrigation levels.