RESPONSE OF COTTON TO NPK FERTILIZATION - THE GREEK EXPERIENCE

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Abstract

Cotton is an economically important crop in Greece and experiments to determine the response of cotton to rates of fertilizers have always been an important part of research. The first experiments started almost 40 years ago and low rates of NPK showed a slight increase in cotton yield due to N and a lack of response to P and K fertilization. The aim of this paper is to summarize the progress of more recent experiments.

Fifty-six experiments were conducted in eight cotton producing areas, for 12 successive years, testing five rates of N (0, 50, 100, 150, 200 Kg N per ha) and two rates of P (0,100 Kg P per ha) and K (0, 100 Kg K per ha). Data showed that N affected seed cotton yield, even at the very low application rate, while the effect of P was limited and that of K negligible. The increase in cotton yield as a result of N fertilization was related to the number of bolls and the boll weight. The maturity of cotton plants was related to N fertilization. Among the cotton fiber characteristics, only lint percentage was affected by fertilization.

Introduction

Cotton (*Gossypium hirsutum*) has been cultivated in Greece for many centuries, showing considerable increase from the 17th century to the present. About 60,000 Greek families now produce cotton and it is the second most important agricultural source of foreign currency for the national economy. Today it covers 250,000 ha, 93% of which is irrigated.

Cotton is grown in Greece mainly between 35° N and 41° N latitude and only 1,000 ha are grown further south than the 38° N parallel. Greece belongs to the so-called Mediterranean climatic zone; characterized by moderate winter rainfall and hot and dry summers. However, there are quite a number of local micro-climates, chiefly due to the influence of the mountains and the sea. The total annual average rainfall ranges from 350 to 1400 mm, from which 50-125 mm correspond to the summer season. The Greek climate is also characterized by high instability, mainly during spring and autumn. This has great influence on cotton, as both are very critical for planting and harvesting. The plains where cotton is cultivated have mostly alluvial soils, which are suitable for cotton growth and when the other growth conditions are favourable the yields are high.

Total cotton production in Greece has increased rapidly during the last 20 years - since 1969 lint production has been higher than 100,000 tonnes each year and the objective for the immediate future is its stabilization at 150-160 thousand tonnes, to cover domestic consumption. The expansion in cotton production has been the result of an increased area of cropping, and improved varieties, cultural techniques and management.

Experiments to determine the response of cotton to rates of fertilizers have always been an important part of research in Greece. Sound nutrition is one component of high yields and there has been a gradual trend for N fertilizer rates to increase over this time span.

The first experiments, started almost 40 years ago and tested low rates of N, P, K application, have shown a slight increase in cotton yield due to N and a lack of response to P and K applied as fertilizer (Anastassiou, 1982). With the aim of obtaining more information about the response of Greek cotton to fertilization and the effect of N, P and K on the yield and boll properties of cotton, a second series of experiments was started, testing higher rates

of N, P, K application. The results generally indicated a variable degree of increase in the yield, as the rate of N application increased, depending on the soil and environmental conditions, while no response due to P and K was observed (Setatou, 1991). As a result of these investigations, farmers today use 150 to 200 kg N per ha, 60 to 100 kg P per ha and in some cases potassium, according to the soil and environmental conditions.

Cotton requires large amounts of N, particularly under irrigation. The amount of fertilizer N applied to cotton should be sufficient to achieve maximum returns of the crop, whilst avoiding possible problems, such as excessive growth, delayed maturity, reduced ginning percentage, greater incidence of disease and greater attractiveness to insect pests (Hearn, 1975; Constable and Hearn, 1981). On light textured soils, it is also important to minimise the potential contamination of ground water with nitrates from excessive fertilizer use. Research (Hardy and Garret, 1965) has shown that cotton yield increased with fertilization of up to 90 kg N per ha on a silty clay soil. More recently, Australian researchers found N rates for maximum cotton yield on clay soils to range from 125 to 220 kg per ha (Constable and Rochester, 1988). The maturity of the cotton crop, as evidenced by first and second picking lint yield, was found to depend on the N rate (Mascagni et al., 1993). Moreover, the percentage of lint was found to increase by the higher rates of fertilization (Wadleight, 1974). Fertilizer N application was reported to exert no significant effect on fiber properties (Benedict, 1984). It was stated that P fertilization increased the amount of fruit set during the early fruiting period and the yields at first harvest, especially when soils were deficient or low in the nutrient (Thompson, 1971), while K applied to the plant increased boll size and fiber quality (Huang, Dong-Mai, 1989). However, Hons et al. (1990) found no influence on lint or seed yields to applied phosphorus.

This paper summarises the progress that has been made on experimental work on cotton N, P, K fertilization in Greece, with emphasis on the data of the more recent experiments.

Materials and Methods

A total of 144 experiments were carried out during the last 40 years on commercial farms under different environments. The climate of these areas was variable within and between years. Most of the experiments were situated on medium-textured free-draining soils with organic matter content ranging between 1% and 2% and pH values between 6.5 and 7.5. The farms had a long history of intensive cultivation, with only N fertilization in general use. The crop was sown in spring each season on a 1 m row spacing and 10 m long, with furrow irrigation as required. The cultivar used was the Greek variety 4S. Cultural practices were consistent with those normally practiced in each area.

Two main series of experiments were conducted:

Early experiments

Eighty-eight experiments were conducted in 15 cotton producing areas, for seven successive seasons, on the same fields, in a 3^3 factorial design with four replications. The 27 treatments included the following rates in all combinations : (a) 0, 30, 60 Kg N per ha applied as ammonium nitrate, (b) 0, 40, 80 Kg P per ha applied as superphosphate and (c) 0, 20, 40 Kg K per ha applied as potassium sulfate.

Recent experiments

Fifty-six experiments were conducted in eight areas, for 12 successive seasons. Differential annual N treatments consisted of 0, 50, 100, 150, 200 Kg N per ha as ammonium sulfate. One third of the amount of N was applied in the drill at planting and the remaining

two thirds as a side dressing, one month after seeding. Annual treatments of P and K consisted of 0 or 100 Kg per ha, applied as superphosphate and potassium sulfate, respectively, in the drill at planting. Treatments were replicated four times in a split plot design.

Yield was measured by machine harvesting the two center rows of each plot and weighing the seed cotton. A subsample (200-300 g) of seed cotton was taken to determine lint percentage. Fiber samples were taken from each plot, blended and prepared for analysis. Fiber length was measured on a digital fibrograph; fineness was measured with the micronaire; and the strength was measured with a stelometer. Data were analysed, statistically, according to the standard methods (Steel and Torrie, 1983).

Results and Discussion

Early experiments

Seed cotton yields at maturity as influenced by fertilizer are shown in Table 1. When no N fertilizer was applied cotton yielded 1678 Kg per ha on an average, while, when 30 or 60 Kg N per ha were applied cotton yields were 1759 and 1811 Kg per ha, respectively - an increase of 5% and 7%, as compared to zero N fertilization. The effect of P fertilization on the yields was negligible (2-3%), while no effect was observed from K ferilization.

Recent experiments

Seed cotton yields are shown in Table 2. Statistical analyses showed that the only significant effect was that of N, even in the very low application rates, while the effect of P was limited and that of K negligible. Lack of response to P and K application in most of the experiments was due to the presence of adequate levels of available P and K in the soil. This is in agreement with the results of other researchers (Amer *et al.*, 1963). On an average of ten experiments, the increase in yield by 50 and 150 Kg N per ha was 286 (14%) and 320 Kg per ha (21%) of seed, respectively, while on an average of nine experiments, the increase in yield by 50 Kg N per ha was 220 Kg per ha (19%) of seed (Fig. 1). No interaction, with few exceptions, was observed between treatments (Table 2). In areas with favourable environmental conditions and high yields (Arta, Preveza, Karditsa, Viotia), the effect of fertilization was higher. On the contrary, in sites located in a marginal area for cotton growth, the effect was generally limited (Table 2).

It was found that N fertilization caused a delay in the maturity of cotton plants - 0.5, 1.3 and 1.9 days for 50, 100 and 150 Kg N applied per ha (Table 3, Fig. 2). The delay in maturity found in these experiments was in agreement with the findings of other workers (Hearn, 1975). However, this delay is important only when the conditions for harvest are unfavourable.

The increase in cotton yield as a result of N fertilization was related with the number of bolls and the boll weight. Boll weight increased 3% and 4% by 50 and 200 Kg N per ha, respectively (Fig. 2).

Among the fibre characteristics only lint percentage was affected by fertilization. It was found that a decrease in lint percentage of 0.5 and 1.0 unit, with 50 and 150 Kg N per ha, respectively (Fig. 2) and in some cases it was related to the increase in boll weight. The data found in relation to the effect of N fertilization on the fiber length and the fiber strength (pressley index) were contradictory, while there was an indication that the fineness (micronaire index) was related to the delay of cotton maturity.

The effect of fertilization, in most of the cases, was the same among years, although yields were quite variable. The average increase resulting from fertilization, for each year, was almost constant (14-21%). It seems that variability in the effect of fertilization might be

expected only when the deviation from the environmental conditions, as they determined by the soil type, the climate or the cultural practices, is very wide. This happened in 1970 and 1972, when the average rainfall in October-May was much higher than that of all the 12 years of experimentation (233 and 449 mm in comparison with the average of 283 mm).

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				Ν					Р					K		
		0		30		60	0		40		80	0		20		40
Sites	no exp								Yiel d							
		Kg/ ha	Kg/ ha	% nil	Kg/ ha	% nil	Kg/ ha	Kg/ ha	% nil	Kg/ ha	% nil	Kg/ ha	Kg/ ha	% nil	Kg/ ha	% nil
Thessaloniki	8	1670	1740	104	1720	103	1690	1720	102	1720	102	1730	1710	99	1690	98
Veria	4	2100	2210	105	2230	106	2110	2180	103	2240	106	2200	2160	98	2180	99
Yannitsa	6	2160	2170	100	2170	100	2170	2150	99	2170	100	2140	2170	101	2180	102
Serres	4	1320	1540	117	1680	127	1510	1520	101	1520	101	1530	1510	99	1510	99
Rodopi	7	1370	1380	101	1410	103	1380	1390	101	1390	101	1410	1370	97	1390	99
Larissa	6	2220	2260	102	2260	102	2210	2220	100	2290	104	2240	2240	100	2260	10
Karditsa	8	1210	1310	108	1350	112	1270	1290	102	1310	103	1218	1300	107	1290	100
Phthiotis	8	2160	2310	107	2400	111	2260	2300	102	2320	103	2290	2310	101	2270	99
Viotia	7	1810	1790	99	1820	101	1780	1790	101	1850	104	1810	1790	99	1810	100
Messologi	4	1690	1730	102	1730	102	1730	1720	99	1690	98	1710	1730	101	1710	100
Arta	3	1470	1610	110	1810	123	1540	1660	108	1700	110	1640	1620	99	1630	99
Preveza	4	1220	1280	105	1330	109	1130	1340	119	1380	122	1270	1280	101	1290	102
Lakonia	7	1920	2070	108	2100	109	2030	2030	100	2040	100	2030	2060	101	2010	99
Ilia	5	1310	1310	100	1290	98	1310	1280	98	1310	100	1300	1300	100	1300	100
Limnos	7	1540	1670	108	1720	112	1630	1670	102	1640	100	1640	1640	100	1650	10
Mean/year	88	1678	1759	105	1801	107	1717	1751	102	1771	103	1744	1746	100	1775	100

Table 1. Effect of NPK fertilization on cotton yield (early experiments).

Reg-	Veria		Serres		Arta		Preveza		Yannitsa		Larissa		
ion ->	>												
Treat-		%		%		%		%		%		%	
ment	Kg/ha	Con	Kg/ha	Con	Kg/ha	Con	Kg/ha	Con	Kg/ha	Con	Kg/ha	Con	ŀ
0	2710	100	2810	100	1960	100	2700	100	2740	100	3690	100	2
50	3030	112	3080	110	2350	120	3260	121	2860	104	4060	110	2
N 100	3230	119	3250	116	2570	131	3560	132	2880	105	4140	112	2
150	3240	120	3230	115	2690	137	3760	139	2880	105	4170	113	2
200	3340	123	4080	145	2760	140	3450	128	2950	107	4350	118	3
P 0	3090	100	3080	100	2470	100	2480	100	2830	100	4050	100	2
100	3050	99	3130	102	2410	98	3390	137	2840	100	4040	100	2
K 0	3060	100	3130	100	2430	100	3260	100	2830	100	4040	100	2
100	3090	101	3080	98	2460	101	3230	99	2840	100	4050	100	2

Table 2. Effect of NPK fertilization on the cotton yield (recent experiments).

Treatmen		Veria	Serres	Arta	Preveza	Yannitsa	Larissa	Karditsa	Viotia
t									
	0	16/9	30/9	9/10	10/10	2/10	29/10	9/10	7/9
Ν	150	0.5	1.1	0.5	0.5	0.8	-0.2	-0.8	0.1
	100	1.4	1.5	2.0	2.0	1.2	1.0	-0.2	0.5
	150	2.5	1.9	3.1	3.1	1.6	0.9	0.8	0.7
	200	2.5	1.8	7.9	7.9	1.2	0.9	2.2	0.9
Р	0	21/9	1/10	11/10	12/10	4/10	29/9	9/10	8/9
		0.3	0.5	-0.2	-0.4	1.3	0.9	-0.9	-0.2
Κ	0	22/9	2/10	11/10	12/10	5/10	30/9	9/10	8/9
	100	0.2	-0.1	-0.3	0.5	0.4	0.7	0.5	-0.2

Table 3. Earliness of cotton (\pm of the control, in days).

Figure 1. Effect of N fertilization on the cotton yield.

Figure 2. Effect of N fertilization on the earliness, the boll weight and the percentage of fibres.