

Full Length Research Paper

Influence of soil and foliar applications of potassium fertilization on growth, yield and fiber quality traits in two *Gossypium barbadense* L. varieties

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Two field experiments were conducted at the experimental farm of the Faculty of Agriculture at Fayoum, Egypt, to study the effect of soil and foliar applications of potassium in the form of potassium sulphate. The treated cotton plants with potassium soil application and with foliar spray improved all the studied growth traits, that is, number of leaf per plant, the total leaf area per plant (dm²) and the dry weight of leaf per plant (g). The best results were found when cotton plants were treated with soil application plus K foliar spray twice, each at early boll formation and peak boll formation stage as compared to the control treatment. Moreover, this treatment also produced significantly higher yield with improved growth and fiber traits. The interaction between varieties and potassium fertilizer treatments had a significant effect on growth, cotton yield and fiber quality, whereas the Giza-90 variety x soil and foliar application (2 times) of potassium out of the interactions proved to have the best results.

Key words: Cotton varieties, foliar potassium application, fiber quality, Nitrogen, Phosphorous, and Potassium (NPK).

INTRODUCTION

Cotton (*Gossypium barbadense* L.) is considered as one of the most important commercial crops and forms the bone back of Egypt textile industry. Therefore, increasing its productivity and fiber quality attributes as well as the cultivated area is highly recommended. Cotton plants require a specific amount of certain nutrients in specific format applied at an appropriate time for their growth and development (Oosterhuis, 2001; Sajid et al., 2008). Nowadays, soil application of macronutrients (that is, N, P and K) is found to be very expensive. In addition, the availability of these macronutrients will be affected by several environmental factors, that is, antagonism, element deposition, leaching ... etc. In contrast, foliar

feeding technique as a particular way to supply these nutrients could avoid these factors and results in a rapid absorption. Foliar feeding is more effective and less costly (Jamal et al., 2006) in most cases.

Potassium (K) is one of the principle plant nutrients underpinning crop yield production and quality determinations. While involved in many physiological processes, potassium's impact on water relations, photosynthesis, assimilate transport and enzyme activation can have direct consequences on crop productivity. It is a major nutrient for cotton apart from nitrogen and phosphorus (EL-Bialy et al., 2001; Ahmed et al., 2006; Pettigrew, 2008).

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Table 1. Physical and chemical properties of the tested soil.

Soil composition (%)			Texture	pH	ECe (dS/m)	N (ppm)	P (ppm)	K (ppm)	O.C. (%)	CaCO ₃ (%)
Silt	Sand	Clay								
21.40	26.43	52.17	Clay	7.35	1.68	73	20	716	1.40	6.01

In cotton, K plays an important role in fiber development. A shortage in K dose will result in poorer fiber quality and lowered yields. The increase in boll number and weight is correlated positively with the increase in K fertilization dose (Brar and Brar, 2004; Kumar et al., 2011; Aladakatti et al., 2011). Recently, great attention has been paid by several Egyptian and foreign investigators. They proved that the productivity of cotton increased by applying a/the technique of foliar feeding (El-Sayed and Abd El-Malik 2001; Abou El-Nour et al., 2001; Gormus, 2002; El-Menshaw, 2003; Pettigrew et al., 2005; Blais et al., 2009 ; Zakaria et al., 2011).

Therefore, two field studies were planned and executed to study the effect of soil and foliar application of potassium with recommended doses of Nitrogen, Phosphorous, and Potassium (NPK) on growth, productivity and fiber quality traits of cotton plants (Table 1).

MATERIALS AND METHODS

Two field studies were conducted during the growing seasons of 2009 and 2010 at the experimental farm of the Faculty of Agriculture, Fayoum, Egypt, to study the effect of soil and foliar application of potassium fertilizer on growth, yield and fiber quality traits of cotton. Two varieties of cotton (Giza, 90; newly developed variety and Giza 85; obsolete variety) were used in this study. The ordinary cultural practices for growing cotton were adopted as recommended, except the experimental treatments.

Fertilization applied in 5 treatments occupied sub plots as follows:

1. F1 (control); N and P were applied excluding K fertilizer.
2. F2; the recommended doses of N, P and K fertilizers (RDF) were applied.
3. F3; recommended NPK + 2% K₂O was foliar sprayed in the form of potassium sulphate at 80 days after sowing [80 DAS; early boll formation stage (EFP)].
4. F4; recommended NPK + 2% K₂O was foliar sprayed in the form of potassium sulphate at 105 days after sowing [105 DAS; peak boll formation stage (PEF)].
5. F5; recommended NPK + 2% K₂O was foliar sprayed twice at both 80 DAS (EFP) and 105 DAS (PEF).

The experiment was laid out in a split-plot design with four replicates where the two cotton genotypes and treatments of fertilizers were allocated in the main and sub plots, respectively. Sowing date was on the 16th and 18th of March for the first and second season, respectively. Ten individual randomly selected plants were tagged to collect data.

The recorded growth traits were: Number of leaf per plant, total leaf area per plant (dm²) and dry weight of leaf per plant (g). Yield and its components were: Seed cotton yield (Kentar /hectar), number of bolls, boll weight (g), lint percentage (%), seed index (g)

and lint index (g). Fiber attributes were: Fiber length (mm), fineness (µg/inch) and fiber strength (g/tex) traits.

The obtained data were subjected to analysis of variance (ANOVA) according to Gomez and Gomez (1984) using MSTAT software and means of treatments were compared using LSD at significance level of 0.05.

RESULTS AND DISCUSSION

Growth traits

Data in Table 2 show that the number of leaves per plant, total leaf area per plant and dry weight of leaf per plant were significantly increased by soil application of K, foliar application of K and their combinations as compared to the control (NP; F1).

It is noticeable that adding NPK plus 2 times K foliar spray with 2% K₂O each at early and peak boll formation stages (F5) surpassed other treatments regarding growth traits. Furthermore, the application of treatments F3 and F4 (NPK + 1 K-foliar spray with 2% K₂O at early or peak boll formation) resulted in improvement in growth traits as compared to the control (NP; F1) and NPK (F2) treatments. In this respect, Pettigrew (2008) reported that potassium deficiency can lead to a reduction in both number of leaves and area of individual leaves. Coupling this reduced amount of photosynthetic source material with a reduction in the photosynthetic rate per unit leaf area, the result is an overall reduction in the amount of photosynthetic assimilates available for growth. These results are in agreement with those reported by EL-Bialy et al. (2001), Gormus (2002), Ahmed et al. (2006) and Zakaria et al. (2011). Regarding the performance of varieties, cotton varieties were not significantly different in their growth traits. This finding may be due to the fact that these genotypes belong to the same species (*G. barbadense* L.), but a slight increase was proved for the genotype of Giza 90 compared to Giza 85. Results indicated a significant interaction between the varieties and fertilizer treatments revealing an interaction of varieties (V) and potassium fertilizer (F) on these traits.

Yield and yield components

Average values of cotton seed yield and its components are given in Table 3. It is obvious that the K fertilization treatments caused significant differences in cotton seed yield, number of bolls, boll weight, lint percentage, seed index and lint index, and yield and its components for F5. F5 has the largest values followed by the two treatments

Table 2. Growth traits as affected by soil and foliar applications of potassium.

Treatment	Number of leaves			Total leaf area			Dry weight of leaf		
	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean
F1: NP (without K)	44.8	40.1	42.5	53.0	48.0	50.5	22.4	18.5	20.4
F2: NPK (RDF)	46.5	41.3	43.9	53.3	49.7	51.5	24.0	19.5	21.8
F3: NPK + K(EBF)	47.6	43.0	45.3	54.4	52.3	53.3	27.4	21.6	24.5
F4: NPK + K(PBF)	47.8	43.1	45.5	57.0	53.0	55.0	27.5	23.2	25.3
F5: NPK + K(EBF +PBF)	48.7	44.4	46.6	58.5	55.0	56.7	26.9	25.0	25.9
Mean	47.1	42.4		55.2	51.6		25.7	21.5	
	V	F	V x F	V	F	V x F	V	F	V x F
LSD*: 5%	N.S	0.47	0.67	N.S	1.05	1.49	N.S	0.81	1.14

*Significant at $p < 0.05$ level of probability. RDF, recommended fertilizer doses (180 N, 54 P₂O₅ and 115 K₂O/hectar). EBF, K-foliar spray with 2% K₂O at early boll formation; PBF, K-foliar spray with 2% K₂O at peak boll formation.

Table 3. Yield and its components as affected by soil and foliar applications of potassium

Treatments	Cotton seed yield (kentar/hectar)			Number of bolls			Boll weight		
	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean
F1: NP (without K)	16.80	16.20	16.51	15.76	14.56	15.16	2.31	2.41	2.36
F2: NPK (RDF)	17.88	16.73	17.30	16.40	15.71	16.05	2.40	2.45	2.43
F3: NPK + K(EBF)	19.46	18.14	18.82	16.06	14.08	15.07	2.58	2.68	2.63
F4: NPK + K(PBF)	19.56	18.50	19.03	16.18	15.95	16.07	2.60	2.70	2.65
F5: NPK + K(EBF +PBF)	20.09	19.63	19.87	17.89	16.59	17.24	2.71	2.74	2.73
Mean	18.77	17.83		16.46	15.25		2.52	2.60	
	V	F	V x F	V	F	V x F	V	F	V x F
LSD: 5%	N.S	0.2	0.4	N.S	0.30	0.43	N.S	0.05	0.08

Treatments	Lint percentage			Seed index			Lint index		
	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean
F1: NP ((without K)	32.93	31.58	32.26	9.11	9.26	9.19	4.47	4.28	4.38
F2: NPK (RDF)	35.46	34.81	35.14	9.50	9.49	9.50	5.19	5.08	5.13
F3: NPK + K(EBF)	33.90	33.37	33.64	9.76	9.76	9.76	5.00	4.89	4.95
F4: NPK + K(PBF)	34.50	35.17	34.84	10.20	10.01	10.11	5.37	5.44	5.41
F5: NPK + K(EBF +PBF)	39.73	36.25	37.99	10.58	10.38	10.48	6.61	5.91	6.26
Mean	35.31	34.24		9.83	9.78		5.33	5.12	
	V	F	V x F	V	F	V x F	V	F	V x F
LSD: 5%	N.S	0.91	1.28	N.S	0.14	0.17	N.S	0.11	0.15

*Significant at $p < 0.05$ level of probability; RDF = recommended fertilizer doses (180 N, 54 P₂O₅ and 115 K₂O/hectar); EBF, K-foliar spray with 2% K₂O at early boll formation; PBF, K-foliar spray with 2% K₂O at peak boll formation.

F4 and F3, then F2 as compared to the control (F1). As the boll is the largest sink of K during its development, the need for K is increased. These results reveal the importance of the increase in bolls number and boll weight followed by lint percentage, seed and lint indices. Mean performances of the tested cotton varieties for yield and its components showed slightly increased values for Giza 90 as compared to Giza 85. The combined analysis showed a significant interaction between the studied

variables. The interaction of V1 x F5 proved to have the best effect. Similar results were obtained by Pettigrew et al. (2005), Blais et al. (2009), Aladakatti et al. (2011) and Kumar et al. (2011). They found that the treatments of potassium fertilizer applied in two forms (soil addition plus foliar spray) in the appropriate time lead to an increase in boll number and boll weight, and consequently an increase in cotton yield. In the meantime, Pettigrew (2008) stated that the production of less photosynthetic

Table 4. Fiber quality traits as affected by soil and foliar applications of potassium.

Treatment	Fiber length			Fiber fineness			Fiber strength		
	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean	Giza 90 (V1)	Giza 85 (V2)	Mean
F1: NP (without K)	29.6	31.0	30.3	4.45	4.38	4.42	29.1	30.7	29.9
F2: NPK (RDF)	30.7	30.8	30.8	4.14	4.12	4.13	30.9	31.8	31.3
F3: NPK + K(EBF)	30.9	31.0	31.0	4.06	3.93	4.00	31.5	31.6	31.5
F4: NPK + K(PBF)	31.1	31.8	31.5	4.00	4.10	4.05	31.7	31.2	31.5
F5: NPK + K(EBF +PBF)	31.9	33.4	32.7	3.76	3.80	3.78	33.1	33.0	33.1
Mean	30.9	31.6		4.08	4.07		31.3	31.7	
	V	F	V x F	V	F	V x F	V	F	V x F
LSD: 5%	N.S	0.23	0.33	N.S	0.09	0.13	N.S	0.17	0.24

*Significant at $p < 0.05$ level of probability. RDF, recommended fertilizer doses (180 N, 54 P_2O_5 and 115 K_2O /hectar). EBF, K-foliar spray with 2% K_2O at early boll formation; PBF, K-foliar spray with 2% K_2O at peak boll formation.

assimilates and reduced assimilate transport out of the leaves to the developing bolls greatly contributes to the negative consequences of potassium deficiencies and are reflected by yield and quality.

Fiber quality attributes

Results of fiber quality traits in Table 4 showed that the application of NPK + foliar sprays of K at both early and peak boll formation stage (F5) caused higher values as compared to the treatments of NP (F1), NPK (F2) and NPK + foliar spray of K at either early or peak boll formation stage (F3, F4) while it produced the lowest values of fiber fineness (desirable effect). The obtained values of fiber length, fineness and strength were 32.65 mm, 33.06 g/tex and 3.78 μ g/inch, respectively, in the F5 treatment. The findings showed that the cotton varieties Giza 90 and Giza 85 were not significantly different for fiber traits. This may be due to the fact that these genotypes belong to the same species (*G. barbadense* L.). Moreover, results also indicated that the interaction between the studied treatments was significant as the effect of fertilizer treatments on fiber quality traits differed with the performance of varieties under study (Table 4). In this respect, Oosterhuis (2002),

Brar and Brar (2004), Kumar et al. (2011) and Aladakatti et al. (2011) reported that the improvement in fiber length, fiber fineness and fiber strength is attributed to foliar application of K at flowering. This may be due to that enough supply of potassium during active fiber growth period may cause an increase in the turgor pressure of the fiber, resulting in higher cell elongation and taller fibers at maturity. Thus the application of potassium in foliar form at later growth stages of cotton might have helped in improving the fiber qualities. It plays a practically important role in fiber development and a shortage will result in poorer fiber quality and lowered yields.

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