Bull. Fac . Agric., Cairo Univ., 70: 409-421 (2019).

INFLUENCE OF POTASSIUM ON THE GROWTH AND DEVELOPMENT OF FIBER IN EGYPTIAN COTTON

(Received: 7.11.2019)

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ABSTRACT

The present investigation was carried out to study the effect of potassium foliar application on cotton fiber length, rate of elongation, cellulose deposition, fiber quality properties and some yield traits. Giza 94 and Giza 95 LS Egyptian cotton varieties were used in pots experiment at the wire green house during 2017 and 2018 seasons. Potassium foliar treatments included four doses, namely control and (10,15 and 20 g/l), where each dose was divided into three equal parts; the first part was applied 80 days after planting (the beginning of flowering), the second was added after two weeks from the first part application (in the middle of fiber elongation stage), and the third part was added after two weeks from the second (in the middle of secondary wall thickening). The results indicated that the foliar application of k proved to have a great effect in improving and raising the productivity and fiber quality. K foliar application in the beginning and during flowering caused clear overlapping between fiber elongation and cellulose deposition (maturity) phases. Furthermore, boll weight, seed index, lint % and most of fiber properties were improved by K foliar treatments. 15g/l of K foliar application showed the longest and more mature fibers and the highest levels of the other fiber properties besides improving boll weight, lint and seed index.

Key word: *Cotton- quality – Fiber development – Potassium – foliar application.*

1. INTRODUCTION

Potassium is a mobile element inside the plant. It can easily move between plant organs. Potassium has an important role in a number of enzymes including those implicated with energy transfer,where plants require potassium for the production of high-energy phosphate molecules (ATP) produced in both photosynthesis and respiration. It is necessary for osmotic regulation and carbohydrates transfer. Furthermore, it affects the rate of transpiration and water uptake through regulating stomata opening. It is also involved in nitrogen metabolism and protein synthesis. Maintaining adequate plant K concentration can reduce the incidence of damping off diseases (Pettigrew, 2008). The amount of photosynthetic available for reproductive sinks is reduced when K is lower than normal because potassium has pronounced effects on carbohydrate partitioning by affecting either phloem export of photosynthess (sucrose) or source organs (Cakmak *et al.*, 1994). Potassium could be added as soil application, it acts as an ion in the soil solution and its uptake is affected by competition with the other cations in that solution including NH_4^+, Na^+, Mg^{++} and Ca^{++}. However, it could be applied as foliar potassium to cotton plants at square initiation, flower initiation and peak boll development. Potassium foliar application may allow correction of these deficiencies more quickly and efficiently than soil application, reflected rapidly and positively on cotton yield and fiber quality (Abaye, 1996; Howord *et al*. 2000). Moreover *Pettigrew et al*.(2000) and Muhammad *et al*. (2016)and (2017) reported that potassium (K) is an essential nutrient for normal plant growth and development, in addition to playing an important role in fiber development. Therefore, its deficiency results in decreased cotton yield and quality. Dewdar,(2013) indicated that, soil application in addition to foliar spray of 2% K_2SO_4 at early and peak boll formation stages showed better levels of growth, yield traits and fiber quality measurements than potassium soil application only. Weir, (1998) and Rajendran *et al*. (2010) reported that, applying both potassium sources K_2SO_4 and KNO_3 as foliar spray increased yield up to 75 kg/ha and improved fiber quality. They added that the physiological role of potassium in fruit formation and ripening can be related to its role in the transportation of metabolism products from the leaves to the growing bolls. Increasing K concentration significantly increased boll weight leading to higher cotton yield. Ali and Armin (2016) and Mohammad *et al.* (2016) also, showed that, the amount of photosynthesis available for reproductive sinks reduced when K is lower than normal. Zhao *et al.* (2001) showed that, accumulation of sucrose in leaves of K deficient plants might be associated with reduced entry of sucrose into the transport pool or decreased phloem loading. K deficiencies during squaring also dramatically reduced leaf area and dry matter accumulation, besides affecting assimilate partitioning among plant tissues. Zahoor *et al*. (2017) indicated that foliar application of potassium at later stage of cotton growth had an important function for good fiber development. They added that adding 1.5 % K_2O enhanced the fiber quality of cotton compered with the other treatments; 0, 1% and 2% K_2O. Zahoor *et al.* (2018) concluded that. K foliar application at the optimal level can decrease the extreme losses imported by the water stress in crop plants as well as efficiently enhances the yield-related parameters. Ruan *et al*. (2001) cleared that potassium plays an important role in fiber elongation and maturity development. Deficiency of this nutrient results in reduced yield (low maturity) and shorter fibers since K provides pressure inside the fiber cell walls necessary for fiber elongation and its role in transportation of photosynthesis products to the boll. Xi *et al.* (1989) reported that, since K is associated with the transport of sugars from leaves to bolls, it is likely implicated with secondary wall deposition in fibers, therefore, it is related to fiber strength and micronair value (maturity). Shanmugham and Bhat, (1991) Aladakatti *et al*. (2011)Found noticeable improvement in fiber length, uniformity ratio, fiber strength and maturity through foliar application of K at flowering. Oosterhuis, (2002) found that, limited supply of potassium during active fiber growth period may cause reduction in the turgor pressure of the fiber resulting in less cell elongation and shorter fibers at maturity. Andrew, (2001) mentioned that potassium deficiency can reduce fiber length even at moderate levels of yield loss due to the very sensitive nature of fiber quality to potassium levels in the boll. Eiaz *et al*. (2011) reported that the rate of potassium foliar spray showed significant effect on the number of bolls, boll weight, yield per plant and lint percentage besides, improved fiber length. Dewdar and Rady (2013) reported that, it is noticeable that adding NPK plus 2 times foliar spray of 2% K_2O surpasses the other treatments in growth traits and fiber quality. Afnan *et al.*,(2015) indicated that, K foliar application can decrease the cost of potassium nutrients and enhance yield quality.

The main objectives of this investigation were to study:

- The effect of potassium foliar application on cotton fiber development (elongation, perimeter and cellulose deposition).
- The effect of potassium foliar application on yield traits and fiber quality measurements.

2. MATERIAL AND METHODS

A pot experiment was carried out in 2017 and 2018 seasons at the wire green house of Plant Physiology Department, Cotton Research Institute, Agricultural Research Center, Giza, Egypt. Two Egyptian cotton varieties namely; Giza 94 and Giza 95 (*Gossypium barbadense* L.) were used. Temperature during both seasons is shown in Table (1). Sowing dates were 10^{th} of May 2017 and 12^{th} of May 2018. 96 pots of 40 cm diameter were used in each season. Twelve pots for each treatment, each pot was filled with soil taken from the Agricultural Experimental Station Farm, CRI, ARC, Giza. Soil samples were taken randomly before sowing to determine the physicochemical properties; the results of soil analysis are recorded in Table (2). Irrigation was carried out regularly when needed using tap water. The cotton plants were thinned to two plants in each pot. Fertilization was conducted according to the recommended dose of N and P but without adding of K. Pest control was conducted by using Tyleton (1.2cm/l) starting from the beginning of boll development and every 15 days for two times. Potassium foliar application treatments included four doses; 0, 10, 15 and 20g/l, each dose was divided into three equal parts; the first part was applied 80 days after planting (the beginning flowering), the second part of each dose was added after two weeks from the first part application (in the middle of fiber elongation stage), the third part was added after two weeks from the second one (in the middle of secondary wall thickening). During flowering, some flowers from the different plants were labeled in the day of an thesis to enable obtaining bolls of known age. Bolls of 10 ages, 5, 10, 15, 20, 25, 30, 35, 40 and 45-48 days from flowering were used in this study. The selected bolls of each age

Table (1): Degree of temperature in 2017 and 2018 seasons.

Month	Period	2017 season Temperature (°C)			2018 season Temperature (°C)		
		Max.	Min.	Mean	Max.	Min.	Mean
May	1-10	34.4	18.7	28.9	33.3	19.9	29.0
	11-20	34.5	19.8	29.2	34.3	19.8	28.7
	21-30	35.0	19.6	29.7	37.6	23.5	32.4
Average		34.6	19.4	29.3	35.1	21.1	30.0
June	1-10	37.1	21.9	30.6	35.7	21.9	30.5
	11-20	36.8	23.5	34.5	35.5	24.2	29.9
	21-30	36.2	29.5	31.7	37.2	34.2	32.4
Average		36.7	25.0	32.3	36.5	26.8	31.5
July	1-10	38.5	24.6	33.6	37.4	23.7	32.3
	11-20	39.2	24.6	34.4	37.9	24.6	32.2
	21-30	37.0	24.3	32.6	38.5	25.0	33.4
Average		38.2	24.5	33.5	37.9	24.4	32.6
August	1-10	37.7	24.8	33.5	37.9	25.4	32.7
	11-20	37.3	25.1	32.6	36.9	25.1	31.9
	21-30	36.4	23.8	31.5	36.6	24.9	31.7
Average		37.1	24.6	32.5	37.1	25.1	32.1
September	1-10	35.4	22.4	31.1	37.0	25.0	31.9
	11-20	36.1	22.8	31.3	35.1	23.4	30.7
	21-30	33.3	21.6	29.2	34.7	23.9	30.6
Average		34.9	22.3	30.5	35.6	24.1	31.1

were taken from the plant and transported directly to the Lab of Fiber Structural Properties, Cotton Fiber Res. Department, Cotton Res. Institute to measure fiber diameter, perimeter (3.14 x diameter) and following up the development of fiber elongation and cellulose deposition (maturity) under different ages. To follow up fiber elongation and its rate, 10 fibers were taken from each side of the clazal part of the seed and measured their length using especial ruler. The obtained length data average to represent fiber length of each boll age. Cellulose deposition was expressed as the degree of thickening, which was calculated according to the formula of Lord, (1981).

$$\text{Degree of thickening} = \frac{area\ of\ cellulose}{(circular\ cross\ section\ area)}\ \%$$

By 50 days boll age, bolls were opened and the fibers were dried therefore, it was treated with 18% sodium hydroxide to be swollen again for measuring fiber perimeter and wall thickening using Image Analysis System. Boll weight in grams, seed index and lint percentage were determined. Micronair reading, maturity ratio,

Table (2): Physicochemical properties of experimental soil (Average of the two seasons)

pH	7.91
Electrical conductivity (dS)	1.52
Saturation percentage (g/cm^3	53.0
Soluble anions (meq/1):	
CO_3^{2-}	--
HCO_3	3.58
Cl	5.30
SO_4	6.35
Soluble cations (meq/1):	
Ca^{2+}	5.96
Mg^{2+}	2.94
Na^+	5.96
K^+	0.37
Available minerals (mg/Kg soil)	
N	44.63
P	9.19
K	478.8
Cu	8.08
Fe	34.70
Mn	8.85
Zn	10.68

fiber length, uniformity index and fiber strength were measured on HVI system according to *ASTM-D*-5867-05(2005). The obtained data were subjected to analysis of variance in a completely randomized design with three replicates. LSD 5% test was employed to compare the different means of each studied character. The analysis of variance and LSD were carried out according to Snedecor and Cochoran (1986). It is worthy to report that applying parttelet test was not significant indicating the homogeneity of the obtained data; therefore, the data of each character was subjected to combine analysis of variance.

3. RESULTS AND DISCUSSION

Cotton fiber development could be noticed in two stages, the first one is the elongation stage which starts in the first day of flowering when cotton fibers begin to initiate from the ovule's outer layer cells, then start lengthening for a period of about 25-30 days, as a thin cell wall of carbohydrate polymers deposited in a form allowing the fiber to elongate. The second stage is the cellulose deposition stage, which starts after the elongation stage when cellulose fibrils start depositing inside the primary wall forming the secondary wall layers. This stage continues 20 to 30 days after the elongation stage; however, an overlapping could be noticed between the two stages.

Aiming to study the effect of potassium foliar application on cotton fiber development (elongation, perimeter and cellulose deposition) it was necessary to follow up fiber elongation and cellulose deposition of the different boll ages from (5 days) of boll age to final age just before boll opening (45-48 day).

3.1. Effect of potassium foliar application on cotton fiber length and elongation rate:

The results in Table (3), Table (4) and illustrated in Fig. (1) indicated that potassium foliar application increased significantly fiber elongation rate and the final fiber length in the two cotton varieties in both seasons, furthermore, the differences in fiber length between potassium treatments, boll ages, growing seasons and their interactions were statistically significant.

Regarding Giza 94, the combined analysis of the two seasons revealed that potassium treatments; 10,15 and 20g/l recorded fiber length 9.33, 10.20 and 9.38 mm, respectively, in 5 days boll age compared to 8.88 mm for the control, while recorded in 30 day boll age 36.14, 36.84 and 36.68 mm, respectively, compared to 34.70 mm in the control, and recorded in the final boll age 36.74, 37.79 and 37.40mm for the same concentrations respectively compared to 35.85mm for the control. Fiber elongation rate and the final fiber length of Giza 95 showed the same trend of Giza 94, to be 8.36, 8.94 and 8.53 mm compared to 7.62 mm for the control in 5 days boll age, while being 31.80, 32.41 and 32.09 mm in 30 day boll age compared to 30.61 mm In the control and being 32.38, 33.36 and 32.48mm in the final age compared to 30.90 mm in the control. Potassium treatments showed the same trend in the two seasons regarding its effect on fiber elongation rate and the final fiber length. 15g/ l potassium treatment showed the highest fiber elongation rate and the final fiber length compared to the other K treatments in both cotton varieties.

There was an overlapping between elongation stage and cellulose deposition stage, elongation stage extent to the 40 days age. While, the cellulose deposition started from 20 day age in potassium treatments and 25 day age for the control. The difference between seasons, concentrations, ages and their interaction were significant. The results indicated that the second season showed significant increase in fiber elongation rates during the different boll ages compared to the first season, which may be due partially to the increase of day temperature and humidity during the main elongation time in July and August (Table 1). Potassium role in fiber elongation rate is related to the role of K in the maintenance of osmotic potential to generate the turgor pressure necessary for fiber elongation, besides increasing IAA, GA3 content in boll fibers, that led to increase fiber elongation and elongation rate in all boll ages. Moreover K application can make the plant more tolerant to water stress that increasing fiber elongation Chen *et al*. (2017, *Howard et al.* 2000; Abaya, 1996; Oosterhuis, (2002,) came to similar conclusion.

3.2. Effect of potassium foliar application on the secondary wall cellulose deposition:

The results in Tables (5, 6) and illustrated in Fig. (2) indicated that, foliar application of potassium increased significantly cellulose deposition rate and the final deposition of cellulose in the fibers of the two cotton varieties in both seasons, furthermore, the differences in cellulose deposition between potassium treatments, boll ages, growing seasons and their interactions were statistically significant.

Table (3): Effect of potassium foliar application treatments on fiber length and elongation rate of Giza 94 variety in 2017 and 2018 season.

Seasons (S)	Potassium Concentration (C)	Fiber length and elongation rate(mm)								
		Boll age (A)								
		5 days	10 day	15 days	20 days	25 days	30 days	35 days	40 days	45-48 days
2017	0 k (control)	8.83	20.20	30.26	32.27	33.14	34.20	34.80	35.58	35.70
	10 g/L	9.20	21.52	32.33	34.48	34.57	35.64	35.80	36.43	36.63
	15 g/L	10.53	22.55	33.31	35.33	35.53	36.34	36.93	37.48	37.66
	20 g/L	9.34	21.45	32.50	34.70	35.20	36.18	36.51	37.03	37.32
	MEAN	9.48	21.43	32.10	34.19	34.61	35.59	36.01	36.63	36.83
2018	0 k (control)	8.92	22.30	31.22	33.17	34.51	35.20	35.76	35.98	36.00
	10 g/L	9.45	23.62	33.06	35.38	36.17	36.64	36.66	36.83	36.85
	15 g/L	9.86	24.65	34.51	36.23	36.97	37.34	37.58	37.88	37.92
	20 g/L	9.42	23.55	32.97	35.60	36.53	37.18	37.27	37.43	37.47
	MEAN	9.41	23.53	32.94	35.09	36.04	36.59	36.82	37.03	37.06
Combined	0 k (control)	8.88	21.25	30.74	32.72	33.83	34.70	35.28	35.78	35.85
	10 g/L	9.33	22.57	32.70	34.93	35.37	36.14	36.23	36.63	36.74
	15 g/L	10.20	23.60	33.91	35.78	36.25	36.84	37.26	37.68	37.79
	20 g/L	9.38	22.50	32.74	35.15	35.87	36.68	36.89	37.23	37.40
	General mean	9.45	22.48	32.52	34.64	35.33	36.09	36.42	36.83	36.95

LSD 0.5 :-

(S): 0.15 (A): 0.31 (C): 0.21

(S X A): 0.43 (S X C): 0.28 (A X C): 0.61 (S X A X C): 0.86

Table (4): Effect of potassium foliar application treatments on fiber length and elongation rate of Giza 95 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Fiber length and elongation rate(mm)								
				Boll age (A)						
		5 days	10 day	15 days	20 days	25 days	30 days	35 days	40 days	45-48 days
2017	0 k (control)	7.28	18.21	28.05	30.04	30	30.16	30.23	30.37	30.4
	10 g/L	8.02	20.06	28.38	30.26	31.1	31.35	31.72	31.83	31.89
	15 g/L	8.60	21.51	28.97	30.75	31.58	31.96	32.4	32.78	32.85
	20 g/L	8.19	20.47	28.42	30.32	31.23	31.64	31.78	31.92	31.98
	MEAN	8.02	20.06	28.45	30.34	30.98	31.28	31.53	31.72	31.78
2018	0 k (control)	7.96	19.91	28.64	30.62	30.73	31.06	31.13	31.37	31.40
	10 g/L	8.70	21.76	29.04	30.84	31.73	32.25	32.47	32.83	32.86
	15 g/L	9.28	23.21	29.42	31.40	32.38	32.86	33.47	33.78	33.86
	20 g/L	8.87	22.17	29.08	30.90	32.00	32.54	32.70	32.92	32.97
	MEAN	8.70	21.76	29.05	30.94	31.71	32.18	32.44	32.72	32.78
Combined	0 k (control)	7.62	19.06	28.35	30.33	30.37	30.61	30.68	30.87	30.90
	10 g/L	8.36	20.91	28.71	30.55	31.42	31.80	32.10	32.33	32.38
	15 g/L	8.94	22.36	29.20	31.08	31.98	32.41	32.94	33.28	33.36
	20 g/L	8.53	21.32	28.75	30.61	31.62	32.09	32.24	32.42	32.48
	General mean	8.36	20.91	28.75	30.64	31.35	31.73	31.99	32.22	32.28

LSD 0.5 :-

(S): 0.13 (A): 0.27 (C): 0.18

(S X A): 0.38 (S X C): 0.25 (A X C): 0.53 (S X A X C): 0.75

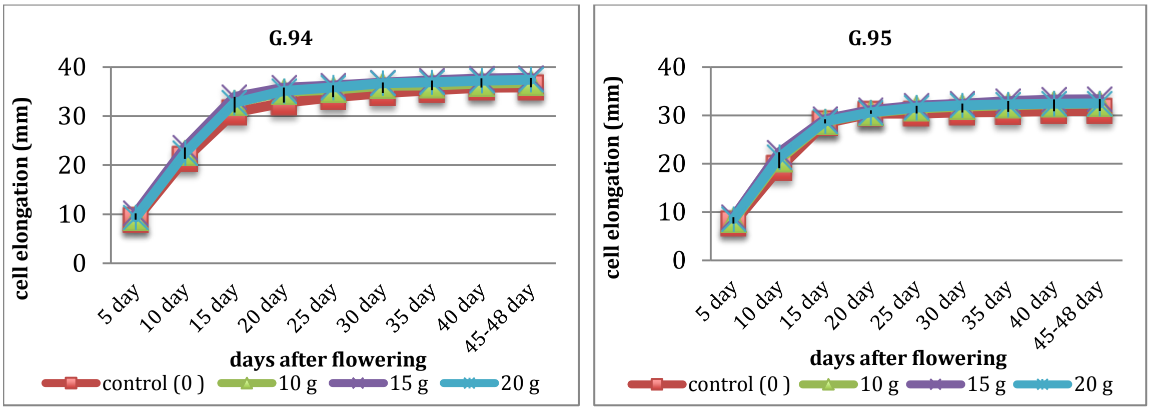

Fig (1): Effect of potassium foliar application treatments on cell elongation stages in both varieties.

Table (5): Effect of potassium foliar application treatments on degree of thickening and its rate of Giza 94 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Degree of thickening %					
		Boll age (A)					
		20 days	25 days	30 days	35 days	40 days	45-48 days
2017	0 k (control)	0.00	29.40	56.87	66.92	74.77	90.74
	10 g/L	47.90	56.94	68.35	78.31	87.18	94.37
	15 g/L	57.52	63.69	81.23	89.52	93.22	97.38
	20 g/L	47.61	63.10	73.19	81.91	89.28	95.90
	MEAN	38.26	53.28	69.91	79.17	86.11	94.60
2018	0 k (control)	0.00	37.52	63.39	72.96	79.36	84.87
	10 g/L	51.33	55.65	75.72	78.85	90.40	93.40
	15 g/L	61.55	68.28	85.44	93.73	95.34	98.96
	20 g/L	52.74	70.67	78.26	88.29	94.27	96.64
	MEAN	41.40	58.03	75.70	83.46	89.84	93.47
Combined	0 k (control)	0.00	33.46	60.13	69.94	77.07	87.81
	10 g/L	49.62	56.30	72.04	78.58	88.79	93.89
	15 g/L	59.54	65.99	83.34	91.63	94.28	98.17
	20 g/L	50.18	66.89	75.73	85.10	91.78	96.27
	General mean	39.83	55.66	72.81	81.32	87.98	94.04

LSD 0.5 :-
(S): 1.62 (A): 2.81 (C): 2.29
(S X A): 3.96 (S X C): 3.23 (A X C): 5.60 (S X A X C): 7.92

Cellulose deposition of the different boll ages starting from 20 days to the final age just before boll opening (45-48 day). was expressed as a degree of thickening.

Regarding Giza 94, the combined analysis of the two seasons revealed that, potassium treatments; 10, 15 and 20 g /l recorded 49.62, 59.54 and 50.18% for the degree of thickening respectively in 20 days boll age while the control did not show any cellulose deposition in this age. At 35 days boll age the three potassium treatments recorded 78.58, 91.63 and 85.10% respectively compared to 69.94% in the control, and recorded in the final boll age 93.89, 98.17 and 96.27 % compared to 87.81% for the control. Cellulose deposition rate and the final deposition of cellulose of Giza 95 showed the same trend of Giza 94 in both seasons, to be 64.86, 65.17 and 66.49 % for K treatments, respectively, in 20 days boll age while the control did not show any cellulose deposition in this age, while being 87.26, 96.66 and 89.22% in 35 days boll age compared to 73.16. In the control it was 96.68, 99.34 and 97.58% in the final age compared to 81.16 % in the control.

Table (6): Effect of potassium foliar application treatments on degree of thickening and its rate of Giza 95 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium concentration (C)	Degree of thickening %					
		Boll age (A)					
		20 days	25 days	30 days	35 days	40 days	45-48 days
2017	0 k (control)	0.00	57.96	64.15	73.82	74.38	80.1
	10 g/L	64.58	68.34	76.07	83.95	90.3	97.29
	15 g/L	62.18	77.48	93.22	96.64	99.08	99.15
	20 g/L	65.85	71.16	81.29	87.52	91.71	97.89
	MEAN	48.15	68.73	78.68	85.48	88.87	93.6
2018	0 k (control)	0.00	55.77	69.34	72.49	77.42	82.22
	10 g/L	65.13	73.73	86.79	90.56	92.39	96.06
	15 g/L	68.16	77.05	91.99	96.67	98.72	99.53
	20 g/L	67.12	75.09	87.67	90.92	93.46	97.27
	MEAN	50.1	70.41	83.95	87.66	90.49	93.77
Combined	0 k (control)	0.00	56.87	66.75	73.16	75.90	81.16
	10 g/L	64.86	71.04	81.43	87.26	91.35	96.68
	15 g/L	65.17	77.27	92.61	96.66	98.90	99.34
	20 g/L	66.49	73.13	84.48	89.22	92.59	97.58
	General mean	49.13	69.57	81.32	86.57	89.68	93.69

LSD 0.5 :-
(S): 1.36 (A): 2.35 (C): 1.92
(S X A): 3.32 (S X C): 2.71 (A X C): 4.69 (S X A X C): 6.64

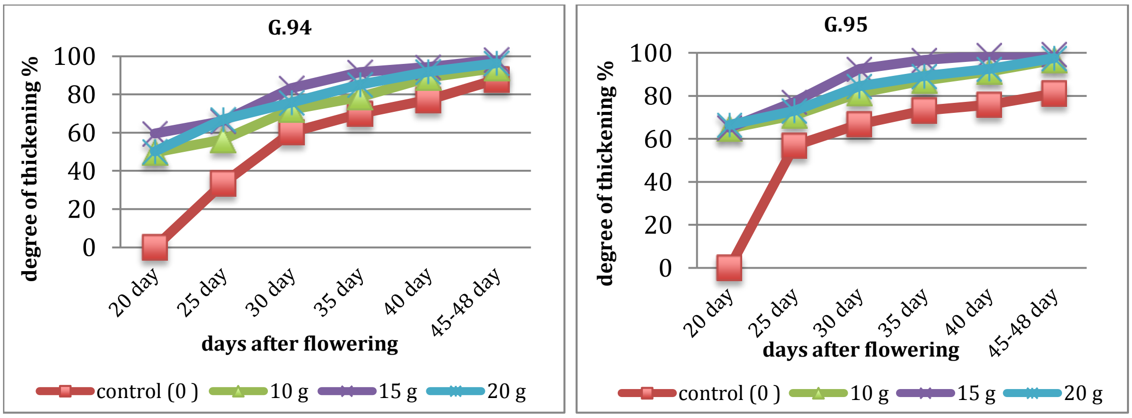

Fig (2): Effect of potassium foliar application treatments on degree of thickening stages in both varieties

potassium treatments showed the same trend in the two seasons regarding its effect on fiber elongation rate and the final fiber length. It is clear from the obtained results that all the potassium foliar application treatments increased significantly the rate of cellulose deposition and the final degree of thickening (fiber maturity). This is true since k is associated with the transport of sugars; it is likely implicated with secondary wall deposition in fibers and, therefore, related to fiber strength and micronaire. Moreover, 15 g/ L potassium treatment showed the highest degree of thickening rate and the final cellulose deposition compared to the other K treatments. Ruan *et al.* (2001) Oosterhuis, (2002) *Xi et al.*(1989) came to similar conclusions.

3.3. Effect of potassium foliar application on cotton fiber perimeter (green boll data):

The effect of seasons, potassium treatments and most of the interactions on fiber perimeter were not statistically significant except for the effect of boll age and the second order interactions which were significant. The results in Tables (7 and 8) and illustrated in Fig . (3) cleared that, the fiber perimeter

Table (7): Effect of potassium foliar application treatments on fiber perimeter of G.94 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Perimeter (µ)									
		Boll age (A)									
		5 days	10 days	15 days	20 days	25 days	30 days	35 days	40 days	45-48 days	Dry fiber
2017	0 k (control)	39.77	41.86	44.27	45.59	47.31	48.91	49.86	50.97	51.33	48.54
	10 g/L	39.98	41.92	44.17	45.90	47.31	48.86	49.27	50.87	51.18	48.55
	15 g/L	39.88	41.79	44.07	45.62	47.30	48.80	49.40	50.66	50.93	48.43
	20 g/L	40.06	41.94	44.30	45.71	47.25	48.88	49.54	51.078	51.23	48.50
	MEAN	39.92	41.88	44.20	45.71	47.29	48.86	49.63	50.89	51.17	48.51
2018	0 k (control)	39.98	42.23	44.07	45.55	47.46	48.71	49.50	50.98	51.39	48.53
	10 g/L	39.88	42.23	43.96	45.55	47.25	48.62	49.23	50.87	51.21	48.49
	15 g/L	40.04	42.22	43.98	45.40	47.21	48.68	49.15	50.91	51.17	48.47
	20 g/L	39.87	42.13	43.96	45.61	47.31	48.75	49.27	51.06	51.21	48.45
	MEAN	39.94	42.20	43.99	45.53	47.30	48.69	49.29	50.95	51.25	48.49
Combined	0 k (control)	39.88	42.04	44.17	45.57	47.38	48.81	49.68	50.98	51.36	48.54
	10 g/L	39.93	42.08	44.06	45.72	47.28	48.74	49.47	50.87	51.20	48.52
	15 g/L	39.96	42.01	44.02	45.51	47.25	48.74	49.28	50.78	51.05	48.45
	20 g/L	39.96	42.03	44.13	45.66	47.28	48.82	49.40	51.07	51.22	48.48
	General mean	39.93	42.04	44.10	45.62	47.30	48.78	49.46	50.92	51.21	48.50

LSD 0.5 :-
(S): 0.19 (A): 0.41 (C): 0.27
(S X A): 0.58 (S X C): 0.38 (A X C): 0.82 (S X A X C): 1.15

Table (8): Effect of potassium foliar application treatments on fiber perimeter of G.95 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Perimeter (µ)									
		Boll age (A)									
		5 days	10 days	15 days	20 days	25 days	30 days	35 days	40 days	45-48 days	Dry Fiber
	0 k (control)	44.05	45.90	47.45	49.07	50.61	52.64	53.58	55.53	57.44	52.00
	10 g/L	43.99	45.88	47.58	48.86	50.69	52.53	53.79	55.55	57.24	51.98
	15 g/L	43.97	45.93	47.49	49.04	50.64	52.33	53.58	55.48	57.20	51.98
	20 g/L	44.05	45.80	47.40	48.81	50.74	52.53	53.83	55.59	57.15	52.04
	MEAN	44.02	45.88	47.48	48.94	50.67	52.51	53.69	55.54	57.26	52.00
2018	0 k (control)	44.17	45.68	47.31	49.29	50.69	52.81	53.80	55.72	57.19	51.87
	10 g/L	44.26	45.53	47.32	49.22	50.67	52.91	53.61	55.59	57.20	52.10
	15 g/L	44.16	45.56	47.33	49.25	50.63	52.76	53.57	55.60	57.04	51.92
	20 g/L	44.12	45.70	47.42	49.32	50.56	52.85	53.66	55.64	57.29	52.13
	MEAN	44.18	45.62	47.35	49.27	50.64	52.83	53.66	55.64	57.18	52.01
Combined	0 k (control)	44.11	45.79	47.38	49.18	50.65	52.73	53.69	55.63	57.32	52.01
	10 g/L	44.13	45.71	47.45	49.04	50.68	52.72	53.70	55.57	57.22	51.99
	15 g/L	44.07	45.75	47.41	49.15	50.64	52.55	53.58	55.54	57.12	51.89
	20 g/L	44.09	45.75	47.41	49.07	50.65	52.69	53.75	55.62	57.22	52.05
	General mean	44.10	45.75	47.42	49.11	50.66	52.67	53.68	55.59	57.22	52.00

LSD 0.5 :-
(S): 0.13 (A): 0.27 (C): 0.18
(S X A): 0.37 (S X C): 0.25 (A X C): 0.54 (S X A X C): 0.76

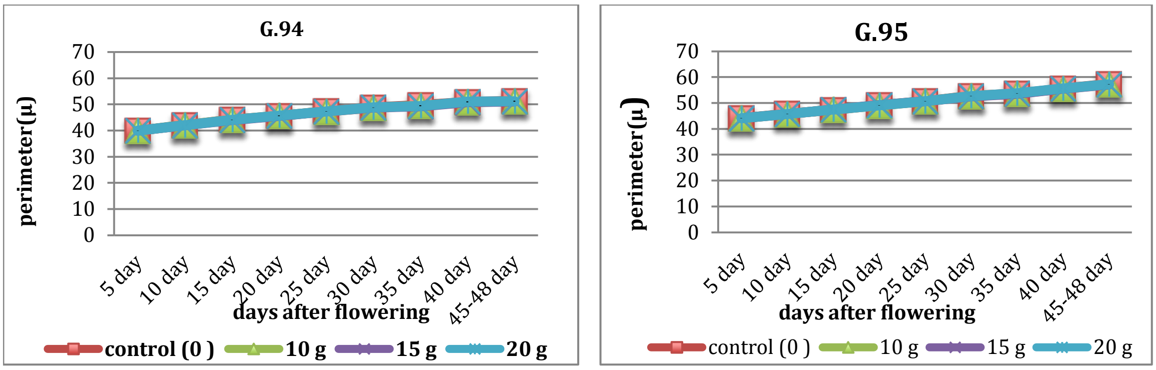

Fig (3): Effect of potassium foliar application treatments on perimeter in both seasons for both varieties.

increased as the fiber became older in both cotton varieties. However, G.95 proved to be coarser than G.94, and showed higher perimeter values along the different boll ages. Fiber perimeter is a varietal trait controlled mainly by genetics. Combined data of the two seasons revealed that fiber perimeter of G.94 ranged from 39.93 µ at 5 days, 48.78 µ at 30 days and 51.21 µ at final boll age before opening. Dry fiber perimeter of G.94 averaged (48.50 µ) while, G.95 perimeter ranged from (44.10 µ at 5 day, 52.67 µ at 30 day and 57.22 µ at final boll age before opening. Dry fiber perimeter of G.95 averaged (52.0 µ). Fiber perimeter of the two varieties showed in 2018 the same trend of 2017 with no statistical difference between the two seasons. It is worthy to report that fiber intrinsic fineness (perimeter) is a varietal trait controlled mainly by genetics and the effect of environment and agronomic practices is of low magnitude. Younis,(2010) and Sief, *et al.* (2016) came to similar conclusions.

3.4. effect of potassium foliar application on some yield and fiber quality traits:

The results in Tables (9 and 10) indicated that potassium foliar application increased significantly yield traits (boll weight, seed index and lint %) and fiber quality (micronaire value, maturity ratio, uniformity index and fiber strength) compared to the control in the two varieties along the two seasons. However, 15g/l of K treatment exhibited the highest level of the mentioned traits in both seasons for the two varieties.

Concerning boll weight of Giza 94, the combined analysis of the two seasons revealed that potassium treatments; 10, 15 and 20 g /l recorded 3.28, 3.44 and 3.28 g compared to 3.07 g in the control. Boll weight of Giza 95 showed the same trend of Giza 94, to be 3.20, 3.34 and 3.23g compared to 2.99g in the control.

As for seed index, the different K treatments recorded in Giza 94 11.06, 12.00 and 11.13 g respectively, compared to 10.74g in the control. K treatments showed the same trend in Giza 95 to be 10.33, 11.22 and 10.53 g compared to 10.05g in the control. Lint percentage showed the same trend of boll weight and seed index in both varieties during the two seasons. The results cleared that 15g/l of K treatment exhibited the best values of yield traits.

It could be concluded that foliar applications of potassium significantly improved the values of the studied yield traits. This may be due to the favorable effects of K on nutrient uptake, photosynthetic activity and improving its mobilization, which directly influences all of them Afinan *et al.* (2015), Pettigrew, (20000 Weir, (19980, Donald and Owen (1998), Cakmak *et al*. (1994) found similar results.

Regarding fiber quality, the results showed noticeable and statistically significant effects of K treatments, seasons and their interactions on fiber quality properties in both varieties compared with the control. The highest levels of fiber quality were obtained from 15g/l K treatment.

Regarding micronaire value of Giza 94, the combined data revealed that potassium treatments; 10, 15 and 20 g /l recorded 3.97, 4.06 and 3.85 compared to 3.97 in the control, and recorded in Giza 95: 4.88, 5.10 and 4.89 compared to 4.53 in the control. Maturity ratio showed the same trend of micronaire value in the two varieties along the two seasons.

Concerning fiber length of Giza 94, the obtained data indicated that potassium treatments; 10, 15 and 20 g /l recorded 35.35,

Table(9): Effect of potassium foliar application treatments on yield and fiber quality in Giza 94 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Yield and fiber quality							
		Yield data			Fiber quality of HVI data				
		boll Weight (g)	Seed index	Lint percent-age%	Micronaire reading	Maturity ratio	Fiber Length (mm)	Uniformity index %	Fiber strength (g/tex)
2017	0 k (control)	2.97	10.69	39.72	3.85	0.89	34.03	86.10	41.40
	10 g/L	3.21	10.86	41.14	3.96	0.91	35.24	87.40	42.03
	15 g/L	3.41	11.80	42.09	4.01	0.92	35.85	87.80	43.43
	20 g/L	3.23	10.93	42.05	3.90	0.91	35.43	86.83	42.30
	MEAN	3.21	11.07	41.25	3.88	0.91	35.14	87.03	42.29
2018	0 k (control)	3.17	10.79	40.50	3.82	0.88	34.00	84.93	41.57
	10 g/L	3.34	11.26	41.54	3.98	0.91	35.45	87.20	42.50
	15 g/L	3.47	12.20	42.49	4.11	0.94	35.98	88.03	43.10
	20 g/L	3.33	11.33	41.50	3.99	0.91	35.63	87.37	42.57
	MEAN	3.33	11.40	41.51	3.97	0.91	35.27	86.88	42.43
	0 k (control)	3.07	10.74	40.11	3.84	0.89	34.02	85.52	41.49
	10 g/L	3.28	11.06	41.34	3.97	0.91	35.35	87.30	42.27
Combined	15 g/L	3.44	12.00	42.29	4.06	0.93	35.92	87.92	43.27
	20 g/L	3.28	11.13	41.78	3.85	0.91	35.53	87.10	42.44
	General mean	3.27	11.24	41.38	3.93	0.91	35.21	86.96	42.36
LSD 0.5	(S)	0.08	0.19	0.61	0.19	0.01	0.62	0.94	0.99
	(C)	0.12	0.27	0.86	0.26	0.02	0.88	1.2	1.41
	(S*C)	0.17	0.39	1.84	0.37	0.023	1.25	1.7	1.98

Table (10): Effect of potassium foliar application treatments on yield and fiber quality in Giza 95 variety in 2017 and 2018 seasons.

Seasons (S)	Potassium Concentration (C)	Yield and fiber quality							
		Yield data			Fiber quality of HVI data				
		Boll Weight (g)	Seed index	Lint percentage %	Micronaire reading	Maturity ratio %	Fiber length (mm)	Uniformity index %	Fiber strength (g/tex)
2017	0 k (control)	2.87	9.94	40.06	4.47	0.92	29.93	83.97	35.43
	10 g/L	3.18	10.31	46.71	4.88	0.93	30.07	84.60	38.27
	15 g/L	3.27	11.19	46.78	5.05	0.94	30.84	85.00	38.63
	20 g/L	3.20	10.57	46.50	4.89	0.94	30.34	85.77	37.80
	MEAN	3.13	10.50	45.01	4.82	0.94	30.30	84.83	37.53
2018	0 k (control)	3.10	10.16	40.70	4.58	0.93	29.83	84.03	35.13
	10 g/L	3.21	10.35	46.83	4.88	0.94	30.42	85.00	37.93
	15 g/L	3.40	11.24	46.90	5.14	0.95	31.52	85.33	38.70
	20 g/L	3.25	10.48	46.64	4.88	0.94	30.3	84.93	38.07
	MEAN	3.24	10.56	45.27	4.87	0.94	30.52	84.83	37.46
Combined	0 k (control)	2.99	10.05	40.38	4.53	0.93	29.88	84.00	35.28
	10 g/L	3.20	10.33	46.77	4.88	0.94	30.25	84.80	38.10
	15 g/L	3.34	11.22	46.84	5.10	0.95	31.18	85.17	38.67
	20 g/L	3.23	10.53	46.57	4.89	0.94	30.32	85.35	37.94
	General mean	3.19	10.53	45.14	4.85	0.94	30.41	84.83	37.50
LSD 0.5	(S)	0.06	0.13	0.82	0.16	0.01	0.34	0.66	0.73
	(C)	0.09	0.18	1.16	0.22	0.01	0.48	0.94	1.03
	(S*C)	0.13	0.25	1.64	0.32	0.02	0.67	1.33	1.45

35.92 and 35.53 mm compared to 34.02 mm in the control. Giza 95 showed the same trend of Giza 94 to be 30.25, 31.18 and 30.32mm compered to 29.88mm in the control. Potassium foliar application improved slightly length uniformity index although of its statistical significance in both varieties along the two seasons.

Potassium foliar application exhibited clear increase in fiber strength of the two varieties in the two seasons, being in Giza 94 (42.27, 43.27 and 42.44 g/tex) compared to (41.49 g/tex) in the control and being in Giza 95 (38.10, 38.67 and 37.94 g/tex) compared to (35.28 g/tex) in the control. The differences in fiber strength between the three K treatments were not statistically significant. It is clear that potassium application treatment improved most of fiber quality traits. 15g/l of K proved to be the best K treatment regarding the studied fiber quality traits in both varieties. These results ensured that the foliar application of K is important during the fiber growth and development. Whereas, less supply of potassium can cause certain disorders such as decreasing fiber turgor pressure, resulting, low fiber elongation and shorter fibers. The obtained results confirmed by Aladakatti *et al.*(2011) Oosterthuis,(2002), Pettigrew, (2003) Shanmugham and Bhat (1991).

Conclusion

Potassium plays vital role in regulatory functions in biochemical and physiological processes that contribute to plant growth and boll development. Foliar application of k proved to have a great effect in improving and raise the productivity and fiber quality. This study indicated that K foliar application in the beginning and during flowering caused clear overlapping between fiber elongation and cellulose deposition (maturity). Furthermore, boll weight, seed index, lint % and most of fiber properties were improved by K foliar treatments.

The improvement in some yield and fiber quality traits, 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 longer fibers at maturity. Moreover, potassium plays a practically important role in fiber development and its shortage will result in poor fiber quality and lowered yield. 15g/l of K foliar application showed the longest and more mature fibers and the highest levels of the other fibers properties besides improving boll weight, lint and seed index.

Acknowledgement

The author would like to acknowledge Dr. Mounir Gad Sief Former Director of Cotton Research Institute, Research Professor of Cotton Technology for his great help and support during the conducting and preparation of this research and manuscript.

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تأثير البوتاسيوم علي نمو وتطور الألياف في القطن المصري

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ملخص

أجريت تجربه لدراسه تاثير الرش الورقي للبوتاسيوم علي مراحل نمو وتطور الألياف من حيث معدل إستطالتـــــها (طول التيله) ومعدل ترسيب السليلوز (نضج التيله) وكذلك التاثير علي جوده الألياف وبعض مكونات المحصول. تم إجراء التجربه بإستخدام صنفين من القطن هما جيزه 94 وجيزه 95 تم زراعتهما في أصص بالصوبه الخاصه بقسم بحوث الفسيولوجي بمعهد بحوث القطن بمركز البحوث الزراعيه بالجيزه خلال موسمي 2017 و 2018. تم الرش بسلفات البوتاسوم بتركيزات 10 , 15 و20 جم / لتر وقد تم تجزئه كل تركيز لثلاث جرعات متساويه تم رشها في مواعيد هي : عند عمر 80 يوم (في بدايه التزهير) ـ بعد أسبوعين من الرشه الاولي (أثناء مرحله الإستطاله) ـ بعد أسبوعين من الرشه الثانيه (أثناء مرحله ترسيب السليلوز).

أوضحت النتائج أن معاملات الرش الورقي بسلفات البوتاسيوم أدت إلي زياده معنويه في كل من معدل إستطاله الألياف ومعدل ترسيب السليلوز(نضج الشعره) . كما أدي الرش بسلفات البوتاسيوم إلي تحسين واضح في معظم صفات جوده التيله وبعض مكونات المحصول بالمقارنه بالكنترول.و ان إستخدام معاملات الرش بسلفات البوتاسيوم في المواعيد المذكوره سبب حدوث تداخل بين مرحلتي الإستطاله وترسيب السليلوز حيث إمتدت مرحله إستطاله الشعره الي عمر 40 يوم وبدا ترسيب السليلوز عند عمر 20 يوم في كلا الصنفين. بينما توقفت مرحله الإستطاله في الكنترول عند عمر 25 يوم وبدات بعدها مرحله ترسيب السليلوز.

ـ كان لعمر اللوزه تاثير معنوي علي قياسات محيط الشعره حيث سجل العمر الأقل محيط اقل بينما لم يتاثر محيط الشعره بمعاملات الرش الورقي للبوتاسيوم حيث سجل الصنفان قياسات محيط الشعره (في العمر النهائي) المعروفه عنهما وهي 48,50 ميكرون و 52,00 ميكرون لكل من جيزه 94 وجيزه 95 علي التوالي.

ـ أدت معامله الرش الورقي بسلفات البوتاسيوم بتركيز 15 جم/لتر إلي أفضل زياده معنويه في معظم الصفات تحت الدراسه ويتضح ذلك من النتائج الآتيه:

ـ فيما يتعلق بمعدل الإستطاله سجلت المعامله 15 جم/لتر أطوال تيله مقدارها 10,20مم، 36,84مم و 37,79مم) عند أعمار 5 ، 30 و45-50 يوم (العمر النهائي) في الصنف جيزه 94 مقارنة بأطوال تيله 8,88مم ، 34،70 و 35,85 لنفس الأعمار علي التوالي في معامله الكنترول. وقد سلك الصنف جيزه 95 نفس الإتجاه حيث كانت الأطوال 8,94 ، 32,41 و33,36 مقارنة بأطوال تيله 7,62 ، 30,61 و 30,90 في معامله الكنترول عند نفس الأعمار علي الترتيب.

ـ سجلت المعامله 15جم/لتر معدل ترسيب السليلوز59,54%، 91,63% و 98,17% عند أعمار 20، 35 و 40-50 يوم(العمر النهائي) في الصنف 94 بينما كانت صفر% (لم يتم الترسيب بعد) ، 69,94%و 87,81% في معامله الكنترول لنفس الأعمار علي التوالي. أما في الصنف جيزه 95 فقد سجلت هذه المعامله 65,17%، 96,66% و 99,34% في حين سجلت معامله الكنترول صفر %، 73,16% و 81,16 % .

ـ أظهرت المعامله 15جم/لتر زياده معنويه إحصائيا في وزن اللوزه، ومعامل البذره ونسبه التيله وكانت القيم في جيزه 94 هي 3,44جم، 12,00جم و 42,29%) علي التوالي مقارنه بـ 3,07جم، 10,74جم و 40,11% في معامله الكنترول، أما في الصنف جيزه 95 فكانت هذه القيم 3,43جم، 11,22جم و 46,84%)لكل من وزن اللوزه، معامل البذره ونسبه التيله مقارنةا بـ 2,99جم ، 10,05جم و 40,38% في معامله الكنترول .

ـ أظهرت نفس المعامله أفضل قيم لصفات الجوده(نسبه النضج، إنتظاميه الألياف و متانه الألياف) حيث كانت في الصنف جيزه 94 كالآتي 0,93 ، 87,92 و 43,27جرام/تكس) علي التوالي مقارنة بـ 0,91 ، 85,52 %و 41,49جرام/تكس في معامله الكنترول أما في الصنف جيزه 95 كانت القيم 0,95 ، 85,17% و 38,67 جرام /تكس مقارنة بـ 0,93، 84,00% ، 35,28جرام/تكس في معامله الكنترول.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – العدد الرابع (أكتوبر 2919): 409-421.