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Effect of potassium foliar fertilization, level and time of nitrogen application on growth and yield of Egyptian cotton

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This investigation was carried out in Sids Agricultural Research station, ARC at Beni-Suef Governorate, Middle Egypt region, Egypt, for two season (2013 and 2014) the study aimed to find out the effect of one or two foliar applications of potassium as potassium sulfate (1%) given at commence of flowering (once) and two weeks later (twice). These two treatments were allocated in two main plots which were split in four first order sub splits which were devoted for two N levels (60 and 75 kg/fed of N) and then into four second order sub plots which included four modes of N addition as two partly split doses given before the 2nd and 3rd irrigation (control), the 2nd and 4th irrigation or as three partly split doses before the 2nd, 3rd and 5th irrigation or before the 2nd, 4th and 5th irrigation. The obtained results could be summarized as follows: two foliar sprays of potassium improved the growth of cotton plants as was expressed in significant increase in plant height, number of open bolls/plant, but not in boll weight and finally the seed cotton yield/fed with significant increase in earliness. The increase of the level of N from 60 to 75 kg/fed didn't affect any significant increase in growth attributes or the seed cotton yield/fed or any of its components except seed index. Splitting N partly in 3 splits given before the 2nd, 3rd and 5th irrigation improved cotton plant growth and seed cotton yield/ fed as well as, earliness than the control. The combination of two foliar potassium sprays with the 60 kg/fed of N level when given in 3 partly split before the 2nd, 3rd and 5th irrigation was the best combination which improved cotton plants growth and finally the seed cotton yield/fed. The fiber properties except fiber strength in the first season were not significantly affected by any of the factors under study or their first and second order interactions in both seasons.

Keywords: *Gossypium barbadense* L., foliar spraying, potassium, nitrogen, growth, fiber quality.

INTRODUCTION

Cotton is a unique crop plant; it is one of the most important commercial fiber crops popularly known as the "White Gold". Raising cotton productivity and quality can be achieved through planting the best selected cultivars optimizing the cultural practices. Fertilization is considered the most important factor among the different critical factors which influence growth, yield and quality of cotton. Cotton plant with its indeterminate type of growth adds more confusing trends due to the increase of vegetative growth on the expense of reproductive growth if the proper balance between fertilizer added nutrients is not maintained. Kumar et al., (2011) and Zakaria et al., (2011) indicated the more efficient use of potassium by cotton plants when foliar added during the reproductive stage. Cotton fiber quality didn't respond to K

fertilization (Abd El-Gayed et al., 2014). Moreover the increase of N fertilization was reported to increase the seed cotton yield (Abou-Zaid et al., 2002). The increase of yield was attributed to the significant increase of the number of bolls/plant and boll weight (Hamoda et al., 2014). Excess N addition promotes vegetative growth oftenly at the expense of reproductive development, particularly at bloom or at early boll stage (Delwar et al., 2000 and Howard et al., 2001). The efficiency of N fertilization was increased through splitting into two or more splits given during the cotton plant growth (Ismail et al., 2000). Potassium is one of the essential macronutrients and the most abundantly absorbed cation in higher plants. It plays an important role in growth and development of plants. It activates enzymes, maintains cell turgor, enhances photosynthesis, reduces respiration, and helps in translocation of photosynthates to the different plant sinks (Moussa and Amira, 2017). Spraying cotton plants with K had a positive effect on cotton productivity Blasis et al., (2009) and Zakaria et al., (2011). K improves crop quality (Pettigrew, 2008). Nitrogen is a major limiting nutrient element for effective production of cotton several available information of N requirements of cotton plant showed positive significant response to moderate rates of N application. Excess N promotes vegetative development often at the expense of reproductive development, especially at bloom or at early boll stage (Howard et al., 2001). With splitting of nitrogen resulted in more number of bolls/plant ultimately resulting into higher seed cotton yield (Pandagale et al., 2018).

The aim of the current study was to determine the effect of foliar potassium and nitrogen fertilizer split application timing and proportion at different times on growth, productivity and fiber quality of Egyptian cotton (Giza 95) in two growing seasons (2013 and 2014).

MATERIALS AND METHODS

This investigation was carried out in Sids Agricultural Research Station, Beni-Suef Governorate, during 2013 and 2014 seasons using Egyptian cotton, *Gossypium barbadense* L. cv. Giza 95 cultivar [Tri-hybrid (Giza 83×(Giza 75×line 5844)×Giza 80)]. The experimental design was a split-split plot based on randomized complete block design with four replications. The main plot consisted of potassium foliar application (one or two spraying), the nitrogen levels (60 or 75 kg/fed) were allocated in the 1^{st} order sub plots while time of adding nitrogen fertilizer was assigned to 2^{nd} order sub plots as D1, D2, D3 and D4. Each sub plots consisted of 5 ridges with 4 meters in length and 65 cm a part. The nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) at two levels (60 and 75 kg/fed) divided into two or three equal doses applied as aforementioned at before second and third irrigation (D1), before second and fourth irrigation (D2), before 2^{nd} , 3^{rd} and 5^{th} irrigation (D3) and before 2^{nd} , 4^{th} and 5^{th} irrigation (D4). Potassium was added as foliar spraying of (1%) potassium sulfate (48% K_2O) the spraying time was beginning of flowering and two weeks later. Phosphorous at rate of 22.5 kg of P_2O_5/fed in the form of ordinary super phosphate (15.5 % P_2O_5) was applied to all plots preplanting. Sowing dates were 25 and 30 of March in the first and second seasons, respectively. The other cultural practices were carried out as recommended for the conventional cotton field in the district. Soil samples were taken before planting cotton to determine some soil properties according to the methods of Page et al. (1982). Tables 1 and 2 shows the different soil properties and some meteorological data of experimental location in respective order. At harvest, ten representative cotton plants were taken at random from each sub-sub plot to determine the analysis.

Growth and earliness characters.

Plant height (cm), Internode length (cm), position of the first sympodial branches node estimated as number of nodes up to first fruiting branch and earliness percentage. Percentage of seed cotton yield at the first pick to the total seed cotton yield/plot of the 1^{st} and 2^{nd} pick.

Yield and yield components.

Number of sympodial branches/plant, number of open bolls/plant, boll weight (g): as average of 50 random bolls, seed cotton yield/feddan (kentar =157.5 kg) and seed index (weight of 100 seeds) taken at random from each cotton sample (g).

Fiber properties.

The fiber properties were measured by using High Volume Instrument according to (A.S.T.M.D-46050-1986). Fiber length at Upper half means (U.H.M.), Fiber uniformity index %. (U.I), fiber strength in g/tex and fiber fineness was expressed as micronaire reading measured by (HVI), all fiber properties were performed under standard atmosphere of temperature (70±2°F) and relative humidity (65±2%) at the laboratories of the Cotton

Research Institute, Agricultural Research Center, Giza.

Statistical analysis.

The obtained data were subjected to proper statistical analysis according to the procedure described by Snedecor and Cochran (1980). The least significant differences test (LSD) at significances of 0.05 levels was used to verify the significance of differences among treatment means and the interactions between treatments.

RESULTS

The Night temperature ranged from 14°C to 24°C whereas day temperature varied from 26°C to 33°C in first season and from 14°C to 25°C and from 24°C to 34°C in the second season, in respective order during the growing season from March to September (Table 1). This seasonal thermo periodicity favours the growth of cotton plants. Data in table (2) regarding the soil physical and chemical properties clearly indicate that the soil has a clay loam texture with poor content of organic matter (1.82 and 1.92% in the two seasons respectively) this content in turn was reflected in poor content of available N (20 and 22 ppm N respectively) but however high content of available phosphorus (16 and 20 ppm in the two seasons respectively) in the soil had a moderate content of available K (188 and 208ppm), respectively. The soil is normal from the salinity point of view with noticeable content of calcium carbonate 1.82 and 1.90 %, respectively and alkalinity pH values of 7.76 and 7.89 in the two seasons respectively.

Growth and earliness characters.

Data in Table (3) revealed that, all growth traits under study were significantly affected by spraying cotton plant with potassium sulphate, rate of and time of nitrogen application where the use of two spraying of potassium and 75 kg N/fed before the 2nd, 4th or5th irrigation induced the maximum averages of plant height, internode length and earliness in both seasons. Position of 1stsympodial node significantly affected by foliar K fertilizer only may be due to level of available phosphorus in soil (16 and 20 ppm in two seasons, respectively) whereas P is known to be involved in photosynthesis and plant metabolism. Also, P regulates many enzymic processes and acts as an activator many enzymes (Helal and Amira, 2017).

The promotive effect of increasing potassium fertilization level on cotton growth could be mainly due to the fact that potassium is an essential nutrient that affects most of biochemical and physiological processes that influence plant growth and metabolism (Seadh et al., 2012). As for nitrogen level, the obtained data showed, that growth characters and earliness significantly responded to the increase of nitrogen level. This increase from 60 to 75 kg N/fed enhanced cotton growth, i.e. plant height and internode length in both seasons, as nitrogen has many functions in plant life cycle (Aslam et al., 2013). On the other hand, the increase of N level up to 75 kg/fed significantly delayed maturity and hence reduced the averages of earliness percentage properly due to a possible extension in the period of vegetative plant growth and delays the onset of fruiting stage (Ismail et al., 2000). Concerning the time of adding nitrogen, the results indicate that added nitrogen three times, before 2nd, 4th and 5th irrigations gave the highest averages of plant height and internode length, while added N at 3 times, before 2nd, 3rd and 5th irrigation gave the highest average of earliness percentage. Considering the interaction between factors under study in Table (4), the obtained results revealed that cotton growth characters were significantly affected by the interaction between treatments or among them. In general, the highest growth parameters were obtained for cotton plants sprayed with potassium twice and fertilized with 75 kg N/fed three times before 2nd, 3rdand 4thor 5th irrigations. Regarding earliness, the highest average was obtained from two spraying with K and adding of 75 kg N/fed in 1st season (80.99%) or 60 kg/fed of N (62.80%) in 2nd season. The interaction between foliar K fertilizer and time of application of N, the highest earliness average was obtained from spraying two sprays and addition of N in 3 equal doses at 2nd, 3rd and 5th irrigation (82.14 and 64.04% in both seasons respectively). Concerning the interaction between N fertilizer level and time of its application, the highest earliness average was obtained for 60kg N/fed giving in 3 equal doses before 2nd, 3rd and 5th irrigation (81.46 and 63.24% in both seasons, respectively). In Table (5), spraying cotton plant with two sprays of potassium and use of 75 kg N/fed before 2nd, 4th, 5th irrigation induced the maximum plant height 132.8 and 138.0 cm, internode length 6.1 and 6.7 cm in both seasons respectively, but the best value of position of 1stsympodial branches was obtained from $K_1N_1D_3$ (one spraying of K+60 kg N before 2nd, 3rd and 5th irrigation) 8.25 and 7.88 in both seasons respectively.

Table 1: Meteorological data for the study period in 2013 and 2014 seasons at Sids Agricultural Research Station.

Month	2013			2014		
	Min.(°C)	Max.(°C)	Mean	Min.(°C)	Max.(°C)	Mean
March	14	26	20	14	24	19
April	16	27	21	16	28	22
May	19	34	26	20	31	26
June	22	35	29	22	34	28
July	23	33	28	23	34	29
August	24	35	29	25	35	30
Sept.	22	33	27	24	34	29

Data obtained from the central laboratory for agriculture climate, A.R.C. Egypt.

Table (2): Soil properties of the experimental site at 0.0-30 cm depth.

Properties	Seasons	
	2013	2014
PH (in 1:2.5 soil–water suspension)	7.76	7.89
EC (mmohs)/cm (in1:5 soil water extraction).	1.1	1.1
Organic matter	1.82	1.90
$CaCO_3$ %	2.8	3.6
Available N (ppm)	20	22
Available P (ppm)	16	20
Available K (ppm)	188	208
Soil texture	Clay- loam	

Table (3): Effects of foliar K fertilizer, rate of N fertilizer and its time of application on some cotton growth characters in 2013 and 2014 seasons.

Treatments	Plant height (cm)		Internode length (cm)		1 st sym.		Earliness (%)	
	2013	2014	2013	2014	2013	2014	2013	2014
K fertilizer								
One spray	124.3	128.8	5.3	5.7	8.41	8.12	79.59	58.38
Two spray	128.1	132.3	5.5	6.0	8.52	8.31	80.87	61.01
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Rate of N fertilizer								
60 kg/fed	123.4	127.9	5.3	5.7	8.48	8.19	80.43	61.56
75 kg/fed	128.9	133.2	5.6	6.0	8.45	8.23	80.03	57.82
F test	Sig.	Sig.	Sig.	Sig.	N.S	N.S	Sig.	Sig.
Time of application of N fertilizer								
D_1	122.7	127.3	5.3	5.7	8.58	8.34	79.86	57.53
D_2	124.9	129.6	5.4	5.7	8.34	8.11	80.15	58.04
D_3	128.3	131.5	5.4	5.7	8.38	8.01	81.18	61.72
D_4	128.7	133.8	5.6	6.2	8.58	8.40	79.69	61.48
LSD 0.05	1.1	1.1	0.2	0.2	N.S	N.S	1.1	2.7

Whereas **D_1**: Before 2nd and 3rd irrigations (control), **D_2**: Before 2nd and 4th irrigations, **D_3**: Before 2nd , 3rd and 5th irrigations and **D_4**: Before 2nd , 4th and 5th irrigations.

Table 4: The effect of first order interaction between foliar K, N fertilizer level, number and dates of adding N fertilizer on some growth and earliness characters (A×B, A×C and B×C) in two seasons.

Treatments		Plant height (cm)		Internode length (cm)		1st sympodium		Earliness (%)	
		2013	2014	2013	2014	2013	2014	2013	2014
Foliar K	**Rate of N fertilizer**								
One spray	**60kg**	121.6	126.4	5.2	5.5	8.44	8.10	80.13	60.33
	75kg	126.97	131.2	5.4	5.8	8.38	8.13	79.59	56.42
Two spray	**60kg**	125.3	129.4	5.3	5.8	8.53	8.29	80.73	62.80
	75kg	130.8	135.2	5.7	6.2	8.52	8.34	80.99	59.21
Foliar K	**Dates of adding N**								
One spray	**D_1**	120.0	126.2	5.2	5.7	8.59	8.34	80.03	55.37
	D_2	123.6	127.8	5.4	5.5	8.31	8.05	79.10	56.15
	D_3	127.1	130.4	5.2	5.6	8.31	7.89	80.23	59.40
	D_4	126.4	130.9	5.5	5.9	8.44	8.19	78.99	62.59
Two sprays	**D_1**	125.4	128.4	5.4	5.7	8.56	8.34	79.70	59.68
	D_2	126.3	131.5	5.4	5.8	8.36	8.16	81.20	59.93
	D_3	129.4	132.6	5.6	5.9	8.44	8.14	82.14	64.04
	D_4	131.1	136.7	5.8	6.4	8.73	8.61	80.40	60.36
Rate of N fertilizer	**Dates of adding N**								
60kg	**D_1**	119.3	124.8	5.2	5.6	8.71	8.44	80.75	59.61
	D_2	121.9	126.1	5.3	5.6	8.40	8.13	79.66	60.07
	D_3	125.9	129.2	5.1	5.5	8.28	7.91	81.46	63.24
	D_4	126.6	131.4	5.5	5.9	8.55	8.30	79.83	63.35
75kg	**D_1**	126.2	129.8	5.4	5.8	8.44	8.24	78.98	55.44
	D_2	127.9	133.1	5.5	5.8	8.28	8.09	80.64	56.01
	D_3	130.6	133.8	5.6	5.9	8.48	8.11	80.90	55.44
	D_4	130.8	136.1	5.8	6.4	8.61	8.50	79.56	59.61
$LSD_{0.05}$ AB		1.1	1.1	0.2	0.2	N.S	N.S	1.1	2.74
$LSD_{0.05}$ AC		1.5	1.5	0.2	0.3	0.13	0.61	1.55	3.88
$LSD_{0.05}$ BC		1.5	1.5	0.2	0.3	0.19	0.61	1.55	3.88

Whereas **D_1**: Before 2nd and 3rd irrigations (control), **D_2**: Before 2nd and 4th irrigations, **D_3**: Before 2nd , 3rd and 5th irrigations and **D_4**: Before 2nd , 4th and 5th irrigations.

Table 5: Effect of interaction among foliar K, N fertilizer, number and dates of adding N fertilizer (A×B×C) in both seasons.

Treatments			Plant height (cm)		Internode length(cm)		1st Sympodium		Earliness (%)	
Foliar K fertilizer(A) (Kg/fed)	Rate of N Fertilizer(B) (Kg/fed)	Dates of adding N fertilizer(C)	2013	2014	2013	2014	2013	2014	2013	2014
One spray	60	D_1	116.0	124.1	5.0	5.7	8.70	8.35	80.73	57.39
		D_2	120.9	124.8	5.4	5.4	8.35	8.05	78.88	56.50
		D_3	125.6	129.2	5.0	5.5	8.25	7.88	81.28	62.19
		D_4	123.9	127.5	5.5	5.6	8.43	8.13	79.63	65.26
	75	D_1	124.0	128.3	5.4	5.7	8.48	8.33	79.33	53.35
		D_2	126.4	130.8	5.5	5.6	8.28	8.05	79.33	55.80
		D_3	128.6	131.6	5.3	5.6	8.33	7.90	79.18	56.61
		D_4	128.9	134.3	5.4	6.2	8.45	8.25	78.35	59.80
Two spray	60	D_1	122.5	125.4	5.3	5.5	8.73	8.53	80.78	61.83
		D_2	123.0	127.5	5.3	5.7	8.45	8.20	80.45	63.64
		D_3	126.3	129.3	5.2	5.6	8.30	7.95	82.65	64.29
		D_4	129.4	135.4	5.4	6.2	8.68	8.48	80.03	61.43
	75	D_1	128.4	131.4	5.4	5.9	8.40	8.15	78.63	57.54
		D_2	129.5	135.5	5.5	5.9	8.28	8.13	81.95	56.23
		D_3	132.6	136.0	6.0	6.2	8.63	8.33	81.63	63.80
		D_4	132.8	138.0	6.1	6.7	8.78	8.75	80.78	59.30
LSD 0.05			2.2	2.2	0.3	0.4	0.27	0.86	2.19	5.49

Whereas D_1: Before 2nd and 3rd irrigations (control), D_2: Before 2nd and 4th irrigations, D_3: Before 2nd , 3rd and 5th irrigations and D_4: Before 2nd , 4th and 5th irrigations.

Table (6): Effect of foliar K, rate of N fertilizer, time of application of nitrogen on some yield and yield components in 2013 and 2014 seasons.

Treatments	Number of open bolls/plant		Boll weight (g)		Number of fruiting branches/plant		Seed index (g)		Seed cotton Yield /fed (kentar)	
K fertilizer One spray	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
	17.9	13.7	2.64	2.61	14.4	13.2	9.8	8.8	13.5	13.2
Two sprays	19.5	15.5	2.52	2.53	14.0	12.8	10.2	9.0	14.1	13.5
F test	Sig.	Sig.	N.S	N.S	N.S	N.S	Sig.	Sig.	Sig.	Sig.
Rate of N fertilizer 60 kg/fed										
	18.9	15.0	2.56	2.58	14.35	13.08	9.8	8.8	13.8	13.4
75 kg/fed	18.5	14.3	2.59	2.56	14.04	12.93	10.2	9.0	13.8	13.3
F test	N.S	N.S	N.S	N.S	N.S	N.S	Sig.	Sig.	N.S	N.S
Time of application of N fertilizer										
D_1	18.2	13.8	2.60	2.58	13.9	12.9	9.7	8.7	13.4	13.2
D_2	19.4	14.9	2.52	2.59	14.4	13.1	9.9	8.9	14.0	13.5
D_3	19.9	16.5	2.53	2.57	14.8	13.5	10.2	9.0	14.4	13.9
D_4	17.4	13.3	2.67	2.56	13.7	12.6	10.2	9.0	13.4	12.9
LSD 0.05	0.9	0.7	N.S	N.S	0.3	0.6	0.3	0.2	0.6	0.6

Whereas D_1: Before 2nd and 3rd irrigations (control), D_2: Before 2nd and 4th irrigations, D_3: Before 2nd , 3rd and 5th irrigations and D_4: Before 2nd , 4th and 5th irrigations.

Yield and yield components. Data in Table (6) showed that, two sprays of potassium instead of one increased significantly no. of open bolls/ plant, seed index and seed cotton yield/fed. The increase of the number of bolls/plant might refer to more dry matter partitioning and hence more photosynthates available for more fruiting sites as expressed here in the number of open bolls/plant due to spraying K twice at commence of flowering and two weeks later. The effect of increasing potassium level on number open bolls could be due to its effect on growth parameters (Abd El-Mohsen and Ahmed, 2015). Data in Table (6) represent the effect of potassium and nitrogen fertilization on cotton yields, namely, seed cotton yield (kentar/fed), and seed index. Where two K sprays treatment gave the highest average of yield and seed index. The relative increase of yield and seed index caused by K_2 over K_1 reached to 4.4 and 4.1% in the first season, respectively. The corresponding values in the second season were 2.2 and 2.2% in the above mentioned order. The superiority of increasing potassium level on cotton yield is mainly due to its effect on growth and yield components (Abd El-Gayed et al., 2014). Increasing N levels from 60 to 75 kg/fed of N didn't affect most of characters under study except of seed index (Hutchinson et al., 1995). The effect of nitrogen level on seed cotton yield/fed is in accordance with its effect on yield components (Nafiu et al., 2017). These results are similar to those by Howard et al. (2001) and Nafiu et al., (2017). With regard to the time of nitrogen application, the results revealed that all studied yield components were significantly affected by number and dates of nitrogen application, except boll weight where highest averages of, open boll, number of fruiting branches/plant, seed index and seed cotton yield/fed were produced when nitrogen was added as three equal doses, before 2^{nd}, 3^{rd} and 5^{th} irrigation (D_3). However, D_4 treatment recorded the lowest averages of number of open bolls/plant, number of fruiting branches/plant and seed cotton yield in both seasons where D_1 treatment recorded the minimum seed index in both seasons. The seed cotton yield caused by D_3 treatment surpassed that D_1 by about 7.5 and 5.3% in the two seasons, respectively. The promotive effect of D_3 on yield parameters is due to its effect on growth and yield components (Abd El-Gayed et al., 2014). Concerning the interaction between and among treatments in the results in Tables (7 and 8) show that cotton yield components were significantly affected by the interaction between treatments. In general, plants treated with two sprays of potassium and fertilized with 75 or 60 kg/fed of N as three equal doses, before second, third and fifth irrigations yielded the highest yield components.

On the other hands, plants received one K spray under N_1 or N_2 added two times (D_1) exerted the lowest average of yield components. With regard to the interaction between any two factors or among the three ones in Table (8), the results show that the highest average of yield parameters were obtained for plants fertilized with two K sprays+N_1(60kg/fed) or N_2 (75kg/fed) added three times, before 2^{nd} , 3^{rd} and 5^{th} irrigation. On the other hand, the plants treated with K_1+N_1 or N_2 added two times (D_4) recorded the minimum yield parameters. Finally the failure of the increase of N level from 60 to 75 kg/fed of N to increase the seed cotton yield/fed and its main yield components could be attributed the excessive vegetative growth and a possible shading effect which might have had reflected more elongation of cotton plant, on the expense of the number of fruiting sites. This effect was finally expressed in a significant decrease of earliness (Table 3). Shading always increases the proportion of the invisible radiation which is known to have an elongating effect on crop plants. Portioning more photosynthesis to plant elongation might have had decreased the amount of photosynthates available for more fruit (boll) set. As expressed herein in the number of open bolls/plant. The significance of N level with its time of application might has had mastered and decreased its main effect on seed cotton yield.

Fiber properties.

Data in Table (9) show that all fiber properties under study were not significantly affected by all treatments under study except fiber strength in the first season where the best value was recorded due addition of N partly before the 2^{nd} and 3^{rd} irrigation. All first and second order interactions between treatments didn't significantly affect any of the technology traits under study. These results are in accordance with those obtained by Ismail et al. (2000) and Abd El-Gayed et al., (2014). These results revealed that each factor was insignificantly acting independently (Hamoda et al., 2014)), these results may be due to that cotton fiber quality is genetically controlled rather than environmental conditions (Subhan et al., 2001).

Table (7): Effect of first order interaction between foliar K, N fertilizer, number and dates of adding N fertilizer on yield and its components in 2013 and 2014 seasons.

Treatments		Number of open bolls/plant		Boll weight (g)		Number of fruiting branches		Seed index (g)		Yield/ fed (kentar)	
		2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
One spray	60 kg/fed	17.6	14.2	2.67	2.60	17.6	14.2	9.6	8.8	13.6	13.3
	75 kg/fed	18.2	13.3	2.61	2.62	18.2	13.3	10.0	10.0	13.4	13.1
Two spray	60 kg/fed	19.5	15.8	2.52	2.57	19.5	15.8	9.9	9.9	14.1	13.6
	75 kg/fed	19.6	15.3	2.51	2.50	19.6	15.3	10.4	10.4	14.0	13.5
One spray	D_1	17.7	13.5	2.69	2.66	13.8	12.8	9.6	8.8	13.4	13.1
	D_2	18.7	14.5	2.56	2.63	14.6	13.2	9.8	8.8	13.9	13.4
	D_3	19.0	14.6	2.58	2.58	15.2	14.0	10.0	8.9	14.0	13.6
	D_4	16.2	12.3	2.74	2.58	14.0	12.8	10.0	8.9	12.9	12.6
Two spray	D_1	18.7	14.1	2.51	2.51	14.0	12.9	9.8	8.8	13.4	13.3
	D_2	20.1	15.4	2.48	2.55	14.3	12.9	10.1	9.0	14.2	13.5
	D_3	20.8	18.3	2.48	2.55	14.4	13.1	10.3	9.1	14.8	14.2
	D_4	18.6	14.3	2.60	2.53	13.4	12.4	10.5	9.1	13.8	13.2
60 kg/fed	D_1	17.8	14.2	2.61	2.61	14.0	12.8	9.5	8.7	13.3	13.3
	D_2	19.3	14.1	2.49	2.63	14.2	12.9	9.6	8.7	13.8	13.3
	D_3	20.7	17.6	2.48	2.54	15.2	13.9	10.0	8.9	14.8	14.0
	D_4	18.0	13.9	2.68	2.55	14.0	12.8	10.0	8.9	13.5	13.0
75 kg/fed	D_1	18.6	13.4	2.59	2.54	13.8	12.9	9.9	8.9	13.6	13.0
	D_2	19.6	15.8	2.55	2.55	14.7	13.3	10.3	9.1	14.3	13.6
	D_3	19.1	15.3	2.58	2.59	14.4	13.2	10.3	9.0	14.0	13.7
	D_4	16.9	12.8	2.66	2.56	13.4	12.4	10.4	9.2	13.2	12.9
LSD 0.05 AB		0.9	0.7	0.11	0.71	0.9	0.7	0.3	0.3	0.6	N.S
LSD 0.05 AC		1.2	0.9	0.16	0.1	0.4	0.9	0.5	N.S	0.9	0.8
LSD 0.05 BC		1.2	0.9	0.16	N.S	0.4	0.9	0.5	0.4	0.9	0.8

Whereas D_1: Before 2nd and 3rd irrigations (control), D_2: Before 2nd and 4th irrigations, D_3: Before 2nd , 3rd and 5th irrigations and D_4: Before 2nd , 4th and 5th irrigations

Table (8): Effect of the interaction among foliar K, N fertilizer, number and dates of adding N fertilizer on some yield components.(A×B×C).

Treatments			No of open bolls/plant		Boll weight (g)		No. of fruiting branches/plant		Seed index (g)		See cotton yield/fed (kentar)	
K fertilizer	N fertilizer	Dates of adding N fertilizer	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
One spray	60 kg/fed	D_1	17.1	14.2	2.7	2.61	13.9	12.60	9.4	8.6	13.2	13.3
		D_2	18.7	13.3	2.53	2.71	14.3	13.18	9.6	8.7	13.6	13.3
		D_3	20.5	16.5	2.50	2.51	15.5	14.25	9.9	8.9	14.6	13.9
		D_4	16.7	12.7	2.73	2.56	14.4	13.18	9.7	8.9	12.9	12.7
	75 kg/fed	D_1	18.3	12.8	2.68	2.68	13.7	12.93	9.8	8.8	13.7	12.8
		D_2	18.8	15.6	2.60	2.55	14.9	13.25	10.0	8.9	14.2	13.6
		D_3	17.6	12.8	2.65	2.65	15.0	13.65	10.1	8.9	13.4	13.3
		D_4	**15.7**	**12.0**	2.75	2.60	13.6	12.38	10.2	9.0	12.8	12.6
Two spray	60 kg/fed	D_1	18.6	14.2	2.53	2.61	14.2	13.05	9.6	8.7	13.3	13.2
		D_2	19.9	14.9	2.45	2.55	14.1	12.58	9.7	8.7	13.9	13.4
		D_3	20.9	18.8	2.45	2.58	15.0	13.45	10.0	8.9	14.9	14.3
		D_4	19.2	15.2	2.63	2.54	13.5	12.35	10.3	9.0	14.2	13.4
	75 kg/fed	D_1	18.8	13.9	2.50	2.41	13.9	12.83	10.1	8.9	13.5	13.3
		D_2	20.4	15.9	2.50	2.55	14.4	13.28	10.6	9.2	14.4	13.6
		D_3	20.7	17.8	2.50	2.53	13.8	12.75	10.6	9.2	14.6	14.0
		D_4	18.1	13.5	2.58	2.52	13.2	12.40	10.6	9.2	13.5	13.1

LSD $_{0.05}$	**1.7**	**1.3**	**0.23**	**0.14**	**0.5**	**1.23**	**0.7**	**0.5**	**1.2**	**1.2**

Whereas **D_1**: Before 2nd and 3rd irrigations (control), **D_2**: Before 2nd and 4th irrigations, **D_3**: Before 2nd , 3rd and 5th irrigations and **D_4**: Before 2nd , 4th and 5th irrigations.

Table 9: Effect of foliar K, nitrogen fertilizer, number and dates of adding nitrogen fertilizer on some fiber properties (A, B and C).

Treatments	Fiber length (mm)		Uniformity index (%)		Fiber strength (g/tex)		Micronaire reading	
K fertilizer One time	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
	29.0	28.8	83.1	81.9	9.7	9.8	3.7	3.7
Two time	28.7	29.4	82.4	81.9	9.9	9.9	3.6	3.6
LSD $_{0.05}$	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S.**	**N.S**
Rate of N fertilizer								
60 kg/fed	28.2	29.2	82.8	82.6	9.9	9.9	3.6	3.7
75 kg/fed	29.5	29.0	82.8	81.2	9.7	9.8	3.7	3.6
LSD $_{0.05}$	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**
Time of application of N fertilizer								
D_1	27.7	29.4	83.3	82.0	10.0	9.9	3.5	3.5
D_2	28.8	28.7	81.6	81.4	9.7	9.9	3.5	3.6
D_3	29.4	29.3	83.4	81.7	9.7	9.8	3.8	3.8
D_4	29.5	29.1	82.9	82.4	9.8	9.8	3.7	3.6
LSD 0.05	**N.S**	**N.S**	**N.S**	**N.S**	**0.1**	**N.S**	**N.S**	**N.S**

Whereas **D_1**: Before 2nd and 3rd irrigations (control), **D_2**: Before 2nd and 4th irrigations, **D_3**: Before 2nd , 3rd and 5th irrigations and **D_4**: Before 2nd , 4th and 5th irrigations.

CONCLUSION

From the obtained results, it could be concluded that under middle Egypt environmental conditions the sprayed cotton plants with potassium sulphate twice and fertilized with 60 kgN/fed as soil application given as three equal doses before 2nd, 3rd and 5th irrigation recorded maximum productivity of Giza 95 cotton cultivar.

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CONFLICT OF INTEREST

All authors named in the manuscript have no conflict of interest; they are entitled to the authorship and have approved the final version of the submitted manuscript.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study.

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