J. Plant Production, Mansoura Univ., Vol. 3 (3): 509 - 524, 2012

RESPONSE OF COTTON GROWTH AND PRODUCTIVITY TO APPLICATION OF POTASSIUM AND ZINC UNDER NORMAL AND LATE SOWING DATES

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ABSTRACT

Two field experiments were carried out in Sakha Agric. Res. Sta., Kafr El-Sheikh Governorate, Egypt during two growing seasons (2007 and 2008) using the Egyptian cotton cultivar Giza 86 (*G. barbadense,* L.), to study the response of cotton growth and productivity to application of potassium and zinc under two planting dates. The experimental design was split-plot with four replications. The main-plots were assigned to two planting dates, i.e., normal planting date on March 30th and late planting date on April 30th. The sub-plots included six potassium and zinc fertilization treatments i.e., two soil application levels (24 and 48 kg K_2O/fed.) alone or with the foliar application of zinc at the level of 0.5 g Zn SO_4/liter. Potassium was also tried as foliar application at the level of 5 kg K_2SO_4/fed. alone or with the abovementioned level of zinc. Soil added potassium was applied at thinning, while foliar added one was partly sprayed at the beginning of flowering and two weeks later. Zinc was sprayed once at beginning of flowering. The results indicated that sowing date gave significant effects on all growth parameters; no. of open bolls/plant, boll weight, no. of plants/fed. at harvest, seed index and seed cotton yield/fed., upper half mean length, micronaire reading, reflectance and yellowness in favour of early planting. Sowing date did not exhibit any significant on lint %, uniformity index, fiber strength and fiber elongation % in both seasons. Foliar application of potassium along with the foliar application of zinc gave a significant increase in plant height at harvest, no. of nodes/plant, no. of sympodia/plant, no. of open bolls/plant, boll weight, seed index and seed cotton yield (ken./fed.) as compared with the other fertilization treatments. The efficiency use of heat units by cotton plants increased in favour of normal sowing rather than in late sowings. The foliar application of potassium and zinc treatments did not exhibit any significant effect on all fiber quality traits in both seasons. It could be concluded that the foliar application of 5 Kg K_2SO_4/fed. sprayed partly twice + foliar application of 0.5 g $ZnSO_4$/L once at beginning of flowering stage could be recommended to increase the yield and its components under normal or late sowing dates., for Giza 86 variety, under Sakha region condition at Kafr El-Sheikh Governorate.

Keywords: Cotton, Sowing dates, Heat units, Potassium, Zinc, Foliar application, Growth, Productivity, Fiber quality.

INTRODUCTION

Cotton is considered one of the most important fiber crops all over the world. It has long been established that planting date exerts profound effects on cotton growth and productivity. Similarly, efficient fertilization management is important for maximizing cotton yield. Nutrient elements must be sufficient enough in the growing environment of the plant to obtain high quality and more yield. Both plant growth and yield are negatively affected by deficiency of nutrient elements and lint quality is decreased as well. To achieve efficient fertilization management, nutrient, recommendations should be continuously updated to fit changes in soil fertility, climatic conditions, newly released cultivars and planting date.

It is well-recognized that delay in cotton planting usually gives plants with vigorous vegetative growth, reduced fruiting efficiency and decreased yield. It seems logic that efficient fertilization management could help in decreasing such adverse effects of delaying cotton planting date. Under local conditions, results of many recent studies indicated that the application of potassium and/or zinc enhances the fruiting efficiency and yield of cotton plant.

In Egypt, sowing date is considered the most important factor among the different factors which influence growth and yield. Planting cotton before end of March leads to the formation of first fruiting branche at lower node, increasing both no. of fruiting branches, no. of flowers and no. of open bolls/plant therefore, increasing the lint %, yield, grade and quality of cotton fiber. Planting date management not only has a large effect on crop growth, development, and yield but it also impacts insect pest management at the end of the season and picking early. Many investigations showed that early sowing had a favorable effect on yield of seed cotton compared with late sowing. Many workers studied the effect of sowing date on cotton plant such as El-Sayed (2005), Emara *et al.* (2006) found that early sowing significantly increased no. of sympodia/plant and no. of fruiting branches/plant. Makram *et al.* (2001), El-Sayed (2005), Emara *et al.* (2006), Elayan *et al.* (2006) and El-Shahawy and Hamoda (2011) mentioned that early sowing date significantly exceeded late sowing in yield and yield components. Makram *et al.* (2001), Emara *et al.* (2006) and El-Shahawy and Hamoda (2011) indicated that early sowing date significantly increased lint % and seed index. While, Makram *et al.* (2001), El-Sayed (2005), Emara *et al.* (2006) and El-Shahawy and Hamoda (2011) cleared that plant height, no. of nodes/plant, internode length, position of first sympodium and no. of sympodia/plant were increased in favour of late sowing. Makram *et al*. (2001) and Emara *et al.* (2006) cleared that they added that early sowing harvested the highest amount of heat units and increased the efficiency use of cotton plants to thermal units. Emara *et al.* (2006) revealed that late sowing on April caused an increase in boll weight and seed index. Concerning the fiber quality, Abd El-Karim (2003), mentioned that early sowing was significantly superior than late sowing to fiber length, uniformity ratio, fiber strength and micronaire reading. However, El-Shahawy and Hamoda (2011) indicated that all fiber properties studied were improved due to in early planting.

Potassium is an essential macro-element required in large amounts for normal plant growth and development. Potassium is an important nutrient that has favorable effects on the metabolism of nucleic acids, proteins, vitamins and growth substances. Furthermore, Potassium plays important roles in the translocation of photsynthates, sugars and activation of many enzymes required from sources to sinks (Cakmak *et al.,* 1994; Marschner, 1997; Bednarz and Oosterhuis, 1999 and Morteza *et al.,* 2005). However, Pettigrew (1999) indicated that the elevated carbohydrate concentrations remaining in source tissue, such as leaves, appear to be part of the overall effect of potassium deficiency in reducing the amount of photosynthate available for reproductive sinks and thereby producing changes in the yield and quality of cotton. Many studies have shown increased yield and quality in response to potassium fertilization as reported by Gormus (2002), Keshavarz *et al.,* (2004), Makhdum *et al.* (2005), Sawan (2006), Sawan *et al.* (2006a), and El-Sayed *et al.* (2007). Information available on potassium requirements of cotton plants showed better response to moderate rate of application potassium, i.e., 24 - 48 kg K_2O/fed. as indicated by Khalifa and Abou-Zaid (2002), El-Shazly *et al.,* (2003), El-Masri *et al.,* (2005), Hamed (2006) and Abou-Zaid *et al.,* (2009).

Zinc is an indispensable element for healthy life plants. It has important functions in protein and carbohydrate metabolism of plants. Furthermore, zinc is an element which directly affects yield and quality because of its function such as its activity in biological membrane stability, enzyme activation ability, protein metabolism, photosynthetic carbon metabolism and Indole Acetic Acid metabolism (Marschner, 1997 and Oktay *et al.,* 1998). The metabolic functions of zinc are mainly based on its role as a structural constituent or regulatory co-factor of enzyme systems involved in several key physiological pathways including; photosynthesis, sugar formation, growth regulation and disease resistance, (Rengel, 2007 and Alloway, 2008). Moreover, its deficiency has been reported to cause reduction in dry matter production of many crop plants, (Price, 1970; Wang and Jin, 2005 and El-Fouly 2006). Several workers documented favorable responses of cotton growth, productivity and fiber quality to foliar application with zinc, Ratinavel *et al.* (1991), Zeng (1996), Elwan *et al.* (2002), El-Masri (2005), Suresh and Kumar (2005), Sawan *et al.* (2006b), El-Menshawi and El-sayed (2007), Mamatha (2007), Kassem *et al.* (2009), Abdel-Aal *et al.* (2011), Ali *et al.* (2011) and Lale and Emine. (2011).

Therefore, the main goal of this investigation was to study the effects of potassium and/or zinc application on cotton growth and yield of normal and late planted cotton under the environmental conditions of Sakha, Kafr El-Sheikh Governorate.

MATERIALS AND METHODS

Two field experiments were carried out in Sakha Agric. Res. Sta., Kafr El-Sheikh Governorate, Egypt during two growing seasons (2007 and 2008) to study the response of cotton growth and productivity to soil and foliar potassium and zinc application under normal and late sowing dates, using the Egyptian cotton cultivar Giza 86 (*G. barbadense* L.,). The experimental design was a split plot with four replications where the sowing dates were allocated to the main plots and the sub-plots included potassium and zinc application treatments as follows:

A- Sowing date (Main-plots):

1) Normal sowing date on March 30th.
2) Late sowing date on April 30th.

B- Potassium and Zinc application (Sub-plots):

1) **T1-** Soil application of 24 kg K_2O/fed. at thinning.
2) **T2-** Soil application of 48 kg K_2O/fed. at thinning.

3) **T3-** Soil application of 24 kg K_2O/fed. at thinning + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering.
4) **T4-** Soil application of 48 kg K_2O/fed. at thinning + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering.
5) **T5-** Foliar application of 5 kg K_2SO_4/fed. sprayed partly twice at beginning of flowering and two weeks later.
6) **T6-** Foliar application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, the fore mentioned dates of application.

Potassium and zinc were foliar added using sprayer in low volume of 200 liter/fed.

The size of each plot was 26 m^2 (including nine ridges each of 0.65 m wide x 5 m long). Distance between hills was 25 cm. Seedlings were thinned as two plants per hill at five weeks of sowing. Phosphorus in the form of ordinary superphosphate (15.5% P_20_5) was applied through land preparation at the rate of 30 kg P_20_5/fed. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was applied in two equal doses (30+30 Kg N/fed.), i.e., the first dose after thinning and before the second irrigation, the second dose before third irrigation. Potassium fertilizer as potassium sulfate (48% K_2O) at the levels of 24 or 48 Kg K_2O/fed. was side-dressed in one dose before the second irrigation, whereas the foliar potassium application was sprayed twice i.e. at beginning of flowering and two weeks later. Zinc in the form of zinc sulphate (36% Zn) was foliar applied once at the beginning flowering stage. The other standard agricultural practices were followed throughout the growing seasons. The preceding crop was Egyptian clover (*Trifolium alexandrinum* L.,) in both seasons.

Some soil properties were determined according to the method described by Page *et al*. (1982) and are presented in Table (1). In both seasons, the soil texture was clay, low content of organic matter, low calcium carbonate and non-saline. The available amounts of macro elements were low for nitrogen, high for phosphorus and medium for potassium. Regarding, available amounts of micro-nutrients, Fe, Mn and Cu were of high levels in the soil, while Zn a low content amount. The concentration of zinc in soil solution falls with increasing pH (above 7), Cardozier (1957). This performance was done to avoid any nutrition factor interfered with the treatments used.

In both seasons, five representative hills (10 plants/plot) were taken at random in order to study the following traits; Plant height at harvest (cm), no. of nodes/plant, internode length (cm), position of first sympodium, no. of sympodia/plant, no. of open bolls/plant, boll weight (g), lint percentage and seed index (g). The yield of seed cotton in kentars/fed. was estimated from the 6 inner ridges, (One Kentar = 157.5kg.). The number of established plants at harvest was counted and calculated/fed. in thousands. The fiber properties i.e., upper half mean length (U.H.M), uniformity index (U.I), fiber strength (g/tex.), fiber elongation percentage, micronaire reading, reflectance (Rd), yellowness (+b). measured by HVI apparatus according to

(A.S.T.M.1986) that included in the fibers technology laboratory at Cotton Research Institute, Giza.

Table (1): Some soil properties of the experimental sites at Sakha in 2007 and 2008 seasons.

Seasons	Soil properties											
	Texture	Organic Matter (%)	pH	EC (m mhos/ cm.)	Ca CO_3 (%)	Available element (ppm)						
						N	P	K	Fe	Mn	Zn	Cu
2007	Clay	1.53	8.23	3.25	1.52	27.7	23.1	231	11.9	9.8	0.79	3.84
2008	Clay	1.47	8.18	3.99	1.77	29.4	26.8	259	11.4	11.1	0.74	3.71

The climatic records were maximum and minimum air temperatures (°C) were recorded in 30-days intervals through the cotton growing season (March - October), in 2007 and 2008 seasons for Sakha Agricultural Research Station. Also, the amounts of heat units (HU) were calculated in 30-days intervals for both seasons are shown in Table (2). Heat units (HU) according to Young *et al.* (1980) equation as follows:

Daily (HU) = mean daily min. and max. temperatures – K (Zero growth = 12.8°C).

Table (2): Mean of 30-day intervals, air temperatures and heat units (HU) for Sakha Agricultural Research Station in 2007 and 2008 seasons.

Intervals	2007				2008			
	Air temperatures °C		Heat units		Air temperatures °C		Heat units	
	Min.	Max.	Normal sowing	Late sowing	MIN.	MAX.	Normal sowing	Late sowing
FROM 30/3 TO 28/4.	14.94	26.16	232.55	-	14.54	27.85	251.85	-
FROM 29/4 TO 28/5.	15.76	30.15	304.70	307.70	14.74	29.29	276.50	281.55
FROM 29/5 TO 27/6.	16.55	31.14	331.35	333.50	15.12	31.67	317.85	316.50
FROM 28/6 TO 27/7.	15.95	32.25	339.00	339.90	15.77	31.63	327.00	329.45
FROM 28/7 TO 26/8.	18.97	32.99	395.50	395.65	18.23	33.02	384.75	387.55
FROM 27/8 TO 25/9.	19.80	31.61	387.25	383.55	19.33	32.57	394.45	393.30
FROM 26/9 TO 17/10.	19.90	30.31	270.85	259.80	19.83	30.21	207.75	194.15

This constant was used as the temperature below which cotton plants do not develop, (Zero growth).

Total heats were summed over the growth period. The efficiency use of heat units through the growing. The efficiency use of thermal heat units by cotton plants estimated by the following equation referred by (Makram *et al.* 2001);

$$\text{Efficiency use of (HU)} = \frac{\text{Total amount of heat units through the whole season}}{\text{Number of open bolls/plant}} \quad \text{(HU/boll)}.$$

The obtained data were subjected to statistical analysis according to the procedures outlined by Snedecor and Cochran (1980) using M Stat-C microcomputer program for split plot design. L.S.D. values at 5% level of significance were used to compare between treatments means.

RESULTS AND DISCUSSION

The effect of application potassium and zinc under the two sowing dates on growth parameters, yield, yield components, efficiency use of heat units and fiber properties of the cotton Giza 86 is shown in tables (3) to (6).

A- Effect of sowing dates:

A-1- Growth parameters:

Data in Table (3) show that sowing date had a significant effect on all growth parameters; plant height at harvest, position of first sympodium, no. of sympodia/plant, no. of nodes/plant and internode length in 2007 and 2008 seasons, respectively. It is evident that late sowing date produced taller plants with longer internode length compared with the normal sowing date.

Table (3): Cotton growth attributes as affected by the application of potassium and zinc under normal and late sowing dates during 2007 and 2008 seasons.

Characters		Plant height at harvest (cm)		First sympodial position (Node)		No. of sympodia/ plant		No. of nodes/plant		Internode length (cm)	
Seasons / Treatments		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Sowing dates (A)	K & Zn (B)										
Normal (30 March)	T1	148.33	158.33	6.90	6.96	13.2	15.0	19.1	19.9	7.77	7.96
	T2	147.00	158.33	6.63	6.90	14.2	16.4	19.9	21.3	7.39	7.43
	T3	148.66	150.66	6.93	6.96	14.3	15.3	20.3	20.3	7.32	7.42
	T4	150.00	158.33	6.96	7.00	14.3	16.5	20.2	21.5	7.43	7.36
	T5	148.66	161.66	7.10	7.03	14.8	16.5	20.9	21.6	7.11	7.48
	T6	152.66	163.50	7.06	7.10	14.9	16.8	20.9	21.8	7.30	7.50
MEAN		**149.22**	**158.47**	**6.93**	**6.99**	**14.3**	**16.1**	**20.2**	**21.1**	**7.39**	**7.53**
Late (30 April)	T1	160.33	160.33	7.90	7.73	12.6	12.7	19.5	18.4	8.22	8.71
	T2	161.33	161.66	7.93	7.20	13.1	12.8	20.1	18.0	8.03	8.98
	T3	162.33	168.33	7.43	7.90	13.2	13.0	20.0	18.9	8.12	8.91
	T4	163.00	167.00	7.70	7.93	13.2	13.6	19.6	19.5	8.32	8.56
	T5	163.66	166.00	7.86	7.90	13.1	13.4	20.0	19.3	8.18	8.60
	T6	164.00	169.50	7.63	7.43	13.4	14.4	20.4	19.8	8.04	8.56
MEAN		**162.44**	**165.47**	**7.74**	**7.68**	**13.1**	**13.3**	**19.9**	**19.0**	**8.15**	**8.72**
General mean of (B)	T1	154.17	159.33	7.40	7.35	12.9	13.8	19.3	19.2	8.00	8.30
	T2	154.33	160.00	7.28	7.05	13.7	14.6	20.0	19.7	7.71	8.12
	T3	155.50	159.50	7.18	7.43	13.8	14.2	20.1	19.6	7.74	8.14
	T4	156.16	162.67	7.33	7.46	13.7	15.0	19.9	20.5	7.86	8.23
	T5	156.16	163.83	7.48	7.46	13.9	14.9	20.4	20.4	7.69	8.03
	T6	158.33	166.50	7.35	7.26	14.1	15.6	20.6	20.8	7.65	8.00
L.S.D at 5% for	A	**1.86**	**3.68**	**0.16**	**0.37**	**0.97**	**0.63**	**0.23**	**0.95**	**0.64**	**0.44**
	B	**1.22**	**3.80**	**N.S**	**N.S**	**0.53**	**0.55**	**0.49**	**0.69**	**0.28**	**0.36**
	A X B	**2.30**	**5.38**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

Plant height was increased by delaying the date of sowing due to on increment of internode length in both seasons as compared to early sowing and these results might be due to fluctuations of climatic conditions and the increment of air and soil temperature at late sowing.

The effect was confirmed during the two studied seasons where plants sown at normal date showed their position of first sympodium at a lower node than that of late sowing date in both seasons. This effect may be due to the balance between vegetative and fruiting growth, which occurred under the earlier date, than late one.

Normal date plants carried highest no. of sympodia/plant with higher no. of nodes/plant than that obtained from late sown ones in both seasons. Number of sympodia/plant and no. of nodes/plant which considered as vegetative-fruiting character was significantly increased in favour of early sowing.

Similar results were obtained by El-Sayed (2005), Emara *et al.* (2006) and El-Shahawy and Hamoda (2011) for plant height, internode length, position of first sympodium, El-Sayed (2005) and Emara *et al.* (2006) for no. of sympodia/plant and no. of nodes/plant.

A-2- Yield and yield components:

Data in Table (4) cleared that no. of open bolls/plant, boll weight, seed index and seed cotton yield/fed. were significantly increased due to the normal sowing date in both seasons. This sowing date produced heavier bolls (2.63 and 2.42 g), and higher no. of open bolls/plant (14.21 and 17.73) with heavier seed index (10.33 and 10.48 g) than late sowing date (2.07 and 2.26 g), (12.31 and 14.31), (10.26 and 10.22 g) in 2007 and 2008 seasons, respectively. This could be attributed to the increase in the number of sympodia/plant and the well-built plants which were shorter and had lower fruiting node than the late sown plants which were etiolated. This in turn might have had increased the amounts of available photosynthates for boll development and hence increased boll weight and as well the seed index.

The earlier sowing date surpassed the later sowing date in the percentages of the increase of seed cotton yield/fed. owing to early sowing date were 34.37 and 29.29% for first and second seasons, respectively. The seed cotton yield/fed. was increased in favor of early sowing as a result of increasing no. of open bolls/plant, boll weight, seed index and optimum no. of plants/fed. at harvest. This might be due to the increase of thermal units which had achieved by early sowing.

But, the highest value of no. of plants/fed. at harvest (50.452 and 50.628) were obtained from late sowing date in 2007 and 2008 seasons, respectively. While, the lowest values (48.194 and 47.057) were obtained from early sowing date in both seasons. Sowing dates did not reflect any significant effect on lint % in both seasons. The decrease in the no. of harvested plants/fed. recorded for the normal sowing date was not reflected in the seed cotton yield/fed. which was increased. This clearly indicates that the increase in the no. of open bolls/plant and boll weight did compensate the decrease in plant population at harvest. The decrease of plant population due to the normal sowing date could be attributed to low seedling emergence which needs further investigate. Form the above mentioned results it could suggested that, normal sowing maximized the efficiency use of heat units early in season by inducing early balance between vegetative growth and fruiting development (Table 5). Consequently, normal sowing produced the highest number of buds, total bolls and early open bolls in the season, as compared to late sowing because most of the heat units were consumed in vegetative growth.

Table (4): Cotton yield and yield components as affected by the application of potassium and zinc under normal and late sowing dates during 2007 and 2008 seasons

Characters		No. of opened bolls/plant		Boll weight (g)		No. of plants (1000 plants/fed.)		Lint percentage (%)		Seed index (g)		Seed cotton yield (Kentar/fed.)	
Seasons / Treatments: Sowing dates (A)	K & Zn (B)	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Normal (30 March)	T1	13.50	16.83	2.46	2.30	48.000	46.633	38.73	38.53	10.15	10.43	8.13	9.26
	T2	14.40	17.10	2.60	2.50	48.800	47.400	38.36	38.46	10.28	10.44	8.54	9.40
	T3	14.20	17.93	2.63	2.36	49.033	47.133	38.56	38.16	10.33	10.43	8.17	9.53
	T4	14.33	17.86	2.70	2.50	48.667	47.367	38.13	38.43	10.40	10.46	8.85	9.43
	T5	14.43	17.73	2.66	2.33	47.00	46.743	38.36	37.60	10.40	10.53	8.95	9.23
	T6	14.43	18.93	2.73	2.56	47.667	47.067	38.66	38.56	10.43	10.60	8.96	9.56
MEAN		**14.21**	**17.73**	**2.63**	**2.42**	**48.194**	**47.057**	**38.47**	**38.29**	**10.33**	**10.48**	**8.60**	**9.40**
Late (30 April)	T1	11.70	12.90	2.00	2.20	50.333	50.667	38.26	38.43	10.20	10.03	6.11	7.10
	T2	12.50	13.16	2.00	2.30	50.600	50.933	38.06	38.56	10.23	10.13	6.52	7.10
	T3	12.30	14.36	2.10	2.26	50.333	50.400	38.43	38.00	10.26	10.16	6.22	7.00
	T4	12.10	14.00	2.10	2.30	50.333	50.733	37.86	38.46	10.28	10.33	6.56	7.20
	T5	12.50	15.23	2.03	2.20	50.477	51.033	37.93	38.43	10.30	10.33	6.39	7.33
	T6	12.80	16.23	2.20	2.30	50.633	50.000	38.03	37.96	10.33	10.36	6.63	7.90
MEAN		**12.31**	**14.31**	**2.07**	**2.26**	**50.452**	**50.628**	**38.10**	**38.31**	**10.26**	**10.22**	**6.40**	**7.27**
General mean of (B)	T1	12.60	14.86	2.23	2.25	49.167	48.650	38.50	38.48	10.18	10.23	7.12	8.18
	T2	13.45	15.13	2.30	2.40	49.700	49.167	38.21	38.51	10.26	10.29	7.53	8.25
	T3	13.25	16.15	2.36	2.31	49.683	48.767	38.50	38.08	10.30	10.30	7.19	8.26
	T4	13.21	15.93	2.40	2.40	49.500	49.050	38.00	38.45	10.34	10.40	7.70	8.31
	T5	13.46	16.48	2.35	2.26	48.738	48.888	38.15	38.01	10.35	10.43	7.67	8.28
	T6	13.61	17.58	2.46	2.43	49.150	48.533	38.35	38.26	10.38	10.48	7.79	8.73
L.S.D at 5% for	A	**0.25**	**0.90**	**0.04**	**0.04**	**0.572**	**1.372**	**N.S**	**N.S**	**0.03**	**0.25**	**0.39**	**0.47**
	B	**0.48**	**0.85**	**0.09**	**0.11**	**N.S**	**N.S**	**N.S**	**N.S**	**0.09**	**0.09**	**0.30**	**0.36**
	A X B	**0.86**	**1.12**	**0.19**	**0.24**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

Table (5): The effect of sowing date on total heat units and efficiency use of heat units per boll of cotton plant in during 2007 and 2008 seasons.

Characters	Total heat units		Efficiency use of heat units/boll (HU/boll)		No. of days from sowing to picking (days)	
Sowing date	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
Normal sowing	2261.20	2160.15	159.13	121.83	202	197
Late sowing	2020.10	1902.50	164.10	132.95	171	166

These results are in harmony with those obtained by Makram *et al.* (2001), Emara *et al.* (2006) and El-Shahawy and Hamoda (2011) for yield and yield components.

The data in Table (5) cleared that normal sowing caused a decrease in the values of heat unit efficiency for producing one open boll that means the increase in efficiency use of thermal air units. This could be achieved by sowing cotton in the suitable time. Finally, it is important to measure the efficiency use of heat units in cotton production, in order to maximize the use of the inputs in cotton fields by using the equation.

A-3- Fiber properties:

Results presented in Table (6) show that the sowing date had an insignificant effect on uniformity index, fiber strength and fiber elongation % under study in the first and second seasons, respectively.

Table (6): Cotton fiber properties as affected by the application of potassium and zinc under normal and late sowing dates during 2007 and 2008 seasons.

Characters		Fiber Length parameters				Fiber bundle tinsel				Micronaire reading		Colour			
		Upper half mean (mm)		Uniformity index (%)		Fiber strength (g/tex)		Fiber elongation (%)				Reflectance (Rd %)		Yellowness (+b)	
Seasons / Treatments															
Sowing dates (A)	K & Zn (B)	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Normal (30 March)	T1	34.2	33.8	89.7	88.3	43.4	44.9	6.96	7.13	4.76	4.46	75.7	77.8	9.46	8.46
	T2	34.4	33.5	88.0	86.8	42.2	43.9	6.46	7.13	4.63	4.70	75.2	77.7	9.26	8.50
	T3	33.9	33.6	88.4	87.5	42.9	43.4	6.66	7.36	4.83	4.70	76.3	77.1	9.43	8.46
	T4	34.9	33.7	88.4	87.5	42.0	43.0	6.90	7.26	4.83	4.50	76.2	77.0	9.36	8.63
	T5	34.2	33.6	88.4	87.6	43.8	42.0	6.90	7.23	4.80	4.73	75.4	76.7	8.80	8.73
	T6	33.8	33.5	88.3	86.8	43.3	44.6	6.66	7.36	4.93	4.86	75.4	77.4	8.70	8.30
MEAN		**34.2**	**33.6**	**88.5**	**87.4**	**42.9**	**43.6**	**6.76**	**7.25**	**4.80**	**4.66**	**75.7**	**77.3**	**9.17**	**8.51**
Late (30 April)	T1	33.5	32.7	88.3	87.5	42.1	43.6	6.56	7.53	4.06	4.30	74.0	75.3	9.13	8.03
	T2	33.1	32.3	88.6	87.3	41.4	42.8	6.80	7.50	4.33	4.30	73.9	75.8	8.93	8.00
	T3	34.3	32.5	89.7	87.9	42.6	45.5	6.53	7.23	4.40	4.20	74.5	75.2	9.10	8.06
	T4	33.7	32.8	89.7	87.2	42.0	42.4	6.80	7.20	4.30	4.23	74.4	76.4	8.10	7.96
	T5	32.9	32.6	88.5	88.1	41.1	43.9	6.70	7.10	4.36	4.43	73.6	76.2	8.13	7.96
	T6	33.5	32.8	88.0	87.9	42.1	45.2	6.80	7.10	4.46	4.56	73.8	75.6	8.80	8.03
MEAN		**33.5**	**32.6**	**88.8**	**87.6**	**41.7**	**43.9**	**6.70**	**7.27**	**4.32**	**4.33**	**74.0**	**75.7**	**8.70**	**8.01**
General mean of (B)	T1	33.8	33.2	89.0	87.9	42.7	44.3	6.76	7.33	4.41	4.38	74.8	76.6	9.30	8.25
	T2	33.7	32.9	88.3	87.1	41.8	43.3	6.63	7.31	4.48	4.50	74.6	76.7	9.10	8.25
	T3	34.1	33.0	89.0	87.7	42.7	44.4	6.60	7.30	4.61	4.45	75.4	76.1	9.27	8.26
	T4	34.3	33.2	89.0	87.4	42.0	42.7	6.85	7.23	4.56	4.36	75.3	76.7	8.73	8.30
	T5	33.5	33.1	88.4	87.8	42.4	43.0	6.80	7.16	4.58	4.58	74.5	76.4	8.47	8.35
	T6	33.6	33.1	88.2	87.3	42.2	44.9	6.73	7.23	4.70	4.71	74.6	76.5	8.75	8.17
L.S.D at 5% for	A	**0.32**	**0.47**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**0.14**	**0.24**	**0.82**	**1.31**	**0.26**	**0.33**
	B	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**
	A X B	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**	**N.S**

But, upper half mean length, micronaire reading, reflectance and yellowness were significantly affected by sowing dates in both seasons. The normal sowing date gave the highest values of upper half mean length (34.2 and 33.6 mm), micronaire reading (4.80 and 4.66), reflectance (75.7 and 77.3%) and yellowness (9.17 and 8.51%) in the first and second seasons, respectively as compared with late sowing date. This increase could be due to the fact that early sowing date help the fibers to have high maturity. The obtained results are in close agreement with those reported by Abd El-Karim (2003) for fiber length and micronaire reading. But are was in contrast with those reported by El-Shahawy and Hamoda (2011) who found sowing date had insignificant effect on fiber properties under study.

B- Effect of potassium and zinc application:

B-1- Growth parameters:

Data present in Table (3) reveal that all treatments of potassium and zinc application had significant effects on plant height, internode length, no. of sympodia/plant and no. of nodes/plant in 2007 and 2008 seasons, respectively.

The tallest plants were produced from foliar application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering, while the shortest plants was produced from soil application of 24 kg K_2O/fed. at thinning in both seasons. But the tallest internode length was produced from soil application of 24 kg K_2O/fed. at thinning, while the internode length was produced from foliar application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering in both seasons. The increase in plant height due to zinc application may be due to application of K and Zn might have helped in vigorous root growth and formation of chlorophyll, resulting in higher photosynthesis. Soil application of micronutrients increased the uptake of N, P and K significantly, which in turn might have helped in better growth of the cotton. Likewise, Zn is a growth promoting element required for the synthesis of the amino acid tryptophan, the precursor for the biosynthesis of the natural auxin IAA responsible for stem elongation, (Alloway, 2008 and Oosterhuis *et al.,* 1991).

However, the highest values of no. of sympodia/plant (14.1 and 15.6) and no. of nodes/plant (20.6 and 20.8) were obtained from foliar application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering in the first and second seasons, respectively. Reversely, the lowest values were obtained from soil application of 24 Kg K_2O/fed. at sowing in both seasons. This beneficial effect might be due to interaction effect of K and Zn and their role in the synthesis of IAA, metabolism of auxins and chlorophyll. The tested treatments had insignificant effect on position of first sympodium.

Though the soil of the experimental site had relatively high available potassium and zinc contents, the response of cotton plants to their addition could probably be attributed to higher needs by these plants and/or un-balanced soil nutrient content. The high P, Fe, Cu and Mn contents might have had affected Zn uptake by cotton plants due to a possible antagonism.

This could account for the response of cotton plant to both potassium and zinc when were given as foliar application. This response was more pronounced as plants are in their maximum growth and high needs with the commence of flowering.

B-2- Yield and yield components:

Results shown in Table (4) indicate that the potassium and zinc application treatments exerted significant increase effects on no. of open bolls/plant, boll weight and seed index in both seasons, where the highest no. of open bolls/plant was recorded. This might be due to the hormonal balance in the plant system brought about by these nutrients resulting in less shedding of squares and young bolls/plant. The increase of boll weight might be due to accelerated mobility of photosynthates from source to sink as influenced by the application of potassium and zinc. This could account for the increase of seed index which was increased due to translocation of photosynthates to the site of storage organ., were obtained from foliar application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering in both seasons. The lowest values no. of open bolls/plant, boll weight and seed index were obtained from soil application of 24 kg K_2O/fed. at thinning in both seasons.

Application of 5 kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering. significantly increased seed cotton yield/fed. which amounted to 7.79 and 8.73 ken./fed. (9.41 and 6.72%), compared to soil application of 24 kg K_2O/fed. at thinning which yielded 7.12 and 8.18 ken./fed. These increases could be due to favorable effects of this nutrient on yield components, i.e., no. of open bolls/plant, boll weight and seed index. This application did not exert any insignificant effect on no. of plants/fed. at harvest, seed index and lint % in both seasons.

Such improvements in yield and its components due to potassium and zinc foliar supply could be a result of their effects on fundamental metabolic activities which may be positively reflected on boll set as expressed in the no. of open bolls/plant as well as boll development as expressed in boll weight, seed index and finally the seed cotton yield/fed. The positive effect of potassium on boll weight may be due to that potassium plays a great role in photosynthates translocation from the source leaves (Ashley and Goodson, 1972). Zinc is required in the synthesis of tryptophan, which is a precursor of IAA (Alloway, 2008 and Oosterhuis *et al.,* 1991), a hormone that inhibits abscission of squares and young bolls. This nutrient also has a favorable effect on the photosynthetic activity of leaves and plant metabolism which might account for higher accumulation of metabolites in reproductive organs.

B-3- Fiber properties:

As seen in Table (6), the tested treatments did not exhibit any significant effect on all fiber quality traits in both seasons. The obtained results are in close agreement with those reported by Abou-Zaid *et al.,* (2009).

C- Effect of the interaction:

The interaction between sowing date and application potassium and zinc treatments are presented in Tables (3, 4 and 6). Generally, the data indicate that this interaction gave a significant effect on plant height, no. of open bolls/plant and boll weight in both seasons. This clearly indicates that the main effects of planting date and fertilization treatments masked any interacting effect between them regarding the seed cotton yield/fed. and all the fiber quality attributes.

CONCLUSION

Finally on the light of the obtained results, it could be concluded that the foliar application of 5 Kg K_2SO_4/fed. sprayed partly twice + One foliar application of 0.5 g $ZnSO_4$/L, at beginning of flowering. once at beginning flowering stage could be recommended to increase the yield and its components under normal or late sowing date., for Giza 86 variety, under Sakha region condition at Kafr El-Sheikh Governorate.

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أستجابة نمو وأنتاجية القطن لإضافة البوتاسيوم والزنك تحت مواعيد الزراعة المعتادة والمتأخرة

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا – محافظة كفر الشيخ – مصر خلال موسمي 2007 و 2008 وذلك بهدف دراسة إستجابة نمو وأنتاجية صنف القطن المصري جيزة 86 لإضافة البوتاسيوم سواء أرضي بمعدلات 24 أو 48 كجم بو $_2$أ/فدان أو رش النباتات بسلفات البوتاسيوم بمعدل 5 كجم/فدان مرتين، ورش سلفات الزنك بمعدل 0.5 جم/لتر ماء مرة واحدة وذلك تحت ظروف الزراعة المعتادة (30 مارس) والمتأخرة (30 أبريل). وكانت مواعيد الرش هي عند بداية التزهير وبعده بإسبوعين، وكان التصميم التجريبى المستخدم هو القطع المنشقة في أربع مكررات حيث وضع ميعادي الزراعة في القطع الرئيسية ووضعت معاملات إضافة البوتاسيوم والزنك في القطع الشقية وتضمنت معاملات التسميد الست معاملتين للتسميد الارضي (24 و 48 كجم بو $_2$أ/فدان) مع عدم الرش أو الرش بسلفات الزنك مستوي 0.5 جم/لتر ماء مرة واحدة أو التسميد التالي ورقياً بأستخدام مستوي 5 كجم سلفات البوتاسيوم/فدان أضيفت علي رشتين بدون إضافة أو إضافة الزنك بالمعدل السابق الاشارة إليه.

وتتلخص أهم النتائج المتحصل عليها فيما يلى:

١) أدت الزراعة المعتادة في 30 مارس الي زيادة كل من عدد العقد/النبات، عدد الأفرع الثمرية/نبات، عدد اللوز المتفتح/نبات، متوسط وزن اللوزة، معامل البذرة ومحصول القطن الزهر بالقنطار/فدان، وكذلك بعض صفات التيلة مثل متوسط طول التيلة، الميكرونير، نسبة الانعكاس في اللون و درجة الاصفرار مقارنة بالزراعة المتأخرة في30 أبريل.

٢) لم تؤثر مواعيد الزراعة معنوياً علي كلا من النسبة المئوية للتيلة، معامل الانتظام، المتانة والاستطالة.

٣) كان لمعاملات إضافة البوتاسيوم والزنك تأثيراً معنوياً علي معظم صفات النمو تحت الدارسة عدا موقع أول فرع ثمري، وكذلك المحصول ومكوناته عدا صفتي عدد النباتات/الفدان والنسبة المئوية للتيلة، وقد تفوقت معنوياً معاملة رش النباتات بسلفات البوتاسيوم بمعدل 5 كجم/فدان مرتين + رش الزنك بمعدل 0.5 جم/لتر ماء مرة واحدة بالمقارنة بباقي المعاملات تحت الدراسة.

٤) لم تظهر معاملات إضافة البوتاسيوم والزنك أي تأثيراً معنوياً علي كل صفات التيلة تحت الدراسة.

٥) لم يظهر التفاعل بين ميعادي الزراعة ومعاملات أضافة البوتاسيوم والزنك أي تثأيرات معنوية علي الصفات تحت الدراسة عدا صفات أرتفاع النباتات عند الحصاد، عدد اللوز المتفتح/نبات ومتوسط وزن اللوزة.

التوصية:

من النتائج السابقة يمكن التوصية بعدم تأخير زراعة صنف القطن جيزة 86 عن 30 مارس مع التسميد ورقياً بأستخدام سلفات البوتاسيوم بمعدل 5 كجم/فدان علي رشتين الاولي مع بداية مرحلة التزهير والثانية بعد 15 يوم من الاولي بالإضافة للرش بسلفات الزنك مرة واحدة بمعدل0.5 جم/لتر ماء أيضاً عند بداية التزهير حيث أعطت هذه المعاملة أعلى محصول للقطن الزهر/فدان وأعلي أنتاجية دون التأثير علي صفات الجودة بالمقارنة بباقي المعاملات تحت الدراسة خلال موسمي النمو تحت ظروف منطقة سخا – محافظة كفر الشيخ - مصر.

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