Minufiya J. Agric. Res. Vol.36 No. 5:1277-1304 (2011) "http://www.mujar.net"

EFFECT OF FOLIAR APPLICATION OF GROWTH REGULATORS, MACRO AND MICRONUTRIENTS ON ABSCISSION, YIELD AND TECHNOLOGICAL CHARACTERS OF EGYPTIAN COTTON (*Gossypium barbadense*, L.).

S.M. Abdel-Aal[1], M.E. Ibrahim[1], A.A. Ali[1], G.A. Wahdan[2], O.A.M. Ali[1] and Y.F.A. Ata Allah[2]

[1] Crop Science Department, Faculty of Agriculture, Minufiya University, Egypt.
[2] Cotton Research Institute, Agriculture Research Center, Egypt

(Received: Aug. 15, 2011)

ABSTRACT: *Two field experiments were conducted at Gemmeiza Agricultural Research Station, Ministry of Agriculture in Gharbia governorate, Egypt, to study the effect of foliar application of some growth regulators (control, Atonik and Pix), macronutrients (control, P and K) and micronutrients (control, Zn and B) on the production and abscission of squares and bolls (numbers of squares "fruiting points", setting bolls and bolls/plant as well as squares, bolls and total abscission percentages), productivity (number of open bolls/plant, boll weight, seed index, earliness % and seed cotton yield per plant and fed) and technological characters of seeds (oil and protein percentages) and fiber (lint%, fiber fineness and fiber strength) of Egyptian cotton (Gossypium barbadense L.), Giza 89 cv. during 2005 and 2006 seasons. The cotton plants were sprayed with Atonik (1 ml/liter), Pix (1 ml/liter), P (phosphoric acid 1 ml/liter), K (potassium citrate 1 g/liter), Zn (zinc chelate 1 g/liter) and B (boric acid 1 g/liter) twice at start of flowering and 30 days later.*

The results obtained could be summarized as follows:

1- *The results indicated that foliar application of Pix significantly increased the values of number of squares and bolls /plant, yield and its components (number of open bolls / plant, boll weight, seed index, seed cotton yield /plant and seed cotton yield/fed) and technological characters of seeds (oil and protein percentages) and fiber (lint %, micronaire reading and strength) but decreased bolls abscission and total abscission percentages compared to the untreated plants in the two growing seasons.*

2- *Foliar application of the tested macronutrients (P and K) significantly increased the most production and abscission of squares and bolls characters, yield and its components and technological characters of seeds and fiber in favour of K compared to untreated plants in the two seasons.*

3- *Foliar application of the tested micronutrients (Zn and B) significantly increased the most production and abscission of squares and bolls* *characters, yield and its components and technological characters of seeds and fiber in favour of B compared to untreated plants in the two seasons.*

4- The interactions among the tested growth regulators, macronutrients and micronutrients were found to be significant for most characters of yield and its components. Foliar application of Pix or K and/or B combinations being the most effective interactions treatments for produce the highest values of yield and its components, while the lowest values were obtained when the plants were untreated with any tested growth regulators, macronutrients and/or micronutrients of these characters in the two seasons.

Key words: Plant growth regulators, macro and micronutrients, abscission, yield, technological parameters, Egyptian cotton.

INTRODUCTION

Cotton is one of the most important fiber crops of the world which plays a key role in the economic activity. It is the oldest among the commercial crops and is regarded as white gold. Cotton enjoys a preeminent status among all the commercial crops in the world, being the principal raw material for flourishing textile industry. It is an important agricultural commodity providing remunerative income to millions of farmers both in developed and developing countries. So, it is necessary to increase cotton productivity to face the wide gab between the production and consumption of fiber and oils.

In Egypt, cotton (*Gossypium barbadense,* L.) requires approximately seven months from sowing to harvest. During this growing season, fertilization has a major direct impact on cotton growth, and influences both yield and quality properties. Fertilization with macro and micronutrients is the primary limiting factor affecting growth and production under intensive land use for two or more crops per year. Furthermore, recently released varieties have high yielding ability, which largely depends on providing the plants essential nutritional requirements. The nutritional status of plants has a considerable impact on partitioning carbohydrates and dry matter accumulation. Hence, there is a need to supplement cotton crop with macronutrients (Abd El- Shafy, 1999; El-Masri *et al.*, 2005 and Abdel-Aal *et al.*, 2009b) and micronutrients (Dordas, 2006; Abdel-Aal *et al.*, 2009a and Ibrahim *et al.*, 2009) in balanced way for flower production and retention for obtaining higher yield and quality.

Plant growth regulators as retardants or stimulators drew the attention as a practical and efficient way to regulate the flowering and fruiting process and to promote the cotton plants to retain more bolls. In this respect, other researchers found that foliar application of Pix increased number of bolls/plant, boll weight and productivity (El- Shahawy, 1999; El-Shahawy and

Abd El-Malik, 2000 and Prasad and Prakash, 2000) as well as Atonik application increased boll weight (Fernandez, 2007) and number of bolls/ plant and productivity (Djanaguiraman *et al.*, 2005 and Djanaguiraman *et al.*, 2010). Considerable interest also exists in using plant growth regulators for cotton production because of their potential altering of crop growth and boll retention and seed cotton yield. Managing the balance of vegetative and reproductive growth is the essence of managing a cotton crop.

Foliar application is importance method because it offers a rapid and efficient method of supplying nutrients and growth regulators to plants. Currently there is a great interest in foliar application due to the high cost of soil fertilizers and concerns about environmental pollution due to their leaching and run-off from soil.

Therefore, the present study was planned to find out the effect of foliar application of some growth regulators such as Atonik and Pix, macronutrients such as P and K as well as micronutrients such as Zn and B on the abscission, productivity and technological characters of Egyptian cotton (Giza 89 cultivar).

MATERIALS AND METHODS

Two field experiments were conducted at Gemmeiza Agricultural Research Station, Ministry of Agriculture in Gharbia governorate, Egypt, to study the effect of foliar application with some growth regulators, macronutrients and micronutrients on growth, flowering and fruiting, yield and its components, seed chemical composition and fiber technology of Egyptian cotton (*Gossypium barbadense*, L.) during 2005 and 2006 growing seasons.

Each experiment included twenty seven foliar application treatments which were the combination of three factors, i.e. three growth regulators, three macronutrients and three micronutrients.

The three tested factors are as follows:

A- Growth regulators

1- Control : (Tap water)
2- Atonik : "Aromatic nitrophenolic compounds" as plant growth stimulator (at the rate of 1 ml/liter)
3- Pix : "Mepiquat chloride" as plant growth retardant (at the rate of 1 ml /liter)

B- Macronutrients

1- Control : (Tap water)
2- Phosphorus (P): Phosphoric acid "H_3PO_4" (at the rate of 1 ml/liter)
3- Potassium (K): Potassium citrate "$C_6H_5K_3O_7$" (at the rate of 1 g/liter)
- The two tested substances were used as pure laboratory chemicals.

C- Micronutrients

1- Control : (Tap water)
2- Zinc (Zn): Zinc chelate "Zn-EDTA" 14 % Zn (at the rate of 1 g/liter)
3- Boron (B): Boric acid "H_3BO_3" 17.7% B (at the rate of 1 g/liter)

The Treatments were arranged in a split split plot design with three replications. The growth regulators were arranged at random in the main plots, and the macronutrients were assigned at random in the sub-plots, as well as the micronutrients were assigned at random in the sub sub-plots.

The area of each experimental plot was 14 m^2, including five rows, 4 meters along and 0.70 m apart. Seeds of Giza 89 cultivar were sown on 26th and 28th March in the first and second seasons, respectively in hills 25 cm apart on one side of the row. After 35 days from sowing, plants were thinned to two plants/hill, i.e. 48000 plants/fed. The preceding crop was Egyptian clover in both seasons. All experimental plots were soil fertilized with NPK. Calcium superphosphate (15.5% P_2O_5) was added during soil preparation at the rate of 15.5 kg P_2O_5 /fed. Nitrogen fertilizer at a rate of 60 kg N / fed in the form of ammonium nitrate (33.5 % N) in two equal doses, the first dose was added after thinning (before the first irrigation), while the second dose was applied before the second irrigation. Potassium fertilizer was added in the form of potassium sulphate (48 % K_2O) at the rate of 24 kg K_2O /fed. The spraying treatments were done twice at start of flowering and 30 days later using 1.5 and 2.5 liter solutions, respectively for each experimental plot in the experiments. First ginning was done 150 days after sowing at 60 % of open bolls/plant, while the second one was done at 30 days later from the first one. Normal cultural practices of sowing cotton plants were conducted in the usual manner followed by the farmers of the district. Soil mechanical and chemical analyses of the experimental site are presented in Table (1).

Table (1): Soil mechanical and chemical properties of the top experimental site (0-30 cm) during 2005 and 2006 seasons.

Properties / Seasons	Texture class	pH	Ec (dS/m)	O.M. %	Available (ppm)				
					N	P	K	Zn	B
2006	Clay loam	7.8	0.98	1.58	30.22	12.10	270	0.50	0.50
2007	Clay loam	7.5	1.00	1.81	32.10	11.89	276	0.65	0.53

Characters studied :

1- Production and abscission of squares and bolls

Ten plants were marked at random at each plot in the field from the inner rows. The following data was recorded on the main stem and branches per each marked plant.

1- Number of squares (fruiting points) / plant. (during flowering period)
2- Number of setting bolls / plant. (during flowering period)
3- Number of bolls at harvest / plant.

4- Abscission of squares / plant (%) =

$$\frac{\text{Number of squares/plant - Number of setting bolls /plant}}{\text{Number of squares/plant}} \times 100$$

5- Abscission of bolls / plant (%) =

$$\frac{\text{Number of setting bolls/plant - Number of bolls at harvest/plant}}{\text{Number of setting bolls/plant}} \times 100$$

6- Total abscission /plant (%) =

$$\frac{\text{Number of squares/plant - Number of bolls at harvest/plant}}{\text{Number of squares/plant}} \times 100$$

2- Yield and yield components

At first pick, random sample of ten guarded plants was taken and labeled from each plot to determine the following characters.

1- Number of open bolls / plant. 2- Boll weight. (g.).
3- Seed index "100-seed weight" (g.).

4- Earliness (%) = $\frac{\text{Seed cotton yield of the first pick}}{\text{Total seed cotton yield (first+second picks)}} \times 100$

5 - Seed cotton yield / plant. (g) 6 - Seed cotton yield / fed. (kentar)

3- Technological characters of seeds and fiber

Seed samples were collected from each treatment at each replicate to determine the oil and protein percentages in the seeds according to the methods described by A.O.A.C (1975). Samples of lint were collected from each treatment at each replicate to determine the following characters:-

1- Lint % = $\frac{\text{Weight of lint cotton/plant}}{\text{Weight of seed cotton/plant}} \times 100$

2- Fiber fineness (micronaire reading): it was determined by Micronaire instrument as reported by A.S.T.M. (1967).
3- Fiber strength (Pressley index): it was determined by Pressley instrument as reported by A.S.T.M. (1967).

All obtained data during the two seasons in this study were analyzed according the methods described by Snedecor and Cochran (1967). The differences among the means of different treatments were tested using the Least Significant Differences (LSD) at probability 5%.

RESULTS AND DISCUSSION

A- Effect of growth regulators

A. 1- Production and abscission of squares and bolls:

The data presented in Table (2) included the mean values of numbers of squares, setting bolls and bolls/ plant as well as squares, bolls and total abscission percentages as affected by foliar application of two tested growth regulators, i.e. Atonik (stimulator) and Pix (retardant) as compared with untreated plants (control). The data show that Atonik and Pix application have the greatest number of squares (fruiting points) and number of setting bolls/ plant but without significant difference between them. On the other hand, untreated plants recorded the lowest mean values in both seasons for such traits. With regard to the number of bolls / plant, results show that the application of Pix produced the highest value in both seasons followed by Atonik treatment. The beneficial effect of Pix and Atonik in this respect may be related to their roles on increasing the photosynthesis activity and the metabolic translocation (Zhao and Oosterhuis, 1999 and Djanaguiraman *et al.*, 2005). In this regard, other researchers reported the importance of Pix for enhancing number of flowers/plant (Biles and Cothren, 2001) number of setting bolls/plant (Abdel – Al, 1998) and number of bolls/plant (El-Tabbakh, 2002 and Prasad and Siddique, 2004) compared to untreated cotton plants.

Table (2): Effect of foliar application with some growth regulators on production and abscission of squares and bolls /plant during 2005 and 2006 seasons.

Characters Growth regulators	No. of squares /plant	No. of setting bolls /plant	No. of bolls /plant	Abscission (%)		
				squares / plant	bolls / plant	total/ plant
2005 season						
Control	35.64	26.13	20.06	26.63	23.21	43.69
Atonik	37.09	27.10	22.53	26.90	16.80	39.23
Pix	36.79	27.27	23.22	25.88	14.73	36.86
LSD 5%	0.62	0.44	0.39	NS	2.75	2.00
2006 season						
Control	35.80	26.33	20.40	26.39	22.50	42.99
Atonik	36.98	26.67	22.18	27.82	16.58	40.02
Pix	36.94	26.59	23.67	27.92	10.76	35.90
LSD 5%	0.59	NS	0.74	NS	4.91	1.78

With regard to the abscission, it can be noticed from the same Table that bolls and total abscission percentages were significantly decreased when the plants were sprayed with Pix and Atonik in the two seasons. Meanwhile, the square abscission was not significantly affect by foliar application with the two tested growth regulators in the two seasons. As an average of the two seasons, Pix application reduced 44.24 % of bolls abscission and 16.06 % of total abscission compared to untreated plants. Thus, it could be concluded that there is a positive relationship between abscission percentage and growth regulators under this study which are useful for increasing the number of setting and total bolls/plant. In this respect, applications of mepiquat chloride (Pix) at peak square to boll setting stages helped form a suitable plant type for high photosynthetic activity to improve the nutritional regimes of squares and bolls (Wu *et al.*, 1994). Increased photosynthesis increases flowering and boll retention (Kler *et al.*, 1989). This finding seems to be in confirmation with that obtained by others who concluded that spraying cotton plants with Pix decrease the squares abscission (Abdel – Al, 1998) and bolls abscission (El- Shahawy, 1999 and El-Shahawy and Abd El-Malik, 2000) compared to untreated plants.

A. 2- Yield and its components:

The data in Table (3) show the effect of foliar application with the tested growth regulators (control, Atonik and Pix) on cotton yield and its components (number of open bolls /plant, boll weight, seed index, earliness % and seed cotton yield per plant and fed). The results reveal that the foliar application of Pix significantly increased number of open bolls / plant, boll weight, seed index and earliness percentage followed by Atonik application in a descending order as compared with untreated in both seasons. The increases due to Pix application might be attributed to that plants became smaller leaves and more thicker due to an increased layer of cells that develops, The thicker leaves and smaller cells of cotton plants treated with Pix give a more concentrated dark-green color (Hake *et al.*, 1992), consequently improved leaf photosynthetic rate (Zhao and Oosterhuis, 1999) and/or the decrease in the boll abscission percentage as presented in Table (2). Increasing earliness may be related to Pix effect on biomass partitioning (inhibiting growth of branches and stems height, expanding leaves and extending stem internodes and petioles), which led to the development of a more compact canopy structure (Fernandez *et al.*, 1991) In this respect, El-Shahawy (1999) and El-Shahawy and Abd El-Malik (2000) found that foliar application of Pix increased number of open bolls / plant, boll weight, seed index and earliness percentage compared to untreated cotton plants.

With regard to seed cotton yield per plant and fed. The data show that significant increases in seed cotton yield per plant and fed were obtained by the application of two tested growth regulators more than the control treatment in favour of Pix in the two seasons. The highest increase in seed cotton yield by growth regulators application might be directly attributed to the increase in yield components (number of open bolls /plant and boll weight). In this concern, Khan (1996) stated that mepiquat chloride could be used for maintaining internal hormonal balance and an efficient sink source relationship that enhances crop productivity. Moreover, many investigators found that seed cotton yield per plant and unit area were increased by foliar application of Pix (Sawan *et al.*, 2009) and Atonik (Abdel -Al *et al.*, 1998) compared to untreated cotton plants.

Table (3): Effect of foliar application with some growth regulators on yield and its components during 2005 and 2006 seasons.

Characters Growth regulators	No. of open bolls /plant	Boll weight (g.)	Seed index (g.)	Earliness (%)	Seed cotton yield/plant (g.)	Seed cotton yield/fed (kentar)
2005 season						
Control	17.86	1.78	9.89	59.80	31.79	9.30
Atonik	20.37	1.78	10.25	61.73	36.80	11.19
Pix	21.34	1.98	10.36	62.21	42.26	12.26
LSD 5%	0.23	0.04	0.06	0.57	0.76	0.20
2006 season						
Control	18.55	1.73	9.87	59.81	31.58	9.90
Atonik	20.40	1.79	10.04	61.79	36.77	11.63
Pix	21.09	1.96	10.18	62.78	41.84	12.14
LSD 5%	0.25	0.03	0.07	0.28	0.38	0.07

A.3- Technological characters of seeds and fiber:

It is clear from the Table (4) that the sprayed plants with the two tested growth regulators (Atonik and Pix) had significant increases in the technological characters of seeds studied (protein and oil percentages) compared to the unsprayed plants in both seasons. Moreover, it can be noticed that the foliar application with Pix produced protein and oil percentages higher than that obtained by Atonik application in the two seasons. These results could be attributed to the role of Pix in increase of total photoassimilates and translocated assimilates to the sink as previous reported. These findings are in harmony with those obtained by Sawan *et al.* (1991) who mentioned that foliar application of Pix at a rate of 10 ppm increased the protein and oil percentages in cotton seeds compared to untreated plants.

From the data in same Table, it is clear that the application of the two tested growth regulators led to an increase in all technological characters studied of fibers (lint %, fiber fineness and fiber strength) compared to that obtained from untreated plants in both seasons. Moreover, it can be noticed that the highest values of these characters were obtained by plants treated with Pix followed by Atonik application. In this concern, Similar results were reported by other researchers who found that foliar application with Pix increased the technological characters such as lint % (El- Shahawy, 1999 and Huang *et al.*, 2000), micronaire reading (El- Bagoury *et al.*, 2008), fiber strength (Prasad and Prakash, 2000) compared to untreated cotton plants.

Table (4): Effect of foliar application with some growth regulators on technological characters of seeds and fiber during 2005 and 2006 seasons.

Characters / Growth regulators	Seed		Fiber		
	Oil (%)	Protein (%)	Lint (%)	Fiber fineness (micronaire reading)	Fiber strength (Pressley index)
2005 season					
Control	19.05	19.46	36.85	4.20	9.41
Atonik	20.88	20.79	38.37	4.44	10.15
Pix	21.41	21.55	39.08	4.55	10.40
LSD 5%	0.12	0.24	0.17	0.02	0.02
2006 season					
Control	19.27	19.54	36.86	4.28	9.44
Atonik	20.96	21.37	38.29	4.52	10.06
Pix	21.52	21.55	39.12	4.62	10.46
LSD 5%	0.08	0.05	0.07	0.03	0.07

B- Effect of macronutrients

B.1- Production and abscission of squares and bolls:

Significant differences among the two tested macronutrients, i.e. phosphorus (P) and potassium (K) compared to untreated plants (control) were obtained for squares abscission in the first season and number of squares (fruiting points) /plant in the second season and numbers of setting bolls and bolls/plant as well as bolls and total abscission percentages in the two seasons as shown in Table (5). It is evident from the data that K application produced the highest numbers of squares (in the second season) as well as setting bolls and bolls/ plant (in the two seasons) followed by P treatment without significant differences among them in the two seasons for the abovementioned characters. On the other hand, the untreated plants produced the lowest mean values of these characters. This finding seems to be in confirmation with that obtained by others investigators who concluded that spraying cotton plants with K at the rate of 1 or 2% (El- Masri *et al.*, 2005) and P at a rate of 4% (Abd El- Shafy, 1999) increased number of flowers and bolls/plant compared to untreated plants.

The results in the same Table show that the application of K significantly reduced the abscission percentage of squares in the first season, while abscission bolls was significantly decreased with application of P (in the first season) and by K (in the second one). With regard to total abscission, the application of the two tested macronutrients reduced the abscission percentage compared to the untreated plants in both seasons. In this regard, Guinn (1985) reported that fruit shedding and boll retention were primarily related to nutrition management, where the nutritional stress increases boll shedding through an increase in ethylene production. These results may be due to the fact that the hormonal balance of plant probably changed with nutritional intensity. Thus, the promoting effect of P and K on flower production and decreasing the abscission of bolls and this was reflected consequently on increasing the number of setting bolls / plant and its productivity. This finding seems to be in confirmation with that obtained by others investigators who concluded that spraying cotton plants with K (El-Shazly *et al.*, 2003 and El- Masri *et al.*, 2005) and P (Abd El- Shafy, 1999 and Ibrahim *et al.*, 2009) reduced boll abscission compared to untreated plants.

Table (5): Effect of foliar application with some macronutrients on production and abscission of squares and bolls/plant during 2005 and 2006 seasons.

Characters / Macronutrients	No. of squares /plant	No. of setting bolls /plant	No. of bolls /plant	Abscission (%)		
				squares / plant	bolls / plant	total / plant
2005 season						
Control	36.38	26.38	21.37	27.46	18.96	41.29
P	36.43	26. 67	22.10	26.75	17.11	39.32
K	36.71	27.46	22.35	25.20	18.68	39.17
LSD 5%	NS	0.31	0.48	1.29	1.08	1.47
2006 season						
Control	36.37	26.24	21.51	27.76	17.93	40.91
P	36.29	26.79	22.29	26.13	16.80	38.56
K	37.07	26.56	22.46	28.25	15.10	39.44
LSD 5%	0.55	0.24	0.38	NS	2.02	0.87

B. 2- Yield and its components:

The results in Table (6) show significant effect of the two tested macronutrients (P and K) on yield components compared to control treatment in both seasons. Application of macronutrients, i.e. P and K raised the number of open bolls/plant, boll weight, seed index and earliness percentage more than the control in favour of K element mostly in both seasons. The superiority of K application might be due to the effect of such element on mobilization of photosynthates, which would directly influence boll weight and increase seed index (Cakmak *et al.*, 1994). Moreover, many researchers found increases in the number of open bolls/plant, boll weight, seed index and earliness percentage due to sprayed cotton plants with macronutrients such as K (El- Masri *et al.*, 2005 and Sawan *et al.*, 2006) and P (Abd El- Shafy, 1999 and Sawan *et al.*, 2008) compared to untreated plants.

It could be concluded from the data presented in Table (6) that spraying cotton plants with macronutrients, i.e. P and K significantly increased seed cotton yield per plant and fed in favour of K in both seasons. The superiority of seed cotton yield obtained due to the application of macronutrients was the logical resultant of the increase in the yield components. Many researchers found an increase in the seed cotton yield per plant and unit area due to the foliar application of some macronutrients such as K (El- Masri *et al.*, 2005 and Sawan *et al.*, 2009) and P (Abd El- Shafy, 1999 and Sawan *et al.*, 2008) compared to untreated plants.

Table (6): Effect of foliar application with some macronutrients on yield and its components during 2005 and 2006 seasons.

Characters / Macronutrients	No. of open bolls /plant	Boll weight (g.)	Seed index (g.)	Earliness (%)	Seed cotton yield/plant (g.)	Seed cotton yield/fed (kentar)
2005 season						
Control	18.92	1.82	10.08	60.46	35.36	10.35
P	20.00	1.86	10.14	61.27	37.27	10.91
K	20.64	1.84	10.27	62.01	38.22	11.49
LSD 5%	0.22	0.03	0.02	0.22	0.35	0.16
2006 season						
Control	19.21	1.81	9.96	60.72	35.25	10.63
P	20.02	1.85	10.03	61.30	37.13	11.34
K	20.81	1.83	10.09	62.35	37.80	11.70
LSD 5%	0.27	0.02	0.05	0.17	0.17	0.07

B.3- Technological characters of seeds and fiber:

It can be noticed from Table (7) that the application of K seemed to be the most effective treatments for increasing the tested technological characters studied of seeds (protein and oil percentages) followed by P in the two seasons. The stimulative effect of K might be due to that K has been implicated in over 60 enzymatic reactions, which are involved in many processes in the plant such as photosynthesis, respiration, carbohydrate metabolism, translocation and protein synthesis (Dong *et al.*, 2004 and Pettigrew, 2008). In this concern, similar results were reported by other investigators who found that seed protein and oil percentages were increased by the foliar application of K at the rate of 1 g potassium citrate /liter as mentioned by Ibrahim *et al.* (2009) and P at a rate of 4% calcium superphosphate solution as reported by Abd El- Shafy (1999) compared to untreated cotton plants.

It is clear from the same Table that foliar application of K recorded the highest values of all tested fiber technological characters (lint %, fiber fineness and fiber strength) followed by P application in a descending order during the both seasons. These results may be attributed to that K plays an important role in the maintenance of osmotic potential and water uptake during fiber development, and a shortage will result in poorer fiber quality (Oosterhuis, 2001). Similar results were obtained by other investigators who found that foliar application of potassium increased lint percentage (Ibrahim *et al.*, 2009), micronaire reading and fiber strength (Sharma and Sundar, 2007) of cotton compared to untreated plants.

Table (7): Effect of foliar application with some macronutrients on technological characters of seeds and fiber during 2005 and 2006 seasons.

Characters / Macronutrients	Seed		Fiber		
	Oil (%)	Protein (%)	Lint (%)	Fiber fineness (micronaire reading)	Fiber strength (Pressley index)
2005 season					
Control	19.90	20.15	37.65	4.26	9.70
P	20.62	20.56	38.10	4.38	10.08
K	20.82	21.10	38.55	4.54	10.18
LSD 5%	0.08	0.16	0.06	0.03	0.05
2006 season					
Control	19.10	20.53	37.62	4.37	9.72
P	20.80	20.54	38.07	4.46	10.07
K	21.04	21.38	38.58	4.60	10.16
LSD 5%	0.09	0.09	0.05	0.03	0.02

C- Effect of micronutrients

C.1- Production and abscission of squares and bolls:

Significant differences were detected among the tested micronutrients, i.e. zinc (Zn) and boron (B) compared to untreated plants (control) for total number of squares (fruiting points) and total abscission percentage /plant (in the first season) and number of bolls /plant and bolls abscission percentage /plant (in the two seasons) as shown in Table (8). On the other hand, insignificant differences between the tested micronutrients for number of setting bolls and percentage of squares abscission in the two seasons. Moreover, the data show that the foliar application of B produced the greatest number of squares/plant and bolls /plant followed by Zn application, while the unsprayed plants recorded the lowest ones compared to the other treatments. The enhancing of numbers of squares/plant and bolls /plant due to boron application may be attributed to its act as activator of many enzymes which stimulates plant growth and flowers formation (Blevins and Lukaszewski, 1998). This finding seems to be in confirmation with that obtained by others investigators who found that spraying cotton plants with B increased number of flowers (El- Masri *et al.*, 2005), number of setting bolls (El- Shazly *et al.*, 2003) and number of bolls/plant (Dordas, 2006) compared to untreated plants.

Table (8): Effect of foliar application with some micronutrients on production and abscission of squares and bolls/plant during 2005 and 2006 seasons.

Characters / Micronutrients	No. of squares /plant	No. of setting bolls /plant	No. of bolls /plant	Abscission (%)		
				squares / plant	bolls / plant	total/ plant
2005 season						
Control	36.22	26.82	21.28	25.92	20.68	41.28
Zn	36.59	26.87	22.01	26.57	18.06	39.88
B	36.70	26.81	22.52	26.91	16.01	38.63
LSD 5%	0.39	NS	0.55	NS	2.55	1.75
2006 season						
Control	36.42	26.71	21.95	26.61	17.80	39.73
Zn	36.51	26.71	21.90	26.80	17.94	40.01
B	36.79	26.17	22.39	28.72	14.10	39.17
LSD 5%	NS	NS	0.48	NS	2.96	NS

Decreases in bolls and total abscission percentages were observed by foliar application of B which had the lower percentages of abscission of bolls and total abscission per plant than untreated plants. As an average of the two seasons, the foliar application of B reduced 21.70 % of bolls abscission and 3.92 % of total abscission compared to untreated plants. The decrease in fruit shedding due to B application may be due to the beneficial effects of B element in increasing relative fruitfullness due to enhanced translocation of photosynthates leaf to fruit resulting in fruit shedding. In this regard, similar results were obtained by other researchers who found that boll abscission percentage was decreased by foliar application of B as reported by El- Shazly *et al.* (2003) and El- Masri *et al.* (2005) compared to untreated cotton plants.

C. 2- Yield and its components:

The data presented in Table (9) included the mean values of yield and its components as affected by foliar application of two tested micronutrients (Zn and B) as compared with untreated plants (control). The data indicate that the foliar application of the two tested micronutrients caused increases in the number of open bolls/plant, seed index and earliness percentage more than untreated plants in both seasons. However, boll weight was insignificantly affected in the two seasons. Yield components (number of open bolls/plant, seed index and earliness percentage) tend to be higher in plants sprayed with B followed by Zn treatment. The superiority of yield components due to the application of B and Zn treatments might be due to the increase the amount of metabolites synthesized by different vegetative growth of the plants which translocation from leaves to fruits and increase seed development. In this concern, similar results were obtained by other researchers who found that foliar application of B increased the number of open bolls per plant (El- Masri *et al.*, 2005 and Gormus, 2006), seed index (Ibrahim *et al.*, 2009) and earliness % (El- Shazly *et al.*, 2003 and El- Masri *et al.,* 2005) as compared with untreated cotton plants.

It is evident from the same Table that the two tested micronutrients caused remarkable increases in seed cotton yield per plant and fed as compared with untreated plants. Moreover, it can be reveal that the foliar application of B seemed to be the most effective treatment for producing high seed cotton yield more than the control treatment. Meanwhile, the application of Zn had the second ranking. This increase in the seed cotton yield may be related to increase in the yield components. In this concern, similar results were reported by other investigators who found that seed cotton yield per plant and unit area were increased by the foliar application of B (El- Masri *et al.*, 2005) and Zn (El- Masri, 2005 and Sawan *et al.,* 2008) compared to untreated cotton plants.

Table (9): Effect of foliar application with some micronutrients on yield and its components during 2005 and 2006 seasons.

Characters / Micronutrients	No. of open bolls /plant	Boll weight (g.)	Seed index (g.)	Earliness (%)	Seed cotton yield/plant (g.)	Seed cotton yield/fed (kentar)
2005 season						
Control	19.13	1.87	10.10	60.90	36.38	10.54
Zn	20.01	1.84	10.18	61.26	36.92	10.93
B	20.42	1.83	10.22	61.58	37.54	11.29
LSD 5%	0.19	NS	0.04	0.23	0.40	0.14
2006 season						
Control	19.70	1.83	9.97	61.06	36.13	10.90
Zn	19.91	1.84	10.03	61.54	37.00	11.24
B	20.43	1.81	10.08	61.78	37.05	11.52
LSD 5%	0.24	NS	0.03	0.24	0.34	0.05

C.3- Technological characters of seeds and fiber:

The data in Table (10) show that the plants sprayed with B possessed the highest values of the technological characters studied in the seeds (protein and oil percentages) followed by Zn in a descending order. These increments in protein and oil percentages by foliar application of micronutrients may be due to the that micronutrients are essential for the activity of various types of enzymes including dehydrogenase, aldolases and transphosphorylases as well as RNA and DNA polymerase, which are associated with carbohydrate metabolism and protein synthesis (Valley and Wacker, 1970). In this respect, similar results were obtained by Ibrahim *et al.* (2009) who found that foliar application of micronutrients such as B (172 ppm) and Zn (140 ppm) enhanced seed chemical composition (oil and protein percentages) compared to untreated cotton plants.

The data in the same Table indicate that foliar application of the two tested micronutrients caused stimulative effect on technological characters of fiber studied (lint %, fiber fineness and fiber strength) in the two seasons. Spraying B was the most beneficial effect in this respect followed by Zn. However, the lowest ones were recorded from untreated plants in the two seasons. The stimulative effect of B on technological characters of cotton may be attributed to that B element is required to support the process of growth and development of cotton fibers in the boll (Stewart, 1986) and fiber quality (Heitholt, 1994). These results are in accordance with other investigators who found that foliar application of B increased lint percentage (Dordas, 2006), micronaire reading (Ahmad *et al.*, 2009) and fiber strength (Ibrahim *et al.*, 2009) of cotton compared to untreated plants.

Table (10): Effect of foliar application with some micronutrients on technological characters of seeds and fiber during 2005 and 2006 seasons.

Characters / Micronutrients	Seed		Fiber		
	Oil (%)	Protein (%)	Lint (%)	Fiber fineness (micronaire reading)	Fiber strength (Pressley index)
2005 season					
Control	20.23	20.31	37.88	4.24	9.78
Zn	20.42	20.63	38.12	4.40	10.01
B	20.69	20.87	38.30	4.54	10.17
LSD 5%	0.11	0.12	0.09	0.02	0.03
2006 season					
Control	20.23	20.55	37.82	4.33	9.80
Zn	20.57	20.83	38.11	4.50	10.03
B	20.94	21.08	38.34	4.60	10.13
LSD 5%	0.10	0.08	0.06	0.04	0.03

D- Effect of the interaction

D.1- Effect of the interactions between growth regulators and foliar application of macronutrients (A x B).

The interaction between the tested growth regulators and foliar application of macronutrients was significant for each number of open bolls /plant, earliness % and seed cotton yield per plant and fed in the two seasons as shown in Table (11). However, the rest characters studied were not significantly affected by such interaction, therefore, the data were excluded.

Data of the interaction between the tested growth regulators and macronutrients in Table (11) indicate that the highest mean values of the number of open bolls (21.82 and 21.78), seed index (10.44 and 10.25 g.) and earliness percentage (63.26 and 63.58%) in the first and second seasons, respectively were obtained when the plants were sprayed with Pix combined with K application. On the other hand, the lowest mean values of open bolls (16.70 and 17.17), seed index (9.83 and 9.78 g.) and earliness percentage (59.00 and 58.57%) in the first and second seasons, respectively were obtained from untreated plants with neither growth regulators nor macronutrients.

The data in the same Table, clear that the greatest seed cotton yield per plant and fed were produced when the plants were sprayed with Pix combined with K application in the two seasons. Moreover, it can be noticed

Table (11): Effect of the interaction between the tested growth regulators and macronutrients application on yield and its components during 2005 and 2006 seasons.

Macro. / Growth regulators	Number of open bolls /plant			Seed index (g.)			Earliness (%)			Seed cotton yield/plant (g.)			Seed cotton yield/fed (kentar)		
	Control	P	K	Control	P	K	Control	P	K	Control	P	K	Control	P	K
2005 season															
Control	16.70	18.23	18.64	9.83	9.82	10.02	59.00	59.89	60.50	31.20	31.87	32.30	8.95	9.32	9.65
Atonik	18.83	20.80	21.47	10.13	10.26	10.35	61.23	61.69	62.28	34.03	37.67	38.70	10.22	11.50	11.85
Pix	21.23	20.97	21.82	10.29	10.35	10.44	61.13	62.22	63.26	40.83	42.27	43.67	11.89	11.92	12.96
LSD 5%	1.39			0.4			1.38			1.60			0.28		
2006 season															
Control	17.17	18.66	19.83	9.78	9.90	9.92	58.57	59.83	61.04	31.15	31.68	31.90	9.42	9.95	10.33
Atonik	19.83	20.56	20.81	9.92	10.07	10.11	60.99	61.93	62.43	34.04	37.87	38.40	11.05	11.79	12.06
Pix	20.64	20.85	21.78	10.17	10.11	10.25	62.63	62.12	63.58	40.57	41.85	43.10	11.43	12.27	12.72
LSD 5%	1.47			0.8			1.30			1.90			0.13		

that such treatment caused an increase in seed cotton yield/plant amounted to 39.97 and 38.36 % and in seed cotton yield/fed amounted to 44.80 and 35.03 % more than the unsprayed plants in the first and second seasons, respectively. However, the lowest seed cotton yield per plant and fed were obtained from the unsprayed plants with neither growth regulators nor macronutrients.

D.2- Effect of the interactions between growth regulators and foliar application of micronutrients (A x C).

There are significant interaction between the tested growth regulators and micronutrients for number of open bolls, seed index, earliness % and seed cotton yield per plant and fed in the two seasons as shown in Table (12). Nevertheless, the other characters studied were not significantly affected by such interaction. Therefore, the data were excluded.

Data in the Table (12) show that the plants exhibited the highest values of number of open bolls, seed index and earliness percentage when they were sprayed with Pix combined with B in the two growing seasons. However, the plants which were not treated with any growth regulators and/or micronutrients produced the lowest values in this respect.

Result in the same Table, indicate that the plants sprayed with Pix combined with B produced the highest values of seed cotton yield per plant and fed in the two seasons compared to the other tested interaction treatments. Moreover, it can be noticed that such treatment caused an increase in seed cotton yield/plant amounted to 36.39 and 35.72 % as well as seed cotton yield/fed amounted to 41.82 and 30.18 % more than the unsprayed plants in the first and second seasons, respectively. However, the lowest values of these traits were obtained by the untreated plants with any growth regulators and micronutrients.

D.3- Effect of the interactions between foliar application of macronutrients and micronutrients (B x C).

The interaction between the tested macronutrients and micronutrients had significant effect on yield and its components (number of open bolls/plant, seed index, earliness % and seed cotton yield per plant and fed) in the two seasons as shown in Table (13). However, the other characters studied were not significantly affected by such interaction, therefore, the data were neglected.

The data in the Table (13) show that the number of open bolls /plant, seed index and earliness % had the maximum mean values when the plants were sprayed with K and B. However, the plants which were unsprayed with any macronutrients or micronutrients produced the lowest mean values of these traits during two seasons.

Table (12): Effect of the interaction between the tested growth regulators and micronutrients application on yield and its components during 2005 and 2006 seasons.

Micro. Growth regulators	Number of open bolls /plant			Seed index (g.)			Earliness (%)			Seed cotton yield/plant (g.)			Seed cotton yield/fed (kentar)		
	Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B
2005 season															
Control	17.47	17.90	18.20	9.84	9.89	9.93	59.20	59.59	60.60	31.60	31.77	32.00	9.11	9.31	9.50
Atonik	19.27	20.83	21.00	10.19	10.26	10.28	61.60	61.96	61.64	36.03	36.83	37.53	10.88	11.26	11.43
Pix	20.65	21.30	22.07	10.28	10.38	10.44	61.89	62.22	62.50	41.50	42.17	43.10	11.63	12.22	12.92
LSD 5%	0.40			0.27			1.40			1.69			0.25		
2006 season															
Control	18.62	18.34	18.70	9.82	9.86	9.91	59.34	59.83	60.27	31.13	31.93	31.66	9.71	9.90	10.08
Atonik	20.09	20.59	20.52	9.97	10.05	10.08	61.56	62.07	61.73	36.03	37.04	37.23	11.33	11.73	11.84
Pix	20.40	20.79	22.08	10.12	10.18	10.23	62.29	62.71	63.33	41.23	42.03	42.25	11.67	12.10	12.64
LSD 5%	0.46			0.26			1.46			1.60			0.29		

Table (13): Effect of the interaction between the tested macronutrients and micronutrients application on yield and its components during 2005 and 2006 seasons.

Micro. / Macro.	Number of open bolls /plant			Seed index (g.)			Earliness (%)			Seed cotton yield/plant (g.)			Seed cotton yield/fed (kentar)		
	Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B
2005 season															
Control	17.93	19.37	19.47	9.97	10.13	10.15	60.33	60.67	60.37	34.87	35.13	36.07	9.94	10.39	10.73
P	19.43	20.17	20.40	10.11	10.12	10.21	60.87	61.28	61.66	36.90	37.23	37.67	10.70	10.85	11.19
K	20.02	20.50	21.40	10.24	10.28	10.30	61.49	61.82	62.72	37.37	38.40	38.90	10.98	11.54	11.93
LSD 5%	0.40			0.27			1.40			1.69			0.25		
2006 season															
Control	18.82	19.22	19.60	9.91	9.98	9.98	60.46	60.90	60.83	34.50	35.51	35.75	10.32	10.60	10.98
P	19.77	20.16	20.14	10.01	10.02	10.06	61.06	61.33	61.50	36.83	37.43	37.13	11.07	11.43	11.51
K	20.52	20.34	21.55	10.00	10.09	10.19	61.68	62.38	63.00	37.07	38.07	38.27	11.33	11.70	12.08
LSD 5%	0.46			0.26			1.46			1.60			0.29		

It is interesting to note from the same Table that the most pronounced interaction between macronutrients and micronutrients for increasing seed cotton yield per plant and fed were happened when the plants were sprayed with K combined with B in the two seasons. Moreover, it can be noticed that such treatment caused an increase in seed cotton yield/plant by 11.56 and 10.93 % and in seed cotton yield/fed by 20.02 and 17.05 % more than the unsprayed plants in the first and second seasons, respectively. However, the lowest values were obtained when the plants were untreated with any tested macronutrients or micronutrients.

D-4. Effect of the interactions among growth regulators, macronutrients and micronutrients (A x B x C).

The second order interaction among the tested growth regulators, macronutrients and micronutrients was significant for yield and its components (number of open bolls/plant, seed index, earliness % and seed cotton yield per plant and fed) in the two seasons as shown in Table (14). However, the other characters studied were not significantly affected by the second order interaction, therefore, the data were not presented.

The data presented in the same Table indicate that the highest number of open bolls/plant, seed index and earliness % were obtained when the plants were sprayed with Pix combined with each of K and B for these traits during the two seasons. On the other side, the lowest values for these traits were recorded by untreated plants with any foliar application.

In addition, the values of seed cotton yield per plant and fed were significantly and positively responded to foliar application of Pix combined with K and B which were the most effective interaction treatment for producing the highest values in the two seasons. Such treatment caused an increase in seed cotton yield/plant amounted to 45.48 and 44.59 % and in seed cotton yield/fed amounted to 60.80 and 46.49 % more than the unsprayed plants in the first and second seasons, respectively.

Table (14): Effect of the interaction among the tested growth regulators, macronutrients and micronutrients application yield and its components during 2005 and 2006 seasons .

Micro. Growth reg. + Macro.		Number of open bolls /plant			Seed index (g.)			Earliness (%)			Seed cotton yield/plant (g.)			Seed cotton yield/fed (kentar)		
		Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B	Control	Zn	B
2005 season																
Control	Control	16.10	17.00	17.00	9.70	9.90	9.88	58.50	59.00	59.50	31.00	31.10	31.50	8.52	9.12	9.20
	P	18.00	18.20	18.50	9.85	9.70	9.90	59.00	59.67	61.00	31.70	31.90	32.00	9.30	9.25	9.40
	K	18.30	18.50	19.11	9.97	10.07	10.02	60.10	60.10	61.30	32.10	32.30	32.50	9.50	9.56	9.90
Atonik	Control	16.70	19.90	19.90	10.00	10.20	10.18	61.50	61.70	60.50	33.10	34.00	35.00	10.10	10.17	10.40
	P	20.00	21.30	21.10	10.23	10.25	10.30	61.30	61.70	62.07	37.00	37.50	38.50	11.30	11.50	11.70
	K	21.10	21.30	22.00	10.35	10.33	10.37	62.00	62.47	62.37	38.00	39.00	39.10	11.25	12.10	12.20
Pix	Control	21.00	21.20	21.50	10.20	10.30	10.38	61.00	61.30	61.10	40.50	40.30	41.70	11.20	11.88	12.60
	P	20.30	21.00	21.60	10.23	10.40	10.42	62.30	62.47	61.90	42.00	42.30	42.50	11.50	11.80	12.47
	K	20.66	21.70	23.10	10.40	10.43	10.50	62.38	62.90	64.50	42.00	43.90	45.10	12.20	12.97	13.70
LSD 5%		1.57			0.22			1.70			2.20			1.43		
2006 season																
Control	Control	16.31	17.70	17.50	9.68	9.80	9.85	58.00	58.50	59.20	30.50	31.60	31.34	9.25	9.40	9.60
	P	18.00	18.87	19.10	9.90	9.88	9.93	59.00	60.00	60.50	31.70	32.20	31.14	9.70	10.00	10.15
	K	21.56	18.46	19.60	9.89	9.90	9.96	61.03	61.00	61.10	31.20	32.00	32.50	10.18	10.30	10.60
Atonik	Control	19.95	19.80	19.75	9.89	9.93	9.95	60.97	61.70	60.30	33.00	34.03	35.10	10.70	11.10	11.35
	P	21.17	20.40	20.10	10.02	10.10	10.10	61.70	62.00	62.10	37.10	38.10	38.40	11.40	11.98	11.98
	K	19.15	21.67	21.70	10.02	10.12	10.20	62.00	62.60	62.80	38.00	39.00	38.20	11.88	12.10	12.20
Pix	Control	20.20	20.17	21.56	10.15	10.20	10.15	62.40	62.50	63.00	40.00	40.90	40.80	11.00	11.30	11.98
	P	20.13	21.20	21.22	10.10	10.08	10.15	62.47	62.00	61.90	41.70	42.00	41.85	12.10	12.30	12.40
	K	20.87	21.00	23.46	10.11	10.25	10.40	62.00	63.63	65.10	42.00	43.20	44.10	11.92	12.70	13.55
LSD 5%		1.70			0.20			1.80			2.04			1.16		

Conclusion

Finally on the light of the obtained results, it could be concluded that the foliar application of Pix (1 ml/liter) combined with K (1g/liter) and B (1g/liter) twice at start of flowering and 30 days later may be recommended treatment for promoting the boll retention bolls which led to an encouragement the seed formation owning to increasing the yield and its components of cotton (Giza 89 cv.).

REFERENCES

Abdel-Aal, S. M., M. E. Ibrahim and Amany A. M. El- Ashmony (2009 a). Studies on the effect of application methods of some micronutrients on germination, flowering, productivity and quality of Egyptian cotton. 1st Nile Delta Conf. on Export Crops, Fac. of Agri., Minufiya Univ.: 105-119.

Abdel-Aal, S. M., M. E. Ibrahim and Amany A. M. El- Ashmony (2009 b). Effect of application methods of some macronutrients on germination, flowering, productivity and quality of Egyptian cotton (Giza 89 cultivar). Minufiya J. Agric. Res., 34 (2): 591-605 "http://www.mujar.net".

Abdel-Al, M. H. (1998). Response of Giza 85 cotton cultivar to the growth regulators Pix and Atonik. Egypt. J. Agric. Res., 76 (3): 1173-1180.

Abdel –Al, M. H., M. S. Ismail and Fatma M. Ahmed (1998). Response of cotton plants to some polyphenols application. Egypt. J. Agric. Res., 78 (2): 735-744.

Abd El- Shafy, N.A. (1999). Effect of phosphorus foliar application on some Egyptian cotton cultivars. J. Agric. Sci. Mansoura Univ., 24 (7): 3253-3264.

Ahmad, S., L.H. Akhtar, S. Ahmad, N. Iqbal and M. Nasim (2009). Cotton (*Gossypium hirsutum* L.) varieties responded differently to foliar applied boron in terms of quality and yield. Soil & Environ, 28 (1): 88-92 .

A.O.A.C. (1975). Association of Official Analytical Chemists. Official Methods of analysis 12th Ed. Washington, D.C., USA.

A.S.T.M. (1967). American Society for Testing and Materials. Part 25, D. 1448 and D. 1578, USA.

Biles, S. P. and J. T. Cothren (2001). Flowering and yield response of cotton to application of mepiquat chloride and PGR-IV. Crop Science, 41 (6): 1834-1837.

Blevins, D.G. and K.M. Lukaszewski (1998). Boron in plant structure and function. Ann. Rev. Plant Physiol. Mol. Biol., 49: 481–500 .

Cakmak, I., C. Hengeler and H. Marschner (1994). Partitioning of shoot and root dry matter and carbohydrates in bean plants suffering from phosphorus, potassium and magnesium deficiency. J. Exp. Bot., 45: 1245-1250 .

Djanaguiraman, M., J. A. Sheeba, D. D. Devi and U. Bangarusamy (2005). Response of cotton to Atonik and TIBA for growth, enzymes and yield. J. Biological Sciences, 5 (2): 158-162.

Djanaguiraman, M., J. A. Sheeba, D.D. Devi, U. Bangarusamy and P.V.V. Prasad (2010). Nitrophenolates spray can alter boll abscission rate in cotton through enhanced peroxidase activity and increased ascorbate and phenolics levels. J. Plant Physiology, 167: 1-9.

Dong, H., W. Tang, Z. Li and D. Zhang (2004). On potassium deficiency in cotton-disorder, cause and tissue diagnosis. Agric. Conspect. Sci., 69 (2-3): 77-85 .

Dordas, C. (2006). Foliar boron application affects lint and seed yield and improves seed quality of cotton grown on calcareous soils. Nutrient Cycling in Agroecosystems, 76 (1): 19-28.

El- Bagoury, Olfet H., A. M. El- Marakby, E.A. Makram and M.A. Emara (2008). Effect of mepiquate chloride and nitrogen fertilization application timing on cotton cultivar Giza 80. J. Agric. Sci. Mansoura Univ., 33 (10): 7087-7099.

El- Masri, M.F. (2005). The prospective requirements of zinc and manganese for cotton under soil Zn and Mn deficiency. J. Agric. Sci. Mansoura Univ., 30 (9): 4969-4978.

El- Masri, M.F., W.M.O. El- Shazly and K.A. Ziadah (2005). Response of Giza 88 cotton cultivar to foliar spraying with boron, potassium or a bioregulator SGA-1. J. Agric. Sci. Mansoura Univ., 30 (10): 5739-5755.

El- Shahawy, M. I. M. (1999). Effect of sowing date and Pix (mepiquat chloride) treatment on growth, earliness and yield of Giza 87 cotton cultivar (*Gossypium barbadense,* L.). Egypt. J. Agric. Res., 77 (2): 829-840.

El- Shahawy, M. I. M. and R. R. Abd El-Malik (2000). Response of Giza 87 cotton cultivar to mepiquat chloride (Pix) and nitrogen fertilization levels. Egypt. J. Agric. Res., 78 (2): 769-780.

El- Shazly, W. M. O., R. Kh. M. Khalifa and O.A. Nofal (2003). Response of cotton Giza 89 cultivar to foliar spray with boron, potassium or a bio-regulator SGA-1. Egypt, J. Appl, Sci., 18 (4B): 676-699.

El- Tabbakh, S. Sh. (2002). Effect of mepiquat chloride concentrations on growth, productivity and fiber properties of two cotton cultivars (*Gossypium spp.*) under three nitrogen levels. Alex. J. Agric. Res., 47 (2): 45-59.

Fernandez, C. J. (2007). Cotton responses to nitrophenolate-based stimulant: effects of foliar application rates on yield and fiber quality. J. Plant Nutrition, 30 (4-6): 965-979.

Fernandez, C.J., J.T. Cothren and K.J. Mcinnes (1991). Partitioning of biomass in well-watered and water-stressed cotton plants treated with mepiquat chloride. Crop Sci., 31: 1224-1228 .

Gormus, O. (2006). Effect of mepiquat chloride and boron on irrigated cotton (*Gossypium hirsutum*) in Turkey. Indian J. Agronomy, 51 (2): 149-151.

Guinn, G. (1985). Fruiting of cotton, nutritional stress and cut out. Crop Sci., 25: 981–985 .

Hake, K., T. Kerby, W. McCarty, D. O. Neal and J. Supak (1992). Physiology of Pix. Cotton Physiology Today, 2 (6).

Heitholt, J. J. (1994). Supplemented boron, boll retention percentage, ovary carbohydrates and lint yield in modern cotton varieties. Agronomy J., 86: 492-497 .

Huang, P., W. BaoJu, C. YaWei, Zhang LiRong and Cai ZhongMin (2000). The effect of the new type of liquid fertilizer "Fengmanle" applied to cotton. China Cottons, 27 (11): 19-20.

Ibrahim, M.E., M.A. Bekheta, A. El-Moursi and N.A. Gaafar (2009). Effect of Arginine, Prophexadione –Ca, some macro and micro-nutrients on growth, yield and fiber quality of cotton plants. World J. Agric. Science 5(S): 863-870.

Khan, N.A. (1996). Response of mustard to ethrel spray and basal and foliar application of nitrogen. J. Agron. Crop Sci., 175: 331-334 .

Kler, D.S., D. Raj and G.S. Dhillon (1989). Modification of micro-environment with cotton canopy for reduced abscission and increased seed yield. Environ. Ecol., 7: 800-802 .

Oosterhuis, D. M. (2001). Physiology and nutrition of high yielding cotton in the USA. Informacoes Agronomicas Piracicaba, 95: 18-24.

Pettigrew, W. T. (2008). Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiol. Plantarum, 133: 670-681.

Prasad, M. and M. R. B. Siddique (2004). Effect of nitrogen and mepiquat chloride on yield and quality of upland cotton (*Gossypium hirsutum*). Indian J. Agric. Sciences, 74 (10): 560-562.

Prasad, M. and R. Prakash (2000). Influence of mepiquat chloride on growth, yield and quality of cotton. Pesticide Research Journal, 12 (2): 261-262.

Sawan, Z. M., A. H. Fahmy and S.E. Yousef (2009). Direct and residual effects of nitrogen fertilization, foliar application of potassium and plant growth retardant on Egyptian cotton growth, seed yield, seed viability and seedling vigor. Acta Ecologica Sinica, 29: 116-123.

Sawan, Z. M., M. H. Mahmoud and Amal H. El-Guibali (2006). Response of yield, yield Components and fiber properties of Egyptian cotton (*Gossypium barbadense* L.) to nitrogen fertilization and foliar-applied potassium and mepiquat chloride. Journal of Cotton Science, 10: 224–234

Sawan, Z. M., M. H. Mahmoud and Amal H. El-Guibali (2008). Influence of potassium fertilization and foliar application of zinc and phosphorus on growth, yield components, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). J. Plant Ecology, 1 (4): 259–270 .

Sawan, Z. M., R. A. Sakr, F. A. Ahmed and A. M. Abd-Al-Samed (1991). Effect of 1,1-dimethyl piperidinium chloride (Pix) on the seed, protein, oil and fatty acids of Egyptian cotton. J. Agronomy and Crop Science, 16 (3): 157-161.

Sharma, S. K. and S. Sundar (2007). Yield, yield attributes and quality of cotton as influenced by foliar application of potassium. J. Cotton Research and Development, 21 (1): 51-54.

Snedecor, G.W and W.G. Cochran (1967). Statistical Methods, 6th Ed. The Iowa State Univ. Press, Ames. Iowa, USA.

Stewart, J. M. (1986). Integrated events in the flower and fruit. Cotton Physiology, p. 261-297.

Valley, B.L. and W.E.C. Wacker (1970). Metalloproteins. In H. Neurath. The Proteins. Vol. 5. Academic Press. New York.

Wu, Z. L., Q.B. Pan, Y.H. Gao, J.Y. Wang and J. Wang (1994). Technical researches on the all round chemical regulation of cotton plants. China Cottons, 21: 10-11 .

Zhao, D. and D. M. Oosterhuis (1999). Physiological, growth and yield responses of cotton to Mepplus and mepiquat chloride. In Proc. Beltwide Cotton Conf., Orlando, FL. 3-7 Jan. Natl. Cotton Counc. Am., Memphis, TN. p. 599-602.

تأثير الرش بمنظمات النمو والعناصر الكبرى والصغرى على التساقط والمحصول والصفات التكنولوجية للقطن المصرى

سيد محمود عبد العال(١) ، محمود الدسوقي إبراهيم(١) ، أحمد عبد الحى على(١) ،
جمالات عبد العزيز وهدان(٢) ، أسامه على محمد على(١) ،
يوسف فتحى أحمد عطا الله(٢)

(١) قسم المحاصيل – كلية الزراعة – جامعة المنوفية – مصر
(٢) معهد بحوث القطن – مركز البحوث الزراعية – مصر

الملخص العربى

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة – محافظة الغربية – مصر لدراسة تأثير الرش ببعض منظمات النمو (كنترول ، الأتونيك "منشط نمو" ، البكس"مؤخر نمو") و العناصر الكبرى (كنترول ، الفسفور ، البوتاسيوم) والصغرى (كنترول ، الزنك ، البورون) على انتاج وتساقط الوسواس واللوز (عدد الوسواس "المواقع الثمرية" وعدد اللوز العاقد واللوز الكلى المتبقى على النبات ، النسبة المئوية لتساقط كل من الوسواس واللوز والتساقط الكلى) ، المحصول ومكوناته (عدد اللوز المتفتح ،وزن اللوزة ، دليل البذرة ، نسبة التبكير ، محصول القطن الزهر للنبات والفدان)، الصفات التكنولوجية للبذور (النسبة المئوية للزيت والبروتين) الصفات التكنولوجية للألياف (نسبة الشعر ، متانة الألياف ، نعومة الألياف) للقطن المصرى (صنف جيزة ٨٩) خلال موسمي الزراعة ٢٠٠٥ ، ٢٠٠٦ حيث تم رش نباتات القطن بالأتونيك بمعدل ١ مل /لتر والبكس بمعدل ١ مل /لتر و الفسفور (حمض الفسفوريك) بمعدل ١ مل /لتر والبوتاسيوم (سترات البوتاسيوم) بمعدل ١ جم /لتر والزنك (زنك مخلبى) بمعدل ١ جم /لتر والبورون (حمض البوريك) بمعدل ١ جم /لتر مرتين الأولى عند بداية التزهير والثانية بعد ٣٠ يوم من الأولى .

ويمكن إيجاز أهم النتائج المتحصل عليها على النحو التالي :-

١- أوضحت النتائج أن الرش بمنظم النمو البكس أدى إلى زيادة معنوية لعدد الوسواس وعدد اللوز الكلى على النبات والمحصول ومكوناته (عدد اللوز المتفتح على النبات ، وزن اللوزة، دليل البذرة ، نسبة التبكير، محصول القطن الزهر للنبات وللفدان) والصفات التكنولوجية للبذور (نسبة الزيت والبروتين) والألياف (نسبة الشعر ، قراءة الميكرونير ، المتانة) فى حين أدى الى تقليل النسبة المئوية لتساقط اللوز على النبات والتساقط الكلى مقارنة بالنباتات غير المعاملة (الكنترول) وذلك خلال موسمى الزراعة.

٢- أدى الرش بالعناصر الكبرى المختبرة (الفسفور والبوتاسيوم) إلى تحسين معظم صفات انتاج الوسواس واللوز على النبات، المحصول ومكوناته ، الصفات التكنولوجية للبذور والألياف وتقليل النسبة المئوية لتساقط الوسواس واللوز على النبات والتساقط الكلى على النبات خاصة معاملة البوتاسيوم وذلك مقارنة بمعاملة الكنترول خلال موسمى الزراعة.

٣- أدى الرش بالعناصر الصغرى المختبرة (الزنك والبورون) إلى زيادة قيم معظم الصفات المدروسة لانتاج الوسواس واللوزعلى النبات ، كمية المحصول ومكوناته ، والصفات التكنولوجية للبذور والألياف خاصة معاملة البورون فى حين أدى الرش بتلك العناصر الصغرى إلى تقليل النسبة المئوية لتساقط اللوز على النبات والتساقط الكلى على النبات وذلك مقارنة بمعاملة الكنترول خلال موسمى الزراعة.

٤- تشير نتائج التفاعل بين العوامل المختبرة (منظمات النمو ، العناصر الكبرى ، العناصر الصغرى) إلى تأثر معظم الصفات المحصولية المدروسة تأثرا معنويا بهذا التفاعل حيث أعطى الرش بمنظم النمو البكس مع كل من البوتاسيوم أو البورون أو كليهما أعلى قيم للصفات المحصولية فى حين سُجلت أقل القيم للنباتات التي لم تعامل بأي من المعاملات المختبرة (معاملة الكنترول) وذلك خلال موسمى الزراعة .