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RESPONSE OF GIZA 89 COTTON CULTIVAR TO FOLIAR APPLICATION OF ASCORBIC ACID, GIBBERELLIC ACID, PHOSPHORUS AND POTASSIUM

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ABSTRACT

Two field experiments were carried out at Gemmeiza Agricultural Research Station, Gharbia Governorate during two seasons (2000 and 2001) to study the effect of foliar application with 1000 ppm ascorbic acid (AA), 100 ppm gibberellic acid (GA_3), 2% calcium superphosphate (SP) and 2% potassium sulphate (KS) in comparison with untreated plots (spraying with water) as a control on leaf nutrients content, growth, earliness, seed cotton yield and yield components of Giza 89 cotton cultivar. The obtained results could be summarized as follows:

1-Foliar application of 1000 ppm AA, significantly increased leaf N, P, Ca, Fe, Zn and Mn contents as compared with the control treatment. However, this treatment insignificantly reduced leaf Cu content and increased leaf K and Mg contents compared with the control. This treatment significantly increased also plant height at harvest as compared with the control treatment or foliar feeding with P or K due to the number of main stem internodes increase, however, it reduced the average internode length. In addition, this treatment significantly increased numbers of total and open bolls/ plant, boll weight, seed cotton yield/ plant as well as/ feddan as compared with the control treatment.

2-Foliar application of 100 ppm GA_3, significantly increased leaf macronutrients content (N, P, K, Ca and Mg) and leaf micronutrients content (Fe, Zn, Mn and Cu) as compared with the control treatment in both seasons. Also, this treatment significantly increased plant height at harvest as compared with the other tested treatments due to a significant increase in each of number of main stem internodes and/or internode length and number of fruiting branches/ plant. In addition, this treatment significantly increased numbers of total and open bolls/ plant in the first season and boll weight, seed cotton yield/ plant as well as/ feddan in both seasons as compared with the control treatment.

3-Foliar application of 2% SP increased leaf N, P, Mg and Mn and reduced leaf K, Ca, Fe, Zn and Cu contents in both seasons compared with the control treatment. This treatment produced the shortest plants with lower number of shorter internodes compared with the control treatment. In addition, this treatment increased seed cotton yield/ feddan and its components but to a less extent, as compared with the other tested treatments.

4-Foliar application of 2% KS produced the highest values of leaf N, K, Fe and Mn contents compared to the other tested treatments, but, decreased leaf Mg content as compared with the control treatment. Also, this treatment produced plants with the same height of the control plants but significantly increased the number of main stem internodes and hence decreased the average internode length compared with the control. In addition, this treatment significantly increased numbers of total and open bolls/ plant, boll weight, seed cotton yield/ plant as well as/ feddan compared with the control treatment.

5-All treatments had insignificant effect on earliness %, lint %, seed index and number of seeds/ boll.

6-The highest seed cotton yield/ feddan and its components as averages of both seasons were obtained from foliar feeding with 2% KS, while the lowest values were obtained from the control treatment.

These results could be concluded that the twice foliar feeding with 2% KS or foliar application with 1000 ppm AA or 100 ppm GA_3 at the beginning of flowering and 15 days later are the best treatments for having good growth and high productivity of Giza 89 cotton cultivar under Gemmeiza location.

Keywords: Foliar, Feeding, An aqueous, Filtered solution, GA_3, AA and Cotton .

INTRODUCTION

Factors which that decrease photosynthesis or increase respiration increase cotton fruit abscission (Guinn, 1974). Among these factors, air pollution with Cd which had two possible mechanisms for toxicity on photosynthesis. The first mechanism is that Cd can alter chlorophyll biosynthesis by inhibiting protochlorophyllide reductase. The second one is that Cd can alter the photosynthetic electron transport by inhibiting the water splitting enzyme located at the oxidizing site of photosystem II (Lagriffoul *et al.*, 1998). Many researchers found that spraying plant leaves with ascorbic acid gives them some protection against the air polluting damage (Baunernfeind, 1982) due to its role in protecting the plant lipids from peroxidation caused by free radicals (Kunert and Ederer, 1985) and by reducing the concentration of cadmium and consequently its uptake (Amer and Fatma Sherif, 2001). Moreover, Golan *et al.*, (1995) reported another benefit from spraying ascorbic acid on soybean seedlings, it was that ascorbic acid or its degradation product protects the seedlings from Cu toxicity by reducing Cu uptake by the plants, and this may be achieved either by chelation of Cu ions or reduction of cupric (+ 2) ions to cuprous (+ 1) ions which are known to be less absorbable by animals.

With regard to cotton crop, Brar *et al.* (1983) found that spraying 100 ppm ascorbic acid at the flowering stage gave higher seed cotton yield. Nehra *et al.* (1987) found that ascorbic acid application increased seed cotton yield/ plant as well as /hectare. Ghourab and Gamalat Wahdan (2000) found that one spray with ascorbic acid significantly increased plant height. However, two sprays at a rate of 200 ppm, significantly increased the number of fruiting branches/ plant. Spraying ascorbic acid seemed to increase number of open bolls per plant as a result of reducing boll shedding.

However, abscisic acid (ABA) which slows growth (Rehm and Cline, 1973), hastens senescence (Fuente and Leopold, 1968), decreases basipetal movement of IAA (Chang and Jacobs, 1973), promotes ethylene production, causes an increase in cellulase activity (Jackson and Osborne, 1972) and hence, causes abscission (Davis and Addicott, 1972). GA3 is known to antagonise the effect of abscisic acid (ABA) (Krishnamoorthy, 1981) Moreover, Abd El-Naby (1986) found that all GA3 treatments in general, increased number of open bolls/ plant, seed cotton yield/ plant and boll weight, while lint % and seed index were not affected. Atia and Ebaid (1990) found that number of total bolls/ plant, number of open bolls/ plant, boll weight, lint percentage, seed index, seed cotton yield/ plant and / feddan were increased by spraying cotton plants with GA3 .

Also, cotton balanced fertilization is one of the most important factor that affect photosynthesis and fruit abscission, cotton plant need a balanced ratios of essential macro and micro- nutrients with none deficient or toxic for optimum and economical yield (Ziadah and El-Shazly, 1998). There are many factors that affect the availability of P and K in soils. Mengel and Kirkby (1987) reported that average clay content probably contributed to more fixation of P and K by clay minerals, leading to reduction of their availability and thus lower available concentrations in soils. Amberger (1993) reported that phosphorus is quite immobile in soils with neutral or high pH and appears in more or less stable Ca phosphates. Added phosphate does not move more than 2 – 3 mm from the fertilizer particle and is precipitated rapidly to dicalcium phosphate ($CaHPO_4$. H_2O) or octocalciumphosphate, entirely unavailable to crops.Sommro (1997) reported that in soils which are rich in calcium and are alkaline in reaction, phosphates added as fertilizer are converted to less available form of calcium compounds.

Thus to give more efficient and economical usage of K and P fertilizers for cotton, foliar feeding with an aqueous filtered solution of potassium sulphate or calcium superphosphate are used by many workers on cotton, Abd El-Aal *et al.* (1995) found that seed cotton yield/ fed. increased by soil and foliar nutrition with potassium as compared to the control. Etidal *et al.* (1997) found that spraying cotton plants with potassium sulphate at the rate of 9 kg/fed. increased plant height, number of open bolls/ plant, boll weight, seed cotton yield/ plant and earliness percentage. The treatment had no significant effect on seed index or lint percentage. Abou Zeid *et al.* (1997) found that seed cotton yield/ fed. and /plant, and its components i.e. number of open bolls/ plant and boll weight were almost significantly affected by K supply. Potassium fertilization showed no effect on seed index. With regard to foliar feeding with an aqueous filtered solution of calcium superphosphate, Girgis *et al.* (1984) reported that P fertilization had a significant effect on boll weight, number of open bolls/ plant, seed cotton yield/ plant and /fed. in favour of the combined application of P to soil and as foliar spray. El-Shahawy (2000) found that spraying 8 kg/fed. superphosphate twice on mid-July and 15 days later significantly reduced final plant height, main stem internodal length, number of sympodia/ plant, number of aborted sites/ plant and number of unopen bolls/ plant as compared with the control. However, this treatment significantly increased boll retention/ plant, earliness percentage, number of open bolls/ plant, boll weight, seed index and seed cotton yield/ feddan in both seasons and lint percentage in the second season only as compared with the control treatment.

The aim of this investigation was to study the response of the Egyptian cotton cultivar Giza 89 to foliar application with ascorbic acid, gibberellic acid, calcium superphosphate and potassium sulphate as compared with untreated plots with regard to leaf nutrients content, growth, earliness, seed cotton yield and yield components.

MATERIALS AND METHODS

Two field experiments were carried out at Gemmeiza Agricultural Research Station, Gharbia Governorate, Egypt, during 2000 and 2001 seasons to study the effect of two foliar sprays of ascorbic acid (AA), gibberellic acid (GA_3), calcium superphosphate (SP) and potassium sulphate (KS) in comparison with untreated plots (spraying with tap water) as a control on leaf nutrients content, growth, earliness, cotton yield and its components of the Egyptian cotton *(Gossypium barbadense* L.), Giza 89 cultivar.

A randomized complete blocks design with four replicates was used in both seasons .

The five treatments were as follows:

T_1 Untreated, sprayed with the same amount of tap water at the time of foliar application of the other tested treatments, as a control.

T_2 Foliar application of an aqueous solution of ascorbic acid twice at the rate of 1000 ppm ascorbic acid (AA) at every spray.

T_3 Foliar application of an aqueous solution of gibberellic acid twice at the rate of 100 ppm gibberellic acid (GA_3) at every spray.

T_4 Foliar application of an aqueous filtered solution of calciumsuperphosphate (15.5% P_2O_5) twice at the rate of 2% calcium superphosphate (SP) at every spray.

T_5 Foliar application of an aqueous filtered solution of potassium sulphate (48% K_2O) twice at the rate of 2% potassium sulphate (KS) at every spray.

The trade name and active ingredient of the tested substances are as follows:-

Trade name	Active ingredient
Cevarol(500 mg $C_6H_8O_6$/ tablet)	Ascorbic acid (Vitamin C)$C_6H_8O_6$
Berelex (0.92g $C_{18}H_{21}O_4COOH$/ tablet)	Gibberellic acid (GA_3)$C_{18}H_{21}O_4COOH$
Calcium superphasphate (15.5% P_2O_5)	Phosphorus pentoxide P_2O_5
Potassium sulphate (48% K_2O)	Potassium oxide K_2O

In all treatments, foliar spray was performed twice, at the beginning of flowering and 15 days later, using hand operated compressed air at the rate of 200 liter/ fed.

Phosphorus fertilizer was applied at the rate of 22.5 kg P_2O_5 /fed. as calcium superphosphate (15.5% P_2O_5) during seed bed preparation. Nitrogen fertilizer was applied as ammonium nitrate (33.5% N) at the rate of 60 kg N/fed. in two equal splits after thinning (36 days after sowing, two plants/ hill) and at the next irrigation. Potassium fertilizer was added at the rate of 24 kg K_2O / fed. as potassium sulphate (48% K_2O) in one dose with the 1^{st} dose of nitrogen. The preceding crop was Egyptian clover (berseem), only one cut. The other cultural practices were carried out as recommended for the conventional cotton planting .

The plot size was 20.475 m^2 (4.5m x 4.55 m) including 7 rows in both seasons. The two outer rows were left to avoid border effect. Sowing date was 29 and 26 March for the first and second seasons, respectively, in rows 65 cm apart and hills 25 cm apart.

Soil analysis :

Soil analysis of the experimental soil in the two growing seasons is shown in Table (1).

Studied traits:

A- Leaf nutrients content :

After 120 days from sowing, a leaf sample of 20 leaves was taken from the youngest fully matured leaf (4^{th} leaf from the apex of the main stem) from each plot. Leaf sample was analyzed after preparation to determine the nutritional status of cotton plant as follows:

Total N with Micro – Kjeldahl method (Allen, 1953 and Ma and Zauzage, 1942). Other nutrients extraction: total P, K, Ca, Mg,Fe, Zn, Mn and Cu were determined according to the procedures suggested by (Chapman and Pratt, 1978).

B- Growth traits:

At harvest, five guarded hills from the second row of each plot were taken at random to determine the following growth traits: Plant height (cm), number of internodes/ plant, average internode length (cm) and number of fruiting branches/ plant.

C- Earliness :

Earliness was estimated as a percentage of first pick yield to total yield.

D- Seed cotton yield and its components:

Also, the five guarded hills at harvest were used to determine the following yield components: numbers of total and open bolls / plant, boll weight (g), seed cotton yield / plant (g), lint percentage, seed index (g) and number of seeds / boll.

At harvest also, seed cotton yield/ feddan (*) in kentars (**) was calculated from the inner 5 rows of each plot in both seasons .

The obtained data were subjected to statistical analysis presented by Le Clerg *et al.* (1966) and the treatments means were compared using LSD at 0.05 level of probability.

RESULTS

Soil analysis :

Analysis of composite soil samples from the experimental sites are described in Table (1). The data presented in this table show that the soils are alkaline in reaction and containing amounts of $CaCO_3$ ranging from 2.4 -

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(*) One feddan = 4200 . 83 m^2

(**) One kentar = 157.5 kg

2.7%. In general, the soil organic matter and the total and available N were very low. The values of available K ranged between 15-18 mg/100 g soil, where these levels are less than the critical level range of 20-30 mg/100 g soil. The amounts of available P ranged between 1.78-1.9 mg/ 100 g soil, where these levels are above the critical level. Concerning the amounts of available micronutrients, the same table shows that available Fe, Mn, Zn and Cu levels were less than the critical levels range of 10-16 ppm, 8-12 ppm, 1.5-3 ppm and 0.8-1.2 ppm, respectively.

Table (1): Analysis (*) of the experimental soil in 2000 and 2001 seasons.

Properties		Methods (References)	2000	2001
Texture		Hydrometer (Bauyoucos, 1951)	Clay loam	Clay loam
pH		1 soil : 2.5 water (Jackson, 1973)	8.0	7.9
EC mmhos/cm.			1.1	0.7
$CaCO_3$	%	Calcimeter	2.7	2.4
O.M.	%	(Walkley and Black, 1934)	1.0	1.05
Total N	Mg/ 100 g soil	Semi-micro Kjeldahl (Piper, 1950)	35.4	32.5
Available N			3.53	2.80
Na HCO_3 – extractable-P	Mg/ 100 g soil	Vanadate- molybdate spectrophotometer (Olsen *et al.*, 1954)	1.9	1.78
NH_4 – OAC - extractable-K	Mg/ 100 g soil	Flame photometer and Atomic absorption (Chapman and Pratt, 1978)	18.0	15.0
NH_4 – OAC - extractable-Ca			15.0	18.5
NH_4 –OAC - extractable-Mg			8.0	8.3
NH_4 – OAC - extractable-Na			28.0	34.0
DTPA– extractable-Fe	Ppm	Atomic absorption spectrophotometer (Lindsay and Norvell, 1978)	4.2	3.8
DTPA– extractable-Mn			1.1	0.7
DTPA– extractable-Zn			0.8	0.6
DTPA– extractable-Cu			0.7	0.9

*** Optimizing of Micronutrient Fertilizers Use Project, National Research Center, Unit of Mariut.**

A-Leaf nutrients content :

Data in Table 2 show that the tested treatments gave a significant effect on leaf macronutrients content (N, P, K, Ca and Mg) in both seasons. The highest leaf N and K contents were obtained by foliar feeding with 2% KS followed by foliar application of 100 ppm GA_3 and 1000 ppm AA, respectively, but the lowest leaf N content was obtained from the control treatment and the lowest leaf K content was obtained from foliar feeding with 2% SP. However, the highest leaf P and Mg contents were obtained from foliar feeding with 2% SP followed by foliar application of 100 ppm GA_3 and 1000 ppm AA, respectively, while the lowest values were obtained by the control treatment or foliar feeding with 2% KS.

Table (3) shows that the tested treatments gave, also, a significant effect on leaf micronutrients content (Fe, Zn, Mn and Cu) in both seasons. The highest leaf Fe content was obtained from foliar feeding with 2% KS followed by foliar spraying with 100 ppm GA_3 and 1000 ppm AA, respectively, but the lowest leaf Fe contents were obtained from foliar feeding with 2% SP and the control treatment. The difference between the two later treatments was significant.

Table (2): Effect of the tested treatments on macronutrients content in leaf at 120 days after sowing in 2000 and 2001 seasons.

The tested treatments	N %		P %		K %		Ca %		Mg %	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Control	3.27	3.57	0.32	0.33	3.07	2.78	2.53	2.45	0.45	0.42
AA (1000 ppm)	3.64	3.78	0.35	0.37	3.10	2.88	2.70	2.73	0.46	0.43
GA_3 (100 ppm)	3.80	3.87	0.36	0.38	3.17	2.93	2.80	2.85	0.48	0.46
SP (2%)	3.59	3.69	0.39	0.43	2.87	2.63	2.47	2.23	0.52	0.50
KS (2%)	4.06	4.16	0.33	0.34	3.20	3.10	2.63	2.55	0.43	0.38
F- Test	**	**	**	**	**	**	**	**	**	**
L.S.D. 0.05	0.18	0.17	0.02	0.03	0.08	0.11	0.13	0.09	0.02	0.02

** Indicates $P<0.01$.
AA = Ascorbic acid GA_3 = Gibberellic acid SP = Superphosphate
KS = Potassium sulphate

The highest leaf Zn content was obtained from foliar spraying with 100 ppm GA_3 in both seasons, but the lowest value was obtained from foliar feeding with 2% SP. The highest leaf Mn content was obtained from foliar feeding with 2% KS followed by foliar spraying of 100 ppm GA_3,1000 ppm AA and 2% SP, respectively, but the lowest leaf Mn content was obtained from the control treatment. The highest leaf Cu content was obtained from foliar spraying with 100 ppm GA_3 in both seasons. However, the lowest leaf Cu content was obtained from foliar feeding with 2% SP.

Table (3): Effect of the tested treatments on micronutrients content in leaf at 120 days after sowing in 2000 and 2001 seasons.

The tested treatments	Fe (ppm)		Zn (ppm)		Mn (ppm)		Cu (ppm)	
	2000	2001	2000	2001	2000	2001	2000	2001
Control	214.3	238.5	41.7	38.3	44.0	45.0	12.3	10.0
AA (1000 ppm)	251.7	259.8	45.3	42.5	55.0	52.0	12.0	9.8
GA_3 (100 ppm)	266.3	270.3	49.7	45.8	58.7	54.3	13.3	12.8
SP (2%)	192.7	217.8	37.0	36.3	53.3	49.5	11.3	8.8
KS (2%)	280.3	286.0	43.7	40.5	63.7	58.0	12.3	10.8
F- Test	**	**	**	**	**	**	**	**
L.S.D. 0.05	14.7	10.5	2.7	1.5	3.0	2.8	1.0	0.6

** indicates $P<0.01$.
AA = Ascorbic acid GA_3 =Gibberellic acid SP =Superphosphate
KS =Potassium sulphate

B- Growth traits:

Data in Table (4) show that the tested treatments had a significant effect on plant height at harvest and average internode length in both seasons and on numbers of main stem internodes and fruiting branches/ plant in the first season only, in favour of foliar application with 100 ppm GA_3. The lowest values of plant height at harvest and numbers of main stem internodes and fruiting branches/ plant were obtained from foliar feeding with 2% SP and the control treatment without any significant differences between these two treatments. However, the lowest average internode length was obtained from foliar spraying with 2% KS.

Table (4): Effect of the tested treatments on some growth traits at harvest in 2000 and 2001 seasons.

The tested treatments	Plant height (cm)		No. of main stem internodes/ plant		Average internode length (cm)		No. of fruiting branches/ plant	
	2000	2001	2000	2001	2000	2001	2000	2001
Control	141.0	143.8	21.98	20.65	6.42	6.97	15.0	13.7
AA (1000 ppm)	146.5	147.6	23.45	21.90	6.25	6.75	16.5	14.9
GA_3 (100 ppm)	159.6	156.0	24.55	21.53	6.51	7.25	18.1	14.1
SP (2%)	138.4	142.4	21.68	20.68	6.39	6.90	15.5	13.7
KS (2%)	141.4	143.3	23.98	21.28	5.90	6.74	17.2	14.3
F- Test	**	**	**	NS	*	*	**	NS
L.S.D. 0.05	3.7	3.3	1.22	–	0.32	0.33	1.1	--

***, ** and Ns indicate P<0.05, 0.01 and not significant, respectively.**
AA = Ascorbic acid GA_3 = Gibberellic acid SP = Superphosphate
KS = Potassium sulphate

C-Earliness :

The tested treatments did not affect earliness % in the two seasons (Table 5), however, the control treatment gave the lowest earliness % in both seasons.

D-Seed cotton yield and its components :

The tested treatments gave insignificant effect on lint %, seed index and number of seeds/ boll in both seasons (Table 5). However, the tested treatments had a significant effect on each of numbers of total and open bolls/ plant, boll weight and seed cotton yield/ plant in both seasons (Table 5), in favour of foliar application with 2% KS, 1000 ppm AA, 100 ppm GA_3 and 2% SP, respectively. However, the lowest values of these traits were obtained from the control treatment. Also, the tested treatments gave a significant effect on seed cotton yield /feddan in both seasons(Table 5). The highest seed cotton yield /feddan was obtained from foliar application with 2% KS in the first season and 1000 ppm AA in the second season followed by foliar application with 100 ppm GA_3 and 2% SP, respectively, but the lowest yield was obtained from the control treatment. The yield increase percentages over the control amounted to 26.35 , 23.9, 23.49 and 13.38 % in the first season and 22.46, 22.67, 19.41 and 10.18% in the second season due to foliar application with 2% KS, 1000 ppm AA, 100 ppm GA_3 and 2% SP, respectively.

Table(5) shows that the highest seed cotton yield/ feddan and its components as averages of both seasons were obtained from foliar feeding with 2% KS, while the lowest values were obtained from the control treatment.

Table (5): Effect of the tested treatments on earliness %, seed cotton yield and its components in 2000 and 2001 seasons.

The tested treatments	Earliness %		Lint %		Seed index (g)		No. of seeds/ boll		No. of total bolls/ plant	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Control	52.1	57.4	36.0	38.9	10.61	9.71	19.0	19.1	17.0	15.2
AA (1000 ppm)	55.2	60.2	35.9	38.8	10.82	10.19	19.5	19.7	18.7	18.9
GA_3 (100 ppm)	53.0	62.2	35.9	39.3	10.73	9.99	19.8	20.0	19.0	16.1
SP (2%)	53.4	62.1	35.4	39.4	11.06	9.72	19.2	20.0	17.8	16.2
KS (2%)	56.1	65.1	36.5	39.1	11.05	10.00	19.7	19.2	19.5	18.9
F- Test	NS	NS	NS	NS	NS	NS	NS	NS	**	*
L.S.D. 0.05	--	--	--	--	--	--	--	--	1.2	2.4

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.
AA = Ascorbic acid GA_3 = Gibberellic acid SP = Superphosphate
KS = Potassium sulphate

Table (5): Cont.

The tested treatments	No. of open bolls/ plant			Boll weight (g)			Seed cotton yield/ plant (g)			Seed cotton yield/ feddan (kentar)		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Control	15.8	14.0	14.9	2.32	2.38	2.35	36.7	33.3	35.0	9.79	9.53	9.66
AA (1000 ppm)	17.6	17.7	17.7	2.66	2.56	2.61	46.9	45.2	46.1	12.13	11.69	11.91
GA3(100 ppm)	18.0	15.6	16.8	2.63	2.71	2.67	47.3	42.2	44.8	12.09	11.38	11.74
SP (2%)	16.3	15.6	16.0	2.59	2.47	2.53	42.1	38.6	40.4	11.10	10.50	10.80
KS (2%)	18.1	17.5	17.8	2.74	2.62	2.68	49.5	45.7	47.6	12.37	11.67	12.02
F- Test	**	*		**	**		**	**		**	*	
L.S.D. 0.05	1.1	2.1		0.07	0.16		3.1	5.9		0.77	1.34	

* and ** indicate P<0.05 and P<0.01 , respectively.
AA = Ascorbic acid GA_3 = Gibberellic acid SP = Superphosphate
KS = Potassium sulphate

DISCUSSION

Effect of AA :-

The positive effect of AA on leaf macronutrients (N, P, K and Ca) content and leaf micronutrients (Fe, Zn and Mn) content may be due to that ascorbic acid enhances nutritional status in higher plants as reported by Grun *et al.* (1982). However, the negative effect of AA on leaf Cu content may be due to that AA or its degradation product protects the seedlings from Cu toxicity by reducing Cu uptake by the plants (Golan *et al.*, 1995).

The positive effect of AA on growth traits i.e. plant height at harvest, numbers of its main stem internodes and fruiting branches may be due to that: (1) AA exert a significant effect on cell division and/ or its elongation in one season or both seasons, and (2) AA might have prevented the formation of indoleacetic acid protein complex, which is the actual growth stimulator (Mapson, 1958).

In this concern, Ghourab and Gamalat Wahdan (2000) found that one spray of AA at start of flowering significantly increased plant height due to the difference in number of stem internodes and/or average internode length. However, two sprays of AA (at start of flowering and at peak of flowering) showed an opposite effect where a reduction in plant height was observed particularly when higher rates were used. Two sprays of 200 ppm ascorbic acid exhibited also, higher number of fruiting branches/ plant.

The foliar application of AA exert a significant increase in numbers of total and open bolls/ plant, boll weight, seed cotton yield/ plant as well as/ feddan as compared with the control treatment and this favourable effect of AA on seed cotton yield and its components may be due to that: (1) AA mainly plays a role as activators or intermediates in the formation of carbohydrate during photosynthesis, also AA increased all chlorophyll forms i.e. chlorophyll a,b and total chlorophyll and this may be attributed to delayed leaf senescence, thus producing more photopigments and this supported that synthesis of AA may be linked with photosynthesis (Ghourab and Gamalat Wahdan, 2000) and (2) AA seemed to stimulate the biosynthesis of carotenoides where they significantly increased after spraying AA twice, also AA enhanced and significantly increased carbohydrate contents i.e. reducing sugars and total soluble sugars (Ghourab and Gamalat Wahdan, 2000).

In this respect, Ghourab and Gamalat Wahdan (2000) found that ascorbic acid application led to a significant increase in number of bolls/ plant.

Effect of GA_3 :

The positive response of leaf macro and micronutrients contents to GA_3 may be due to that GA intensifies an organ ability to function as a nutrient sinck (Addicott and Addicott, 1982).

The positive effect of GA_3 on growth traits under study may be due to that: (1) the increase in GA concentration of GA_3 treated plants and consequently the increase of GA biosynthesis which have a role in cell division and expansion and hence internode elongation, (2) GA_3 significantly increased the leaf macro and micro- nutrients content under study as shown in Tables (2 and 3) and this might have increasing the production of metabolites synthesized and thus the plant had the chance to bear more fruiting branches, and (3) GA_3 treatment might have led to the production of an inhibitor which retarded auxin destroying system namely the IAA-oxidation system (Housley and Deverall, 1961).

In this respect, El-Fouly and Mostafa (1969) found that GA_3 application at several times increased cotton plant height. Bhatt and Ramanujam (1971) found that spraying cotton plants (*Gossypium hirsutum* L. c.v. PRS 72) with 100 ppm GA_3 significantly increased main stem length and number of nodes at harvest. Aly (1975) reported that gibberellins (GA) have been reported to increase the length of internodes and number of internodes of treated plant. Gamalat (1990) found that GA_3 significantly increased plant height and average length of internode. Bondok *et al.*, (1991a) using growth promotor, GA_3 at 100 and 200 ppm significantly increased cotton plant height and caused insignificant increase in internode length.

GA_3 treated plants produced the higher numbers of total and open bolls/ plant, heavier bolls and higher seed cotton yield/ plant and/ fed. as compared with the control treatment and this may be due to that :- (1) sprayed cotton plants with GA_3 produced the greatest number of flowers/ plant (Aly, 1975) and significantly increased boll- set (Abdel Al, 1981) as GA_3 antogenises the effect of abscisic acid (ABA), which causes boll shedding (Krishnamoorthy, 1981) or to that gibberellins may retard abscission of intact fruit by mobilizing nutrients to that fruit and by stimulating growth (Addicott, 1970). Moreover, Bondok *et al.*, (1991 a,b) found that GA_3 applied to cotton plants significantly increased the levels of auxin and gibberellin-like substances, over the control and recorded insignificant levels of inhibitors (containing ABA) during full bloom stage and significant decrease in flower and fruit shedding, as well as leaf abscission percentage with GA_3 . Therefore GA_3 retarded the shedding of young bolls, and (2) GA_3 significantly increased the leaf macro and micro- nutrients contents as shown in Tables (2 and 3) and hence improved cotton plant growth and this was reflected on producing higher number of open bolls/ plant and heavier boll weight and consequently high yield per plant or per feddan.

In this respect, Bhatt and Ramanujam (1971) found that the number of harvested bolls, boll weight and seed cotton yield/ plant were not affected by spraying cotton plants with GA_3. Aly (1975) found that spraying the Egyptian cotton, Giza 69 with 100 ppm GA_3 at 100 days after sowing increased seed cotton yield/plant or /feddan than the control. Boll weight and seed index were not significantly affected by GA_3 treatment. Abdel- Al (1981) found that GA_3 sprays insignificantly increased boll set, seed cotton yield/ plant, boll weight and number of seeds/ boll. Abd El-Naby (1986) found that all GA_3 treatments in general, increased number of open bolls/ plant, seed cotton yield/ plant and boll weight, while lint % and seed index were not significantly affected. Abdel-Al *et al.*, (1990) found that application of 100 ppm GA_3 significantly increased seed cotton yield/ plant ,but boll weight and seed cotton yield/ fed. were not affected by this application. They added that lint% was not affected by foliar application of GA_3 in the first season, while in the second season it was significantly decreased. However, Atia and Ebaid (1990) found that number of total bolls/ plant, number of open bolls, boll weight, lint percentage, seed index, seed cotton yield per plant and per fed. were increased by spraying cotton plants with GA_3. Furthermore, Gamalat (1990) found that GA_3 application significantly increased seed cotton yield/ plant and seed index.

Effect of P :-

The positive effect of SP on leaf macro nutrients (N, P and Mg) content and leaf Mn content may be due to the role of phosphorus in physiological processes of cotton plant (Hearn, 1981). However, the negative effect of SP on leaf K, Ca, Fe, Zn and Cu contents may be due to that P antogenises the absorption of these nutrients (El-Fouly and Abd El-Hamed, 1992).

Foliar feeding with 2% SP produced the shortest plants as compared with the other tested treatments. However, the differences between foliar feeding with 2% SP and the control treatment were insignificant with regard to growth traits under study and this may be due to that : foliar feeding with phosphate fertilizer may alter the nitrogen balance of the plant (Girgis *et al.,* 1984). Moreover, foliar feeding with fertilizer can be control the excessive vegetative growth of cotton plants. (El-Shahawy, 2000).

In this regard, El-Shahawy (2000) found that spraying 8 kg/ fed. superphosphate twice significantly reduced final plant height, main stem internodal length and number of sympodia/ plant.

The increase in boll weight of foliar feeding with 2% SP as compared with the control treatment may be due to that : (1) a very large proportion of P in mature plants is located in seeds and fruits which affects boll development and formation (Mayer and Anderson, 1960). Also, P is involved in energy transfer processes in both photosynthesis and respiration (Hearn, 1981). Moreover, phosphate regulates many enzymic processes and phosphorus also acts as an activator of some enzymes which may affect boll formation and stability (Epstein, 1972), foliar feeding with P control the excessive vegetative growth of cotton plants and consequently led to increase stimulation of yield components characters and caused high seed cotton yield, and (2) P increased leaf N, P, Mg and Mn as compared with the control treatment as shown in Tables (2 and 3), and thus improved flow of assimilates and accumulate more dry weight in fruiting organs as shown from the increase in boll weight (Table 5).

In this respect, Girgis *et al.,* (1984) reported that P fertilization had a significant effect on boll weight, number of open bolls/ plant, seed cotton yield/ plant and /fed. in favour of the combined application of P soil and foliar spray. Mohamad *et al.,* (1988) found that P foliar application did not affect boll weight. Number of open bolls/plant was significantly increased by foliar application of P in one season only due to reducing boll shedding induced by P application. P application increasing seed cotton yield/ plant and /feddan. El-Sayed (1996) found that three foliar sprayings of phosphorus at 75, 90 or 105 days from sowing increased boll set, number of open bolls and seed cotton yield. El-Shahawy (2000) found that spraying 8 kg/fed. superphosphate twice significantly reduced number of aborted sites/ plant and number of unopen bolls/ plant as compared with the control. However, this treatment significantly increased boll retention/ plant, earliness percentage, number of open bolls/ plant, boll weight, seed index and seed cotton yield/ feddan in both seasons and lint percentage in the second season only as compared with the control treatment.

Effect of K :-

Potassium (K), like N, is an essential element required in large amounts for normal plant growth and fiber development.

Potassium is taken into the leaf as the ion K^+. It diffuses across the leaf cuticle; and uptake is decreased into leaves that expanded during a period of water stress . Cotton bolls are heavy consumers of K during the entire boll development stage. If the soil's ability to supply K is nott sufficient, the boll will pull K from adjacent leaves leading to their breakdown. If K leaves drop below 2% their ability to function decline. At 1% K they have essentially shut down. Leaves shed when the level drops to 0.2% K. When leaves breakdown, boll development is halted, resulting in late set bolls with immature fiber and low micronaire. In addition to low yield and micronaire, K deficient cotton suffers reduced length and strength. Apparently, K nutrition is important for many aspects of fiber quality. Incidentally, planting seeds from K deficient fields has inferior germination. Foliar K had been developed as a tool to correct K deficiency discovered during the growing season. Where sufficient time allows for an application of soil K to correct deficiencies, this is the preferred method. K deficiencies can develop even when soil K levels are more than adequate. This is due to the use of higher- yielding faster fruiting varieties, coupled with the decline in root growth during boll development (Oosterhuis *et al.,* 1991).

The positive effect of K on leaf macro nutrients (N, K and Ca) content and leaf micronutrients (Fe and Mn) content may be due to that K is involved in N metabolism and protein synthesis (Hearn, 1981) or to that K increases the outword translocation of photosynthate from leaf (Ashley and Goodson, 1972) and to that K application may enhance many nutrients uptake (Mengel and Kirkby, 1987). However, K reduced leaf Mg content and this negative effect may be due to that K antogenises the absorption of this element (El-Fouly and Abd El-Hamed, 1992).

Foliar feeding with K did not affect plant height at harvest as compared with the control treatment. However, it significantly increased number of main stem internodes and number of fruiting branches/ plant in the first season. The same trend was obtained in the second season, while this treatment decreased average internode length in both seasons as compared with the other tested treatments and this effect may be due to that :- (1) K occurs in the plant as a free ion and is not a constituent of any organic compound. The ion is a cofactor activating a number of important enzymes, including some involving energy transfer and is vitally involved in the translocation of carbohydrates and in the osmotic regulation of turgor. K is also, involved in N metabolism and protein synthesis (Hearn, 1981).

Foliar feeding with K significantly increased numbers of total and open bolls/ plant, boll weight, seed cotton yield per plant and per feddan as compared with the control and this may be due to that:(1) K significantly increased leaf N concentration as compared with the other tested treatments in both seasons as shown in Table 2. K is involved in N metabolism and protein synthesis (Hearn, 1981), (2) K increased leaf K concentration as compared with the other tested treatments as shown in Table 2. K increases both the quantity and the distance that photosynthate moved from the source leaves (Ashley and Goodson, 1972), (3) K significantly increased leaf Fe and Mn contents as compared with the other tested treatments in both seasons and increased leaf Zn content as compared with foliar feeding with 2% SP or the control treatment, as shown in Table 3. K application may enhance many nutrients uptake (Mengel and Kirkby, 1987), (4) major role of K is in photosynthesis (Huber, 1985) by directly increasing leaf growth, leaf area index and therefore CO_2 assimilation (Wolf *et al.,* 1976), and (5) The positive effect of foliar feeding with K is mainly attributed to that the available K in the experimental soil sites is less than the critical level as shown in Table 1. Also, increasing efficiency from applied K was attributed to the partial saturation of K fixation sites from previous additions and thus a larger proportion of newly added K remained in available K pools (Ziadah *et al.*, 2000).

In this concern, Oosterhuis *et al.* (1991) found that K deficiencies can develop even when soil K levels are more than adequate. This is due to the use of higher yielding faster fruiting varieties, coupled with the decline in root growth during boll filling. Melgar *et al.* (1994) found that yield was correlated with petiole K content at floral initiation. Etourneaud (1997) found that the most amount of K^+ which needed by cotton plant is laying after flowering, while at early stages of growth, the seedling requirements is very low. Abd El-Aal *et al.* (1995) found that seed cotton yield/ fed. and most of its attributing variables increased by soil and foliar nutrition with potassium as compared to the control. Lint % and seed index did not significantly affect by the studied potassium fertilizer treatments. Etidal *et al.* (1997) found that spraying cotton plants with potassium sulphate (48 K_2O) at the rate of 9 kg/fed. increased seed cotton yield due to the increase in number of open bolls/ plant and average of boll weight. The treatment had no significant effect on seed index and lint percentage. Abou Zeid *et al.* (1997) found that seed cotton yield/ fed. and/ plant, and its components i.e. open bolls/ plant and boll weight were almost significantly affected by K supply indicating that cotton plant positively responsed to the applied potassium. The benefit from foliar application of K-solution 2 weeks after 1st bloom as realized, especially when it was applied as a supplementary feeding combined with soil application after thinning. Potassium fertilization showed no effect on seed index.

CONCLUSION

Finally, it could be concluded that:

1-Foliar feeding twice with an aqueous filtered solution of potassium sulphate (48% K_2O) at the beginning of flowering and 15 days later at the level of 2% potassium sulphate is the best treatment for cotton growing and productivity .

2-Foliar spraying twice with ascorbic acid solution at the level of 1000 ppm or foliar spraying with gibberellic acid solution twice at the level of 100 ppm produced higher seed cotton yield than the control treatment.

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استجابة صنف القطن جيزة ٨٩ للرش بحمض الأسكوربيك ، حمض الجبريليك والفوسفور والبوتاسيوم

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة محافظة الغربية خلال موسمى (٢٠٠٠ ، ٢٠٠١) لدراسة تأثير الرش بحمض الأسكوربيك بتركيز ١٠٠٠ جزء فى المليون ،حمض الجبريليك بتركيز ١٠٠ جزء فى المليون ، سوبر فوسفات الكالسيوم بتركيز ٢% ، سلفات البوتاسيوم بتركيز ٢% مقارنة بعدم المعاملة (الرش بالماء) ككنترول على محتوى الورقة من العناصر ، النمو ، التبكير ، محصول القطن الزهر ومكوناته لصنف القطن جيزة ٨٩

ويمكن تلخيص أهم النتائج المتحصل عليها كما يلى

أدى الرش بحمض الأسكوربيك بتركيز ١٠٠٠ جزء فى المليون لزيادة معنوية فى محتوى الورقة من النيتروجين ، الفوسفور ، الكالسيوم ، الحديد ، الزنك ، المنجنيز مقارنة بمعاملة الكنترول بينما أدت هذه المعاملة إلى نقص غير معنوى فى محتوى الورقة من النحاس مع زيادة فى محتواها من البوتاسيوم والماغنسيوم مقارنة بمعاملة الكنترول . أعطت أيضا هذه المعاملة زيادة معنوية فى طول النبات عند الجنى مقارنة بمعاملة الكنترول أو التغذية الورقية بالفوسفور أو بالبوتاسيوم ويرجع ذلك لزيادة عدد سلاميات الساق بينما قل متوسط طول السلامية . بالإضافة إلى ذلك فان هذه المعاملة أعطت زيادة معنوية فى عدد اللوز الكلى والمتفتح على النبات ، وزن اللوزة ، محصول القطن الزهر للنبات وكذلك للفدان مقارنة بمعاملة الكنترول .

أدى الرش بحمض الجبريليك بتركيز ١٠٠ جزء فى المليون لزيادة معنوية فى محتوى الورقة من العناصر الكبرى (النيتروجين ، الفوسفور ، البوتاسيوم ، الكالسيوم ، الماغنسيوم) ومن العناصر الصغرى (الحديد ، الزنك ، المنجنيز ، النحاس) وذلك مقارنة بمعاملة الكنترول فى الموسمين ، وقد أدت هذه المعاملة أيضا لزيادة معنوية فى طول النبات عند الجني مقارنة بباقى المعاملات المختبرة الأخرى بسبب زيادة عدد سلاميات الساق ومتوسط طول السلامية وعدد الأفرع الثمرية على النبات. بالإضافة لذلك فان هذه المعاملة أدت إلى زيادة معنوية فى عدد اللوز الكلى والمتفتح على النبات فى الموسم الأول ووزن اللوزه ، محصول القطن الزهر للنبات وكذلك للفدان فى الموسمين وذلك مقارنة بمعاملة الكنترول .

أدى الرش بسوبر فوسفات الكالسيوم بتركيز ٢% لزيادة فى محتوى الورقة من النيتروجين والفوسفور والماغنسيوم والمنجنيز وقلل محتوى الورقة من البوتاسيوم والكالسيوم والحديد والزنك والنحاس فى الموسمين مقارنة بمعاملة الكنترول . وقد أعطت هذه المعاملة أقصر نباتات وأقل عدد من السلاميات مع قصر فى طول السلامية مقارنة بمعاملة الكنترول . بالإضافة لذلك فان هذه المعاملة أدت إلى زيادة فى محصول القطن الزهر للفدان ومكوناته ولكن إلى مدى أقل مقارنة بباقى المعاملات الأخرى المختبرة .

أعطى الرش بسلفات البوتاسيوم بتركيز ٢% أعلى القيم من حيث محتوى الورقة من النيتروجين ، البوتاسيوم ، الحديد ، المنجنيز مقارنة بباقى المعاملات الأخرى المختبرة بينما أدى الى نقص محتوى الورقة من الماغنسيوم مقارنة بمعاملة الكنترول . أعطت أيضا هذه المعاملة نباتات لها نفس طول نباتات المقارنة بينما ادت الى زيادة معنوية فى عدد سلاميات الساق مع قصر السلاميات مقارنة بمعاملة الكنترول بالإضافة لذلك فإن هذه المعاملة أعطت زيادة معنوية فى عدد اللوز الكلى والمتفتح على النبات ، وزن اللوزة ، محصول القطن الزهر للنبات وكذلك للفدان مقارنة بمعاملة الكنترول .

أعطت كل المعاملات المختبرة تأثير غير معنوى على النسبة المئوية للتبكير ، تصافى الحليج ، معامل البذرة ، عدد البذور فى اللوزة .

تم الحصول على أعلى محصول قطن زهر للفدان وكذلك مكوناته كمتوسط للموسمين من التغذية الورقية بسلفات البوتاسيوم بتركيز ٢% بينما تم الحصول على اقل القيم من معاملة الكنترول.

وتوضح هذه النتائج أن التغذية الورقية بسلفات البوتاسيوم بتركيز ٢% هى افضل المعاملات ويليها الرش بحمض الأسكوربيك بتركيز ١٠٠٠ جزء فى المليون او حمض الجبريليك بتركيز ١٠٠جزء فى المليون وذلك مرتين (عند بداية التزهير ثم بعدها بـ ١٥ يوم) من حيث النمو والإنتاجية العالية لصنف القطن جيزة ٨٩ تحت ظروف منطقة الجميزة .