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Role of Application Method in Responses of Cotton Plants to Micronutrients and Potassium Humate

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ABSTRACT

Afield experiment was carried out in a clayey textured soil (Clayey, Smectitic, Superactive, Mesic, Typic) located at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate, Egypt (30^o 56 N latitude and 31^o 05 E longitude) to study the effect of different application methods (foliar fertilization and seed coating) with mixture of some micronutrients (Fe, Mn, Zn) and potassium humate on cotton Giza CV 94 during summer seasons of 2015 and 2016. A split plot design was used with three replicates. The main plots were assigned with three application methods: foliar application, seed coating and (foliar + seed coating). The sub plots were assigned with three treatments of Micronutrients, potassium humate and mixture of (micronutrients + potassium humate) in addition to the control treatment. The obtained results can be summarized as follow:- Plant height and number of fruiting branches were increased by (spraying + seed coating) method during the two seasons. Meanwhile the fertilizer treatment of (micronutrients mixture + potassium humate) significantly increased plant height (cm) and number of fruiting branches.plant^{-1}. Foliar spraying + seed coating treatment gave the highest values of number of open bolls, boll weight, seed index and seed cotton yield. fed^{-1}., compared with the other two application methods. Plants sprayed or coated with mixture of (micronutrients + potassuim humate) caused a significant increase in number of bolls.plant^{-1}, boll weight and seed index. Mix of (micronutrients + potassuim humate) produced the highest significant values of seed cotton yield.fed.$^{-1}$, but untreated plants gave the highest values of earliness in the two season compared with other treatments. The highest values of the fiber fineness were obtained by spraying plants with mixture of (micronutrients + potassium humate). On the other hand, coating seeds with (micronutrients + potassium humate) gave the highest values of fiber strength. Mixture of (micronutrients + potassium humate) increased the concentrations of N, P, K, Mn, Zn and Fe in cotton last mature leaves. Also, the highest values of N, P, K, Mn, Zn and Fe in cotton last mature leaves were obtained when (seeds coating and foliar) was used with mixture of (micronutrients + potassium humate).

Keywords: *Micronutrients, Potassium Humate, Coating, Foliar and Cotton.*

INTRODUCTION

In Egypt, cotton (*Gossypium barbadense L.*) is one of the most important fiber and oil crops for local industry and export.

Available statistics show that cotton makes up 20 percent of Egypt's agricultural exports and provides livelihood to more than half a million Egyptian rural households and indirectly generates over one million additional jobs .

During 2016/2017 season Cotton planted area reached around 216, 800 feddan in all Governorates of Egypt, where seed cotton yield reached to 10 kentar.fed.$^{-1}$ MASR (2017).

Cotton seed production per unit area is affected by many factors i.e. (Genotypes, time of sowing, irrigation intervals, fertilization and soil status).

So that fertilization plays an important role to realize maximum cotton seed. Yield of cotton can be significantly increased with the suitable method of micronutrients application. Soil application proved to be not ideal and sufficient because that method led to not only fixation of the nutrients in the soil but also leaching them during frequency irrigation Harris (2014). Therefore, now many attempts were done to use other application methods of fertilizers such as foliar application and seed coating.

Micronutrients are elements which are essential for plant growth, but are required in much smaller amounts than those of the primary nutrients, N, P and K. Mengel and Kirkb (1987). Vasudevan, *et al*., (2016) observed that seed coating with micronutrients helps in increasing productivity of cotton.

Iron is involve in the production of chlorophyll , also it is a component of many enzymes associated with energy transfer, legnin formation and nitrogen reduction fixation. It is associated with sulfur in plant to form compounds that catalyze other reactions. Foliar Application of Iron was found to be benfical for cotton plant growth, yield, and fiber properties. Eleyan, (2008) and Eleyan, *et al*., (2014).

Manganese is nimportant in photosynthesis process that allows the plant to convert sunlight to energy , nitrogen metabolism and to form other componends required for plant metabolism. Abdalla and Mohamed (2013) studied the response of cotton cultivars to foliar application of a combined of each of iron, manganese and zinc and they found that cultivars significantly varied in each of plant height, number of sympodial branches per plant. Manganese and Iron application significantly affected cotton growth and yield (Eleyan, 2008).

Zinc is essential components of various enzyme systems for energy production, protein synthesis, and growth regulation. Zinc is known to have an important role in nutrients uptake and metabolism. in addition, hormonal regulation (Li, *et al*., 2009).

Humic acid is the major components of humic substances (HS) which formed through the chemical and biological humification of plant and animal matter and through the biological activities of microorganisms (Anonymous, 2010).

The effects of humic acid on plant growth depended on the source and concentration, as well as on the molecular fraction weight of humus . It seems that humic acids may influence both respiration and photosynthesis (Nardi *et al*., 2002)

Humic acid may directly have positive effects on plant growth and increases the growth of roots and shoots, absorpition of N, P, K, Ca, Zn, Mn, Fe by plant. Also it is consistent with nature and isn't dangerous for the plant and envernoment (Haghighi *et al*., 2013 and Saruhan *et al*., 2011). Potassium humate is a potassium salt of humic acids.

Abdel Mawgoud *et al*., (2007) show that humic acids increases plant growth through chelating different nutrients to overcome the lack of nutrients, and has useful effects on growth increase, production and quality. Also, Mayhew, 2004 states that humic acids may possibly enhance the uptake of minerals through the stimulation of microbiological activity. The tallest cotton plant and the great number of sympodial.plant[1] were produced by foliar spraying of humex three times with the rate of 5 $cm^3.L^{-1}$ (Emara and Hamoda 2012).

The aim of this investigation is to study the response of cotton plants to application methods (foliar , coating and foliar + coating) with mixture of micronutrients and potassium humate and their effects on the productivity and quality of Egyptian cotton.

MATERIALS AND METHODS

Afield experiment was carried out in a clayey textured soil (Clayey, Smectitic, Superactive, Mesic, Typic) located at Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate, Egypt (30^o 56 N latitude and 31^o 05 E longitude) to study the effect of different application methods (foliar fertilization and seed coating) with mixture of some micronutrients (Fe, Mn, Zn) and potassium humate on cotton Giza CV 94 during summer seasons of 2015 and 2016.

A split plot design was used with three replicates. The main plots were assigned with three application methods: foliar application, seed coating and (foliar + seed coating).

The sub plots were assigned with three treatments (Micronutrients, potassium humate and mixture of micronutrients + potassium humate) in addition to the control treatment. Thus 10 treatments were examined.

Mechanical and chemical analyses of soil of the experimental field were done according to Black *et al.*, (1965) and Jackson (1967) before cultivation (Table 1).

Table 1. Some physical and chemical properties of the surface (0-30 cm) of the experimental soil at 2015 and 2016 seasons.

Variances		2015	2016
Practical size distribution	Sand	11	11.2
	Silt	38.3	38.1
	Clay	50.7	50.7
Texture		clayey	Clayey
pH *		8.15	8.15
EC dSm^{-1} **		2.6	2.7
Anion $meq.l^{-1}$	$SO4^{--}$	6	5.9
	Cl^-	17	18
	CO_3^-	3	3.1
	HCO_3^-	-	-
Cation $meq.L^{-1}$	K^+	3.5	3.7
	Na^+	8.1	8.3
	Ca^{++}	7.8	8.4
	Mg^{++}	6.6	6.6
Available nutrients $mg.kg^{-1}$	N	35.39	33.14
	P	7.7	7.23
	K	235.1	220.0
	Fe	2.91	2.72
	Mn	0.76	0.67
	Zn	3.13	3.12

***pH in 1:2.5 soil : water suspension. **Ece in soil paste extract.**

Tested application methods:

1-coating application:

With regard to coating treatments, the cotton seeds first, were coated with a solution of sticker substance (Triton B), and then mixed with the tested nutrient mixture (3% Fe, 1% Mn and 0.5% Zn ($FeSO_4.7H_2O$, $MnSO_4.5H_2O$, $ZnSO_4.7H_2O$) at a rate of 5 $g.kg^{-1}$ seed from the treated and then cultivated in three replicates.

Seeds were coated with K-humate at a rate of 100 g potassium $humate.kg^{-1}$ seed or coated with mix of (micronutrients + K- humate).

2-Foliar application :

In the case of foliar spray of micronutrients treatment a solution from 5 g of micronutrients mixture in 5 litre water was prepared for spraying in three replicates through two doses. The first dose was applied at before squaring, and the second dose was before flowering.

Foliar spray of K-humate : a solution of 100 g potassium humate in 5 litre water was prepared for spraying in three replicates through two doses. The first dose applied at before squaring, and the second dose was before flowering.

3- coating + foliar application:

In the case of coating + foliar spray of micronutrients treatment, 2.5 g of micronutrients mixture for coating and its coated with K-humate at a rate of 50 g potassium $humate.kg^{-1}$ seed .

Foliar spray of micronutrients + K-humate : a solution of 2.5 g of Micronutrients + 50 g potassium humate in 5 litre water was prepared for spraying in three replicates through two doses. The first dose applied at before squaring, and the second dose was before flowering.

The experimental plot consisted of six rows, 3.5 m long and 0.6m width (plot area=12.6 m^2). The seeds were sown on 25 and 27 April in the first and second seasons, respectively. All plots were soil fertilized with nitrogen fertilizer at a rate of 60 kg $N.fed^{-1}$ in the form of urea (46.5%) 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. Phosphorus fertilizer was applied during soil preparation in the form of Calcium supr phosphate (15.5% P_2O_5) at a rate 30 kg $P_2O_5.fed^{-1}$. Potassium at the rate of 24 kg $K_2O.fed^{-1}$ in the form of potassium sulphate (48% K_2O).

Ten plants were collected randomly from each plot at 120 DAS sowing to determine Plant height (cm), number of fruiting $branches.plant^{-1}$, yield and yield components.

At harvest, samples of ten guarded plants were taken randomly and labeled from each plot to determine number of open bolls. $Plant^{-1}$, boll weight (g), seed index "100 seed weight"(g) and seed cotton $yield.fed^{-1}$ (kentar), i.e. 157.5 kg. was determined from the three middle rows from each sub- plot.

$$\textbf{Earliness \%} = \frac{\textbf{Yield of cotton for the first picking}}{\textbf{Total yield of seed cotton for the first and second picking}} \textbf{ x 100}$$

Samples of lint cotton were taken from the above ten representative plants from each sub plot after ginning seed yield on a laboratory gin stand to determine fiber fineness (Micronaire value), fiber strength (Gm/ tex)

The two fiber quality characteristics were determined at the laboratoris of cotton technology research division at Cotton Research Inistitute, ARC, Giza by using a high volume instrument (HVI model statex fiberotex 900). All according to (ASTM :D 3818-1986).

Soil sample were taken after harvesting to Determine some available elements. Available nitrogen of the soil was extracted by 1N potassium chloride and determined by Kjleldhl method (Jackson, 1967), phosphorus was extracted by 0.5N sodium bicarbonate and calorimetrically measured by spectrophotometer (Jackson, 1967). Available Potassium was extracted by 1N ammonium acetate and measured by flame photometer (Jackson, 1967). Available iron, manganese and zinc were extracted by EDTA (Ethylene di amine tetra acetic acid) and measured by atomic absorption (Jackson, 1967). Plant samples (the fourth leaf as the first mature leaf) oven dried 70C° and ground thoroughly, wet digested using sulphoric and perchloric acids mixture, total nitrogen , total phosphorus , total potassium. total iron, total manganese and total zinc were determined according to Jackson (1967).

The analysis of varience was carried out for each character in each season as out lined by Gomez and Gomez (1984). The differences between the means of different treatment were tested using (LSD) at 5% level of probability were used to compare between treatments means.

RESULTS AND DISCUSSION

Data recorded in Table 2 show that (Coating) application method induced highly significant effect on Plant height in first season only. The highest value (173.33). Also, data observed that (foliar + coating) application method induced highly significant effect on number of fruiting branches.plant^{-1}in first season only.The highest value (18.87).

Plant treated with (micronutrients + K-humate) treatments gave the highest values of the number of fruiting branches (19.15 & 18.95) in the first and second season respectively, in comparison with the control treatment. On the other hand nither application methods nor fertilizer treatments had no significant effects on plant height (cm) during 2015 and 2016 seasons.

These results may be due to these micronutrients nutrients in cotton leaves and petiole's which increased number of fruting branches.plant^{-1} (Oosterhuits *et al.*, 2010 and Ahmad *et al.*, 2016). Zinc application improved the transport and deposition of assimilates in fruiting body resulting in enhanced fruit yield and quality Wójcik *et al.*, (2008).

Dordas, 2009 and Abdallah and Mohamed,2013 found that the cotton cultivars significantly varied in plant growth due to Mn, Zn and Fe application.

Table 2. Effect of application methods and fertilizer treatments on some vegetative growth parameters (plant height (cm) and No. of fruting branches.plant^{-1}) of Egyptian cotton.

Treatments	Plant height (cm)		No. of fruiting branches.plant^{-1}	
	2015	2016	2015	2016
A) Application methods				
Foliar	171.18	165.94	18.74	18.07
Coating	173.33	167.05	18.62	17.94
Foliar + coating	168.33	164.98	18.87	18.60
L.S.D at 0.05	3.19	6.68	0.09	1.30
Control	172.67	166.45	18.42	17.55
B) Fertilizer treatments				
Micronutrients	171.14	166.42	18.72	18.42
K - Humate	170.17	166.20	18.68	17.88
Mixture	169.80	164.87	19.15	18.95
L.S.D at 0.05	2.04	6.49	0.17	0.78
F.T.	*	N.S	*	*

Data represented in Table 3 reveal that there are a significant effect on plant height during the first season only. On the other hand, no significant effect of the interaction on plant height in the second season and on number of fruiting branches.plant^{-1} in the two seasons.

Ahmad *et al*, (2016), who found that the integrated use of zinc and macronutrients (NPK) caused a significant improvement in cotton plant height.

Higher uptake of zinc promote the synthesis of growth promoting hormones, especially the production of auxins resulting in enhanced growth and increased the number of internodes that promoted the development of main shoot as well growth of sympodial branches (Yaseen *et al*, 2013)

Table 3. Effect of the interaction between application methods and fertilizer treatments on some vegetative growth (plant height (cm) and No. of fruting branches.plant^{-1}) of Egyptian cotton.

Treatments		Plant height (cm)		No. of fruiting branches. Plant^{-1}	
		1 st	2 nd	1 st	2 nd
Foliar	Control	172.35	166.37	18.70	18.66
	Microelements	172.28	166.07	18.58	18.33
	Potassium Humate	170.53	165.33	18.56	18.28
	Mixture	169.68	165.23	19.10	18.19
Coating	Microelements	173.78	168.15	18.70	18.95
	Potassium Humate	173.09	166.51	18.73	18.93
	Mixture	172.87	166.38	19.03	18.66
Foliar + Coating	Microelements	168.78	164.06	18.45	17.31
	Potassium Humate	168.06	163.77	18.33	17.20
	Mixture	168.95	163.16	19.33	17.17
L.S.D at 0.05		0.23	25.12	12.23	0.27
F.T.		*	NS	N.S	N.S

Application of (micronutrients + K-humate) using any method (foliar or coating) significantly increased No. of open bolls.plant^{-1} as compared with control plants in both seasons. The maximum values of number of open bolls.plant^{-1} were obtained from (foliar + coating) (34.78 & 29.49) in the first and second season respectively, compared with other application methods. But all treatments of application methods had no significant effects during two seasons on boll weight (g) (Table 4).

Plants treated with (micronutrients + K-humate) caused a significant increase in number of open bolls.plant^{-1}. The heighest values were (34.26 & 29.56) on No. of open bolls.plant^{-1}. The increase may be due to its positive effects on transpiration, stomata regulation, nutrient uptake and its transport.

Regarding the effect of micronutrients and K-humate treatments on boll weight, the data show that treatment plants with mix of (micronutrients + K-humate) gave the highest values compared with other treatments (3.07 & 2.82) in first and second seasons respectively. Sharma *et al.,* (1982) found a significant increase on the mean of the boll weight and he attributed this to the favorable effect of this nutrients on the carbohydrate metabolism.

Also, Ahmad *et al* (2016), demonstrated that , Zinc fertilizers gave the maximum of the number of bolls/plant.

The balanced use of macro and micronutrients resulted in a significant increase in yield and product quality. Lint quality is adversely affected by micronutrients deficiency as it has a primary role in regulating boll development (Kausar *et al*., 2001 and Ahmad *et al*., 2009).

Abdallah and Mohamed (2013) studied the response of Giza 90 and Giza 92 cotton cultivars to foliar application of a combined of each of iron, manganese and zinc. The results showed that cultivars significantly varied in each of plant height.

Table 4. Effect of application methods, fertilizer treatments on No. of open bolls.plant^{-1} and boll weight of Egyptian cotton.

Treatments	No. of open bolls.plant^{-1} 1st	No. of open bolls.plant^{-1} 2nd	Boll weight (g) 1st	Boll weight (g) 2nd
A-Application methods				
Foliar	33.31	29.05	2.92	2.74
Coating	32.82	28.99	2.97	2.80
Foliar+Coating	34.78	29.49	2.92	2.74
L.S.D at 0.05	1.40	0.73	0.05	0.12
F.T.	*	*	N.S	N.S
B) Fertilizer treatments				
Control	32.83	28.23	2.73	2.68
Mix of micronutrients	34.08	29.49	3.01	2.79
Potassium humate	33.38	29.15	2.94	2.75
Mixture	34.26	29.56	3.07	2.82
L.S.D at 0.05	1.02	0.74	0.08	0.11
F.T.	*	*	*	*

It is clear from Data of Table 5 indicated that the interaction effects between application methods and fertilizer treatments on No. of open bolls. plant^{-1} and boll weight (g). The data indicate that the application of (mixture of micronutrients and K-humate) with (foliar and coating) produced the highest significant increase in No. of open bolls.plant^{-1} (37.89 and 35.66) in first and second seasons respectively. On the other hand, the lowest values were obtained by foliar or coating plants with the control treatment.

The interaction between application methods and fertilizer treatments led to significant increase on means of boll weight in the first season. Foliar + coating with (mix of micronutrients and K-humate) gave the highest values compared with other treatments (3.10 g) compared with the control treatments. On the other hand, there are no significant effects for the interaction in second season.

These results are harmony with those obtained by Eleyan, (2008) who found that Manganese and iron application significantly affected number of bolls.plant^{-} .

Dordas (2009) and Yaseen *et al*., (2013) reported that Manganese application increased the number of bolls per plant in cotton plant.

Table 5. Effect of the interaction between application methods and fertilizer treatments on No. of open bolls.plant^{-1} and boll weight of Egyptian cotton.

Treatments		No. of open bolls.plant^{-1} 1st	No. of open bolls.plant^{-1} 2nd	Boll weight (g) 1st	Boll weight (g) 2nd
Foliar	Control	35.44	33.59	2.90	2.78
	Microelements	35.00	33.53	2.84	2.77
	Potassium Humate	34.87	33.30	2.61	2.75
	Mixture	36.78	32.97	3.06	2.74
Coating	Microelements	36.00	35.12	2.70	2.85
	Potassium Humate	35.88	35.05	3.00	2.84
	Mixture	36.66	34.21	3.03	2.79
Foliar + Coated	Microelements	34.67	32.66	2.93	2.71
	Potassium Humate	34.50	32.36	2.96	2.61
	Mixture	37.89	35.66	3.10	2.63
L.S.D at 0.05		0.05	0.03	0.12	6.42
F.T.		*	*	*	NS

Data presented in Table 6 show that application methods in the two seasons had no effects on earliness%. On the other hands, all fertilization treatments : Control plants, plants treated with mix on micronutrients and treated with potassium humate had significant increase of earliness. compared with other treatments.

Table 6. Effect of application methods and fertilizer treatments on earliness %, seed index and seed cotton yield of Egyption cotton.

Treatments	Earliness % 1st	Earliness % 2nd	Seed index (g) 1st	Seed index (g) 2nd	Seed cotton yield / fed/ kentar 1st	Seed cotton yield / fed/ kentar 2nd
A) Application Methods						
Foliar	60.24	56.46	12.04	11.87	9.49	8.26
Coating	60.28	56.67	11.88	11.97	9.35	8.40
Foliar+coating	58.73	56.27	12.32	11.79	10.00	8.00
L.S.D at 0.05	3.72	0.83	0.08	0.27	0.40	0.19
F.T.	N.S	N.S	*	N.S	*	N.S
B) Fertilizer treatments						
Control	60.66	57.38	11.88	11.14	9.35	8.00
Mix of micronutrients	60.10	56.87	12.20	12.13	9.62	8.42
Humic acid	59.14	56.60	11.92	12.04	9.71	8.29
Mixture	59.10	55.04	12.34	12.19	10.10	8.80
L.S.D at 0.05	3.02	0.72	0.04	0.16	0.29	0.20
F.T.	N.S	*	*	*	*	*

***Kentar = 157 .5 kg**

The data presented in Table 6 show that (foliar plants + coating seeds) with micronutrients gave the highest values from seed index (g) (12.34 & 12.19) in first and second seasons respectively. Also, the highest values from seed cotton yield (10.10 & 8.80)) Kentar.fed^{-1}. In first and second seasons, respectively, compared with the other two application methods. This might be due to its favorable effect on photosynthetic activity, which improves mobilization of photosynthesis and directly influences boll weight that coincides with increased seed index (Hai *et al*, 1999).

The beneficial effect of spraying micronutrient elements could be attributed to the role of micronutrients on fundamental metabolic reactions and acceleration of protein synthesis which affects boll development and hence promoting open bolls number which resulted in increased seed cotton yield, Abdallah and Mohamed, (2013).

The interaction effect between application methods and micronutrients or k-humate, the data indicate that the application as spraying plants and coating seeds with mix of micronutrients produced the highest significant increase in seed index and seed cotton yield. The highest values of seed index (g) were (12.43 & 12.59), also, the highest values of seed cotton yield (Table 7) kentar/fed were (10.16 & 8.62) in first and second seasons respectively.

Several previous studies had determined the positive effect of boron and zinc along with NPK fertilizers on growth, yield, lint quality of Bt-cotton (Ali *et al*., 2011 and Singh *et al*., 2015).

Haroon *et al*., (2010) demonstrated that, addition of 1.0 $kg.ha^{-1}$. Humic could supplement NPK fertilizer and enhance farmer's income by increasing yield. Foliar application of micronutrients during flower and boll development stages have been shown to increase cotton yield Radhika *el al*., (2013).

Table 7. Effect of the interaction between application methods and fertilizer methods on Earliness %, Seed index and Seed cotton yield of Egyptian cotton.

Treatments		Earliness %		Seed index (g)		Seed cotton yield / fed/ kentar	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Foliar	Control	60.11	56.85	12.29	11.83	9.36	8.20
	Microelements	59.96	56.75	12.28	11.98	9.39	8.28
	Potassium Humate	59.41	56.68	12.20	11.99	9.49	8.31
	Mixture	59.24	56.50	12.39	12.34	10.00	8.54
Coating	Microelements	60.99	57.76	11.58	11.11	9.20	7.86
	Potassium Humate	60.76	57.29	11.77	11.28	9.22	8.01
	Mixture	60 15	57.26	12.34	12.20	9.98	8.46
Foliar + coating	Microelements	58.74	55.36	12.11	12.07	9.57	8.35
	Potassium Humate	58.22	54.63	11.87	12.08	9.75	8.45
	Mixture	57.73	53.74	12.43	12.59	10.16	8.62
L.S.D at 0.05		23.14	0.02	0.07	2.14	0.36	0.18
F.T.		NS	*	*	*	*	*

*** Kentar = 157.5 kg**

Significant differences among the three application methods for fiber fineness in both seasons (Table 8). The highest values were obtained by foliar application among the two seasons . The highest values on fiber fineness were (4.7 & 4.4) and the highest values on fiber strength were (9.5 & 9.9) in first and second seasons respectively.

Concerning the effect of nutrient elements on fiber technology, all treatments had no significant effect on fiber fineness and strength during the first season only , but in second season Micronutrients + K-humate gave the highest values (4.2 & 9.8) respectively, compared with other treatments and a chieved the sognificancy.

Table 8. Effect of application methods and fertilizer treatments on Fiber fineness and Fiber strength of Egyptian cotton.

Treatments	Fiber fineness (Micronaire value)		Fiber strength (Pressely)	
	1st	2nd	1st	2nd
A) Application methods				
Foliar	4.7	4.4	9.5	9.9
Coating	4.6	4.1	9.5	9.4
Foliar+coating	4.5	4.2	9.5	9.3
L.S.D at 0.05	0.04	0.05	0.27	17.86
F.T.	*	*	N.S	*
B) fertilizer treatments				
Control	4.8	4.1	9.4	9.3
Mix of micronutrients	4.8	4.1	9.4	9.5
Potassium -humate	4.8	4.1	9.4	9.6
Mixture	4.8	4.2	9.4	9.8
L.S.D at 0.05	0.09	0.04	0.23	15.59
F.T.	NS	*	NS	*

These results are in line with findings of Eleyan, 2008 and Abdallah and Mohamed 2013 who reported that cotton fiber length was significantly affected by spraying cotton plant with micronutrients (Fe, Mn, Zn).

Foliar application of manganese and iron indicated marked improvement and produced significant effect on increasing seed cotton yield (Eleyan *et al*., 2014).

Table 9 represents the effect of interaction treatments between application methods, fertilizer treatments on fiber fineness and strength. The maximum values were obtained when (seeds coating + plant sprayed) with mixture of (micronutrients + K-humate) (4.9 & 4.3), but the lowest values with (control) (4.4 & 4.1) on Fiber Fineness in first and second seasons respectively.

Table 9. Effect of the interaction between application methods and fertilizer treaments on Fiber fineness and Fiber strength of Egyptian cotton.

Treatments		Fiber fineness (Micronaire value)		Fiber strength (Pressely)	
		1 st	2 nd	1 st	2 nd
Foliar	Control	4.4	4.1	10.0	9.4
	Microelements	4.5	4.0	10.1	9.4
	Potassium Humate	4.5	4.0	9.5	9.4
	Mixture	4.8	4.2	10.0	9.4
Coating	Microelements	4.6	4.2	9.5	9.5
	Potassium Humate	4.6	4.1	9.8	9.5
	Mixture	4.8	4.2	9.9	9.4
Foliar + coating	Microelements	4.8	4.2	9.4	9.3
	Potassium Humate	4.9	4.0	10.0	9.3
	Mixture	4.9	4.3	10.1	9.2
L.S.D at 0.05		0.004	0.13	0.02	17.58
F.T.		*	*	*	NS

On the other hand, all interaction treatments gave no significant effect on fiber strength in the second season, but gave a significant effect in the first season which the highest values had gaven when (seeds coating + foliar sprayed) with mixture of (micronutrients + K-humate) (10.1)

Data presented in Table 10 show that application methods significantly affected N%, P% and K% in the last mature leaf in cotton plants. They had the same sequence. The highest N, P and K% values were obtained with (foliar+ coating) application method. On the other hand the lowest values were recorded with foliar application method. This may be due to (foliar +coating) had high chance to potassium humate and micronutrient absorption.

Table 10. Effect of application methods and fertilizer treatments on N, P and K percentage in last mature leaf of Egyptian cotton.

Treatments	N% 1st	N% 2nd	P% 1st	P% 2nd	K% 1st	K% 2nd
A- Application methods						
Foliar	2.64	2.43	0.14	0.13	2.10	1.83
Coating	3.46	3.23	0.15	0.14	2.67	2.30
Foliar + coating	4.20	4.05	0.16	0.14	3.26	2.95
L.S.D at 0.05	0.12	0.07	0.003	0.004	0.09	0.06
F.T.	*	*	*	*	*	*
B- Fertilizer treatments						
Control	1.89	1.72	0.14	0.12	1.50	1.23
Micro elements	3.35	3.11	0.15	0.14	2.58	2.27
Potassium Humate	3.89	3.68	0.16	0.14	3.00	2.69
Mixture	4.44	4.26	0.17	0.15	3.45	3.08
L.S.D at 0.05	0.10	0.06	0.002	0.002	0.09	0.05
F.T.	*	*	*	*	*	*

Table 10 also show that, mixture of micronutrients fertilizers and potassium Humate substances significantly increased N, P and K% in the last mature leaf of cotton plants. The highest values (4.94, 0.17 & 3.95) and (4.76, 0.15 & 3.58) of N%, P% and K% in first and second seasons, respectively were obtained with mixture treatments. On the other hand the lowest values were recorded with control treatments. This may be due to humate substances have growth enhancing effects and micronutrients completed the plant need which enhance N, P and K uptake . Similar findings were reported by Rady *et al*., (2016).

Data presented in Table 11 reveal that (foliar + coating) application with (micronutrients + K-humate) treatment produced the highest percentages of N, P & K (N, P & K) in last mature leaf in the cotton plants (5.31, 0.17 & 4.15) and (5.21, 0.15 & 3.8) in both seasons respectively.

These results may be due to that the addition of K-humate increased plant uptake of mineral elements due to better developed root system. Also , the stimulation of ions uptake under the application of KH led to that these material affected membrane permeability, on the other hand KH may interact with the phospholipids structures of the cell membranes and react as carriers of nutrients through them. These results were coincided with those reported by Tattini *et al*., (1990) who demonstrated that the humates can stimulated the uptake of macro nutrients.

In addition, Zn plays an important role on nitrogen, phosphorus and potassium uptake by plants and their metabolism and mobilization of photosynthates. These results agree with Li *et al*., (2009).

Iron and Zinc has a synergistic relationship with most of essential nutrients especially nitrogen. Iron is a component of many enzymes associated with nitrogen reduction and fixation. Also Zinc fertilization significantly improved phosphorus accumulation in seeds that enhance the protein contents resulting in the higher seed yield as reported by Aref (2007).

Table 11. Effect of interaction between application methods and fertilizer treatments on N, P and K percentage in last mature leaf of Egyptian Cotton.

Treatments		N% 1st	N% 2nd	P% 1st	P% 2nd	K% 1st	K% 2nd
Foliar	Control	1.82	1.61	0.14	0.12	1.46	1.17
	Microelements	2.07	1.88	0.14	0.13	1.56	1.40
	Potassium Humate	2.32	2.12	0.16	0.15	1.69	1.46
	Mixture	2.85	2.59	0.14	0.13	2.19	1.78
Coating	Microelements	3.02	2.73	0.16	0.14	2.32	1.88
	Potassium Humate	4.27	3.91	0.17	0.15	3.30	2.88
	Mixture	5.15	4.99	0.16	0.15	3.87	3.66
Foliar + coating	Microelements	3.96	4.71	0.16	0.14	3.87	3.53
	Potassium Humate	5.12	5.02	0.18	0.16	4.02	3.71
	Mixture	5.31	5.21	0.17	0.15	4.15	3.8
L.S.D at 0.05		0.18	0.11	0.003	0.004	0.16	0.10
F.T.		*	*	*	*	*	*

Application methods significantly affected Mn, Zn and Fe concentration where they increased Mn $mg.kg^{-1}$ in the second season only, while Zn and Fe $mg.kg^{-1}$ in both season in Table (12) (Foliar + coating) had the highest values (32.44 & 135.42) and (29.74 & 132.24) in first and second seasons respectively, but the lowest values (25.72 & 22.94) and (131.28 & 126.72) were detected with foliar application in first and second seasons respectively . This may be due to foliar + coating causes absorption via, leave and roots. This results are agree with Abdallah and Mohamed (2013) who reported that foliar application of a combined of each of iron, manganese and zinc. They showed that significantly increased in growth parameters and yield components.

Radhika *et al.,* 2013 showed that foliar application of micronutrients have been shown to be effective in efficient utilization of nutrients by cotton and increase the yield.

Eleyan, *et al*., (2014) showed that application of manganese and iron at 200 mgl^{-1} recorded the maximum growth, yield and quality properties.

In respect to fertilizer treatments the values of Mn, Zn & Fe $mg.kg^{-1}$ (37.12, 19.68 & 64.76) and (35.09, 18.22 & 76.62) in 1st and 2nd seasons, respectively were obtained with mixture treatment of fertilizer (micro + KH). On the contrary control treatment recorded the lowest values (28.35, 8.54 & 31.92) and (25.93, 7.14 & 30.12) mg.kg-1 in first and second season, respectively. This may be due to growth the enhancing by HS and effect of microelements.

Table 12. Effect of application methods and fertilizer treatments on Mn, Fe and Zn meg.kg^{-1} in last mature leaf of Egyptian cotton.

Treatments	Mn mg.kg^{-1}		Zn mg.kg^{-1}		Fe mg.kg^{-1}	
	1st	2nd	1st	2nd	1st	2nd
A- Application methods						
Foliar	56.56	42.18	25.72	22.94	131.28	126.72
Coating	61.52	55.00	31.26	27.82	57.26	80.54
Foliar + coating	80.12	57.26	32.44	29.74	135.42	132.24
L.S.D at 0.05	15.23	0.26	0.19	0.11	0.46	0.10
F.T.	N.S	***	***	****	***	***
B- Fertilizer treatments						
Control	56.7	51.86	17.08	14.28	63.84	60.24
Microelements	69.82	65.40	34.24	31.04	124.94	121.74
Potassium Humate	63.48	58.46	28.56	25.56	113.66	117.44
Mixture	74.24	70.18	39.36	36.44	97.28	153.24
L.S.D at 0.05	14.88	0.20	0.13	0.16	0.42	0.19
F.T.	NS	*	*	*	*	*

Data presented in Table 13 that (foliar + coating) application with (micronutrients + K-humate) treatment significantly affected Mn (80.34mg.kg^{-1}) in the second season only while, Mn had no significant effect in the first season.

Table 13 showed that, (Zn & Fe) in both seasons were increased significantly due to the (foliar + coating) application with (micronutrients + K-humate) treatment. The highest values of Zn and Fe were (40.8 & 174.54 mg.kg^{-1}) and (37.2 & 171.6 mg.kg^{-1}) in the first and second seasons, respectively.

This may due to a mechanism through K-humate can stimulate plant growth and element accumulation.

Foliar application of nutrients (N, Mg, Fe, Zn, Mn and B) on growth and yield parameters gave the highest seed cotton yield Singh *et al*., 2015

Table 13. Effect of interaction between application methods and fertilizer treatments on Fe, Mn and Zn ppm in last mature leaf of Egyptian cotton

Treatments		Mn mg.kg^{-1}		Zn mg.kg^{-1}		Fe mg.kg^{-1}	
		1 st	2 nd	1 st	2 nd	1 st	2 nd
Foliar	Control	57.6	52.34	17.2	14.36	64.86	60.15
	Microelements	61	58.14	26.36	23.3	151.54	146.2
	Potassium humate	49	44.42	20.4	18	146.84	142.54
	Mixture	58.6	53.82	38.94	36.14	161.92	158
Coating	Microelements	73	68.34	37.74	35	68.84	69.04
	Potassium humate	69.4	63.66	31.06	26.6	43.26	63.74
	Mixture	79.6	76.4	39.06	36	52.14	130.14
Foliar +coating	Microelements	75.6	69.74	38.6	35.4	154.46	150
	Potassium humate	72	67.32	34.18	32.06	150.86	147.06
	Mixture	84.4	80.34	40.08	37.2	174.54	171.6
L.S.D at 0.05		24.82	0.3602	0.2465	0.2601	0.7258	0.2972
F.T.		N.S	*	*	*	*	*

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اهمية طريقة الاضافة فى استجابة القطن المصرى للتسميد بالعناصر الدقيقة وهيومات البوتاسيوم .

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تم تنفيذ تجربة حقلية فى محطة البحوث الزراعية بسخا – محافظة كفر الشيخ لدراسة تاثير الطرق المختلفة لاضافة العناصر الصغرى وهيومات البوتاسيوم (التسميد بالرش وتغليف البذور) مع خليط من بعض العناصر الصغرى (الحديد والمنجنيز والزنك) وهيومات البوتاسيوم على محصول القطن صنف جيزة 94 خلال الموسمين الزراعين 2015-2016. استخدم تصميم القطع المنشقة فى ثلاثة مكرارات . شغلت القطع الرئيسية من ثلاثة طرق للاضافة : 1- طريقة الرش و 2- التغليف و 3- (الرش والتغلف). شغلت القطع المنشقة من ثلاثة معاملات من : 1- عناصر صغرى 2- هيومات البوتاسيوم و 3- خليط من (العناصر الصغرى وهيومات البوتاسيوم) بالاضافة الى معاملة الكنترول. ويمكن تلخيص النتائج المتحصل عليها كالاتى : ادت طريقة (الرش + التغليف) الي زيادة فى طول النبات وعدد الافرع المثمرة للنبات خلال الموسمين الزراعين . ادت اضافة (خليط العناصر الصغرى + وهيومات البوتاسيوم) الى زيادة معنوية فى طول النبات وعدد الافرع المثمرة للنبات خلال الموسمين الزراعيين. ادت معاملة الرش والتغليف معا الى زيادة عدد اللوز المتفتح عند الجنى , ووزن اللوزة و دليل البذرة ومحصول القطن الزهر قنطارزفدان-1 مقارنة بطريقتي الاضافة الاخريين . تسببت معاملة رش النباتات وتغليف البذور مع التسميد بالعناصر الصغرى وهيومات البوتاسيوم الى زيادة معنوية فى عدد اللوز للنبات ووزن اللوزة ودليل البذور . اعطى خليط العناصر الصغرى وهيومات البوتاسيوم زيادة معنوية فى قيم محصول القطن الزهر للفدان بينما اعطت المعاملات الغير معاملة اعلى القيم فى النسبة المئوية للتبكير خلال الموسمين مقارنة بالمعاملات الاخرى. ظهرت اعلى القيم من نعومة التيلة مع رش النباتات وخليط العناصر الصغرى وهيومات البوتاسيوم وعلى الجانب الاخر اعطت معاملة تغليف البذور مع خليط العناصر الصغرى وهيومات البوتاسيوم اعلى القيم فى متانة التيلة. ادت الخلط بين العناصر الصغرى وهيومات البوتاسيوم الى زيادة تركيز كلا من النيتروجين والفسفور والبوتاسيوم والحديد المنجنيز والزنك والحديد فى اخر ورقة ناضجة من القطن. ظهرت اعلى القيم من كلا من (النيتروجين والفسفور والبوتاسيوم والمنجنيز والزنك والحديد) فى اخر ورقة ناضجة من القطن عندما غلفت البذور ورشت بخليط من العناصر الصغرى وهيومات البوتاسيوم.