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Effect of Foliar Feeding with some Micronutrients on Cotton Leaf Nutrient Content, Growth, Earliness, Yield, Yield Components and Fiber Quality Based on Soil Micronutrients Status

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TWO field experiments were carried out at Kafr El-Zayat District, Gharbia Governorate, Egypt in 2000 and 2001 seasons to study the effect of foliar feeding with some micronutrients (Fe, Mn and Zn, EDTA) either alone or in mixtures which contain two or three of these elements at two levels (*i.e.* 1.5g/L and 3.0 g/L) for each treatment twice (*i.e.* at the beginning of flowering and 15 days later) in comparison with untreated plants (control) on leaf nutrient content, growth, earliness, yield and its components and fiber quality of the Egyptian cotton Giza 89 cultivar. The experimental design was a randomized complete blocks with four replicates.

The important results could be summarized as follows :

-The effect of the different micronutrients on leaf N content was negative in the first season as compared with the control. However, the effect of the tested micronutrients was positive for leaf P-content in the first season and for leaf K and Mg contents in both seasons. The tested micronutrients significantly increased leaf Fe, Mn, Zn and Cu contents as compared with the control especially when using complete mixture of Fe, Mn and Zn at the high level in both seasons.

-Foliar feeding with the tested micronutrients gave a positive effect on growth traits, earliness, yield and yield components in both seasons either using the three tested micronutrients alone or in their mixtures at the low or high levels as compared with the control (untreated). The highest values of these traits were obtained from foliar feeding twice with the mixture of Fe + Mn + Zn at the high level in both seasons. All mixture compounds of micronutrients gave higher yield than single elements at the two levels in both seasons.

-Also, the results cleared that some treatments had a good effect on fiber properties under study.

-The diagnostic analysis revealed that low yield was relevant to deficiency of micronutrients in these poor alkaline soils and consequently plants grown on them.

-Yield increases were accompanied by improvement of nutrient status in plant leaves.

-It could be concluded that cotton yield can be increased by correction micronutrients deficiency in plant upon soil tests and leaf analysis. Also, soil tests are recommended to evaluate fertility status of cotton fields.

According to available evidence, the low yields obtained were attributed to probable micronutrients deficiency, which was assumed to be a side effect of constructing the Aswan High Dam, Naguib and El-Fouly (1978). Also, Sillanpää (1982) and El-Fouly (1983) mentioned that low availability of micronutrients in soil and plants grown under arid and semi arid climates because of high pH and low organic matter. El-Mowelhi *et al.* (1973) reported that the continued cropping system and the low solubility of micronutrients on most Egyptian soils increased the problem of micronutrients deficiency. Hamissa and Abdel Salam (1999) concluded that the important factor that makes fertilization with micronutrients an important issue is the high level of pH value of most Egyptian soils which hinders the utilization of these elements by the cotton plants and the progress in the field of soil testing and plant tissue tests which facilitates diagnosing the deficiency of micro elements.

Eid *et al.* (1997) reported that Fe, Mn and Zn are important for the metabolic processes of cotton plant leading to both better production and high quality.

Foliar spraying of cotton plants with solution containing micronutrients *i.e.* Fe, Mn or Zn alone was found to increase the yield and its components and improved fiber quality (Saini *et al.,* 1969; Singh *et al.,* 1970 and Abou Khadrah and Zahran, 1979) as well as their mixtures (Huertas, 1963; Singh and Dupey, 1969, Abou Khadrah and Zahran,1979; El-Hattab *et al.*,1981 and El-Fouly *et al.,* 1997).

The aim of the present study was to utilize soil testing as criterion for more efficient and economical use of micronutrients *i.e.* Fe, Mn and Zn and to evaluate the effect of foliar feeding with these micronutrients either alone or in mixtures, on leaf nutrient content, growth, earliness, yield and its components and fiber quality of cotton Giza 89 cultivar in Kafr El-Zayat District, Gharbia Governorate, Egypt.

Material and Methods

Two field experiments were carried out in view of soil micronutrients status at two sites of Kafr El-Zayat District, Gharbia Governorate, Egypt, during 2000 and 2001 seasons to study the effect of two foliar applications of Fe, Mn and Zn either alone or in mixtures as compared with the control (untreated plants) on leaf nutrient content, growth, earliness, yield and yield components and fiber quality of the Egyptian cotton (*Gossypium barbadense* L.), Giza 89 cultivar.

The experiment included 15 treatments of foliar feeding with Fe-EDTA (14% Fe), Mn-EDTA (14% Mn) and Zn-EDTA (14%Zn) either alone or in mixtures which contain two or three elements at two levels for each *i.e.*, low (L) and high (H) levels (1.5 grams and 3 grams per liter of water). These treatments were :

T_1	Control (untreated), spraying with tap water	T_8	$Fe_L + Mn_L$
		T_9	$Fe_H + Mn_H$
T_2	Fe_L	T_{10}	$Fe_L + Zn_L$
T_3	Fe_H	T_{11}	$Fe_H + Zn_H$
T_4	Mn_L	T_{12}	$Mn_L + Zn_L$
T_5	Mn_H	T_{13}	$Mn_H + Zn_H$
T_6	Zn_L	T_{14}	$Fe_L + Mn_L + Zn_L$
T_7	Zn_H	T_{15}	$Fe_H + Mn_H + Zn_H$

The addition of foliar spraying of all treatments was twice, the first one at the beginning of flowering and the second one after 15 days from the first spraying.

A randomized complete block design with four replications was used in both seasons.

Sowing date was 20/3 in both seasons. The plot area was $41.6m^2$ (8m x 5.2m) in both seasons, including 8 rows of 65cm apart and 8 meters long. Hill spacings were 25cm and two plants/hill. The two outer rows of each plot were left as a border.

Phosphorus fertilizer was added at the rate of 22.5 kg P_2O_5/fed. as calcium superphosphate (15.5% P_2O_5) during land 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 and at the next irrigation. Potassium fertilizer was added at the rate of 24kg K_2O/fed. as potassium sulphate (48% K_2O) in one dose at the 1^{st} dose of nitrogen.

The preceding crop was Egyptian clover (berseem). The other cultural practices were done as recommended for the conventional cotton planting.

Studied parameters

A. Soil analysis

Representative soil samples were taken from the experimental soil sites before planting in both seasons and prepared for analysis, according to Chapman and Pratt (1978), the following analyses were carried out as described by El-Moursi *et al.* (1980): soil mechanical analysis, pH, E.C., $CaCO_3$, organic matter, total N, $NaHCO_3$ -extractable- P, NH_4OAC-extractable K, DTPA extractable Fe, Mn, Zn and Cu.

B. Leaf analysis

115 days after sowing, a representative leaf sample (20 leaves) was taken from the youngest fully matured leaf (4^{th} leaf) on the main stem from each plot. After preparation of the samples for analysis, concentration of Fe, Mn, Zn and Cu was determined with an atomic absorption spectrophotometer, and contents of total N, P, K and Mg were determined according to Chapman and Pratt (1978).

C. Growth traits

At harvest, five guarded hills were taken at random from the second row of each plot to determine the following traits :

Plant height (cm) and number of fruiting branches/plant.

D. Earliness

Earliness % was determined as a percentage of the first pick to the total yield.

E. Seed cotton yield and its components

From the above sample taken at harvest, the following yield components were determined: numbers of total and open bolls/plant, boll weight (g), seed cotton yield/plant (g), lint % and seed index (g).

Seed cotton yield/feddan* in kentars** was calculated from the yield of the six inner rows of each plot.

F. Fiber technological properties

Fiber length at 2.5% SL (mm), length uniformity (%), fiber strength at 1/8 inch gauge and fiber elongation (%) [HVI], according to ASTM (D-4605), 1986.. Also, Micronaire reading, fiber maturity % and fiber weight (Micromat).

All fiber tests were carried out at the Cotton Fiber Research Section, Cotton Research Institute, Agricultural Research Centre, Giza, Egypt, at a constant relative humidity 65 + 2% and temperature of 20 + 1.2°C, by using High Volume Instrument (HVI) and Micromat Instrument.

The obtained data were subjected to statistical analysis according to the procedures outlined by Snedecor and Cochran (1976). The treatments means were compared using L.S.D. at 0.05 level of probability.

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*One feddan = 4200.83m^2.

** One kentar = 157.5 kg.

Results

A. Soil tests

Mechanical, physical and chemical properties of soils of the two sites in kafr El-Zayat District, Gharbia Governorate are presented in Table 1. The results show that the two experimental soil sites had high pH and low salinity. $CaCO_3$ and organic matter contents were low. Soil texture was clay. The electrical conductivity of the saturated extract (E.C.) was three times high as in the soil of first season.

Concerning soil macronutrients content, the soils of the two sites were fairly low in total N, very high in extractable-P, and medium in available K.

Regarding soil micronutrients content, the soils of the two sites were poor in their available contents of Fe, Mn, and Zn measured by the critical levels according to Ankerman and Large (1974).

TABLE 1. Soil analysis of the experimental sites in 2000 and 2001 seasons.

Characteristics	2000 season	2001 season
Soil granules %		
Clay	44.2	46.3
Silt	33.0	32.0
Sand	22.8	21.7
Texture	clay	clay
pH	8.0	7.9
E.C. mmhos/cm	1.1	0.35
$CaCO_3$ %	2.4	0.80
Organic matter %	1.6	1.8
Total N	3	3.31
Available P } mg/100g soil	4.3	4.5
Available K	26.5	25.8
Available Fe	9.3	4.3
Available Mn } ppm	3.8	4.0
Available Zn	0.28	0.37
Available Cu	2.3	1.6

B. Leaf nutrient content

Tables 2 and 3 show the effect of the tested micronutrients treatments on leaf macro and micro nutrients content, respectively in both seasons.

TABLE 2. Effect of micronutrients treatments on total leaf content of N, P, K and Mg in 2000 and 2001 seasons.

Treatments	N %		P %		K %		Mg %	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1 Control	4.2	4.3	0.27	0.25	0.2	0.5	0.52	0.33
T_2 Fe_L	2.8	4.4	0.27	0.30	0.9	1.0	0.60	0.56
T_3 Fe_H	2.9	3.8	0.28	0.28	0.9	0.9	0.63	0.49
T_4 Mn_L	2.8	3.8	0.24	0.29	0.7	1.2	0.43	0.53
T_5 Mn_H	2.9	4.0	0.21	0.32	0.7	1.0	0.59	0.57
T_6 Zn_L	3.7	4.1	0.25	0.29	0.6	1.4	0.43	0.57
T_7 Zn_H	2.6	4.2	0.22	0.29	0.6	1.3	0.44	0.56
T_8 $Fe_L + Mn_L$	2.8	4.1	0.31	0.25	0.6	0.8	0.60	0.55
T_9 $Fe_H + Mn_H$	2.9	4.1	0.31	0.26	0.9	0.8	0.60	0.64
T_{10} $Fe_L + Zn_L$	3.2	3.9	0.29	0.25	0.6	0.6	0.53	0.82
T_{11} $Fe_H + Zn_H$	3.1	4.0	0.29	0.26	0.2	0.7	0.61	0.68
T_{12} $Mn_L + Zn_L$	2.7	4.1	0.31	0.25	1.0	0.8	0.59	0.74
T_{13} $Mn_H + Zn_H$	2.7	4.0	0.36	0.27	0.8	1.0	0.64	0.71
T_{14} $Fe_L + Mn_L + Zn_L$	3.0	4.2	0.22	0.29	1.1	1.3	0.51	0.55
T_{15} $Fe_H + Mn_H + Zn_H$	2.7	4.0	0.24	0.31	1.0	1.4	0.52	0.53
F-test	**	NS	**	NS	**	**	**	**
L.S.D 0.05	0.6	-	0.06	-	0.2	0.3	0.07	0.08

** and NS indicate $P < 0.01$ and not significant, respectively.

TABLE 3. Effect of micronutrients treatments on total leaf content of Fe, Mn, Zn and Cu in 2000 and 2001 seasons.

Treatments	Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1 Control	274	208	79	54	39	21	7	12
T_2 Fe_L	299	316	49	91	55	35	8	19
T_3 Fe_H	278	281	41	88	31	29	9	19
T_4 Mn_L	255	287	62	62	28	38	10	17
T_5 Mn_H	208	318	62	95	35	38	11	18
T_6 Zn_L	387	275	46	85	37	37	19	20
T_7 Zn_H	411	215	61	82	29	41	12	18
T_8 $Fe_L + Mn_L$	421	229	76	84	42	36	13	12
T_9 $Fe_H + Mn_H$	389	226	135	71	38	42	17	12
T_{10} $Fe_L + Zn_L$	523	239	68	75	32	36	12	9
T_{11} $Fe_H + Zn_H$	376	226	47	83	35	38	16	9
T12 MnL+ZnL	395	239	124	82	44	38	16	11
T13 MnH+ZnH	363	242	116	84	43	41	19	11
T14 FeL + MnL + ZnL	365	338	64	85	38	36	23	20
T15 FeH + MnH + ZnH	583	410	145	89	72	44	25	22
F-test	**	**	**	**	**	**	**	**
L.S.D 0.05	121	69	8	19	15	8	4	2

** Indicates $P < 0.01$

The effect of the tested micronutrients treatments was negative on leaf N content and, in general, positive on leaf P content as compared with the control in the first season, where the highest leaf P content was obtained from two foliar applications of Mn + Zn combination at the high level. In the second season, the tested treatments gave insignificant effect on leaf N and P contents. However, they gave a positive effect on leaf K content in both seasons, where the highest leaf K contents were obtained from the application of the three micronutrients combination either at the low or high levels.

The highest leaf Mg content was obtained from foliar feeding twice with the high level of Mn + Zn combination in the first season and from foliar feeding with the low level of Fe + Zn combination in the second season.

Leaf Fe, Zn and Cu contents were significantly affected by the tested treatments in both seasons, where the highest contents of leaf Fe, Zn and Cu were obtained from the high level of the mixture of Fe + Mn + Zn. Leaf Mn content was significantly affected by the tested treatments in both seasons, where the highest content was obtained from the application of Fe + Mn + Zn combination at the high level in the first season and from the application of Mn at the high level in the second season.

C. Growth traits

The results given in Table 4 indicate clearly that cotton plant height at harvest was significantly affected by different micronutrients foliar treatments in both seasons, where the tallest plants were produced when the three micronutrients were applied in combination at the high level, while the short plants were produced from untreated plants. The same Table shows that the mean values of plant height tend to increase with increasing micronutrients level.

Treatments gave a significant effect on number of fruiting branches/plant in both seasons, where the highest value was produced from two foliar feeding with Fe + Mn + Zn combination at the high level. Also, the best results were obtained when the mixtures of micronutrients were applied either at the low or high levels as compared with the three micronutrients when used alone (Table 4).

D. Earliness

Data in Table 4 show that treatments gave significant effect on earliness % in both seasons, where the highest values of earliness % were obtained from two foliar applications of Fe + Mn + Zn mixture either at the high or low levels and from spraying Zn twice at the high level. However, the lowest value was obtained from untreated plants.

TABLE 4. Effect of micronutrients treatments on plant height at harvest, number of fruiting branches/plant, lint %, seed idnex and earliness % in 2000 and 2001 seasons.

Treatments	Plant height at harvest (cm)		No. of fruiting branches/plant		Lint %		Seed index (g)		Earliness %	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
T_1 Control	132	125	12.9	12.7	37.2	37.6	9.8	9.7	50	52
T_2 Fe_L	133	128	13.0	13.2	37.4	37.9	9.9	10.1	59	59
T_3 Fe_H	138	131	12.8	13.0	37.4	37.9	10.2	9.8	59	59
T_4 Mn_L	135	128	13.4	13.8	37.7	37.9	10.0	10.2	52	54
T_5 Mn_H	138	132	14.2	14.6	38.4	38.7	10.3	9.8	55	57
T_5 Zn_L	134	128	13.4	13.6	37.1	38.1	10.0	10.2	60	61
T_7 Zn_H	138	131	13.7	13.0	37.5	37.7	10.0	10.1	61	64
T_8 $Fe_L + Mn_L$	136	129	13.6	13.6	37.4	38.0	10.1	10.0	55	58
T_9 $Fe_H + Mn_H$	140	131	14.6	14.7	38.3	37.7	10.2	10.2	56	59
T_{10} $Fe_L + Zn_L$	136	128	12.9	13.0	37.5	37.8	10.3	10.4	56	64
T_{11} $Fe_H + Zn_H$	139	132	13.9	14.0	38.2	38.5	10.5	10.4	56	61
T_{12} $Mn_L + Zn_L$	136	129	14.0	14.8	37.9	37.7	10.3	10.1	55	56
T_{13} $Mn_{LH} + Zn_H$	139	132	14.1	15.2	38.1	38.9	10.5	10.4	55	58
T_{14} $Fe_L + Mn_L + Zn_L$	137	131	14.4	15.2	38.1	38.3	10.7	10.7	62	64
T_{15} $Fe_H + Mn_H + Zn_H$	142	132	15.4	15.9	39.1	39.1	10.8	10.7	64	66
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D 0.05	4	3	0.9	0.7	0.6	0.7	0.3	0.3	2	6

** Indicates $P < 0.01$.

E. Seed cotton yield and its components

Results in Table 4 show a positive effect for the tested microntrients on lint % and seed index in both seasons, where two foliar applications of Fe + Mn + Zn combination at the high level gave the highest values of these two traits.

With respect to numbers of total and open bolls/plant, boll weight and seed cotton yield/plant, results in Table 5 show a positive effect for the micronutrients under study on these traits in both seasons of study. The highest mean values of these traits were obtained by two foliar sprayers with Fe + Mn + Zn combination at the high level, while the lowest values were obtained from untreated plants (control). Generally, the best results were obtained when the different mixtures of micronutrients were applied either at the low or high levels as compared with the three micronutrients when used alone.

Data in Table 5 show that seed cotton yield/fed. was significantly increased by the tested micronutrients as compared with the control in both seasons with the exception of using Mn at the low or high levels which insignificantly increased seed cotton yield/fed. as compared with the control. Two foliar sprayings with Fe + Mn + Zn combination either at the high or low levels led to the highest yield/fed. followed by the two foliar sprayings with Mn + Zn either at the high or low levels without significant differences among these four treatments, while the lowest yield/fed. was obtained from untreated plots (control). The same table shows that the different micronutrients mixtures increased seed cotton yield/fed. in order of $Mn_H + Zn_H > Mn_L + Zn_L > Fe_H + Zn_H > Fe_L + Zn_L > Fe_H + Mn_H > Fe_L + Mn_L$, while, yield increases of single elements were in the order of $Zn_H > Zn_L >$ (Fe_H or Fe_L) $> Mn_H > Mn_L$.

The high level of Fe + Mn + Zn mixture significantly increased seed cotton yield/fed. by 37.08 and 40.29% over the control in the first and second seasons, respectively. Also, the low level of Fe + Mn + Zn mixture significantly increased seed cotton yield/fed. by 33.08 and 40.14% over the control in the first and second seasons, respectively.

F. Fiber Properties

Fiber length parameters

Data in Table 6 show that the analysis of variance of the 2.5% span length and fiber length uniformity % indicated that the differences in these parameters were significant in both seasons under study.

In the first season, it could be conclude that the measure of the 2.5% span length did not show any tendency to be higher or lower for different treatments. On the other hand, the 2.5 % span length in the second season was increased by using Fe, Mn and Zn at the lower level, as well as Fe + Zn and Fe + Mn at both levels.

Regarding the fiber length uniformity %, it was increased by using $Fe_H + Zn_H$ in the first season and by using $Mn_H + Zn_H$ in the second season.

TABLE 5. Effect of micronutrients treatments on numbers of total and open bolls/plant, boll weight, seed cotton yield/plant and seed cotton yield/fed. In 2000 and 2001 seasons.

Treatments	No. of total bolls/plant		No. of open bolls/plant		Boll weight (g)		Seed cotton yield/plant (g)		Seed cotton yield (kentar/fed.)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
T_1 Control	11.3	11.7	10.7	10.9	2.20	2.39	23.6	26.0	6.50	7.00
T_2 Fe_L	13.0	13.1	12.4	12.4	2.26	2.44	28.0	30.2	7.38	8.06
T_3 Fe_H	13.0	13.1	12.4	12.4	2.26	2.44	28.0	30.2	7.38	8.06
T_4 Mn_L	12.0	11.7	11.3	11.0	2.21	2.50	25.0	27.5	6.76	7.42
T_5 Mn_H	12.5	12.4	11.9	11.8	2.23	2.40	26.5	28.3	7.08	7.72
T_5 Zn_L	13.1	13.4	12.7	12.9	2.25	2.47	28.6	31.9	7.39	8.18
T_7 Zn_H	13.5	13.6	12.8	13.1	2.27	2.44	29.0	32.0	7.72	8.23
T_8 $Fe_L + Mn_L$	13.4	13.9	12.7	13.2	2.30	2.50	29.2	32.9	7.82	8.26
T_9 $Fe_H + Mn_H$	13.4	14.2	12.7	13.3	2.36	2.52	30.0	33.5	7.89	8.43
T_{10} $Fe_L + Zn_L$	12.9	14.0	12.0	13.4	2.56	2.55	30.6	34.1	7.92	8.77
T_{11} $Fe_H + Zn_H$	12.6	14.3	11.9	13.6	2.60	2.57	30.9	34.9	8.12	9.10
T_{12} $Mn_L + Zn_L$	13.1	14.5	12.6	13.7	2.63	2.62	33.1	35.9	8.39	9.56
T_{13} $Mn_H + Zn_H$	13.6	14.6	12.8	13.9	2.66	2.60	34.0	36.0	8.62	9.72
T_{14} $Fe_L + Mn_L + Zn_L$	13.5	14.4	12.9	13.9	2.67	2.63	34.4	36.5	8.65	9.81
T_{15} $Fe_H + Mn_H + Zn_H$	13.8	15.4	13.0	14.9	2.70	2.65	35.0	39.4	8.91	9.82
F-test	**	**	**	**	**	**	**	**	**	**
L.S.D 0.05	1.2	1.3	1.1	1.4	0.12	0.12	2.6	3.4	0.62	0.67

** Indicates $P < 0.01$.

TABLE 6. Effect of micronutrients treatments on some fiber technological properties in 2000 and 2001 seasons.

Treatments	The 2.5% span length (mm)		Fiber length uniformity (%)		Fiber strength at 1/8 inch gauge (g/tex)		Fiber elongation %		Micronaire reading		Fiber weight (millitex)		Fiber maturity (%)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
T_1 Control	33.5	32.1	49.5	49.8	28.15	27.7	6.8	6.67	4.98	4.63	168	173	79.8	78.0
T_2 Fe_L	32.9	33.6	51.1	52.0	28.9	28.27	6.42	7.13	4.98	4.93	164	165	80.0	82.7
T_3 Fe_H	32.4	32.8	52.0	53.6	27.85	26.6	6.38	6.40	5.20	5.10	174	166	81.0	80.0
T_4 Mn_L	32.9	34.0	51.2	52.1	29.45	28.1	6.08	7.07	4.92	5.17	172	169	78.5	80.7
T_5 Mn_H	32.7	33.8	52.1	51.5	29.3	28.1	6.5	7.10	5.2	4.83	168	173	80.0	78.5
T_5 Zn_L	32.9	34.2	52.7	51.7	28.38	29.6	6.5	6.83	5.22	5.17	171	171	80.8	77.5
T_7 Zn_H	33.1	33.4	51.5	50.9	26.93	30.0	6.35	7.5	5.08	5.00	169	169	75.5	79.5
T_8 $Fe_L + Mn_L$	33.4	33.9	52.4	52.1	27.52	25.5	6.15	7.2	5.05	5.20	166	180	79.5	78.5
T_9 $Fe_H + Mn_H$	33.0	33.8	51.8	48.1	26.38	27.37	6.05	7.2	5.18	5.10	171	180	77.0	77.5
T_{10} $Fe_L + Zn_L$	32.2	33.8	52.4	51.4	28.15	27.7	6.40	7.2	5.08	4.7	169	180	78.5	75.0
T_{11} $Fe_H + Zn_H$	32.8	34.3	53.1	51.8	28.2	27.2	6.65	7.0	5.25	5.0	166	165	79.8	81.0
T_{12} $Mn_L + Zn_L$	32.5	32.6	49.5	50.2	29.45	27.37	6.58	6.9	5.20	5.07	168	173	80.8	81.0
T_{13} $Mn_H + Zn_H$	32.9	32.8	50.0	59.6	28.3	28.8	6.42	7.4	4.95	5.17	162	173	80.3	81.0
T_{14} $Fe_L + Mn_L + Zn_L$	32.5	31.9	50.9	50.3	29.5	26.37	6.38	6.5	5.02	5.00	173	168	76.0	81.0
T_{15} $Fe_H + Mn_H + Zn_H$	33.0	32.0	52.1	51.6	27.98	27.47	6.20	6.77	4.85	5.07	172	180	76.8	79.3
F-test	*	**	*	*	*	**	*	**	NS	**	NS	**	NS	*
L.S.D 0.05	0.9	0.6	2.1	2.1	2.8	0.84	0.64	0.45	-	0.19	-	9.0	-	3.3

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

Fiber strength and elongation %

Data in Table 6 show that the analysis of variance of fiber strength at 1/8 inch gauge and fiber elongation % indicated that the differences in these properties were significant. In spite of the above result, the data in the first season did not show any tendency to be higher or lower for different treatments. Whereas, in the second season, the data showed that the results of fiber strength were increased by using each of Zn_H, Zn_L and Mn_H + Zn_H. Also, fiber elongation % was increased by using each of Zn_H and Mn_H + Zn_H.

Fiber fineness and maturity

Data in Table 6 show that the analysis of variance of Micronaire reading, fiber maturity% and fiber weight indicated that the differences in these properties were not significant in the first season. Whereas, the differences in these properties were significant in the second season.

Regarding the second season, the results showed that the mean of fiber maturity % was increased by 4.7%, whereas the mean of fiber weight was decreased by 8.0 millitex. by using Fe_L. The same trend was obtained by using Fe_H + Zn_H.

Discussion

The previous results revealed that high alkali reaction and low organic matter in soil considerably reduced availability of most nutrients to plant (Wallace, 1983). However mean contents of available Fe, Mn and Zn are not deficient in such alluvial soils. Compactness of soil due to high clay proportion was suggested to hinder root growth leading to shortage of plant nutrients needed for high yield (Talha *et al.*, 1978). The total content of K, Mg, Fe, Mn, Zn and Cu in cotton leaf tended to increase with foliar application with micronutrients such increases in total nutrient content enhance plant metabolism and increase the dry weight of cotton plant (El-Hattab *et al.*, 1981), and improve root growth which led to greater absorbing surface (Wittwer and Bukovac, 1969). Besides, high available Cu in soil may increase Cu content of cotton leaf.

The maximum increase in majority of elements content and growth measurements of cotton plants were reached at high level of foliar application treatments in response to mixture compound of Fe, Mn and Zn would find an interpretation through metabolic function of micronutrients in plant (Amberger, 1980).

The noticed effect of Zn in complete mixture on cotton plant height at harvest may be related to its role in biosynthesis of the natural auxin, indole acetic acid (Mengel and Kirkby, 1982) and account for promotion of stem elongation.

The mean values of plant height at harvest tend to increase with increasing micronutrients level. This may be due to that Mn activates several important metabolic reactions and plays a direct role in photosynthesis (Amberger, 1980 and 1991).

The number of fruiting branches/plant was reached the highest increase due to two foliar sprayings with the mixture of Fe + Mn + Zn containing the high level of these three trace elements. In this connection, it is worthy to note that trace elements were reported to control the hormonal balance of the plant (Coke and Whittington, 1968).

The highest numbers of total and open bolls/plant and earliness % were obtained by applying the high level of Fe + Mn + Zn combination. This result may be due to that foliar feeding with micronutrients stimulated biological activities, *i.e.* enzyme activity, chlorophyll synthesis and rate of translocation of photosynthetic products. Amberger (1980) and (1991) cleared that direct activation of the relevant enzymes may be one of the possible reasons, where Zn, Mn or Fe acts as prosthetic group.

The results show that the heaviest bolls were produced from plants receiving a complete mixture of the three micronutrients either at the high or low levels. This result is in harmony with that obtained by Abou Khadrah (1974), Sorour *et al.*, (1975) and Abou Khadrah and Zahran (1979).

It is interesting to note that the lint percentage tended to increase by foliar feeding with micronutrients mixture. This may be due to the important direct role of trace elements on RNA-synthesis and the following protein formation, which in turn affected directly fiber growth. These results confirmed by Amberger, (1974) and Hegab *et al.* (1987).

For seed index, the results indicated that seed index was highly affected by different micronutrients treatments. This result may be due to that the three micronutrients have important functions in plant metabolism especially in chlorophyll synthesis, photosynthesis, nitrate reduction, amino acid and protein synthesis. In this respect, Tailakov (1976) cleared that spraying cotton plants with trace elements were reported to increase the uptake of other nutritive elements which must be reflected on the final yield.

The increases in seed cotton yield/plant and/fed. were found due to two foliar applications with Fe + Mn + Zn at the high level in both seasons. These increases may be attributed to the effect of micronutrients on dry matter yield or due to the great efficiency of enzyme activities which affect plant pigments and the rate of photosynthesis (Amberger, 1974, Hegab *et al.*, 1987 and Eid *et al.*, 1997). Another possibility may be the quantitative increase of enzyme responsible for these reactions as a result of more intake and mobilization of nutrients in plant (El-Sayed *et al.*, 1992). Moreover, increasing growth of cotton plants and its yield, indicated the improvement of physiological performance in treated plants due to more nutrients uptake by treated cotton plants from soil. This interpretation could be confirmed by the observation that leaves of plants treated with the high level of micronutrients contained more nutrients than the control, not only Fe, Mn and Zn but also K and Mg. Such results are in agreement with those obtained by Fawzi (1991). In addition, Sillanpää (1982) reported that the increases in seed cotton yield in response to micronutrients would further mean that plants can't take up their micronutrients requirements under undesirable soil conditions, such as high pH, low organic matter content and clay percentage.

In this respect, Abdel Shafy *et al.* (2001) reported that Zn, Fe and Mn sprayed for two times at the beginning of flowering stage and the following spray after 15 days gave the best effect in promoting plant growth, yield and chemical constituents of leaves and seeds.

Regarding the effect of micronutrients under study, it could be reported that the beneficial effect of spraying Fe, Mn and Zn either alone or in combinations at the low or high levels may be due to the role of these elements on fundamental metabolic reactions and acceleration protein synthesis which affects boll development and formation as reported by Abdel Shafy *et al.* (2001) and hence affects fiber properties. In this concern El-Halwany (1979) found that Zn gave insignificant effect on fineness and fiber strength. The fiber uniformity ratio was highly significantly increased, while fiber span length was insignificantly increased by Zinc application. Hegab *et al.* (1982) found that foliar spray of Fe, Mn and Zn as chelating compounds at the concentrations of 0.043, 0.036 and 0.025%, respectively gave the highest significant effect on micronaire reading and fiber strength. However, Eid and Monged (1986) found that application of iron and zinc at the beginning and at the maximum of flowering showed no effect on fiber properties.

Conclusion

From the previous results it could be concluded the following :

Micronutrients foliar feeding is important to correct the nutrient balance in cotton plants under undesirable soil conditions.

Soil testing is considered as a helpful tool for suggesting the deficiency of micronutrients and giving more efficient and economical usage of micronutrients which the soil sites suffer from their deficiencies.

All mixtures of the three micronutrients used gave higher yield than separate elements either at the low or high levels.

Foliar feeding with the mixture of Fe + Mn + Zn at the high level (3g/L) at the beginning of flowering and 15 days later could be recommended for cotton Giza 89 cultivar at any cultivation region has similar soil conditions of that at Kafr El-Zayat region where the experiments were carried out. This treatment increases leaf macronutrients (K and Mg) and micronutrients (Fe, Mn, Zn and

Cu) content and gave best growth which reflect on high fiber quality and high seed cotton yield.

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تأثير التغذية الورقية ببعض العناصر المغذيــة الصــغرى علـــى المحتوى الغذائي لورقة القطــن والنمــو والتبكيــر والمحصــول ومكوناته وجودة التيلة طبقاً لحالة التربة من العناصـــر المغذيـــة الصغرى

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أجريت تجربتان حقليتان بمنطقة كفر الزيات – محافظة الغربية – مصر فــي موســمي ٢٠٠٠، ٢٠٠١م لدراسة تأثير التغذية بالرش ببعض العناصر المغذية الصغرى (حديــد، منجنيز، زنك في الصورة المخلبية) سواء بمفردها أو في مخاليط تشتمل على أثنـــين أو ثلاثة من هذه العناصر عند مستويين (١,٥جم/لتر، ٣ جم/لتر) مع الرش مرتين عند بداية التزهير وبعد ١٥ يوم من الرشة الأولى وذلك مقارنة بالنباتات غير المعاملة وتأثير تلــك المعاملات على المحتوى الغذائي للورقة والنمو والتبكير ومحصول القطن الزهر للفــدان ومكوناته وصفات الجودة لتيلة القطن المصري صنف جيزة ٨٩ وكان التصميم الاحصائي المستخدم هو القطاعات الكاملة العشوائية في أربع مكررات.

وكان أهم النتائج المتحصل عليها :

١–أعطت معاملات الرش بالعناصر المغذية الصغرى تأثير سلبي على تركيز النيتروجين بالورقة في الموسم الأول، مقارنة بالغير معامل، بينما كان تأثير المعاملات المختبرة إيجابياً على محتوى الورقة من الفوســفور فـــي الموســم الأول ومــن البوتاســيوم والماغنسيوم في كلا الموسمين – كما أدت المعاملات المختبرة إلى زيادة معنوية في محتوى الورقة من الحديد والمنجنيز والزنك والنحاس مقارنة بالغير معاملة وخاصة عند استخدام التركيز العالي من مخلوط العناصر الصغرى (حديد + منجنيز + زنك) وذلك في موسمى الدراسة.

٢–أعطت التغذية الورقية بالعناصر المغذية الصغرى المختبرة تأثيراً إيجابياً على صفات النمو والتبكير والمحصول ومكوناته وذلك في عامى الدراسة سواء استخدمت هــذه العناصر الثلاثة المختبرة بمفردها أو في مخاليط مع بعضها عند المستوى المنخفض أو المرتفع وذلك مقارنة بالغير معاملة. أعلى القيم لهذه الصفات تم الحصول عليهـــا من التغذية الورقية بالرش مرتين لمخلوط العناصر المغذية الصغرى الثلاث (الحديد + المنجنيز + الزنك) وذلك باستخدام المستوى المرتفع. وقد أعطت العناصـــر فـــي مخاليط محصول أعلى من استخدامها بمفردها.

٣–وقد أوضحت النتائج أيضاً أن بعض المعاملات لها تأثير جيد على صفات التيلة تحت الدراسة.

يتضح من التحليل التشخيصي أن انخفاض المحصول يرتبط بنقص العناصر في هذه الأراضي القلوية والنباتات النامية بها كما يتواكب زيادة المحصول مع التحسن في الحالة الغذائية لأوراق النبات ويمكن أن يستنتج أن محصول القطن يمكن أن يرتفــع بتصــحيح نقص العناصر في النبات عن طريق اختبارات التربة وتحليل النبات. كما توصي الدراسة بإجراء اختبارات التربة لتقييم خصوبة حقول القطن.