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Effect of Foliar Feeding with some Chelated Nutrients on Productivity and Quality of Egyptian Cotton Cultivar Giza 86

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ABSTRACT

Field experiment was carried out through 2018 season and repeated through 2019 season at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt. These experiments aimed to study the effect of three foliar sprays with chelated magnesium and/or zinc on productivity and quality of the Egyptian cotton cultivar Giza 86. Two levels (2 and 4 g of each nutrient/liter water) , in addition to the control treatment were used. The experimental design was a randomized complete blocks with 3 replications.The data indicated that combination between chelated magnesium and chelated zinc at the two levels used significantly increased the concentrations of Mg, Zn and photosynthetic pigments in the leaves in both seasons. In addition, combination between chelated magnesium and chelated zinc at the low level (2 g/liter water of each nutrient) significantly increased total dry weight/plant, leaf area index, plant height, number of fruiting branches/plant, number of total flowers/plant, number of total bolls set/plant, boll setting percentage, earliness percentage, number of open bolls/plant, boll weight, seed index, lint percentage and seed cotton yield/feddan, fiber length, uniformity index and fiber strength in both seasons. The control treatment recorded the lowest values of these traits and significantly increased boll shedding percentage. Micronaire reading was insignificantly affected. It could be concluded this combination three times to obtain the high quality and productivity and recommended the possibility of being applied by farmers to enhance cotton productivity in light of the lack of magnesium and zinc in the soil under conditions similar to El-Gemmeiza region.

Keywords: Cotton, feeding, chelated, magnesium, zinc.

INTRODUCTION

The Egyptian cotton (*Gossypium barbadense* L.) is characterized by higher fiber quality. It is a mainstay of our textile industry and garments as well as the production of cottonseed meal for livestock and oil for human consumption.

Regarding Zn deficiency, it has increased because, (1) New varieties are much more brone to Zn deficiency than locally adapted crop genotypes, (2) Intensive cultivation remove at every harvest large amounts of Zn from the soil, (3) The excess use of phosphorus fertilizers and fertilizers with less Zn-containing impurities can lead to increased deficiency of Zn (Loneragan and Webb, 1993). Yang *et al.* (2011) reported that excess phosphorus inhibited uptake of Zn in roots. and (4) In Egypt, cotton (*Gossypium barbadense* L.) is grown on flood-irrigated clay loamy or clayey soils with high pH (around 8). Above pH 7, soil zinc becomes less available. The most Zn deficient soils are high in pH (> 8.5), low in organic carbon (< 0.4%), high in $CaCO_3$ (> 0.5%) and intensively cultivated (Shukla *et al*., 2019). The experimental soil which had clay loam with high pH reduced the availability of Zn to plants (El-Fouly, 1983),

Regarding Mg deficiency, it has increased because, (1) High application of K can increase the leaching of Mg by displacing it from cation exchange sites, leading to lower Mg availability in the root zone, (2) Soil pH has a direct effect on Mg release from clay minerals and Mg uptake by plant, (3) Excess calcium interferes (similar to K) with uptake of Mg (Wilkinson *et al.* 1990) and (4) Similar to K and Ca antagonisms with Mg, NH_4 nutrition decreases Mg uptake through (i) its acidifying character when assimilated, and (ii) ion competition at the adsorbing surfaces of the roots. However, NO_3-based fertilizers do not interfere with Mg uptake and it is recommended in soils with limited plant-available Mg (Mulder, 1956).

Soil sites had clay loamy and clayey with high pH and soil Mg and Zn remain inaccessible to plant roots. However, an alternative approach under such circumstances is foliar application of nutrients (Rab and Haq, 2012) primarily for three reasons. First, it eliminates the effect of high soil pH on the availability of these two nutrients. Second, it is more effective and less costly. Third, to correct severe deficiencies complete coverage with foliar feeding is necessary. Foliar feeding with these two nutrients as Mg and Zn in the chelated form, where true chelates are compounds containing ligands that can combine with a single metal ion to form a well-defined, relatively stable cyclic structure called a chelation complex (Mortvedt *et al.*, 1999). Singh *et al.* (2015) reported that it is inferred that cotton responds to foliar application with magnesium and zinc.

Therefore, this work aimed to evaluate the effect of foliar feeding with two levels of chelated magnesium and zinc either alone or in mixture for cotton maximum production with high fiber quality of cotton cultivar Giza 86 in light of the lack of magnesium and zinc in the soil under conditions of El-Gemmeiza region.

MATERIALS AND METHODS

Field experiment was carried out through 2018 season and repeated through 2019 season at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, Egypt, to study the response of the Egyptian cotton cultivar Giza 86 to three foliar sprays with chelated magnesium and/or zinc.

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Two levels (2 and 4 g of each nutrient/liter water, in addition to the control treatment (sprayed with tap water) were used. To evaluate the initial soil fertility status, representative soil samples were taken from the experimental soil sites before sowing in both seasons and prepared for analysis according to Chapman and Pratt (1978). The data are presented in Table 1.

Table 1. Soil analysis of the experimental site prior to sowing in 2018 and 2019 seasons

Properties	Optimal Value (Ankerman and Large, 1974)	Season 2018	Season 2019
Mechanical analysis:			
Clay%		38.0	44.2
Silt%		38.0	33.0
Sand%		24.0	22.8
Texture		Clay loamy	clayey
Chemical analysis:			
pH (1 soil: 2.5 distilled water)	6.7-7.3	8.0	8.1
EC ds/m^2 (1 soil: 2.5 distilled water)	1.5	0.37	0.99
Organic matter %	2.6-3	1.23	1.40
Total N (mg/100g)	30-60	43.05	49.00
Available P (mg/100g)	1.2-2.7	1.19	1.28
Available K (mg/100g)	21-30	21.5	31.0
Available Mg (mg/100g)	30-180	19	23
Available Fe (ppm)	10-16	6.0	12.4
Available Mn (ppm)	8-12	2.1	3.9
Available Zn (ppm)	1.5-3.0	0.70	1.12
Available Cu (ppm)	0.8-1.2	0.9	1.7

Chemical composition, growth, bolls retain, yield and fiber quality of cotton are often restricted by inadequate or unavailable of one or more nutrient elements in the soil. Magnesium and zinc available levels in the experimental soil sites under study in both seasons are less than critical levels according to (Ankerman and Large, 1974).

The experimental design was a randomized complete blocks with 3 replications, where the following seven treatments were applied:

T_1- Untreated (sprayed with tap water) as a control.
T_2- Foliar feeding with 2 g magnesium chelate (14% Mg)/liter water
T_3- Foliar feeding with 4 g magnesium chelate (14% Mg)/liter water
T_4- Foliar feeding with 2 g zinc chelate (15% Zn)/liter water
T_5- Foliar feeding with 4 g zinc chelate (15% Zn)/liter water
T_6- Foliar feeding with [2 g magnesium chelate (14% Mg) + 2 g zinc chelate (15% Zn)]/liter water
T_7- Foliar feeding with [4 g magnesium chelate (14% Mg) + 4 g zinc chelate (15% Zn)]/ liter water

The chelate compounds were: 14% Mg chelated by citric acid and amino acids and Zn-EDTA (15% Zn). The chelated compounds were applied three times (at squaring stage, flowering start and the top of flowering) using hand operated sprayer compressed at a low volume of 200 liter/fed.

In both seasons, the plot size was 14 m^2, (4 m x 3.5 m) including 5 rows of 70 cm wide and 4 m long with hills 25 cm apart with two plants/hill after thinning.

Preceding crop was sugar beets (*Beta vulgaris* L.) in the first season and Egyptian clover (*Trifolium alexandrinum* L.) "berseem" from which one cut was taken in the second season.

Sowing was took place on 8th April in the first season and on 10th April in the second season. Seeds of cotton cultivar Giza 86 from Cotton Research Institute were sown.

Phosphorus fertilizer was added at a rate of 22.5 kg P_2O_5 /fed as calcium super phosphate (15.5 % P_2O_5) during land preparation. Nitrogen fertilizer was applied at a rate of 45 kg N/fed as ammonium nitrate (33.5 % N) in two equal splits after thinning (21 days after planting, two plants/hill) and 15 days later, Potassium fertilizer in the form of Potasin-P at the rate of 1 liter/feddan was applied as foliar application three times (at squaring stage, flowering start and the top of flowering).

The other cultural practices were followed as recommended in cotton fields

Studied characters:

A-Chemical analysis of leaves: The chemical composition of leaf was carried out after two weeks from the last foliar feeding with Mg and Zn (at 117 days old), where a representative leaf sample (ten leaves) were randomly taken from the youngest fully matured leaves (4th leaf from the apex of the main stem) from each plot. After sample preparation for analysis, concentration of Zn in ppm was determined with an atomic absorption spectrophotometer and percentage of Mg was determined according to Chapman and Pratt (1978). Chlorophyll a, b and a+b (mg/g dry weight) were determined following the method described by Arnon (1949). Leaf carotenoids content (mg/g dry weight) was determined using the method described by Rolbelen (1957).

B-Growth traits: After 117 days from planting (after 15 days from the last spraying of chelated compounds), six plants of three guarded hills were taken at random from each plot carefully. Samples were immediately transferred to the laboratory. Roots of sample plants were removed at the cotyledonary nodes, then the different plant fractions were washed and oven dried to a constant weight at 70 C^0 and their dry weights were obtained. Leaf area index was determined according to Watson (1958). At harvest, five guarded hills from each plot were taken to determine plant height (cm) and number of fruiting branches/plant.

C-Earliness traits: Number of total flowers/plant (Kadapa, 1975), number of total bolls/plant, boll setting percentage, boll shedding percentage and first picking percentage (Richmond and Radwan, 1962).

D- Seed cotton yield and its components: Number of open bolls/plant, boll weight (g), lint percentage and seed index **(**weight of 100 cotton seeds in grams**).** The seed cotton yield per feddan was estimated as the weight of seed cotton in kilograms picked twice from each plot and transformed to kentars per feddan (one kentar = 157.5 kg)

E-Fiber quality: After ginning seed cotton of each treatment, samples of lint were taken to determine the following characters at the laboratories of Cotton Research Institute, ARC, under standard conditions of test as reported by A.S.T.M. (1986): Fiber length (2.5% span length in mm) and uniformity index (%) were determined by fibrograph, fiber fineness (micronaire reading) was determined by Micronaire instrument and fiber strength (Pressley index) was determined by Pressley instrument.

Statistical analysis

The obtained data collected were subjected to statistical analysis as outlined by **Steel *et al.*, 1997**. Whenever, the results were found to be significant, the treatments means were compared using LSD at 0.05 level of probability**.**

RESULTS AND DISCUSSION

A-Leaves chemical composition:

The results in Table 2 indicated significant differences for cotton leaf photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll and carotenoids), Mg and Zn concentrations in both seasons, in favor of foliar feeding with the combination between magnesium and zinc at the two levels examined as compared to the control. Regarding chemical analysis of leaves, the positive effect of foliar feeding with the combination between magnesium and zinc as compared with control plants is mainly due to the role of magnesium and zinc on plant growth.

Table 2. Effect of foliar feeding with chelated Mg and Zn as well as their combinations on cotton leaf photosynthetic pigments, Mg and Zn concentrations in 2018 and 2019 seasons.

Treatments	Chl. a (mg /g dry weight)	Chl. b (mg /g dry weight)	Total chl. (mg / g dry weight)	Carote. (mg /g dry weight)	Mg (%)	Zn (ppm)
Season 2018						
T_1- Control	3.15	1.24	4.39	1.35	0.27	18.20
T_2- 2 g Mg chelated/L	4.26	1.92	6.18	1.93	0.39	18.50
T_3- 4 g Mg chelated/L	4.37	1.94	6.31	1.99	0.45	18.70
T_4- 2 g Zn chelated/L	3.48	1.31	4.79	1.45	0.28	29.00
T_5- 4 g Zn chelated/L	4.00	1.90	5.90	1.95	0.29	33.30
T_6- (2 g Mg chelated +2 g Zn chelated)/L	4.43	1.96	6.39	2.04	0.41	29.50
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	4.55	1.98	6.53	2.08	0.47	33.50
LSD at 5%	0.11	0.06	0.08	0.08	0.02	0.83
Season 2019						
T_1- Control	3.98	1.44	5.42	1.49	0.34	25.00
T_2- 2 g Mg chelated/L	4.50	2.02	6.52	2.07	0.56	27.00
T_3- 4 g Mg chelated/L	4.64	2.05	6.69	2.08	0.73	28.00
T_4- 2 g Zn chelated/L	4.10	1.48	5.58	1.50	0.33	38.00
T_5- 4 g Zn chelated/L	4.39	1.51	5.90	1.52	0.34	45.00
T_6- (2 g Mg chelated +2 g Zn chelated)/L	4.72	2.06	6.78	2.11	0.59	39.00
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	4.75	2.08	6.83	2.14	0.76	46.00
LSD at 5%	0.08	0.03	0.10	0.08	0.02	1.23

It was reported that, magnesium is the central molecule in chlorophyll and is 2.5% of it and therefore plays a major role in plant photosynthesis (Rajasekar *et al*., 2017) and photosynthetic fixation of carbon dioxide (Gerendás and Führs, 2013). It is very important for plants to absorb phosphorus and assists iron in chlorophyll formation (Lohry, 2007) and low Mg lowers the rate of photosynthesis, decreases carbohydrate transport from source to sink tissues, increases sugar accumulation in the leaves and causes feedback inhibition of Rubisco (Yilmaz *et al.*, 2017).

As for zinc importance, it was reported that, Zinc delays the senescence of plant through encourages green plastids enzymes, increases indole acetic acid (IAA) levels, chlorophyll and ATP/chlorophyll ratio (Lohry, 2007), Zinc deficiency reduces net photosynthesis by 50 to 70% (Ohki, 1976). In C_3 plants, Zinc is involved in carbonic anhydrase (CA) enzyme which is located in the chloroplast and cytoplasm and it facilitates the transfer of CO_2/HCO_3 for photosynthetic CO_2 fixation (Sharma *et al*., 1982). Zn is also, regulates consumption of sugars. In addition to that, magnesium and zinc available levels in the experimental soil sites under study in both seasons are less than critical levels as shown in Table 1. In this concern, El Masri (2005) found that the highest leaf zinc content was obtained from foliar feeding with zinc-EDTA (14% Zn) twice at the high level (3 g/liter water) or low level (1.5 g/liter water) as compared with control. Sawan *et al.* (2008) found that foliar application of zinc, in chelated form (ethylene diamine tetra acetic acid), twice (at 70 and 85 days old) significantly increased concentration of total chlorophyll and uptake of zinc and Rezaei and Abbasi (2014) reported that chlorophyll a and b increased in treatments with chelate of zinc as compared with mineral fertilizer of zinc.

B-Growth traits:

The examined treatments gave a significant effect on plant height and its number of fruiting branches at harvesting in both seasons (Table 3). The tallest plants (161.5 and 169.9 cm; 160.0 and 165.5 cm) were recorded by foliar feeding with the combination between magnesium and zinc at the two levels examined compared with the control in the two seasons. Also, the tested treatments gave a significant positive effect on number of fruiting branches/plant in both seasons, in favor of foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient) and foliar feeding with magnesium at the low level (2 g Mg /L). However, the lowest numbers were obtained from the control in both seasons.

The examined treatments gave a significant effect on plant dry weight and LAI at 117 days old in both seasons (Table 3). The highest plant dry weight (119.23 and 111.17 g; 114.34 and 95.67 g) and LAI (3.22 and 2.57; 3.13 and 2.40) were recorded by foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient), followed by the high level (4 g /L of each nutrient), while the lowest plant dry weight (104.88 and 79.97 g) and LAI (2.68 and 2.03) were produced from the control (untreated plants) in 2018 and 2019 seasons, respectively.

The positive influence on plant growth traits is mainly due to the presence of sufficient leaf area (source) to provide enough photosynthate and adequate supplies of water and mineral nutrition. The significant increase in leaf area index (Table 3) which reflects on increasing assimilates by the source (sufficient area) and consequently significant increase in plant dry weigh, plant height and number of fruiting branches. The significant increase of photosynthetic pigments (chlorophyll a, b, total chlorophyll and carotenoids) in cotton leaves (Table 2) reflects in significant increase in assimilates production by the leaves (source) and thus the plant had the chance to bear more fruiting branches and better plant growth. The synthesis of typtophan, a precursor of indole–3–acetic acid synthesis required Zn (Oosterhuis *et al*., 1991), that can stimulate cell division and thus increase the plant height and number of fruiting branches. Zinc is involved in membrane integrity (Cakmak and Marschner, 1988). Magnesium is a key element of chlorophyll production and therefore plays a major role in plant photosynthesis, and thus it ensures high growth (Rajasekar *et al.*, 2017) and Mg is a key function in chelation to nucleotidyl phosphate forms, phloem loading, being a co-factor and allosteric modulator for >300 enzymes including Calvin cycle, kinases, RNA polymerases and ATPases (Verbruggen and Hermans, 2013) and low Mg decreased carbohydrate transport from source to sink tissues and sugar accumulation in the leaves. This effect causes feedback inhibition of Rubisco and lowers photosynthesis rate (Yilmaz *et* *al*., 2017).In this concern, El Masri (2005) found that the tallest plants were produced from foliar feeding with zinc-EDTA (14% Zn) twice at the high level (3 g/liter water) or low level (1.5 g/liter water) as compared with control, Sawan *et al.* (2008) found that application of zinc to the foliage, in chelated form (ethylene diamine tetra acetic acid), twice (at 70 and 85 days old) significantly increased dry matter yield, Sankaranarayanan *et al.* (2010) reported that foliar feeding with $MgSO_4$ 0.5% at 60, 75 and 90 days old significantly increased the bolls/plant, leaf area index and total plant dry weight at 90 days old by 30, 26 and 27% over the control and Rezaei and Abbasi (2014) found that the maximum height and dry weight were obtained in treatments with chelate of zinc as compared with mineral fertilizer of zinc.

Table 3. Effect of foliar feeding with chelated Mg and Zn and their combinations on cotton growth traits in 2018 and 2019 seasons.

Treatments	Final plant height (cm)	No. of fruiting branches/ plant at harvest	Total dry weight at 117 days old (g/plant)	LAI at 117 days old
		Season 2018		
T_1- Control	148.48	14.77	104.88	2.68
T_2- 2 g Mg chelated/L	148.17	17.00	110.91	2.97
T_3- 4 g Mg chelated/L	149.17	15.67	113.07	3.00
T_4- 2 g Zn chelated/L	153.83	16.33	106.77	2.71
T_5- 4 g Zn chelated/L	156.17	16.67	110.61	2.80
T_6- (2 g Mg chelated +2 g Zn chelated)/L	161.50	18.00	119.23	3.22
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	160.00	16.00	114.34	3.13
LSD at 5%	1.70	0.95	5.80	0.11
		Season 2019		
T_1- Control	152.00	14.00	79.97	2.03
T_2- 2 g Mg chelated/L	151.40	16.07	90.68	2.32
T_3- 4 g Mg chelated/L	152.87	14.80	93.19	2.33
T_4- 2 g Zn chelated/L	159.00	15.50	85.06	2.11
T_5- 4 g Zn chelated/L	161.40	15.90	88.11	2.24
T_6- (2 g Mg chelated +2 g Zn chelated)/L	169.90	16.63	111.17	2.57
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	165.50	15.03	95.67	2.40
LSD at 5%	1.11	0.91	3.96	0.28

C- Earliness traits:

The examined treatments significantly affected number of total flowers/plant, number of total bolls set/plant, percentages of boll setting and earliness in both seasons (Table 4), in favor of foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient) and foliar feeding with magnesium at the low level (2 g Mg /L). However, untreated plants (the control treatment) produced the lowest values of these traits. The inverse trend was found in boll shedding percentage. Guinn (1985) suggested that when the demand for photosynthates increases and exceeds the supply, bolls shedding increase. The role of Zn and Mg suggest that they affect abscission. The positive effect of foliar feeding with the combination between magnesium and zinc at the two levels examined as compared to the control is mainly due to that the positive effect on leaves chemical composition (Table 2) and growth traits (Table 3) ensures flowering and boll retention increase. Higher leaf area, plays a major role in production of more photosynthates which has a direct link with fruiting points. Zn is required for the synthesis of typtophan, a precursor of indole–3–acetic acid synthesis (Oosterhuis *et al*., 1991), which is the major hormone that increases retained bolls/plant through inhibits abscission. Carbohydrate metabolism required Zinc due to its effects on photosynthesis and sugar transformation and magnesium assists the movement of sugars within a plant, it is very important for plants to absorb phosphorus and because of Mg high phloem mobility, it can easily be translocate to active growing parts of the plant, where it is needed for chlorophyll formation, enzyme activation for protein biosynthesis, and phloem export of photosynthates (Uchida, 2000). In this connection, Zeng (1996) found that cotton ripened early by the application of Zn to cotton on calcareous soil, Nofal *et al.* (2002) found that the highest values of earliness % were obtained from foliar spraying with zinc twice at the high level, however the lowest values were obtained from untreated treatment and Sawan *et al.* (2008) found that application of zinc to the foliage, in chelated form (ethylene diamine tetra acetic acid), twice (at 70 and 85 days old) significantly increased earliness of harvest.

D-Seed cotton yield and its components:

The tested treatments gave a significant effect on number of open bolls/plant, boll weight, seed index, lint percentage and seed cotton yield/feddan in both seasons (Table 5). The higher number of open bolls/plant seed index, lint percentage and heavier bolls were obtained from foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient). However, the lowest values of these traits were recorded by untreated plants (the control treatment).

With regard to seed cotton yield/feddan, yield attributing characters are totally responsible for the variation in the seed cotton yield. The highest yield was obtained from foliar feeding with the combination between magnesium and zinc at the low level (2 g/L of each nutrient), followed by foliar feeding with magnesium at the low level (2 g Mg/L), foliar feeding with zinc at the low level (2 g Zn/L), foliar feeding with zinc at the high level (4 g Zn/L), foliar feeding with the combination between magnesium and zinc at the high level (4 g/L of each nutrient) and foliar feeding with magnesium at the high level (4 g Mg/L), respectively. While, the lowest yield was obtained from untreated plants (the control treatment) in both seasons. The yield increase percentages over untreated plants (the control) amounted to 26.16, 20.15, 17.19, 16.56, 13.61 and 12.34% in the first season and 21.31, 15.78, 13.53, 12.06, 4.40 and 4.06% in the second season, in respective order.

Positive response to foliar feeding with the combination between magnesium and zinc at the two levels examined as compared to the control could be due to: (1) The favorable effects of these two nutrients on the yield components, number of open bolls per plant and boll weight (Table 5), leading to higher cotton yield. (2) Increased seed index and boll weight (Table 5) coincidence with increased total chlorophylls (a and b, Table 2) which increased photosynthetic activity and improved mobilization of photosynthesis, (3) More number of open bolls

(Table 5) coupled with higher boll setting percentage (Table 4) and (4)Higher LAI resulted in better interception, absorption and utilization of radiation energy leading to higher photosynthetic rate and improvement of growth which in turn enhanced plant dry matter and consequently increased the yield attributes.

Table 4. Effect of foliar feeding with chelated Mg and Zn as well as their combinations on earliness traits in 2018 and 2019 seasons.

Treatments	No. of total flowers/plant	No. of total bolls/ plant	Boll setting %	Boll shedding %	Earliness %
		Season 2018			
T_1- Control	25.39	16.64	65.53	34.47	55.70
T_2- 2 g Mg chelated/L	26.16	19.20	73.39	26.61	63.67
T_3- 4 g Mg chelated/L	25.56	17.45	68.28	31.72	58.40
T_4- 2 g Zn chelated/L	25.56	18.02	70.50	29.50	63.27
T_5- 4 g Zn chelated/L	25.99	17.60	67.71	32.29	57.27
T_6- (2 g Mg chelated +2 g Zn chelated)/L	26.22	19.50	74.36	25.64	64.23
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	26.26	18.25	69.50	30.50	62.80
LSD at 5%	0.25	0.96	3.25	3.25	0.99
		Season 2019			
T_1- Control	25.67	17.20	67.01	32.99	57.67
T_2- 2 g Mg chelated/L	27.11	20.80	76.73	23.27	63.60
T_3- 4 g Mg chelated/L	26.24	18.82	71.71	28.29	59.10
T_4- 2 g Zn chelated/L	26.32	19.25	73.14	26.86	62.17
T_5- 4 g Zn chelated/L	26.09	18.40	70.52	29.48	59.47
T_6- (2 g Mg chelated +2 g Zn chelated)/L	26.19	19.92	76.06	23.94	62.73
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	26.50	19.50	73.59	26.41	61.03
LSD at 5%	0.46	1.03	3.02	3.02	1.58

Table 5. Effect of foliar feeding with chelated Mg and Zn as well as their combinations on seed cotton yield and its component in 2018 and 2019 seasons.

Treatments	No. of open bolls/plant	Boll weight (g)	Lint %	Seed index (g)	Seed cotton yield (kentar/ fed)
	Season 2018				
T_1- Control	16.48	3.11	39.90	10.35	9.48
T_2- 2 g Mg chelated/L	19.04	3.20	42.04	11.20	11.39
T_3- 4 g Mg chelated/L	17.36	3.18	41.50	10.85	10.65
T_4- 2 g Zn chelated/L	17.84	3.22	41.85	10.90	11.11
T_5- 4 g Zn chelated/L	17.40	3.17	40.09	10.60	11.05
T_6- (2 g Mg chelated +2 g Zn chelated)/L	19.32	3.31	42.15	11.45	11.96
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	18.00	3.13	41.15	10.85	10.77
LSD at 5%	0.90	0.05	0.14	0.14	0.24
	Season 2019				
T_1- Control	17.13	3.00	40.83	9.58	8.87
T_2- 2 g Mg chelated/L	20.57	3.20	41.27	10.50	10.27
T_3- 4 g Mg chelated/L	18.60	3.05	41.59	9.90	9.23
T_4- 2 g Zn chelated/L	19.07	3.11	41.78	10.22	10.07
T_5- 4 g Zn chelated/L	18.27	3.14	41.96	10.45	9.94
T_6- (2 g Mg chelated +2 g Zn chelated)/L	19.70	3.29	42.32	11.01	10.76
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	19.33	3.09	41.56	10.22	9.26
LSD at 5%	1.01	0.08	0.27	0.20	0.34

Untreated plants showed lowest values of leaf area index, number of fruiting branches, number of total flowers/plant, number of total bolls set/plant, boll setting percentage, yield parameters (number of open bolls/plant, boll weight, seed index and lint %) and leaves photosynthesis pigments as well as lowest seed cotton yield/feddan. Untreated plants had smaller photosynthetically supplied sinks for carbohydrates and other metabolites.

Comparing the two years, the seed cotton yield was more in the first season than the second one. This is attributed to favorable weather condition. Higher seed cotton yield was realized with complementary alliance of Zn and Mg application in the present study. The combination of these two nutrients attempts to achieve high nutrient supply system with synchrony between nutrient demand of the crop and nutrient release in soil system, while deficiency of these two nutrients recorded lower yield. In this regard, Eweida *et al.* (1979) reported that applying magnesium and zinc separately or in combination significantly increased seed cotton yield. Application of zinc to the foliage, in chelated form (ethylene diamine tetra acetic acid), two times at 70 and 85 days old significantly increased seed cotton yield/ha and its components as compared with the untreated control (Sawan *et al.* 2008). Foliar sprays of $MgSO_4$ 0.5% twice increased seed cotton yield by more than 18% above the control (Sankaranarayanan *et al.* 2010). Foliar spray of Mg on cotton produced greater number of bolls, higher boll weight and seed cotton yield (Rajakumar and Gurumurthy, 2008), Ahmed *et al.* (2010) found that boll bearing, boll weight, seed index, and seed cotton yield were increased with zinc use. Maximum yield increase was 15%, with 7.5 kg Zn ha^{-1}. However, yield depressed under greater levels of Zn. Positive relationship of leaf Zn concentration was observed with boll weight. Thus, Zn fertilization of low-Zn soil is suggested for improving cotton productivity and seed quality, Rezaei and Abbasi (2014) found that application of zinc chelate can improve cotton performance by increasing the number of bolls per plant and mean weight of 20 bolls and Singh *et al.* (2015) reported that two foliar sprays with magnesium and zinc significantly enhanced seed cotton yield by increasing its contributing parameters.

The maximum yield is reached at moderate Mg supply. The high level of Mg did not induce a further increase in yield as compared with the low level and this result may be due to the antagonistic effects of imbalanced supply of cationic nutrients (K, NH_4, Ca, Mg) and increased the concentration of toxic glycol alkaloids by increasing Mg supply as reported by Gransee and Führs (2013). Also, the high level of Zn did not induce a further increase in yield as compared with the low level as shown in Table 5. In this concern, Ahmed *et al.* (2010) found that greater Zn levels depressed yield and concluded that, Zn fertilization of low-Zn soil is suggested for improving cotton productivity and seed quality.

E- Fiber quality traits:

Regarding the effect of the tested treatments on fiber quality, the results in Table 6 show that, fiber length, uniformity index and fiber strength were significantly affected by the tested treatments in both seasons, where the longest fibers (33.75, 33.70 and 33.60 mm; 34.05, 33.90 and 33.85 mm) were obtained from foliar feeding with the combination between magnesium and zinc at the low level (2 g/L of each nutrient), foliar feeding with zinc at the high level (4 g Zn/L) and foliar feeding with magnesium at the low level (2 g Mg/L) in 2018 and 2019 seasons, respectively. However, the shortest fibers (32.20 and 33.40 mm) resulted from untreated plants (the control treatment). Also, foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient) and foliar feeding with magnesium at the low level (2 g Mg /liter water) gave the highest uniformity index (86.70 and 86.20%; 87.20 and 87%), but the lowest uniformity index (84.40 and 85.90%) were obtained from the control treatment, in 2018 and 2019 seasons, respectively. The highest values of fiber strength (10.60 and 10.60 Pressley units; 10.95 and 10.63 Pressley units), resulted from foliar feeding with the combination between magnesium and zinc at the low level (2 g /L of each nutrient) and foliar feeding with zinc at the high level (4 g Zn/liter water) in 2018 and 2019 seasons, respectively. Untreated plants gave the lowest values (10.00 and 9.90 Pressley units) in 2018 and 2019 seasons, respectively. Micronaire reading did not affect by the tested treatments.

Table 6. Effect of foliar feeding with chelated Mg and Zn as well as their combinations on cotton fiber traits in 2018 and 2019 seasons.

Treatments	Micronaire reading	Pressley index	2.5% span length (mm)	Uniformity index (%)
		Season 2018		
T_1- Control	4.60	10.00	32.20	84.40
T_2- 2 g Mg chelated/L	4.70	10.20	33.60	86.20
T_3- 4 g Mg chelated/L	4.70	10.30	32.80	85.00
T_4- 2 g Zn chelated/L	4.60	10.30	33.00	84.80
T_5- 4 g Zn chelated/L	4.50	10.60	33.70	86.10
T_6- (2 g Mg chelated +2 g Zn chelated)/L	4.60	10.60	33.75	86.70
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	4.60	10.40	33.30	85.60
LSD at 5%	NS	0.06	0.20	0.29
		Season 2019		
T_1- Control	4.60	9.90	33.40	85.90
T_2- 2 g Mg chelated/L	4.60	10.18	33.85	87.00
T_3- 4 g Mg chelated/L	4.70	10.40	33.80	86.80
T_4- 2 g Zn chelated/L	4.60	10.25	33.45	86.85
T_5- 4 g Zn chelated/L	4.60	10.63	33.90	86.30
T_6- (2 g Mg chelated +2 g Zn chelated)/L	4.60	10.95	34.05	87.20
T_7- (4 g Mg chelated + 4 g Zn chelated)/L	4.60	10.40	33.50	86.40
LSD at 5%	NS	0.48	0.19	0.32

The positive effect of foliar feeding with Mg and Zinc chelate is mainly due to the role of these two nutrients on cotton growth and development. In this regard, Livingston *et al.* (1991) indicated that fiber strength expression is attributed to genetic to a large degree than to environmental conditions, Zeng (1996) indicated that applying Zn to cotton on calcareous soil improved fiber quality, Ahmed *et al.* (2010) found that fiber quality remained unaffected with Zn use. Positive relationship of leaf Zn concentration was observed with fiber characters and Sankaranarayanan *et al*. (2010) reported that two foliar sprays of $MgSO_4$ 0.5% gave significant enhancement for uniformity ratio and Halo length.

CONCLUSION

The study concluded that foliar feeding with a combination of chelated magnesium and chelated zinc at the level (2 g/liter of each nutrient) three times (at squaring stage, flowering initiation and the top of flowering) gives the best chemical composition, the highest concentration of photosynthetic pigments in the leaves, the better growth and the highest productivity. The study recommended the possibility of being applied by farmers to enhance cotton productivity in light of the lack of magnesium and zinc in the soil under conditions similar to El-Gemmeiza region.

REFERENCES

A.S.T.M. (1986): American Society for Testing and Materials. Designation, D-1445-67, D-1447-63 and D-1448-59, Philadelphia, Pa.

Ahmed, N.; M. Abid and A. Rashid (2010): Zinc fertilization impact on irrigated cotton grown in an Aridisol: Growth, productivity, fiber quality, and oil quality. Communication in Soil Sci. and Plant Analysis, 41(13): 1627-1643.

Ankerman, D. and L. Large (1974): Soil and Plant Analysis. Agric. Lab. Inc., New York. USA.

Arnon, D.I. (1994). Copper enzymes in isolated chloroplasts. Plant Physiol., 24: 1-15.

Cakmak, I. and H. Marschner (1988): Increase in membrane permeability and exudation in roots of zinc deficient plants. J. of Plant Physiol., 132: 356–61.

Chapman, H.D. and P.P. Pratt (1978): Methods of analysis for soils, plants and water. Univ. of California, Div. of Agric. Sci., Priced Publ. 4034.

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

El-Fouly, M.M. (1983): Micronutrients in arid and semi-arid areas: levels in soils and plants and the need for fertilizers with reference to Egypt. Proc.15th Coll. Int. Potash Inst. (Bern) 163.

Eweida, M. H. T.; A. M. Hassanein; M. A. Risk and S. El-Halawany (1979): Interactive effects of nitrogen, magnesium and zinc on yield and chemical properties of seed oil in Egyptian cotton. Res. Bull., Fac. of Agric, Cairo 1193: 16.

Gerendás, J. and H. Führs (2013): The significance of magnesium for crop quality. Plant and Soil, 368: 101–128.

Gransee, A. and H. Führs (2013): Magnesium mobility in soils as a challenge for soil and plant analysis, magnesium fertilization and root uptake under adverse growth conditions. Plant and Soil, 368: 5 –21.

Guinn, G. (1985): Fruiting of cotton. III. Nutritional stress and cutout. Crop Sci., 25: 981–985.

Kadapa, S.N. (1975): Earliness in cotton I.A study of component characters. AICCIP, Agric. Res. St., Dharwar, India, Mysore. J. of Agric. Sci., 9(2): 219-229.

Livingston, S. D.; D. A. Anderson and B. F. Cowan (1991): An evaluation of five foliar applied products to enhance yields of DPL 50 cotton. Joint Meeting. Cotton Improvement and Physiology Conferences. Beltwide Cotton Conf., 1011–4.

Lohry, R. (2007): Micronutrients: functions, sources and application methods. Indiana CCA Res. Conf. Proceeding.

Loneragan, J.F. and M.J. Webb (1993): Interactions between zinc and other nutrients affecting the growth of plants. In: Robson, A.D. (Ed.), Zinc in Soils and Plants. Kluwer Academic Publishers, pp. 119-134, Dordrecht, The Netherlands, pp. 119-134.

Mortvedt, J.J.; L.S. Murphy and R.H. Follett (1999): Fertilizer Technology and Application. Meister Publishing Company Willoughby, OH.

Mulder, E. G. (1956): Nitrogen–magnesium relationships in crop plants. Plant and Soil, 7: 341–376.

Nofal, O. A.; R. Kh. Khalifa; M. T. Nawar and W. M. O. El-Shazly (2002): Effect of foliar feeding with some micronutrients on cotton leaf nutrient content, growth, earliness, yield, yield components and fiber quality on soil micronutrients status. Egypt. J. Bot., 42(1-2): 1-19.

Ohki, K. (1976): Effect of zinc nutrition on photosynthesis and carbonic anhydrase activity in cotton. Physiol. Plant, 38: 300–304.

Oosterhuis, D.; K. Hake and C. Burmester (1991): Foliar feeding cotton. Cotton Physiol. Today. National Cotton Council of America, 2: 1–7.

Rab, A. and I. Haq (2012): Foliar application of calcium chloride and borax influences plant growth, yield, and quality of tomato (*Lycopersicon esculentum* Mill.) fruit. Turk. J. Agric. For., 36: 695-701.

Rajakumar, D. and S. Gurumurthy (2008): Effect of plant density and nutrient spray on the yield attributes and yield of direct sown and polybag seedling planted hybrid cotton. Agric. Sci. Digest, 28: 174–177.

Rajasekar, M.; D. U. Nandhini; V. Swaminathan and K. Balakrishnan (2017): A review on role of macro nutrients on production and quality of vegetables. Int. J. of Chem. Studies, 5(3): 304-309.

Rezaei, M. and H. Abbasi (2014): 'Foliar application of nano chelate and non-nano chelate of zinc on plant resistance physiological processes in cotton (*Gossipium hirsutum* L.). Iranian J. of Plant Physiol., 4 (4) :1137-1144.

Richmond, T.R. and S.R.H. Radwan (1962): Comparative study of seven methods of measuring earliness of crop maturity in cotton. Crop Sci., Vol. 2: 397-400.

Rolbelen, G. (1957): Untersuchungen on strohleninduzieten blat arbumutonten Von arbidopoid. Thaliana (L.) Verbangsic.

Sankaranarayanan, S.; C. S. Praharaj; P. Nalayini; K. K. Bandyopadhyay and N. Gopalakrishnan (2010): Effect of magnesium, zinc, iron and boron application on yield and quality of cotton (*Gossypium hirsutum*). Indian. J. Agric. Sci., 80: 699–703.

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

Sharma, C. P.; P. N. Sharma; S. S. Bisht and B. D. Nautiyal (1982): Zinc deficiency induces changes in cabbage. In Proceedings of the Ninth Plant Nutrition Colloqzuium, ed. A. Scaife, pp. 601–606. Commonwealth Agric. Bureau, Farnham Royal, UK. Wallingford,UK:CAB Int.

Shukla, A. K.; K. B. Sanjib; T. Satyanarayana and K. Majumdar (2019): Importance of Micronutrients in Indian Agriculture. Better Crops-South Asia 2019.

Singh, K.; P. Rathore and R. K. Gumber (2015): Effects of foliar application of nutrients on growth and yield of bt cotton (*Gossypium hirsutum* L.). Bangladesh J. Bot. 44(1):9-14.

Steel, R. G. D.; J. H. Torrie and D. A. Dickey (1997). Principles and Procedures of Statistics: A Biometrical Approach. 3rd Ed., McGraw Hill Book Co. Inc. New York. 400-428 p.

Uchida, R. (2000): Essential nutrients for plant growth: nutrient functions and deficiency symptoms. Plant Nutrient Management in Hawaiis soils. Approaches for tropical and Subtropical Agric., Chapter 3: 31-55.

Verbruggen, N. and C. Hermans (2013): Physiological and molecular responsesto magnesium nutritional imbalance in plants. Plant and Soil, 368: 87 –99.

Watson, D.J. (1958): The dependence of net assimilation rate on leaf area index. Ann. Bot. (N.S.) Lon., 22: 37 – 54.

Wilkinson, S. R.; R. M. Welch; H, F. Mayland and D. L. Grunes (1990): Magnesium in plants uptake, distribution, function, and utilization by man and animals. Metal Ions in Biological Systems 26, 33 –56.

Yang, X.; X.Tian; X. Lu; Y. Cao and Z. Chen (2011): Impacts of phosphorus and zinc levels on phosphorus and zinc nutrition and phytic acid concentration in wheat (*Triticum aestivum* L.). J. of the Sci. of Food and Agric., 91: 2322-2328.

Yilmaz O.; K. Kahraman and L. Ozturk (2017): Elevated carbon dioxide exacerbates adverse effects of Mg deficiency in durum wheat. Plant Soil, 410(1-2):41–50.

Zeng, Q. F. (1996): Researches on the effect of zinc applied to calcareous soil in cotton field. China Cottons, 23:21

تأثير التغذية الورقية ببعض العناصر المخلبية على انتاجية وجودة صنف القطن المصرى جيزة 86

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اجريت تجربة حقلية خلال موسم 2018م وتم تكرارها خلال موسم 2019م بمحطة البحوث الزراعية بالجميزة - محافظة الغربية - مصر بهدف دراسة تاثير التغذية الورقية بالماغنيسيوم المخلّبى و/ او الزنك ثلاث مرات على انتاجية وجودة صنف القطن المصري جيزة 86، باستخدام مستويين (2 و 4 جرام من كل عنصر/لتر ماء) مقارنة مع النباتات غير المعاملة . واستخدم تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات. واوضحت النتائج ان التغذية الورقية بأستخدام مخلوط الماغنيسيوم المخلّبى والزنك المخلّبى فى تركيزاتهما المستخدمة أدت الى زيادة معنوية فى محتوى أوراق القطن من الماغنيسيوم ، الزنك ، وصبغات التمثيل الضوئى في الموسمين. كما أدت التغذية الورقية عند أستخدام مخلوط الماغنيسيوم المخلّبى والزنك المخلّبى عند مستوى (2 جم / لتر ماء من كل عنصر) إلى زيادة معنوية في صفات الوزن الكلى الجاف للنبات ، دليل المساحة الورقية ، طول النبات وعدد افرعه الثمرية ، عدد الازهار الكلية/النبات ، النسبة المئوية للعقد والتبكير ، عدد اللوز الكلى والمتفتح/ النبات ، وزن اللوزة ، معامل البذرة ، النسبة المئوية للتيلة ومحصول القطن الزهر/الفدان ، طول التيلة ، دليل الانتظام ومتانة التيلة في الموسمين وكانت النباتات غير المعاملة اقلها فى هذه الصفات مع زيادة معنوية فى النسبة المئوية للتساقط ولم تتأثر النعومة معنويا. وخلصت الدراسة الى أن التغذية الورقية بمخلوط الماغنيسيوم المخلّبى والزنك المخلّبى عند المستوى (2 جم / لتر ماء من كل عنصر) ثلاث مرات (في مرحلة الوسواس ، بداية التزهير وقمة التزهير) حققت أعلى انتاجية كما ونوعا واوصت الدراسة بامكانية تطبيقها من قبل المزارعين لتعزيز إنتاجية القطن في ظل نقص الماغنيسيوم والزنك في التربة تحت ظروف مماثلة لمنطقة الجميزة.