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الاستجابة الفسيولوجية لنبات الثوم المنزرع في أرض رملية للرش الورقي بالحديد والزنك والمنجنيز منفرداً أو في مخلوط

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الملخص العربي

أجرى هذا البحث خلال موسمي شتاء ٢٠٠٩/٢٠٠٨ ، ٢٠١٠/٢٠٠٩ بمزرعة محطة بحوث البساتين بالقصاصين – التابعة لمعهد بحوث البساتين- محافظة الاسماعيلية- مصر وذلك لدراسة تأثير الرش الورقي بكل من الحديد والزنك والمنجنيز بتركيز ١٠٠ ، ٢٠٠ ، ٣٠٠ جزء في المليون لكل منهم منفردا أو في مخاليط على بعض الصفات الفسيولوجية والبيوكيمائية والمحصول لنباتات الثوم (صنف سدس ٤٠) النامي في أرض رملية وباستخدام نظام الري بالتنقيط.

ويمكن إيجاز أهم النتائج المتحصل عليها فيما يلي :.

(١) أدى رش نبات الثوم بمخلوط من الحديد +الزنك + المنجنيز بتركيز ٢٠٠ جزء في المليون لكل منهم (المخلوط الثاني) إلى الحصول على أعلى قيم لكل من عدد الأوراق على النبات، وقطر كل من العنق والبصلة، والوزن الجاف الكلى للنبات، ومحتوى أنسجة الورقة من الكاروتينات، ومحتوى البصلة والأوراق من النتروجين والبوتاسيوم وكذلك الممتص بهما.

(٢) سجل رش النباتات بمخلوط من الحديد + الزنك + المنجنيز بتركيز ١٠٠ جزء في المليون لكل منهم (المخلوط الأول) إلى الحصول على أعلى قيم لكل من محتوى أنسجة الأوراق من كلوروفيل أ ، ب ، الكلوروفيل الكلى (أ+ب)، وعدد الفصوص في البصلة، ومتوسط وزن البصلة والمحصول الكلي للفدان.

(٣) أزداد محتوى الأبصال من الحديد والزنك والمنجنيز برش النباتات بمخلوط من الحديد +الزنك +المنجنيز بتركيز ٣٠٠ جزء في المليون لكل منهم (المخلوط الثالث).

PHYSIOLOGICAL RESPONSE OF GARLIC PLANT GROWN IN SANDY SOIL TO FOLIAR SPRAY WITH IRON, ZINC AND MANGANESE EITHER INDIVIDUAL OR IN MIXTURE FORM

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ABSTRACT: ***This experiment was carried out during the two winter seasons of 2008/2009 and 2009/2010 at El-Kassaien, Experimental Farm, Hort. Res. Station, Ismailia Governorate, Egypt, to investigate the effect of foliar spray with Fe, Zn and Mn at 100, 200 and 300 ppm of each individual or in mixture form on some physiological and chemical measurements as well as yield and its components of garlic plants cv sids 40 grown in sandy soil and using drip irrigation system.***

10Spraying of garlic plants with Fe+Zn +Mn at 200 ppm of each (mixture 2) recorded the maximum values of number of leaves/plant, both neck and bulb diameter, total dry weight/plant, carotenoids contents in leaf tissue, N and K content and their uptake by bulb and leaves. While, spraying plants with Fe+Zn +Mn at 100 ppm of each (mixture 1) gave the highest values of chlorophyll a, b, total chlorophyll (a+b), number of cloves /bulb, average bulb weight and total yield/feddan. On the other hand, the highest values of Fe, Zn and Mn were obtained by plants which were sprayed with Fe+Zn+Mn at 300 ppm of each (mixtures 3).

Key Words: ***Garlic, foliar spray, iron, zinc, manganese, Physiological, biochemical traits, yield and its components.***

INTRODUCTION

Allium sativum **L., commonly known as garlic, is considered as one of the most important species in the onion family Alliaceae . It is an important vegetable bulb crops and is next to onion in importance. Increasing garlic production has become of great necessary to meet the ever increased demand of exportation and local consumption (El-Hifny, 2010). Garlic has been used throughout recorded history for both culinary and medicinal purposes. It has a characteristic pungent, spicy flavor that mellows and sweetens considerably with cooking.**

In Egypt, it has been generally cultivated for both local consumption and export. The total area devoted for production in 2009 in Egypt, was 18,322 fed., which produced 174,659 tons with average 9.532 ton/fed. (FAO, 2009).

It is well know that, sandy soil is infertile and has very small amounts of microelements and high soil pH. Micronutrients deficiencies are more frequent in many soil types; i.e., alkaline, calcareous and sandy soils

(Srivastava and Gupta, 1996), moreover the availability and uptake by plants of Fe, Zn and Mn decreases with increasing soil pH (Mortvedt *et al*., 1991). The mobility of microelements in soil, plant and their translocation to plants as well as interaction among them selves or with macroelements in the soil and plant play an important role in plants nutrition (Marschner, 1998).

Foliar sprays are widely used to apply micronutrients, especially iron and manganese, for many crops. Soluble inorganic salts generally are as effective as synthetic chelates in foliar sprays, so the inorganic salts usually are chosen because of lower costs. Suspected micronutrient deficiencies may be diagnosed with foliar spray trials with one or more micronutrients. Also, advantages of foliar sprays are: (1) application rates are much lower than for soil application; (2) a uniform application is easily obtained; and (3) response to the applied nutrient is almost immediate so deficiencies can be corrected during the growing season. (Mortvedt *et al*., 1991).

Foliar spray of garlic plants with mixture of Fe+Zn +Mn at 300 ppm of each (Ibrahim *et al*., 1991, Hassan *et al*., 1993, Abdel -Hamied, 1997 and El-Morsy *et al.,* 2004) and at 100 or 200 ppm of each (Ahmad, 2002) significantly increased plant height, number of leaves/ plant, total dry weight/ plant, chlorophyll a, b, total chlorophyll (a+b) and carotenoids in leaf tissues , N,P and K contents in bulb and their uptake by plants , average bulb weight and total yield.

Therefore, the present investigation was undertaken to determine the suitable concentration of iron, zinc and manganese as foliar spray individual or in mixture form to obtain the highest yield quantity and best quality of garlic under sandy soil conditions.

MATERIALS AND METHODS

This experiment was carried out during the two winter seasons of 2008/2009 and 2009/ 2010 at El-Kassaien, Experimental Farm, Hort. Res. Station Ismailia Governorate, Egypt, to investigate the effect of foliar sprays with Fe, Zn and Mn individual or in mixture form on some physiological and biochemical analysis as well as yield and its components of garlic plants (*Allium Sativum* L.) cv. Sids 40 grown in sandy soil and using drip irrigation system. Available Fe, Zn and Mn were extracted by DTPA (Diethylene triamine penta acetic acid) Lindsay and Norvell, (1978). The physical and chemical analyses of the soil are presented in Table (1).

Table (1): The physical and chemical properties of soil during 2008/2009 and 2009/2010 seasons

Characters	Seasons	
Physical properties	**1st season**	**2nd season**
Sand (%)	95.3	94.4
Silt (%)	1.9	1.8
Clay	2.8	3.8
Chemical properties		
pH	8.2	8.1
Organic matter(%)	0.03	0.07
Available K (ppm)	59	65
Available P (ppm)	5.9	6.7
Available N (%)	5.7	6.8
Calcium carbonate (%)	0.19	0.21
Available Fe (ppm)	4.72	4.53
Available Zn (ppm)	3.18	3.25
Available Mn (ppm)	2.11	2.25

This experiment included 13 treatments which were the combinations among Fe, Zn and Mn at three concentrations for each alone or in mixture as follows: 1. Unsprayed (control), 2: Fe at 100, 200 and 300 ppm, Zn at 100, 200 and 300 ppm and Mn at 100, 200 and 300 ppm, 3: mixture 1 (Fe+Zn+Mn at 100 ppm of each), mixture 2 (Fe+Zn+Mn at 200 ppm of each) and mixture 3 (Fe+Zn+Mn at 300 ppm of each

These treatments were arranged in a completely randomized block design with three replications.

The cloves of garlic *cv* sids 40 were sown on 15th and 20th Sept. in the 1st and 2nd seasons, respectively. Garlic cloves were selected for uniformity in shape and size sown on both sids of the dripper lines at distance 10 cm a apart.

The experimental unit area was 12.6 m^2. It contains three drippers lines with 7m length each and 60 cm distance between each two drippers lines. One line was used for taking samples to measure the morphological and physiological traits and the other two lines were used for yield determinations. Plants were sprayed three times at 60,75 and 90 days after planting with micronutrients; i.e., Fe, Zn and Mn solutions in the form of ferrous sulphate ($FeSO_4.7H_2O$), Zinc sulphate ($ZnSO_4.7H_2O$) and Manganese sulphate ($MnSO_4.7H_2O$), respectively. Each plot received 2L. solutions of each concentration using spreading agent in all treatments to improve adherence of the spray to the plant foliage for increasing Fe, Zn and Mn absorption by the plants (Mortvedt *et al.* , 1991). The untreated plants (check) were sprayed with tap water and spreading agent.

All plots received equal amounts of farmyard manure at rate of 30 m^3/fed. and one third of all commercial fertilizers; i.e., ammonium sulphate (20.5 % N), calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48 % K_2O) during soil preparation in the center of planting line , then covered by sand. These commercial fertilizers were added at the rates of 500, 450 and 200 kg/fed. respectively. The rest amounts of these fertilizers (two thirds) were splitted into five equal portions and added to the soil every 15 days , beginning one month after planting. The normal agricultural practices were carried out as commonly used in the district.

The following data were recorded

Plant Growth Characters

A random sample of ten plants from every experimental unit was taken at 135 days after planting and the following data were recorded: plant height (cm), number of leaves/ plant and both neck and bulb diameter (cm).

Different plant parts (bulb and leaves) were oven dried at 70 ^oC for 48 hr. till constant weight, and dry weight of bulb and leaves as well as the total dry weight/ plant were recorded.

Physiological and Chemical Analysis

Photosynthetic pigments

Disk samples from the fourth upper leaf were obtained at 135 days after planting to determine chlorophyll a and b as well as carotenoids according to the method described by Wettestein (1957).

N, P and K contents and their uptakes

The dry matter of bulb and leaves at 135 days after sowing in both seasons were finely ground and wet digested with sulfuric acid and perchloric acid (3:1). Nitrogen, phosphorus and potassium contents were determined according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively, then N, P and K uptake as well as total uptake by bulb and leaves were calculated.

Yield and Its Components

As plants reached the proper maturity stage, plot bulbs were harvested, counted, weighed and the following data were recorded: average bulb weight

and total yield/fed. A random sample of 10 bulbs from every plot was taken to determined number of cloves/bulbs.

Bulb Quality

Iron, zinc and manganese contents: they were determined by atomic absorption spectrophotometer as described by Evenhuis and Dewaard (1980).

Statistical analysis

The data of this experiment were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1980) and the differences among treatments were compared using Duncan's multiple range test (Duncan, 1995).

RESULTS AND DISCUSSION

Plant Growth Characters

Morphological traits

It can be seen from data in Table (2) that foliar spray of garlic plants grown in sandy soil and sprayed with Fe, Zn and Mn as single or in mixture at different concentrations reflected significant differences on plant height, number of leaves/ plant , and both neck and bulb diameter in both seasons. It is obvious from such data that spraying with Fe+Zn +Mn at 300 ppm of each (microelements mixture 3) gave the tallest plants followed by spraying with Fe+Zn +Mn at 200 ppm of each and recorded the maximum values of number of leaves/plant and both neck and bulb diameter with no significant differences with Fe+Zn +Mn at 200 ppm of each (microelements mixture 2) with respect to bulb diameter .

These results could be attributed to the effective role of such micronutrients in controlling various enzymes activities and photosynthetic pigments formation, consequently affecting plant growth. The promotive effect of Fe could be explained as Fe plays a prominent role in several vital processes in plant such as photosynthesis consequently affecting plant growth. Also, Zn is well known to be directly involved in biosynthesis on IAA hormone which induces cell division and cell elongation (Katyal and Randhawa, 1983). Also, the effect of Zn on plant growth parameters might be due to its essential role in many important metallic functions such as transport of carbohydrates, regulation of meristematic activity, photosynthesis, respiration, energy production and protein metabolism. Such functions would directly or indirectly contribute to plant growth (Srivastava and Gupta, 1996).These results are coincided with those reported by Hassan *et al.* (1993), Abdel-Hamied (1997), Ahmad (2002) and El-Morsy *et al*. (2004).

Table 2

Dry weight

It is quite clear from data in Table 3 that spraying garlic plants with different concentrations of Fe, Zn and Mn single or in mixture showed a significant effect on dry weight of leaves, bulb and total (leaves +bulb) dry weight/ plant compared with unsprayed plants in both seasons. Foliar spray of garlic plants with microelements mixture2 (Fe+Zn +Mn at 200 ppm of each) gave the highest values of leaves, bulb and total (leaves + bulb) dry weight / plant compared to foliar spray with Fe, Zn and Mn alone at different concentrations or in mixture at 100 or 300 ppm of each or unsprayed plants. The increases in total dry weight/ plant were about 5.29 and 5.54 gm/ plant for spraying plants with microelements mixture 2 over the control (unsprayed) in 1st and 2nd seasons, respectively.

Table (3): Effect of foliar spray with Fe, Zn and Mn individually or in mixture on dry weight (g)of different plant parts of garlic plant (*cv* Sids 40) at 135 days after planting during 2008/2009 and 2009/2010 seasons

Treatments	Leaf		Bulb		Total	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	10.75 e	11.68 fg	8.257 g	8.207 g	18.97h	19.89 g
Fe at 100 pm	12.81 c	13.22 bc	9.980 c	10.11 ab	22.78 bc	23.33 b
Fe at 200 pm	11.97 d	12.28 d-g	9.807 cd	9.287 cd	21.78 de	21.56 cd
Fe at 300 pm	13.00 c	11.72 fg	8.330 g	8.513 f	21.33 e	20.24 fg
Zn at 100 ppm	11.86 d	11.97 e-g	8.743 f	9.097 de	20.60 fg	21.07 de
Zn at 200 ppm	13.75 b	12.00 e-g	9.160 e	9.123 de	22.91 b	21.12 de
Zn at 300 ppm	11.69 d	12.58 de	8.703 f	9.473 c	20.40 g	22.06 c
Mn at 100 ppm	12.92 c	11.66 g	8.677 f	8.903 e	21.59 fg	20.57 ef
Mn at 200 ppm	10.70 e	11.78 fg	9.657 d	9.293 cd	20.35 g	21.07 de
Mn at 300 ppm	13.08 c	12.31d-f	9.163 e	9.267 cd	22.25 cd	21.57cd
Mixture 1	12.74 c	13.47 b	10.21 b	9.950 b	22.95 b	23.43 b
Mixture 2	14.81 a	15.14 a	10.46 a	10.29 a	25.26 a	25.43 a
Mixture 3	12.67 c	12.75 cd	10.31 ab	10.10 ab	22.98 b	22.85 b

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

The stimulative effect of Fe, Zn and Mn on dry weight/ plant could be attributed to that Fe, Zn and Mn plays a vital role in plants as follows: Iron is a component of many enzymes associated with energy transfer, nitrogen reduction and fixation, and lignin formation. Iron is associated with sulfur in plants to form compounds that catalyze other reactions (Mortvedt *et al*., 1991). Zinc is a components of many enzymes such as dehydrogenase, proteinase , peptidases and phosphohydrolass important for metabolism of carbohydrate, protein and phosphate (Kabat-Pendias and Pendias, 1992; Srivastava and Goupta, 1996). Manganese is involved in the evolution of O_2 in photosynthesis (Hill reaction). It is a component of several enzyme systems. It has also, function in chloroplast as a part of electron-transfer (oxidation-reduction) reactions and electron transport system (Srivastava and Goupta, 1996). These results agree with those reported by Hassan *et al*. (1993), Abdel-Hamied (1997), Ahmad (2002) and El-Morsy *et al*. (2004). They reported that spraying garlic plants with Fe, Zn and Mn at 200 ppm gave the highest values of dry weight of plant.

Physiological and Chemical Analysis
Photosynthetic pigments

It is evident from data in Table (4) that, spraying of garlic plants with Fe, Zn and Mn at different concentrations alone or in mixture had a significant effect on the concentration of chlorophyll a, b, total (a+b) and carotenoids in leaf tissues in both seasons. It is clear from data that foliar spray with microelements mixture 1 recorded the highest values of chlorophyll a, b and total chlorophyll (a+b) and microelements mixture 2 recorded the highest values of carotenoids in leaf tissue with no significant differences with Zn at 200 ppm, whereas Mn at 200 ppm recorded the maximum values of chlorophyll b in leaf tissues. Micronutrients play an indispensable role in cell division and development of meristematic tissues, stimulate photosynthesis, respiration, energy and nucleotide transfer reactions and fasten the plant maturity (Marschner, 1998)..

These results are in harmony with those reported by Ahmad (2002) who found that chlorophyll a, b and carotenoids in leaf tissue of garlic increased with increasing foliar spray with Fe + Zn and Mn .

Table 4

Contents of N, P and K

The obtained results in Tables (5 and 6) show that spraying Fe, Zn and Mn alone or in their combinations significantly increased N and K contents in bulb and leaves of garlic. It is obvious from the data that spraying of plants with microelements mixture 2 was the best treatment for enhancing N and K content in both bulb and leaves.

Table (5): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on N,P and K contents (%) in bulb of garlic (*cv* Sids 40) at 135 days after planting 2008/2009 and 2009/2010 seasons

Characters / Treatments	N %		P %		K %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	1.76cd	1.71 d-f	0.355 a	0.359 a	1.76 c	1.66 d
Fe at 100 pm	1.76 cd	1.72 c-e	0.344 a	0.351 a	1.81 bc	1.72 c
Fe at 200 pm	1.60 e	1.56 g	0.327 a	0.318 a	1.63 d	1.62 d
Fe at 300 pm	1.54 f	1.66 f	0.310 a	0.309 a	1.54 e	1.52 e
Zn at 100 ppm	1.60 e	1.56 g	0.334 a	0.326 a	1.61 de	1.52 e
Zn at 200 ppm	1.50 f	1.50 h	0.315 a	0.322 a	1.62 de	1.66 d
Zn at 300 ppm	1.86 b	1.83 a	0.343 a	0.339 a	1.96 a	1.94 a
Mn at 100 ppm	1.80 c	1.80 ab	0.337 a	0.347 a	1.85 b	1.81 b
Mn at 200 ppm	1.86 b	1.77 bc	0.350 a	0.349 a	1.88 b	1.82 b
Mn at 300 ppm	1.81 bc	1.75 b-d	0.326 a	0.342 a	1.76 c	1.73 c
Mixture 1	1.73 d	1.67 ef	0.362 a	0.364 a	1.80 bc	1.73 c
Mixture 2	1.95 a	1.84 a	0.356 a	0.331 a	1.97 a	1.92 a
Mixture 3	1.81 bc	1.72 c-e	0.327 a	0.329 a	1.80 bc	1.72 c

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

The data also show that P content in bulbs and leaves did not significantly affect by foliar application of Fe, Zn and Mn alone or in combination. This reduction in P percentages in garlic tissues after foliar application of Fe and Zn may be due to the antagonism between Zn or Fe and P in tissues. Spraying garlic plants with different concentrations of Fe, Zn and Mn in mixture significantly increased N, P and K in bulbs compared to untreated plants (Abdel-Hamied, 1997).

Table (6): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on N,P and K contents (%) in leaves of garlic (*cv* Sids 40) at 135 days after planting during 2008/2009 and 2009/2010 seasons

Characters / Treatments	N %		P %		K %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	3.57 d	3.63 e	0.315 b	0.309 b	2.51 d	2.51 fg
Fe at 100 pm	3.72 d	3.81 d	0.309 b	0.294 b	3.27 b	3.11 ab
Fe at 200 pm	3.63 d	3.65 e	0.300 b	0.289 b	2.63 cd	2.58 e-g
Fe at 300 pm	3.68 d	3.59 e	0.281 b	0.274 b	2.50 d	2.40 g
Zn at 100 ppm	4.21 bc	3.57 e	0.290 b	0.291 b	2.80 c	2.62 d-g
Zn at 200 ppm	3.73 d	3.91 cd	0.269 b	0.275 b	2.41 d	2.69 d-f
Zn at 300 ppm	4.27 b	4.03 bc	0.387 a	0.383 a	3.63 a	3.10 ab
Mn at 100 ppm	4.25 b	4.08 b	0.279 b	0.283 b	2.83 c	3.09 ab
Mn at 200 ppm	4.27 b	4.03 bc	0.310 b	0.315 b	3.56 a	2.80 c-e
Mn at 300 ppm	4.13 bc	4.08 b	0.293 b	0.289 b	2.84 c	2.88 b-d
Mixture 1	4.03 c	3.92 bcd	0.321 b	0.317 b	3.40 ab	3.19 a
Mixture 2	4.61 a	4.34 a	0.305 b	0.308 b	3.50 ab	3.35 a
Mixture 3	4.47 a	4.30 a	0.326 b	0.296 b	3.23 b	3.06 a-c

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

Uptake of N, P and K

Presented data in Tables 7 and 8 show that spraying garlic plants with Fe, Zn and Mn as single or in mixtures at different concentrations significantly increased N, P and K uptake by bulb and leaves in both seasons. Spraying with microelements mixture 2 significantly increased N,P and K uptake by bulb and leaves. The stimulative effect of Fe+Zn +Mn on N,P and K uptake in leaves and bulb may be due to that the mixture of Fe, Zn and Mn at 200 ppm of each increased dry weight of leaves and bulbs (Table ,2).

Table (7): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on N,P and K uptake (mg) by bulb of garlic plant (*cv* Sids 40) at 135 days after planting during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Characters / Treatments	N (mg)		P (mg)		K (mg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	145.3 g	140.7 de	29.34d	29.50 g	145.9 e	136.3 f
Fe at 100 pm	176.3c	173.7 b	34.33 b	35.50 a	181.3 b	174.1c
Fe at 200 pm	157.5 ef	144.9 d	32.09c	29.56 g	159.8d	151.1 e
Fe at 300 pm	128.5 i	141.3 de	25.85 e	26.37 h	128.8 f	129.4 g
Zn at 100 ppm	139.9gh	141.9 de	29.22 d	29.68 fg	141.3 e	138.2 f
Zn at 200 ppm	137.4 h	136.9 e	28.92d	29.38 g	148.5 e	152.1 e
Zn at 300 ppm	162.5de	173.7 b	29.91d	32.15c-e	171.2 c	183.8 b
Mn at 100 ppm	156.2 f	160.9 c	29.30 d	30.93 ef	160.8 d	161.5 d
Mn at 200 ppm	179.9c	164.9 c	33.80bc	32.45 cd	181.9 b	169.2 c
Mn at 300 ppm	166.4 d	162.5 c	29.90 d	31.75de	161.9d	160.4 d
Mixture 1	177.3c	166.2 c	36.96 a	36.26 a	184.1 b	172.5 c
Mixture 2	204.6 a	190.1 a	37.30 a	34.08 b	206.4 a	197.7 a
Mixture 3	187.4 b	174.5 b	33.76bc	33.31 bc	186.0 b	173.8 c

Table (8): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on N,P and K uptake (mg) by leaves of garlic plant (*cv* Sids 40) at 135 days after planting during 2008/2009 and 2009/2010 seasons

Characters / Treatments	N (mg)		P (mg)		K (mg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	461.8 fg	423.9 f	40.69 b	36.13d-f	324.2 e	293.1 hi
Fe at 100 pm	476.8 ef	504.6 cd	39.62 bc	38.87 c	418.2 bc	411.6 bc
Fe at 200 pm	435.0 g	448.6 ef	35.96d-f	35.53 ef	315.2 e	317.6gh
Fe at 300 pm	478.8d-f	420.8 f	36.61 c-f	32.12 h	325.3 e	281.3 i
Zn at 100 ppm	499.4 de	427.3 f	34.47 ef	34.92 fg	331.9 e	314.1 g-i
Zn at 200 ppm	514.1 cd	469.6 e	37.09c-e	33.04 gh	332.1 e	322.8f-h
Zn at 300 ppm	499.9 de	507.5 c	45.29 a	48.19 a	424.7 b	390.9cd
Mn at 100 ppm	456.9 fg	476.5 de	30.00 g	33.06 gh	305.3 e	361.0 de
Mn at 200 ppm	457.5 fg	474.7 de	33.21fg	37.11c-e	381.5 cd	329.1e-g
Mn at 300 ppm	541.3 bc	502.6 cd	38.34b-d	35.62 ef	372.4 d	355.2ef
Mixture 1	514.4 cd	528.9 bc	40.93 b	42.74 b	433.0 b	430.1 b
Mixture 2	683.5 a	657.8 a	45.24a	46.68 a	518.2 a	507.4 a
Mixture 3	567.2 b	549.4 b	41.31b	37.82cd	409.8bc	390.7cd

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

Total uptake of N, P and K

Presented data in Table (9) show that spraying garlic plants with different concentrations of Fe, Zn and Mn separately or in mixture significantly increased N, P and K total uptake by plants in both seasons. Also, microelements mixture 2 treatment gave the highest values of N,P and K total uptake by garlic plant. The stimulative effect of Fe+Zn +Mn in mixture on N, P and K total uptake by garlic plants compared to other treatments.

Table (9): Effect of foliar spray with Fe, Zn and Mn individually or in mixture on total uptake of N,P and K (mg) by garlic plant (bulb and leaves) *cv* Sids at 135 days after planting during 2008-2009 seasons under sandy soil conditions

Characters / Treatments	N (mg)		P (mg)		K (mg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	607.1 fg	564.6 f	70.03 d	65.63de	470.1 e	429.4 gh
Fe at 100 pm	653.1 e	678.3 c	73.95 c	74.37 b	599.5 bc	585.7 bc
Fe at 200 pm	592.5 g	593.5 ef	68.05 de	65.08 e	475.0 e	468.6 ef
Fe at 300 pm	607.3 fg	562.1 f	62.46 gh	58.48 g	454.1 e	410.7 h
Zn at 100 ppm	639.2 ef	569.2 f	63.68 fg	64.60 e	473.2 e	452.3 fg
Zn at 200 ppm	651.5 e	606.5 e	66.01 ef	62.41 f	480.6 e	474.9 ef
Zn at 300 ppm	662.4de	681.2 c	75.20 bc	80.34 a	595.9 bc	574.7 bc
Mn at 100 ppm	613.1 fg	637.3 d	59.30 h	63.98 ef	466.1 e	522.4 d
Mn at 200 ppm	637.4 ef	639.6 d	67.00 d-f	69.55 c	563.4 cd	498.3 de
Mn at 300 ppm	707.7 c	665.1 cd	68.24 de	67.37 d	534.3 d	515.6 d
Mixture 1	691.7 cd	695.1 bc	77.88 b	78.99 a	617.1 b	602.6 b
Mixture 2	888.1 a	847.9 a	82.55 a	80.76 a	724.6 a	705.1 a
Mixture 3	754.6 b	723.8 b	75.07 bc	71.13 c	595.8 bc	564.5 c

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

Yield and Its Components

The results in Table (10) show that spraying with Fe, Zn and Mn at different concentration alone or in combinations significantly affected number of cloves/bulb, average bulb weight and total yield/ fed. in both seasons. Spraying plants with microelements mixture 1, 2 or 3 recorded the highest values of number of cloves /bulb, average bulb weight and total yield/fed. compared to unsprayed plants (check) or plants which were sprayed with different concentration of Fe,Zn and Mn individually.

The increases in total yield were about 3.230 and 3.749; 3.360 and 3.887; 3.204 and 3.680 ton/fed. for plants which were sprayed with microelements mixture 1, 2 or 3 over the plants which unsprayed in 1st and 2nd seasons, respectively..

The increase in growth of garlic plants, total uptake of N, P, K and total yield/fed. by spraying with Fe+Zn+Mn as mixture might be due to that sandy soil has low available N,P and K and has very amounts of microelements (Table 1).

The increase in total yield was owing directly to the increase in vegetative growth (Tables 2 and 3), high photosynthesis capacity expressed in leaf pigments (Table 4) and high average bulb weight (Table 10). These increases might be ascribed to the favorable role of the used micronutrients in pigments formation, photosynthesis activation and carbohydrates assimilation diverted to the bulbs which represented the economic part of

plant (Hilman and Asandhi, 1987). Similar results were reported by Hassan *et al*. (1993), Abdel -Hamied (1997), Ahmad (2002) and El-Morsy *et al*. (2004). They concluded that spraying garlic plants with Fe, Zn and Mn in mixture at 100 or 200 or 300 ppm of each significantly increased yield and its components.

In this concern, El-Tohamy *et al.* (2009) on onion found that, foliar application of Fe, Zn and Mn significantly improved total yield compared to control plants.

Table (10): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on yield and its components during 2008/2009 and 2009/2010 seasons

Characters / Treatments	Number of cloves/bulb		Bulb weight (g)		Total yield (ton/fed.)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	10.12 e	9.970 h	41.48 e	40.87 h	6.343 e	6.203 g
Fe at 100 pm	10.67 e	12.19 e	42.69 e	48.76 e-g	6.600 e	6.373 fg
Fe at 200 pm	11.46 e	11.33 fg	46.99 e	46.47 fg	6.763 e	6.583 e-g
Fe at 300 pm	13.73 d	10.94 g	57.66 cd	45.95 g	7.783 cd	6.517 e-g
Zn at 100 ppm	15.17 b	11.57 e-g	65.23 b	49.75 ef	8.807 b	6.717 ef
Zn at 200 ppm	13.10 d	11.42 efg	55.04 d	47.98 e-g	7.430 d	6.477 e-g
Zn at 300 ppm	15.24 bc	13.12 d	62.94 bc	54.19 d	8.497 bc	7.317 d
Mn at 100 ppm	15.89 a-c	11.84 ef	67.53 ab	50.29 e	9.117 ab	6.790 e
Mn at 200 ppm	14.50 cd	13.66 cd	58.00 cd	54.64 d	7.830 cd	7.377 d
Mn at 300 ppm	16.37 ab	14.15 c	70.37 a	60.86 c	9.500 a	8.217 c
Mixture 1	16.88 a	17.55 a	70.91 a	73.70 a	9.573 a	9.950 a
Mixture 2	17.41 a	18.09 a	71.88 a	74.71 a	9.703 a	10.09 a
Mixture 3	16.45 ab	17.03 a	70.72 a	73.21 a	9.547 a	9.883 a

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)

Fe, Zn and Mn Contents in Bulb at Harvest Time

The obtained data in Table (11) reveal that spraying garlic plants with microelements mixture 3 or Fe, Zn and Mn alone at 300 ppm of each recorded maximum values of Fe, Zn and Mn in bulb at harvesting date, whereas garlic plants which unsprayed with any micronutrients recorded minimum values of Fe, Zn and Mn contents in bulbs (average two seasons).

These results agree with those reported by El-Morsy (2005) who found that all concentrations of Fe, Zn and Mn in cloves at harvest time were significantly increased due to spraying the garlic plants with mixture of micronutrients (Fe + Zn + Mn) at 250 ppm in comparing with the other treatments.

From the results of this study, it could be concluded that, spraying garlic plants with mixture 2 of micronutrients (Fe + Zn + Mn) at 200 ppm was the

recommended treatment for increasing garlic yield and improving bulb quality of garlic under similar conditions to this work.

Table (11): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on Fe, Zn and Mn contents (ppm) in garlic bulb at harvesting time (average two seasons) under sandy soil conditions

Characters / Treatments	Fe	Zn	Mn
Unsprayed	20.4e	13.4e	6.4d
Fe at 100 pm	22.8b-e	14.2de	6.8d
Fe at 200 pm	24.4a-c	13.8de	8.4c
Fe at 300 pm	25.8ab	15.6d	8.4c
Zn at 100 ppm	19.6e	19.4c	7.2d
Zn at 200 ppm	20.0e	22.6a	8.6c
Zn at 300 ppm	21.2de	23.8a	10.2b
Mn at 100 ppm	20.6de	12.6e	9.8b
Mn at 200 ppm	22.4c-e	12.6e	10.4b
Mn at 300 ppm	21.2de	13.0e	12.0a
Mixture 1	23.6a-d	20.4bc	9.6b
Mixture 2	24.4a-c	21.8ab	10.6b
Mixture 3	26.6a	23.4a	12.8a

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test . Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each).

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الاستجابة الفسيولوجية لنبات الثوم المنزرع في أرض رملية للرش الورقي بالحديد والزنك والمنجنيز منفرداً أو في مخلوط

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الملخص العربي

أجرى هذا البحث خلال موسمي شتاء ٢٠٠٨/٢٠٠٩ ، ٢٠٠٩/٢٠١٠ بمزرعة محطة بحوث البساتين بالقصاصين - التابعة لمعهد بحوث البساتين- محافظة الاسماعيلية- مصر وذلك لدراسة تأثير الرش الورقي بكل من الحديد والزنك والمنجنيز بتركيز ١٠٠ ، ٢٠٠ ، ٣٠٠ جزء في المليون لكل منهم منفردا أو في مخاليط على بعض الصفات الفسيولوجية والبيوكيمائية والمحصول لنباتات الثوم (صنف سدس ٤٠) النامي في أرض رملية وباستخدام نظام الري بالتنقيط.

ويمكن إيجاز أهم النتائج المتحصل عليها فيما يلي :.

(٤) أدى رش نبات الثوم بمخلوط من الحديد +الزنك + المنجنيز بتركيز ٢٠٠ جزء في المليون لكل منهم (المخلوط الثاني) إلى الحصول على أعلى قيم لكل من عدد الأوراق على النبات، وقطر كل من العنق والبصلة، والوزن الجاف الكلى للنبات، ومحتوى أنسجة الورقة من الكاروتينات، ومحتوى البصلة والأوراق من النتروجين والبوتاسيوم وكذلك الممتص بهما.

(٥) سجل رش النباتات بمخلوط من الحديد + الزنك + المنجنيز بتركيز ١٠٠ جزء في المليون لكل منهم (المخلوط الأول) إلى الحصول على أعلى قيم لكل من محتوى أنسجة الأوراق من كلوروفيل أ ، ب ، الكلوروفيل الكلى (أ+ب)، وعدد الفصوص في البصلة، ومتوسط وزن البصلة والمحصول الكلي للفدان.

(٦) أزداد محتوى الأبصال من الحديد والزنك والمنجنيز برش النباتات بمخلوط من الحديد +الزنك +المنجنيز بتركيز ٣٠٠ جزء في المليون لكل منهم (المخلوط الثالث).

Table (2): Effect of foliar spray with Fe, Zn and Mn individually or in mixture on morphological characters of garlic plants cv. Sids 40 at 135 days after planting during 2008/2009 and 2009/2010 seasons under sandy soil conditions

Treatments	Plant height (cm)		Number of leaves/plant		Neck diameter (cm)		Bulb diameter (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	54.33 e	56.00 h	9.333 c	11.33 a-e	1.20 de	1.30 b-d	5.21 f	5.10 g
Fe at 100 pm	56.00 e	57.33 gh	10.00 bc	9.000 f	1.04 fg	1.04 f	5.31 ef	5.25 fg
Fe at 200 pm	66.50 bc	66.67 b-d	12.00 ab	12.67 ab	1.43 ab	1.42 a-c	6.58 a	6.63 b
Fe at 300 pm	71.00 a	65.33 cd	12.67 a	11.00 b-e	1.05 fg	1.13 ef	5.94 b	6.30 c
Zn at 100 ppm	60.67 d	61.00 f	9.333 c	9.667ef	1.00 g	1.10 ef	5.10 f	5.44 ef
Zn at 200 ppm	61.00 d	64.00 de	10.00 bc	9.667 ef	1.20 de	1.26 c-e	5.93 b	5.76 d
Zn at 300 ppm	68.67 ab	68.00 bc	12.00 ab	12.00 a-d	1.13 ef	1.08 f	5.51 de	6.33 c
Mn at 100 ppm	60.67 d	59.67 fg	10.67 a-c	10.33 d-f	1.19 e	1.21 d-f	5.61 cd	5.56 de
Mn at 200 ppm	68.67 ab	68.00 bc	11.67 a-c	12.00 a-d	1.30 cd	1.39 a-c	5.92 b	6.83 ab
Mn at 300 ppm	64.00 cd	61.00 f	10.33 a-c	10.00 ef	1.14 ef	1.16 d-f	5.81 bc	5.66 de
Mixture 1	64.00 cd	61.67 ef	11.33 a-c	10.67 c-f	1.48 ab	1.45 ab	5.68 cd	5.63 de
Mixture 2	68.33 ab	71.00 a	11.67 a-c	12.33 a-c	1.40 bc	1.45 ab	6.46 a	6.89 a
Mixture 3	71.00 a	69.33 ab	12.00 ab	13.00 a	1.52 a	1.54 a	6.66 a	6.86 ab

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3(Fe+Zn+Mn at 300 ppm of each).

Table (4): Effect of foliar spray with Fe,Zn and Mn individually or in mixture on photosynthetic pigments (mg/gm DW) in leaf tissues of garlic *cv* Sids 40 at 135 days after planting during 2008/2009 and 2009/2010 seasons

Treatments	Chlorophyll a		Chlorophyll b		Total Chlorophyll (a+b)		Carotenoids (mg/gm DW)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Unsprayed	2.61 de	2.62 c	1.64 h	1.61 b	4.26 f	4.23 e	1.89 h	1.83 h
Fe at 100 pm	3.33 bc	3.32 b	1.74 fg	1.72 ab	5.08 b-d	5.04 bc	2.05 g	2.06 g
Fe at 200 pm	3.20 bc	3.16 b	1.76 fg	1.75 ab	4.96 de	4.92 bc	2.25 f	2.19 g
Fe at 300 pm	3.63 a	3.28 b	1.86 cd	1.82 ab	5.49 a	5.10 b	3.19 b	3.09 bc
Zn at 100 ppm	3.26 bc	3.34 b	1.83 de	1.80 ab	5.09 b-d	5.14 b	2.35 f	2.37 f
Zn at 200 ppm	3.28 bc	3.38 ab	1.93 ab	1.69 ab	5.21 bc	5.07 bc	3.34 a	3.23 ab
Zn at 300 ppm	3.16 c	3.18 b	1.85 d	1.81 ab	5.01 c-e	5.00 bc	2.49 e	2.44 ef
Mn at 100 ppm	2.69 d	3.05 b	1.76 fg	1.69 ab	4.45 f	4.74 cd	2.76 c	2.71 d
Mn at 200 ppm	2.45 e	2.40 c	1.94 a	1.84 a	4.39 f	4.25 e	3.09 b	3.01 c
Mn at 300 ppm	2.65 d	2.64 c	1.79 ef	1.79 ab	4.44 f	4.44 de	2.72 c	2.67 d
Mixture 1	3.73 a	3.66 a	1.91 abc	1.81 ab	5.65 a	5.48 a	3.11 b	3.06 bc
Mixture 2	3.39 b	3.36 ab	1.88 b-d	1.80 ab	5.27 b	5.16 ab	3.34 a	3.35 a
Mixture 3	3.15 c	3.08 b	1.72 g	1.65 ab	4.88 e	4.74 cd	2.62 d	2.57 de

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. Microelements mixture 1 (Fe+Zn+Mn at 100 ppm of each); mixture 2 (Fe+Zn+Mn at 200 ppm of each); mixture 3 (Fe+Zn+Mn at 300 ppm of each)