Effect of Foliar Spraying with Micronutrients and Salicylic Acid on Growth, Yield and Quality of Garlic Plants

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ABSTRACT

Two field experiments were carried out during the two seasons of 2011/ 2012 and 2012/2013 at the Experimental Farm of South Tahrir, Horticulture Research Station, Ali Moubarak Village, El-Bostan area, Behiera Governorate to investigate the effect of micronutrients mixture concentrations (Cont., 10, 15 and 20%) and three foliar application of salicylic acid (0,150, 300 ppm)as well as their interactions on growth, chemical constituents and bulb yield and its components of garlic plants (Balady cv.)grown in sandy soil under drip irrigation system. The obtained results showed that the foliar spraying with 20 % micronutrient or 300 ppm salicylic acid were the best treatment for increasing plant height, number of leavesplant^{-1},plant fresh weight, both bulb weight, diameter and total yield fed^{-1} of garlic plants. Results ,also, showed that foliar application of micronutrients improved the total chlorophyll, bulb dry matter, N and K contents in bulbs and as well as total soluble solids in bulbs, in both seasons. The best results of vegetative growth, yield potential and chemical constituents were achieved when garlic plants were sprayed of 20 % micronutrient and 300 ppm salicylic acid.

Key words: garlic- salicylic acid- micronutrients- yield- quality.

INTRODUCTION

Garlic (*Allium sativum*L.) is member of the genus *Allium*, which comprises approximately 750 species belonging to the family Alliaceae. It is a strongly aromatic bulb that has long been used in cooking as spice and medicine throughout the world. Egypt ranks the fourth leading country in the world for garlic production (244.626 MT) after China, India and Korea. It is one of the main vegetable crops grown in the world as well as in Egypt and second cultivated bulb crop after onion and it is an important for local consumption and exportation (Abou El-Magd *et al*., 2012). Nowadays , in Egypt, a great attention is given for promoting garlic production to satisfy the increased demands of local fresh market, developing processing industry and rapidly growing exportation. From the economic stand point, more efforts should be directed towards increasing yield per unit area and improving head quality characteristics.

Sandy soils are characterized with poor macro- and micro-elements content and unfavorable environmental condition which negatively affect growth and productivity of vegetables (Shafeek*et al*., 2012). Most studies were conducted on macro-nutrients fertilization for garlic plants. However, micronutrients application studies, especially in sandy soil ,are limited. The micronutrient play a vital role in driving the plant growth, cell division, water relation and development of plants. Also, it have important role of metal component of enzymes or functional structural or regulatory factor of large number of enzymes (Marschner,1995)**.** Furthermore, foliar application of microelements improves the effectiveness of macronutrients under high soil pH, solubility of most microelements in soil decreased causing plant physiological disorders (Srivastava and Gupta, 1996). El-Fouly (1983) reported that foliar application of microelements is highly recommended under Egyptian soil conditions. In view of this fact, the Egyptian soil pH exceeds 7.5 and sometimes even 8.5 and some areas show high CaCO3 content which makes application of micronutrients more necessary.

The few studies respecting the effects of applied micronutrient as a foliar spraying on growth and yield of garlic plants Mondal *et al*.(2016) and Yousuf *et al*.(2016) recorded that the foliar application with micronutrient improved the vegetative growth; Islam *et al*.(2012)enhanced yield and yield attributes of garlic Chanchan, *et al*. (2015). In this respect, application of zinc and boron gave positive effects on plant growth and improvement of production of garlic (Rohidas *et al*., 2011). In addition, zinc application improves root system, which results in better absorption of water and other dissolved nutrients and, consequently improved different organs and entire plant growth(Brady,1990). Moreover, roots are unable to absorb some important nutrients such as zinc, because of soil properties, such as high pH and calcium carbonate. Thus, in this situation, foliar spraying is better as compared to soil application (Kinaci and Gulmezoglu, 2007). Boron is required in very small quantity but it is one of the most important micronutrients. Application of boron can increase bulb size, number of cloves per bulb and yield of garlic (Rani, 2015).

Salicylic acid is a naturally occurring plant hormone acting and is introduced as an important messenger molecule in plant responses to the different biotic and abiotic stresses (Shama *et al*., 2012).It plays a vital role in plant growth, ion uptake and transport. Salicylic acid can also play a significant role in plant water relations, photosynthesis and growth in plants (Kazemi, 2013). Salicylic acid is assigned diverse regulatory roles in the metabolism of plants. Salicylic acid is a phenolic derivative, distributed in a wide range of plant species (Gad El-Hak *et al*., 2012).

Foliar application of salicylic acids caused an increase in the growth and development of plants. In this respect, (Li *et al*.,2000) found that salicylic acid played an important role in garlic bulb formation and that enhanced the endogenous SA content of garlic plant, thus improving bulbing. Khadr (2015) clarified that spraying garlic plants with salicylic acid at 50 ppm after 45, 60, and 75 days of seed sowing gave the highest mean values of plant height, total fresh and dry weights, fresh weight and number of leaves and leaf area plant-1. In addition, the highest mean values of total marketable and exportable bulbs yield, average fresh and dry bulb weight, N, P, K, Ca, chlorophyll a, b, total (a+b) and carotenoid contents were attained. Recently ,(Meena *et al*., 2016 and Pradhan *et al*., 2016) reported that foliar spray with salicylic acid improved the growth, yield and biochemical of garlic and onion plants, respectively.

Information concerning the interaction effects between micronutrients and salicylic acid concentrations are scant. There is a real need for more detailed study on this subject. Therefore, the aim of the present investigation was to study the effect of the foliar application with micronutrients and salicylic acid concentrations on growth, yield and quality of garlic plants grown under sandy soil conditions.

MATERIALS AND METHODS

This investigation was conducted at the Experimental Farm of South Tahrir, Horticulture Research Station, Ali Moubarak Village, El-Bostan area, Behiera Governorate, during the two successive winter seasons of 2011/ 2012 and 2012/2013. The experimental site belongs to the newly reclaimed sandy soils which irrigated through the drip irrigation system. Before conducting the experiment, in each season, soil samples from the upper layer of the experimental site to 20- 30 cm depth were collected and analyzed for some chemical and physical properties, according to the published procedures of (Page,1982). The results of soil analyses are given in Table 1.

The Baldy garlic cultivar was used in this study. It is a local cultivar grown in Egypt for their strong smell owing to its natural properties, whose mature cloves have white covering scale with relatively long storability. Uniform and healthy cloves (each 1.0 g±0.1/clove) of the Baldy garlic cultivar were planted upright with apical tip on two sides of the ridge (width 60cm) at in-row spacing 10 cm. Planting was done on the first week of September in 2011/ 2012 and 2012/ 2013.All experimental units received identical doses of nitrogen, phosphorus and potassium at the rates of 100,70 and 100 kg N, P_2O_5 and K_2O fed^{-1}, orderly. Ammonium sulphate (20.5% N), Phosphoric acid (58%) and potassium sulphate (48% K2O) were the respective forms of fertilizers. The fertigation process started after two weeks of planting. They were injected directly into the irrigation water, using a venture injector. The drip irrigation system consisted of laterals GR of 16 mm in diameter with drippers at 0.3 m distance. The drippers had a discharge rate 4 L h^{-1}.

Table 1: Some physical and chemical characteristics of the soil at 'Ali Moubarak' Experimental Farm, the two successive winter seasons of 2011/ 2012 and 2012/2013.

Characteristics	Growing Season	
	2011/2012	**2012/2013**
EC, (dS m^{-1})	0.37	0.33
PH	8.3	8.1
Organic Matter (%)	0.24	0.22
$CaCO_3$ (%)	5.25	5.20
NO_3 + NH_4(µg g^{-1})	33.81	32.50
Exch.-K (µg g^{-1})	119.30	119.60
$NaHCO_3$-P(µg g$^{-1)}$	9.43	9.70
Sand (%)	92.70	93.0
Soil texture class	Sandy	Sandy

Treatments and experimental design:

The experimental design used was split-plot system in a randomized complete block design (RCBD) with three replications. Main plots were consisted of micronutrients mixture concentrations (10, 15 and 20%), the mixture of micronutrients (Fe + Zn + Mn + Cu) added as Fe-EDTA (6% Fe), Zn-EDTA (15% Zn), Mn-EDTA (12% Mn), and $CuSO_4.5H_2O$ (25.45 % Cu) with three different concentrations (10, 15 and 20 g 100 L^{-1} H_2O).as well as control treatment (foliar spraying with tap water). Sub-plots were allocated to three treatments of salicylic acid (0,150,300ppm) as a foliar spraying Tween 20 (0.5%) was added as a wetting agent. The foliar application treatments of micronutrients were repeated three times starting 60,75and 90days after planting. Meanwhile, salicylic acid were sprayed at three times, at 15 days intervals, starting 67,82and 97 days after planting. Plot area was 36 m^2. It contained 6 ridges with 10 m long and 60 cm wide one row was left between each two experimental units as a guard row to avoid the overlapping of spraying solution. All other agricultural practices were performed when they were required and as recommended for the commercial garlic production. When older leaves turned yellowish green and had started withering, plants of each plot were harvested.

Data recorded

Vegetative growth characters: A random sample of five plants was collected from each sub-plot was taken at 130 days after planting and the following vegetative characters were recorded: plant height (cm), number of leaves plant^{-1} and fresh weight of whole plant.

Chemical constituents: Dry matter of bulb(%), total soluble solids of bulb were determined. N, P, K of bulb(%) were determined according to the method described by (Cataldo*et al*., 1975), (Scalbert*et al*.,1989) and (Ranganna,1986), orderly.

After 130 day from planting, Leaf's total chlorophyll content was determined by chlorophyll meter SPAD-502 plus according to Sub *et al*. (2015).

Bulb yield and its components: At harvest time, all plants of sub-plot were harvested and total yield (fed.$^{-1}$) was calculated after curing for 15 days. A random samples were taken from 10 head bulbs to determine bulb fresh weight (g), bulb diameter (cm), (cm) and bulbing ratio which was calculated as follows: Bulbing ratio = neck diameter / bulb diameter.

Statistical analysis

All obtained data were statistically analyzed using Co-Stat Software (2004), computer program for statistics. Revised L.S.D test was used to compare the differences among the means of the different treatments as elucidated by Steel and Torrie (1984).

RESULTS AND DISCUSSION

Vegetative growth characters

The results concerning the differences between the two studied factors as well as their interactions on the vegetative growth characters of garlic plants are shown in Table (2). Results, clearly, clarified that the foliar application of different concentrations of micronutrient treatments had significant effect on all vegetative growth characters of garlic plants with superiority of the 20% concentration of micronutrient, in both growing seasons. Similar results were obtained for garlic and onion plants by (Ahmed, 1998 and Ballabh *et al*., 2013).

Table 2: Vegetative growth characters of garlic plants as affected by foliar spraying with micronutrient concentrations, salicylic acid and their interactions, in the two winter seasons of 2011/2012 and 2012/2013.

Characters	Plant height (cm)		Number of leaves plant^{-1}		Plant fresh weight (gm)	
Seasons / Treatments	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013
Micronutrient concentration (%)						
Cont.	56.00^{D}	60.67^{D}	6.67^{D}	6.18^{D}	69.78^{D}	67.44^{D}
10	61.11^{C}	63.67^{C}	7.00^{C}	6.80^{C}	76.33^{C}	77.56^{C}
15	66.00^{B}	69.89^{B}	7.59^{B}	7.28^{B}	85.11^{B}	85.22^{B}
20	72.44^{A}	74.78^{A}	7.87^{A}	7.80^{A}	90.67^{A}	92.22^{A}
Salicylic acid (ppm)						
Cont.	63.00^{B}	65.42^{B}	7.17^{C}	6.87^{C}	77.76^{C}	77.75^{C}
150	64.42^{A}	68.17^{A}	7.27^{B}	7.02^{B}	80.58^{B}	81.67^{B}
300	64.25^{A}	68.17^{A}	7.41^{A}	7.16^{A}	83.08^{A}	82.92^{A}
Micronutrient(%)Salicylic acid (ppm)						
Cont. × cont.	56.67^{g}	55.00^{f}	6.57^{h}	6.07^{i}	66.00^{i}	65.33^{i}
Cont. ×150	56.33^{g}	56.33^{f}	6.67^{gh}	6.17^{hi}	69.35^{h}	68.33^{h}
Cont. × 300	55.00^{g}	56.67^{ef}	6.77^{fg}	6.30^{h}	74.00^{fg}	68.67^{h}
10 % × cont.	59.00^{f}	59.00^{e}	6.83^{f}	6.63^{g}	73.33^{g}	74.33^{g}
10 % × 150	61.67^{e}	61.70^{d}	7.00^{e}	6.80^{fg}	76.66^{ef}	78.33^{f}
10 % × 300	62.67^{de}	62.67^{cd}	7.17^{d}	6.97^{ef}	79.00^{c}	80.00^{ef}
15 % × cont.	66.33^{bc}	64.7^{bc}	7.47^{c}	7.13^{de}	83.00^{d}	81.33^{e}
15 % × 150	67.00^{b}	66.30^{b}	7.53^{c}	7.27^{cd}	84.67^{cd}	86.00^{d}
15 % × 300	64.67^{cd}	67.00^{b}	7.77^{b}	7.43^{c}	87.66^{bc}	88.33^{c}
20 % × cont.	71.67^{a}	71.7^{a}	7.80^{ab}	7.63^{c}	88.67^{ab}	90.00^{bc}
20 % × 150	72.33^{a}	72.30^{a}	7.87^{ab}	7.83^{a}	91.66^{a}	92.00^{b}
20 % × 300	73.33^{a}	73.33^{a}	7.93^{a}	7.93^{a}	91.67^{a}	94.67^{a}

* Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Such a general positive response of vegetative growth characters due to the various micronutrient treatments levels might be referred to that the available amounts of microelements to plants in soil were relatively low and or not available as appeared form the soil analyses results which characterized by sandy soil texture and high PH (Table,1). The enhancing effect of micronutrients on plant growth might be due to its role in many physiological processes and cellular functions. In addition, they, also, play an important role in improving plant growth through biosynthesis of endogenous hormones, which are responsible for promoting of plant growth (Hansch and Mendel, 2009).

Foliar spraying with salicylic acid (SA) had positive effect on vegetative growth of garlic at the concentrations of 150 and 300 ppm compared with the untreated control, in the two growing seasons (Table,2). The highest mean values of number of leaves plant^{-1} and plant fresh weight were recorded when salicylic acid was sprayed at the concentration of 300 ppm. However, no significant differences were detected between 150 and 300ppmin terms of plant height, in the two growing seasons. The positive effect of salicylic acid on garlic plant growth might be attributed to increased water use, endogenous phytohormones and carboxylation efficiencies in association with high photosynthetic rate in plants (Shehata *et al*., 2000). These findings appeared to agree with the results reported by (Mady, 2009; Khedr, 2015and Shama *et al*., 2016), who found that salicylic acid spray significantly and positively, affected the vegetative growth characters of garlic plants.

The interaction effects between micronutrient concentration and the different levels of salicylic acid on the vegetative growth characters were found to be significant, in both growing seasons. The most beneficial treatment for vegetative growth was the combination of spraying 20 % micronutrients with SA (300 ppm) , which recorded the highest mean values of the studied vegetative growth characters, in both seasons. The presented increase in garlic vegetative growth may be ascribed to the beneficial effect of both micronutrients and SA together on absorption and efficiency of plant nutrients as well as high photosynthetic rate in plants.

Chemical constituents

Significant differences were observed in chemical constituents (i.g. leaf's total chlorophyll content, TSS and dry matter of bulb garlic) as influenced by foliar application of different micronutrient concentrations (Table, 3). The most effective treatment of micronutrient mixture that gave the highest mean values of leaf's total chlorophyll and bulb's TSS and dry matter contents was 20%, in both seasons. The only exception was found in bulb's TSS content, in the first season. These findings might be due to that the micronutrients play a pivotal role in strengthening the plant cell wall and translocation of carbohydrates from leaves to the other plant parts, meaning that they increase the dry matter content of bulb. The present investigation results confirm the findings of Alam *et al*. (2010), Rani(2015) and Khedr (2015), they stated that spraying garlic plants recorded the highest mean values of bulb dry weight. In addition, the improvement in T.S.S due to foliar application of micronutrient had, also, been reported by (Selvaraj *et al*. 2002), who explained that the enhancement in bulb T.S.S content might be attributed due to the enhance the metabolic processes involved in biosynthesis of total soluble solids such as carbohydrates, organic acid, amino acid and other inorganic constituents and translocation of available assimilates from source to bulbs.

Data presented in Table (3) indicated that SA treatments, significantly, affected leaf's total chlorophyll content and bulb's TSS and dry matter, in both seasons. Foliar application with 300 ppm of SA was responsible for the highest mean values of leaf's total chlorophyll content and bulb's TSS and dry matter content, in both seasons. The only exception was found in leaf's total chlorophyll content, in the first season. Where, the differences among the three tested SA were not significant. Similar results were reported by Bardisi (2004), who found that foliar spray of garlic plants with SA at 50 ,100 and 200 ppm increased concentration of chlorophyll a ,b and total (a+b) in leaf tissue. Moreover, Khedr (2015) demonstrated that spraying garlic plants with SA at 50 ppm produced bulbs with higher dry weight content.

The combined effect of micronutrient mixture at 20% and salicylic acid treatment at 300 ppm resulted in the highest leaf's total chlorophyll and bulb's TSS and dry matter contents, in both seasons (Table, 3). The only exception was found in bulb's TSS content, in the first season.

Bulb's N, P, and K content

The concentration of N, P and K in garlic bulbs in response to foliar spraying with micronutrient, salicylic acid concentrations and their interactions are presented in Table (5). The obtained results reflected significant differences among micronutrient treatments on N and K, in both seasons. Bulb's P content however, was not affected. Foliar spraying with micronutrient mixture at the rate of 20% gave the highest mean values of N and K, in both seasons. These results are in conformity with the finding of Brady (1990), who clarified that zinc application improves root system, which results in better absorption of water and other dissolved nutrients.

Data presented in Table (5) Revealed that application of SA with the concentration of 300 ppm recorded the highest significant mean values of N and K compared to the untreated control, in both seasons. The only exception was found in bulb's N content, in the first season. Meanwhile, bulb's P content did not reflect any significant differences, in both growing seasons. Similar results were reported by Khedr (2015), who found that spraying garlic plants at 45, 60, and 75 days after planting with SA at 50 ppm gave the highest mean values of bulb dry weight, N, P and K contents

The interaction effects between micronutrients and salicylic acid treatments on bulb's N, P, and K content of garlic plants were significant, in both seasons (Table 5). The combination of micronutrient mixture at 20% and salicylic acid treatment at 300 ppm recorded the highest mean values of N and K content in garlic bulbs, in both seasons. On the other hand, bulb's P content did not reveal any significant differences, in both growing seasons. These findings were in general agreement with those reported by Marschner (1995).

Bulb yield and its components

Data shown in Table(3) illustrated that spraying garlic plants with micronutrients concentrations, significantly and positively, affected bulb yield and its components as expressed by bulb weight, diameter, blubing ratio and total yield, in both seasons. The results indicated that spraying micronutrients at 20% exhibited higher mean values of the above mentioned characters than those of the other three treatments, in both seasons. The only exception was blubing ratio, where, the untreated control recorded the highest mean values. The favorable effects of micronutrients at 20% could be due to the optimum concentration of micronutrients which encourage the vegetative growth to go forward and accelerate the photosynthetic rate (Table, 2) which lead to produce higher bulb yield. Micronutrient helps in translocation of constituents from leaves to bulb. The results are in conformity with the finding of Alam *et al*. (2010) and Samad *et al*. (2011) on onion.

Table 3: Chemical constituents of garlic plants as affected by foliar spraying with micronutrient, salicylic acid concentrations and their interactions, in the two winter seasons of 2011/2012 and 2012/2013

Characters	Leaf's total chlorophyll Content (SPAD)		Bulb's T.S.S (Brix^{o})		Bulb's dry matter Content (%)	
Treatments \ Seasons	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013
Micronutrient concentration (%)						
Cont.	52.19^{D}	46.76^{B}	27.28^{C}	27.69^{D}	30.35^{D}	29.88^{D}
10	57.42^{C}	55.17^{AB}	27.98^{B}	28.08^{C}	31.20^{C}	30.48^{C}
15	59.93^{B}	58.11^{A}	29.73^{A}	29.18^{B}	32.86^{B}	32.11^{B}
20	65.14^{A}	61.33^{A}	29.64^{A}	29.60^{A}	33.54^{A}	32.91^{A}
Salicylic acid (ppm)						
Cont.	57.65^{B}	51.77^{A}	28.17^{C}	28.20^{B}	31.40^{C}	30.73^{C}
150	58.95^{A}	56.85^{A}	28.81^{B}	28.78^{A}	32.18^{B}	31.45^{B}
300	59.42^{A}	57.43^{A}	28.98^{A}	28.93^{A}	32.42^{A}	31.85^{A}
Micro (%) X salicylic acid (ppm)						
Cont. × cont.	51.33^{h}	36.16^{b}	26.93^{h}	27.57^{fg}	29.67^{g}	29.17^{i}
Cont. × 150	52.4^{g}	51.87^{a}	27.30^{g}	27.80^{f}	30.50^{f}	30.10^{gh}
Cont. × 300	52.83^{g}	52.30^{a}	27.53^{f}	27.70^{f}	30.88^{e}	30.40^{fg}
10 % × cont.	56.23^{f}	53.36^{a}	26.93^{h}	27.20^{g}	30.00^{g}	29.77^{h}
10 % × 150	57.83^{e}	55.37^{a}	28.26^{e}	28.53^{e}	31.63^{d}	30.67^{ef}
10% × 300	58.20^{de}	56.77^{a}	28.77^{d}	28.50^{e}	31.97^{d}	31.00^{e}
15 % × cont.	59.00^{d}	57.27^{a}	29.66^{b}	28.70^{de}	32.57^{c}	31.39^{d}
15% × 150	60.23^{c}	58.53^{a}	29.77^{ab}	29.17^{cd}	33.03^{b}	32.11^{c}
15 % × 300	60.57^{c}	58.53^{a}	29.77^{ab}	29.67^{ab}	32.99^{b}	32.84^{ab}
20 % × cont.	64.03^{b}	60.33^{a}	29.17^{c}	29.33^{bc}	33.19^{b}	32.60^{b}
20 % × 150	65.33^{a}	61.53^{a}	29.93^{a}	29.60^{a-c}	33.57^{a}	32.99^{a}
20 % × 300	66.07^{a}	62.13^{a}	29.83^{ab}	29.87^{a}	33.85^{a}	33.14^{a}

*Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

Table 4: bulb's mineral contents of garlic plants as affected by foliar spraying with micronutrient, salicylic acid concentrations and their interactions, in the two winter seasons of 2011/2012 and 2012/2013

Characters	N (%)		P (%)		K (%)	
Seasons / Treatments	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013	Winter 2011/2012	Winter 2012/2013
Micronutrient concentration (%)						
Cont.	1.82^{B}	1.83^{C}	0.30^{A}	0.32^{A}	2.93^{D}	2.92^{D}
10	1.86^{B}	1.84^{C}	0.31^{A}	0.31^{A}	3.17^{C}	3.04^{C}
15	1.94^{AB}	1.91^{B}	0.33^{A}	0.30^{A}	3.26^{B}	3.20^{B}
20	2.05^{A}	2.01^{A}	0.34^{A}	0.29^{A}	3.36^{A}	3.36^{A}
Salicylic acid (ppm)						
Cont.	1.89^{A}	1.87^{B}	0.31^{A}	0.31^{A}	3.12^{B}	3.07^{B}
150	1.92^{A}	1.90^{AB}	0.32^{A}	0.30^{A}	3.19^{AB}	3.15^{A}
300	1.96^{A}	1.93^{A}	0.33^{A}	0.30^{A}	3.23^{A}	3.17^{A}
Micro (%) X salicylic acid (ppm)						
Cont. × cont.	1.81^{b}	1.82^{c}	0.29^{a}	0.29^{a}	2.89^{e}	2.85^{f}
Cont. × 150	1.82^{b}	1.82^{c}	0.31^{a}	0.29^{a}	2.94^{e}	2.94^{ef}
Cont. × 300	1.84^{b}	1.85^{c}	0.31^{a}	0.28^{a}	2.98^{de}	2.97^{ef}
10 % × cont.	1.83^{b}	1.81^{c}	0.31^{a}	0.30^{a}	3.13^{cd}	2.98^{ef}
10 % × 150	1.86^{a}	1.84^{c}	0.31^{a}	0.29^{a}	3.13^{cd}	3.10^{c-e}
10% × 300	1.90^{a}	1.88^{c}	0.33^{a}	0.31^{a}	3.23^{c}	3.03^{de}
15 % × cont.	1.92^{a}	1.90^{b}	0.30^{a}	0.29^{a}	3.26^{bc}	3.20^{b-d}
15% × 150	1.96^{a}	1.91^{b}	0.34^{a}	0.33^{a}	3.26^{bc}	3.23^{bc}
15 % × 300	1.95^{a}	1.92^{b}	0.34^{a}	0.32^{a}	3.23^{c}	3.16^{b-d}
20 % × cont.	1.99^{a}	1.96^{b}	0.34^{a}	0.33^{a}	3.20^{c}	3.20^{bc}
20 % × 150	2.02^{a}	2.02^{a}	0.33^{a}	0.31^{a}	3.40^{ab}	3.33^{ab}
20 % × 300	2.15^{a}	2.04^{a}	0.34^{a}	0.34^{a}	3.46^{a}	3.50^{a}

* Values followed by the same alphabetical letter(s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D test at 0.05 level of probability.

According the results in Table (3), the results reflected that the foliar spraying with salicylic acid at the rates of 150 and 300 ppm attained the highest mean values of bulb weight and total yield over the control treatment, in both growing seasons. However the differences between the latter concentrations were not high enough to be significant. On the other hand there were insignificant differences among the three tested concentrations in relation to their effects on bulb diameter and bulb ratio characters, in both growing seasons. The increased yield might be attributed to increased water use and carboxylation efficiencies in association with high photosynthetic rate induced by SA. Also, salicylic acid application augmented uptake of ions, control stomata functions and gravity sensing and pathogenesis (Lucas and Lee, 2004). Similar results were reported by Khadr (2015), who clarified that spraying garlic plants with salicylic acid at 50 ppm after 45, 60, and 75 days of seed sowing gave the highest mean values of exportable yield, marketable yield, total yield and bulb dry weight.

The results of the two experimental seasons reflected that the interaction effects between micronutrients and salicylic acid treatments on bulb characters and yield of garlic plants were found significant (Table,3). The combined effect of micronutrients at 20 % and salicylic acid treatment at 150 or 300 ppm resulted in the highest total yield and most bulb characters compared to the other treatment combinations, in both seasons. These yield increments, due to micronutrients and salicylic acid treatments, might be attributed to the increase in vegetative growth characters of garlic plants (Tables 2), stimulating of mineral uptake (Table, 4) and enhancement of photosynthetic pigments (Table ,3),which increased photosynthesis, resulting in assimilation of more carbohydrates accumulation and their translocation to the garlic bulbs, leading to increase in yield potential of garlic plants.

CONCLUSION

Their fore, it is possible to conclude to use the treatment the combination treatment of 20% micronutrient mixture and 300 ppm salicylic acid is recommended as the optimum micronutrient mixture and salicylic acid levels for maximizing the yield production of garlic with better quality characteristics, under the prevailing conditions of such a new reclaimed sandy soil.

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الملخص العربي

تأثير الرش بالعناصر الصغرى وحامض الساليسيليك على النمو والإنتاجية وصفات الجودة لنباتات الثوم

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نفذت هذه الدراسة على محصول الثوم – الصنف البلدي – تحت ظروف الأراضي الرملية المستصلحة حديثا بالمزرعة البحثية لمركز البحوث الزراعية بقرية على مبارك –البستان – منطقة النوبارية وذلك خلال موسمي شتاء عامي ٢٠١٢/٢٠١١ و٢٠١٣/٢٠١٢ وذلك بهدف دراسة تأثير مدي استجابة نباتات الثوم البلدي للرش بأربع تركيزات من العناصر الصغرى(كنترول و١٠ و١٥ و٢٠جم/ ١٠٠ لتر ماء) وثلاث تركيزات من حمض الساليسيليك(كنترول و١٥٠و٣٠٠جزء في المليون) والتداخل بينهم لبعض الصفات الهامة والتي اشتملت على صفات النمو الخضري، وصفات أخرى خاصة بالمحصول ومكوناته وصفات خاصة بالجودة والتي اشتملت على بعض المكونات الكيميائية.

أظهرت النتائج بصفة عامة أن رش نباتات الثوم بالعناصر الصغرى بتركيز(٢٠%) قد أعطى زيادة معنوية فى قيمة المتوسط لصفات النمو الخضري وهى ارتفاع النبات وعدد الأوراق للنبات والوزن الطازج للنبات و كما أدى إلى تحسن صفات الجودة للرؤوس المتمثلة في (المواد الصلبة الكلية الذائبة ومحتوى الرؤوس من العناصر الغذائية) وأيضا أدى إلى تحسن محتوى الأوراق من الكلوروفيل الكلى والمادة الجافة للرؤوس. وايضا بالنسبة لصفات المحصول ومكوناته التى تشمل وزن الرؤوس و قطر الرؤوس ونسبة قطر عنق الرأس /قطر الرؤوس.

أوضحت النتائج بصفة عامة أن رش نباتات الثوم بتركيز ١٥٠ أو ٣٠٠ جزء فى المليون من حمض الساليسيليك قد عكس ايضا تأثير إيجابي لمعظم الصفات موضع الدراسة الا انه لم يكن له تأثير معنوي على صفات الجودة الخاصة بالرؤوس فيما عدا صفة المادة الجافة للرؤوس فى كلا موسمي الزراعة والتى عكست أعلى القيم عند المعاملة بحامض الساليسيليك بتركيز ٣٠٠ جزء فى المليون.

أوضحت النتائج الخاصة بالتداخل بين الرش بالعناصر الصغرى والرش بحمض الساليسيليك أن رش النباتات الثوم بتركيز ٢٠% من العناصر الصغرى و٣٠٠ جزء في المليون من حمض الساليسيليك أعطت أعلى القيم الخاصة بالنمو الخضري والإنتاجية الكلية والمحتوى الكيماوي للرؤوس.