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Essential Oil, Growth and Yield of Onion (*Allium Cepa* L.) In Response to Foliar Application of Some Micronutrients

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Abstract: The experiments were conducted under sandy soil conditions to study the effects of foliar application of Fe, Zn and Mn on essential oil, growth and yield of onion plants (*Allium cepa* L.). Plants were sprayed with two concentrations of each of Fe, Zn and Mn (chelated form). Essential oil, growth characters and yield were measured in response to the applications of these micronutrients. The results revealed that essential oil, growth and yield of onion plants significantly increased by the application of Fe, Zn and Mn compared to control plants. The results showed that the high concentration of Fe and the low concentrations of both Zn and Mn had the best effects compared to the other concentrations. The effects of Fe, Zn and Mn on essential oil, growth and yield of onion plants are discussed.

Key words: Onion, Essential oil, yield, Fe, Zn, Mn

INTRODUCTION

Sandy soils are characterized with poor nutrients (including micronutrients) and unfavorable environmental conditions which negatively affect growth and productivity of vegetables including onion plants. Onion (*Allium cepa* L) is one of vegetables widely consumed due to its flavouring and health-promoting properties. It has been reported that onion extract can be potent cardiovascular and anticancer agents with hypocholesterolemic, thrombolitic and antioxidant effects (Block, 1985). There is evidence that micronutrients such as Zn increased the dry yield of onion plants (Sliman *et al*., 1999). Also, Bybordi and Malakouti (1998) found that some micronutrients such as Fe, Zn and Mn gave higher yield of onion. Singh and Tiwari (1995) found that plant height and bulb fresh weight, bulb diameters were highest with sprays of Zn and Fe. Sindhu and Tiwar (1993) studied the effects of micronutrients such as Zn, Fe and Mn on the yield and quality of onion plants and found positive effects of the micronutrients on the yield, TSS, sugars and ascorbic acid. Moreover, the positive effects of foliar application of micronutrients such as Zn on growth and yield are evident for other crops such as bean (El-Tohamy and El-Greadly, 2008) and groundnuts (Gobara *et al*., 2006). On the other hand, Khalid (1996) reported that trace elements such as Fe, Zn and Mn increased the vegetative growth characters and essential oil content of different plants such as anise, coriander and sweet fennel. However, further investigation is needed to explore the effects on onion plants grown under new-reclaimed lands. The present study was designed to investigate the impact of micronturients such as Fe, Zn and Mn on onion plants grown under sandy soil conditions considering their growth, yield and essential oil.

MATERIALS AND METHODS

The experiments were carried out under sandy soil conditions in new-reclaimed lands at the experimental station of the National Research Center in Nubaria region (physical and chemical properties of the soil are presented in Table 1) during two successive seasons of 2006 and 2007. Onion seeds 'Giza 6 improved' were sown in the first week of October. The seedlings were transplanted 70 days after sowing. Transplanting was done in rows (2 per each ridge) with a spacing of 10 cm in the row. Onion plants were sprayed twice with chelated form of each of Fe, Zn and Mn at 15 days interval beginning after 40 days from transplanting as follows:

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1. Fe : 1g/L
2. Fe: 2g/L
3. Zn: 0.3 g/l
4. Zn : 0.5 g/l
5. Mn: 1g/L
6. Mn: 2g/L
7. Control: (sprayed with only water).

Table 1: Physical and chemical properties of the experimental soil.

Physical properties							
Sand	Clay	Silt	Texture	F.C. %	W.P. %		
90.08	9.26	0.66	Sandy	16.57	5.25		
Chemical analysis							
E.C. M/moh.	P.H.	Meq./L.					
		Ca	Mg	Na	K	HCO_3	Cl
1.7	8.2	7.02	0.527	0.982	0.31	1.3	0.566

The following measurements were recorded:

1- Plant growth and yield measurements: (plant height, number of leaves, bulb diameter, fresh weight of bulb and total yield) were recorded.

2- Essential oil measurements: Bulbs were collected from each treatment during the vegetative and harvesting stages. They were dried by air and weighed to extract the essential oil. Dry plant material (300 g) from each replicate of all treatments was subjected to steam distillation for 3 h using a Clevenger type apparatus (Clevenger, 1928). The essential oil content was calculated as a percentage. The essential oils extracted from *Allium cepa* L bulbs were collected from the vegetative and harvesting stages, then, the essential oils were collected from each treatment to identify the chemical constituents of the essential oil.

Chemical Constituents of Essential Oil:

Constituents of essential oil were determined by gas-liquid chromatography. The chromatograph (Model Perkin Elmer 3920B) was equipped with a thermal conductivity detector and a 2.0 m X 0.3 cm column packed with 10 percent Carbwax 20M on 80/100 Chromsorb WAW and hydrogen was used as the carrier gas at 0.5 cm^3/s. The column temperature was 130 °C and detector and injector temperatures were 200 °C. Constituents were identified by retention times and in conjunction with known structures.

Statistical Analysis:

The design of the experiments was established as complete randomized block design with 4 replicates and analysis of variance was calculated according to Snedecor and Cochran (1967). Least significant difference (L.S.D.) at 5% was used to compare between means.

RESULTS AND DISCUSSION

Effects of Foliar Application of Fe, Zn and Mn on Vegetative Growth and Yield:

As presented in Table (2), foliar application of Fe, Zn and Mn significantly improved vegetative growth of onion plants (as plant height and number of leaves significantly increased by the application of the micronutrients). The treatments also resulted in a significant increment in the bulb diameter, fresh weight of bulb and total yield compared to control plants. These effects were clear especially with the high level of Fe and the low levels of both Zn and Mn. Micronutrients such as Zn increased the dry yield of onion plants (Sliman *et al.*, 1999). On the other hand, Bybordi and Malakouti (1998) found that some micronutrients such as Fe, Zn and Mn gave high yield of onion. Also, Singh and Tiwari (1995) found that plant height and bulb fresh weight, bulb diameters and were highest with sprays of Zn and Fe. In a pot trial, Singh and Tiwari (1996) found that onion cv. Pusa Red plants sprayed 60 and 70 days after transplanting with Zn, Fe and B had high bulb yield , TSS, total sugar and ascorbic acid contents. Moreover, Sindhu and Tiwar (1993) studied the effects of micronutrients such as Zn, Fe and Mn on the yield and quality of onion plants and found positive effects of the micronutrients on different characters including yield, TSS, sugars and ascorbic acid.

Table 2: Effects of Fe, Zn and Mn on vegetative growth and yield of onion.

Treatment	Plant height (cm)	Number of leaves	Bulb diameter (cm)	Fresh weight of bulb (g)	Total yield (ton/Fed.)
			1st season		
Fe (1g/L)	38.67	6.67	4.17	93.4	3.92
Fe (2g/L)	51.67	8.33	5.3	106.27	4.46
Zn (0.3 g/L)	40	7.33	4.87	102.5	4.31
Zn (0.5 g/L)	38	7	4.1	88.63	3.72
Mn (1g/L)	44	7.67	5.17	100.23	4.21
Mn (2g/L)	40.33	7.33	4.07	90.6	3.81
Control	31	6	3.93	64.13	2.69
L.S.D. at 5%	3.62	1.48	0.97	4.9	0.76
			2nd season		
Fe (1g/L)	41.67	7.67	4.1	84	3.528
Fe (2g/L)	45.67	8.67	5.23	107.23	4.5038
Zn (0.3 g/L)	44.67	8.33	4.87	97.37	4.0894
Zn (0.5 g/L)	42	7	4.2	87.73	3.68
Mn (1g/L)	44	8.33	5	96.3	4.04
Mn (2g/L)	42.67	6.67	4.1	91.5	3.84
Control	36	6	3.77	67.9	2.85
L.S.D. at 5%	4.52	1.55	0.96	13.25	0.78

The application of Zn alone resulted in a higher yield with a low percentage of rotting (11.1%), sprouting (1.8%) and physiological weight loss (3.1%), during 60 days' storage (Mukesh-Kumar *et al,* 1999). Bhonde *et al* (1995) reported that the trace elements zinc, copper and boron had a significant effect on bulb development and yield as well as bulb quality when applied in combination instead of singly. The results indicated that micronutrients alone encouraged growth and yield of onion plants while other investigator found more effects of micronutrients when combined with other substances such as indoles as found by Omran *et al*. (1984) who indicated that the best combination with regard to bulb weight was generally IAA at 200 ppm+ ZnSO4 at 0.05% and found that ZnSO4 up to 0.05% or MnSO4 up to 0.1% increased bulb weight whereas higher rates decreased it. Also, Meena and Singh (1998) found that S and Zn treatments significantly enhanced the dry weight of onion tops and bulbs. Even other applications of micronutrients other that foliar spraying such as soaking seeds resulted in effects on onion growth and yield as indicated by Firgany *et al* (1980) who studied the effects of soaking onion seeds for 24 h in Mn or Cu solutions, each at 200, 400 or 800 p.p.m. and found that the best germination (93-94%), highest seedling dry weight, mean bulb diameter (4.4-4.5 cm) and total yields (17.71-17.78 t/ha) were obtained from treatment with Mn or Cu, each at 400 p.p.m.

Effects of Foliar Application of Fe, Zn and Mn on the Essential Oil of Onion Bulbs:

The effects of the different treatments of Fe, Zn and Mn on the essential oil of bulbs are represented in Table (3). Generally, all levels of Fe, Zn and Mn progressively increased the essential oil of bulbs compared with control treatment especially with high level of Fe and the low levels of Zn and Mn which seem to be optimal for obtaining higher concentrations of essential oil. The highest percentage of essential oil of *Allium cepa* L was obtained by adding Zn especially with the treatment of 0.3 g /L. The essential oil percentage was progressively increased towards the harvesting stage during both seasons.

Table 3: Effects of Fe, Zn and Mn on the essential oil percentage of onion bulbs.

Treatment	Essential oil percentage			
	Vegetative stage		Harvesting stage	
	1st season	2nd season	1st season	2nd season
Fe (1g/L)	0.003	0.0029	0.0035	0.003
Fe (2g/L)	0.0033	0.0034	0.0037	0.0035
Zn (0.3 g/L)	0.0041	0.0042	0.0049	0.0053
Zn (0.5 g/L)	0.0036	0.0035	0.0047	0.0049
Mn (1g/L)	0.0039	0.0039	0.0041	0.0042
Mn (2g/L)	0.0034	0.0031	0.0039	0.0037
Control	0.002	0.0021	0.0031	0.0021
L.S.D. at 5%	0.0002	0.0001	0.0003	0.0002

The results on the effects of micronutrients on the essential oil of onion plants agreed with the results obtained by Khalid (1996) who reported that trace elements such as Fe, Zn and Mn increased the vegetative growth characters and essential oil content of different plants such as anise, coriander and sweet fennel.

Effects of Fe, Zn and Mn on the Chemical Constituents of Essential Oil Extracted from of Onion Bulbs.
Table 4 shows the effect of Fe, Zn and Mn levels on the chemical composition of essential oil extracted from onion bulbs. The main components were found to be 3.4-Dimethylthiophene; Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale; 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine; 6-Ethyl-4,5,7-trithiadecane; 2,4,6-Triethyl- 1,3,5-trithiane and 6-Ethyl-4,5,7,8-tetrathiaundecane.

Table 4: Effects of Fe, Zn and Mn on the main constituents percentage of essential oil extracted from of onion bulbs.

No.	Components	Treatments						
		Fe (1g/L)	Fe (2g/L)	Zn (0.3g/L)	Zn (0.5g/L)	(Mn (1g/L)	Mn (2g/L)	Control
1	3.4-Dimethylthiophene	1.8	2.2	1.9	2.3	1.9	1.9	2
2	Propyl 1-propenyl disulphide, cis	8.8	9.3	10.4	11.6	10.6	11.2	9.2
3	Propyl 1-propenyl disulphide, trans	6.5	6	6.2	7.2	7.4	6.8	5.5
4	Methylpropyl trisulphide	1.9	2.1	3.1	2.4	3.1	2.4	1.8
5	3,5-Diethyl- 1,2,4-trithionale	27.6	27.9	29.4	30.4.4	29.4	27.8	27
6	Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5,6-dithiazine	2.6	2.2	2.6	2.6	2.2	2.6	2.4
7	5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine	9.8	10.3	11.3	10.2	10.9	9.8	11
8	6-Ethyl-4,5,7-trithiadecane	1.9	1.8	2.1	2.4	2.3	2.1	1.7
9	2,4,6-Triethyl- 1,3,5-trithiane	1.5	1.6	1.8	2	1.9	1.8	1.3
10	6-Ethyl-4,5,7,8-tetrathiaundecane	2.1	2.02	2.3	2.01	2.3	2.1	2.2

Fe (1g/L) treatment increased the constiuents of Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale; 5,6- Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 6-Ethyl-4,5,7-trithiadecane and 2,4,6-Triethyl- 1,3,5-trithiane but it decreased the constituents of 3.4-Dimethylthiophene; Propyl 1-propenyl disulphide, *cis*; 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine and 6-Ethyl-4,5,7,8-tetrathiaundecane.

Fe (2g/L) treatment increased the components 3.4-Dimethylthiophene; Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale, 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 6-Ethyl-4,5,7-trithiadecane and 2,4,6-Triethyl- 1,3,5-trithiane while it decreased the components of 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine and 6-Ethyl-4,5,7,8-tetrathiaundecane.

Zn (0.3 g/L) treatment increased the components of Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale; 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 5,6- b Dihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine; 6-Ethyl-4,5,7-trithiadecane; 2,4,6-Triethyl- 1,3,5-trithiane and 6-Ethyl-4,5,7,8-tetrathiaundecane but 3.4-Dimethylthiophene was decreased.

Zn (0.5 g/L) treatment increased the components of 3.4-Dimethylthiophene; Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale; 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 6-Ethyl-4,5,7-trithiadecane and 2,4,6-Triethyl- 1,3,5-trithiane while it decreased the components of 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine and 6-Ethyl-4,5,7,8-tetrathiaundecane.

Mn (1g/L) treatment increased the components of Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale; 6-Ethyl-4,5,7-trithiadecane; 2,4,6-Triethyl- 1,3,5-trithiane and 6-Ethyl-4,5,7,8-tetrathiaundecane. while it decreased 3.4-Dimethylthiophene; 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine and 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine; Mn (2g/L) treatment increased the components of Propyl 1-propenyl disulphide, *cis*; Propyl 1-propenyl disulphide, trans; Methylpropyl trisulphide; 3,5-Diethyl- 1,2,4-trithionale and 5,6 -Dihydro-6-methyl-2,4-diethyl-4H- 1,3,5-dithiazine; 6-Ethyl-4,5,7-trithiadecane and 2,4,6-Triethyl- 1,3,5-trithiane but it decreased the components of 3.4-Dimethylthiophene; 5,6- bDihydro-2,4,6-triethyl-4H- 1,3,5 -dithiazine and 6-Ethyl-4,5,7,8-tetrathiaundecane.

These results are in accordance with those obtained by Farkas *et al.,* 1992.

The present study indicated that under sandy soil conditions, growth, yield and essential oil of onion can be maximized by the applications of some micronutrients such as Zn, Fe and Mn.

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