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Investigation of different levels micro nutrients on tomato in hydroponic culture system

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ABSTRACT

Use of greenhouse cultures accompanied by new techniques such as soilless or hydroponic culture on the one hand improves suitable control of plants nutrition and on the other hand it has created a great progress in greenhouse productions. In order to greenhouse tomato cultivar of Hamra was cultured in a hydroponic system and effect of micronutrients different levels was studied on it. The experiment design was as randomized complete block with five treatments and four replications. Experimental treatments were included: Lack of micronutrients application, Full application of sulfate manganese (4.06 mg/lit), Full application of sulfate zinc (4.42 mg/lit), 50% sulfate manganese (2.03 mg/lit) + 50% sulfate zinc (2.21 mg/lit) and Full application of sulfate manganese + Full application of sulfate zinc. The results showed that the highest fresh fruit yield, fruit dry matter percentage and content of Mn and Zn in fruit obtained from full application Mn, Zn and Mn + Zn. However micronutrients different levels had significantly effect on content of nitrogen, but they haven't significantly effect on fruit size of tomato.

Key words: Micronutrients, Tomato, Hydroponic culture, Yield

INTRODUCTION

Agriculture has been essential for sustaining life and we are constantly improving technology to increase food production. There have been agricultural technology with concerning issues but the invention of new technology is not necessarily a threat to the environment. Modern agriculture has made a significant impact on environmental enhancement. The demand for food has been increasing throughout the world in direct correlation to the population increasing. Technological advances in food production have been abundant all over the world to minimize this matter. Different methods of farming have strayed from the traditional system of soil based farming. New techniques of farming have been developed through a controlled environment. This particular method is hydroponics, which eliminates from the pest and disease infested soil-based cultivation. This optimal approach for plant production is providing a controlled environment for plants to be maintained in a carefully managed system. The origins of soilless culture go back at least to the 17th century when, in 1666, Boyle attempted to grow plants in "vials containing nothing but water", and reported that one species (spearmint, *Raphanza aquatica)* survived for nine months. However, it was not until the 19th century that Liebig (1803-73) and Knop and Sachs (around 1859) initiated the systematic study of plant nutrition [4]. Hydroponics may be defined as "any method of growing plants without the use of soil as a rooting medium, which involves supply of all inorganic nutrients exclusively via the irrigation water". This is achieved by the supply of a *nutrient solution*, i.e. water containing dissolved fertilizers at proper concentrations, in place of raw irrigation water. There are several advantages to hydroponic culture. Some of the problems associated with conventional soil culture such as poor soil structure, poor drainage and non-uniform texture, as well as weeds and soil-borne pathogens, are eliminated. In automated hydroponic culture, some of the watering and fertilizer additions can be computerized, reducing labor input. In soilless culture, all essential plant nutrients should be supplied via the nutrient solution, with the exception of carbon, which is taken up from the air as carbon dioxide. To prepare nutrient solutions containing all the essential nutrients, inorganic fertilizers are used to provide most of them. Iron forms an exception to this role, since it is added in chelated form, to improve its availability for the plants [13]. In most cases, the fertilizers used to prepare nutrient solutions are highly soluble inorganic salts. Tomato (*Lycopersicon esculentum* mill) production is one of the most important vegetables crops grown in Iran, and has the potential for increased production because of its high demand [9&5]. Tomato is grown under various environments and management in Iran. It is grown in gardens, Urban and Peri-urban Agriculture, and under controlled environments. Harsh environments in most parts of Iran necessitate the need to grow tomatoes in controlled environments. With due attention to importance of tomato culture in region and necessity of using agriculture modern systems for reaching to high yield, aim of this research is study of some quantity and quality characteristics of tomato in hydroponic culture condition.

MATERIALS AND METHODS

This experiment was done in the greenhouse. This research was performed in randomized complete block design with five treatments. Experimental treatments were: control (Mn and Zn-free nutrient solution), application of manganese equal to full Hoagland's nutrient solution (4.06 mg/l), application of zinc equal to full Hoagland's nutrient solution (4.42 mg/l), application of Mn and Zn equal to 50% Hoagland's nutrient solution (2.03 mg/l Mn + 2.21 mg/l Zn), and application of Mn and Zn equal to full Hoagland's nutrient solution (4.06 mg/l Mn + 4.42 mg/l Zn). Treatments were studied in four replications and with two pots for each experimental units. Greenhouse tomato seeds (*Lycopersicon esculentum* Mill) (Hamra cultivar) were planted in early of April 2007 in perlit bed which was set equal for all treatments. From time of planting seeds till germination stage, moisture which was needed for plants growth was supplied from municipal water. Average of temperature of greenhouse in the night was 15±2 degree centigrade and in day 25±2 degree centigrade and humidity of greenhouse was variable from 65% to 80%.

After germination, process of liquation and treatments was done. Nutrition liquids according to Hoagland formula [8]. were supplied in 100 liter gallons and it was given to plants by pomp and drop irrigation system (Table 1).

Table 1. Nutrient elements content in nutrient solution of tomato (Hogland solution)

Basic solution	Chemical formula	amount	unit
Calcium Nitrate	$Ca(NO_3)_2.4H_2O$	1181	g/100lit water
Potassium Nitrate	KNO_3	505.5	g/100lit water
Ammonium dehydrogenase phosphate	$NH_4(H_2PO_4)$	115.0	g/100lit water
Magnesium Sulfate	$MgSO_4.7H_2O$	439	g/100lit water
Boric Acid	H_3BO_3	2.86	g/lit
Manganous Chloride	$MnCl_2.4H_2O$	1.81	g/lit
Zinc Sulfate	$ZnSO_4.7H_2O$	0.22	g/lit
Cupric Sulfate	$CuSO_4.5H_2O$	0.08	g/lit
Molybdic acid	$H_2MoO_4.H_2O$	0.02	g/lit
Chelated Iron		2	milt/lit

Factors which were measured in this experiment were included:

(1) Yield of the fresh fruits (g/plant), (2) percentage of dry matter of fruit, (3) Size or diameter of the fruit and (4) content of nitrogen, manganese and zinc in fruit, which nitrogen was measured by Kejeldal method [12]. and manganese and zinc was determined via dry ashing method and combination with chloridric acid (HCl), and for this work was used from atomic absorption machine, model of GBCAventa, ver.1.31.

Finally, data were analyzed using SAS software; mean comparison was done using Duncan Multiple Comparison at 5% probability level.

RESULTS AND DISCUSSION

Yield of fresh fruit

The results of variance analysis showed that using of zinc and manganese had a significant affect by the probability level of 5% on fresh fruits (Table 2). The highest fruit yield was belong to full consumption of manganese sulfate with zinc sulfate and the lowest one belonged to treatment of lack of application of zinc and manganese (Table 3).

Probability increase in tolerance of tomato on drought by nutrition of zinc and manganese, and increase in rate of photosynthesis by reason of usage of manganese led to increase of fresh fruit yield of tomato [11&14]. The results of experiments of other researchers showed that using of micronutrients elements led to increase in yield of pepper and tomato [6]. The results similar to this research was reported on crops by [1,2&12].

Table 2. Variance analysis of nitrogen, protein and sulphur content in seed

SOV	df	Fresh fruit yield	Dry matter fruit	Diameter fruit	Nitrogen content	Manganese content	Zinc content
		Mean Square					
Replication	3	0.1 ns	0.011 ns	0.073 ns	0.39 ns	15.74 ns	8.05 ns
Treatment	4	30.73*	2.01*	17.06 ns	21.94*	1059.46*	741.18*
Error	12	1.41	0.057	1.26	10.06	74.92	50.19
CV	-	8.42	11.75	10.93	10.26	16.73	20.06

**, ** significant at the 5% and 1% levels of probability respectively and n.s (non-significant)*

Dry matter of fruit

Effect of zinc and manganese treatments was significant on dry matter of (P< 5%) (Table 2). The results of experiment showed that dry matter of fruit will increase by application of zinc and manganese. According to table 3, with increase in amount of manganese element in nutrient solution, amount of dry matter of fruit increased, so that the highest percentage of dry matter of fruit obtained from full consumption of manganese (equal to full amount of Hoagland solution) and full consumption of manganese and zinc. On the other hand with decreasing content of these elements in solution has decreased from percentage of dry matter of fruit, so that the lowest amount of dry matter percentage was achieved from treatment of without use of zinc and manganese.

With due attention to role of manganese in increasing of chlorophyll content in plant green organs, and then increase in rate of photosynthesis and producing hydrocarbonic materials; decrease of manganese concentration in nutrient solution lead to decrease of production of hydrocarbonic materials and consequently decrease of dry matter of fruits. Other researchers reported that shortage of manganese in tomato lead to decrease of rate of photosynthesis and consequently decrease of dry matter of fruit [3].

Diameter (size) of fruit

Manganese and zinc elements had no any effect on size of fruit (Table 2). Generally this part from yield (diameter or size of fruit) has stability so much and these treatments can't be effective on these factors [10].

Content of nitrogen in fruit

Treatments of zinc and manganese had significant effect on content of nitrogen in fruit (P<5%) (Table 2). The most content of nitrogen in fruit obtained from full consumption zinc and also full consumption of zinc with manganese. On the other hand with decrease of zinc concentrations in nutrient solution, from nitrogen content in fruit was decreased. In treatment of without application of zinc and manganese, the lowest nitrogen content in fruit as achieved (Table 3).

Increase of nitrogen content in condition of consumption of zinc sulfate can be by reason of indirect effect of zinc on increase of nitrogen absorption. Since zinc is one of elements that have important role in plant nitrogen metabolism, so deficit of it can lead to disorder in nitrogen production [9&5].

Table 3. Mean comparison of experimental treatments on yield and nutrient elements content in tomato

Treatments	Freash fruit yield (g/plant)	Dry matter of fruit (%)	Diameter of fruit (mm)	Nitrogen content (%)	Mn content (mg/g)	Zn content (mg/g)
control (Mn and Zn-free nutrient solution)	2479.1 d	5.2 c	51.6 a	4.2 d	200.8 c	45.4 c
application of manganese equal to full Hoagland's nutrient solution	3106/3 c	6.9 a	53.8 a	4.9 c	251.1 a	47.8 bc
application of zinc equal to full Hoagland's nutrient solution	2994.7 c	5.3 c	55.1 a	7.3 a	209.7 c	63.4 a
application of Mn and Zn equal to 50% Hoagland's nutrient solution	3412.8 b	5.9 b	55.4 a	6.1 b	230.4 b	51.9 b
application of Mn and Zn equal to full Hoagland's nutrient solution	3521.4 a	6.1 b	56.3 a	6.9 a	246.2 a	59.2 a

Mean followed by similar letters in each column, are not significantly different at the 5% level of probability

Content of Mn and Zn in fruit

Effect of zinc and manganese treatments was significant on content of Zn and Mn (P< 5%) (Table 2). The highest content of Zn and Mn in fruit obtained from full consumption of every one from these elements, but was absorbed significant different between these treatment with treatment of complete consumption zinc + manganese (Table 3).

With consumption of manganese sulfate and zinc sulfate fertilizers, content of these elements in fruit increased. [7] in an experiment on tomato reported the results similar to this research.

CONCLUSION

The results of this research shown that, Zn and Mn can lead to increase of quantitative yield of tomato, and this preference can be related to role of Mn element in increasing of chlorophyll concentration in green organs of plants [11], and consequently increasing amount of photosynthesis and finally increase of percentage of dry matter of fruit. Moreover application of different levels of Mn and Zn and specially Zn lead to increase of nitrogen content in fruit. This increase can be by reason of indirect effect of zinc on increase of nitrogen absorption [14]. On the other hand maximum content of Zn and Mn in fruit was achieved from complete consumption of each one from them lonely and with together. This subject can be because of lux absorption of these elements in nutrient solution by tomato.

In the end, according to results of experiment was suggested with increasing Mn and Zn concentration in nutrient solution of tomato, Hamra cultivar, to concentration of more than Hugland's solution, increase of quantitative yield and concentration of some elements (N, Mn and Zn) in fruit was achieved.

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