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RESEARCH ARTICLE

IMPROVEMENT OF TOMATO (*LYCOPERSICON ESCULENTUM* L.) PRODUCTIVITY IN CALCAREOUS SOIL BY IRON FOLIAR APPLICATION

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Abstract

In order to explore the role of foliar iron application as a supplement for obtaining higher yield of tomato (*Lycopersicon esculentum* L.), an experiment was conducted during the winter and spring seasons of 2013/2014 in ISA Chott-Mariem, in a sandy loam soil having alkaline pH (8.02). The experiment was laid out in a randomized complete block design with 5 treatments and 3 replications per treatment. Five concentrations of iron i.e. 0, 500, 1000, 1500 and 2000 mg.l^{-1} $FeSO_4$ were applied exogenously after 40 days after transplantation by hand sprayer. The data for different physiological and yield parameters recorded during the course of study was subjected to statistical analysis for comparison purposes. Exposure of tomato to iron foliar application increased the physiological and yield parameters. Plant height, number of leaves, number of green leaves, leaf length, fruit number, fruit size, fruit weight and yield were significantly increased as compared to plants grown under iron-free environment. Similarly, foliar iron application also increased CO_2 assimilation and photosynthetic pigment content. Foliar spray of 500 and 1000 mg.l^{-1}$FeSO_4$ solutions was found to be most effective for enhancing physiological and yield parameters. Further increase in the concentrations of FeSO4 spray was not found to be useful as it declined the yield or even more probably due to its toxicity. This study proves that foliar application of iron at optimum level, through action as growth promoter, can increase the growth and yield in tomato.

INTRODUCTION

Foliar fertilizers are commonly used in horticulture to manage nutrient deficiencies. In vegetable production, they can correct and effectively prevent several types of deficiencies related to secondary and micro elements. Microelements such as iron is important in plant biochemical reactions which can directly or indirectly increase the performance of crops (Malakouti and Tehrani, 2005; Zeidan et al, 2010; Zarghamnejad et al, 2015). All plants need a continuous supply of iron during growth because it is not translocated from the mature to developing leaves and is classified as an immobile nutrient element (Crane et al, 2007).

Iron is an important micronutrient that is closely involved in chlorophyll synthesis, thylakoid synthesis, chloroplast development and the electron transport system of the respiration (Taiz and Zeiger, 1998). It is an essential component of several enzymes as well as cytochromes and in chloroplast contain prophyrin ring and is required for production of NADPH for CO_2 fixation in photosynthesis (Srivastava and Gupta, 1996).

Iron is considered a growth-limiting factor at high pH and calcareous soils (Abadia et al., 2011; Borowski and Michalek, 2011). In high pH environment, iron is not soluble enough to provide adequate nutrition to plants, because it is closely related to soil particles or precipitated as ferric oxide which was insoluble as well as the limitation of iron uptake by root cell cytosol (Nikolic and Kastori, 2000) and inhibit iron transport to shoots and its transfer from apoplasm to cytoplasm in shoot tissues (Nikolic and Romheld, 2002). In such conditions, plants generally suffer from deficiencies in this element. Iron deficiency impairs fruit quality and yield, and can ultimately lead to plant death (Alvarez-Fernandez et al., 2003, 2006). Since iron is a cofactor for approximately 140 enzymes that catalyze unique biochemical reactions (Brittenham, 1994). In spite of low toxicity when compared with other heavy metals (Amils et al., 2002) iron becomes toxic when it reaches high concentrations. Iron generates hydroxyl radicals that can damage lipids, proteins, and DNA (Amils et al., 2002).

Foliar application of iron greatly affects plant growth and crop production. In this regard, Ghafari and Raazmjoo (2013) reported significant positive effect of iron treatment on grain yield, yield components and quality as well as foliar chlorophylls and carotenoids contents of bread wheat (*Triticum aestivum* L.). Zarghamnejad et al (2015) indicated that foliar application of ferrous sulfate significantly increased growth parameters, yield and its components of tomato plants in green house. Therefore, a greenhouse experiment was conducted to study the effect of foliar application of iron fertilizer on the growth and yield of tomato and to find out the optimum concentration of foliar application of iron for maximum growth and yield of tomato.

MATERIALS AND METHODS

The present investigation was carried out in the Experimental Farm of the High Institute of Agronomy Chott-Mariem, Sousse, Tunisia; under unheated greenhouse conditions, during winter and spring seasons 2013-14, to study the effect of different levels of iron used in spraying solution on the growth, CO_2 assimilation, photosynthetic pigments and yield of tomato (var. Amal). Soil in the test was sandy loam. Electrical Conductivity (EC) and pH of this soil were 4.1 $dS.cm^{-1}$ and 8.02 respectively. The experiment was arranged in a randomized complete block design with 5 treatments and 3 replications per treatment. Iron foliar application was carried out at five concentrations (T_0=0, T_1=500, T_2=1000, T_3=1500 and T_4=2000 $mg.l^{-1}FeSO_4$) by hand sprayer. All foliar application was carried out early in the morning, starting from 40 days after transplanting. A total of eight sprays were given at an interval of 7 days.

Plant height, leaf length, total number of leaves, number of green leaves per plant, number of fruit per plant, fruit length, fruit diameter, weight of individual fruit and fruit yield were determined for 20 plants per treatments. Total carotenoids and chlorophylls *a* and *b* of leaf were determined according to the methods of Lichtenthaler and Wellburn (1985).CO_2 assimilation was measured by using a portable gas exchange system (CI- 301 CO_2 GAS ANALYSER, CID, Inc.). Data were analyzed by SPSS 17 software and comparing averages was done by Duncan's test and a probability value of 0.5%.

RESULTS AND DISCUSSION

Growth

Our results showed that application of iron significantly influenced plant height, leaf length, total number of leaves and number of green leaves per plant (Table 1). The highest rates of these variables were found at 500 and 1000 $mg.l^{-1}$ $FeSO_4$. Iron is an essential nutrient element that plays key roles in plants. Huda et al. (2009) reported that the optimal $FeSO_4$ concentration should be sufficient to satisfy the basic energy requirements for cell division and differentiation indication that $FeSO_4$ is one of the factors controlling the induction and growth of shoots. Leaf number is considered as an important factor in growth, responsible for photosynthesis and ultimately affecting the flower yield and quality (Fahad et al, 2014). According to Chopde et al. (2015**),** iron applied with proper concentration acts as an important catalyst in the enzymatic reaction of metabolism. This ultimately would have helped in larger biosynthesis of photoassymilates, thereby enhanced vegetative growth of plant.

Application of higher concentrations (1500 and 2000 $mg.l^{-1}$ $FeSO_4$) of iron fertilizer decreased the value of the parameter in question (Table 1). Rout and Sahoo, (2015) stated that excessive quantities of iron is potentially toxic to plant and can promote the formation of reactive oxygen-based radicals, which are able to damage vital cellular constituents (e.g., membranes) by lipid peroxidation.

Table 1: Plant height (cm), total number of leaves, number of green leaves per plant and leaf length as influenced by different $FeSO_4$ treatments

Treatments	Plant height (cm)	Total no. of leaves per plant	No. of green leaves per plant	Leaf length (cm)
T_0	140 b	25,5b	14,2 b	42 ab
T_1	155 a	31,7 a	21,1 a	45 a
T_2	150 a	28,8 ab	18,6 a	46 a
T_3	138 b	22,6b	13,1 b	39 b
T_4	132 c	18,9c	9,8 c	38 b

Photosynthetic Pigments and CO_2 Assimilation

Iron significantly affected CO_2 assimilation and photosynthetic pigments i.e. chlorophyll a, chlorophyll b and carotenoid (Table 2). The highest values were obtained at 1000 mg.l^{-1} $FeSO_4$. Results indicated a reduced in these parameters as iron concentration increased. The encouraging effect of iron application on CO_2 assimilation and photosynthetic pigments is due to the association of iron with chlorophyll formation (Rout and Sahoo, 2015). Iron functions as a component of proteins in significant cellular events such as respiration and cell division; moreover, it has a role in the reduction steps of important biological events, such as nitrogen fixation, transpiration and photosynthesis, and also in chlorophyll biosynthesis (Zocchi et al., 2007).

Table 2: CO_2 assimilation, chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content as influenced by different $FeSO_4$ treatments

Treatments	CO_2 assimilation (µmol m^{-2} s^{-1})	Chlorophyll *a* (µg.mg^{-1} MF)	Chlorophyll *b* (µg.mg^{-1} MF)	T. Chlorophyll (µg.mg^{-1} MF)	Carotenoid (µg.mg^{-1} MF)
T_0	8,22 b	11,94 c	5,56 c	20,52 c	6,7 b
T_1	11,15 a	25,50 a	9,13 b	36 a	12,38 a
T_2	12,97 a	27,55 a	15,3 a	39,41 a	13,46 a
T_3	7,98 b	15 ,43 b	8,83 b	25,72 b	7,77 b
T_4	4,95 c	15,21 b	6,90 c	19,4 c	5,30 b

In line with our results, Borowski and Michalek (2011) reported that foliar application of iron salt increased photosynthesis, chlorophylls *a*, *b* and carotenoids content of French bean. Amanullah et al. (2012) showed that application of iron sulfate in soil and foliar spray increased chlorophyll content of maize leaf. Recently, Incesu et al, (2015) claim that iron supply affects the content of chlorophyll and hence photosynthesis in plants.

Yield, number of fruit, mean fruit weight, fruit length and fruit diameter

The highest yield, number of fruit per plant, weight, length and diameter of individual fruit were significantly influenced by different concentrations of $FeSO_4$ (Table 3).

Table 3: Yield, fruit number per plant, fruit weight, fruit diameter and fruit length as influenced by different $FeSO_4$ treatments

Treatments	Yield per plant (Kg)	Fruit number per plant	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)
T_0	13.3 c	78.1 c	166.4 bc	57.7 ab	68.0 c
T_1	17.2 a	97.8 a	175.8 b	62.3 ab	72.3 b
T_2	16.5 b	85.3 b	193.8 a	66.2 a	76.0 a
T_3	12.3 c	76.8 c	160.5 bc	58.6 ab	68.5 c
T_4	11.4 c	74.1 c	154.6 c	52.2 b	65.4 c

The maximum values of yield and number of fruit were found at 500 $mg.l^{-1}$ of $FeSO_4$. However, the plants showed the minimum response to the treatment with 2000 $mg.l^{-1}$ $FeSO_4$. The maximum length, diameter and weight of individual fruit were found at 1000$mg.l^{-1}$ $FeSO_4$, while the minimum were recorded in the 2000 $mg.l^{-1}$ $FeSO_4$ treatments. These results are in relation with the physiological parameters, were the amelioration in these parameters was observed at 500 and 1000 $mg.l^{-1}$ $FeSO_4$, whereas, 1500 and 2000 $mg.l^{-1}$have a negative impact. These concentrations seem to be toxic to tomato plants. Foliar application of iron fertilizer to increase tomato yield component and yield has also been reported by others (Tamilselvi et al, 2002; Azeem and Ahmed, 2011; Ali et al, 2013; Zarghamnejad et al; 2014). Iron improves photosynthesis, yield and assimilates transportation to sinks and finally increases yield (Alvarez-Fernandez et al, 2006). This might be due to the fact that, iron activates several enzymes and involves itself in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged, due to which the fruit yield might have been increased. In this study, iron applied at 500 and 1000$mg.l^{-1}$ $FeSO_4$ enhanced photosynthetic pigments contents, relived the plant from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis which in turn have increased fruit production and ultimately yield.

CONCLUSION

It is clear from our results that foliar application of iron fertilizer enhanced the growth, and marketable yield of tomato var. Amal under the agro-climatic conditions of Chott-Mariem, Sousse, Tunisia. This improvement in growth, and yield might be attributed to the favorable influence of iron on metabolism and its stimulating effect on photosynthetic pigments and CO_2 assimilation which in turn encourage vegetative growth and yield of plants.

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