International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 20 No. 2 Feb. 2016, pp. 268-271

http://www.ijisr.issr-journals.org/

Fruit yield and quality of iron-sprayed tomato (*Lycopersicon esculentum* Mill.) grown on high pH calcareous soil

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ABSTRACT: This study was conducted to determine the effect of foliar iron applications on fruit quality and yield of tomato under unheated greenhouse conditions. Tomato plants were treated with foliar iron applications at different concentrations (0, 500, 1000, 1500 and 2000 mg.l^{-1}). Iron was applied with spraying eight times during the vegetation at 7-day intervals 40 days after planting. In the study, it was determined that foliar applications of iron showed positive effect on some fruit characteristics. Fruit number and yield of medium and large sized fruits were significantly increased in the 500 and 1000 mg.l^{-1} treatments, which subsequently resulted in an increase of marketable yield. Iron treatments had no effect on pH of fruit tomato. Whereas, firmness and total soluble solids increased with foliar iron sprays. According to our results, applications of 1000 mg.l^{-1} iron should be recommended in order to improve marketable yield in tomato production.

KEYWORDS: Iron, Foliar spray, Tomato, Fruit quality, Yield.

1 INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.), a member of the family Solanaceae, is one of the most popular and important vegetables grown in the world. Since the tomato plays an important role in human health, the quality of the nutritional components of this major crop fruit of particular concern to producers throughout the world [1]. In Tunisia, tomato is cultivated in different agro climatic conditions, but the productivity and the fruit quality of tomato were affected in different areas due to deficiencies of micronutrients observed especially in high pH calcareous soil.

Among micronutrients that influence the quality of tomato, iron plays a key role, since it is involved in metabolic processes, such as photosynthesis and respiration. It is also implied in many enzymatic systems like chlorophyll synthesis [2]. Iron is important in plant biochemical reactions which can directly or indirectly increase the performance of crops [3]. Therefore soil iron deficiency can cause significant reductions in yield and induces leaf chlorosis that is expressed as a gradual loss of chlorophyll in leaves associated with an intense nervature located greening and inter-nervature yellow area [4], especially in young leaves due to the relative immobility of Fe in the plants [5]. The incidence of Fe deficiency affects both fruit-crop yields and quality ([4], [6]). Several studies have been shown that a small amount of iron, applied by foliar spray can significantly increase the yield of crops ([7], [8], [9], [10]). Also, foliar nutrition is an option when nutrient deficiencies cannot be corrected by applications of nutrients to the soil ([11], [12]). Therefore, the present investigation was undertaken to find out the effect of foliar applications of iron at different concentrations on yield and some quantitative and qualitative characteristics of tomato.

2 MATERIALS AND METHODS

The experiment was conducted in order to evaluate the effect of different levels of iron used in spraying solution on the Fruit yield and quality of tomato during the winter and spring seasons of 2014 in Chott-Mariem, Sousse, (Elevation 6 m, Latitude North 35°52’, Longitude East 10°38’), Tunisia. Electrical Conductivity (EC) and pH of this soil were 4.1 dS/cm and 8.02 respectively. Seedlings of tomato cultivar Sahel were transplanted during December 11. 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 four concentrations (500, 1000, 1500 and 2000 mg.l^{-1} $FeSO_4$) by hand sprayer. For the control treatment, pure water was sprayed onto the leaves. 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.

Fruits were harvested weekly from the first to sixth fruit cluster between Mars 5 and May 11. Fruits were weighed and graded into small (< 100g), medium (100-200g), and large (> 200g). The number and the weight of fruits per plant by fruit size were calculated. Nine representive medium sized fruits were selected and the firmness was measured using GUESS penetrometer. The fruit was cut and soluble solids and pH of flesh were measured from the juice of the half-fruit. Data were analyzed by SPSS 17 software and comparing averages was done by Duncan's test and a probability value of 0.5%.

3 RESULTS AND DISCUSSION

In the presence study, we investigated the benefic effect of iron foliar application on tomato cultivated in calcareous soil, to prevent iron blockage by $CaCO_3$, and ameliorate growth and yield of tomato in such conditions.

3.1 NUMBER OF FRUITS PER PLANT

The total number of fruits per plant was not affected by iron treatments (table 1). The number of small fruits was greatest in response to 2000 mg.l^{-1} $FeSO_4$, which was found to be at par with 0 and 1500 mg.l^{-1} treatments, and lowest in the 1000 mg.l^{-1}, indicating that the highest concentration resulted in the greater number of small fruits. In contrast, the number of medium sized fruits was greatest in response to 1000 mg.l^{-1} $FeSO_4$ and lowest in the 2000 mg.l^{-1} treatment. The large sized fruits were mainly produced in the 500 and 1000 mg.l^{-1} $FeSO_4$. As a result, marketable fruit was greatest in the 1000 mg.l^{-1} treatment, followed by the 500 mg.l^{-1} treatment. The 2000 mg.l^{-1} $FeSO_4$ showed even less marketable fruits than the control.

The importance of iron in plant nutrition and agricultural crop production has been well documented and foliar spray is being considered an ideal method of its application for improvement of crops production. Previous studies indicate that foliar feeding of Iron increased number of fruit in Pomegranate [10], lemon [10], apple tree [13] and strawberry [6]. In present study, exogenous application of iron significantly affected marketable fruit (table 1). It may be due to reason that iron has a positive effect on the synthesis and activity of chlorophylls and thereby increase the photosynthesis and thus ultimately enhanced fruit weight [10].

Table 1. The cumulative number of fruits per plant as affected by various concentrations of $FeSO_4$

$FeSO_4$ ppm	N. of fruits/plant				
	Small	Medium	Large	Total	Marketable fruit
0	**28.2 a**	**28.3 c**	**14.3 b**	**70.8 a**	**42.6 c**
500	**21.0 b**	**33.7 b**	**16.0 a**	**70.7 a**	**49.7 b**
1000	**15.6 c**	**39.3 a**	**17.4 a**	**72.3 a**	**56.7 a**
1500	**29.5 a**	**28.2 c**	**13.7 b**	**71.4 a**	**41.9 c**
2000	**32.8 a**	**27.0 c**	**10.3 c**	**70.1 a**	**37.3 d**

Small (< 100g), medium (100-200g), large (> 200g), marketable fruit= medium + large sizes

3.2 YIELD PER PLANT

The yield per plant was affected by iron treatments (table 2). Specifically, the total yield was greatest in 1000 mg.l^{-1} $FeSO_4$ and then decreased as the concentration increased. The yield of small fruits was greatest in 2000 mg.l^{-1} $FeSO_4$, but was lowest in the 1000 mg.l^{-1}. The medium size fruit yield was greatest in 1000 mg.l^{-1} $FeSO_4$, which was more than 43% of the control, and was lowest in 2000 mg.l^{-1} $FeSO_4$. Large fruit yield was mainly observed in 1000 mg.l^{-1} $FeSO_4$. As a result, marketable yield in response to the 1000 mg.l^{-1} treatment was more than 40% of the control, while the yield at 2000 mg.l^{-1} was less than 22 % of the control.

The1000 mg.l^{-1} $FeSO_4$ was most effective at promotion of yield, followed by the 500 mg.l^{-1} $FeSO_4$. However, the 1500 and 2000 mg.l^{-1} treatments were inhibitory and resulted in greatly reduced.

Promotional effects of iron on fruit weight have been reported in several studies. Foliar application of iron has led to significant increases in mean fruit weight in strawberry [10], as well as fruits number and yield per tree of lemon [6]. Similar results were founded in pomegranate [9]. Our results indicated that 1000ppm was the optimum level for tomato production based on the yield of medium and large fruits.

Table 2. The cumulative fruit yield per plant as affected by various concentrations of $FeSO_4$

$FeSO_4$ ppm	Yield (g/plant)				
	Small	Medium	Large	Total	Marketable fruit
0	2064 b	4113 c	1903 c	8080 c	6016 c
500	1874 c	5962 b	2320 b	10156 b	8282 b
1000	1688 d	7268 a	2913 a	11869 a	10181 a
1500	2150 b	4038 c	1777 c	7965 c	5815 c
2000	2385 a	3195 d	1472 d	7052 d	4667 d

Small (< 100g), medium (100-200g), large (> 200g), marketable fruit= medium + large sizes

3.3 Fruit quality

The fruit firmness and the total soluble solid (TSS) content were affected by $FeSO_4$ treatments (table 3). However, the pH of the flesh was not affected by $FeSO_4$ treatments. The fruit firmness was greatest in the 1000 $mg.l^{-1}$ treatment and was lowest in the control (Table 3). The total soluble solid content was highest in the 1000 $mg.l^{-1}$ and was lowest in the 2000 $mg.l^{-1}$ treatment (table 3). Our results were in accordance with the previous finding that soluble solids were increased by foliar spray of iron in fruit of novel orange [14], and Tangerine [6]. It is well known that iron plays a key role in carbohydrate metabolism and fruit quality [15]. Since iron has an important role in photosynthesis that cause higher photosynthetic rate. Given that the main product of photosynthesis is sugar, so increasing the photosynthesis, lead to increase the sugar compounds and cause more soluble solids in fruit juice [9].

Table 3. Quality parameters of tomato fruits as affected by various concentrations of $FeSO_4$

$FeSO_4$ (ppm)	Firmness ($g.mm^{-1}$)	pH	TSS (°Brix)
0	0.93 c	4.1 a	4.13 b
500	0.94 c	4.1 a	4.24 b
1000	1.08 a	4.2 a	4.52 a
1500	1.00 b	4.1 a	4.09 b
2000	0.96 b	4.2 a	3.78 c

4 Conclusion

We consider that foliar iron application with concentration of 1000 $mg.l^{-1}$ of $FeSO_4$ could increase the performance, the number and yield of marketable fruit per plant, total soluble solids and firmness in tomato plants.

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