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Effects of iron and zinc on Sweet lime (*Citrus limmetta*) fruit quantity and quality in calcareous soils

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ABSTRACT: This study was conducted on 5-years-old grafted sweet lime trees as factorial arrangement in randomized complete block design with 4 replicates in Jahrom region. The first factor was iron sulfate (0, 5 and 10 mgL^{-1}) and the second factor was zinc sulfate (0, 5 and 10 mgL^{-1}). Both factors were applied as spraying in mid-June after June drop. In the harvest time were measured leaf iron and zinc amount; fruit volume; fruit peel water percent; vitamin C and total acid in fruit juice and tree yield. Results showed that the treatments had significant effect on characteristics including fruit volume; yield; vitamin C; total acid, fruit peel water percent and leaf iron and zinc amount. In general, based on the results can be recommended spraying 10 mgL^{-1} iron and zinc sulfates during June to improve the quantity and quality characteristics as well as increased yield of sweet lime in calcareous soil.

***Keywords*:** Yield, Total acid, Vitamin C, Fruit size, Iron, Zinc

INTRODUCTION

Iron (Fe) is the first microelement, which it is necessary for plant life. Grace established it in 1844 during removing of chlorosis in grape via iron sulfate sparing. Iron is essential for the activity of several enzymatic systems and plant components such as Catalase, Cytochrome, Frodoxin, Frichrome, Hematin, Hem and Cytochrome oxidase. In addition, it seems iron be involved in nucleic acids metabolism in chloroplast. Usually relation between iron and vegetative growth of fruit trees is more complex than other nutrient elements. (Saatsi and Yamur, 2000) reported that in the early stages of iron deficiency are not observed decrease in tree growth and yield but when deficiency is continued for 2-3 years, growth and development of many of the leaves were stopped and some of them are falling. In these conditions reduce the total leaf area and followed by growth and fruit production is less. (Devi et al.,1997) after application of iron, zinc and manganese sulfates in soil and as foliar spray reported that application of these materials reduced leaf chlorosis and significantly increased the yield. According to the report of (Mohamed et al.,1995) combine or alone application of cupper, manganese and iron sulfates in concentrations 0.5 to 1 % as foliar spray, in addition to enhanced performance, improved quality of orange juice followed. (Alla et al., 1985) reported that application of cupper, manganese and iron increased the yield of sweet orange trees but these materials had no influence on fruit internal quality. Zinc is an essential component of some enzymes such as dehydrogenase, proteinase and peptidases. In this regard, zinc can affect electron transfer reactions such as the Krebs cycle and energy production of the plant. Zinc is also involved in other reactions such as protein construction and analysis (Bose et al., 1988). According Suayn idea, total amount of zinc in soils is normally in the range of 300-100 ppm. Alkali soil, high utilization of phosphorous and nitrogen, high organic matter in soil, high soil moisture and excessive amounts of potash and copper can be effective in zinc deficiency symptoms. Usually zinc deficiencyare found in very sandy soils with low pH and alkaline soils (Reuther et al., 1968). Although the effect of zinc on tree

growth is not directly, but its indirect effect should be considered. Zinc is a prerequisite for making tryptophan and trryptophan is the raw material for making auxin and auxin plays an important role in increasing the leaf area and tree canopy (Supriya et al., 1993). (Supriya et al., 1993) during an experiment on the effect of zinc on fruit set of Assami lemon reported that zinc consumption as chelate or zinc sulfate as foliar spray significantly increased fruit set, fruit number on tree, fruit volume, fruit weight and yield than control treatment. In their experiment the treatment 0.4% zinc sulfate has been reported as the best treatment. (Rajput et al., 1991) reported that spraying citrus trees with 0.5% zinc sulfate increased the yield, vitamin C, TSS and total acid. (Bhattacharrya and Langthasa, 1995) during the experiment applied 0.1, 0.2, 0.3 and 0.4% zinc on Assami lemon trees and reported that the highest fruit juice, TTS, total sugar and vitamin C observed in 0.4% treatment. Hamid (1993) obtained the highest vitamin C and TSS from the grapefruit fruits sprayed with 0.4% zinc sulfate. (Mann et al., 1989) reported that spraying Mg, Fe, Cu and Zn had no effect of change sweet orange fruit quality.

MATERIALS AND METHODS

This study was performed as factorial arrangement in randomize complete block design with four replications on 5-years-old grafted Sweet lime trees on Mexican lime rootstock. The factors were consist: iron sulfate (0, 5 and 10 mg/L) and zinc sulfate (0, 5 and 10 mg/L). iron and zinc sulfates were used as foliar spray on June 4. To prevent leaf burn was added some limewater to the solution. Evaluated traits were consist: Leaf iron and zinc that was measured by extracting from leaf ash (in 500 °C for 5 hours) by using HCl 2N and double-distilled water at boiling by atomic absorption device. Fruit volume by dipping method in measuring cylinder containing water. Fruit peel water percent was calculated by using 100 g fresh fruit peel in 75 °C for 48 hours in the oven. Vitamin C was measured by titration method with iodine in potassium iodide and 10 cc fruit juice. Total acid (TA) was measured after adding a few drops phenolphthalein to 5 cc fruit juice by using titration method and NaOH. The yield of each tree was harvested separately and then was weighted by using 500 kg scale. Obtained data was analyzed by MSTATC software and the means was compared by using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Influence of different levels of iron and zinc sulfates separately on quantitative and qualitative traits of Sweet lime fruits

Results showed that different levels of iron and zinc sulfates (0, 5 and 10 mg/L as foliar spray) had significant influence ($p<0.05$ DMRT) on fruit volume, yield, vitamin C, total acid, fruit peel water percent and leaf iron and zinc amount in the harvest time (Table 1). Above results are according to the findings of (Tucker et al., 1995;Sing 1984; Hassan, 1994; Devi et al., 1997 and Rajput et al., 1991).

Interaction between iron and zinc sulfates on quantitative and qualitative traits of Sweet lime fruits

Mean comparison showed significant interaction between two factors ($p<0.05$ DMRT) on fruit volume, yield, vitamin C, total acid, fruit peel water percent and leaf iron and zinc amount (Table 2). The above results are according to the findings of (Alla et al., 1985) in relation to yield, (Bhattacharrya and Langthasa, 1995), (Mohamed et al., 1995) and (Hamid, 1993) but in relation to qualitative characters did not conform to the finding of (Mann, 1989 and Alla et al., 1985).

Table 1. Mean comparison of effect of different levels of iron and zinc sulfates separately on the evaluated characteristics

Treatment / Characteristics	Iron sulfate (foliar spray)			Zinc sulfate (soil application)		
	0 (Fe_0) mg/L	5 (Fe_5)	10 (Fe_{10})	0 (Zn_0) mg/L	5 (Zn_5)	10 (Zn_{10})
Fruit volume (cc)	150.6[a]	154.4[a]	151.2[a]	142.0[b]	155.6[a]	158.7[a]
Tree yield (kg)	123.4[b]	134.9[a]	140.9[a]	119.2[b]	144.9[a]	135.1[a]
Vitamin C (mg/100 cc)	48.2[b]	51.4[a]	50.7[a]	49.7[b]	49.7[b]	51.0[a]
Total acid (mg/100 cc)	1.279[b]	1.379[a]	1.253[c]	1.396[a]	1.288[b]	1.287[b]
Fruit peel water percent	85.4[a]	84.8[b]	85.1[b]	85.5[a]	85.2[b]	84.7[c]
Leaf iron (mg)	46.9[b]	46.7[c]	49.3[a]	50.4[a]	45.8[c]	46.7[b]

In the separated columns, in each row, the means having same letter are not significantly different in $p<0.05$ DMR

Table 2. Mean comparison in relation to interaction between iron and zinc sulfates on the evaluated characteristics

Characteristics / Fe × Zn		Fruit volume (cc)	Tree yield (kg)	Vitamin C (mg/100 cc)	Total acid (mg/100 cc)	Fruit peel water percent	Leaf iron (mg)	Leaf zinc (mg)
	Zn_0	132.2^{c}	104.0^{d}	47.4^{d}	1.415^{b}	85.7^{a}	45.3^{f}	42.9^{f}
Fe_0	Zn_5	162.0^{a}	135.9^{bc}	47.1^{d}	1.115^{d}	85.9^{a}	44.0^{g}	55.3^{c}
	Zn_{10}	157.6^{a}	139.3^{bc}	50.2^{c}	1.308^{c}	84.7^{bc}	51.3^{b}	55.3^{c}
	Zn_0	151.6^{ab}	117.0^{cd}	50.3^{bc}	1.592^{a}	85.2^{b}	47.7^{c}	49.0^{e}
Fe_5	Zn_5	154.9^{a}	134.3^{bc}	51.8^{ab}	1.177^{d}	84.9^{bc}	46.7^{d}	50.7^{d}
	Zn_{10}	156.7^{a}	156.2^{a}	52.0^{a}	1.367^{bc}	84.4^{c}	45.7^{e}	68.6^{a}
	Zn_0	142.2^{bc}	122.8^{bcd}	51.2^{abc}	1.180^{d}	85.6^{a}	58.3^{a}	43.8^{f}
Fe_{10}	Zn_5	149.8^{ab}	142.5^{ab}	50.2^{c}	1.393^{bc}	84.8^{bc}	46.7^{d}	54.2^{c}
	Zn_{10}	161.8^{a}	157.4^{a}	50.8^{abc}	1.187^{d}	84.9^{bc}	43.0^{h}	59.2^{b}

In each column, the means having same letter are not significantly different in p<0.05 DMRT

In general can be concluded that alone or combine utilization of iron and zinc sulfates as foliar spray have important role on enhancement of quantitative and qualitative traits of sweet lime crop. However, the effect of different levels of each the above factors on fruit characteristics are different. What is certain, application of above materials is able to reduce the fruit abscission rate and cause a large increase in the yield. It is important that growers achieve to high yields but fruit quality characteristics should also be noted. On the principle, foliar spraying 10 mg/L iron and zinc sulfate, in addition to increased yield, better quality fruit will have and there is a saving than chelates application.

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