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Effects of nitrogen and iron 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 a factorial arrangement in randomized complete block design with 4 replicates. The first factor was ammonium sulfate (0, 250 and 500 g for every tree as soil application) and the second factor was iron sulfate (0, 5 and 10 mgL^{-1} as spraying in mid-June after June drop). In the harvest time were measured iron leaf; fruit volume; peel water percent; vitamin C and total acid in fruit juice and finally tree yield. Results showed that the treatments had significant effect on some characteristics including fruit volume; yield; vitamin C; total acid; peel water percent and iron leaf amount. In general, based on the results can be recommended application of 250 g of ammonium sulfate for every tree in soil and spraying 10 mgL^{-1} iron sulfate 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.

INTRODUCTION

Citrus plants require to nitrogen fertilizers more than the other fertilizers and whereas nitrogen exit from soil via sublimation, leaching and taking by crop, its continual application is necessary. In nitrogen deficit, vegetative growth is stopping and the yield is decreasing. On the other hand, nitrogen toxicity also can be had undesirable effect on yield quality and absorption of other elements. Since nitrogen is one of the forming components of proteins, chlorophyll and other necessary compounds for plant, its deficit lead to the stopping of vegetative growth, leaves chlorosis, shoot drying and reducing of flowering in addition, fruit set. The most obvious symptom of nitrogen deficiency in most citrus varieties is their thin leaves and fall before maturity (Bose et al., 1988). Under conditions of nitrogen deficiency, fruit size reduces, fruit peel is soft and its water level is high (Werner and Nelson, 1951). 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 acid metabolism in the chloroplast. (Bopath and Srivastava, 1982) found that application of 100-600 g nitrogen lead to reduce the incidence of chlorosis in mandarin. (Hirob, 1981) evaluated the effect of 100, 200, 300 and 400 kg/ha nitrogen fertilizer for 9 years in mandarin trees and concluded that the tree trunk diameter in 300 kg/ha N and crown volume in 400 kg/ha N were in maximum size. (Alla et al., 1985) in the three-year experiment concluded that the annual application of 800 g N per tree has the best effect on citrus root growth. 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 a foliar spray reported that application of these materials reduced leaf chlorosis and significantly increased the yield.(Sing, 1984) in evaluating the effect of different concentrations of

nitrogen on quantity and quality of the Mexican lime fruit reported that the most water was obtained from the fruit of trees that the highest nitrogen (1200 g per tree) were received in the summer. The most vitamin C and total soluble solid were observed in fruit juice of the trees that the highest nitrogen (1200 g per tree) was received in the fall. 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.

MATERIALS AND METHODS

This study was performed as a factorial arrangement in randomized complete block design with four replications on 5-years-old grafted Sweet lime trees on Mexican lime rootstock. The factors were consist: ammonium sulfate (0, 250 and 500 g per tree) and iron sulfate (0, 5 and 10 mg/L). The application of iron sulfate and ammonium sulfate were used as a foliar spray and in the soil respectively. To prevent leaf burn was added some limewater to the solution. The treatments were applied on June 4. Evaluated traits were consist: Leaf iron 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 the atomic absorption device. Fruit volume by dipping method in measuring cylinder containing water. The 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 the 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 the titration method and NaOH. The yield of each tree was harvested separately and then was weighted by using a 500 kg scale. Obtained data were 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 ammonium and iron sulfates separately on quantitative and qualitative traits of Sweet lime fruits

Results showed that different levels of ammonium sulfate (0, 250 and 500 g per tree) and iron sulfate (0, 5 and 10 mg/L as foliar spray) had a significant influence ($p<0.05$ DMRT) on fruit volume, vitamin C, total acid, fruit peel water percent and leaf iron amount in the harvest time (Table 1). The 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) but in relation to effect of nitrogen did not conform to the finding of Dasbery *et al* (1988).

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

Mean comparisons showed significant interaction between the two factors ($p<0.05$ DMRT) on fruit volume, yield, vitamin C, total acid, fruit peel water percent and leaf iron amount (Table 2). The above results are according to the findings of Devi *et al* (1997) and Alla *et al* (1985) but did not conform to the finding of Bhattacharrya and Sing (1975).

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

Treatment	Iron sulfate (foliar spray)			Ammonium sulfate (soil application)		
	0 (Fe_0)	5 (Fe_5)	10 (Fe_{10})	0 (N_0)	250 (N_{250})	500 (N_{500})
Characteristics	mg/L			g		
Fruit volume (cc)	150.6^{a}	154.4^{a}	151.2^{a}	144.8^{b}	142.9^{b}	168.6^{a}
Tree yield (kg)	123.4^{b}	134.9^{a}	140.9^{a}	105.7^{b}	111.9^{b}	191.6^{a}
Vitamin C (mg/100 cc)	48.2^{b}	51.4^{a}	50.7^{a}	50.4^{a}	49.3^{b}	50.6^{a}
Total acid (mg/100 cc)	1.279^{b}	1.379^{a}	1.253^{c}	1.378^{a}	1.280^{b}	1.253^{c}
Fruit peel water percent	85.4^{a}	84.8^{b}	85.1^{b}	84.7^{c}	85.0^{b}	85.7^{a}
Leaf iron (mg)	46.9^{b}	46.7^{c}	49.3^{a}	45.8^{b}	52.4^{a}	44.7^{c}

In the separated columns, in each row, 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 ammonium sulfate as soil-application and iron sulfate 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, application of 250 g ammonium sulfate per tree in soil and foliar spraying 10 mg/L iron sulfate, in addition to increased yield, better quality fruit will have and there is a saving than chelates application.

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

Characteristics N × Fe		Fruit volume (cc)	Tree yield (kg)	Vitamin C (mg/100 cc)	Total acid (mg/100 cc)	Fruit peel water percent	Leaf iron (mg)
N_0	Fe_0	144.2^{bc}	88.1^{e}	50.2^{b}	1.189^{c}	85.3^{b}	38.0^{i}
	Fe_5	152.3^{b}	101.5^{c}	49.3^{b}	1.577^{a}	84.6^{cd}	45.0^{f}
	Fe_{10}	137.8^{c}	127.5^{de}	51.8^{a}	1.368^{b}	84.2^{d}	54.3^{a}
N_{250}	Fe_0	142.3^{bc}	88.2^{e}	45.4^{c}	1.256^{c}	85.2^{b}	53.0^{c}
	Fe_5	145.8^{bc}	101.8^{de}	52.3^{a}	1.167^{c}	84.9^{bc}	53.7^{b}
	Fe_{10}	140.6^{bc}	115.5^{cd}	50.2^{b}	1.417^{b}	84.9^{bc}	50.7^{d}
N_{500}	Fe_0	165.3^{a}	175.9^{a}	49.1^{b}	1.393^{b}	85.8^{a}	49.7^{e}
	Fe_5	165.0^{a}	193.2^{b}	52.4^{a}	1.392^{b}	85.1^{b}	41.3^{h}
	Fe_{10}	175.3^{a}	205.7^{a}	50.2^{b}	0.975^{d}	86.1^{a}	43.0^{g}

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

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