Plant Archives Vol. 19 No. 2, 2019 pp. 4215-4218 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF FOLIAR APPLICATION WITH FERROUS SULPHATE AND AG3 ON SAPLINGS GROWTH OF SOUR ORANGE (*CITRUS AURANTIUM* L.)

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Abstract

The experiment was conducted in the lath house of the Horticulture and landscape Department, Faculty of Agriculture, University of Kufa, Najaf, Iraq to determine the effect of foliar application with ferrous sulfate at concentrations of (0, 100, 150, 200) mg/l and (GA3) at concentrations of (0, 150, 200, 300) mg/l and their interactions in the vegetative characteristics of the sour orange saplings. Randomized complete block design (RCBD) with four replications was used. The results showed that the foliar application of ferrous sulfate at 200 mg/l concentration and GA3 at 300 mg/l concentration significantly increased rate of saplings height, stalk diameter, the leaf total chlorophyll, total carbohydrate accumulation in leaves, gibberellins, auxin (IAA) and nutrients studied N, P and Fe (with the exception of K).

***Key words*:** Sour Orange, Saplings, Ferrous Sulfate, IAA and GA3.

Introduction

The genus of citrus belongs to the family of Rutaceae. East Asia is its home country and India (Salman, 1998). In Iraq, the cultivation of most citrus species in the central and southern regions, citrus trees take an important place among fruit trees due to their nutritional, economic, medical, aesthetic and environmental importance. Fruits are rich in mineral salts which are necessary for the construction of the human body such as K, Ca, Mg, Fe, Na, S and P, and also a source of vitamin C and small amounts of vitamin A, B1 and B2 (Dawwi and Fadhilah, 2010) and Ibrahim (2015).

Sour orange is one of the most important stock for various types of citrus fruits to provide its seeds in large quantities. Also it is good and suitable stock in the lands with medium and heavy texture in different environmental conditions and resists. The disease caused by the rise of the ground water and the incidence of some types of pathogenic fungi (Salman, 1988). The saplings of sour orange has slow growth however, using foliar application on sour orange saplings has a significant role in increasing the growth of saplings plants (Abou Dahi and Alyounis, 1988). The aim of the study was to determine the effect of foliar application of ferrous sulfate and AG3 on saplings of sour orange.

Materials and Methods

The experiment was carried out in the lath house of the department of Horticulture and landscape, Agriculture College, University of Kufa, Iraq, for the period of 1-3 to 1-12-2018, to study the effect of foliar application of ferrous sulfate and AG3 on saplings of sour orange. Ferrous sulfate was tested at concentrations of 0, 100, 150 or 200 mg/L and while GA3 was applied at concentrations of 0, 150, 200 or 300 mg/L and their interactions to be 16 experimental units in total with four replications each. Six months old saplings were planting in plastic bags with sandy loam soil. (Table 1).

Measurements:

• Saplings plant height rate (cm): The height of the saplings was measured by a metric strip from the surface of the soil to the top of the main stalk of each sapling.

• Rate of main stalk diameter (mm): The main stalk diameter is measured at a height (10) cm from the surface of the soil by the Vernire calipers for each treatment with average.

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• Total carbohydrates: Estimating the percentage of total carbohydrates in the leaves according to (Joslyn, 1970).

• Leaf content of total chlorophyll (mg/100g/soft weight) was assessed according to the following equation (20.2 × (0.d645) + 8.02 (0.d645)

• Leaf content of the gibberellins, auxin (IAA) (mg/kg fresh weight) was done in accordance with the method used by Nuray *et al*., (2002).

• Saplings leaves contents of N, P and K: The amount of N using a device (Kjeldah) According to Chapman, Pratt (1961).

• Total P is estimated according to Page (1982).

• Potassium (K) has been estimated by the Flame photometer according to Haynes (1980).

Statistical analysis

All the experimental data were analyzed using analysis of variance using GenStat, 2012 software. The differences between treatment means were compared using least significance difference (LSD) test at 5% level of significance (Steel and Torrie, 1980).

Results

Table 2, showed that there are significant differences in the height of the sour orange sapling. The highest value of the saplings height (24.6cm) was recorded in the ferrous sulfate treatment at the concentration of 200 mg/l exceeded the highest value of the increase in the height of saplings (24.6cm) compared to the control treatment which had lowest value height that of 16.02cm. It is also noted that the foliar application of sour orange saplings with GA3 at the concentration of 300 mg/l gave the highest value of (23.74). However, the highest value of 27.32cm was recorded due to the interaction between ferrous sulfate at a concentrations of 200 mg/l and (GA3) at concentration of 300 mg/l in comparison to the lowest value of 12.15cm.

Table 1: Physical and chemical properties of the pre-planting soil.

Property	Unit	value
EC	dS/m	1.2
pH	-	7.7
Available N	%	0.42
Available P		0.03
K^+	milli moles charge/l	0.61
Na^+		4.48
Ca^{++}		1.45
Texture class		Sandy loam

Table 2: Effect of foliar application of ferrous sulfate and GA3 and their interaction on saplings height of sour orange.

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	12.15	14.40	16.19	21.35	16.02
100	17.44	18.32	19.50	22.08	19.33
150	20.11	21.16	22.60	24.22	22.02
200	22.20	23.17	25.71	27.32	24.6
Average	17.97	19.26	21.00	23.74	
LSD	Ferrous sulfate= 0.10 Gibberellins= 0.10 Interaction= 0.30				

Values are means of four replicates.

Table 3: The effect of foliar application of ferrous sulfate and GA3 and their interaction on stalk diameter of sour orange.

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	5.17	6.20	7.81	8.70	6.97
100	6.82	7.50	8.16	9.60	8.02
150	8.60	8.90	9.10	10.45	9.26
200	9.50	9.85	10.20	10.90	10.11
Average	7.52	8.11	8.81	9.91	
LSD	Ferrous sulfate= 0.10 Gibberellins= 0.10 Interaction= 0.30				

As regarding to table 3, that foliar application of ferrous sulfate at the concentration of 200 mg/l had a significant effect on the rate of the stalk diameter (10.11) cm comparison to the lowest stalk diameter, while the foliar application of GA3 at the concentration of 250 mg/l recorded 8.81mm. Regarding with the interaction effect of both factors (ferrous sulfate and GA3) gave the highest value of 10.90mm compared to the control treatment (5.17)mm.

As shown in table 4, that the treatment of ferrous sulfate had a significant effect in the percentage of total carbohydrates in the leaves, at the concentration of 200 mg/l by giving the highest value of 21.53% comparison to the control which was recorded 16.18%. Also, the

Table 4: The effect of foliar application of ferrous sulfate and GA3 and their interaction on carbohydrates in leaves (%) of sour orange.

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	15.10	16.75	16.34	16.51	16.18
100	17.23	17.54	17.66	19.28	17.93
150	19.53	19.66	20.50	20.64	20.08
200	20.58	21.37	21.42	22.73	21.53
Average	18.11	18.83	18.98	19.79	
LSD	Ferrous sulfate= 0.26 Gibberellins= 0.25 Interaction= 0.62				

Table 5: The effect of foliar application of ferrous sulfate and GA3 and their interaction on leaf total chlorophyll (%) of sour orange.

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	189.98	221.47	231.78	234.21	219.36
100	223.50	231.34	240.98	263.01	239.71
150	271.17	277.05	288.50	296.07	283.20
200	296.71	296.71	298.81	303.80	299.01
Average	245.34	256.64	265.02	274.27	
LSD	Ferrous sulfate= 5.61 Gibberellins= 5.11 Interaction= 8.52				

Table 6: Effect of foliar application of ferrous sulfate and GA3 and their interaction on sour orange leaves content of IAA (mg/kg).

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	22.02	26.82	28.95	35.78	28.39
100	26.51	33.16	34.77	36.82	32.81
150	36.11	37.51	37.96	39.23	37.70
200	40.09	42.85	43.11	45.07	42.78
Average	31.18	35.08	36.20	39.22	
LSD	Ferrous sulfate= 2.50 Gibberellins= 2.57 Interaction= 5.21				

spraying of AG3 at 300 mg/l had a significant effect on the percentage of total carbohydrate (19.79%) in the leaves, compared to the lowest value of 18.11% in the control treatment. The interaction effect of ferrous sulfate at level of 200 mg/l and 300 mg/l with the treatment of AG3 gave the highest value (22.73%) compared to 15.10% which obtained from the control treatment.

Table 5, showed that the foliar application of saplings with ferrous sulphate at concentration of 200 mg/l had a significant effect on the leaf content of the total chlorophyll, and recorded the highest value of 299.01 mg/100g compared to the control treatment which was obtained 219.36 mg/100g. Foliar application of AG3 at concentration of 300mg/l obtained 274.27 mg/100g compared to the control 245.34 mg/100g. The interaction effect of ferrous sulfate at level of 200 mg/l and AG3 at level of 300 mg/l gave the highest value of 303.80 mg/100g compared to the control which was recorded the lowest value of 189.98mg/100g.

Table 6, showed that the foliar application of ferrous sulphate had a significant effect on the content of the leaves of auxin (IAA), which was recorded the highest value 42.78 mg/kg, while the comparison treatment gave the lowest value of 28.39 mg/kg. The foliar application of AG3 at 300 mg/l, also gave a significant effect in the IAA leaves contents 39.22 mg/kg, while the lowest value 31.18 mg/kg was recorded in the control treatment. The interaction effect between the ferrous sulphate and the (GA3) at 200 mg/l and 300 mg/l, respectively is significantly affected the content of auxin in the leaves, and obtained 45.07 mg/kg.

Table 7: The effect of foliar application of ferrous sulfate and GA3 and their interaction on N content of the leaves (%).

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	1.56	1.90	1.95	2.10	1.88
100	2.20	2.45	2.63	2.30	2.40
150	2.59	2.68	2.40	2.66	2.58
200	2.78	2.48	2.75	2.87	2.72
Average	2.28	2.38	2.43	2.48	
LSD	Ferrous sulfate= 0.39 Gibberellins= 0.43 Interaction= 0.78				

Table 8: The effect of foliar application of ferrous sulfate and GA3 and their interaction on P content of the leaves (%).

GA3 treatments	Ferrous sulfate mg/L				Average
	0	200	250	300	
0	0.18	0.20	0.22	0.21	0.20
100	0.21	0.23	0.27	0.31	0.25
150	0.24	0.28	0.28	0.31	0.27
200	0.29	0.29	0.31	0.33	0.30
Average	0.23	0.25	0.27	0.29	
LSD	Ferrous sulfate= 0.06 Gibberellins= 0.06 Interaction= 0.07				

Data presented in table 7, showed that the foliar application at of ferrous sulfate at concentration of 200 mg/l, had a significant effect in the rate of the N leaf content, giving the highest value 2.72%, while the lowest value 1.88% was recorded in the control. Also the foliar application of AG3 at 300 mg/l, recorded the highest value of 2.48% while the control treatment obtained 2.28%. The interaction between the ferrous sulphate and the (GA3) is significantly affected the N leaf content and obtained the highest value of 2.87% compared to value of 1.5% obtained by the control treatment.

Table 8, shows that the treatment of ferrous sulphate at 200 mg/l had a significant effect in increasing the rate of the P leaf content by giving the highest value 0.30%, while the lowest value 0.20%, was recorded in the control treatment. Foliar application of AG3 at 300 mg/l concentration had a significant effect by giving the highest value of 0.29% while the lowest value of 0.23% was obtained in the control treatment. The interaction effect between the ferrous sulphate and the (GA3) is significantly affected the P leaf content and obtained the highest value of 0.33% compared to value of 0.18% obtained by the control treatment.

The results of this study confirmed that there is insignificant effect in increasing K in the leaves of the saplings when using ferrous sulphate and AG3.

Discussion

Overall, saplings height of sour orange, stalk diameter, total carbohydrates and chlorophyll in the leaves, auxin content, NP content were increased when using foliar application of ferrous sulphate and AG3 at the concentrations of 200 mg/l and 300mg/l, respectively. These increases may due to the role of ferrous sulphate which plays an important role in the plant's bioactivity, chlorophyll formation and stimulation of many enzymes leading to increased efficiency of photosynthesis and this is reflected in the growth of plant (Abou Dahi, 1991).

Abou Dahi (1991) also reported that the treatment with iron (Fe) may play a role in increasing the amount of food Manufactured in leaves that are used in various growth processes as a result of increasing the leaf space of the petals when adding iron individually or bilaterally with GA3, where iron has an important role for the bioconstruction of chlorophyll, which reflects response in the growth of saplings. These results are consistent with (Araji, 2003), when using foliar application of Fe on sour orange saplings which led to an increase in the height of saplings. These results generally concur with previously published results on the effects of Fe on growth characteristics (Pestana *et al.,* 2002).

The positive effect of Fe in activating many enzymes and entering it as a catalyst in chlorophyll formation and growth has been previously documented. Zieger and Taiz, (1988) reported that Fe fertilization improved plant height, stalk diameter of saplings and photosynthesis then reflected in Increasing the materials manufactured in the leaves and thus increasing the growth of the plant. Focus (2003) reported that Fe plays an important role in electrons transporting, protein formation and DNA formation and Fe positively affects the plant growth.

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