EFFECT OF FOLIAR APPLICATION OF SALICYLIC ACID, MAGNESIUM, AND IRON ON THE SEEDLIGS OF *Citrus medica* L.

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ABSTRACT

A field experiment was carried out on *Citrus medica* at University of Baghdad - College of Agricultural Engineering Sciences. During the fall season of 2020 and spring season of 2021 in order to evaluate the effect of foliar application of Salicylic acid (0, 150, and 300) mg L^{-1}, Magnesium (0, 10, and 20) mg L^{-1}, and Iron (0, 5, and 10 mg L^{-1}) on the vegetative growth characteristics of citron *citrus medica* L. seedlings local var. citronella grafted on one year old bitter orange. The experiment was conducted at Sept. 2020 until the first of July 2021 according to the factorial experiment within RCBD design that consisted of two factors and three replicates with45ex... un., for fall and spring season and a total of 90 seedlings. The results revealed a significant differences under the foliar application of salicylic acid in 150mg l^{-1} and 300mg l^{-1} in most of the studied traits, as treatment 150mg l^{-1} recorded the highest values of plant's height for both seasons, and treatment 300mg l^{-1} recorded the highest leaves area, root's number, leaves content of chlorophyll, leaves content of Mg and Fe, shoots content of carbohydrates for both seasons, respectively. While the foliar application of magnesium and iron, at the treatment of (10 Mg+5 Fe) mg l^{-1} recorded the highest values of plant's height, leaves area for the spring season, and C/N ratio for both seasons, and leaves content of chlorophyll for the fall season. The (20 Mg+ 10Fe) mg l^{-1} treatment recorded the highest root Volume, leaves content of Mg and Fe; shoot's content of carbohydrates, while the interaction treatments between the studied factors recorded the most significant values in all the studied indicators.

Key words: leaves area, fruit trees, citron ,vegetative growth, plant height, roots
***Part of M.Sc. thesis of the 1st author.**

تأثير الرش بحامض السالسليك والمغنيسيوم والحديد في نمو شتلات الطرنج *Citrus medic* L.

ذكرى سالم احمد اسامة يحيى صالح
باحث مدرس

نفذت تجربة حقلية في المحطة البحثيه A التابعة لكلية علوم الهندسة الزراعية –جامعة بغداد –الجادرية وللموسمين خريفي 2020 وربيعي 2021, اجريت التجربة في ايلول 2020 ولغاية الاول من تموز 2021 على شتلات الطرنج صنف محلي المطعمة على اصل النارنج وبعمر سنة واحدة. بهدف معرفة تاثير الرش بحامض السالسليك (0, 150, 300) ملغم لتر$^{-1}$ وعنصري المغنيسيوم (0 ,10 ,20) ملغم لتر$^{-1}$ والحديد (0 ,5 ,10) ملغم لتر$^{-1}$ في نمو شتلات الطرنج. التجربة عاملية ضمن تصميم RCBD مكونه من عاملين وبثلاثة مكررات بواقع نباتين لكل وحدة تجريبية ليصبح العدد الكلي 90 شتلة للموسمين الخريفي والربيعي، تم مقارنة المعدلات باستعمال اختبار اقل فرق معنوي LSD وبمستوى احتمال 0.05% بينت نتائج التحليل الاحصائي تفوق معاملتي الرش بالساليسليك يالتراكيز 150 و300 ملغم لتر$^{-1}$ في معظم الصفات المدروسة ,اذ اعطت اعطى الرش بالسالسليك بتركيز 150ملغم لتر$^{-1}$ اعلى ارتفاع للنبات لكلا الموسمين، واعطى الرش بالسالسليك بتركيز 300ملغم لتر$^{-1}$ اعطت اكبر(مساحة ورقية، عدد جذور، محتوى كلوروفيل، نسبة مئوية للعناصر Mg و Fe، نسبة مئوية للكاربوهيدرات في المجموع الخضري) للموسمين الخريفي والربيعي وبالتتابع، واما بالنسبة للرش بعنصري المغنيسيوم والحديد بينت النتائج تفوق المعاملة M1 (5+10) ملغم لتر$^{-1}$ في (ارتفاع النبات، المساحة الورقية للموسم الربيعي، نسبة Ratio C/N لكلا الموسمين ومحتوى الكلوروفيل للموسم الخريفي)، واعطت المعاملة M4 (20+10)ملغم لتر$^{-1}$ اعلى حجم جذر، نسبة مئوية للعناصر Mg و Fe، نسبة مئوية للكاربوهيدرات في المجموع الجذري، اما التداخل بين عاملي الدراسة فقد اعطى معنوية في جميع مؤشرات الدراسة

الكلمات المفتاحية: مساحة ورقية، أشجار الفاكهة، طرنج، نمو خضري، ارتفاع النبات، جذور

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INTRODUCTION

Citron *Citrus medica* is an aromatic citrus tree, the name is derived from its historical name Median mentioned by Theophrastus, who believed that it belongs to the Mediterranean (27). It is unexploited enough, as it contains effective compounds in all the plant's parts, including ezulemon, citral, limonene, phenols, vitamin C, pectin, linalool, and decanal. It has many health benefits that have been proven by pharmacological studies; for instance, anti-cold flu, juices, soft, alcoholic drinks, and jams (14). Salicylic acid is a phenolic compound that consisted of an aromatic ring carrying a hydroxyl group (17). It is involved in many physiological processes such as growth, photosynthesis, cellular metabolism, protein synthesis, stomata opening, and gas release, in addition to its role in strengthening the plant's defense system against various diseases and increasing the effectiveness of antioxidants and enzymes (25). Al-Asadi (6) concluded from his study on *Ziziphus spina-christi* plant that the foliar application of salicylic acid at a concentration of 200 mg L^{-1} had a significant effect on all studied vegetative characteristics. Also In a study was conducted to investigate effect of foliar spraying of salicylic acid in combination with chelated zinc on Halawani grapes, the study showed there was an increase in leaf area and distance chlorophyll content in grape leaf (7). Also, in an experiment conducted by Al-Hayani et al. (9) on several citrus rootstocks to evaluate the effect of salicylic acid on vegetative and root growth, the study revealed an increase in the leaves number, wet and dry weight of the shoot and roots. Also, in a study on *Citrus aurantium*, revealed that the application of four concentrations of salicylic acid (0,50,100,150) mg L^{-1}, the treatment of 150 mg L^{-1} recorded a significant effect on the leaves content of chlorophyll and nitrogen (19). Magnesium is one of the macro-nutrients that activates enzymes required for plant's growth. It is an essential nutrient for adenosine triphosphate (ATP) production, it also ensures the carbohydrates transfer from the leaves to of the plant (23). Iron is one of the necessary microelements and has two main functions in the plant's metabolism, the first of which is to activate oxidation and reduction enzymes through its ability to lose and gain electrons, and the second is that the iron is involved in the chlorophyll. Also, plants require the iron in cells division, respiration and photophosphorylation Al-Sahaf (11). Al-Tamimi (12) found in an experiment conducted on Washingtonia palm seedlings that the application of iron at three concentrations (0,25,50) mg L^{-1} has significantly increased the leaves number, leaves area, leaves content of chlorophyll and carbohydrate. Also, Hanafy et al (18) recorded that the foliar application of magnesium on navel orange trees at a concentration of 137.5 ppm has improved growth and productivity of trees. This study was aimed to evaluate the effect of foliar application of salicylic acid, magnesium, and iron on the growth of *Citrus medica* and evaluate the mutual effect between the root and the scion.

MATERIALS AND METHODS

The experiment was carried out at Research Station A which belongs to the College of Agricultural Engineering Sciences - University of Baghdad AL- Jadiriyah during the fall season of 2020 and the spring season of 2021. The experiment was conducted in September 2020 until the first of July 2021 on seedlings of a local variety grafted on the origin of the bitter orange at the age of one year, the seedlings were brought from one of the reliable nurseries in Baghdad. The seedlings were planted in plastic pots with a diameter of 35 cm using an agricultural medium consisting of mixed soil and peat moss at a ratio of 2:1. The land was prepared by creating a canopy covered by saran net layer in a permeability of 50%, with a water source secured, then the seedlings were distributed, and the irrigation and fertilization were applied, as all seedlings were fertilized by NPK (10:10:10) to the pots every 45 days throughout the research period, as well as controlling insects on demand. A factorial experiment within RCBD consisting of two factors and three replicates was carried out with two plants for each treatment, and the total number of seedlings was 90 for fall and spring season . The first factor was the foliar application of salicylic acid with three concentrations (0, 150, 300) mg L^{-1} which were symbolized as S_0, S_2, S_3 respectively. The second factor was a combination of the

two nutrients which were the magnesium and iron applied in the form of an interaction between them and in three concentrations for each (0 mg L^{-1} Mg + 0 mg L^{-1} Fe), (10 mg L^{-1} Mg + 5 mg L^{-1} Fe), (20 mg L^{-1} Mg + 5 mg L^{-1} Fe), (10 mg L^{-1} Mg + 10 mg L^{-1} Fe), (20 mg L^{-1} Mg + 10 mg L^{-1} Fe), which were symbolized as M0 , M1, M2, M3, M4 respectively.

Studied Properties: The plant's height (cm) measured by using the metric tape for the two study seasons.

Leaves number (leaves Plant^{-1}) leaves number were calculated for the two study seasons.

Leaves area (dm^2 plant^{-1}) Three leaves were collected from each plant and by using a cork drill, they were punctured into 12 discs with a known area, and then dried in an electric oven at a temperature of 60-70 °C until the weight was stable (29).

Main roots number (root. seedling^{-1}) was calculated at the end of the experiment after taking off the root and the roots Volume was calculated according to the Archimedes principle, measurements were taken at the end of the experiment after separating the root system from the vegetative growth and washing from the soil.

Root's dry weight (g) was carried out at the end of the experiment after taking off the roots, cleaned and dried until the weight was stable.

Leaves content of chlorophyll (mg 100 g^{-1} wet weight) was estimated by taking a specific weight of 0.2 g of fresh leaves and extracting using acetone (80%), and then taking the light absorption of the sample with a Spectrophotometer at wavelengths 663 nm and 645 nm, then the amount of chlorophyll was estimated by the following equation (16).

Leaves content of magnesium (%) and iron (%) the amount of magnesium and iron, using an atomic absorption spectrometer.

The vegetative and root's growth content of carbohydrates were estimated according to (A. O. A. C.)(7) **C/N ratio** calculated by dividing the carbohydrates percent by the nitrogen percent in the shoot.

RESULTS AND DISCUSSIONS

Vegetative characteristics: Results in Table (1) revealed that foliar application of salicylic acid had a significant effect on the plant height, leaves number, and leaves area for the fall season of 2020 and spring season of 2021, the concentration of 150 mg L^{-1} (S1) recorded the highest values of plant's height for both seasons, reached 13.40 and 22.40 cm, compared to treatment S0, which gave the lowest values for both seasons, which reached 5.93 and 15.27 cm. Also, Treatment S1 recorded the highest leaves number reached 24.60 leaves. Plant^{-1} for the fall season, while the treatment S2 recorded the highest leaves number for the spring season reached 80.13 leaves plant^{-1} compared to treatment S0 which gave the lowest leaves number (14.73 and 56.67). leaves. plant^{-1} for both seasons respectively. Also, the treatment S2 recorded the highest leaves area for both seasons, reached 32.37 and 67.62 dm^2 plant^{-1} respectively, compared to treatment S1 which recorded the lowest values reached 25.40dm^2 plant^{-1} for the fall season, while for the spring season, treatment S0 gave the lowest leaves area reached 59.43dm^2 plant^{-1}. The foliar application of magnesium and iron revealed a significant effect on the vegetative characteristics, as the treatment M2 (20 mg L^{-1} Mg + 5 mg L^{-1} Fe) gave the highest plant height values reached 13.33 cm, compared to the treatment M4 (20 mg L^{-1}Mg + 10 mg L^{-1} Fe), which gave the lowest value reached 5.89 cm for the fall season, while the treatment M1 (10 mg L^{-1} Mg + 5 mg L^{-1} Fe) recorded the highest value reached 21.56 cm, compared to the M0 treatment (0 mg L^{-1}Mg + 0 mg L^{-1} Fe), which gave the lowest value reached 17.67 cm for the spring season. The foliar application of magnesium and iron did not have a significant effect on the leaves number, while it had a significant effect on the leaves area during the spring season, as the M1 treatment gave the highest area reached 69.58 dm2, which did not differ significantly from the M4 treatment, compared to the M3 treatment, which gave the lowest leaves area reached 57.49 dm2. As for the interaction treatments, results showed a significant increment in the plant's height, leaves number, and leaves area, as the treatment S1M1 gave the highest value of plant's height for both seasons, reached 18.33 and 27.00 cm respectively, compared to the treatment S0M1, which recorded the lowest values of plant's height reached 4.00 cm for

the fall season, while the control treatment S0M0, recorded the lowest values of plant's height reached 12.33 cm for the spring season. Also, treatment S1M0 recorded the highest leaves number reached 35.67 leaves. $Plant^{-1}$ for the fall season, compared to treatment S0M2, which gave the lowest leaves number reached 7.330 leaves. $Plant^{-1}$, while the treatment S1M4 recorded the highest leaves number for the spring season, which reached 90.00 leaves. $plant^{-1}$, compared to treatment S0M2, which gave the lowest values, which reached 41.00 leaves. $Plant^{-1}$. Whereas the treatment S0M4 gave the highest leaves area reached 34.72 dm^2Plant^{-1} for the fall season, compared to treatment S1M0, which gave the lowest leaves area reached 24.04 dm^2 $Plant^{-1}$ while the treatment S2M4 recorded the highest leaves area for the spring season, reached 79.94 dm^2 $Plant^{-1}$,compared to the treatment of S0M2, which recorded the lowest leaves area reached 50.46 dm^2Plant^{-1}

Table 1. Effect of the foliar application of salicylic acid, magnesium, and iron on the vegetative characteristics of *citrus medica* seedlings for the fall season of 2020 and the spring season of 2021

Treatments	Plant's height (cm)		Leaves number (Leaves $Plant^{-1)}$		Leaves area (dm^2Plant^{-1})	
	Full 2020	Spring 2021	Full 2020	Spring 2021	Full 2020	Spring 2021
S_0	5.93	15.27	14.73	56.67	30.60	59.43
S_1	13.40	22.40	24.60	74.67	25.40	65.03
S_2	12.07	20.00	19.93	80.13	32.37	67.62
L.S.D	1.40	1.99	2.657	4.559	1.102	2.003
M_0	7.56	17.67	21.44	77.67	29.45	62.40
M_1	13.22	21.56	19.67	74.56	29.54	69.58
M_2	13.33	18.00	16.89	60.89	28.68	63.46
M_3	12.33	19.22	19.89	64.44	28.83	57.49
M_4	5.89	19.67	20.89	74.89	30.78	67.22
L.S.D	1.81	2.57	N.S	5.886	N.S	2.585
S_0M_0	4.33	12.33	7.670	72.00	30.04	55.92
S_0M_1	4.00	20.00	12.00	63.67	32.44	72.33
S_0M_2	5.33	13.00	7.330	41.00	28.21	50.46
S_0M_3	11.67	13.67	14.67	56.33	27.59	65.76
S_0M_4	4.33	17.33	32.00	50.33	34.72	52.70
S_1M_0	13.00	20.00	35.67	75.00	24.04	66.44
S_1M_1	18.33	27.00	17.00	76.67	28.40	66.00
S_1M_2	18.00	18.33	27.00	75.00	24.86	69.70
S_1M_3	12.33	23.33	27.00	56.67	24.43	54.00
S_1M_4	5.33	23.33	16.33	90.00	25.26	69.01
S_2M_0	5.33	20.67	21.00	86.00	34.28	64.84
S_2M_1	17.33	17.67	30.00	83.33	27.78	70.41
S_2M_2	16.67	22.67	16.33	66.67	32.98	70.20
S_2M_3	13.00	20.67	18.00	80.33	34.47	52.71
S_2M_4	8.00	18.33	14.33	84.33	32.36	79.94
L.S.D	3.13	4.46	5.942	10.19	2.465	4.478

Root's characteristics: Results in Table (2) showed that the foliar application of salicylic acid had a significant effect by recording the highest root's number, root's Volume, and root's dry weight. As the treatment S2 recorded the highest root's number, reached 22.70 roots $plant^{-1}$, compared to the treatment S1, which recorded the lowest root's number, reached 20.77 roots $plant^{-1}$, it also recorded the highest root's volume reached 115.0 mm^3 compared to the treatment S1 which recorded the lowest root's volume reached 91.00 mm^3, while the treatment S2 recorded the highest dry weight reached 39.27 g compared to the S1 treatment which recorded the lowest root's weight reached 34.87 g. On the other hand, the

foliar application of magnesium and iron increased the root characteristics; the treatment M1 recorded the highest root's number, reached 22.50 roots Plant^{-1}, compared to the M0 treatment, which recorded the lowest root's number, reached 19.28 roots plant^{-1}. While the M4 treatment recorded the highest root's volume reached to 129.2 mm^3 compared to the M2 treatment, which recorded the lowest root's volume reached to 94.20 mm^3. Also, the M3 treatment recorded the highest root's dry weight that reached 40.61 g, compared to M1 treatment, which recorded the lowest root's dry weight 35.39 g. The interaction treatments recorded significant values; the S2M2 treatment recorded the highest root's number 26.50 roots Plant^{-1} compared to the control treatment (S0M0), which recorded the lowest root's number 15.00 root plant^{-1}. While the S2M4 Treatment recorded the highest root's volume that to reached 157.5 mm^3 compared to the control S0M0 treatment, which recorded the root's lowest volume 72.50 mm^3. Also, the S2M4 treatment gave the highest root's weight reached 44.50 g, compared to S1M4 treatment which recorded the lowest value of root's weight reached 28.00 g.

Table 2. Effect of the foliar application of salicylic acid, magnesium, and iron on the root's characteristics of *citrus medica* seedlings for the fall season of 2020 and the spring season of 2021

Treatments	Main root's number (Roots Plant^{-1})	Root's volume (mm^3)	Root's dry weight (g)
S_0	21.00	102.3	39.00
S_1	20.77	91.00	34.87
S_2	22.70	115.0	39.27
L.S.D	1.457	5.580	2.407
M_0	19.28	95.83	36.17
M_1	22.50	95.00	35.39
M_2	22.00	94.20	39.06
M_3	21.83	99.70	40.61
M_4	21.83	129.2	37.33
L.S.D	1.881	7.210	3.108
S_0M_0	15.00	72.50	31.00
S_0M_1	23.50	120.0	44.00
S_0M_2	20.50	92.50	37.50
S_0M_3	23.50	119.2	43.00
S_0M_4	22.50	107.5	39.50
S_1M_0	22.83	75.00	36.50
S_1M_1	20.50	85.00	29.50
S_1M_2	19.00	80.00	36.50
S_1M_3	22.50	92.50	43.83
S_1M_4	19.00	122.5	28.00
S_2M_0	20.00	140.0	41.00
S_2M_1	23.50	80.00	32.67
S_2M_2	26.50	110.0	43.17
S_2M_3	19.50	87.50	35.00
S_2M_4	24.00	157.5	44.50
L.S.D	3.259	12.49	5.383

chemical characteristics: The results in Table (3) showed that the foliar application of salicylic acid had a significant effect on the chemical characteristics ; as the S2 treatment recorded the highest values of the leaves content chlorophyll reached 325.5 mg g^{-1} wet weight for the spring season, and the highest leaves content of Mg and Fe for both seasons, which reached (0.788, 0.811) % and (541, 538) ppm respectively, compared to control treatment (S0), which gave the lowest leaves content of magnesium and iron reached (0.408 and 0.431)% and (360 and 381) ppm. Also, the M4 treatment gave the highest content of carbohydrates for both seasons, reached (11.01%, and 14.11%), compared to the control treatment (S0), which gave the lowest content of carbohydrates in both seasons, reached 7.35% and 8.78% respectively. While the treatment of S2 gave the highest root's content of carbohydrates, reached 17.00%, compared to treatment S0, which gave the lowest root's content of carbohydrates reached 12.47%. Also, the treatment of S2 recorded the highest C/N ratio for both seasons, reached 3.847% and 5.583%, respectively, compared to the control treatment (S0), which recorded the lowest C/N ratio for both seasons, reached 2.580% and 3.415% respectively. As for the foliar application of magnesium and iron; results revealed a significant increment on the chemical characteristics, as the treatment of M2 recorded the highest leaves content of chlorophyll for the fall season reached 261.1 mg g^{-1} wet weight compared to the M4 treatment which recorded the lowest values reached 221.0 mg g^{-1} wet weight. Also, the M4 treatment recorded the highest percent of Mg at (0.684 and 0.711) % for both seasons compared to the treatment that gave the lowest percentage for both seasons, which amounted to (0.497 and 0.517) ppm Also, the treatment of M4 recorded the highest leaves content of iron for the fall season, reached 482 ppm, while the treatment of M3 recorded the highest values reached 487 ppm in the spring season, compared to the treatment of M0, which recorded the lowest values for both seasons (360 and 381) ppm respectively. Moreover, the treatment of M4 recorded the highest content of carbohydrates for the fall season, reached 9.85%, compared to the treatment of M0, which recorded the lowest values reached 7.94%. while the treatment of M1 recorded the highest content of carbohydrates for the spring season, reached 12.58% compared to the M0 treatment, which gave the lowest value 10.15%. Also, the treatment of M4 gave the highest root's content of carbohydrates reached 15.43%, compared to the M0 treatment, which recorded the lowest values reached 13.31%. while the M1 treatment recorded the highest C/N ratio for both seasons, reached 3.679% and 4.693% respectively, compared to the M0 treatment, which gave the lowest values of C/N ratio for both seasons, reached 2.563% and 3.533% respectively. The interaction treatment at S2M3 gave the highest leaves content of chlorophyll for the fall season, reached 318.8) mg 100 g^{-1} wet weight, while in the spring season, treatment S2M1 gave the highest values reached 372.4 mg g^{-1} wet weight. compared to the S1M4 treatment, which recorded the lowest values in both seasons, reached 175.0 and 220.6 mg g^{-1} wet weight. While the treatment of S2M4 recorded the highest leaves content of magnesium in both seasons, reached 0.886% and 0.916% respectively, compared to the treatment of S0M0, which recorded the lowest leaves content of magnesium in both seasons, reached 0.327% and 0.350% respectively. Also, the treatment of S2M4 was recorded the highest leaves content of iron in the fall season, reached 0.482%, while in the spring season, the treatment of S2M3 recorded the highest values reached 0.487%, compared to the control treatment (S0M0), which gave lowest values for both seasons reached 0.251% and 0.285% respectively. Moreover, the treatment of S2M3 gave the highest content of carbohydrates for the fall season, reached 11.60%, while the treatment of S2M1 recorded the highest values in the spring season reached 18.06%, compared to the control treatment, which gave the lowest content of carbohydrates for both seasons, reached 5.96% and 7.73% respectively. Also, the treatment of S2M2 gave the highest root's content of carbohydrates for the spring season reached 17.70% compared to the control treatment which gave the lowest values reached 11.03%. While the treatment of S1M2 gave the highest

C/N ratio for the fall season, reached 4.277%, compared to the control treatment (S0M0), which were recorded the lowest values reached 2.248%, while the treatment of S2M3 recorded the highest C/N ratio for the spring season reached 6.072% compared to the treatment of S1M0, which gave the lowest C/N ratio reached 2.759%. The results showed that the foliar application of salicylic acid had an increment in plant's height, leaves number, leaves area, main root's number, root volume, and root's dry weight; this can be due to the role of salicylic acid in the growth stimulation and plant development. Salicylic acid is also among the plant growth promoters, contribute to increase the plant growth regulators, such as auxins and cytokinin, which affect the processes of cells division and elongation, it also helps to reduce the abiotic environmental stress that inhibit the growth (15). Also, the salicylic acid increases the root's and shoot's content of carbohydrates, and the C/N Ratio in the shoot, and this can be attributed to the role of salicylic acid in the formation of chlorophyll and carotene pigments, accelerating the photosynthesis process, and also activating some important enzymes for physiological processes, thus increasing the accumulation of metabolic products (2). Several studies have indicated that the foliar application of salicylic acid has increased vegetative traits (**4**), roots traits (5), yield traits (24) and chemical characteristics (10, 26) of various plants. These results agreed with Abdel-Razek et al (2), who indicated that the foliar application of salicylic acid improved the vegetative growth characteristics of olive trees. Al-Abbasi et al. (5) also recorded that the foliar application of salicylic acid on lemon seedlings had a significant increment on all vegetative growth characteristics, including plant's height, leaves number, and leaves area. Also, the foliar application of salicylic acid had a significant effect on the root's characteristics of citrus seedlings Hassan (19). Al-Hamidawi and Al-Shammari (8) recorded that the foliar application of salicylic acid at concentrations 0, 50, 75, and 100 mg L^{-1} on the grape var. Halwani, produced a significant increment in the leaves content of chlorophyll, carbohydrates, nitrogen concentration, and C\N Ratio. Khairallah et al. (20) mentioned that the application of salicylic acid on palm seedlings grown under tissue culture technology has recorded a significant increment in the leaves content of chlorophyll and nitrogen concentration. The effect of the foliar application of magnesium and iron on the studied characteristics can be due to the role of both nutrients on the growth and development of the plant. Magnesium is an essential nutrient that plants require to produce cytoplasmic particles (cell organelles), such as mitochondria, endoplasmic reticulum, dictyosomes, etc., it also has a role in building nucleic acids and the ATP molecule (22), Also, iron which is involved in many vital processes within the plant, including the formation of nucleic acids, proteins and enzymes that work to increase cell divisions and elongation, and thus increase the growth of plant tissues. It also increases the root absorption of water and nutrients, which stimulates the plant towards vegetative growth, as well as increasing the root's number and length in which cytokines are built and transferred to the leaves, stimulating cell division and enlargement, which leads to an increase in vegetative growth, leaves area, and accumulates the carbohydrates, which increases the shoot's dry weight (11) (30). This is consistent with studies on the effect of magnesium and iron on improving plant growth; Waskel et al., (28) mentioned that the foliar application of magnesium at a concentration of 0.75% on guava plants had a significant increment on plant's height, leaves number, stem diameter, and leaves area. Al-Tamimi et al. (13) found that the application of magnesium and phosphorous on walnut trees has significantly increased chlorophyll leaves content, the macro and micro nutrients, and the shoot's content of carbohydrate. This result was confirmed by Khudair (21), who found that the foliar application of iron recorded an increase in most of the vegetative characteristics of apricot seedlings.

Table 3. Effect of the foliar application of salicylic acid, magnesium, and iron on the chemical characteristics of *citrus medica* seedlings for the fall season of 2020 and the spring season of 2021

Treatments	Leaves content of chlorophyll (mg 100 g^{-1})		Mg (%)		Fe (ppm)	
	Full 2020	Spring 2021	Full 2020	Spring 2021	Full 2020	Spring 2021
S_0	237.4	292.9	0.408	0.431	331	356
S_1	229.2	290.5	0.573	0.593	436	437
S_2	247.4	325.5	0.788	0.811	541	538
L.S.D	27.74	19.73	0.003	0.009	0.003	0.022
M_0	250.3	325.6	0.497	0.517	360	381
M_1	222.8	305.5	0.545	0.567	417	434
M_2	261.1	291.2	0.602	0.637	450	446
M_3	234.8	312.2	0.620	0.626	471	487
M_4	221.0	280.3	0.684	0.711	482	472
L.S.D	35.81	25.47	0.004	0.012	0.004	0.029
S_0M_0	212.2	270.8	0.327	0.350	251	285
S_0M_1	268.6	270.4	0.377	0.401	329	340
S_0M_2	283.4	250.8	0.438	0.462	333	402
S_0M_3	184.6	324.8	0.425	0.435	368	382
S_0M_4	238.0	347.6	0.476	0.507	374	373
S_1M_0	304.8	347.0	0.482	0.500	363	377
S_1M_1	215.1	273.7	0.521	0.543	407	430
S_1M_2	250.1	312.6	0.579	0.607	450	417
S_1M_3	200.9	298.5	0.594	0.607	472	492
S_1M_4	175.0	220.6	0.691	0.712	489	472
S_2M_0	233.9	359.1	0.683	0.701	467	483
S_2M_1	184.7	372.4	0.738	0.759	515	532
S_2M_2	249.7	310.1	0.790	0.842	566	520
S_2M_3	318.8	313.2	0.842	0.837	574	586
S_2M_4	250.0	272.6	0.886	0.916	583	570
L.S.D	62.03	44.12	0.007	0.020	0.008	0.050

Table 4. Effect of the foliar application of salicylic acid, magnesium, and iron on the chemical characteristics of *citrus medica* seedlings for the fall season of 2020 and the spring season of 2021

Treatments	Shoot's content of carbohydrates (%)		Root's content of carbohydrates (%)	C/N Ratio	
	Full 2020	Spring 2021		Full 2020	Spring 2021
S_0	7.35	8.78	12.47	2.580	3.415
S_1	9.45	11.08	14.68	3.508	4.281
S_2	11.01	14.11	17.00	3.847	5.583
L.S.D	0.292	0.256	0.152	0.180	0.121
M_0	7.94	10.15	13.31	2.563	3.533
M_1	9.42	12.58	14.64	3.679	4.693
M_2	9.77	11.22	15.30	3.557	4.590
M_3	9.36	10.90	14.90	3.356	4.690
M_4	9.85	11.75	15.43	3.404	4.625
L.S.D	0.376	0.330	0.196	0.232	0.157
S_0M_0	5.96	7.73	11.03	2.248	2.840
S_0M_1	7.50	8.70	12.23	2.862	3.949
S_0M_2	8.20	8.96	12.60	2.663	3.910
S_0M_3	7.10	8.50	13.00	2.375	3.409
S_0M_4	8.00	10.00	13.50	2.749	3.968
S_1M_0	7.73	10.13	13.20	2.425	2.759
S_1M_1	9.60	11.00	14.80	3.983	4.193
S_1M_2	10.16	11.70	15.60	4.277	5.234
S_1M_3	9.40	10.60	14.50	3.443	4.589
S_1M_4	10.36	11.96	15.30	3.413	4.630
S_2M_0	10.13	12.60	15.70	3.016	5.000
S_2M_1	11.16	18.06	16.90	4.192	5.936
S_2M_2	10.96	13.00	17.70	3.731	5.628
S_2M_3	11.60	13.60	17.20	4.249	6.072
S_2M_4	11.20	13.30	17.50	4.049	5.278
L.S.D	0.652	0.573	0.339	0.402	0.272

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