

EFFECT OF FERTILIZATION, ROOTSTOCKS AND GROWTH STIMULANT ON GROWTH OF *Citrus limon* L. SAPLING.

*A. R. Alkhafaji
Researcher

N. H. Khalil
Assist. prof.

Dept. of Hort. And Landscape- Coll. of Agric. Engin. Sci. – University of Baghdad
Ameeralkhafajy91@gmail.com

Nazik_95@yahoo.com

ABSTRACT

A research was carried out in the lath house of the College of Agricultural Engineering sciences / University of Baghdad / Al-Jadriyah, for three growth seasons Spring 2017, Fall 2017 and Spring 2018 to study the effect of different fertilization methods, were Fertigation (Ft) , Foliar application (Fa), traditional soil fertilization (Fo) and growth stimulant with two concentrations 0 (D0) and 1.5 mg.L⁻¹ (D1) on the growth of local *Citrus limon* L. Saplings grafted on *Citrus aurantium* L. (So), *C. volkameriana* (Vo), and Citrumello (Co). Saplings were cultivated in 10 kg plastic containers. A factorial experiment was carried out according to the Nested-Factorial Experimental design. Results indicated foliar application (Fa) superiority, followed by Fertigation (Ft) in plant height, rootstock and scion diameter, while the number of shoots increased significantly using (Ft). Lemon trees grafted on (So) showed superiority in plant height, while trees grafted on (Vo) recorded higher rates in rootstock, scion diameter, and shoot number. Plants fertilized with (Fa) surpassed in nutrient use efficiency (NUE) of N, P, K they were 1.18, 0.43 and 1.30 g.dw⁻¹ respectively. (Vo) indicated highest value in (NUE) of N, P, K elements in plants (1.32, 0.48 and 1.45 g. dw⁻¹) in comparison to So and Co. The Fa * Vo * D0 treatment increased significantly rootstock stem diameter (73.15 and 126.03%), while the highest rate in plant height was recorded by Fa * So* D0 (111.19%). The highest increase rate of shoot number (483.9%), was by Ft * So * D1. The treatment Fo * Co * D1, gave the highest carbohydrate (4.92%).

Keywords: *Citrus Aurantium* L., Volkamer lemon, Citrumello, Fertigation, Foliar Application.

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جدوع و خليل

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تأثير التسميد والاصل ومحفز النمو في نمو شتلات الليمون الحامض *Citrus limon* L.

نازك حقي خليل

امير رزاق جدوع

استاذ مساعد

باحث*

قسم البستنة وهندسة الحدائق - كلية علوم الهندسة الزراعية - جامعة بغداد

المستخلص

اجريت الدراسة في الظلة التابعة للمحطة البحثية B في كلية الزراعة / جامعة بغداد/ الجادرية ، لثلاثة دورات نمو هي ربيع 2017 وخريف 2017 وربيع 2018 لدراسة تأثير نوع الاصل واختلاف طرق التسميد التي تتضمن الرسمة (Ft) ، والتسميد الورقي Foliar Application (Fa) ، والتسميد الارضي التقليدي (Fo) باستخدام سماد NPK فضلا عن المعاملة بمحفز للنمو بالتركيزين 0 (D0) و 1.5 ملغم.لتر⁻¹ (D1) في نمو شتلات الليمون الحامض المحلي *Citrus limon* L. المطعم على اصول النارنج *Citrus Aurantium* L. (So) والفولكامارينا Volkamer lemon (Vo) والستروميلو Citrumello (Co) المزروعة في اصص بلاستيكية سعة 10 كغم. اشارت النتائج الى تفوق الرش الورقي Fa تلتها الرسمة Ft في زيادة نسبة ارتفاع النبات وقطر ساق الاصل والطعم فيما ازاد عدد الافرع معنويا في Ft. تفوقت اشجار الليمون المطعمة على So في ارتفاعها فيما سجلت الطعم على Vo اعلى النسب في قطر الاصل والطعم وعدد الافرع. تفوقت نباتات Fa في كفاءتها في استخدام العناصر (NUE) لعناصر K,P,N اذ بلغت 1.18 و 0.43 و 1.30 غم. وزن جاف⁻¹ على التوالي ، وسجل الاصل Vo اعلى القيم في (NUE) لعناصر K,P,N في النبات (1.32 و 0.48 و 1.45 غم. وزن جاف⁻¹) متفوقا بذلك على الاصلين So و Co. تفوقت المعاملة D0*Vo*Fa بتحقق اعلى نسبة زيادة في قطر ساق الاصل والطعم اذ بلغت 73.15 % و 126.03 % ، فيما كانت اعلى نسبة زيادة في ارتفاع النبات في المعاملة D0*So*Fa بلغت 111.19%، وسجلت اعلى نسبة زيادة في عدد الافرع 483.9% في المعاملة D1*So*Ft ، اما اعلى نسبة للكربوهيدرات فقد وجدت في المعاملة D1*Co*Fo بلغت 4.92 % .

الكلمات المفتاحية: النارنج *Citrus Aurantium* L. ، الفولكامارينا Volkamer lemon ، الستروميلو Citrumello ، الرسمة ، الرش الورقي.

*البحث مسئل من رسالة ماجستير للباحث الاول.

INTRODUCTION

Lemon trees, *Citrus limon* L. a citrus species, cultivated in Iraq for many years due to suitable growing conditions. Despite small-sized fruit's, they are of high quality and low acidity making the local lemon one of the most desirable varieties for consumers, (3). The production of most citrus species, in nurseries is done by grafting them onto various citrus rootstocks, which effects the varieties grafted on them. Castle (12) and Wutscher (29) explain that variety and strength of rootstocks had a significant effect on growth and production of citrus nursery plants. Successful commercial production of citrus seedlings is influenced by the type of rootstocks (10). Sour orange (*Citrus aurantium* L.) rootstocks commonly used for the production of Citrus seedlings, for Oranges, Mandarins and Lemons produce high quality fruit. Volkamer lemon (*Citrus volkameriana*) is a hybrid rootstock, which produces high-yielding trees with fruit of excellent size, though are cold sensitive and are susceptible to the brown wood rot fungi, but are tolerant to Tristeza, (31). Citrumello (Swingle Citrumelo), is a hybrid rootstock resulting from *Citrus paradisi* (Duncan) Macf. X *Poncirus*, It is a strong-growing tree, multi-seed fruit and conforms to all varieties of citrus (19). Citrus tree production depends on irrigation and fertilization, particularly in the semi-arid regions (18 and 25). Trees need to be equipped with nutrients, for vital plant activity in order to prevent a physiological disorder due to nutrition deficiency which may adversely affect rootstock and scion growth (23). Production of citrus plants in nurseries is controlled by fertilization to improve growth, it is one of the most important factors influencing the success of citrus seedling production. Managing, fertilization is a necessity to reduce excessive costs and avoid pollution with Fertilizer over use. Plants must be fertilized with balanced elements (21). Fertilization methods vary depending on the purpose fertilizer, components, plant species and growth stage it may be applied to the soil directly, with irrigation water or foliar applied. Citrus seedling producers try to achieve the best fertilization programs that help the

exploitation of added fertilizers and to decrease loss, Ground fertilization can equip the plant with nutrients necessary to improve growth and increase productivity (13 and 16), Bataglia et al. (11) referred to the possibility of producing seedlings with excellent quality through fertilization programs based on fertilization with irrigation (fertigation). Yuan et al. (31) and Schumann et al. (26) indicated that fertigation depends on the use of nutritious solutions or small amounts of highly soluble fertilizers in water, which contain all the necessary elements for plant growth that are added through drip irrigation system, thus the rationalization in the use of water and fertilizer together is performed while increasing the efficiency in their use and reducing the chance of fertilizer loss. Melgar et al. (20,22 and 24) demonstrated that fertigation might work to modify root and vegetative growth, which may lead to increased efficiency of elements absorption by plants. Foliar application, one of the modern methods and techniques used by researchers is intended to provide the plants with nutrients necessary to increase production and improve growth by reducing the constraints that reduce the existence of the elements in the soil (30). Organic compound extracts stimulate plant growth, Al-Rawi et al.(2) and Al-Karam and Al-Biaty(8) Mentioned that the foliar application of seaweed extract stimulated vegetative growth characteristics and leaf content of minerals in peach trees. Hifny and others (14) proposed adjusting the level of fertilizer added to small citrus trees depending on the type and strength of the rootstock, so the study aimed to determine the best fertilization's method for local lemon trees grafted on sour orange, Volcamarina and Citrumello rootstock, by stimulating growth and building a strong structure for sapling, minimizing fertilizer's quantities commonly used in nurseries and increasing efficiency in their use by fertigation and foliar application.

MATERIALS AND METHOD

The study was carried out in the lath house of the research station at the College of Agriculture - University of Baghdad - Al-Jadriyah, for three growth seasons Spring 2017, Fall 2017 and Spring 2018 to study the

effects of different fertilization methods, rootstocks and an organic growth stimulant in the growth of local citrus lemon, 225 two year old and fairly equal in size citrus lemon sapling were grafted on sour orange *Citrus aurantium* L., Volkamer lemon *C. volkameriana*, and Citrumello, 75 saplings per rootstock are cultivated in 10 kg plastic containers. The research was carried out as a factorial experiment based on the design of the Nested-Factorial Experiment (1) 18 treatments with three replicates and four seedlings per experimental unit with three factors and three replicates as follows: 1st- Rootstock type as ,sour orange (So), Volkamer lemon (Vo) and Citrumello (Co) seedlings .2^{ed}- fertilization programs: - 1Fertigation (Ft): fertilization of plants with irrigation water using a drip irrigation system (a fertilizer combination consisting of all the major and minor elements, high solubility in water for the growth of seedlings, and the plants will be fertilized with irrigation water once every 10 days).2-Foliar Application (Fa): leaves fertilized by spraying (a fertilizer combination consisting of all the major and minor elements necessary for seedling growth, and high solubility in water, foliar application was performed every 10 days). 3. conventional soil fertilization (Fo) using commercial N.P.K fertilizer, which was added once a month.3^{red} Foliar application with a growth stimulant consisting of organic compounds composed of a number of organic acids and growth regulators, with two concentrations of 0 and 1.5 g.l⁻¹.The results compared with the least significant difference (L.S.D) at the probability level of (0.05) using the GenStat.

Studied charcters

Measurements (Plant height, rootstock stem diameter and number of branches,) were taken in three growth seasons (Spring 2017, Fall 2017 and Spring 2018). The Percentage increase rates were obtained using the following equations: Increase rate % = $(T_2 - T_1) / T_1 \times 100$

- Shoot content of Carbohydrate % (15).

-Plant Efficiency Use Nutrients (EUN) according to the following equation:

EUN = Concentration of element % × Total

RESULTS AND DISCUSSION

Increase in plant height%

The results in Figs. 1, 2 and 3 show a significant increase in plant height due to treatment effects. Figure 1 shows that fertilization (Fa) results are higher in season 1 and 3 as achieving a higher rate in the first season of 33.13%, and 100.66% in the third season, followed by Ft with rates of 28.32%, 100.5% for the first and third seasons respectively, which differed significantly from Fo, which achieved the lowest rate of increase in plant height of 7.36% in the first season and 84.49% in the third season. In the second season, Ft has significantly affected by obtaining the highest increase reaching 57.00 %, followed by Fa reaching 52.48%, which significantly differed from Fo, which achieved the lowest plant height during the second growing season reaching 47.03%.

Figure 2 shows a highly significant effect of rootstock in this characteristic as the rootstock Co achieved the highest rate in the first season at 24.58%, followed by So 22.53%, which in turn surpassed to Vo which obtained the lowest increase rate of 21.71%, the rootstock Vo in the second season was significant different in comparison the rest of the rootstocks as the highest percentage was 53.98% followed by Co, which had a ratio of 52.17% and So which was (50.36%), while in the third season So was higher with highest percentage of 99.19%, followed by the rootstock Co, (96.25%), differed significantly from Vo, (89.75%).Spraying the plant with the growth stimulant resulted in significant differences in plant height (Fig. 3) as the treatment D₁ achieved the highest percentage of 23.55% and 53.90% in the first and second seasons respectively, compared with the treatment D₀, which achieved the lowest value in the first season of 22.33% and the second season at 50.95%, while in the third season, the treatment D₁ achieved lower rates 94.47% compared to the treatment of D₀, with the highest rate of 95.67%. The triple interference values between the experimental factors in Table 1 indicate the significant effect of the treatment Fa* So*D₀ with the highest increase in plant height of 111.19% compared to the treatment Fo * Vo* D₀,

which achieved the lowest rate of increase in plant height of 70.59%.

Rootstock stem diameter %

The results of the statistical analysis in Figs. 4, 5 and 6 indicate a significant increase in the rootstock diameter, fertilization shows a increased rate in the diameter of the rootstock stem for three growth seasons (fig. 4), Fa gave highest value for the first and third season 13.65% and 64.64%, respectively, with a significant difference in comparison to other fertilization methods followed by Ft with an increase rate of 11.76 for the first season and 59.09% for the second, which differed significantly from Fo, which achieved the lowest increase in the diameter of 9.30% and 47.93% for the first and third seasons respectively. Fo has surpassed for the second season significantly reaching 45.85% compared to the rest of the experimental methods followed by Fa reaching 40.21% with a significant difference in comparison with Ft, which achieved the lowest increase rate in diameter of the rootstock stem reaching 37.64%. The results in Figure 5 explained the significant effect of the rootstock type in the diameter of the rootstock stem. The rootstock Co surpassed the rest of the rootstocks with the highest value of 21.23% for the first growth season followed by So by 11.80% while Vo gave lowest increase rate of 10.68%. Vo had a significant Second and third seasons recorded the highest rates with an increase of 51.67% and 65.45%, respectively, followed by Co with 37.28% for the second season and 53.23% for the third season, which was higher than So which were 34.75% and 51.99% for the second and third seasons respectively. The treatment D1 achieved the highest rate in the first, second and third growth season (Fig. 6). They were 12.63%, 43.46%, and 61.09%, respectively compared with the D0 which achieved the lowest percentage in the diameter of the rootstock stem for the first, second and third growth season by 10.51%, 39.00% and 52.66% respectively. The treatment of Fa * Vo * D0 recorded a significantly higher increase rate in rootstock stem diameter as a result of the interaction between the three research factors (Table 1) with rates of 73.15% and 126.03% respectively compared

with Fo * So * D0 which achieved the lowest value 31.46%.

Scion stem diameter %

The difference between fertilization had a significant effect on scion stem diameter. Fig.7 shows that the effect of Fa was significantly higher for the three seasons reaching 40.86% in the 1st growth season, 51.55% in the Autumn growth season and 89.37% for the 3rd growth season, followed by Ft in the 1st and 3rd seasons by 31.66% and 85.93% respectively, while Fo, achieved the lowest scion stem diameter 23.05% and 61.29% for the 1st and 3rd seasons respectively, Fa surpassed in the second growth season by achieving the highest scion stem diameter of 55.51% followed by Fo (50.27%), significantly surpassing Ft, which achieved the lowest value in the 2nd season 49.34%. The results in Fig. 8 show that rootstock Vo surpassed significantly by obtaining the highest scion diameter in the 1st season (38.09%), and 2nd season (61.59%) and in the 3rd season it reached 84.93%, followed by the rootstock So in the all three seasons (30.85%, 46.90%, 77.10%) respectively, surpassing Co which had the lowest scion diameter in the 1st, 2nd and 3rd (26.63%, 42.68%, 74.56%) respectively. The treatment D0 achieved the highest rootstock stem diameter in the 1st, 2nd and 3rd seasons reaching 35.19%, 55.99%, 86.39%, respectively, compared with D1 which recorded a low percentage in all three growth seasons of 28.53% and 44.78% and 71.34%, respectively. The treatment Fa*D0*Vo obtained the highest value of the rootstock stem diameter reaching 126.03% affected by the three studied factors in comparison to the other treatments, the lowest rate was recorded by the treatment Fo * So * D0 was 39.77% (Table 1).

Number of plant branches %

The results of the statistical analysis in Figs. 10, 11 and 12 indicate a significant increase in the number of branches of the plant due to the

effect of the treatments. The difference of the fertilization method had a significant effect in this parameter for three growth seasons as Fo surpassed significantly for the 1st and 2nd seasons by achieving rates of 77.22% and 144.66% respectively followed by the Ft by obtaining rates of 70.92% and 133.07% respectively, which differed significantly from Fa, which had the lowest number of branches recording 57.35% in the 1st season and 120.23% in the 2nd season, while the highest increase rate achieved by Ft in the 3rd season 436.9%, followed by Fa achieving a rate of 349.1% surpassing the Fo which achieved the lowest rate of 281.7%. The rootstock So surpassed the rest of the rootstocks in the 1st and 2nd growth seasons by achieving the highest branches number 82.1% and 148.79% respectively, followed by Vo reaching 68.27% in the 1st season and 127.66% in the 2nd season while Co obtained the lowest branch number in the 1st and 2nd seasons 55.18% and 121.50% respectively. As for the 3rd growth season, rootstock Vo exceeded the rest of the rootstocks by achieving the highest branch number of 378.6% followed by So, by 362.4% which differed significantly from Co, with lowest number of branches was 326.7%. The treatment D0 achieved the highest branch number of 68.89% and 133.51% for the 1st and 2nd seasons respectively compared with treatment D1 which recorded a low rate in 1st and 2nd seasons of 68.10% and 131.76% respectively, while D1 surpassed by achieving the highest branch number in the 3rd growth season reaching 374.1% compared to D0, which achieved the branch number 337.6%. The highest number of branches (Table 1) was 483.9%, which was recorded by Ft * So * D1 effected by the factors compared to the lowest number in the treatment of Fo * Co * D1 reaching 191.8%. The results indicate that the highest increase in vegetative parameters was found in the 3rd growing season, effected by both foliar application, and Fertigation compared to conventional fertilization, that may be due to the fact that the plants in the first growth season did not have high nutrients requirements because plants have been sufficient by storing elements. Plants of small

size may be another reason explaining why they do not need intensive fertilization, the results are consistent with (28) and (9). The results agreed with Alfalahy (5) that leaf nutrition led to an increase in branch number, stem diameter, and the increase in vegetative growth characteristics represented in plant height, number of branches and increasing in stem diameter due to supplement the plants with the major and minor necessary nutrients through fertilization (table 2 and 3) as these elements have a direct effect on plant growth. Nitrogen plays a role in the synthesis of amino acids, proteins and nucleic acids, and is a Chlorophyll component. Phosphorus is an important cell component represented as phosphosaccharides, phospholipides, energy compounds and nucleic acids, so its presence at sufficient levels increases the efficiency of photosynthesis and the optimum growth of the plant. The availability of Potassium at appropriate levels in the plant leads to an increase in photosynthesis and may be due to the activation of the enzymatic system of photosynthesis process, (33 and 27). The strength and activity of the *Volcamer limon* rootstock may be the cause of significant increase in both rootstock and scion diameter and branch number, these results were consistent with (4) on the incorporation effect of *Volcamarina* rootstock in increasing the number of branches. While the trees grafted on the sour orange rootstock were distinguished with distinctive heights, which may be due to decreased number of branches which lead to an increase in plant height growth.

Nutrient use efficiency (NUE)

nitrogen

The results in Table 2 show that there are significant differences in NUE of Nitrogen in the plant due to the effect of the factors involved in the experiment, since the quantity of this element in the plant differed according to the method of fertilization through the surpassedity of the fertilization (Fa) by achieving the highest value of 1.18 g followed by (Ft) with a value of 1.00 g, which differed significantly from (Fo) with the lowest value of 0.95 g. NUE affected by the different rootstock type, as the rootstock Vo was surpassed to achieve the highest value of 1.32

g, Co has achieved 0.99 g which differed significantly from So with the lowest value of 0.83 g. Growth stimulant resulted in significant differences in NUE as D1 treatment has recorded the highest value of 1.24 g, surpassed to D0 which recorded the lowest value of 0.85 g. Table 3 indicated that the values of the interaction among the three experimental factors had a significant effect on this feature by the succeeding of the treatment Fa * Vo * D1 with the highest value of 2.34 g compared to the lowest value of 0.53 g from the treatment Ft * So * D0.

Potassium

Fa fertilization has surpassed in **NUE of K** (Table 2) by achieving the highest value of 1.30 g followed by Fo with a value of 1.25 g which differed significantly in comparison to Ft recording lowest value of 0.72 g. The results indicated that Vo rootstock, is a high NUE for K element, by obtaining the highest value of 1.45 g followed by the rootstock Co with a value of 1.07 g, which differed significantly from So, which achieved the lowest value of 0.75 g, Growth stimulant increased plant **NUE of K**, results in table 2 clarified that plants in D1 achieved the highest value of 1.14 g superior to D0 with the lowest value of 1.04 g.

Plants in treatment Fo * Vo * D1 have a high NUE of K, reaching 2.93 g compared to D0 * So * Ft which achieved the lowest value of 0.41 g (Table 3).

Phosphorus

The results in Table 2 show that the research parameters have significantly affected the plant **NUE of phosphorus (P)**. The fertilization method Fa recorded the highest value of 0.43 g, followed by Ft with a value of 0.38 g which was significantly different from Fo that has a lower value of 0.33 g. Rootstocks have a significant effect on the plant **NUE of (P)**, as the rootstock Vo surpassed by achieving the highest value of 0.48 g compared with the rest of the rootstocks included in the experiment, followed by Co with a value of 0.38 g which differed from (So) with the lowest value of 0.29 g. **NUE of (P)**, was significantly affected by the growth stimulant, the treatment D1 achieved the highest value of 0.41 g compared to D0 (0.35 g). The interaction

treatment among the factors of the experiment significantly effected characteristic (table 3) by achieving the treatment Fa * Vo * D1 the highest value of 0.79 compared to the treatment Fo * So * D0 which recorded the lowest value of 0.20 g.

Carbohydrates in shoots %

The results in Table 2 indicate that the fertilization method Fo obtained the highest rate of carbohydrates reaching 2.27% compared to the Fa fertilization (2.02%) which differed significantly from the Ft that achieved the lowest carbohydrate rate of 1.72%. Rootstock variety indicated a significant difference in carbohydrates shoot content, as the rootstock Co surpassed by achieving the highest rate of 2.58%, followed by the rootstock Vo by a rate of 1.99%, which also differed from the rootstock So that the lowest percentage of the carbohydrate was 1.44%. The plants that were treated with growth stimulant D1 had the highest rate reaching 2.26%, which made them significantly different in comparison to D0 plants which gave the lowest rate of carbohydrates reaching 1.72%. The interaction among the three experimental factors referred to the significant effect on the carbohydrate percentage in plant shoots (table 3) by the surpassedity of the treatment Fo * Co * D1 recording the highest rate of 4.92%, while the treatment Ft * So * D0 had the lowest percentage of 1.14%.

The results indicate a higher NUE of K, P, N in dry plant material, this may be due to plant processing with the elements required for growth and development, through fertilization in its various ways, as fertilization leads to adequate ratios of major and minor elements (27), plants fertilized by foliar application have excelled with their high content of elements, probably because of the direct effect of the elements that penetrated to the leaves and reduce loss in fertilizers, as agreed with (17) and (5).

Plants fertilized by fertigation showed a good nutrient use efficiency as agreed with (22), who mentioned that fertigation may modify the root and vegetative growth, which increases the efficiency of the plant in the absorption of elements. Root-stock NUE depends on genetic and physiological

differences that are modified by plant interactions with environmental variables (22). Carbohydrates increased by fertilization this may be due to the effect of NPK high Nitrogen fertilizer, as the Nitrogen affects the vegetative growth by activation of enzymes

and reactions and increase Photosynthetic products. The genetic differences between rootstocks and growth features determines vegetative growth, NUE of elements and Carbohydrates, the results were consistent with (12) (6) and (7).

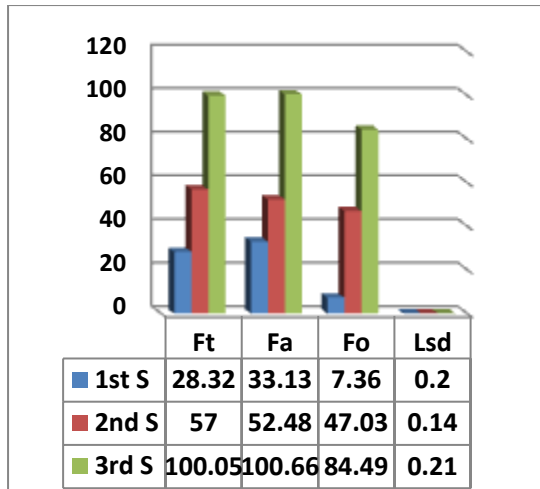


Figure 1. Effect of fertilization on plant height for three growth seasons (%).

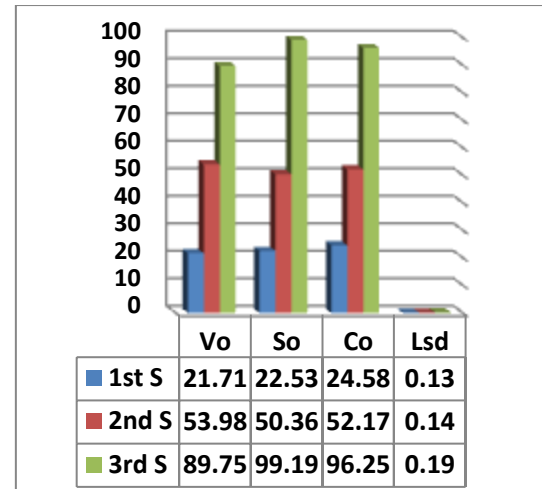


Figure 2. Effect of rootstock on plant for three growth seasons (%).

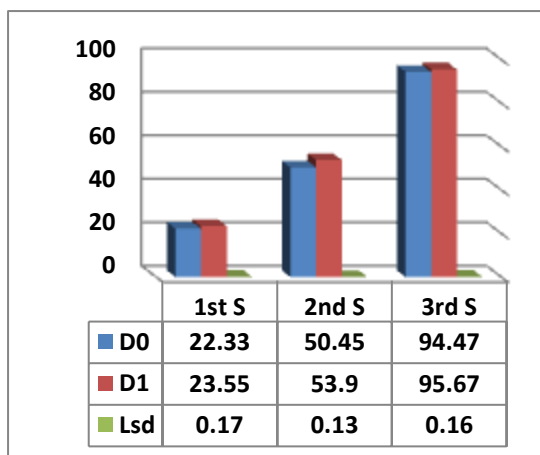


Figure 3. Effect of growth stimulant on plant height for three growth seasons (%).

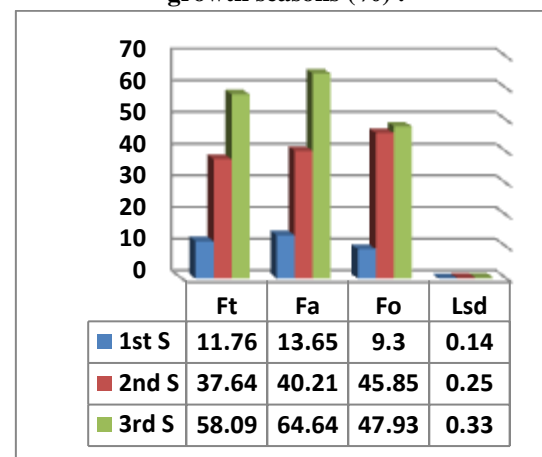


Figure 4. Effect of fertilization on stem diameter for three growth seasons (%).

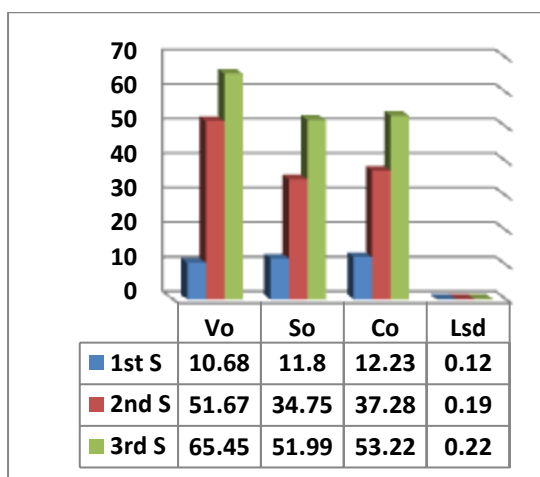


Figure 5. Effect of rootstock on stem diameter of rootstock for three growth seasons (%).

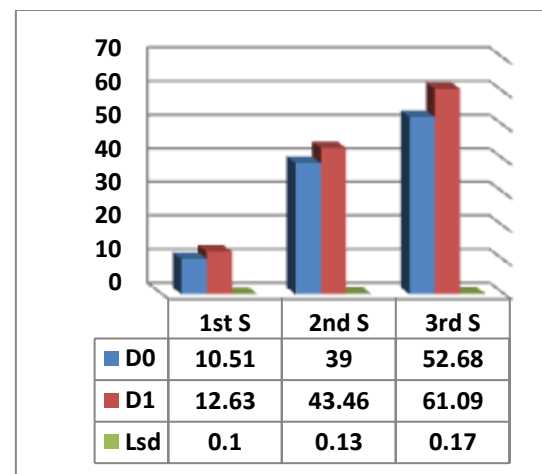


Figure 6. Effect of growth stimulant on stem diameter of rootstock for three growth seasons (%).

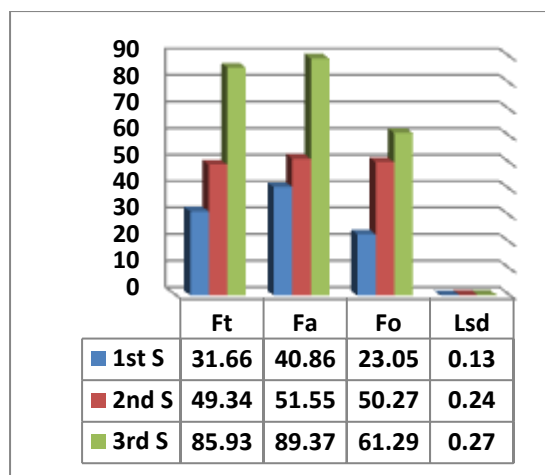


Figure 7. Effect of the fertilization on scion stem diameter for three growth seasons (%)

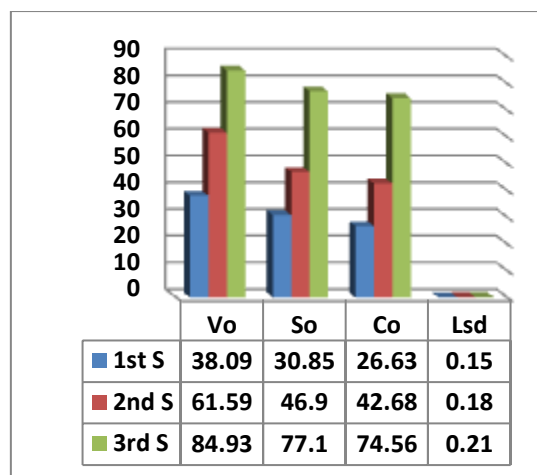


Figure 8. Effect of rootstock on scion stem diameter for three growth seasons (%)

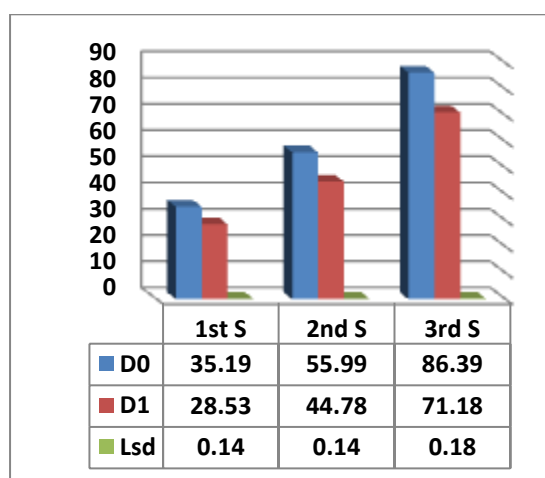


Figure 9. Effect of growth stimulant on scion stem diameter for three growth seasons (%)

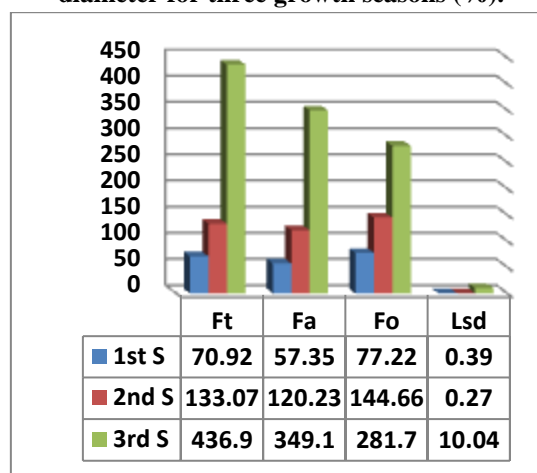


Figure 10. Effect of fertilization on plant branch number for three growth seasons (%)

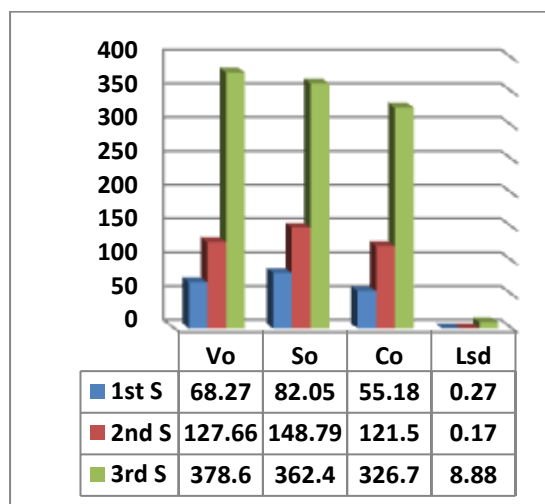


Figure 11. Effect of rootstock in plant branch number for three growth seasons (%)

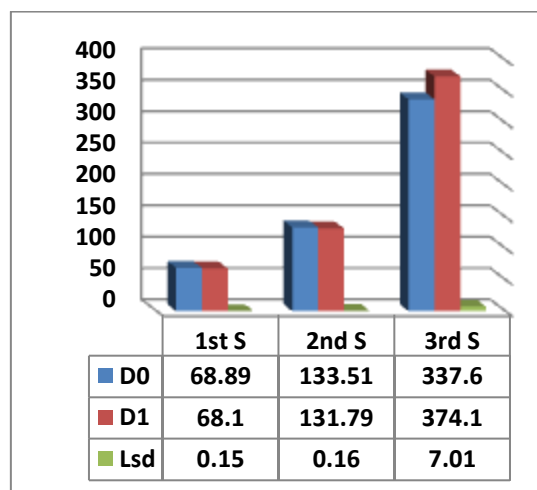


Figure 12. Effect of growth stimulant in plant branch number for three growth seasons (%)

Table 1. Effect of interaction between fertilization, rootstocks and growth stimulant on plant height, rootstock diameter, grafted branch diameter and number of branches%

Treatments			Plant height %	Rootstock diameter %	Grafted stem diameter %	Number of branches %
Fertilization	rootstock	Growth stimulant				
Ft	Vo	D0	109.23	65.12	79.65	368.0
		D1	75.38	70.55	66.20	464.2
	So	D0	100.85	48.54	125.19	345.0
		D1	99.43	56.38	105.38	483.9
	Co	D0	109.15	56.23	88.53	478.7
		D1	106.27	51.73	50.63	481.6
Fa	Vo	D0	100.65	73.15	126.03	400.1
		D1	93.65	71.02	96.53	409.4
	So	D0	111.19	56.96	72.59	358.7
		D1	108.01	70.89	64.93	332.6
	Co	D0	91.50	54.22	95.31	361.1
		D1	98.94	61.57	80.83	232.7
Fo	Vo	D0	70.59	48.25	76.58	210.2
		D1	89.02	64.61	64.61	419.7
	So	D0	76.36	31.46	39.77	302.7
		D1	99.33	47.73	54.73	351.3
	Co	D0	91.47	40.22	73.87	214.2
		D1	80.16	55.33	58.18	191.8
LSD			0.44	0.54	0.51	20.30

Table 2. Effect of fertilization, rootstock and growth stimulant on absorbing of N, P and K elements and percentage of carbohydrates

Factors	NUE Nitrogen	NUE Phosphorus	NUE Potassium	Carbohydrates
Fertilization				
Ft	1.00	0.38	0.72	1.72
Fa	1.18	0.43	1.30	2.02
Fo	0.95	0.33	1.25	2.27
LSD	0.01	0.006	0.03	0.04
Rootstock				
Vo	1.32	0.48	1.45	1.99
So	0.83	0.29	0.75	1.44
Co	0.99	0.38	1.07	2.58
LSD	0.02	0.004	0.02	0.03
Growth stimulant				
D0	0.85	0.35	1.04	1.74
D1	1.24	0.41	1.14	2.26
LSD	0.02	0.003	0.02	0.02

Table 3. Effect of interaction between fertilization, rootstock and growth stimulant on absorbing of N, P and K and carbohydrates.

Fertilization	Treatments		NUE Nitrogen	NUE Phosphorus	NUE Potassium	Carbohydrates
	rootstock	Growth stimulant				
Ft	Vo	D0	1.00	0.47	0.86	1.37
		D1	1.47	0.38	0.80	3.44
	So	D0	0.53	0.21	0.41	1.14
		D1	1.17	0.38	0.98	1.26
	Co	D0	1.12	0.55	0.65	1.16
		D1	0.73	0.27	0.64	1.94
Fa	Vo	D0	0.63	0.33	1.13	1.38
		D1	2.34	0.79	1.91	2.08
	So	D0	0.78	0.37	1.27	1.35
		D1	0.92	0.27	0.46	1.57
	Co	D0	0.99	0.33	1.89	3.57
		D1	1.42	0.52	1.13	2.15
Fo	Vo	D0	1.04	0.38	1.09	1.84
		D1	1.43	0.52	2.93	1.85
	So	D0	0.71	0.20	0.60	2.14
		D1	0.85	0.29	0.81	1.16
	Co	D0	0.85	0.34	1.46	1.73
		D1	0.84	0.26	0.63	4.92
LSD			0.05	0.010	0.05	0.07

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