Response of Balady Lime Tree Growth and Productivity to Rootstock Type and NPK Nutrient Levels under Upper Egypt Conditions.

A- Response of Balady Lime Tree Growth to Rootstock Type and NPK Nutrient Levels.

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ABSTRACT

Experimental treatments were carried out during (2017-2020) seasons respectively, on 10-year- old Balady lime (*C. aurantifolia* L.). Thirty six-Balady lime tree- budded on 3 citrus stocks: A1) Troyer citrange; A2) *C. volkameriana* and A3) *C. macrophylla"* Factor A" carefully selected for vigorous growth. Trees grown in sandy soil in a private orchard at Sahel- Sleem district, Assiut Governorate under drip irrigation. Trees seasonally received three NPK, nutrient fertilizer levels: "Factor B": B1: NPK (3:1:2) "control". B2: NPK (2:1:1). B3: NPK (3:2:2) and B4: NPK (4:3:3) for every rootstock alone. Experimental treatments resulted that both Citrus: Macrophylla or Volkamer lemon stocks expressed a superiority with positive effect on most tree growth parameters as compared to Troyer citrange stock during studied seasons. Moreover, NPK nutrient levels B2, B3 or B4 significantly gave the highest values for the previous Balady lime parameters when compared to NPK B1 (the control) during the experimental seasons. In spite of, Troyer citrange, *Citrus macrophylla* or Volkamer lemon stocks plus NPK nutrient levels B3 or B4 statistically improved Balady lime parameters as compared to the same stocks plus NPK nutrient levels B1 or B2. Finally, it can be concluded that, both *Citrus macrophylla* or Volkamer lemon stocks plus NPK nutrient levels B3 or B4 were the best during the studied seasons.

Keywords: Balady lime - Citrus rootstock - NPK fertilizer – Tree growth parameters.

INTRODUCTION

Economically, Citrus fruits are very important crop in Egypt, yield reached 4.4 Million tons in 2020; representing about 37.5 % of total fruits yield. Balady lime yield reached about 38.4 thousands ton (9.9 ton/Fed). According to "Agri. Ministry Statistics & Planning Dep. 2020". Despite of the great importance enjoyed by the Balady lime fruits for both local or export markets, however, trees still suffer from low yields and fruit quality. Practically, Balady lime orchards cultivated by using seedy seedlings cultivated at different distances according to soil types. To avoid some soil problems, producers tended to use suitable rootstocks.

Citrus rootstocks play a significant role in the global expansion of the citrus sector, they have a significant impact on scion performance, (it can dwarf; scion hardiness will be influenced; and maturity and precociousness of the scion are further factors). They differ in their capacity to grow under different soils types or climates, as well as with different scion kinds (Bitters, 2021). Furthermore, the effective selection of a rootstock is critical since it will be a permanent element of the orchard and cannot be changed at any time, unlike cultural practices, fertilizer or irrigation programs. It is well known that, citrus trees

require large quantities of mineral nutrients to attain adequate tree growth and productivity.

Moreover, Egyptian soils differ in their texture from sandy to heavy clay soils containing a low value of soluble N or organic matters. Available P is moderate; however, available K ranged between low and high, in addition, soil solution reaction was slightly alkaline. Nutrient applications can influence: vegetative growth vigor. As for, the scarce information on lime trees nutrient requirements. Growers normally apply the managements practices used for oranges, including fertilizer programs. Thus, by carefully choosing the components of fertilizer program, the grower can nudge a crop toward earlier, heavier fruit set **(**Muhammad and Manzoor, 2010).

Beanland et al. (2003) reported that, nutrient deficiency or imbalances may alter primary and secondary metabolism, and thus faster growth of herbivores.

Phosphorus is the 2nd major essential macro-elements for trees, it is considered as a key role of energy storage and transferring. But, its availability quickly changes after fertilization due to high soil reaction. Jr. et al. (2010) demonstrated that, greater growth of citrus trees corresponded to greater root development as evaluated by root growth rate and architecture, which varied according to phosphorus availability in soil. Excessive phosphorus can adversely affect citrus growth and development.

Potassium plays a critical role in citrus trees; it has obvious effects on many phenomena (visible or invisible). Citrus tree requirements of potassium ranked for next nitrogen (0.5 to 2.0 % of leaf content). Malavolta (1992) reported that, potassium fertilization increased leaf potassium content of 1.5-1.7%. **.** In spite of, nitrogen and potassium elements are considered as the key basic macronutrients, but they rapidly drain from soil. On the other hand, phosphorus, another macronutrient, and nutrient are less important, especially in replanting conditions where they may have accumulated in grove soils year after year of fertilization, Tom et al. (1975).

A readily available supply of necessary nutrient components is unquestionably the key to the success of any fertilizer program. Thus, the availability of nutrients is determined by the timing of fertilizer application, the ability of soil particles to absorb and release nutrients plus rootstock type .It's well known that , sandy soils are relatively barren and lack this nutrient retention capability. Fertilizer must be used on a regular basis. Therefore, fertigation system must be maintained at all times to transfer nutrients to roots where absorption occurs (Ferguson and Davies, 1999).

The objectives of the present study was to investigate the response of Balady lime tree growth to N,P,K fertilization levels and rootstock type interactions under Upper Egypt conditions.

MATERIALS AND METHODS

Treatments were carried out during three studied seasons (2017/ 2020). Thirty six-10-year-old Balady lime (*C. aurantifolia* L.) budded on three citrus stocks: Troyer citrange (*C. sinensis x P. trifoliata*), *C. volkamariana* (*C. reticulata* x *C. medica*) and Alemow (*C. macrophylla*) were carefully selected for vigorous tree growth, grown in sandy soil (Table 1) in a private orchard at Sahel- Sleem district, Assiut Governorate under drip irrigation.

Table (1): Analysis of the tested soil.

Constituents	Values	Constituents	Values
Clay %	9.00	O.M. (%)	2.20
Silt %	9.60	Total N (%)	0.09
Sand %	81.40	Available P (ppm)	4.3
Texture	Sandy	Available K (ppm)	48.5
$CaCO_3$ %	1.80	Fe (ppm)	1.1
pH (1:2.5 extract)	7.89	Zn (ppm)	0.9
E.C. (1: 2.5 extract) ppm	1050	Mn (ppm)	0.8

Experimental trees seasonally received the same horticultural practices adopted in this orchard as "Agriculture Ministry recommendations" without chemical fertilizers levels under experiment, which included three NPK "nutrient fertilizer levels" (B1 "the control", B2 & B3) and three rootstocks as follows:-

I) **Treatments:**

A1) Troyer Citrange plus NPK at:

1- B1: "the control": [N (700 g) + P_2O_5 (300 g) + K_2O (500 g)/tree.
2- B2: [N (500 g) + P_2O_5 (250 g) + K_2O (250 g)] NPK "2:1:1"/tree.
3- B3: [N (750g) + P_2O_5 (500 g) + K_2O (500 g)] NPK "3:2:2"/tree.
4- B4: [N (1000g) + P_2O_5 (750 g) + K_2O (750g)] NPK "4:3:3"/tree.

A2) Volkamer lemon plus NPK at:

1- B1: "the control": [N (700 g) + P_2O_5 (300 g) + K_2O (500 g)/tree.
2- B2: [N (500 g) + P_2O_5 (250 g) + K_2O (250 g)] NPK "2:1:1"/tree.
3- B3: [N (750g) + P_2O_5 (500 g) + K_2O (500 g)] NPK "3:2:2"/tree.
4- B4: [N (1000g) + P_2O_5 (750 g) + K_2O (750g)] NPK "4:3:3"/tree.

A3) Alemow plus NPK at:

1- B1: "the control": [N (700 g) + P_2O_5 (300 g) + K_2O (500 g)/tree.
2- B2: [N (500 g) + P_2O_5 (250 g) + K_2O (250 g)] NPK "2:1:1"/tree.
3- B3: [N (750 g) + P_2O_5 (500 g) +K_2O (500 g)] NPK "3:2:2"/tree.
4- B4: [N (1000 g) + P_2O_5 (750 g) + K_2O (750g)] NPK "4:3:3"/tree.

N/tree has been added as ammonium nitrate (33% N) divided into twenty eight equal doses and weekly added during the period from mid of (February to September)/season.

5- **P_2O_5/tree** was divided into equal doses: the 1st dose has been added as mono-calcium superphosphate (15.5 % P_2O_5) form at January with winter management/season. While, the 2nd dose was divided to eight equal doses as phosphoric acid 80% P_2O_5 form and four doses has been added during April and the other same four doses at July for every individual season .
6- **K_2O/tree** has been added as potassium sulfate 50% K_2O form, divided into two doses, at the 1st dose about 40% from the total K_2O/tree divide to 16 equal dose and weekly applied from the 1st week of March to the 4th week of June. The 2nd dose about 60 % from the total K_2O/tree, divided into 12 equal doses and weekly applied from the 1st week of July to the 4th week of September for individual season.

II) Experimental parameters:

1- Vegetative growth:

At the 1st week of April four branches (one inch in diameter) at the four original directions/tree were selected and tagged; then, ten vegetative shoots/branch were tagged. At mid of September, shoot {length & diameter (cm.)}, number of leaves /shoot and leaf area (cm^2) were measured & recorded.

2- Leaf pigments contents and total carbohydrates: in mid of September, 25

mature leaves/tree from non-fruiting shoots were picked and prepared for determination of chlorophylls a & b; total chlorophylls & carotenoids were extracted and measured as (mg/g F.W), according to Saric et al. (1967) & (A.O.A.C. 2000).

3- **Leaf NPK contents (%):** 0.5 gram of dried samples were digested using the H_2SO_4 and H_2O_2 as described by Cottenie (1980)**.** The extract was used to determine the following:

- N (g/100g. D. wt.): was determined by the modified micro-Kjeldahl method as described by Plummer (1971).
- P %: was measured calorimetrically, using the Beckman Du 7400 spectrophotometer according to Murphy and Riley (1962).
- K (g/100g. D. wt.): were determined by using flame-photometer (JENWAY – pfp7 Flame Photometer) according to Piper (1950).

III) Experimental design & Statistical analysis:

The investigation was planned out as a factorial experiment in a complete randomized block design with 3 replications. The statistical analysis of the present data was carried out according to Snedecor and Cochran (1980); followed by Duncan's New Multiple Range t-Test (Steel and Torrie, 1980) for means comparison; data were analyzed by MSTAT-C.

RESULTS AND DISCUSSIONS

1- Vegetative growth: i.e. (Leaf area, shoot length and the number of leaves/ shoot):

As for rootstock effect, data in **Table (2)** revealed that Balady lime scion on *Citrus macrophylla* stock significantly gave the highest leaf area (40.22, 40.55 & 39.97 cm^2), shoot length (7.017, 7.017 & 7.917 cm), respectively, as compared to both Troyer citrange or Volkamer lemon stocks during the three studied seasons. Whereas, Troyer citrange stock was the lowest and Volkamer lemon stock was moderate. In addition the effect of Balady lime scion on Volkamer lemon stock significantly has the highest number of leaves/shoot, *Citrus macrophylla* has a moderate number of leaves/shoot whereas, Troyer citrange was the lowest. On the other hand, present data indicated that NPK nutrient applications treatment (T4) has a superior effect with insignificant difference with T3 on the scion leaf area (37.49, 38.60 & 38.60 cm^2), shoot length (6.933, 6.900 & 6.822) cm. respectively, when compared to other treatments T1 or T2, while T1 gave the lowest values for studied seasons. With respect to the interaction effect of rootstock type plus NPK nutrient levels, data in (**Table, 2**) showed that *Citrus macrophylla* stock plus NPK nutrient levels T2 or T3 or T4 significantly increased Balady lime scion leaf area, & shoot length. Whereas, T4 gained significant differences by achieving the highest values when compared with other NPK levels during the studied seasons.

It's well known that, different rootstocks vary in their adaptability to grow in different soils and under different climatic conditions, as well as with different scion varieties. Thus it may greatly affect the scion performance, whereas, it may be dwarf or invigorate it. Also, NPK nutrient play an important role in the formation a suitable tree canopy which lead to a good yield. Citrus trees vary in their nutrient requirement response according to soil type, irrigated water and environmental conditions. The previous results are in line with those obtained by Wutscher (1979); Bitters (2021) and Muhammad and Manzoor (2010).

Table (2): Effect of rootstock type And NPK Fertilizer rates on Balady lime tree vegetative growth during (2017/18; 2018/19 & 2019/20) seasons.

NPK levels / Rootstocks	B1	B2	B3	B4	Mean	B1	B2	B3	B4	M. A	B1	B2	B3	B4	M. A
	1st season, 2017/2018					2nd season; 2018/2019					3rd season; 2019/2020				
Leaf area															
Troyer citrange	25.17g	30.47f	31.47 f	33.20e	30.08 C	24.30h	29.13g	32.03f	34.03e	29.88C	23.30g	28.13f	32.70e	33.70de	29.46C
C. volkameriana	31.17f	35.30d	37.10bc	38.10b	35.42 B	35.13de	36.40d	39.50bc	40.33ab	37.84B	35.47cd	36.07c	39.50b	40.00b	37.76B
C. macrophylla	36.20cd	41.30a	42.20a	41.17a	40.22 A	38.10c	41.47a	41.20a	41.43a	40.55A	36.10c	40.80ab	40.87ab	42.10a	39.97A
Mean	30.84C	35.69B	36.92A	37.49 A		32.51D	35.67C	37.58B	38.60A		31.62C	35.00B	37.69A	38.60A	
LSD	A = 0.81; B= 0.93; AB= 1.62					A= 0.76; B= 0.87; AB = 1.51					A= 0.98; B= 1.13; AB= 1.96				
Shoot length (cm.)															
Troyer citrange	3.93h	5.10g	5.57f	6.50cd	5.27C	4.40g	4.90f	5.80e	6.20d	5.33 C	4.2e	4.80d	5.73c	6.10bc	5.21C
C. volkameriana	5.03g	6.27de	6.70c	6.80bc	6.20B	4.97f	6.57c	6.90b	7.00b	6.36 B	4.80d	6.33b	6.50b	7.00a	6.16B
C. macrophylla	5.97e	7.17ab	7.43a	7.50a	7.02A	6.00de	7.20ab	7.37a	7.50a	7.02 A	5.80c	7.10a	7.40a	7.37a	6.92A
Mean	4.98D	6.18C	6.57B	6.93A		5.12D	6.22C	6.69B	6.90A		4.93D	6.08C	6.54B	6.82A	
LSD	A = 0.19; B= 0.22; AB= 0.38					A= 0.15; B= 0.16; AB = 0.18					A= 0.22; B= 0.25; AB= 0.43				
New. leaves/shoot															
Troyer citrange	16.00h	18.00g	21.00f	23.00e	19.50C	16.00g	18.33f	21.00e	24.00c	19.83B	15.00d	18.00c	20.67b	22.67b	19.08C
C. volkameriana	23.00e	25.67cd	27.00c	29.00b	26.17B	23.33cd	27.00b	29.00ab	30.33a	27.42A	22.33b	26.67a	27.67a	29.00a	26.42A
C. macrophylla	25.00d	30.00ab	31.00a	30.67a	29.17A	17.00fg	21.67de	22.33cde	22.67cde	20.92B	16.67cd	21.33b	21.00b	23.00b	20.50B
Mean	21.33D	24.56C	26.33B	27.56A		18.78D	22.33C	24.11B	25.67A		18.00C	22.00B	23.11B	24.89A	
LSD	A = 0.83; B= 0.95; AB= 1.65					A= 1.10; B= 1.27; AB = 2.21					A= 1.22; B= 1.41; AB= 2.44				

NPK rates =B1, B2, B3 & B4: Levels one, two, three and four.

- Mean followed by the same letter in a column or raw don't differ significantly according to Duncan's New Multiple Range t Test at 5 % level.

2- Leaf pigments & carbohydrates contents:

Data in **Tables (3)** indicated that citrus rootstocks under study significantly affect Balady lime leaf pigments as: Chl. a, b & total chlorophylls and carotenoids (mg/100 g F.W.) & carbohydrates percentage contents.

Whereas, Balady lime scion on *Citrus macrophylla* stock gave the highest Chl. a, b & total chlorophylls and carotenoids (mg/100 g F.W.) contents {Chlorophyll a (6.392, 6.567 & 6.408); Chlorophyll b (2.575, 2.600 & 2.675); total chlorophylls (8.950, 9.175 & 9.083) and carotenoids (2.850, 3.008 & 3.108) (mg/100 g F.W.), respectively, and carbohydrates (20.23, 20.41 & 19.66 %) content respectively, as compared to other rootstocks under study. Whereas, Troyer Citrange stock gave the lowest values during the three seasons.

As for NPK nutrient levels effect, data also, showed that (T4) level increased leaf Chlorophyll a with significant difference (6.078; 6.100 & 6.089) (mg/100g f. w.) respectively. Moreover, either (T3) or (T4) significantly gave the highest values of chlorophyll b, total chlorophylls & carotenoids in compared to (T1) which was the lowest for the studied seasons.

Regarding rootstocks type plus NPK nutrient levels interaction effect data presented in (Table, 3) cleared that Balady lime on *Citrus macrophylla* plus NPK nutrient levels; (T2); (T3) or (T4) significantly improved leaf pigments Chl. a, b & total chlorophylls and carotenoids (mg/100 g F.W.) and carbohydrates contents. In general, *citrus macrophylla* plus NPK (T4) level has superior effect when compared to the Troyer citrange stock plus (T1) NPK level for the three studied seasons.

Undoubtedly, plant pigments at its optimum content are considered as the best evidence of plant health through several physiological roles i.e., photosynthesis ...etc. It has been found that rootstock type and the best tree nutrient status directly affect leaf pigments content and their performances and are usually the ones most limiting to growth. In respect to the fertilizer levels increased

chlorophyll a, b and total chlorophylls over the farmer treatment during studied seasons. These finding are in line with those obtained by Du-Plesis and Koen (1988) on Valencia orange trees, Malavolta (1992), El-Sabrout and Kassem (2002), ElAbd (2005), Glenn (2009) on lemon trees, Muhammed and Manzoor (2010) on sweet orange trees; Muhammad et al., *(*2010) and Jover et al., (2012) who found that the influence of rootstocks on scion photosynthetic capacity may play a key role in citrus plant performances in terms of vigor, crop load, and fruit characteristics and should be considered.

Table (3): Effect of rootstock type And NPK fertilizer rates on Balady lime leaf pigments & total carbohydrates during (2017/18; 2018/19 & 2019/20) seasons.

NPK levels / Rootstocks	B1	B2	B3	B4	Mean	B1	B2	B3	B4	M. A	B1	B2	B3	B4	M. A
	1st season, 2017/2018					2nd season; 2018/2019					3rd season; 2019/2020				
Chlorophyll a															
Troyer citrange	3.57f	4.20e	4.43e	5.10d	4.33C	3.43i	3.90h	4.50g	4.90f	4.183C	3.40h	3.93g	4.47f	4.93e	4.18C
C. volkameriana	5.10d	5.23d	5.80c	6.43b	5.64B	5.20e	5.47d	5.90c	6.50b	5.767B	5.23de	5.43d	5.97c	6.50b	5.78B
C. macrophylla	5.47cd	6.53ab	6.87a	6.70ab	6.39A	5.60d	6.90a	6.87a	6.90a	6.567A	5.43d	6.57ab	6.80ab	6.83a	6.41A
Mean	4.71D	5.32C	5.70B	6.08A		4.74D	5.42C	5.76B	6.10A		4.69D	5.31C	5.74B	6.09A	
LSD	A =0.18; B=0.21; AB=0.38					A =0.11; B=0.13; AB=0.22					A =0.15; B=0.18; AB=0.31				
Chlorophyll b															
Troyer citrange	1.50f	1.60ef	1.80de	1.97cd	1.72C	1.40d	1.43d	1.63d	1.90c	1.59C	1.50e	1.53e	1.60e	1.87c-e	1.63C
C. volkameriana	1.60ef	2.17c	2.50b	2.53b	2.20B	1.50d	2.10c	2.60b	2.60b	2.20B	1.53e	2.13b-e	2.50a-d	2.67a-c	2.21B
C. macrophylla	1.50f	2.97a	3.00a	2.83a	2.58A	1.60d	2.80ab	3.00a	3.00a	2.60A	1.63de	2.93ab	3.10a	3.03a	2.68A
Mean	1.53C	2.24B	2.43A	2.44A		1.50C	2.11B	2.41A	2.50A		1.56B	2.20A	2.40A	2.52A	
LSD	A =0.11; B=0.13; AB=0.22					A =0.13; B=0.15; AB=0.26					A =0.51; B=51; AB=0.90				
Total chlorophylls															
Troyer citrange	5.07f	5.80ef	6.23d-f	7.10c-e	6.05C	5.17h	5.33h	6.20g	6.80ef	5.88C	4.90h	5.47g	6.07f	6.80e	5.81C
C. volkameriana	6.70de	7.40cd	8.30bc	8.97ab	7.84B	6.70f	7.57d	8.50c	9.10b	7.97B	6.77e	7.57d	8.47c	9.10b	7.98B
C. macrophylla	6.97de	9.50ab	9.87a	9.47ab	8.90A	7.20de	9.70a	9.90a	9.90a	9.18A	7.07de	9.50ab	9.90a	9.87a	9.08A
Mean	6.24C	7.57B	8.13AB	8.51a		6.36D	7.53C	8.20B	8.60A		6.24D	7.51C	8.14B	8.59A	
LSD	A =0.65; B=0.71; AB=1.30					A =0.24; B=0.27; AB=0.47					A =0.26; B=0.30; AB=0.51				
Total Carotenoids															
Troyer citrange	1.40f	1.50ef	1.70e	2.00d	1.65C	1.37f	1.50f	1.90e	2.20d	1.74C	1.40g	1.60g	1.93f	2.37e	1.83C
C. volkameriana	2.50bc	2.50bc	2.60b	2.50bc	2.53B	2.37cd	2.40cd	2.80b	2.83b	2.60B	2.47de	2.47de	2.80bc	2.87bc	2.65B
C. macrophylla	2.30c	2.97a	3.03a	3.10a	2.85A	2.57bc	3.13a	3.20a	3.13a	3.01A	2.73cd	3.10b	3.10b	3.50a	3.11A
Mean	2.07C	2.32B	2.44AB	2.53A		2.10C	2.34B	2.63A	2.72a		2.20D	2.39C	2.61B	2.91A	
LSD	A =0.13; B=0.15; AB=0.26					A =0.14; B=0.16; AB=0.27					A =0.16; B=0.19; AB=0.33				
Leaf total Carbohydrates (%)															
Troyer citrange	15.90hi	15.37i	16.43gh	17.17fg	16.22C	15.90e	14.67f	16.17e	17.30d	16.01C	15.27e	14.33e	17.17cd	18.63b	16.35C
C. volkameriana	18.77cd	18.30de	19.17bc	19.63b	18.97B	16.97d	18.20c	19.27b	19.60b	18.51B	16.63d	17.20cd	18.27bc	19.93a	18.01B
C. macrophylla	17.90ef	20.80a	21.07a	21.13a	20.23A	18.07c	21.33a	21.07a	21.17a	20.41A	17.73bcd	20.33a	20.40a	20.17a	19.66A
Mean	17.52c	18.16b	18.89a	19.31a		16.98d	18.07c	18.83b	19.36a		16.54d	17.29c	18.61b	19.58a	
LSD	A =0.41; B=0.48; AB=0.81					A =0.24; B=0.28; AB=0.48					A =0.63; B=0.72; AB=1.25				

NPK rates =B1, B2, B3 & B4: Levels one, two, three and four.

- Mean followed by the same letter in a column or raw don't differ significantly according to Duncan's New Multiple Range t Test at 5 % level.

3- **Leaf NPK percentage** :

As for citrus stocks type data presented in **Table (4)** demonstrated that Balady lime leaf N& K percentage significantly increased on *Citrus macrophylla* stock: N % (2.064, 2.064 & 2.063) and K % (1.448, 1.465 & 1.485) respectively, as compared to other rootstocks under study. Whereas, Volkamer lemon was the moderate and Troyer citrange was the lowest during the studied seasons. On the other hand, either *Citrus macrophylla* or Volkamer lemon stocks significantly increased Balady lime leaf P % content when compared to Troyer citrange stock for the three studied seasons.

With regard to NPK nutrient levels, data presented cleared that either NPK (T3) or (T4) treatments significantly increased

Balady lime leaf (N & K) percentage when compared to (T2) or (T1) level during studied seasons. On the other hand, all NPK nutrient levels have insignificant effect on leaf P % during the three seasons.

As for the interaction between rootstocks type and NPK nutrient levels on Balady lime leaf (N, P & K) percentage content, data in **Table (4)** illustrated that *Citrus macrophylla* stock plus both NPK nutrient level (T3) or (T4) significantly gave the highest leaf N,P&K values, whereas, Troyer citrange was the lowest for all studied seasons due to the variation in root system distribution between citrus rootstock types .

In addition, *Citrus macrophylla* or *Volkamer lemon* rootstocks has the highest and more distributed roots, which increase elements absorption efficiency. Moreover, applications of NPK elements in balanced form and sufficient for tree requirements will be improved leaf N, P & K contents. Results were in agreement with those obtained by Koo (1963) who mentioned that potassium requirement for lemon was higher than that for orange and recommended rates of potassium 25% higher than those for nitrogen, for optimal lemon yield. Quaggio et al., (2002); Jr. et al., (2003); Toplu et al., (2008) and Jr. et al. (2010) demonstrated that, greater growth of citrus plants corresponded to greater root development as evaluated by root growth rate and architecture. Rootstock type affects many traits such as leaf mineral elements. Also, Toplu et al. (2008) mentioned that rootstocks directly affect the ability of plants to uptake water and nutrients from soil. In general, plant nutrient concentrations in scion cultivars may differ, even though they are grown under the same conditions. For this reason, it is important to determine the effects of rootstocks on plant nutrient status to optimize fertilization programs.

Table (4): Effect of rootstock type And NPK fertilizer rates on Balady lime leaf N, P &K percentage during (2017/18; 2018/19 & 2019/20) seasons.

NPK levels / Rootstocks	B1	B2	B3	B4	Mean	B1	B2	B3	B4	M. A	B1	B2	B3	B4	M. A
	1st season, 2017/2018					2nd season; 2018/2019					3rd season; 2019/2020				
Nitrogen (%)															
Troyer citrange	1.72fg	1.67g	1.75e-g	1.80ef	1.73C	1.71g	1.62h	1.76fg	1.83ef	1.73C	1.70g	1.59h	1.76f	1.83e	1.72C
C. volkameriana	1.81e	1.94cd	1.99cd	2.02bc	1.94B	1.80e-g	1.88de	1.98bc	2.07ab	1.93B	1.79ef	1.85e	1.99c	2.04bc	1.92B
C. macrophylla	1.93d	2.08ab	2.12a	2.12a	2.06A	1.93cd	2.14a	2.10a	2.09a	2.06A	1.92d	2.12a	2.09ab	2.12a	2.06A
Mean	1.82C	1.90B	1.95A	1.98A		1.81C	1.88B	1.95A	2.00A		1.80D	1.85C	1.95B	2.000A	
LSD	A =0.05; B=0.05; AB=0.09					A =0.05; B=0.05; AB=0.09					A =0.02; B=0.03; AB=0.05				
Phosphorus (%)															
Troyer citrange	0.110e	0.137c-e	0.130de	0.150b-e	0.132B	0.103d	0.123cd	0.133cd	0.157b-d	0.129B	0.107e	0.197abc	0.133de	0.160c-e	0.149B
C. volkameriana	0.167a-d	0.177a-d	0.190a-c	0.197ab	0.183A	0.153b-d	0.177a-c	0.190ab	0.207ab	0.182A	0.167b-d	0.177a-d	0.193a-c	0.207a-c	0.186A
C. macrophylla	0.200ab	0.193ab	0.210a	0.210a	0.203A	0.173abc	0.220a	0.203ab	0.220a	0.204A	0.177a-d	0.220ab	0.200abc	0.223a	0.205A
Mean	0.159A	0.169A	0.177A	0.186A		0.143B	0.173AB	0.176A	0.194A		0.150B	0.198A	0.176AB	0.197A	
LSD	A =0.03; B=0.03; AB=0.05					A =0.03; B=0.03; AB=0.05					A =0.03; B=0.03; AB=0.05				
Potassium (%)															
Troyer citrange	1.073f	1.160ef	1.223de	1.333cd	1.197C	1.000f	1.130e	1.203d	1.280c	1.153C	1.007g	1.147f	1.220ef	1.273e	1.162C
C. volkameriana	1.150ef	1.390c	1.450bc	1.463a-c	1.363B	1.150de	1.420b	1.423b	1.450b	1.361B	1.170f	1.417d	1.503bc	1.447cd	1.384B
C. macrophylla	1.170ef	1.441c	1.583ab	1.597a	1.448A	1.180de	1.573a	1.557a	1.550a	1.465A	1.200ef	1.593a	1.573ab	1.573ab	1.485A
Mean	1.131C	1.330B	1.419A	1.464A		1.110C	1.374B	1.394B	1.427A		1.126C	1.386B	1.432A	1.431A	
LSD	A =0.07; B=0.08; AB=0.014					A =0.03; B=0.03; AB=0.05					A =0.04; B=0.04; AB=0.08				

NPK rates =B1, B2, B3 & B4: Levels one, two, three and four.

- Mean followed by the same letter in a column or raw don't differ significantly according to Duncan's New Multiple Range t Test at 5 % level.

Conclusion:

To conclude, it is apparent that Balady lime (*C. aurantifolia* L.) budded on both Alemow (C. *macrophylla*) or Volkamer lemon "*C. volkamariana*" (*C. reticulata* x *C. medica*) rootstocks , grown in sandy soil at Assiut Governorate under drip irrigation system and yearly fertilized with N, P, K at

[N (750g) + P_2O_5(500g) + K_2O(500 g)] 3:2:2/tree], had no significant differences between the two citrus stocks the best tree growth and tree nutrient balance .

REFERNCES

A.O.A.C. (2000). Association of Official Agricultural Chemists. Official and Tentative Methods of analysis. 13th ed., Washington, D.C., USA.

Beanland, L., PLarry P. and Seppo S. (2003). Micronutrient interaction on soybean growth and the developmental performance of three insect herbivores. Environ. Entomol., 32: 641-651.

Bitters, W.P. (2021). Citrus rootstocks: Their characters and reactions (an unpublished manuscript). Journal of Citrus Pathology, 8(1).

Cottenie, A. (1980). Soil and plant testing as a Basis of Fertilizer Recommendations FAO Soil Bulletin 38/2.Rome.

Du Plesis, S.F.and Koen,T. J. (1988). Effect of N and K fertilization on yield and fruit size of Valencia. In Citriculture: proceedings of the Sixth International Citrus Congress: Middle-East, Tel Aviv, Israel, March 6-11, 1988/scientific editors, R. Goren and K. Mendel, editor, N. Goren. Rehovot, Israel: Balaban, c1989.

El-Abd, A.A. (2005). Influence of fertilization and irrigation on Washington navel orange orchards (Doctoral dissertation, Ph. D. Thesis, Fac. Agric., Tanta Univ., Egypt).

El-Sabrout, M.B. and Kassam, H. A. (2002). Effect of fertilization with nitrogen and potassium on vegetative growth, yield and leaf mineral content of Washington Navel orange trees grown in sandy soil. J. Adv. Agric. Res., 7(3):539-553.

Ferguson, J.J. and Davies , F.S. (1999). Fruit Crops Fact Sheet: Fertilization of Young Citrus Trees1. Fruit Crops Fact Sheet: Fertilization of Young Citrus Trees.

Glenn, C. W. (2009). Evaluation of nitrogen fertilization practices for surface irrigated lemon Trees-2009. Final report for project (2008-04) Dep. of Plant Sci. Univ. Ariz. Yuma Agric. Center, Yuma, AZ.

Jover, Sara, Martínez-Alcantara, B., Rodríguez-Gamir, J., Legaz, F., Primo-Millo, E., Forner, J. and Forner-Giner, M. A.(2012). Influence of rootstocks on photosynthesis in navel orange leaves: Effects on growth, yield, and Carbohydrate distribution.–Crop Science 52: 863- 848.

Jr., D. M., Quaggiou, J., Cantarella, H. and Ashok, K. A. (2003). Nutrient content of biomass components of Hamlin sweet orange trees. Scientia Agricola, 60(1): 155-160.

Jr.,D.M., Danilo, R. Y., Rodrigo, M. B., Fernando, C.B. Z. and Jose, A. Q. (2010). Root development of young citrus trees in soils fertilized with phosphorus. 19th World Congress of Soil Sci. Soil Solutions for Changing World 1-6 August 2010. Brisbane Australia Congress Proc. Pp. 197-203.

Malavolta, E. (1992). Leaf analysis in Brazil-present and perspectives. Processing of the Inernational Soc. of Citriculture, 2: 570-574.

Muhammad, Y. and Manzoor, A. (2010). Nutrition management in citrus: Effect of multi nutrients foliar feeding on the yield of kinnow at different locations. Pak. J. Bot., 42(3): 1863-1870.

Muhammad, S., Abdur-Rab, N. A., Muhammad, A., Louise, F. and Masood, A. (2010). Effect of foliar application of Zn and B on fruit production and physiological disorders in sweet orange cv. Blood orange. Sarhad J. Agric., 26 (3).

Murphy, J. and Riley, J. P. (1962). A modified single solution method for the determination of phosphate in natural waters. Anal . Chimica Acta, 27: 31-36.

Piper, C.S. (1950). Soil and plant Analysis. Inter. Sci., Pulb, New York, USA, 368 p.

Plummer, D.T. (1971). An introduction to practical biochem. Published by Mc Graw Hill Book Company (U.K.) Limited.

Quaggio, J.A., Cantarella, H. and Van Raij, B. (2002). Phosphorus and potassium soil test and nitrogen leaf analysis as a base for citrus fertilization. Nutrient Cycling in Agroecosystems, 52: 67-74.

Saric, M., Kastrori, R., Curie, R., Cupina, T. and Gerie, I. (1967). Chlorophyll Determination. Univ. Unoven sadu parktikum is fiziologize Bibjoke, Beagard, Hauncna, Anjiga, pp. 215.

Snedecor, G. W. and Cochran, W. G. (1980). Statistical Methods. Oxford and J.B.H. publishing com. 7th Edition, Press, Ames, Iowa, 593.

Steel, R. G. D. and Torrie, J. H. (1980). Principles and Procedures of Statistics. McGrow Hill Book Co., Inc., New York, p: 377-400.

Thomas, A. O. (2001). Managing phosphorus fertilization of citrus using soil testing. Florida Cooperative Extension Service, Institute of Food and agric. Sci. Univ. of Florida SL, 186: 1-6.

Tom, W. E., Winston W. J., and Robert G. P. (1975). Plant Nutrition and Citrus Fruit Crop Quality and Yield. HortScience, 10(1):48-50.

Toplu, C., Kaplankıran, M., Demirkeser, T.H. and Yıldı,E. (2008). The effects of citrus rootstocks on Valencia late and Rohde Red Valencia oranges for some plant nutrient elements. – African Journal of Biotechnology, 7(24): 4441-4445.

Wutscher, H. K. and Hardesty, C. (1979). Concentration of 14 elements in tissues of blight affected and healthy Valencia orange trees. J. Amer. Soc. Hort. Sci., 104(1):9-11.

إستجابة نمو ومحصول شجرة الليمون البلدي لنوع الأصل ومستويات مختلفة من النيتروجين والفوسفور والبوتاسيوم تحت ظروف مصر العليا

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أجريت هذه التجربة خلال ثلاث سنوات 2020/2017 علي التوالي علي 36 شجرة ليمون بلدي عمر 10سنوات مطعومة علي ثلاث أصول وهي: 1) ترويرستر انج؛ 2) فولكاماريانا؛ 3) ماكروفيللا (العامل الاول "A"). نامية في تربة رملية في حديقة خاصة بزمام مركز ساحل سليم/محافظة أسيوط تحت نظام الري بالتنقيط (تم اختيار تلك الاشجار بعناية). خضعت تلك الاشجار لمعاملات تسميد تجريبية لثلاث مستويات مختلفة من الازوت والفوسفور والبوتاسيوم (العامل الثاني "B") سنويا وهي:

1- (B1)= [النيتروجين (700 جم) + الفسفور (300 جم) + البوتاسيوم (500 جم)] /شجرة /عام.
2- (B2)= [النيتروجين (500 جم) + الفسفور (250 جم) + البوتاسيوم (250 جم)] 1:1:2 /شجرة/عام.
3- (B3)= [النيتروجين (750 جم) + الفسفور (500 جم) + البوتاسيوم (500 جم)] 2:2:3 /شجرة/عام.
4- (B4)= [النيتروجين (1000 جم) + الفسفور (750 جم) + البوتاسيوم (750 جم)] 3:3:4/شجرة/عام.

حيث أعتبر المستوي (B1) هو المقارنة، (تم اضافة تلك المستويات لكل أصل علي حدة)، وتهدف هذه الدراسة إلى الوقوف علي مدي استجابة اشجار الليمون البلدي المطعومة علي أصول مختلفة لإضافة مستويات مختلفة من الازوت والفوسفور والبوتاسيوم تحت ظروف مصر العليا، حيث أوضحت الدراسة النتائج الاتية:

1- تفوقت الأشجار المطعومة علي أصلي الموالح ماكروفيلا أو الفولكاماريانا في النمو الخضري تحت الدراسة علي تلك المطعومة علي أصل الترويرستر انج خلال سنوات الدراسة.
2- تفوقت الأشجار المطعومة علي الأصول الثلاثة والتي تم إضافة الـ NPK عند المستوي B2; B3; B4 في جميع الصفات الخضرية مقارنة بالمستوي B1 (المقارنة).
3- تفوقت أشجار الليمون البلدي المطعومة علي أصلي الماكروفيلا أو الفولكا والتي تم إضافة الـ NPK لها بمستويات B3 أوB4 عن مثيلتها المضاف إليها مستويات B1 (المقارنة) أو B2 علي الأصول الثلاثة.

عند التوسع في زراعة أشجار الليمون البلدي تحت ظروف مصر العليا وللتغلب علي بعض مشاكل التربة أو بعض الأمراض الفيروسية ينصح بزراعة أشجار مطعومة علي الماكروفيللا أو الفولكاماريانا وإضافة الـ NPK بالمعدل التالي: [النيتروجين (750 جم) + الفسفور (500 جم) + البوتاسيوم (500 جم)] 3:2:2/ شجرة/عام.