

## **Growth performance of two lemon [*Citrus limon* (L.) Osbeck] cultivars budded on three rootstocks, Gezira State, Sudan**

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### **ABSTRACT**

Lemon [*Citrus limon* (L.) Osbeck ], family Rutaceae, is one of the world's major fruit crops with global popularity contributing to human diets. Lemon rootstocks and scion cultivars play an important role in the rapid development of citrus in the world. This study was conducted to evaluate the growth performance of two lemon cultivars budded on three rootstocks under Gezira State conditions, Sudan. The experiment was conducted in the nursery of the Department of Horticultural Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, in 2017. Volkamariana, Rough Lemon and Macrophylla rootstocks were grafted with buds of Eureka and Teresa cultivars. The T- budding technique was used in this study. Treatments were arranged in a randomized complete block design with three replicates. Parameters measured were rootstock height and thickness, height of scion, number of branches, length of branches and stem circumference of the scion. The parameters were recorded for 10 months. Rootstocks were significantly different in their vegetative growth. Rough Lemon rootstock resulted in the best vegetative growth. However, there were no significant differences in growth parameters between Volkameriana and Macrophylla rootstocks. Lemon cultivars were highly significantly different in their vegetative performance. Teresa lemon cultivar resulted in the largest plant height (73.9 cm), number of branches (27), length of branches (68 cm) and stem circumference (11.8 cm). The interaction effects of rootstocks and cultivars on vegetative performance of lemon were significant. The largest plant height (84.33 cm), number of branches (31.7), length of branches (75.7 cm) and stem circumference (12.3 cm) were obtained by Teresa cultivar

budded on Rough Lemon rootstock and the smallest parameters were obtained by Eureka cultivar budded on Volkameriana, whereas the smallest length of branches (55.3) and stem circumference (9.5 cm) were obtained by Eureka cultivar budded on Macrophylla. Depending on the results of this study, it is recommended to bud the lemon cultivar Teresa on Rough Lemon rootstock under Gezira State Conditions, to obtain the best growth performance.

## INTRODUCTION

Lemon fruits are an integrated part of daily diet, playing key roles in providing vitamin C and in health promotion. The lemon is a small evergreen tree, native to Asia and the tree produces a yellow fruit (FAO, 2016). The fruit is used primarily for its juice, which has about 6% citric acid, with a pH of around 2.2, giving it a sour taste (Dugo and Giacomo, 2002; Izquierdo and Sendra, 2003; Liu *et al.*, 2012 ).

Sudan, with its vast areas of fertile soils and abundant water resources, has great potentialities for large scale commercial production of lemon to satisfy the local market and for export (Sidahmed and Geneif, 1984).

Rootstocks play an important role in the production of citrus crops in the world. The importance of using rootstocks for citrus production is to have profitable commercial production to overcome some limiting factors such as climate, poor soil conditions and diseases (Richardson *et al.*, 2003; Ahmed *et al.*, 2006), . Beside these factors, the use of citrus rootstocks provides a large amount of choices to the growers to increase fruit quality and yield, early fruiting, uniform cropping and control of tree size. Choosing a rootstock is an important decision and local climatic and soil conditions are important factors in rootstock selection (Roose, 2014). Although any citrus variety can be used as a rootstock, some of them are better suited to specific conditions than others (Castle, 1992). Sour orange, which is still the main rootstock used in citrus orchards in the world, is used as a rootstock for all citrus cultivars in the Sudan (Sidahmed and Geneif, 1984).

Lemon cultivars vary in their ability to withstand different climatic conditions. Eureka has great tolerance to dry and hot conditions. Fruits also tend to be produced on the inside of trees and so are less likely to be damaged by wind (Shokrollah *et al.*, 2006). Eureka lemon trees grow between 3 and 7 m tall, with a spreading and open growth habit. It produces abundant oblong juicy fruits with a medium-gold color, all year round when grown in warm climates. Teresa lemon cultivar, which was originated in Italy, is a highly productive and disease resistant cultivar (Morton, 1987).

Research work on the effects of rootstocks on lemon propagation is lacking. Therefore, this study was conducted to evaluate growth performance of two lemon [*Citrus limon* (L.) Osbeck] cultivars budded on three rootstocks under Gezira State Conditions, Sudan.

## MATERIALS AND METHODS

The experiment was conducted in the nursery of the Department of Horticultural Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan. The experimental site was located at latitude 14° 24' N, longitude 33° 29' E and altitude 407 masl. The climate of the region is semi-desert with a mean annual precipitation of 250 mm/year, with the rainy season extending from June to October. The mean annual evapotranspiration is 2400 mm/year. The mean annual minimum and maximum temperatures are 15 °C in January and 42°C in May. The soil of the area is heavy clay (60%), with a pH of 8.0-8.5, low organic matter and nitrogen, adequate potassium and low available phosphorous (Elbasher, 2016).

Treatments consisted of three rootstocks, *viz* Volkameriana, Rough Lemon and Macrophylla and two lime cultivars, *viz* Eureka and Teresa, making a total of 6 treatments. They were arranged in a randomized complete block design with three replicates.

The seeds of the rootstocks Volkameriana, Rough Lemon and Macrophylla and the buds of the cultivars Eureka and Teresa were provided by the Department of Horticultural Sciences, Faculty of Agricultural Sciences, University of Gezira, Sudan.

Parameters measured were scion height, number of branches, length of branches and stem circumference. The parameters were recorded monthly for 10 months.

Plastic plates with drainage holes at the bottom were filled with sand. Fifty seeds of each rootstock were sown in each plate. The plates were kept weed free, irrigated and then seedlings of 2-months-old and 20 cm in height were transplanted in black plastic bags (one seedling per bag), watered with tap water as required and without fertilizers. After two months, the seedlings were transplanted in the field at a spacing of 6X6 m. Data on growth parameters of rootstocks (plant height and stem circumference) were taken for 10 months before grafting.

When the rootstocks were ready for grafting, scion buds were obtained from the mother trees of Eureka and Teresa cultivars. The T budding grafting technique was used in this study (Hardy, 2004). The bark was carefully stripped from the stem of the rootstock exposing a "pocket" into

which the bud shield was placed. Care was taken not to tear the flaps of bark in the process of spreading them. The bud shield was carefully slipped in between the bark flaps. The top of the bark strip on the bud shield was trimmed to fit tightly against the horizontal cut (the cross of the T) so that the bud was fitted within the "pocket" snugly. The bark flaps were held tightly against the bud as they were wrapped with a plastic tape (Willey, 2016). After the union healed, the upper part of the rootstock plant was cut off to force the bud to grow. The rootstock suckers were removed as soon as they appeared. After that the scion bud grew vigorously (Thokchom and Singh, 2018) .

### Statistical analysis

Data were analysed using the standard analysis of variance procedure. Means were separated using Duncan`s Multiple Range Test at  $P \leq 0.05$ .

## RESULTS AND DISCUSSION

### Plant height of rootstocks

Rootstocks were significantly different in their plant height (Fig.1). Rough Lemon rootstock resulted in the largest plant height. However, there were no significant differences in plant height between Volkameriana and Macrophylla rootstocks during the last month of the experiment. These results are consistent with those reported by Richardson *et al.* (2003). Their selected rootstocks included Rough Lemon, Volkameriana, Mexican lime, Sour Orange and Macrophylla.

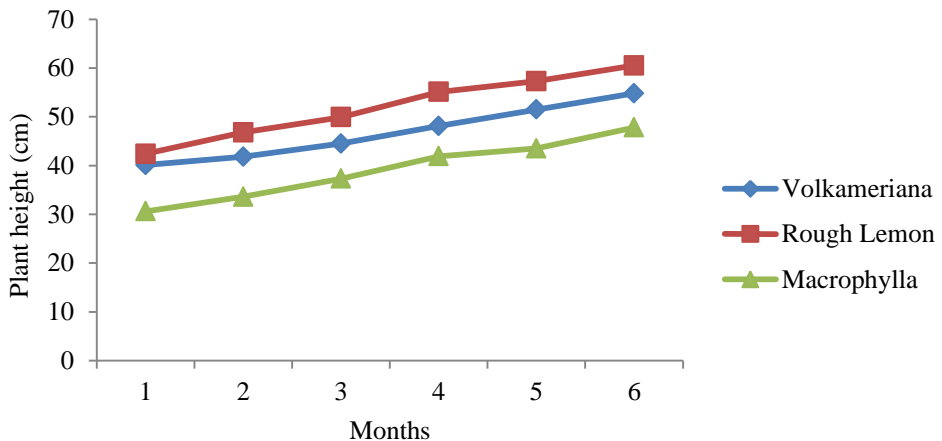


Fig. 1.Plant height of rootstocks.

### Stem circumference of rootstocks

Rootstocks were significantly different in their stem circumference (Fig.2). Rough Lemon rootstock displayed the largest stem circumference, while Volkameriana and Macrophylla showed the smallest stem circumference. There were no significant differences in stem circumference between Volkameriana and Macrophylla.

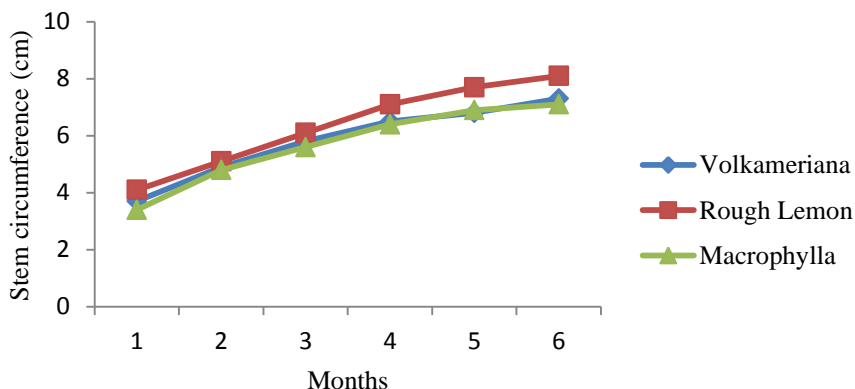


Fig 2. Stem circumference of rootstocks.

Rootstock girth is considered very important to determine the degree of compatibility between stock and scion. Sometimes rootstocks show incompatibility with scion leading to unbalanced physiological functions, plant vigor and productivity as well as fruit quality. Ahmed *et al.* (2006) showed significant differences among rootstocks due to increment in rootstock girth. They also found that Rough Lemon was the most adapted rootstock under highly alkaline soil.

### Plant height of the scion

Scions were significantly different in their plant height (Fig. 3). Teresa lemon cultivar resulted in the largest plant height. These results are consistent with those reported by Thokchom and Singh (2018).

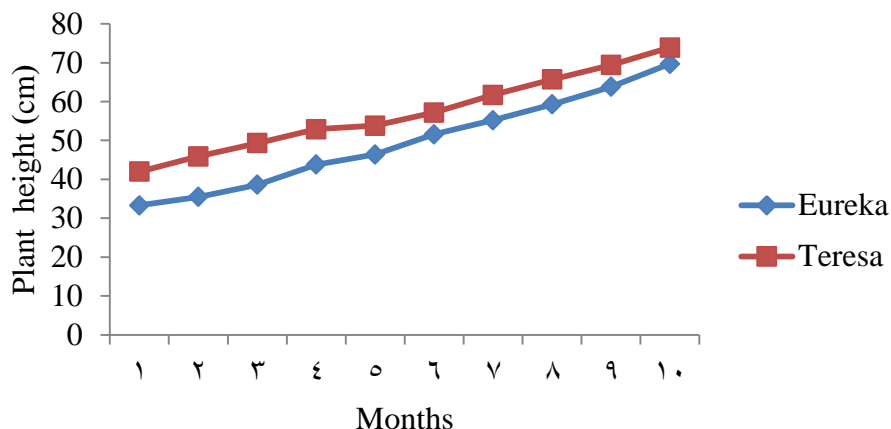


Fig.3. Plant height of the scion.

### Interaction effects of rootstocks and cultivars on scion height

The interaction effects of rootstocks and cultivars on scion height were significant (Table 1). The largest plant height was obtained by Teresa cultivar budded on Rough Lemon rootstock and the smallest plant height was obtained by Eureka cultivar budded on Volkameriana. These results are consistent with those reported by Shokrollah *et al.* (2006) who found that the rootstocks had significant effects on scions. Maximum plant height, trunk diameter and canopy diameter were observed with Teresa lemon cultivar budded on Macrophylla rootstock.

Table 1. Interaction effects of rootstocks and cultivars on scion height.

Rootstock	Cultivar ( scion )		Mean
	Eureka	Teresa	
Rough Lemon	74.50 ab	84.33 a	79.4 A
Volkameriana	66.67 b	70.33 b	68.5 B
Macrophylla	68.00 b	67.00 b	67.5 B
Mean	69.7 B	73.9 A	71.8

$$SE_{\pm \text{Interaction}} = 4.64, \quad CV\% = 7.92$$

\* Means followed by the same letter(s) are not significantly different accordingly to Duncan's Multiple Range Test at  $P \leq 0.05$ .

### Effects of scions on number of branches

Fig. 4 shows that Teresa lemon cultivar had more branches than those of Eureka. These results indicate that Teresa lemon cultivar had more vigorous vegetative growth compared to Eureka and they are consistent with those reported by Shokrollah *et al.* (2006).

Growth performance of two lemon cultivars budded on three rootstocks

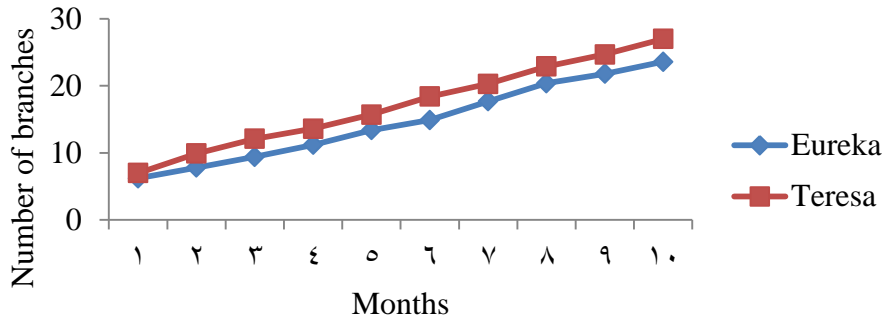


Fig. 4. Number of branches per plant of the scion.

**Interaction effects of rootstocks and cultivars on number of branches**

Table 2 shows significant interaction effects of rootstocks and cultivars on number of branches. Number of branches displayed by Eureka and Teresa grafted on the root stock Rough Lemon were significantly higher compared to grafting on Volkameriana and Macrophylla rootstocks.

These results are in agreement with those reported by Ahmed *et al.*(2006) who found that Rough lemon was a strong rootstock which resulted in vigorous vegetative growth of lemon. A successful rootstock should have compatibility between scion and rootstock besides having tolerance against prevalent edaphic and environmental conditions. Rootstocks are useful tools to growers to manipulate vigour and production of citrus trees. Effects on tree size, fruit quality, fruit production and maturity are achieved through complex interrelationship between the roots and canopy of the plant (Roose, 2014). Higher yields of sweet orange grafted on Rough Lemon rootstock were obtained than on other rootstocks. Rootstocks directly affected the ability of plants to take up water and nutrients and significantly alter the pattern of canopy development and photosynthesis (Richardson *et al.*, 2003).

Table 2. Interaction effects of rootstock and cultivar on number of branches.

Rootstock	Cultivar		Mean
	Eureka	Teresa	
Rough Lemon	26.7b	31.7a	29.2 A
Volkameriana	23.3bc	25.3b	24.3 B
Macrophylla	30.7c	24.0bc	27.4 B
Mean	26.9 B	27 A	26.9

SE± Interaction 1.82 CV% = 8.87

\* Means followed by the same letter(s) are not significantly different accordingly to Duncan's Multiple Range Test at P ≤ 0.05.

**Effects of cultivar on length of branches of the scion**

Fig. 5 shows that Teresa lemon cultivar had longer branches than those of Eureka. These results are consistent with previously reported data in this study (Table 2) which indicated that Teresa lemon cultivar had more number of branches.

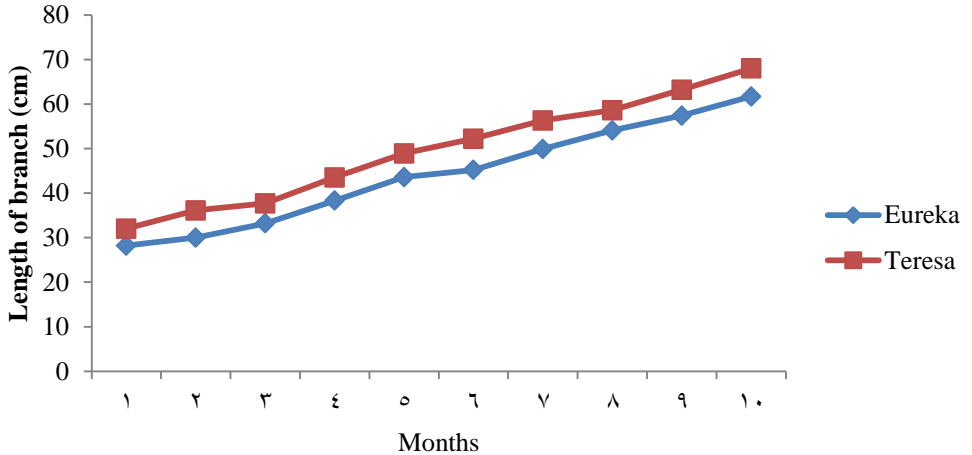


Fig. 5. Length of branches of the scion.

**Interaction effects of rootstocks and cultivars on length of branches**

Table 3 shows significant interaction effects between the rootstocks and cultivars on length of branches. The length of branches displayed by Eureka and Teresa cultivars grafted on the rootstock Rough Lemon were significantly higher compared to those grafted on the rootstocks Volkameriana and Macrophylla.

These results showed that Rough Lemon rootstock was superior to the other two rootstocks. It resulted in significantly larger number of branches (Table 2) and taller branches (Table 3) than those grafted on the rootstocks Volkameriana and Macrophylla. Similar results were reported by Ahmed *et al.* (2006).



Growth performance of two lemon cultivars budded on three rootstocks

Table 3. Interaction effects of rootstock and cultivar on length of branches.

Rootstock	Cultivar		Mean
	Eureka	Teresa	
Rough Lemon	65.0 b	75.7 a	70.4 A
Volkameriana	64.8 b	65.5 b	65.2 B
Macrophylla	55.3 c	62.8 bc	59.1 B
Mean	61.7 B	68 A	76.9

SE $\pm$  Interaction = 3.98 CV% = 7.53

\* Means followed by the same letter(s) are not significantly different accordingly to Duncan's Multiple Range Test at P  $\leq$  0.05.

**Effects of cultivars on stem circumference of the scion**

Fig 6 shows that the stem circumference of Teresa cultivar was larger than that of Eureka. These results are consistent with previously reported data in this study which indicated that Teresa lemon cultivar had more number of branches (Table 2) and taller branches (Table 3) than those of Eureka. These results are also consistent with those reported by Ahmed *et al.* (2006).

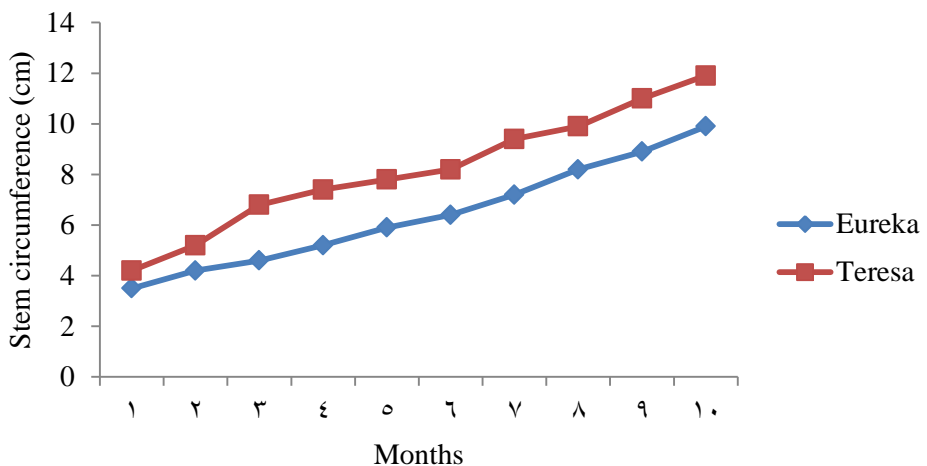


Fig 6. Circumference of the scion.

**Interaction effects of rootstocks and cultivars on stem circumference of the scion**

Table 4 shows significant interaction effects between the rootstocks and cultivars on stem circumference of lemon scion. The stem circumference displayed by Eureka and Teresa grafted on Rough Lemon

rootstock were significantly higher compared to grafting them on the root stock Volkameriana and Macrophylla.

The results also support the previous findings (Ahmed *et al.*, 2006) that the rootstock Rough Lemon was significantly better than the other two rootstocks with respect to all vegetative growth parameters of the scion.

Table 4. Interaction effects of rootstock and cultivar on circumference of the scion

Rootstock	Cultivar		Mean
	Eureka	Teresa	
Rough Lemon	11.9 a	12.3 a	12.1 A
Volkameriana	9.6 b	12.3 a	10.9 B
Macrophylla	9.5 b	10.8 b	10.1 B
Mean	10.3 B	11.8 A	11.3

$$SE_{\pm \text{ Interaction}} = 1.32 \quad CV\% = 12.18$$

\* Means followed by the same letter(s) are not significantly different accordingly to Duncan's Multiple Range Test at  $P \leq 0.05$ .

In the present study, plant height, number of branches, length of branches and stem circumference of cultivars Eureka and Teresa were significantly affected by the various rootstocks (Rough Lemon, Volkameriana and Macrophylla). Rough Lemon rootstock resulted in the largest plant height, number of branches, length of branches and stem circumference of Eureka and Teresa cultivars, followed by Volkameriana. This vigorous increment of vegetative growth shows the compatibility of Rough Lemon with Eureka and Teresa cultivars. This trend showed that this rootstock was physiologically compatible and actively growing under alkaline soil conditions. Similar results were reported by Shokrollah *et al.* (2006) who found that Rough Lemon and Volkameriana were superior rootstocks and were adapted to variable types of soil conditions.

Depending on the results of this study, it is recommended to bud the lemon cultivar Teresa on Rough Lemon rootstock under Gezira State Conditions to obtain the best growth performance.

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