



**PERFORMANCE OF MUSAMBI SWEET ORANGE ON ROUGH LEMON AND VOLKAMERIANA ROOTSTOCKS AT SARGODHA, PAKISTAN**

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**ABSTRACT**

Musambi (*Citrus sinensis*) is the commercial variety of the sweet oranges group well flourishing in Pakistan. For many years Musambi has been on the way of rapid decline with reduced life span besides drastic reduction in yield and fruit quality grafted on rough lemon rootstock. To overcome this problem, we tested the Volkameriana as an alternative rootstock to rough lemon with the focus to find out more compatible rootstock to prevent mentioned issues. Observations on different plant growth parameters such as plant height, stock and scion circumference, canopy volume, plant fruit yield and important quality characteristics of fruit were made. The rough lemon depicted statistically significant result in plant height, spread and canopy volume in responses recorded for 10 years consecutively from 2008 to 2017. The degree of compatibility in both root stocks in the year 2008 to 2009 was statistically non-significant. The yield was measured in terms of average No. of fruits per plant depicted that Rough Lemon and Volkameriana rootstock produced average 362.62 and 228.04 No. of fruits per plant respectively for the years 2012 to 2017. Moreover, results in different important quality characters i.e. fruit weight (g), Peel thickness (mm), Juice percentage, TSS and acidity were found better in the case of the plants grafted on Rough Lemon with the mean values of 176.23, 3.35, 46.56, 10.51 and 0.41 respectively for the six years consecutive 2012-2017. Results of studied rootstocks with context to given parameters remained at par; so other promising rootstocks should be taken in account for further studies.

**Key word:** Musamabi, rough lemon rootstock, Volkameriana root stock, vegetative growth characteristics, fruit yield.

**INTRODUCTION**

Citrus belongs to family *Rutaceae* and it is a good source of vitamin C which accounts for 64% individual daily nutritional requirements (Jacquemon *et al.*, 2004). It is also a rich source of potassium, folic acid, antioxidants and also it's an economically important trade commodity of the country. Sweet orange is widely distributed group of citrus and it contributes about 60% global citrus production (Khan *et al.*, 2014). The citrus industry has a considerable contribution to the economy of the world, especially with reference to sweet orange.

The production of citrus is promising in tropical and subtropical areas that are located between 23.5° North and South latitude. In addition, citrus is cultivated between 0 and 2,000 meters above sea level (Rodríguez *et al.*, 2011). However, at Pakistan sweet oranges offer the best economic performance among various citrus groups, mainly due to early harvesting in the months of Sep-Dec. In tropical conditions sweet orange, plants vigorously grow and attain a higher size than in subtropical conditions. In a tropical climate, the intensity of flowering, duration and distribution are low due to hot climate and water stress. Moreover, fruit growth is fast due to warm weather, but unfortunately quality of fruit and external appearance (green rind, pale yellow colored fruit, low total soluble solids and total titratable acid), because of the warm climate and respiratory rate is higher that metabolize the sugars and acids.

Narrow genetic pool (monoculture) in the case of citrus could be the reason for the diseases and pest attack. So the research on the evaluation of performance of root stock will contribute to success of citrus industry. Similarly the potential effects of roots stock performance on the quality and yield of fruits have been tested by (Hussain *et al.*, 2013). As root stock is responsible for the absorption of nutrient and water from the soil and alteration of tree canopy and the rate of photosynthesis (Richardson *et al.*, 2003). Also root stock store carbohydrates, scion adaptation for the particular soil conditions and inducing tolerance against disease. Rodríguez *et al.* (2011) has worked on the different root stock to see their effects on the quality and tree growth and yield. But the majority of the researchers used rough lemon root stock.

The evaluation of rootstock is dynamic for the commercial development of citrus crops because the rootstock affects more than twenty horticultural variables of citrus plants including yield. Evaluation of rootstock for scion variety must be done in the vicinity, to check the plant response to the weather, soil, disease and crop management (Wutscher and Bistline, 1988). The response of the rootstocks for the above mentioned variables could improve the actual yield of the sweet oranges grafted over the rough lemon because of its resistance against warm weather and water scarcity in Punjab, Pakistan. Selecting new rootstocks and understanding the productive, vegetative and fruit quality behavior could provide information for making decisions about yield, field

distribution and quality of fruit according to market demands.

## MATERIALS AND METHODS

The study was conducted at the Citrus Research Institute, Sargodha, Punjab, Pakistan, during 2008-2017. For this purpose, rough lemon and Volkameriana root stocks were taken into account. The rootstocks were propagated from mother plants located and, after one year, the plants were grafted using inverted T-bud with sweet orange (*Citrus sinensis* [L.] Osbeck) bud. Rough lemon is the traditional rootstock being used for various scion varieties at Punjab successfully (Figure 1).



Figure 1: Scion and stock circumference grafted on rough lemon) (A), Volkameriana (B), Musambigrafted on Volkameriana (C) and rough lemon (D).

The purpose of this study was aimed to evaluate alternative rootstock to cope the threat to the citrus industry depending upon single rootstock: rough lemon. Plant height and spread were measured with measuring scale;

$$CV = \pi/4 * EW * NS * HT * (1 - (1 - ((HI/HT)^2)/3))$$

Where CV = canopy volume per tree (m<sup>3</sup>), EW = canopy diameter in east-west direction (m), NS = canopy diameter in north-south direction (m), HT = tree height (m), and HI = height of intercept between two adjacent trees (m); which is the maximum height where the trees touch or grow together in the row.

### Quality parameters of fruits: Preparation of orange fruit juice:

Orange fruits were selected on the basis of quality attributes uniform size, shape, color and abrasion free. Then the selected fruits were washed under running water and after that treated with 5% sodium hypochlorite solution to remove surface contaminants and immediately rinsed with distilled water for half minute. Fruit was peeled off with sterile knife and its pulp and seed were separated. The fruit pulps were blended in a blender and the homogenized mixture was filtered with the double layer of muslin cloth.

The filtrate was stored in sterile air tight jars and then refrigerate at 45°C before further analysis. Total soluble solids (TSS) were recorded by digital hand refractometer (Atago, Japan). The fruit acid content was determined by titrating juice against 0.1 N (NaOH), using phenolphthalein as an indicator. Data were analyzed statistically to an Analysis of Variance (ANOVA) and differences among the means were determined for significance at p<0.05 by LSD test using statistical analysis system at 5% level of probability (Steel *et al.*, 1997).

Titrate acidity (TA) was determined by titration with 0.1M NaOH and phenolphthalein indicator in 100 mL of juice and was expressed as percentage citric acid followed by Chemists and Chemists (1920). It was titrated until a pink coloration was observed and the corresponding burette reading taken using the following formula.

$$\text{Acidity \%age} = \frac{\frac{N}{10} \text{NaOH used} \times 0.0064}{\text{Weight of sample}} \times 100$$

## RESULTS AND DISCUSSION

**Fruit yield (number of fruits):** Fruit production started in the fourth year, with the first harvest in the fifth year, and the production stabilized in the seventh year. The production attained in the 2017 with the number of fruits 455 and 373 from rough lemon and Volkameriana respectively (Fig. 2). For the cumulative production, rough lemon was the rootstock that had the highest number of fruits followed by Volkameriana with significant differences.

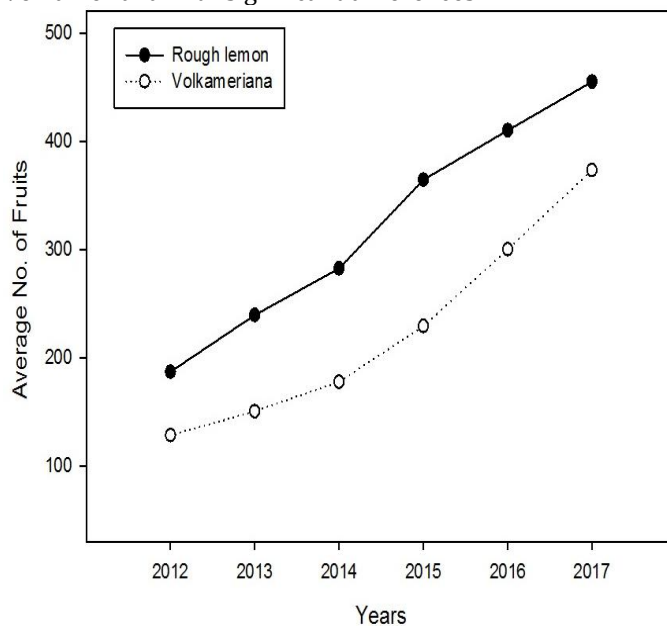


Figure 2: Number of fruits of Musambi (sweet orange) grafted on both rootstocks.

**Plant growth parameter: Height:** Rough lemon showed vigor plant growth and attained better height in the field during the years 2013-2014. While, the 'Volkameriana' plants had the lower height. In the last three years of the evaluation (2015-2017), plants of both rootstocks showed the same

behavior in terms of increase of height. Rough lemon showed lowest value 287.95 cm for 2017 as described in (Table 1). Qureshi *et al.* (1993) recorded similar results of variation in plant height in different sweet orange varieties. Similar results of these rootstocks for Clementine mandarin were also recorded by Georgiou (2002).

**Plant spread:** Plants spread in Rough lemon rootstock recorded the last evaluation was 416.10 (cm<sup>2</sup>) and Volkameriana 320.03 (cm<sup>2</sup>) according to data results of 2017 as depicted in (Table 1).

**Canopy volume:** Table 1 showed the plant canopy volume of 'Rough lemon' and 'Volkameriana' in which Rough lemon root stock showed maximum canopy volume 29.77 (cm<sup>3</sup>) and Volkameriana showed least plant canopy volume of 15.62 (cm<sup>3</sup>) in 2017.

**Scion and stock circumference:** Table 1 showed the scion and stock circumference respectively of 'Rough lemon' and 'Volkameriana' in which Rough lemon root stock showed maximum scion and stock circumference 43.35(cm<sup>2</sup>), 50.98

the 325.11 cm plant height while Volkameriana showed (cm<sup>2</sup>) while Volkameriana showed scion and stock circumferences 32.55(cm<sup>2</sup>), 40.35 (cm<sup>2</sup>) in 2017.

**Fruit quality:** The data for fruit quality was taken during the main harvest period in the years from 2012 to 2017. 'Rough lemon' and 'Volkameriana' gave the higher fruit weights (176.23 and 163.33 g), with statistical differences (Table 2). Furthermore, the root stocks with a higher TSS were 'rough lemon' with 10.51%, followed by 'Volkameriana' 9.43%. The results were corroborated with the findings of Khan *et al.* (2010), which showed significant variation in acidity levels in fruits of different sweet orange varieties. However, the acidity levels were variable showed significant differences between the rootstocks. In fruit size, 'Rough lemon' was on top (72.59 mm); while 'Volkameriana' (69.22 mm) and peel thickness 3.35 and 3.80 mm was recorded in rough lemon and Volkameriana respectively. Lastly, 'Rough lemon' had the fruits with the highest juice percent per fruit (46.56%) and the lowest juice percent was obtained by 'Volkameriana' (38.60%).

Table 1: Plant height (cm), Plant Spread (cm<sup>2</sup>), Plant canopy (cm<sup>3</sup>), Scion circumferences (cm<sup>2</sup>), Stock circumferences (cm<sup>2</sup>) of sweet orange grafted on two root stocks from 2008 to 2017.

Years	Root stock									
	Plant height (cm)		Plant Spread (cm <sup>2</sup> )		Plant canopy (cm <sup>3</sup> )		Scion circumferences (cm <sup>2</sup> )		Stock circumferences (cm <sup>2</sup> )	
	Rough Lemon	Volkameriana	Rough Lemon	Volkameriana	Rough Lemon	Volkameriana	Rough Lemon	Volkameriana	Rough Lemon	Volkameriana
2008	84 a	74.4 b	55.54 a	42.716 b	0.14 a	0.072 b	5.94 a	4.46 b	6.98 a	6.49 a
2009	100.8 a	89.28 b	66.64 a	51.259 b	0.24 a	0.13 b	7.12 a	5.35 b	8.38 a	7.28 a
2010	131.04 a	116.06 b	66.636 b	66.636 b	0.52 a	0.28 b	9.26 a	6.95 b	10.89 a	8.62 b
2011	180.83 a	160.16 b	119.56 a	91.95 b	1.37 a	0.72 b	14.64 a	10.99 b	17.21 a	13.63 b
2012	267.63 a	237.04 b	188.91 a	145.29 b	5.05 a	2.65 b	23.13 a	17.36 b	27.20 a	21.53 b
2013	289.05 a	256.01 b	224.80 a	172.90 b	7.72 a	4.05 b	29.60 a	22.23 b	34.82 a	27.56 b
2014	297.71 a	263.69 b	236.04 a	181.54 b	8.77 a	4.60 b	32.57 a	24.45 b	38.30 a	30.32 b
2015	300.69 a	266.33 b	306.86 a	236.01 b	14.97 a	7.85 b	35.82 a	26.90 b	42.13 a	33.35 b
2016	306.70 a	271.65 b	368.23 a	283.21 b	22 a	11.54 b	39.41 a	29.59 b	46.35 a	36.69 b
2017	325.11 a	287.95 b	416.10 a	320.03 b	29.77 a	15.62 b	43.35 a	32.55 b	50.98 a	40.35 b

Table 2: Fruit quality (average of six years 2012-2017) of sweet orange grafted on two root stocks.

Rootstock	Fruit weight (g)	Fruit size (mm)	Peel thickness (mm)	Juice %	TSS (%)	Acidity g/L
Rough Lemon	176.23 a	72.59 a	3.35 b	46.56 a	10.51 a	0.41 b
Volkameriana	163.33 b	69.22 b	3.80 a	38.60 b	9.43 b	0.46 a

Rough lemon root stock superseded the Volkameriana root stock in vegetative growth, fruit quality and yield parameters. Volkameriana attained a comparable average fruit weight of 163.33 g as compared to fruit from Rough Lemon (176.23g). The same results were recorded in fruit size (Diameter) as fruit from Volkameriana had diameter of 69.22 mm as compared to 72.59 mm in rough lemon which is quite comparable. Although fruit from Volkameriana had lesser juice percentage as In case of quality rough lemon had significantly better results than Volkameriana. The union of scion and stock are very

compared to rough lemon mainly due to thicker peel and more raga percentage.

Fruit obtained from Rough lemon has better juice percentage with better TSS value 10.51 as compare to 9.43 in case of fruit obtained from Volkameriana with higher acidity value of 0,46 as compared to 0.41 in Rough lemon. Fruit from Rough lemon also have a better taste and TSS/acid ratio indicating early maturity and overall acceptability as a fresh table fruit. important parameter for metabolic activity in plants to sustain each other. The scion and stock circumference of both

variants showed more degree of compatibility. The interaction between both rootstocks revealed that rough lemon has faster vegetative growth rate and Volkameriana rootstock exhibited poor growth rate for Musambi scion in Sargodha climatic conditions. Although fruit from Volkameriana had lesser juice percentage as compared to Rough Lemon mainly due to thicker peel and more rase percentage.

#### CONCLUSION

Rough lemon excelled in vegetative growth parameters considered in this study, however Volkameriana also thrived well showing good plant height and spread. Regarding fruit quality and yield, although Rough lemon superseded the Volkameriana but in various important parameters Volkameriana also attained reasonably good results. Volkameriana attained a comparable average fruit weight of 163.33g as compared to fruit from Rough Lemon.

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