

GRAFTED SWEET ORANGE [*CITRUS SINENSIS* (L.) OSBECK] INFLUENCED BY VARIABILITY IN WOODAPPLE [*FERONIA LIMONIA* (L.) SWINGLE] ROOTSTOCK.

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Abstract: Sweet orange [*Citrus sinensis* (L.) Osbeck] can be grown in the low-country dry zone as a grafted plant on woodapple rootstock. However, a wide variation in growth and fruit characteristics was observed in these plants. This experiment was therefore conducted to study the variability of sweet orange grafted onto woodapple [*Feronia limonia* (L.) Swingle] rootstock with special emphasis on fruit quality characteristics. The rootstock seedlings were sorted out into three groups based on length of spines. The growth rate and the intensity of pigmentation were higher in the longer spine rootstock group. Magnitude of growth difference at the bud-union, canopy size, fruit weight and cumulative fruit yield/year of the grafted plants were higher when long spine rootstock was used. However, the same group of rootstocks produced fruits with very poor skin quality, juice with low citric acid and low brix content. Improved citric acid, brix contents and fruit skin quality were observed in the orange plants grafted onto rootstock seedlings with short spines.

Key words: *Citrus sinensis*, grafting, rootstock variability, woodapple

INTRODUCTION

Sweet orange [*Citrus sinensis* (L.) Osbeck] grafted onto woodapple [*Feronia limonia* (L.) Swingle] rootstock has successfully adapted to the dry zone and shows a tendency to produce fruits year round.¹ Drought tolerance is considered advantageous to the upland rain-fed farming. However, it was found that enormous variability has occurred in fruit quality among the plants grafted onto woodapple even with scion taken from a single mother tree of orange.¹ Variability in woodapple rootstock plants may play a vital role in fruit quality and other growth characteristics in sweet orange plants grafted onto woodapple plants. Variability in latex yield was previously observed in monoclonal rubber grafted on rootstock seedlings cv Tjir-1^{2,3} and it was proposed that this could be due to variability in rootstock seedlings.⁴ The stock/scion ratio is the relative size of the rootstock and scion at the bud-union of the grafted plants. The ratio varied previously in grafts of sweet orange on woodapple and average stock/scion ratio became greater than one.¹ The differential growth at the bud-union was previously explained as incompatibility of the grafts.⁵ However, no attempt has been made so far to study the variability in sweet orange caused by

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woodapple rootstock. Therefore, this research was conducted to find out the effect of rootstock variability of woodapple on the variability of growth, yield and fruit quality in sweet orange.

METHODS AND MATERIALS

Raising woodapple seedlings: Fully ripened woodapple fruits were collected from several trees. Seeds were extracted by removing the pulp and washed thoroughly to remove all mucilage. Thereafter, the seeds were kept in shade for about 12 h taking precautions to avoid drying. Seeds were sown in a sand nursery. Watering was done twice a day so as to keep the sand wet until the seeds germinated. Copper oxychloride at a concentration of 25 g/12 l water was sprayed onto seedlings for control of fungal diseases. When they attained about 5 cm height they were transplanted in polyethylene bags of 15 cm width and 20 cm length filled with potting mixture of 1:1:1 sand : cattle manure : top soil. The plants were maintained in a greenhouse to receive uniform environmental conditions. Fertiliser mixture [16:20:12 (N:P₂O₅:K₂O)] was applied at the rate of 2 g per plant once in 4 wks. After six months of potting, woodapple seedlings were grouped as spine length of 20 ±4 (long), 10 ±2 (intermediate) and 4 ±1.5 (small) mm. Bud-wood was obtained from a healthy sweet orange var. Bibile sweet tree. Inverted 'T' budding was done.

Field establishment: The experiment was performed at the Regional Agricultural Research and Development Centre, Angunakolapelessa, where an average rainfall of 120 cm is received. Soil type of the area is reddish-brown earth (*Rhodustalfs*), with the depth varying from 0.8 to 1.6 m. Soil pH of the site ranges from 6.5 to 7.0. Planting holes of 45 x 45 x 45 cm were filled with compost. Grafts were planted in the field 2 m apart in March 1993. Three groups of woodapple seedlings (as mentioned above) were the treatments tested. Each treatment consisted of a single grafted plant. Number of replicates was 24. Treatments were laid out in a completely randomized design. The crop was maintained purely under rain-fed conditions. Fertilizer mixture [16:20:12 (N : P₂O₅ : K₂O)] was applied at the rate of 500 g/plant once every 6 months. The first flowers observed in February 1994 were removed since the plants were too young to bear fruits at this stage.

Data collection: The growth rate of the woodapple seedlings was measured as elongation rate during the 5th month after germination at weekly intervals. The pigmentation of the seedlings was recorded at the 5th month after germination by giving scores for the intensity of the pigments as follows: 1= no pigments; 2= light pink colour only in some parts of the seedling; 3=light pink colour in entire seedling; 4=dark pink colour in the entire seedling. The height and the radius of the canopy, circumference of stock and scion at the bud-union of the plants were recorded. Records were taken from the fruits harvested during the months of April to May in order to avoid variability in quality due

to seasonal effects. The peel appearance was measured visually giving scores for peel roughness (i.e., score 1 to 3 indicate soft peel and 4 to 5 indicate rough peel). Peel weight, fruit weight, number of fruits/plant/year, peel thickness, juice volume/fruit, brix value and acidity of the juice were also recorded. The peel/fruit ratio was computed by fruit weight and the corresponding peel weight. Growth, yield and fruit characteristics were measured in the years 1995 and 1996. A comparison was done at the significant level of 5% for each character measured in the years 1995 and 1996.

RESULTS

Variability in rootstock seedlings: The weekly elongation rate of the seedlings was 1.8 ± 0.2 , 3.0 ± 0.2 and 5.0 ± 0.4 cm in the short spine, intermediate spine and long spine seedlings groups respectively during the period of measurement. The scores of the pigmentation intensity in rootstock seedlings were 1.5 ± 0.03 , 2.3 ± 0.04 and 3.5 ± 0.04 in the short spine, intermediate spine and long spine seedling groups respectively .

Stock /scion ratio: The stock/scion ratio did not vary between the year 1995 and 1996 (Table 1). However, the ratio varied significantly between the grafts on short spine, intermediate spine and long spine rootstocks (Plates 1 & 2). The magnitude of the stock/scion ratio varied under different groups of rootstocks in the following order: short spine< intermediate spine< long spine.



Plate 1: Bud-union of the compatible graft of orange on woodapple.



Plate 2: Bud-union of the incompatible graft of orange on woodapple.

Growth characteristics: Canopy radius of the grafted plants varied significantly between three plant groups in both years (Table 1). However, canopy height of the grafted plants varied only in 1996 between the three groups. The variation of canopy radius and canopy height in different plant groups occurred in the following order: short spine < intermediate spine < long spine.

Fruit yield: The average fruit weight did not vary significantly between three groups (Table 1). The number of fruits/plant/year varied significantly between all three groups in 1995 and 1996 in the following order: short spine < intermediate spine < long spine (Table 1).

Fruit quality: The peel/fruit ratio did not vary significantly between the three plant groups (Table 1). However, peel thickness and peel appearance varied significantly between the three groups of plants in both years in the following order: short spine < intermediate spine < long spine (Table 1 and Plates 3 & 4). The percentage of the juice content in the fruit by fresh weight varied significantly only in 1996 having the greatest values only in the short spine plant group. However, brix value and the percentage of citric acid in juice varied significantly in the following order: long spine < intermediate spine < short-spine.

Table: Growth, yield and fruit quality characteristics in young orange plants grafted onto woodapple.

Characteristic	Rootstock group											
	Small spines			Intermediate spines			Long spines					
	1995	1996	1995	1995	1996	1996	1995	1996	1996	1995	1996	1996
Stock/scion	1.10±0.03	1.13±0.06	1.39±0.02	1.41±0.03	1.63±0.02	1.61±0.04						
Canopy height (cm)	81.90±5.40	85.50±4.40	95.60±4.90	102.60±4.60	105.50±6.10	118.60±0.04						
Canopy radius (cm)	60.00±2.80	70.00±2.60	77.60±2.70	82.60±3.00	82.70±3.70	93.50±3.30						
No. of fruits/plant/year	18.40±2.10	85.00±6.00	33.60±3.40	110.00±4.60	44.50±5.70	240.00±7.20						
Fruit weight (g)	197.80±19.70	191.00±21.20	217.00±10.90	338.00±32.00	265.60±18.60	360.70±25.30						
Peel/fruit ratio by F. Wt.	0.20±0.02	0.30±0.02	0.23±0.04	0.26±0.02	0.32±0.03	0.24±0.05						
Peel thickness (mm)	3.70±0.23	4.85±0.24	4.60±0.29	6.14±0.41	5.50±0.17	7.18±0.40						
Peel appearance*	2.00±0.17	1.60±0.18	3.00±0.21	3.14±0.38	4.00±0.20	4.20±0.26						
% of juice content **	0.28±0.04	0.42±0.05	0.29±0.03	0.21±0.03	0.24±0.03	0.20±0.02						
Brix value	Nd\$	8.8±0.32	Nd	7.5±0.31	Nd	6.8±0.28						
Acidity***	Nd	0.67±0.02	Nd	0.61±0.01	Nd	0.55±0.02						

± standard error of the mean; * 1: very soft, 2: soft, 3: normal, 4: rough, 5: very rough; ** % juice content in the fruit by dry weight basis; *** presented as % citric acid; \$ not determined.



Plate 3: Surface appearance of fruits in compatible graft.



Plate 4: Surface appearance of fruits in incompatible graft.

DISCUSSION

Growth rate and anthocyanin pigmentation were varied in woodapple rootstock seedlings. The growth rate and pigmentation were found to be positively related with the spine length of the woodapple seedlings. Woodapple is a cross pollinated crop⁶ and the presence of spine is one of the xerophytic characteristics of the plants that is an adaptation to adverse climates.⁷ The variability of the seedlings may be of the result from segregation of the heterozygous mother plants from which the seeds are extracted.

Stock/scion ratio of the grafted plants was related to the type of woodapple rootstock used. The ratio was higher when the spine length was higher in stock seedlings. This could be due to high growth rate of the long spine rootstock seedlings causing unequal growth rates of stock and scion tissues at the bud-union. Compatibility was explained as equalisation of radial growth rate of rootstock and scion at the bud union.^{8,9} Therefore, the unequal growth at the bud-union in the grafted plants is a sign of incompatibility. Despite the incompatibility indicated in the grafted plants under long spine rootstock group, their canopy radius, canopy height and cumulative fruit yield per year were greater than those in the short or intermediate spine groups. Consistently, canopy volume of grapefruit was influenced by the rootstock used for grafting¹⁰ and also the latex yield in grafted rubber was influenced by the vigour of the rootstock seedlings.^{3,4} Therefore, the development of large canopy and the high yield in grafted sweet orange on long spine woodapple rootstock could be due to its higher vigour.

Variability in fruit peel qualities of orange grafted onto woodapple has also been noted previously.¹¹ It was revealed that significant variability exists in orange peel qualities when grafted onto different citrus rootstocks.^{11,12} Moreover, peel quality was also determined by rootstock and seasonal interactions.⁹ However, peel and fruit qualities were measured from April to May in the present study. Therefore, occurrence of the rough and thick peel qualities could be due to high vigour of the long spine rootstock not compatible with growth of sweet orange scion. The soft and thin peel qualities of orange may be brought about by the low vigour of the short spine rootstocks which is compatible with the growth of orange scion. The juice volume of the fruit of orange varied in a previous study when different citrus rootstocks were used for grafting orange.¹¹⁻¹³ Therefore, high juice volume, high brix content and high citric acid content in orange fruits on short spine rootstocks may be due to the influence of the short spine rootstocks and their compatibility with orange scion.

The results suggest that selection of woodapple rootstock seedlings in the nursery for grafting of sweet orange will be useful for production of good quality sweet orange fruits. The presence of short or no visible spines and the

absence of anthocyanin pigmentation on the woodapple seedlings are preferable for selecting rootstocks. A reduction in the canopy volume in grafted plants by selection of such rootstock seedlings can be compensated by increasing the plant density in the cultivation.

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