PERFORMANCE OF SWEET ORANGE GRAFTED ONTO WOODAPPLE ROOTSTOCK IN LOW COUNTRY DRY ZONE OF SRI LANKA

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ABSTRACT

Orange (*Citrus sinensis* (L) Osbeck) was bud-grafted on woodapple (*Feronia limonia* (L) Swingle) rootstock to evaluate the scion-stock compatibility and to asses the ability to withstand moisture stress. The grafted and seedling plants were tested in the field for seven years under rainfed condition in the low country dry zone. In comparison to seedling plants, grafted plants did not suffer due to moisture stress during the dry periods of the year. Fruit bearing occurred in grafted plants as early as nine months after grafting, but this varied between the plants until 21 months. The flowering in seedling plants occurred after five years of transplanting. Profuse fruit sets were produced in grafted plants several times a year. The quality of the fruit juice was superior in grafted plants than in seedling oranges. However, surface appearance of the oranges in grafted plants was not as smooth as oranges obtained from seedling plants. It was also observed that grafted plants became unproductive after seven years of grafting.

KEY WORDS: Fruit quality, Rootstock, Sweet orange, Woodapple

INTRODUCTION

In the dry zone of Sri Lanka, the effective monsoon rains terminate by the end of December and citrus flowers during late January when there is a good supply of residual soil moisture. However, with the depletion of soil moisture, plants are subjected to water stress during the period from early January to late March. The probability of rains during this period is very low (Panabokke and Walgama, 1974) which coincides with the critical period of fruit enlargement and maturity. In the absence of supplementary irrigation, the bulk of the fruit load is shed and the quality of the remaining fruits is impaired. During the seasons of severe water stress even whole plant begins to die off. The major limitation for successful cultivation of the citrus in the dry zone is lack of soil moisture. Therefore, the objective of this paper is to

report on the possibility of grafting orange on woodapple rootstock and performance of the grafted plants under rainfed conditions in the dry zone.

MATERIALS AND METHODS

The orange and woodapple seedlings were raised in the experimental field randomly, spaced at 3m×3m at the Regional Agricultural Research Centre, Angunakolapelessa (16° N latitude, 81° E longitude and 30m elevation). Fifty seedlings each of woodapple and orange were raised. When the woodapple seedlings reached the size of 5—6mm diameter they were bud-grafted with orange scions obtained from a productive mother plant. Both seedlings and grafted orange plants were managed under uniform management conditions for comparison. All the plants were fertilized with the mixture of 16—20—12 ($N:P_2O_5:K_2O$) which is recommended by the Department of Agriculture, Sri Lanka for citrus plants. Each plant was fertilized at the rate of 250g per year. Application of fertilizer was done with the two rainy spells during South-West monsoon (April to June) and North-East monsoon (September to December). The plants were raised purely under rainfed condition and weeding was done manually.

The growth rate of the plants was measured in terms of shoot elongation rate. The measurements taken during 1983, 1985 and 1987 were averaged separately to calculate mean shoot elongation rate for each year. The width of the third leaf from the top of the aerial branch was also measured during the same periods as above in each plant to compare leaf expansion rate. The moisture content of the bulk samples of fully mature leaves was measured in each month of 1983, 1985 and 1987 in comparison to soil moisture content at 22.5cm depth from the surface. For measurement of leaf water content harvested leaves were sun-dried after taking fresh weight. Moisture content was expressed as percentage on wet weight basis. Soil samples were taken from twenty random locations in the field, once a week and dried in an oven at 105°C for three days. The mean soil moisture content for each month was calculated (% dry weight basis) from measurements taken during each month.

The flowering was recorded in each plant to assess the time taken for initial flowering. After the initial flowering, number of flowers and harvested fruits per plant were recorded in each month. The cumulative yield per plant per year was then calculated.

The plant height and total number of branches were recorded at three-month intervals in 1983, 1985 and 1987 with the development of plants. The canopy radius of the plant was measured from four different directions of the plant and mean canopy radius was then calculated.

The stem girth in the rootstock and in the orange scion at the bud-union of the grafted plants as well as the stem girth at 2.5 cm above the ground level of the seedling orange plants were recorded for four years (1981, 1983, 1985 and 1987) to compare enlargement of the rootstock, scion and the normal seedling orange stem.

Leaf analysis for Mg, Mn, Zn and Fe was performed in the third leaf from top of five seedling plants and five grafted plants selected randomly, by sealed digestion method of atomic absorption spectroscopy.

Peel thickness of the orange fruit was measured with a micrometer after peeling out the oranges. The quality of the orange juice was measured in comparison to the orange produced on seedling plants. The quality parameters that have been measured were as follows: juice volume, pulp/juice ratio, brix value, pH, invert sugar content, acidity on citric acid basis and sugar/acid ratio.

RESULTS AND DISCUSSION

The growth rate of the plants measured as shoot elongation rate and the width of the third leaf from the top of aerial shoot were greater in grafted plants than in seedling orange plants (Table 1). The higher rate of growth measured in grafted plants could be due to the greater supply of water and nutrients from the deeper layer of the soil by the deep root system of the woodapple rootstock. Higher number of branches and large canopy radius were measured in grafted plants compared to seedling plants. However, height of the grafted plants was lower than that of the seedling plants (Table 1). The dwarf nature

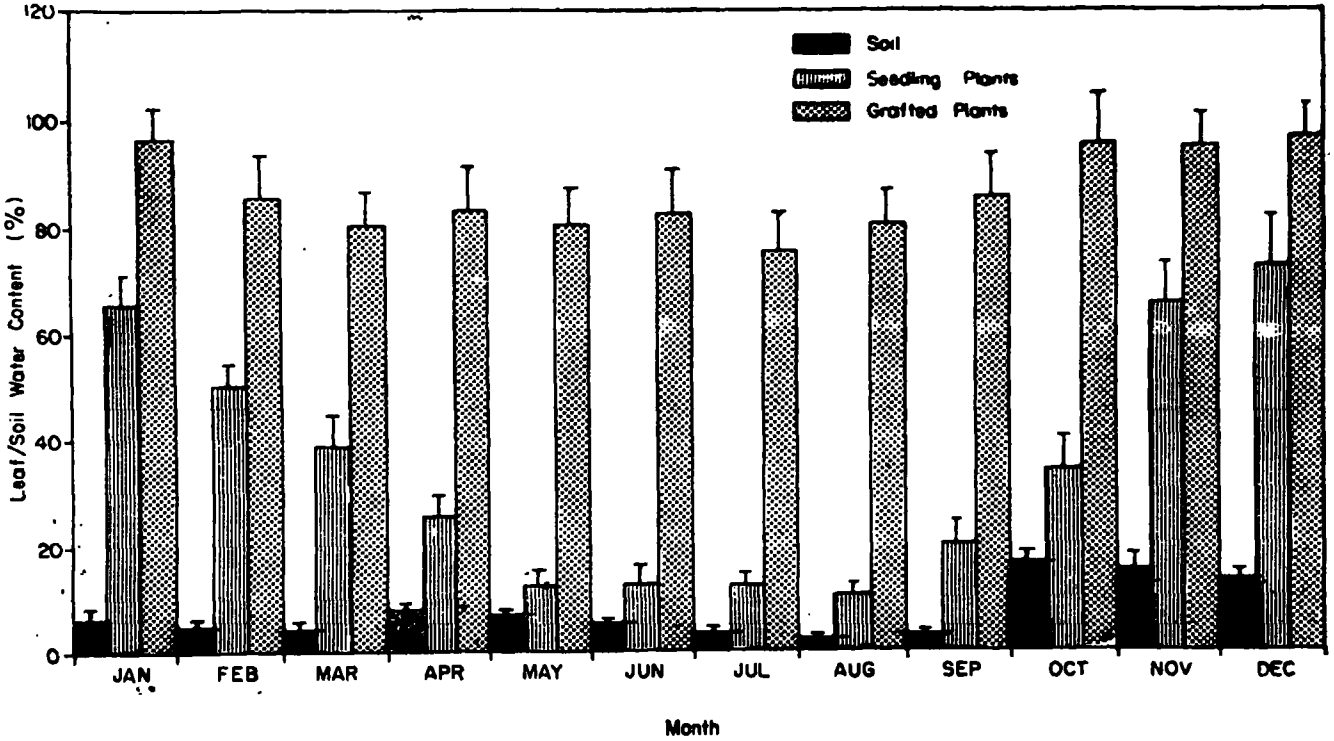


Fig. 1. Fluctuation of water content in orange plants during the year in relation to fluctuating soil moisture content at 22.5 cm depth. Error bar indicates SED of the means.

of grafted plants was reported in a study where four cultivars of mandarin orange were grafted onto four different rootstocks, viz. rough lemon, *Poncirus trifoliata*, Troyer citrange and Cleopatra mandarin; all grafts showed dwarfness, the least being in the graft with rough lemon rootstock (Devadas *et al.*, 1988). However, Fallahi *et al.* (1991) observed small canopy volume in Orlando tangelo trees on rough lemon rootstock. Therefore, these results suggest that dwarfing character in orange grafted onto woodapple rootstock may be due to the interaction effect between orange scion and woodapple rootstock. The high canopy area which comprised higher number of branches could be due to activation of lateral buds for growth resulting from the greater supply of water and nutrients from woodapple rootstock.

The moisture content in mature leaves was greater in grafted plants than in seedling plants throughout the year. On the other hand, leaf water content did not vary with the varying moisture content in the soil measured at 22.5cm below the soil surface. However, in seedling orange plants, leaf water content was reduced with the depletion of soil moisture content at the 22.5cm depth of the soil during the dry period of the year (Fig. 1). Albrigo (1977) also found increased plant water potential in Valencia orange leaves grafted onto rough lemon rootstock. Therefore, this high leaf water content is due to the fact that grafted plants take up moisture from the deep soil layers and hence fluctuation of moisture content in surface layers does not affect the water uptake. However, due to occurrence of shallow roots in seedling plants water uptake is suppressed with the lowering of the moisture content in the surface layers of the soil.

The stem enlargement of orange measured as stem circumference at the bud-union in grafted plants was greater than the stem circumference of the seedling orange plants measured at 2.5cm above the ground level (Fig. 2). The enlargement of the woodapple rootstock was approximately similar to the orange scion in the bud-union at early stage of growth. However, enlargement of rootstock was found to be greater than the orange scion during the late stage (at seven years) of development (Fig. 3). These results suggest that growth of orange scion and the rootstock at later stage is not similar. This may be due to expression of different growth rates in scion and the rootstock.

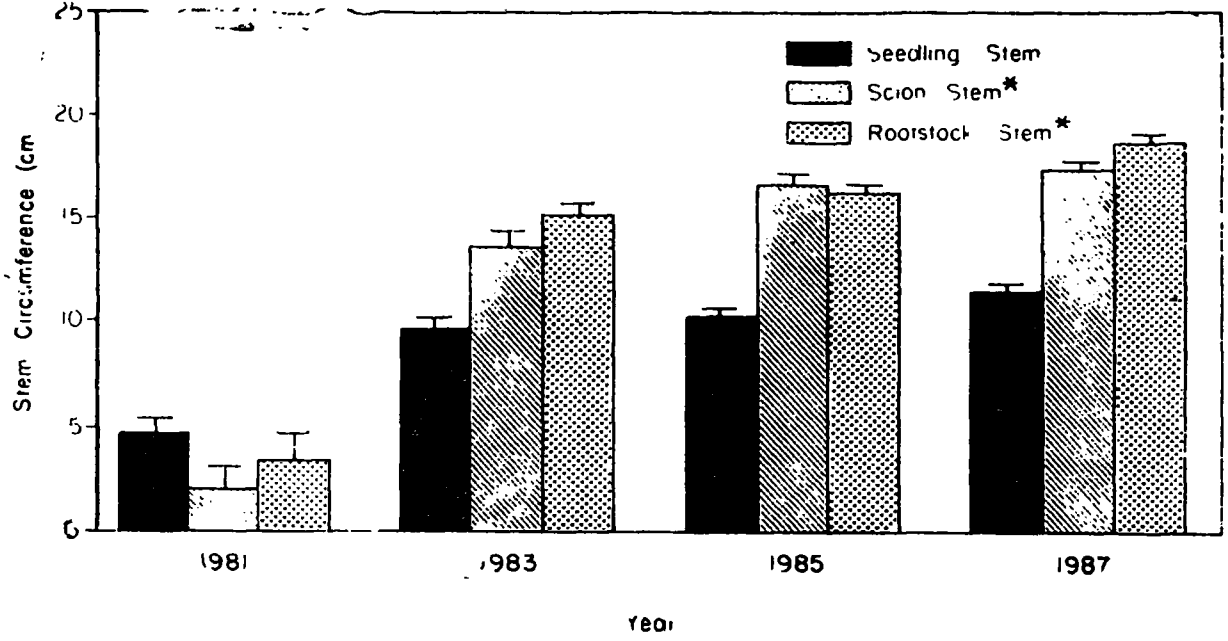


Fig. 2. Enlargement of seedling stem, scion stem and rootstock stem. * in grafted plants. Error bar indicates SED of the means.

Some of the grafted plants came to flower as early as nine months after grafting. However, it required 21 months to have flower in all the grafted plants. The early bearing of the grafted plants could be because buds were taken from mature plants for grafting in this experiment. Haleem (1984) too observed early bearing in grafted plants when buds were taken from mature plants. The variability of the flowering age between the grafted plants could presumably be due to the variability of the woodapple rootstocks. The seedling plants came to flower at the fifth year of development since physiological maturity to attain the required C/N ratio for flowering occurs in these plants only after five years of growth.

The fruit bearing habit in grafted plants was different from the seedling orange plants. Most of the grafted plants produced fruits throughout the year (Fig. 3) whereas only a few seedling plants produced fruits and that too only during April to June. This could occur due to the abundant supply of moisture and nutrients to the grafted plants throughout the year from the deeper layers of soil. The seedling plants could not get adequate moisture and nutrients for the attainment of the required C/N ratio for flowering due to absence of deep root system.

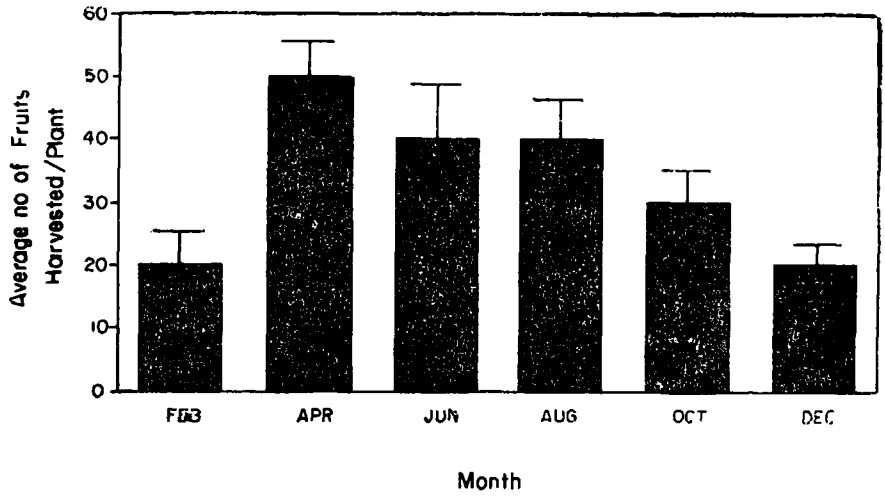


Fig. 3. Fruit bearing pattern in grafted orange plant during the year (mean of 1983, 1985 and 1987 values). Error bar indicates SED of the means.

The Mg, Mn, Zn, and Fe contents in young leaves of grafted orange were greater than those in the seedling orange plants (Table 1). Higher micro-elements in leaves have been correlated with the vigour of the rootstock (Mehrotra and Jawanda, 1983). Aso *et al.* (1978) also found increased micro and macro elements in leaves of lemon grafted on deep-rooted citrus rootstocks. Therefore, the occurrence of higher amount of Mg, Mn, Zn and Fe in grafted plants could be due to the greater vigour in woodapple rootstock.

Table 1. Growth, yield and status of some nutrient elements in orange plants

Characteristic	*Seedling plants*			*Grafted plants*		
	Year			*Year*		
	1983	*1985*	*1987*	*1983*	*1985*	*1987*
Shoot elongation rate (cm/day)	0.44 (±0.06)	0.38 (±0.08)	0.40 (±0.10)	0.81 (±0.08)	0.90 (±0.08)	0.71 (±0.10)
Total no. of branches	3.60 (±0.3)	3.80 (±0.2)	4.00 (±0.3)	4.80 (±0.3)	5.00 (±0.2)	7.00 (±0.2)
Leaf width (cm)	4.80 (±0.2)	4.70 (±0.5)	3.80 (±0.4)	6.30 (±0.3)	6.40 (±0.3)	6.40 (±0.4)
Canopy radius (cm)	38 (±3)	40 (±4)	42 (±7)	53 (±4)	63 (±3)	70 (±5)
Plant height (cm)	165 (±7)	190 (±5)	280 (±12)	149 (±4)	170 (±5)	182 (±16)
Average fruit yield/plant	** —	20 (±5)	40 (±8)	120 (±11)	350 (±30)	140 (±28)
Leaf nutrient element content*						
Mg (%)	0.66 (±0.11)	0.78 (±0.10)	0.70 (±0.12)	0.73 (±0.09)	0.75 (±0.11)	0.64 (±0.13)
Mn (ppm)	49 (±22)	42 (±12)	51 (±14)	114 (±18)	140 (±17)	105 (±23)
Zn (ppm)	35 (±3)	33 (±4)	38 (±5)	47 (±2)	48 (±3)	52 (±4)
Fe (ppm)	981 (±40)	910 (±34)	1002 (±41)	1402 (±34)	1500 (±33)	1307 (±43)

*Dry weight basis. **Plants did not start flowering. Each value is the mean of fifty readings except the values presented for nutrient elements in which five values were averaged. SE of the mean in each value is given in brackets.

The average fruit yield in grafted plants was always higher than that in seedling orange plants (Table 1). This could occur due to greater supply of moisture and nutrients for the enlargement of fruits. The low yields in seedling plants may be attributed to the water stress during most part of the year. The fruits produced on some of the grafted plants appeared rough on the skin whereas all the seedling oranges were smooth and shiny on the fruit surface indicating that there was no variability between orange scions since they were obtained from the same mother plant for this experiment. Therefore, this variability could be due to the effect of the rootstocks. The peel thickness of the fruits (5.0 ± 1.0 mm) produced on grafted plants was greater than those in the seedling plants (2.8 ± 1.0 mm). Further studies are needed to explain these differences.

The juice volume per fruit, brix value, pH, invert sugar and sugar : acid ratio were higher in oranges produced on grafted plants than those in seedling plants (Table 2). George (1932) observed that percentage juice and sugar content on fresh weight basis in oranges were influenced by the rootstock. Deidda and Milella (1978) also observed variation of fruit quality in the range of citruses when grafted on different citrus rootstocks. Therefore, greater juice volume and high sugar content in grafted oranges observed in this experiment could

Table 2. Quality evaluation of orange fruits

Quality parameter	*Orange from seedling plants*	*Orange from grafted plants*
Colour of the pelides	Yellow group 12c	Yellow group 11a
Flavour	Moderately sweet; acidic	Sweet; no acidic flavour
Juice volume (ml/per fruit)	43	115
Brix value	9	9
pH	3.8	4.0
Invert sugar (g/100g juice)	2.7	3.2
Acidity on citric acid (g/100ml juice)	0.8	0.7
Sugar acid ratio	3.4	4.6
Pulp juice ratio	2.3	1.6

Each value is the mean of five values taken from fruits of five different plants

also be due to the effect of woodapple rootstocks. After seven years of grafting, plants turned yellow and became unproductive; some of the grafted plants were completely dead possibly due to the reduction of water and nutrient transport in these plants.

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