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Effect of different rootstocks on growth, leaf sclerophylly and chlorophyll fractions of Kinnow mandarin

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ABSTRACT

A study was undertaken to evaluate growth performance, leaf sclerophylly and chlorophyll content of Kinnow mandarin budded on different rootstocks. In the pre-bearing stage, the magnitude of vegetative growth revealed stimulated increase during April-September compared to September-December. The vegetative growth of Kinnow on *Jatti khatti* was better in terms of per cent increase in plant height, plant spread and canopy volume. Reduced vegetative growth was observed in Kinnow trees on Troyer citrange rootstock. Maximum increment in scion (88.37%) and root diameter (83.64%) was recorded on *Jatti khatti* between April-September. Congenial relationship was observed between scion and rootstock and had mean values for this relationship close to 1.0. Leaf sclerophylly studies exhibited higher leaf area (166.24 cm^2), fresh mass (4.36 g) and dry matter (1.85 g) on *Jatti khatti* with higher density of foliar tissue (433.70 g^{-1} kg) on *Karna khatta*. Minimum leaf area (85.07 cm^2), fresh mass (2.50 g) and dry matter (0.92 g) was recorded on rough lemon, but leaves were significantly more succulent. Chlorophyll fractions, *viz*., Chlorophyll '*a*' (1.60 mg g^{-1} FW), total chlorophyll (1.87 mg g^{-1} FW) and chlorophyll *a:b* (6.20) were significantly higher in leaf of Kinnow on rough lemon and minimum on Carrizo citrange rootstock.

Key words: Chlorophyll, Kinnow, growth, leaf sclerophylly, rootstock.

INTRODUCTION

Kinnow mandarin cultivation is being successfully done in the arid and semi-arid tracts of the Indian subcontinent. Due to higher productivity per unit area and consumers preference, its cultivation in the recent past has also extended to non-traditional areas, such as national capital regions of Delhi, Haryana, U.P., M.P., Chhattisgarh *etc*. The rootstocks commonly used for raising Kinnow mandarin is *Jatti khatti*. The monopolised cultivation of Kinnow on *Jatti khatti* however, cannot be considered as an ideal rootstock for all set of agro-climatic conditions. Even in the traditional areas, diversification in rootstock is essential keeping in view the climate change, biotic and abiotic stresses. The significance of rootstock in citrus industry needs no emphasis, because rootstocks have perhaps contributed more than any factors to the success or failure of citrus orcharding. Several studies have indicated profound influence of rootstocks on scion cultivars including plant stature, physiological parameters, yield and leaf level nutrients (Aviles *et al*., 1; Awasthi *et al*., 2; Goswami *et al*., 4; Sharma *et al*., 9). Given that the rootstocks are unlike genotypes and may modify growth and other growth related parameters, the present study was aimed to evaluate the effect of different rootstocks on Kinnow tree growth and also to understand the variations in leaf sclerophylly and chlorophyll fractions due to rootstocks in a pre-bearing three-year-old orchard of Kinnow.

MATERIALS AND METHODS

The present work was carried out during 2014-2015 at the Division of Fruits and Horticultural Technology, ICAR-IARI, New Delhi (77°12' E longitude, 28°40'N latitude, 228.6 m asl). The climate is categorized as semi-arid, sub-tropical with hot dry summer (41-44°C) and cold winter (3-7°C). The average annual rainfall during the period of experimentation was 719 mm and more than 60% rainfall received during July, August and September. Plant materials for the experiment consisted of three-year-old non-bearing plants of Kinnow budded on seven rootstocks, *viz*., rough lemon (*Citrus jambhiri* Lush.), *Karna khatta* (*Citrus karna* Raf.), Carrizo citrange (*Citrus sinensis* [L.] Osb. × *Poncirus trifoliata* [L.] Raf.), Rangpur lime (*Citrus limonia* [L] Osb.), Troyer citrange (*Citrus sinensis* [L.] Osb. × *Poncirus trifoliata* (L.) Raf.], *Jatti khatti* (*Citrus jambhiri* Lush.) and sour orange (*Citrus aurantium* L.). The budded plants were planted during the year 2011. Plant growth in terms of plant height (m), stock diameter (mm), scion diameter (mm) and canopy volume (m^3) were recorded two months after the emergence of spring (February), rainy (July) and autumn (October) season flush, *i.e*., April, September and December.

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Plant height was determined by measuring the distance from the ground to the top of the plant with the help of measuring scale. Plant spread [N-S (D1)] and [E-W (Dr)] was recorded with the help of metre scale and canopy volume (V) was determined from individual measurements of tree height (H) and width in parallel (D1) and perpendicular (Dr) by the formulae V = (π/6) × H × D1 × Dr (Zekri, 11). Scion diameter was taken at fixed height 10 cm above the graft union and trunk diameter 10 cm below the graft union. The positions were marked with black paint for recurrent observations. The scion: rootstock ratio was calculated by dividing the scion value with rootstock value. The data recorded on different vegetative parameters were compared in terms of per cent increase by calculating the growth difference between September-April and December-September. Observation on leaf sclerophlly was taken using ten mature leaves from rainy season (August) flush, collected from Kinnow trees grown on different rootstocks during October. The parameters examined were leaf area (LA), using a LI-COR, LI 3100 area meter (LI-COR, USA), fresh mass (FM) and dry mass (DM) per leaf. The leaves were weighed immediately after harvest to determine their fresh mass. The leaves were then oven dried at 70°C for 48 h and their dry mass was determined. Several indices of leaf physiological parameters were calculated by the formulae suggested by Ennajeh *et al*. (3). These included Specific leaf area (SLA = LA/DM: in $cm^2 g^{-1}$ DW), specific leaf weight (SLW = DW/LA: in g cm^2 LA), density of foliar tissue (D = DW/FW × 1000: in g kg^{-1}) and succulency [S = (FW-DW)/LA: in mg H_2O cm^{-2}. The leaf chlorophyll content (chlorophyll *a*, *b* and total ll) were extracted from leaves collected during September and determined the following the method suggested by Hiscox and Israelstam (5). The experiment was conducted in randomised block design with four replications. Data for all the parameters were subjected to analysis using statistical analysis system software (SAS version 9.3).

RESULTS AND DISCUSSION

Rootstock influenced the growth behaviour of Kinnow significantly (P≤ 0.05). Irrespective of rootstock, the overall per cent increase in the growth parameters, *i.e.,* plant height, canopy spread and canopy volume was more between April-September as compared to the period between September-December (Table 1). The difference in plant height between April-September and September-December revealed that Kinnow trees on *Jatti khatti* was most vigorous thus exhibiting an increase of 49.42 and 20.83%, respectively, followed by rough lemon rootstock, which recorded an increase of 44.45 and 19.0% between the said period. Minimum increase in the plant height between April-September (12.31%) and September-December (2.76%) was recorded in trees on Troyer citrange. Similar to plant height, per cent increase in canopy volume was also significantly higher on *Jatti khatti* during both the periods, while it was minimum in trees on Troyer rootstock. The findings of the present study clearly suggest the differential response of the rootstock on the scion variety may be due to the inherent genetic character of the rootstocks. In the present study, *Jatti khatti* and rough lemon (both *Citrus jambhiri*) showed its superiority in terms of plant height including enhanced canopy volume of Kinnow on *Jatti khatti* rootstock over other rootstocks, thus indicating their well adapted nature to soil conditions with efficient root system that might have resulted in higher accumulation of nutrients. Reduced growth

Table 1. Seasonal increase in plant height, canopy spread and canopy volume of Kinnow mandarin budded on different rootstocks.

Rootstock	Plant height (%)		Canopy spread (%)				Canopy volume (%)	
	Rainy	Winter	Rainy Winter (N-S)		Rainy Winter (E-W)		Rainy (N-S)	Winter (E-W)
Rough lemon	44.45[b]	19.00[a]	51.07[c]	9.52[c]	47.10[dc]	9.23[d]	222.56[c]	42.36[d]
Karna khatta	16.26[e]	5.80[cb]	39.77[d]	23.07[a]	35.20[e]	21.43[b]	119.75[f]	58.10[b]
Carrizo citrange	23.49[d]	19.14[a]	54.35[c]	16.36[b]	51.23[c]	16.86[cb]	188.30[d]	61.97[b]
Rangpur lime	35.32[c]	7.17[b]	63.87[b]	6.40[c]	64.32[b]	7.56[d]	264.71[b]	22.66[e]
Troyer citrange	12.31[e]	2.76[c]	54.06[c]	6.94[c]	44.55[d]	6.71[d]	150.09[e]	17.27[f]
Jatti khatti	49.42[a]	20.83[a]	73.62[a]	29.25[a]	70.82[a]	31.47[a]	341.58[a]	105.58[a]
Sour orange	24.04[d]	19.50[a]	64.21[b]	12.08[cb]	60.19[b]	12.22[cd]	226.73[c]	50.33[c]
LSD (P ≤ 0.05)	4.06	3.06	4.84	6.23	5.27	6.83	7.14	4.61

attributes in Kinnow trees on Troyer rootstock may be due to the weak nutrient accumulating behaviour of rootstock and higher accumulation of phenol content in the scion leaf which might have imparted low vigour to the scion variety. Variation in growth parameters of Kinnow due to rootstocks have also been reported earlier by Josan and Thatai (6) and Goswami *et al.* (4).

Scion and rootstock diameter equilibrium is very important for the compatibility of rootstocks with the scion. Significant differences were recorded with respect to the cumulated percentage increase in scion and root diameter during rainy (July) and autumn (October) over the summer (April) and rainy season (July) growth (Table 2). Maximum increment in scion (88.37%) and root diameter (83.64%) was recorded in *Jatti khatti* followed by Kinnow trees on Rangpur lime rootstock (76.06 and 73.70%, respectively) during April-September. Minimum increase in the scion (23.48%) and root (21.83%) diameter was recorded in Kinnow trees on Carrizo rootstock, which did not differ significantly with the trees on rough lemon. Contrary to the minimum increase in the scion and rootstock diameter on these rootstocks during September, it was maximum during December with a higher increase in the scion (8.89%) and root diameter (8.71%) in trees on rough lemon, followed by Kinnow trees on Carrizo rootstock. Although, significant differences in the scion and rootstock diameter was observed during different growth periods, the relationship between the scion and rootstock diameter above and below the budding line did not reflect any sign of incompatibility. Plants budded on different rootstocks had mean values for this relationship closest to 1.0, which is an ideal indication of congenial relationship.

The rootstock influence resulted in quite significant difference in the leaf sclerophylly parameters of Kinnow (Table 3). Kinnow trees budded on *Jatti khatti* rootstock exhibited higher leaf area (166.24 cm^2) and leaf fresh mass (4.36 g) followed by leaf area (147.72 cm^2) and leaf fresh mass (4.01 g) on sour orange rootstock. The minimum leaf area (85.07 cm^2) and fresh mass (2.50 g) was measured in scion leaf of Kinnow on rough lemon. Leaf dry matter was higher in Kinnow leaves on *Jatti khatti* (1.85 g) rootstock, while it was minimum (0.92 g) on rough lemon and Troyer citrange (1.05 g). Highest SLA (0.013 cm^2/g) was measured in Kinnow leaves on *Karna khatta* rootstock, followed by rough lemon and sour orange (0.011 cm^2/g) but the difference was not significant. SLW was recorded maximum (104.31 g/ cm^2) and minimum (92.39 g/cm^2) in Kinnow leaf on Carrizo and rough lemon respectively. Comparative study with respect to density of foliar tissue revealed higher density of foliar tissues (DFT) in scion leaf of Kinnow on *Karna khatta* rootstock (433.70 g/kg^{-1}) followed by *Jatti khatti* and sour orange rootstocks with similar statistical values. Minimum DFT was recorded in scion leaf of Kinnow on rough lemon and Carrizo rootstocks without any significant difference. Although leaf area, leaf fresh mass and dry matter was minimum in Kinnow leaf on rough lemon rootstock, leaf succulency (0.018 mg H_2O/cm^{-2}) was significantly higher on the said rootstock followed by leaf succulency (0.017 mg H_2O/cm^{-2}) in leaf of Kinnow on *Karna khatta*.

In the present study, higher leaf area and fresh mass in scion leaf of Kinnow on *Jatti khatti* and sour orange rootstock may be attributed to higher leaf area, thus accumulating moisture in proportion to the leaf area and *vice-versa* resulting in lower fresh mass of Kinnow leaves on rough lemon rootstock. It is interesting to note that although the leaf area was lower in Kinnow leaves on rough lemon rootstock, leaf succulency was significantly higher in leaves of Kinnow on *Jatti khatti* and sour orange rootstocks. The

Table 2. Seasonal increase in scion diameter, root diameter and scion/ stock ratio of Kinnow mandarin budded on different rootstocks.

Rootstock	Scion dia. (%)		Root dia. (%)		Scion/stock ratio	
	Rainy	Winter	Rainy	Winter	Rainy	Winter
Rough lemon	24.52^e	8.89^a	20.49^e	8.71^a	1.17^a	1.02^b
Karna khatta	64.39^c	2.15^{dc}	62.17^c	2.17^{dc}	1.03^a	0.98^b
Carrizo citrange	23.48^e	5.28^b	21.83^e	5.26^b	1.08^a	1.00^b
Rangpur lime	76.06^b	1.54^{de}	73.70^b	1.57^e	1.03^a	0.98^b
Troyer citrange	47.33^d	2.47^c	45.28^d	2.55^c	1.04^a	0.97^b
Jatti khatti	88.37^a	1.97^{dce}	83.64^a	1.79^{de}	1.05^a	0.98^b
Sour orange	23.48^e	1.36^e	58.58^c	1.38^e	1.11^a	0.98^b
LSD ($P \leq 0.05$)	7.25	0.63	5.41	0.56	0.15	0.05

Table 3. Leaf Sclerophylly characteristics of Kinnow mandarin budded on different rootstocks.

Rootstock	Leaf area (cm^2)	Fresh mass (g)	Dry matter (g)	SLA (cm^2/g)	SLW (g/cm^2)	DFT (g/kg^{-1})	Succulency ($mg\ H_2O/cm^2$)
Rough lemon	85.07^f	2.50^f	0.92^f	0.011^b	92.39^d	367.28^d	0.018^a
Karna khatta	139.14^c	4.25^a	1.72^b	0.013^a	75.47^e	433.70^a	0.017^b
Carrizo citrange	143.02^{cb}	3.79^c	1.37^d	0.010^c	104.31^a	361.95^d	0.017^{cb}
Rangpur lime	122.55^d	3.38^d	1.29^d	0.010^{cb}	94.59^{cd}	383.72^c	0.016^{cb}
Troyer citrange	104.03^e	2.72^e	1.05^e	0.010^c	98.77^b	387.07^c	0.016^c
Jatti khatti	166.24^a	4.36^a	1.85^a	0.010^c	96.62^{cb}	394.49^b	0.016^c
Sour orange	147.72^b	4.01^b	1.60^c	0.011^b	92.28^d	398.69^b	0.016^{cb}
LSD ($P \leq 0.05$)	6.24	0.17	0.079	0.006	3.58	5.76	0.001

observation suggests anatomical modification, which might have been imparted by the rootstock. Higher leaf succulence also suggests the maintenance of high relative water content (RWC). Scion leaf of Kinnow on *Karna khatta* had the highest density of foliar tissue, which might be due to the thick cuticle layer. It is possible that leaves with high tissue density are able to survive a severe drought because of higher resistance to physical damage by desiccation (Mediavilla *et al.*, 8).

Rootstock impact on chlorophyll fraction of Kinnow leaves was found significant (Fig. 1). Irrespective of rootstocks, chlorophyll *a* concentration was higher than chlorophyll *b* in Kinnow leaves on different rootstocks. Leaves of shoots budded on to rough lemon rootstock had the highest chlorophyll *a* (1.60 mg g^{-1} FW), total chlorophyll (1.87 mg g^{-1} FW) and chlorophyll *a:b* ratio (6.20) with similar trend in Kinnow leaves budded on sour orange rootstock. Leaves of shoots budded on to Carrizo rootstock had the lowest chlorophyll concentration and as compared to the maximum value recorded on rough lemon rootstock chlorophyll *a*, total chlorophyll and chlorophyll *a:b* ratio was reduced by 43.12, 35.82 and 49.03 per cent, respectively. Higher amount of chlorophyll fraction *a*, total chlorophyll and chlorophyll *a*:*b* ratio in scion leaf of Kinnow on rough lemon and sour orange rootstock may be due to effective absorption of micronutrients like Fe, because Fe is an important cofactor of many

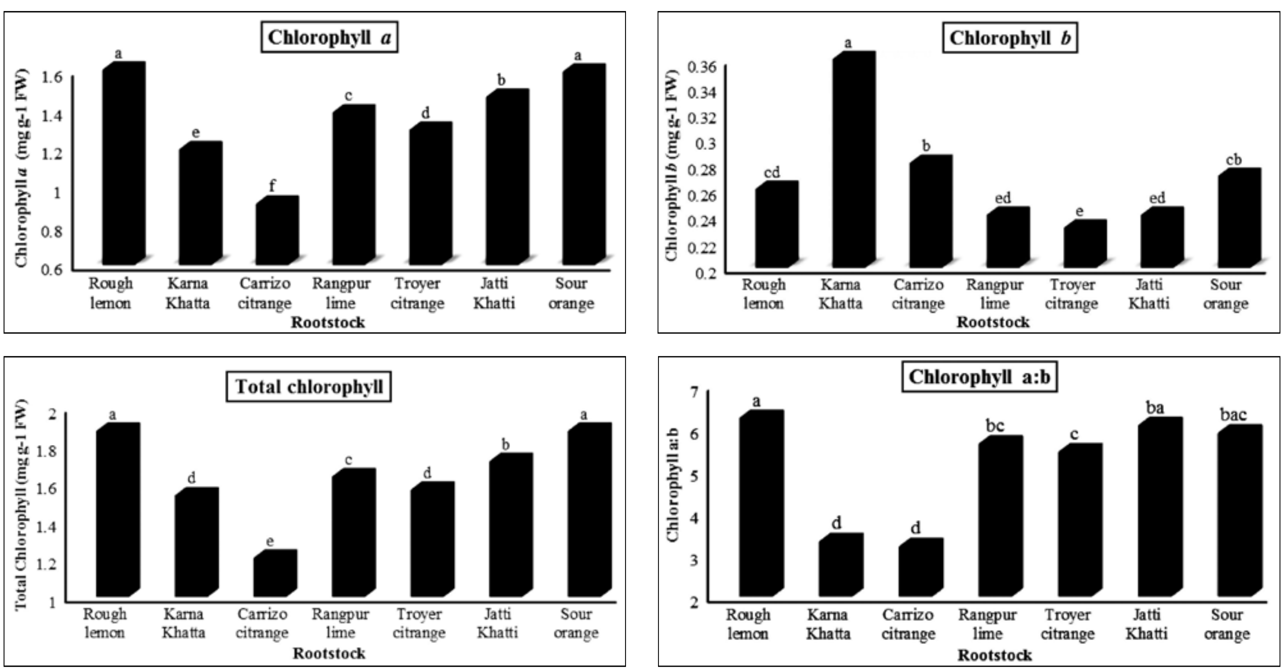

Fig. 1. Variation in chlorophyll fractions of Kinnow mandarin budded on different rootstocks.

enzymes, including those involved in the biosynthetic pathway of chlorophylls (Marschner, 7). The ability of sour orange rootstock to maintain high leaf Fe and chlorophyll concentrations have been documented previously (Sudahono *et al*., 10).

It can be concluded from the present study that overall Kinnow responded differently to the seven rootstocks tested. *Jatti khatti* was found vigorous and can be an ideal rootstock for both arid and semi-arid conditions. Succulent leaves of rough lemon and higher DFT in *Karna khatta* indicates their potential as a rootstock for drought prone areas. Carrizo proved to be an inferior rootstock in our conditions for most of the traits studied.

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