

Review Article

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Evaluation of Mandarin Cultivars on Different Root Stocks-A Review

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ABSTRACT

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In Punjab sweet orange and commercial mandarin cultivars are generally grafted or budded on rootstock of rough lemon. This rootstock is highly vulnerable to phytophthora (foot rot) like diseases. Moreover, quality of kinnow plants budded or grafted on an effective rootstock should have good compatibility between both, scion and rootstock besides decent tolerance against predominant edaphic and environmental circumstances. The rootstocks have major effect in tree vigour, quality of the fruit, juice quality, yield including tolerance to salt and cold conditions. The monopolized cultivation of this cultivar scion grafted over rough lemon requires a substituted rootstock for advanced yield/good returns along with lengthier productive life of the tree. Among numerous factors answerable for citrus decline, rootstocks may be considered as major contributor regarding climatic conditions. Nowadays rootstocks associated with this problem in Citriculture industry have presumed a great implication. Every country having citrus cultivation is facing this burning problem. At one time particular rootstock seems very appropriate but may completely fail in future including monoculture may be the basic problem of the all Citrus growing estates. Hence selection of appropriate rootstock for scion cultivar may lead to the success or failure of the citrus plantation. Till now it was reported that Volkamer lemon, Citrumello 4475 along with Brazilian sour orange were the consistent rootstocks for citrus industry of the Punjab. Present review will contribute in selecting appropriate rootstock to overcome dependability of one particular rootstock in citrus industry of Punjab to overcome the future problems.

Introduction

The position of citrus fruit to agriculture and economy of the world is established by large-scale production and wide cultivation. It is an important member of the family Rutaceae. Several species of citrus plant are supposed to be indigenous to tropical and sub-tropical regions of Asia and Malaya archipelago

(Hooker, 1872). Citrus is a third most important fruit crop of India. But in Punjab it is at no.1 position. Among various citrus cultivars, Kinnow fruit is the most significant and having major shares of total citrus production in India. Choice of rootstock is important aspect in fruit crops especially in citrus because scion cultivars respond variously to growth, quality and nutrients

buildup when grown on varied rootstocks. Sometimes plant nutrient concentrations may fluctuate even if they are grown under same conditions (Bergmann, 1992). It was revealed that Rangpur lime rootstock induces high yield when sweet orange proliferated on the same. Size of the tree also decreases along with production of good quality fruit but susceptible to foot rot and blight disease but accepting soil salinity and tristeza etc. Lima (1992) explained that plants budded on Rangpur lime were vigorous ingrowth and comparable to trees budded on Rough lemon. Plants were large in size, but cold tolerance was minimum. Moreover, these were prone to blight disease. He also described various strains of Rangpur lime viz. Brazil Orange, Florida Rangpur lime, Brazil Rangpur, Sylhet lime, Phillipian Red Lime, Nemytengs, Texas Rangpur Lime, PinkFleshed Lime etc. Niaz and Chattha (1994) recorded that 50 seeds per fruit in case of Rubidoxtrifoliolate orange showed poor germination in contrast to Roughlemon rootstock which gave fruit with less seeds i.e. 26 seeds per fruit with outstanding germination. Niaz *et al.*, (1994) revealed that Kinnow and Feutrell's early budded on rootstock of Rough lemon is more prolific than other stocks but this is susceptible to *Phytophthora* disease. Further, fruit quality was very poor in case of this rootstock. Singh *et al.*, (2002) revealed that Kinnow trees vigour and grown on Cleopatra mandarin was decent and tree size was standard. Fruit quality on was also excellent. Broadbent and Sarooshi (1993) described that Rough lemon (*Citrus jembhiri*, Lush) used as rootstock for various citrus cultivars in Australia, India and many other countries. Plants budded on Rough lemon were usually vigorous having good fruit size and poor quality of juices when compared to different used rootstocks. Snokar *et al.*, (2001) described that experiments conducted at Montgomery (Sahiwal), Pakistan and disclosed that Rough lemon is the fine stroot

stock for Blood Red malta while for other mandarins and oranges, Kharnakhatta is the superlative. They further supported that Rough lemon is commonly widely used rootstock followed by Kharnakhatta. Likewise, Sharma (2006) described that trees grafted on rootstock of Rough lemon were vigorous and gave high yield but with poor quality. However, Sharma and Srivastava (2004) revealed that Rough lemon can be cultivated on various soils and is highly sensitive to cold conditions. At the same time, Rangpurlime is well adjustable in saline soils and cool environment. Overall, rootstock of Rangpurlime is very poor seedier (7 seeds per fruit) and Rough lemon is much better seedier (32seeds per fruit). In another experiment (Anon *et al.*, 2007) kinnow was grafted on three different rootstocks viz. Kinnow, Rangpur lime and Rough lemon. It reported that Kinnow trees grafted on rootstock of Rough lemon were more vigorous growth in height and spread while plants grafted on rootstock of Rangpur lime achieved minimum plant height and spread. Volkamer lemon is a capable rootstock for Kinnow under the dry climate conditions.

Environmental effects on rootstocks have been well defined but the variation is due to weather conditions and intercultural practices. The climate of the Punjab is very harsh during summer and vigorous rootstock is obligatory to sustain the flushes of spring. So according to previous theories Volkamer lemon showed quite satisfactory results and could be used as a supernumerary rootstock for existing Rough lemon as rootstock variety in Citriculture industry.

Effect of stock scion combination on vegetative parameters of citrus fruit

Plant height/tree size

Georgiou (2009) established that the most capable rootstocks that may substitute sour

orange for local lemon variety 'Lapithkiotiki' under Cyprus conditions are Volkameriana, Yuma Ponderosa lemon, *C. macrophylla* and Citremon 1449. Dubey and Sharma (2016) discovered that plant height was more on rough lemon and RLC-4 rootstocks. Tazima *et al.*, (2013) revealed that maximum plant growth for the trees on 'Cleopatra' mandarin and 'Caipira DAC' sweet orange was obtained as compare to 'Volkamer' lemon and trifoliolate orange trees. Shafieizargar *et al.*, (2012) explained that the rootstocks have noteworthy effects on most of the calculated characters, indicating that tree height of 'Queen' orange can be controlled by using appropriate rootstocks. They discovered that Volkamer lemon is a better rootstock for 'Queen' orange. Espinoza-Nunez *et al.*, (2011) discovered that rootstocks affected plant vigor, particularly 'Flying Dragon' trifoliolate, which declined tree height by 47% in contrast to the 'Rangpur' lime. Legua *et al.*, (2011) found that rootstock influenced fruit quality variables. *C. macrophylla* and *C. volkameriana* appeared to encourage the bigger tree size. Jaskarni *et al.*, (2002) revealed that diploid trees of kinnow trees were more lengthy than tetraploid trees. Cimen *et al.*, (2014) revealed that plants on Tuzcu No.31, 31 and Gou Tou sour orange rootstocks were the least affected regarding plant growth. Forner-Giner *et al.*, (2010) established that trees on rootstock *C. volkameriana* were the largest followed by trees on rootstock Carrizo citrange.

Plant spread

Cantuarias-Aviles *et al.*, (2010) established that 'Flying Dragon' trifoliolate showed a distinct result over the 'Okitsu' mandarin trees performance, inducing lower canopy size. Dubey and Sharma (2016) discovered that canopy amount was higher on rough lemon and RLC-4 rootstocks while girth was higher on Billikichlli and RLC-4 rootstocks. Forner-Giner *et al.*, (2010) revealed that trees

on C-13 hybrid selection were proficient in yield m⁻³ of canopy spread. Jaskarni *et al.*, (2002) detailed that diploid Kinnow trees were larger in spread than tetraploid. Singh *et al.*, (2002) revealed that Rangpur lime root stock reduced size of the tree. Rootstocks may affect the capability of plants to take up water, nutrients etc. Kumar *et al.*, (1994) reported that dynamic rootstocks are required under arid environmental conditions, to give a boost to citrus trees.

Scion girth

Jaskarni *et al.*, (2002) discovered that diploid kinnow trees attained more stem girth than tetraploid ones. Shah *et al.*, (2016) established that Meyer lemon when grafted on sour orange rootstock affected scion diameter and scion length.

Effect of combination of rootstock and scion on Chlorophyll content

Cimen *et al.*, (2014) found maximum decrease in the leaf chlorophyll content in (-) Fe plants of Navelina on trifoliolate (local) and C-35 citrange. Performance of citrus rootstocks and their effects on nutrient levels of leaf have been considered for dissimilar climatic conditions across the world (Fallahi and Rodney, 1992; Georgiou, 2002; Smith *et al.*, 2004; Srivastav *et al.*, 2005; Toplu *et al.*, 2012).

Effect of combination of rootstock and scion on fruit yield

Dubey and Sharma (2016) established that rootstock RLC-4 yielded heaviest (weightwise) fruits. Cantuarias-Aviles *et al.*, (2010) found that 'Flying Dragon' trifoliolate had a distinctive result over the 'Okitsu' mandarin performance. This kind of combination had more yield potential whereas in 'Sun Chu Sha Kat' and 'Sunki' mandarins

and the 'Orlando' tangelo showed lower yield efficiency. Georgiou (2009) revealed that the most proficient rootstocks that may substitute sour orange for lemon variety 'Lapithkiotiki' under Cyprus conditions are Yuma Ponderosa lemon, Volkameriana, Citremon 1449 and *C. macrophylla*. Shafieizargar *et al.*, (2012) established that rootstocks have significant effects on most of parameters, indicating that tree yield of 'Queen' orange can be controlled by appropriate assortment of rootstock. They found that Volkamer lemon is a best rootstock for grafting of 'Queen' orange. Zekri *et al.*, (2004) found highest fruit weight on trees budded on rough lemon, Volkamer lemon and *Citrus macrophylla*, while the least fruit weight was recorded on trees budded on Sour orange and Cleopatra mandarin. Hussain *et al.*, (2013) found advanced performance of Carrizo citrange while evaluating common clementine for yield on nine rootstocks. They found that Clementine was incompatible on Da Hong Pao mandarin and Gou Tou sour orange. Yildiz *et al.*, (2013) publicized that 'Troyer' citrange had low yield than those budded on other rootstocks, whereas yield of 'Rhode Red Valencia' and 'Valencia Late' orange trees on 'Carrizo' citrange were more than those on 'Troyer' citrange, likewise. Legua *et al.*, (2011) found that rootstock considerably affected fruit quality. They recorded that *C. macrophylla* and *C. volkameriana* appeared to induce the heaviest fruit weight. Zekri (2000) recorded that fruit yield was the highest for volkamer lemon. Georgiou (2000) also observed maximum yield from the trees on Brazilian sour orange and Volkameriana rootstock.

Fruit size

Zekri *et al.*, (2004) reported heavier fruits on trees budded on rough lemon, *Citrus macrophylla* and Volkamer lemon while the smaller fruits were found on trees budded on Sour orange and Cleopatra mandarin.

McCollum *et al.*, (2017) revealed that rootstock effects on fruit size were noteworthy. 'Sour orange' and 'Swingle' yielded the largest fruits, whereas US-897 formed the smallest sized fruits. Zekri (2000) reported that highest fruit sizes were obtained for Volkamer lemon and the smallest for Cleopatra mandarin. The fruit size an important feature for both producers as well consumers. Medium to large sized fruit contribute profitable returns (Hussain *et al.*, 2013). In a study Dubey and Sharma (2016) produced medium to large sized fruits being biggest fruits on RLC-4 rootstock except rough lemon and Billikichlli. Analogous findings were submitted by Bielicki *et al.*, (2006).

Fruit weight

Legua *et al.*, (2011) established that rootstock significantly affected fruit quality variables. *C. macrophylla* and *C. volkameriana* would appear to encourage the highest fruit weight. Jaskarni *et al.*, (2002) discovered that diploid kinnow trees were much better than tetraploid as for as fruit weight was concerned.

Fruit yield

Legua *et al.*, (2011) considered Cleopatra mandarin and Gou TouChen to be the most reviving rootstocks for 'Lane Late' where as plants on *C. macrophylla* rootstock gave the maximum yield. Tazima *et al.*, (2013) obtained highest yield in plants of 'Okitsu' Satsuma mandarin on 'Swingle' citrumelo whereas 'Rangpur' lime and 'Volkamer' lemon resulted in the lower yields.

Georgiou (2009) observed that most proficient rootstocks that may be replaced with sour orange for local lemon variety 'Lapithkiotiki' under Cyprus conditions were, Yuma Ponderosa lemon, Volkameriana, Citremon 1449 and *C. macrophylla*. Castle *et*

al., (2010) found that fruit yield was associated with tree height regardless of deviations among rootstocks but performance of trees on rootstocks with moderately low productivity/tree, like those on Kinkoji and C-35 citrange, would be identical those on sturdier rootstocks. Mademba-Sy *et al.*, (2012) found that yields were 0.5 to 2.8 times greater than those of the same cultivar on the standard rootstock when trees were grafted on Flying Dragon trifoliolate orange. Dubey and Sharma (2016) stated that RLC-4 root stock had performed well over other rootstocks regarding fruiting density and trailed by Attani-2, rough lemon and Karna Khatta, although it was bottommost on Troyer citrange.

d) Peel/Rind thickness

Jaskarni *et al.*, (2002) discovered that diploid kinnow trees were better than tetraploid regarding rind thickness. McCollum *et al.*, (2017) reported that rind thickness was maximum in 'Sour Orange' but early in the season and it was not so at the end of the season.

e) Juice content (%)

Dubey and Sharma (2016) revealed that rough lemon and RLC-4 had considerably yielded higher percentage of juice. Tazima *et al.*, (2013) revealed that 'Carrizo' and trifoliolate orange produced the premium juice content. Zekri *et al.*, (2004) found trees on rough lemon that those fruit trees having lesser juice content. But Valencia trees produced high juice content. Yildiz *et al.*, (2013) revealed that the rootstocks had no noteworthy effects on juice volume of 'Rhode Red Valencia' and 'Valencia Late' oranges. They also reported that effects of the rootstocks in both scion cultivars on juice volume were seen to be of no consequence. Simón-Grao *et al.*, (2014) found that 'Ellendale' resulted in highest

amount of juice. They observed that 'Clementina Fina' and 'Clemenules' cultivars were the most suitable for a high volume of excellent value juice. Jaskarni *et al.*, (2002) discovered that juice %age was much better in diploid than triploid Kinnow. Zekri (2000) reported that juice content and soluble solids were advanced for Swingle citrumelo and Cleopatra mandarin than for the lemon rootstocks.

f) Seed number

Yildiz *et al.*, (2013) revealed the effects of the rootstocks were insignificant in case of in number of seeds per fruit. Jaskarni *et al.*, (2002) discovered more seeds in diploid Kinnow trees than triploid Kinnow.

Biochemical parameters

Various bio-chemical characters of the fruit like TSS, acidity and Vitamin-C were affected significantly by use of root stock (Wutscher and Hill, 1995).

Total Soluble Solids (⁰Brix)

Cantuarias-Aviles *et al.*, (2010) found that in 'Sun Chu Sha Kat' and 'Sunki' mandarins and the 'Orlando' tangelo conferred smaller amounts of soluble solids. Dubey and Sharma (2016) revealed that RLC-4 and Karna Khatta shown better TSS in fruit juice. Benjamin *et al.*, (2013) found TSS levels of all species were less in juice of fruits on Volkathan on Zekri *et al.*, (2004) found maximum soluble solids on *Citrus marophylla* and Carrizo citrange accumulated the lowest soluble solids whereas Valencia trees yielded more soluble solids than Navel trees. Simón-Grao *et al.*, (2014) found that 'Ellendale' produced the highest amount of juice, 'Nova' and 'Clementina Fina' showed high total soluble solids. McCollum *et al.*, (2017) reported that rootstock effects on total solids were

significant. Castle *et al.*, (1988) revealed that plants budded on Trifoliolate orange and Carrizo citrange exhibited better performance regarding TSS while lowest TSS was obtained from the plants grafted on Rough lemon species.

Acidity (%)

Castle *et al.*, (1988) confirmed that acidity is graft transmissible feature and influenced by rootstocks type and environmental conditions. Dubey and Sharma (2016) revealed that RLC-4 and Karna Khatta shown better acid contents in the fruit juice.

Benjamin *et al.*, (2013) found acidity levels were less in juice of fruits on Volka than on Yildiz *et al.*, (2013) revealed that total acids (TA), Brix: TA ratio were seen to be insignificant.

Simón-Grao *et al.*, (2014) found that 'Nova' and 'Clementina Fina' showed low titratable acidity. It was reported that some root stocks like sour orange, RLC-4, rough lemon and Karna Khatta including Troyer citrange promoted titratable acidity of lemon fruits. Differences in quality characteristics were due to different rootstocks (Yonemoto *et al.*, 2005).

TSS/acid ratio

McCollum *et al.*, (2017) reported rootstock effects on solids acid ratio were significant.

Waqar *et al.*, (2006) reported that with increase in the ratio of TSS / acid ratio, there was a reduction in acidity so with less TSS / acid ratio, fruit quality is poor, and taste becomes watery and dull. Again, this ratio is used to determine the fruit maturity values, so where the ratio is more, the fruit will mature earlier. Zekri (2000) also reported that higher the Brix: acid ratio caused earlier maturation of the fruit.

Vitamin-C

Dubey and Sharma (2016) revealed that RLC-4 and Troyer citrange proved their domination in terms of higher ascorbic acid content. Stuchi *et al.*, (2008) reported cumulative yield and fruit quality of all cultivars were not influenced by the rootstocks. Parameshwar *et al.*, (2018) exhibited t significant effect fruit quality of Valencia late like acidity (1.01%) and ascorbic acid (57.86 mg/100 ml juice) was greatly improved in fruit tree that were budded on rough lemon rootstock.

Plant nutrients

Toplu *et al.*, (2008) recommended use of Carrizo and Troyer citrange rootstocks for eastern mediterranean region citrus production as they had more ability to use more plant nutrient elements playing significant roles in production and quality. Substantial consequences of various rootstocks on uptake of N were also submitted previously in Fairchild mandarin (Fallahi and Rodney, 1992). Smith *et al.*, (2004) and Dubey and Sharma (2016) discovered higher leaf nutrient P on Troyer citrange and lower levels on rough lemon root stock. Alike findings were revealed by Toplu *et al.*, (2012) and Tsakelidou *et al.*, (2002). But nonappearance of significant alterations between the mean P nutrient of leaves from most of the root-stocks was confirmed the earlier findings of Iyengar *et al.*, (1982). There are contradictory discoveries in the literature regarding the influence of rootstocks on up taking of Na nutrient as Georgiou (2002) have reported that there was effect of rootstocks on uptake of Na, whereas Toplu *et al.*, (2012) found noteworthy incline in Na nutrient concentration of leaf micronutrients of rootstocks. Less quantity of foliar Mn on Troyer citrange rootstock was reported by Iyengar *et al.*, (1982). It was also mentioned by Dubey and Sharma (2016) that alterations

in foliar micronutrients were also submitted earlier due to rootstocks in various fruit crops (Fekete *et al.*, 2012) which may differ with the nutrient's absorption capacities over roots (Marschner *et al.*, 1986; Kayon, 2008).

In conclusion, rootstock should have good compatibility between both, scion and rootstock and have major effect in physical parameters like tree vigour, quality of the fruit, juice quality, yield as well as biochemical parameters like TSS, Acidity, Sugars, Vitamin C etc. depending upon environmental circumstances. At one time particular rootstock seems very appropriate but may completely failure in future. Under present situation no single rootstock is accessible that can be regarded as perfect for Kinnow mandarin species under all agro-climatic environments. Hence selection of appropriate rootstock for scion cultivar may lead to the success or failure of the citrus plantation. So judicious selection of rootstock leads to success of citrus plantation whereas wrong selection leads to decline.

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