EVALUATION OF SUITABLE ROOTSTOCK FOR ENHANCEMENT OF YIELD AND QUALITY OF KINNOW (CITRUS RETICULATA BLANCO) UNDER SARGODHA CONDITIONS

Mohammad Akram Nasir*, Muhammad Maaz Aziz**, Tanveer Ahmed Mohar***, Javed Iqbal** and Muhammad Kashif Raza**

ABSTRACT

A field experiment was conducted to evaluate the suitable rootstock for yield enhancement of Kinnow (Citrus reticulata Blanco) at progeny garden of Citrus Research Institute Sargodha, Pakistan during the year 2002-2011. The seeds of Rough Lemon, Kinnow and Rangpur Lime were sown in nursery during 2002. The seedlings of root stocks were grafted with scion wood of Kinnow mandarin through T-grafting technique during 2004. The grafted plants were transplanted to actual field during September, 2005. Fruit yield was recorded during mid January of three consecutive years (2009, 2010 and 2011). The parameters studied were fruit weight, yield, fruit size, total soluble solids, rind thickness, TSS /acid ratio and juice percentage. The results revealed that rootstocks differ significantly in average fruit weight, fruit size, number of fruits per tree and yield in kg per tree during three successive seasons. Maximum fruit weight (225.12g), diameter (8.02 cm), yield (64.89 kg/plant), rind thickness (0.47 cm), TSS (12.92%), juice (48.11%) and TSS/acid ratio (19.58%) were produced by Rough Lemon rootstock, budded with Kinnow. While these parameters were found minimum in Rangpur Lime rootstocks budded with Kinnow. Results revealed that Rough Lemon rootstock has better effect on the yield and physicochemical characteristic of Kinnow under the prevailing climatic conditions of Sargodha, Pakistan.

KEYWORDS: Citrus reticulata; Kinnow; rootstocks; Rough Lemon; Rangpur Lime; physicochemical characteristics; TSS; fruit yield; fruit quality; Sargodha, Pakistan.

INTRODUCTION

Rough Lemon is commonly used as root stock for raising Mandarin and sweet oranges in Punjab province of Pakistan. This stock ensures proper vigor and productivity of scion cultivars but scion age especially in case of Kinnow is very short on this root stock.
Palestine Lime is used in Middle East and India while Rangpur Lime is commercially used in Brazil and America and Trifoliate orange in Japan and China as a citrus rootstock for various scion cultivars (12).

Lima (8) reported that Rangpur Lime rootstock enhanced the yield of sweet oranges. It reduced tree size but produced good quality fruit. However, foot rot and blight was noticed but tolerant to soil salinity. Chaudhry and Saeed (6) reported that Khatti rootstock gave better results for sweet orange cv. Blood Red as compared to other seven rootstocks tested with maximum yield (271 fruits/tree), fruit size (6.25 cm length and 7.20 cm diameter), juice (41.3%), TSS (8.0%) and TSS /acid ratio (14.05). Chaudhry and Chatha (4) reported the presence of 50 seeds per fruit in Rubidox Trifoliate orange and poor seed germination as compared to Rough Lemon. Chaudhry et al. (5) found that Kinnow and Feutrell’s Early budded on Rough Lemon rootstock were more vigorous than on other stocks but were found susceptible to Phytophthora and also quality of fruit was poor. The vigour, growth of Kinnow trees budded on Cleopatra mandarin was good and it produced standard size trees (11). Quality of fruit was excellent. Broadbent and Sarooshi (2) reported that Rough Lemon (Citrus Jembhiri, Lush) is used as rootstock for citrus cultivars in India, Australia, South Africa and many other countries of the world. The plants budded on Rough Lemon were usually vigorous, large sized having bigger fruits with thick peel and poor quality juice when compared with plants budded on other rootstocks. Rough Lemon was the best rootstock for Blood Red sweet orange while for Mandarins, Kharna Khatta is the best (12). He further advocated that Rough Lemon is widely used rootstock for most of the scion cultivars of citrus in Punjab.

Similarly Sharma (9) reported that trees grafted on Rough Lemon rootstock are vigorous, high yielder but with poor quality fruits. Rough Lemon can be grown on wide range of soils, well adopted to deep coarse and sandy soils but is highly sensitive to cold climate and wet soils (10). In contrary to this Rangpur Lime is well adopted to saline soils and cool climate. Chattopandhyay (3) reported that Rangpur Lime proved to be inferior quality rootstock to Mandarin with respect to fruit quality. Rough Lemon is used under Punjab agro-climatic conditions on light soils while sour orange in KPK province on heavy soils. Thus the present study was conducted to evaluate the influence of different rootstocks on plant growth and fruit quality of Kinnow under climatic conditions of Sargodha, Pakistan.
MATERIALS AND METHODS

The research work was carried out in progeny garden of Citrus Research Institute Sargodha, Pakistan during 2002-2011. Fruits of Rangpur Lime were collected from Horticultural Research Station Sahiwal for obtaining seeds. Seeds were extracted and sown in nursery. Fruits of Rough Lemon and Kinnow seeds were collected from Citrus Research Institute, Sargodha. Germination of seed took place in October 2002 and seedlings were transplanted to nursery during October, 2003. The scions wood of Kinnow were T-grafted during September 2004. These grafted plants were transplanted to actual field during September, 2005. Experiment was laid out in RCBD. There were three treatments (rootstocks), four replications and three plants per treatment. Thus the total number of plants were 36.

Yield in terms of number of fruits per tree and kg/tree were calculated at the time of harvesting (during mid January, 2009, 2010 and 2011). During each year average weight per fruit (g) was calculated by taking 12 fruits from all sides of the tree. Size (length and diameter) of fruit and rind thickness were measured in centimeters with the help of vernier calliper for 12 fruits and then mean values were obtained. Juice was extracted from each sample and weight per fruit was taken by subtracting the combined weight of rind, rag and seed from the whole fruit weight. The juice per fruit was expressed as percent of total fruit weight. Total soluble solids (TSS) were measured by digital refractometer (ATAGO, RX 5000), as described in AOAC (1) method No. 983.17.

For acidity percentage estimation as procedure described by Hortwiz (7) was adopted.

\[
\text{Percent citric acid} = \frac{\text{ml of 0.1 N NaOH used} \times 0.0064}{\text{ml of juice taken}} \times 100
\]

For each sample TSS was divided by acidity to find out TSS/acid ratio. The treatment means were compared by using analysis of variance techniques at 5% probability level (13).

RESULTS AND DISCUSSION

Fruit Size

The fruit size (length and diameter) was found statistically significant (Table-1). Maximum fruit length (6.40 cm) and diameter (8.02 cm) were produced by Kinnow fruits when grafted on Rough Lemon. Minimum length

J. Agric. Res., 2014, 52(3)
(4.79 cm) and diameter (6.71 cm) of fruits were found in plants grafted on Rangpur Lime during 2009. Almost similar trend was noted during 2010 and 2011. This increase of fruit size both in length and diameter was due to vigorous growth of Kinnow plants grafted on Rough Lemon stock that leads to probably more number of leaves which results in more photosynthetic activities ultimately affect the fruit size positively. Present results are in line with findings of Chaudhry and Saeed (6) who reported that sweet oranges Blood Red grafted on Rough Lemon gave, more yield with large sized fruits. Similar findings were also reported by Broadbent and Sarooshi (2).

Table 1. Fruit size and fruit weight of Kinnow fruit as affected by various rootstocks.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Fruit length (cm)</th>
<th>Fruit diameter (cm)</th>
<th>Av. Fruit weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough Lemon</td>
<td>6.11a</td>
<td>6.30a</td>
<td>6.40a</td>
</tr>
<tr>
<td>Kinnow</td>
<td>5.35b</td>
<td>5.50b</td>
<td>5.70b</td>
</tr>
<tr>
<td>Rangpur Lime</td>
<td>4.79c</td>
<td>5.21c</td>
<td>5.15c</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>0.06</td>
<td>0.16</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Fruit weight

The data (Table 1) shows that rootstocks significantly affected the weight of Kinnow fruit during 2009. The treatment means exhibited the maximum fruit weight (206.72g) in case of plants grafted on Rough Lemon followed by Kinnow stock (163.76g) and Rangpur Lime (116.08g).

During 2010 maximum average fruit weight was harvested from plants grafted on Rough Lemon (199.26g) followed by Kinnow (156.15g) and Rangpur Lime stocks (142.98g). Almost similar trend was noted during 2011 as the maximum fruit weight (225.12g) was found in plants grafted on Rough Lemon and minimum (155.7g) from plants grafted on Rangpur Lime. Present results fully support the findings of Broadbent and Sarooshi (2) and are contrary with the findings of Singh et al. (11). They reported that Rangpur Lime rootstock induced high yield of sweet orange when grafted on it and also produced fruit of good quality.

Number of fruits per tree

Data regarding number of fruits per tree is presented in Table-2. Significantly maximum yield in kg per tree was obtained from plants grafted on Rough Lemon (163 fruits/tree) with 23.35 kg fruit weight per tree followed by plants grafted on Kinnow rootstock (128 fruits/tree) with 20.96 kg fruit per tree, while minimum were found in trees grafted on Rangpur Lime rootstock (116 fruits/tree) with 13.46 kg fruit per tree during 2009.

J. Agric. Res., 2014, 52(3)
Almost similar results were observed during 2010 and 2011. This increase in number and weight of fruit per tree was probably due to vigorous growth of Kinnow plants grafted on Rough Lemon. These results are totally in line with findings of Snokar (12) who reported that Rough Lemon was found the best among all the tested rootstocks for sweet orange (cv. Blood red).

However, these results do not support the earlier findings of Singh et al. (11) regarding the effect of Rangpur Lime stock on Pineapple Sweet orange scion.

### Table 2. Fruit number and weight/tree of Kinnow as affected by various rootstocks.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Number of fruits/tree</th>
<th>Fruit weight (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough Lemon</td>
<td>163a</td>
<td>326a</td>
</tr>
<tr>
<td>Kinnow</td>
<td>128b</td>
<td>246b</td>
</tr>
<tr>
<td>Rangpur Lime</td>
<td>116b</td>
<td>157c</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>20.48</td>
<td>13.24</td>
</tr>
</tbody>
</table>

**Rind thickness**

The effect of various rootstocks on rind thickness of fruits as presented in Table-3 was found to be non significant.

**Fruit juice percentage**

Data in Table 3 shows maximum juice (46.17%) in Kinnow grafted on Rough Lemon rootstock followed by Kinnow stock (35.77%) while minimum juice (31.43%) was found in Kinnow grafted on rootstock Rangpur Lime during 2009.

### Table 3. Rind thickness and juice percentage of Kinnow fruits as affected by various rootstocks.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Rind thickness (cm)</th>
<th>Juice (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough Lemon</td>
<td>0.47</td>
<td>0.30</td>
</tr>
<tr>
<td>Kinnow</td>
<td>0.45</td>
<td>0.34</td>
</tr>
<tr>
<td>Rangpur Lime</td>
<td>0.47</td>
<td>0.34</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>0.00</td>
<td>0.37</td>
</tr>
</tbody>
</table>

During year 2010 maximum juice (47.72%) of fruits of Kinnow plants grafted on Rough Lemon rootstock followed by Kinnow rootstock (46.54%) and least on Rangpur Lime rootstock (37.64%). Almost similar trend was
observed during third year (2011). Present results fully support the findings of Broadbent and Sarooshi (2).

**Total soluble solids (TSS)**

It is evident from Table-4 that in 2009, TSS of Kinnow plants grafted on Rough Lemon excelled (12.92%) the other rootstocks. However, during 2010 and 2011 results were non-significant. These results partly support the findings of Chaudhry and Saeed (6). They reported that Jatti Khatti stock produced better results as compared to other seven rootstocks used with maximum TSS.

**Table 4. Total soluble solids, acidity and TSS/acid ratio of Kinnow fruits as affected by various rootstock.**

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Total soluble solids %</th>
<th>Acidity %</th>
<th>TSS/acid ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough Lemon</td>
<td>12.92a</td>
<td>11.50</td>
<td>12.00</td>
</tr>
<tr>
<td>Kinnow</td>
<td>11.80b</td>
<td>11.38</td>
<td>12.50</td>
</tr>
<tr>
<td>Rangpur Lime</td>
<td>10.33c</td>
<td>10.22</td>
<td>12.60</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.12</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: Non significant

**Acidity**

Maximum acidity (0.84%) was recorded in Kinnow trees grafted on Rangpur Lime rootstocks and minimum (0.66%) in those grafted on Rough Lemon in 2009 (Table 4). During 2010 significant effect of various rootstocks on acidity was also observed. Maximum acidity (0.84%) was noted in Kinnow plants grafted on Rangpur Lime followed by Kinnow (0.81%) and Rough Lemon stocks (0.71%). During the third year similar trends were also observed. Present results fully support the findings of Chattopandhyay (3) who graded the Rangpur Lime as an inferior rootstock for Mandarin from quality point of view.

**Total soluble solids/acid ratio**

The data (Table-4) regarding effect of various rootstocks on TSS/acid ratio of Kinnow shows that TSS /acid ratio was significantly affected by rootstocks in 2009. The maximum TSS/acid ratio (19.58) was found in case of Kinnow plants grafted on Rough Lemon followed by Kinnow rootstock (15.32) and minimum from those plants grafted on Rangpur Lime rootstock (12.30).
Significant effect of various rootstocks was also noted on TSS/acid ratio in 2010. Maximum TSS/acid ratio was noted from Kinnow plants grafted on Rough Lemon rootstock (16.20) followed by those on Kinnow (14.05) and Rangpur Lime rootstocks (12.17).

However, during 2011, various rootstocks did not affect the TSS/acid ratio of Kinnow fruits harvested from plants either grafted on Rough Lemon or Kinnow or Rangpur Lime stock. TSS/acid ratio ranged from 18.00 to 21.55.

**CONCLUSION**

It is concluded from the study that Rough Lemon root stock proved to be the best root stock with respect to yield and physicochemical characters regarding fruit weight, size, rind thickness, TSS/acid ratio and juice percentage for Kinnow scion among all tested rootstocks under climatic conditions of Sargodha, Pakistan. On the basis of this study grafting of Kinnow can be recommended on Rough Lemon for commercial cultivation of Kinnow under climatic conditions of Sargodha.

**REFERENCES**


