Performance of ‘Ponkan’ Mandarin on Seven Rootstocks in Southern Brazil

Neusa M.C. Stenzel¹
Agricultural Research Institute of Paraná – IAPAR, CP 481 CEP-86001-970-Londrina, PR, Brazil

Carmen S.V.J. Neves²
State University of Londrina—UEL, CP 6001, CEP-86051-990-Londrina, PR, Brazil

José C. Gomes³
Agricultural Research Institute of Paraná—IAPAR, CP 481 CEP-86001-970-Londrina, PR, Brazil

Cristiane C. Medina²
State University of Londrina—UEL, CP 6001 CEP-86051-990-Londrina, PR, Brazil

Additional index words. yield, tree size, fruit quality, Citrus reticulata, alternate bearing index

Abstract. This study reports the performance (yield, tree size, and fruit quality) of ‘Ponkan’ mandarin (Citrus reticulata Blanco) on seven rootstocks, evaluated for 11 years under Southern Brazil conditions. Trees on C13 citrange had higher cumulative yield for seven harvests than those on trifoliate orange. Cleopatra mandarin, rough lemon, Rangpur lime, Sunki mandarin, and Volkamer lemon rootstocks maintained their values at an intermediate position and did not present any significant difference regarding C13 citrange, and trifoliate orange. Trees on C13 citrange and on trifoliate orange exhibited the lowest alternate bearing index. Cleopatra mandarin induced the greatest canopy volume, but it was not significantly different from Sunki mandarin and rough lemon. The smallest trees were those on Volkamer lemon and trifoliate orange. The highest yield efficiency came from trees on C13 citrange and the smallest on Cleopatra mandarin. Rootstocks did not significantly affect fruit weight.

‘Ponkan’ (Citrus reticulata Blanco) is an early midseason mandarin. The trees are vigorous with upright growth habit, and are productive, but with a tendency to alternate bearing. The fruits are tender and juicy with a mild, pleasant, and aromatic flavor, an orange flesh color, and rind puffs. ‘Ponkan’ mandarin is also known as ‘Batangas’, ‘Nagpur Sun’ tara’ or ‘Santra’, and has a good reputation in the South of China, Formosa, and India (Hodgson, 1967). In Brazil, this mandarin is the most important one, and is mainly grown in southeast and southern regions, where it shows an excellent adaptation to soil and climatic conditions. Rangpur lime (Citrus limonia Osb.) is the main rootstock used for ‘Ponkan’ mandarin in Brazil (Pompeu Júnior, 1991). Rangpur lime has performed well and grows satisfactorily in the presence of citrus tristeza virus; however, it has a moderate tolerance to Phytophthora citrophthora (R.E. Sm. and E.H. Sm.) Leonian and Phytophthora parasitica Dastur, and is susceptible to citrus blight (Timer et al., 1984). Citrus rootstocks have interactive effects on tree size, yield and fruit quality. Therefore, it is important to evaluate the performance of ‘Ponkan’ mandarin on rootstocks in regions where it is cultivated because the results from rootstock research can vary from area to area due to climate, soil, diseases, and cultural practices (Wutscher and Bistline, 1988). In Brazil, research on citrus rootstocks are mostly from São Paulo state and for orange cultivars, because orange is 95% of citrus growing in Brazil. So, there is a lack of information on rootstocks under other conditions and for mandarin cultivars. The aim of this study was to evaluate the performance of ‘Ponkan’ mandarin on seven rootstocks, 11 years after planting in the state of Paraná, southern Brazil.

Materials and Methods

The rootstocks tested were: C13 citrange [Citrus sinensis (L.) Osb. × Poncirus trifoliata (L.) Raf.], a selection from Brazil; Cleopatramandarin (C. reticulata Blanco); rough lemon (C. jambhiri Lush.); Rangpur lime (C. limonia Osb.); Sunki mandarin (C. reticulata var. australis Swing.); Volkamer lemon (C. volkameriana Ten. and Pasq.); and trifoliate orange [Poncirus trifoliata (L.) Raf.]. These rootstocks were chosen because they are the main ones used in most citrus-growing countries. The rootstocks were propagated from seeds obtained from productive and virus-free trees. The seedlings were T-budded with a virus-free ‘Ponkan’ mandarin. Seeds and buds were obtained from a germplasm collection at the Agricultural Research Institute of Paraná (IAPAR). The trees were planted in Dec. 1988, at a commercial grove in Paraná State, Brazil (lat. 23°27’S; long. 51°59’W; 500 m altitude), with 7.0 x 4.0 m spacing. The soil type in the experimental area was a clayey Typic Haplorthox, with 600 g kg⁻¹ of clay, 70 g kg⁻¹ of silt, 330 g kg⁻¹ of sand, and pH 4.61 in the 0–25 cm soil layer. The climate classification is Cfa according to Köppen, and the area has an average annual rainfall of 1,504 mm, occurring mainly in the spring and summer. The average temperature ranges from 17.7 °C to 28.3 °C, and relative humidity (RH) ranges from 70% to 75% (Caviglione et al., 2000).

The experiment had a randomized complete-block design, with three-tree plots and four replications. The experimental site was surrounded on all sides by ‘Ponkan’ mandarin trees on Rangpur lime rootstock. The trees received standard commercial care for disease control, fertilization, and chemical weed control within the rows. The areas between rows were covered with grass. Foliar spray nutrients were applied when leaf analysis indicated a deficiency. The trees were not irrigated, a common practice in the commercial orchards of southern Brazil.

Fruits were harvested and weighed in April and May, from the seasons of 1992 until 1999 (except 1998, probably due to low rainfall during flowering that year). The yield efficiency for each rootstock was calculated by the formula [volume = (4/6) · π · height · radius²]. The ratio of the average yield (1992–99) to the average volume (1992–99), was calculated to estimate the canopy efficiency for each rootstock. The fluctuation in yield was expressed in terms of alternate bearing index (I), calculated as I = 1 / n-1 × |(a(n) – a(n–1))| / (a(n) + a(n–1)) + |(a(n) – a(n–2))| / (a(n) + a(n–2)) + ... + |(a(n–1) – a(n–2))| / (a(n–1) + a(n–2)), where n = number of years, and a(n), a(n–1), ..., a(n–2), a(n–1) = yields of corresponding years (Pearce and Dobersek-Urbanc, 1967). In 1991, 1994, before harvest, an eight-fruit sample was taken from each plot and then analyzed for fruit quality. Fruits were weighed and juice was extracted with an electric reamer. The juice content was measured, also the total soluble solids (TSS) were determined with a refractometer and total acids (TA)/ascorbic acid equivalent by titration with 0.1 N NaOH.

Data were analyzed using SAS program (SAS Institute, 1989) for analysis of variance (ANOVA), in order to evaluate rootstock effects on ‘Ponkan’ mandarin characteristics. Covariance analysis was used to factor out the influence of canopy volume on the yield. The means were separated by Duncan’s multiple range test at P ≤ 0.05.

Results and Discussion

No effect of rootstocks on trees for canopy diameter and canopy volume occurred in 1991.
Table 1. Tree height, canopy diameter and canopy volume in 1991 and 1999, of ‘Ponkan’ mandarin trees on seven rootstocks in southern Brazil.

| Rootstock         | Tree height (m) | Canopy diameter (m) | Canopy volume (m³) |
|-------------------|-----------------|---------------------|--------------------|
|                   | 1991     | 1999     | 1991     | 1999     | 1991     | 1999     |
| C13 citrange      | 2.72 ab  | 4.82 bc | 1.4 a    | 4.4 bc   | 2.9 a    | 50.5 bc  |
| Cleopatra mandarin| 2.82 ab  | 5.57 a  | 1.3 a    | 5.0 a    | 2.9 a    | 72.3 a   |
| Rough lemon       | 2.67 bc  | 5.25 ab | 1.4 a    | 4.7 ab   | 2.9 a    | 60.5 ab  |
| Rangpur lime      | 2.60 bc  | 4.82 bc | 1.3 a    | 4.4 bc   | 2.6 a    | 50.2 bc  |
| Sunki mandarin    | 3.00 a   | 5.42 a  | 1.4 a    | 4.6 ab   | 3.2 a    | 59.7 ab  |
| Volkamer lemon    | 2.40 c   | 4.37 c  | 1.2 a    | 4.1 c    | 2.0 a    | 38.5 c   |
| Trifoliate orange | 2.52 b   | 4.42 c  | 1.3 a    | 4.4 bc   | 2.2 a    | 45.6 c   |

Table 2. Annual and cumulative yield of seven harvests (1992–99) except 1998, mean yield efficiency, and alternate bearing index of ‘Ponkan’ mandarin trees on seven rootstocks in southern Brazil.

| Rootstock         | Yield/tree (kg) | Cumulative yield (original data) (kg·m–3) | Mean yield efficiency (kg·m–3) (1992–99) | Alternate bearing index (1992–99) |
|-------------------|-----------------|-------------------------------------------|------------------------------------------|----------------------------------|
|                   |                 | 1992–99                                   |                                         |                                  |
| C13 citrange      | 20.9 ab         | 84.3 ab                                   | 842.4                                    | 4.0 a                            |
| Cleopatra mandarin| 12.5 ab         | 90.8 ab                                   | 840.0                                    | 2.9 b                            |
| Rough lemon       | 29.4 a          | 73.0 ab                                   | 761.2                                    | 3.1 ab                           |
| Rangpur lime      | 20.3 ab         | 42.3 b                                    | 695.6                                    | 3.3 ab                           |
| Sunki mandarin    | 22.5 ab         | 114.2 a                                   | 669.0                                    | 3.7 ab                           |
| Volkamer lemon    | 30.1 a          | 70.7 ab                                   | 663.3                                    | 3.4 ab                           |
| Trifoliate orange | 9.4 b           | 70.5 ab                                   | 530.4                                    | 3.8 ab                           |

Table 3. Fruit quality analysis of ‘Ponkan’ mandarin on seven rootstocks in southern Brazil (harvest 1994).

| Rootstock         | Fruit wt (g) | Juice content (%) | Total soluble solids (TSS) (%) | Total acids (TA) (%) | TSS:TA ratio |
|-------------------|--------------|------------------|------------------------------|---------------------|--------------|
| C13 citrange      | 225.0 a      | 24.1 b           | 6.6 b                        | 0.52 a              | 13.0 b       |
| Cleopatra mandarin| 242.5 a      | 28.1 ab          | 7.0 ab                       | 0.47 ab             | 14.9 ab      |
| Rough lemon       | 247.5 a      | 28.1 b           | 7.0 ab                       | 0.41 b              | 17.8 a       |
| Rangpur lime      | 209.0 a      | 36.5 a           | 7.1 ab                       | 0.49 b              | 14.9 ab      |
| Sunki mandarin    | 230.0 a      | 25.3 b           | 7.2 ab                       | 0.50 a              | 14.6 ab      |
| Volkamer lemon    | 262.5 a      | 26.7 b           | 7.6 ab                       | 0.51 a              | 15.1 ab      |
| Trifoliate orange | 242.5 a      | 29.6 b           | 7.8 a                        | 0.54 a              | 14.4 ab      |

*Data corrected by covariance analysis, using tree canopy volume as the co-factor.
*Mean separation within columns by Duncan’s multiple range test at P ≤ 0.05.
‘Ponkan’. Similarly, lower ratios were reported with ‘Temple’ mandarin on ‘Carrizo’ citrange (Levy et al., 1993).

Based on these results, in terms of yield all the evaluated rootstocks except trifoliate orange would be suitable to ‘Ponkan’ mandarin in Parana state as well as other regions that present similar soil and climate conditions. The rootstocks that presented lower alternate bearing index were C13 citrange and trifoliata orange.

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