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# Preliminary Evaluation of Six *Prunus* Rootstocks for Peach in Italy

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**Abstract**

**In Italy, the evaluation of rootstocks is sponsored by the Ministry of Agriculture and carried out in a network of trials along the country. This study evaluated growth and yield performance of the 'Big Top' nectarine and the 'Rome Star' peach grafted on six rootstocks of different origin and vigor, namely GF677 (the most widespread in Italy), Garnem, Adesoto, RootPac®20, RootPac®40, and RootPac®90, in three different locations, Castelvetrano (Sicily), Forlì and Cesena (Emilia-Romagna). Yield, number of fruits, trunk cross-sectional area (TCSA), average fruit weight, flesh firmness, soluble solids content (SSC) and titratable acidity (TA) were determined at the third leaf (2015). In all sites, trees on GF677, Garnem, and RootPac®90 were the most vigorous, and trees on RootPac®40 (-40 to -51% of GF677 TCSA) and RootPac®20 (-48 to -60% of GF677 TCSA) the least vigorous. In Castelvetrano, trees on Adesoto and RootPac®20 matured fruit slightly earlier than trees on other rootstocks; trees on RootPac®40 were the most productive and yield efficient, followed closely by trees on Adesoto and RootPac®20, the latter exhibiting the highest SSC; yield differences were mainly due to differences in fruit weight rather than in fruit number. In Emilia-Romagna, yield was directly related to tree vigor, with trees on GF677 being the most productive. In this case, yield differences were mainly due to differences in the number of fruits. Yield efficiency was also higher in the most vigorous trees, with the only exception of RootPac®40, which combined a size-controlling effect with high yield efficiency and large fruit size. While GF677 confirmed a good yield performance, RootPac®40 seems promising for high-density plantings, as it associates high yield efficiency and reduced tree vigor.**

**Keywords:** harvest date, fruit quality, soluble solids, tree vigor, trunk cross-sectional area, yield efficiency

## INTRODUCTION

Tree size control by dwarfing rootstocks represents one of the most efficient methods to avoid, or at least delay, competition for available space, especially in high density plantings. Size-controlling rootstocks may also alter dry matter partitioning in favor of reproductive growth, mostly by reducing competition by vegetative organs (Caruso et al., 1997). This often results in increased yield efficiency and improved fruit quality (De Salvador et al., 2007; Marra et al., 2013).

In peach, the tight association between vegetative growth and tree water status (Basile et al., 2003a; Solari et al., 2006) seems to favor the hypothesis that size control is mainly operated by the specific ability of peach rootstocks to transport water (i.e. hydraulic conductance) (Cohen and Naor, 2002; Basile et al., 2003b). For this specific reason, growth control by peach rootstock-scion combinations may also vary with and depend on soil and climate conditions. For example, young trees on the high-vigor GF677 rootstock exposed to drought exhibited lower stem water potentials than trees on the low-vigor RootPac®20, suggesting a better performance of the latter under soil drying conditions (Jimenez et al., 2013). In other trials with peach x almond hybrid rootstocks, trees on low-vigor rootstocks seem to experience higher leaf dehydration than trees on GF677 during irrigation withholding (Marra et al., 2013).

Unlike apple, there are no widely acceptable size-controlling rootstocks for peach. The need for such rootstocks to improve the management efficiency of high-density peach orchards has induced intensive work by several research Institutions around the world. In Italy, breeding programs have allowed for selection of hybrid rootstocks for peach inducing various degrees of tree size control (Loreti and Massai, 1998 and 2006; Massai et al., 2003). In Spain, the RootPac® series recently developed by Agromillora Catalana includes also size-controlling interspecific *Prunus* rootstocks for peach (Iglesias, 2013).

The objective of this work was to test growth, yield and fruit quality of nectarine and peach cultivars in combination with six hybrid rootstocks inducing a wide range of tree vigor. Three different locations across Italy with different soils and climates were chosen to evaluate the above rootstock-scion combinations.

## MATERIALS AND METHODS

The experiment was conducted in three sites: Forlì and Cesena in Emilia-Romagna (north-east of Italy) and Castelvetrano, in Sicily (south of Italy). The field performance of GF677 (*Prunus persica* x *P. dulcis*), Garnem (*P. dulcis x P. persica*), Adesoto (*P. insititia*), and the RootPac® (hereafter RP) hybrid rootstocks, namely RP20 (*P. besseyi x P. cerasifera*), RP40 [(*P. persica x P. persica*) *x* (*P. dulcis x P. persica*)], and RP90 [(*P. persica x P. davidiana*) *x* (*P. dulcis x P. persica*)], grafted with 'Big Top' nectarine (Castelvetrano and Cesena) and 'Rome Star' peach (Forlì) was evaluated in 2015, when trees were at their 3$^{rd}$ leaf. In all sites, the evaluation trials were arranged in a randomized block design with 10 single-tree replicates for each scion-rootstock combination. Trees were spaced at 4 x 5 m, trained to delayed vase in Forlì and Cesena, and to modified Spanish bush in Castelvetrano (Caruso et al., 2015), regularly irrigated and fertilized. In Forlì and Cesena, soil was a silty-clay with medium-low organic matter content, neutral pH and medium cation exchange

capacity. In Castelvetrano, soil was a clay-loam with medium-low organic matter content, pH 7.6 and 5.1% active carbonates.

Trunk circumference (cm) was measured above the graft union and converted into trunk cross-sectional area (TCSA, $cm^2$). Yield (kg $tree^{-1}$), crop load (n) and fruit weight were recorded at harvest in each experimental site, and yield efficiency was calculated as kg of fruit per $cm^2$ of TCSA. Fruit were harvested in different picking dates, using ground color (in Forlì and Cesena) and flesh firmness (in Castelvetrano) as maturity indices. Average harvest date for each rootstock was calculated as [(average yield per pick) x (days from 1$^{st}$ pick)]/(total yield per tree).

In the laboratory, fruit flesh firmness was determined with a pressure tester mounting an 8-mm tip and expressed as kg $cm^{-2}$. In the juice, titratable acidity (TA, grams of malic acid per liter of juice) and pH were measured with an automated titrator, whereas total soluble solid content (SSC) was measured with a digital refractometer and expressed as °Brix. Fruit quality was not evaluated in Cesena.

SYSTAT procedures (Systat software Inc., Chicago, Illinois, USA) were used to carry out analysis of variance on all data, and Tukey's multiple range test was used to separate means.

## RESULTS AND DISCUSSION

### Rootstock Vigor

In all experimental sites, regardless of scion varieties, GF677, Garnem and RP90 induced the highest vigor (largest TCSA), while RP40 and RP20 the lowest (Fig. 1). However, trees grown in Sicily exhibited smaller TCSA than those grown in Emilia-Romagna (Fig. 1). Such TCSA differences between locations can be for the most part explained by the different training systems. Specifically in Forlì and Cesena, trees trained to delayed vase received minimal pruning and maintained their central axis (generally removed after the 3$^{rd}$ leaf). On the other hand in Castelvetrano, trees trained to modified Spanish bush received severe summer and winter pruning, and the four main branches were headed to about 2 m. In addition, differences in vigor could be due to the different environmental conditions between sites. In particular, the 2014-2015 winter season was extremely mild in Sicily, possibly preventing the complete fulfillment of the cultivar chilling requirement, followed by a very hot and dry summer. Most likely the concurrence of these events negatively influenced tree growth in all grafting combinations.

### Harvest Date

In Sicily, fruit matured over a relatively long period, and 3 to 5 picking dates were necessary in order to harvest uniformly ripe fruit (Fig. 2). This may be in part due to the insufficient chilling mentioned above. Adesoto and RP20 slightly anticipated 'Big Top' harvest as compared to the other grafting combinations. In Forlì, the harvest of 'Rome Star' was completed in three picks in all grafting combinations, with no significant differences in the average harvest date among rootstocks (Fig. 2).

### Fruit Yield

Regardless of rootstock, trees grown in Emilia-Romagna produced more and were more efficient than trees grown in Sicily (Tabs. 1-3). This can be easily explained by the small canopy size (modified Spanish bush) and insufficient chilling experienced by trees grown in Sicily. Trees on RP40 were the most productive and yield efficient under Sicilian conditions, followed closely by trees on Adesoto and RP20 (Tab. 1). Yield differences were mainly due to fruit weight rather than to a higher fruit number. In both experimental sites of Emilia-Romagna, yield was generally related to tree vigor, with trees on GF677 being the most productive (Tabs. 2 and 3). In this case, yield differences were mainly due to differences in crop load. Yield efficiency was also higher in vigorous rootstocks, with the only exception of RP40, which combined a size-controlling effect with high yield efficiency. Similarly to what observed in Sicily, RP40 trees grown in Emilia-Romagna yielded the largest fruit.

**Fruit Quality**

In Castelvetrano, fruit of trees on RP20 and Adesoto exhibited the highest SSC (Tab. 4). No differences were found in terms of flesh firmness, as expected, and TA among trees on different rootstocks. In Forlì, significant differences in flesh firmness were found among rootstocks (Tab. 5). Hence, flesh firmness was used as covariate in the analysis of variance model, in order to compare fruit at the same degree of maturity. In Forlì, RP90 induced the highest juice SSC, while RP40 induced the lowest. Similarly to Castelvetrano, TA values were not affected by the rootstock.

## CONCLUSIONS

Although preliminary, the results presented in this study already highlight marked differences among the tested rootstocks in terms of vigor, yield and yield efficiency. In Forlì and Cesena, endowed with heavy-textured soils of medium-low fertility, the peach x almond hybrid GF677 exhibited a better field performance than excessively size-reducing rootstocks, such as the RP20 tested in this trial. This confirms the outcomes of previous network studies on rootstocks in Italy (Ancarani et al., 2009; Massai and Loreti, 2009). The performance of the peach x almond RP40 seems worth of interest, as it combined in all the experimental sites a remarkable size-controlling effect with high yield efficiency and good fruit quality. These characteristics could be fully exploited in high-density plantings, where the relatively low yield per tree could be offset on a hectare basis.

## ACKNOWLEDGEMENTS

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## Literature Cited

Ancarani, V., Fei, C., Godini, A., Giovannini D., Grandi, M., Liverani, A., Lugli, S., Massai, R., Palasciano, M. and Sansavini, S. 2009. Monografia dei portinnesti dei fruttiferi. Ministero delle politiche Agricole Alimentari e Forestali, Rome.

Basile, B., Marsal, J. and DeJong, T.M. 2003a. Daily shoot extension growth of peach trees growing on rootstocks that reduce scion growth to daily dynamics of stem water potential.

Tree Physiol. 23:695-704.
Basile, B., Marsal, J., Solari, L.I., Tyree, M.T., Bryla, D.R. and DeJong, T.M. 2003b. Hydraulic conductance of peach trees grafted on rootstocks with differing size-controlling potentials. J. Hortic. Sci. Biotechnol. 78:768-774.
Caruso, T., Guarino, F., Lo Bianco, R. and Marra, F.P. 2015. Yield and profitability of modified Spanish bush and Y-trellis training systems for peach. HortScience 50:1160-1164.
Caruso, T., Inglese, P., Sidari, M. and Sottile, F. 1997. Rootstock influences seasonal dry matter and carbohydrate content and partitioning in above-ground components of 'Flordaprince' peach trees. J. Amer. Soc. Hort. Sci. 122:673-679.
Cohen, S. and Naor, A. 2002. The effect of three rootstocks on water use, canopy conductance and hydraulic parameters of apple trees and predicting canopy from hydraulic conductances. Plant Cell Environ. 25:17-28.
De Salvador, F.R., Giovannini, D. and Liverani, A. 2007. Effects of crop load and rootstock on fruit quality in ‘Suncrest’ peach cultivar. Acta Hort. 732:279-283.
Iglesias, I. 2013. Peach production in Spain: Current situation and trends, from production to consumption. Proc. 4th Conf. Innovation in Fruit Growing, Belgrade, Serbia 11 February. p. 74-98.
Jiménez, S., Dridi, J., Gutiérrez, D., Moret, D., Irigoyen, J.J., Moreno, M.A. and Gogorcena, Y. 2013. Physiological, biochemical and molecular responses in four *Prunus* rootstocks submitted to drought stress. Tree Phys. 33:1061-1075.
Loreti, F. and Massai, R. 1998. Il contributo dell'Università di Pisa al miglioramento genetico dei portinnesti. Riv. Frutticoltura 4:9-13.
Loreti, F. and Massai, R. 2006. ‘Castore’ and ‘Polluce’: Two new hybrid rootstocks for peach and nectarine. Acta Hort. 713:275-278.
Marra, F., Lo Bianco, R., La Mantia and M., Caruso, T. 2013. Growth, yield and fruit quality of ‘Tropic Snow’ peach on size-controlling rootstocks under dry Mediterranean climates. Sci. Hort. 160:274-282.
Massai, R. and Loreti, F. 2009. I portinnesti del pesco. Proc. Int. Conf. Fruit Tree Rootstocks, Pisa, Italy 26 June. p. 117-136.
Massai, R., Loreti, F. and Fei, C. 2003. Evaluaciòn de nuevo patrones hibridos melocotonero x almendro. ITEA 99:27-37.
Solari, L.I., Johnson, S. and DeJong, T.M. 2006. Relationship of water status to vegetative growth and leaf gas exchange of peach (*Prunus persica*) trees on different rootstocks. Tree Physiol. 26:1333-1341.

**Tables**

Table 1. Fruit production of 'Big Top' nectarine grafted on six *Prunus* rootstocks and grown in Castelvetrano. Different letters indicate significant differences within each column (Tukey's test at $P<0.05$).

| Rootstock | Yield (kg tree$^{-1}$) | Crop load (n) | Fruit weight (g) | Yield efficiency (kg cm$^{-2}$) |
|---|---|---|---|---|
| RP40 | 4.27 a | 26.6 | 161 a | 0.22 a |
| ADESOTO | 3.52 a | 26.1 | 134 b | 0.18 ab |
| RP20 | 2.22 ab | 20.2 | 108 c | 0.18 ab |
| RP90 | 2.91 ab | 21.8 | 132 b | 0.11 bc |
| GF677 | 3.25 ab | 23.9 | 135 b | 0.11 bc |
| GARNEM | 2.12 b | 16.0 | 130 b | 0.06 c |

Table 2. Fruit production of 'Big Top' nectarine grafted on six *Prunus* rootstocks and grown in Cesena. Different letters indicate significant differences within each column (Tukey's test at $P<0.05$).

| Rootstock | Yield (kg tree$^{-1}$) | Crop load (n) | Fruit weight (g) | Yield efficiency (kg cm$^{-2}$) |
|---|---|---|---|---|
| RP90 | 31.5 ab | 189 a | 168 ab | 0.62 a |
| RP40 | 18.2 c | 96 c | 196 a | 0.60 ab |
| GF677 | 33.7 a | 188 a | 182 ab | 0.55 ab |
| GARNEM | 27.0 b | 156 ab | 171 ab | 0.49 ab |
| RP20 | 15.1 c | 91 c | 167 b | 0.47 ab |
| ADESOTO | 18.2 c | 120 bc | 159 b | 0.44 b |

Table 3. Fruit production traits of 'Rome Star' peach grafted on six *Prunus* rootstocks and grown in Forlì. Different letters indicate significant differences within each column (Tukey's test at $P<0.05$).

| Rootstock | Yield (kg tree$^{-1}$) | Crop load (n) | Fruit weight (g) | Yield efficiency (kg cm$^{-2}$) |
|---|---|---|---|---|
| GF677 | 29.1 a | 196 a | 149 ab | 0.67 a |
| RP40 | 11.0 c | 66 b | 169 a | 0.57 ab |
| RP90 | 19.6 b | 143 a | 139 b | 0.55 ab |
| GARNEM | 21.1 b | 147 a | 146 ab | 0.43 ab |
| RP20 | 7.4 c | 49 b | 157 ab | 0.42 ab |
| ADESOTO | 12.0 c | 76 b | 164 a | 0.39 b |

Table 4. Fruit flesh firmness, soluble solid content (SSC) and titratable acidity (TA) of 'Big Top' nectarine grafted on six *Prunus* rootstocks in Castelvetrano. Different letters indicate significant differences within each column (Tukey's test at $P<0.05$).

| Rootstock | Flesh firmness ($kg\ cm^{-2}$) | SSC (°Brix) | TA ($g\ L^{-1}$) |
|---|---|---|---|
| RP20 | 4.49 | 17.7 a | 5.38 |
| ADESOTO | 4.96 | 16.9 ab | 5.47 |
| RP40 | 4.78 | 15.3 bc | 5.54 |
| RP90 | 4.24 | 15.2 bc | 5.32 |
| GF677 | 4.54 | 15.1 bc | 5.70 |
| GARNEM | 4.97 | 14.3 c | 5.05 |

Table 5. Fruit flesh firmness, soluble solid content (SSC) and titratable acidity (TA) of 'Rome Star' peach grafted on six *Prunus* rootstocks in Forlì. Flesh firmness was used as covariate in the ANOVA to adjust for differences in fruit maturity. Different letters indicate significant differences within each column (Tukey's test at $P<0.05$).

| Rootstock | Flesh firmness ($kg\ cm^{-2}$) | SSC (°Brix) | TA ($g\ L^{-1}$) |
|---|---|---|---|
| RP90 | 5.86 bc | 14.5 a | 9.7 |
| RP20 | 5.32 c | 14.4 ab | 10.4 |
| ADESOTO | 4.85 c | 13.8 ab | 10.1 |
| GF677 | 7.40 a | 14.0 ab | 10.3 |
| RP40 | 5.28 c | 13.7 b | 10.2 |
| GARNEM | 6.69 ab | 13.9 ab | 10.6 |

## Figures

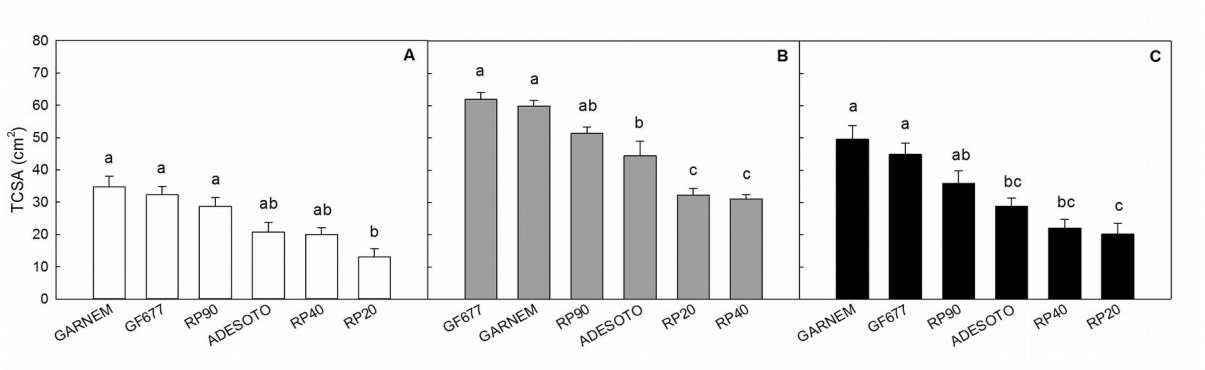


Fig. 1. Trunk cross-sectional area (TCSA) of 'Big Top' and 'Rome Star' grafted on six Prunus rootstocks in Castelvetrano (A), Cesena (B) and Forlì (C). Different letters indicate significant differences within each panel (Tukey's test at $P<0.05$).

| 'Big Top' | June | | | | | | | | | | | July | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 | **27** | **28** | **29** | 30 | 1 | **2** | 3 | 4 | 5 | **6** | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Adesoto | | | | | | | | 2 | 9 | 31 | | | 45 | | | | 13 | | | | | | | | | |
| Garnem | | | | | | | | | | 7 | | | 35 | | | | 58 | | | | | | | | | |
| GF677 | | | | | | | | | | 3 | | | 45 | | | | 52 | | | | | | | | | |
| RP20 | | | | | | | | | 4 | 23 | | | 45 | | | | 28 | | | | | | | | | |
| RP40 | | | | | | | | | 5 | 24 | | | 29 | | | | 42 | | | | | | | | | |
| RP90 | | | | | | | | | | 10 | | | 32 | | | | 58 | | | | | | | | | |

| 'Rome Star' | July | | | | | | August | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26 | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | **7** | 8 | 9 | 10 | **11** | 12 | 13 | **14** | 15 | 16 | 17 | 18 | 19 | 20 |
| Adesoto | | | | | | | | | | | | | 10 | | | | 68 | | | 22 | | | | | | |
| Garnem | | | | | | | | | | | | | 2 | | | | 60 | | | 38 | | | | | | |
| GF677 | | | | | | | | | | | | | 3 | | | | 49 | | | 48 | | | | | | |
| RP20 | | | | | | | | | | | | | 10 | | | | 69 | | | 21 | | | | | | |
| RP40 | | | | | | | | | | | | | 13 | | | | 73 | | | 14 | | | | | | |
| RP90 | | | | | | | | | | | | | 4 | | | | 57 | | | 39 | | | | | | |

Fig. 2. Percentages of picked fruit at each pick date (bold), harvest period (light gray) and average harvest date (dark gray) for 'Big Top' and 'Rome Star' grafted on six different rootstocks, in Castelvetrano and Forlì, respectively.