Performance and Physiology of the Controller™ Series of Peach Rootstocks

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Abstract

Over the past ten years six new peach rootstocks have been released by UC Davis. All of these rootstocks have been shown to rely on a decreased rootstock hydraulic conductance mechanism to impart the size-controlling behavior. Previous research has indicated that strongly dwarfing peach rootstocks that depend on decreased rootstock hydraulic conductance-related size-controlling tend to produce fruit with decreased mean fruit sizes for a given crop load. The objective of this experiment was to evaluate the fruit size versus crop load relationships of the latest series of new peach rootstocks that are known to be size-controlling because of reduced xylem hydraulic conductance. This research compared fruit size characteristics for three new rootstocks that ranged in tree vigor from 70 to 95% of trees on the current industry standard rootstock ('Nemaguard'). This research documented that, unlike the previously released Controller™ 5 rootstock the fruit size and box yields of marketable fruit per tree on the newer Controller™ rootstocks are comparable to trees on 'Nemaguard' for a wide range of crop loads. Furthermore, the box yields of marketable-sized fruit indicate at typical crop loads for the peach and nectarine scion cultivars used in this study may be less than optimal for achieving maximum yields of marketable fruit.

INTRODUCTION

While numerous new peach rootstocks have been made available in recent years, adoption of these rootstocks in commercial orchards in California is quite limited because of erratic performance. In 1986 a screening study of *Prunus* genotypes with widely varying genetic backgrounds was begun to evaluate rooting capacity, peach scion compatibility and size-controlling characteristics. This study eventually led to the release of two *P. salicina* × *P. persica* hybrid rootstocks, 'Controller™ 5' and 'Controller™ 9'. A second rootstock development program initiated in the early 90's focused on hybrids between the two peach genotypes; 'Harrow Blood' and 'Okinawa'. This project eventually led to the release of four additional size-controlling rootstocks that also have resistance to root-knot nematode; 'Controller™ 6, 7, 8 and 9.5' which correspond experimental rootstock numbers HBOK 27, 32, 10 and 50, respectively. The numbers of each of the Controller™ rootstocks corresponded to the relative order of vigour they impart to scions; i.e., 50, 60, 70, 80 and 90 percent of trees on the standard peach rootstock used in California, 'Nemaguard'. The 'Controller™ 6, 7, 8 and 9.5' rootstocks are also resistant to root-knot nematodes.

While there are a number of proposed theories about physiological mechanisms involved in making reduced vigor rootstocks work, research on the mechanism of recently released dwarfing rootstocks for peach cultivars in California has shown that their dwarfing capabilities are due to reduced hydraulic conductance of the rootstock genotype and complex interactions between the rootstocks and the scions (Basile et al., 2003a, 2003b; Solari and DeJong, 2006; Solari et al., 2006b, 2006c; Weibel et al., 2003). These size-controlling rootstocks have xylem vessels that are smaller in diameter compared to those of the grafted scions and the industry standard rootstock, 'Nemaguard' (Solari et al., 2006a; Tombesi et al., 2010a). The smaller diameter of the xylem vessels in size-controlling rootstocks lowers the hydraulic conductance of the rootstock's water conducting tissues which restricts water availability to the scion (Solari and DeJong,

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2006; Tombesi et al., 2010). This restriction causes a slight lowering of the water potential in the stems and leaves of the scion which lessens the elongation of stems and, over time, causes the overall vigor of the tree to be less (Basile et al., 2003a; Solari et al., 2006a, 2006b, 2006c). The reduced water potential acts as a limit to the amount of vegetative growth a tree can produce in the spring and over the course of a season. This can be seen when compared to a normal vigor rootstock such as 'Nemaguard'. While the trees are still able to meet their demand for nutrients and water as the season goes on, the initial growth lag builds upon itself over the years and can lead to trees being half the size of trees on the vigorous 'Nemaguard' rootstock (DeJong et al., 2011; Weibel et al., 2003).

We know that size controlling in the HBOK ('Controller™6, 7, 8 and 9.5') series of rootstocks is caused by reduced xylem hydraulic conductance in the rootstocks that alters the stem water potential and vigor of the scion (Tombesi et al., 2010b). Previous research has indicated that strongly dwarfing peach rootstocks that depend on this mechanism of size controlling tend to produce fruit with decreased mean fruit sizes for a given crop load (DeJong et al., 2011; Reginato et al., 2007; Stover et al., 2001). The objective of this experiment was to evaluate the fruit size versus crop load relationships of a series of new peach rootstocks that are known to be size-controlling because of reduced xylem hydraulic conductance. This research compared fruit size characteristics for three new rootstocks that ranged in tree vigor from 70 to 95% of trees on the current industry standard rootstock ('Nemaguard'). The research focused on the fruit yields from trees on the rootstocks located at the University of California Kearney Agricultural Center. The yield data from the 2009 and 2010 harvest season were compared among trees on different rootstocks to see if there was a loss in production as a result of using vigor reducing rootstocks. Fruit sizes were also used to compare rootstock performance and to determine if trees on size-controlling rootstocks produced fruits of inherently smaller size at comparable crop loads. Both commercial and a range of levels of fruit thinning were used to determine if fruit sizes on vigor reducing rootstocks were affected by crop loads differently than on the 'Nemaguard' control.

MATERIALS AND METHODS

The experiment took place at the University of California Kearney Agricultural Center in Parlier, California. The two plots used in the experiment were planted in 2003 and 2004 as part of a rootstock trial project designed to evaluate reduced tree vigor in combination with root-knot nematode resistance. Peach (*Prunus persica* L. Batsch) and nectarine cultivars 'O'Henry' and 'Summer Fire', respectively, were planted on several different rootstocks in replicated trials. The replicated trials consisted of five tree replicates for each rootstock with four replicate plots per rootstock. The trees in the trials were clonally propagated. The trees were planted on slightly raised beds, 2.13 meters apart in the row with 5.49 meters between rows vegetated with mowed grasses. Trees were micro-sprinkler irrigated to replace used water as estimated from calculations of crop evapotranspiration. Guard trees were also planted at the beginning and end of each row but there were no guard trees between plots in a row or between rows. Trees were trained to a perpendicular V (DeJong et al., 1994) and were treated in a manner similar to that of commercial orchards, with dormant and summer pruning as well as hand thinning.

In both plots, the rootstocks focused on in this study were from a series of controlled genetic crosses between 'Harrow Blood' peach and 'Okinawa' peach, designated as HBOK. In the plot planted in 2003 the experimental rootstocks were HBOK 32 ('Controller™ 7'), HBOK 10 ('Controller™ 8', HBOK 50 ('Controller™ 9.5', and 'Nemaguard' (control) with peach cultivar 'O'Henry' as the scion. (Since this experiment was initiated prior to their release, hereafter the rootstocks are referred to by their experimental numbers (HBOK 32, 10 and 50). These rootstocks and their scion are further referred to in this study as O'Henry. In the plot planted in 2004 'Summer Fire' nectarine was used as the scion and the rootstocks were HBOK 32, HBOK 10, and 'Nemaguard' (control).

Trunk circumferences were measured in the late fall/early winter on each tree in the years before and after the harvest experiment, measuring 20 cm above the ground or the graft union, whichever was higher. Trunk cross-sectional area (TCA) was calculated from the trunk circumference data and used as an indicator of overall tree size.

Trees were hand-thinned approximately 40 days after bloom, purposely leaving a range of numbers of fruit per tree. Fruit were harvested in three picks, with the last pick being a strip pick. Fruit harvests took place on July 30th, August 3rd and August 7th for the 'O'Henry' cultivars and on July 21st, July 27th and August 4th for the 'Summer Fire' cultivar. During each pick all fruit were picked into boxes and the source tree of the fruit in each box was registered. The fruit from each box were then passed over a commercial fruit sizer and the fruit from each tree were sorted into a range of size classes. The numbers of boxes of fruit of each size class were calculated per individual tree from these data.

RESULTS AND DISCUSSION

Of the rootstocks discussed here trees on HBOK 32 were the most size-controlling followed by trees on HBOK 10 and 50. Trees on the control rootstock, 'Nemaguard', were the largest in both the peach and nectarine plots (Table 1). Relative dormant and summer pruning weights corresponded with the TCA data with HBOK 32 and 10 requiring 50 to 30 percent less pruning than trees on 'Nemaguard' (data not shown).

Mean fruit yield per tree and fruit size tended to be higher for trees on 'Nemaguard' followed by trees on HBOK 50, HBOK 10 and HBOK 32 for 'O'Henry' peach and HBOK 32 and HBOK 10 for 'Summer Fire' nectarine (Table 2). However, mean yield and fruit size data by themselves can be misleading since both mean tree yield and fruit size vary dramatically depending on tree crop load. Therefore, mean fruit weight per tree was plotted against crop load per tree and the slope and intercept of the resulting linear plots provided a better picture of the fruit size and yield potential under varying tree crop loads (Figs. 1 and 2). A very positive result of these analyses was that trees on all the size-controlling rootstocks tended to produce fruit sizes comparable to trees on 'Nemaguard' at low to moderate crop loads in both the 'O'Henry' and 'Summer Fire' plots. Even at the higher crop loads the differences among rootstocks were relatively small for the 'O'Henry' trees but tended to be larger for 'Summer Fire'.

However, even plots of mean fruit size vs. crop load per tree are not reflective of the potential of trees on specific rootstocks to produce commercially valuable fruit yields because mean fruit size calculations incorporate fruit of the total range of sizes and fruit of all sizes equally influence the mean fruit size. On the other hand growers are only interested in the number of fruit of marketable sizes and larger size fruit are of much greater value both because of price differences per box and because fruit are sold by the box and it takes substantially fewer large fruit to fill a box than when small fruit are packed into the same size box. Therefore, the fruit size data per tree were used to regress the number of boxes of each fruit size class per tree against the fruit numbers harvested per tree for the trees on each of the rootstocks. When data for the marketable 'O'Henry' peach fruit with box fruit counts of 72 or less were combined (Fig. 3), differences in the production behavior of trees on the size-controlling rootstocks compared with trees on 'Nemaguard' were negligible until crop loads became very high. The slopes for the regressions of marketable 'Summer Fire' nectarine fruit with box fruit of 72 or less against fruit number harvested per trees were even more closely aligned (Fig. 4). Thus the yield performance of the size-controlling rootstocks in this trial was very similar to trees on 'Nemaguard'. Yield data taken during the subsequent year (2010, data not shown) in the same plots were very similar to those in 2009.

A surprising result of these analyses was that the number of marketable boxes continued to linearly increase with crop load with the 'Summer Fire' nectarine (Fig. 4) and only slightly fall off at high crop loads with 'O'Henry' peach (Fig. 3). This means that even at crop loads ~6 boxes per tree (~56 tons/hectare) both the 'O'Henry' and 'Summer Fire' trees were not at their maximum marketable yield potential. While trees on the more size-controlling rootstocks tended to have fewer fruit per tree it is likely that, since the trees on less vigorous rootstocks could be planted at higher densities than in this trial, per hectare crop loads could be the same on smaller trees planted more densely as with trees on more vigorous rootstocks planted at the densities in this trial without sacrificing fruit size.

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Tables

Table 1. Trunk cross sectional areas of 'O'Henry' peach and 'Summer Fire' nectarine trees on four rootstocks measured in the winter before and after the 2009 harvest year.

Year	'O'Henry'				'Summer Fire'		
	HBOK 10	HBOK 32	HBOK 50	Nemaguard	HBOK 10	HBOK 32	Nemaguard
2008	82.0	68.8	113.7	120.0	100.6	86.7	144.8
± S.E.	7.21	3.63	6.01	5.41	8.07	9.03	5.19
2009	99.5	86.2	131.3	140.7	121.4	104.2	174.9
± S.E.	8.16	9.09	11.31	5.97	9.12	10.53	6.04

Table 2. Mean ± SE harvest data for 'O'Henry' peach and 'Summer Fire' nectarine trees on different rootstocks harvested in 2009.

Rootstock	Mean fruit weight per tree (kg)	Mean # fruit harvested per tree	Mean weight of fruit (g)
		'O'Henry'	
HBOK 10	53.1± 3.3	266.2± 20.5	203.0± 6.9
HBOK 32	52.7± 2.7	270.3± 17.5	198.0± 5.4
HBOK 50	59.7± 1.7	301.2± 11.3	200.1± 4.0
Nemaguard	60.3± 2.1	291.8± 10.9	207.6± 3.1
		'Summer Fire'	
HBOK 10	37.2± 2.9	209.5± 19.0	193.1± 5.2
HBOK 32	39.2± 2.5	222.4± 17.5	185.2± 4.6
Nemaguard	40.4± 3.4	216.6± 21.6	203.2± 2.5

Figures

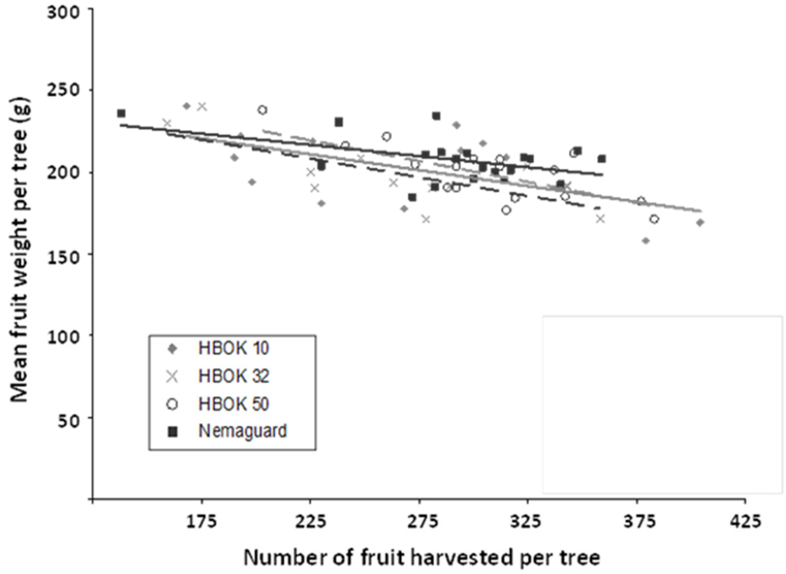

Fig. 1. Mean individual fruit weight per tree vs. the number of fruit harvested per tree for 'O'Henry' peach trees grown on four different rootstocks in the seventh year after planting.

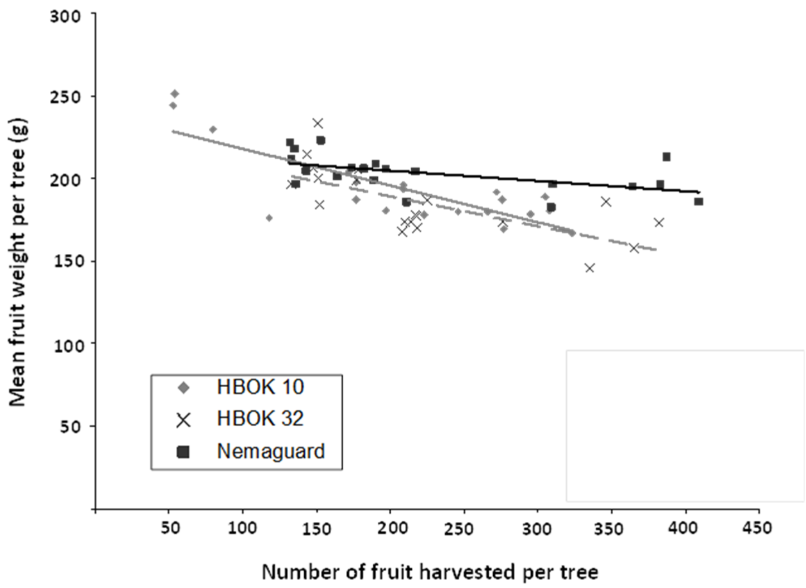

Fig. 2. Mean individual fruit weight per tree vs. the number of fruit harvested per tree for 'Summer Fire' nectarine trees grown on three different rootstocks in the sixth year after planting.

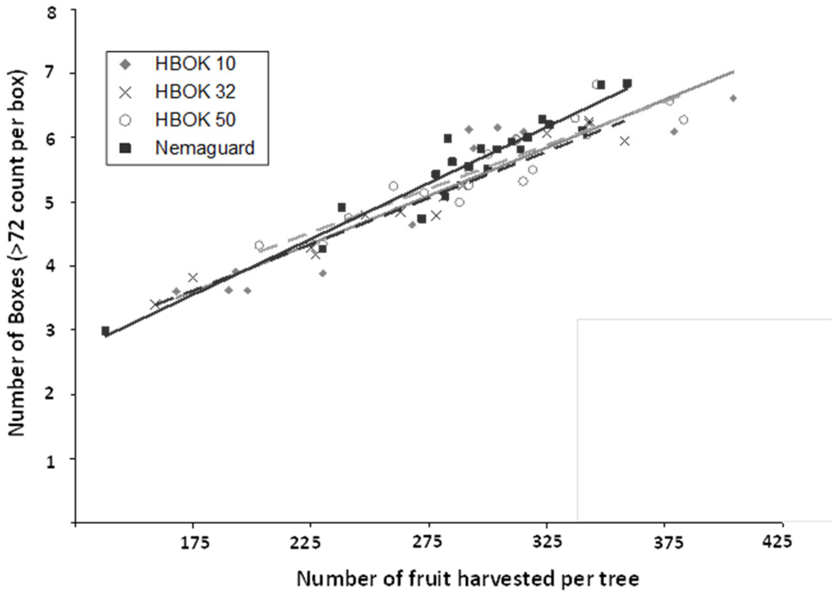

Fig. 3. Mean number of marketable boxes of fruit (box fruit counts of 72 or less) per tree vs. the number of fruit harvested per tree for 'O'Henry' peach trees grown on four different rootstocks in the seventh year after planting.

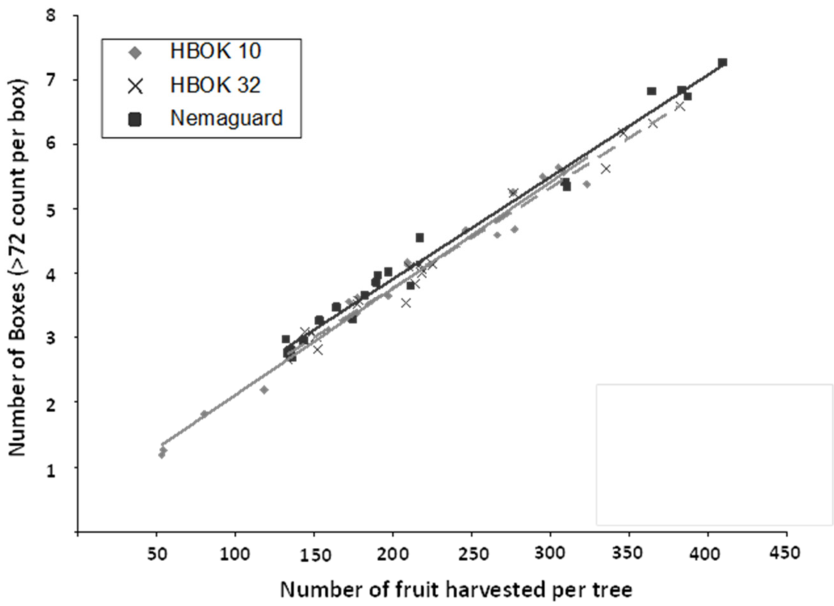

Fig. 4. Mean number of marketable boxes of fruit (box fruit counts of 72 or less) per tree vs. the number of fruit harvested per tree for 'Summer Fire' nectarine trees grown on three different rootstocks in the sixth year after planting.