EVALUATION OF SIZE CONTROLLING ROOTSTOCKS FOR CALIFORNIA PEACH PRODUCTION

T.M. DeJong, A. Weibel, W. Tsuji, J.F. Doyle, R.S. Johnson and D. Ramming
Department of Pomology, University of California, One Shields Avenue, Davis, CA 95616, USA

Keywords**:** dwarfing rootstocks, *Prunus persica*, peach productivity.

Abstract

The primary factor limiting the use of size controlling rootstocks in stone fruit production is the lack of availability of suitable rootstocks with a wide range of compatibility among cultivars. From 1986 to 1994 we evaluated 80+ genotypes representing a broad range of genetic backgrounds for their rooting capacity, compatibility with peach (O'Henry) and plum (Santa Rosa), and size controlling characteristics. During 1990 and 1991 we identified 19 potential size controlling rootstock genotypes for peach. In February, 1996 a four-acre experimental rootstock trial was planted at the Kearney Agricultural Center to evaluate the potential of eight of these rootstocks compared to commercially available stocks. This experiment involves ten different rootstocks and two scions. The ten rootstocks are: Alace, Hiawatha, Sapalta (open pollinated seedlings of a *Prunus besseyi* x *P. salicina* hybrid), K-145-5, K-146-43, K-146-44, P-30-135, (*P. salicina* x *P. Persica* hybrids) K-119-50 (*P salicina* x *P. dulcis* hybrid), Citation and Nemaguard. The two main scion cultivars are Loadel (an early clingstone processing cultivar) and Flavorcrest (an early fresh market freestone cultivar). Although three of the test rootstocks have exhibited some tree loss due to delayed incompatibility with selected scion cultivars, the results of the other scion/rootstock combinations have been positive. One rootstock (P-30-135) appears very promising with tree size/vigor approximately 70% of Nemaguard and fruit size potential across a range of crop loads $\geq$ all other tested rootstocks.

1. Introduction

Over half of the annual production costs for California peaches involves hand labor for pruning, thinning and harvesting which is done on ladders because of large tree size (DeJong *et al.* 1999). It is widely recognized that production costs could be substantially reduced if the size of peach trees could be reduced enough to eliminate the need for ladders in the orchard. The benefit of size-controlling rootstocks has been clearly demonstrated with apples and revolutionized apple industries around the world.

The primary factor limiting the use of size-controlling rootstocks in stone fruit production is the lack of availability of suitable size controlling rootstocks with a wide range of compatibility among cultivars (Rom and Carlson 1987). In 1986 a rootstock screening experiment was initiated at the University of California Kearney Agricultural Center to identify potentially suitable size controlling rootstocks for California peach and plum production. More than one hundred and twenty *Prunus* genotypes from a broad range of genetic backgrounds were evaluated for their rooting capacity, size controlling characteristics and compatibility with peach (cv. O'Henry) and Japanese plum (cv. Santa Rosa). At the conclusion of that experiment, nineteen size controlling rootstocks were selected as having commercial potential for California peach production. The purpose of this study was to further evaluate the eight most promising of those rootstocks under growth and management conditions that are comparable to standard commercial practices. This report summarizes the results of the first three years of this trial.

2. Materials and Methods

In February, 1996 a field rootstock trial was established at the University of California Kearney Agricultural Center, Parlier, CA. The research block consisted of two peach scion cultivars (*Prunus persica* L. Batsch cvs. Loadel (clingstone) and Flavorcrest (freestone)) bud-grafted onto ten different rootstock genotypes. The ten rootstocks were Alace, Hiawatha, Sapalta (open pollinated seedlings of Sapa, a *Prunus besseyi* x *P. salicina* hybrid), K-145-5, K-146-43, K-146-44, P-30-135 (*P. salicina* x *P. persica hybrids*) K-119-50 (*P. salicina* x *P. dulcis* hybrid) and two control rootstocks, Citation (*P. salicina* x *P. persica*) and Nemaguard (*P. persica*). A total of thirty-six trees of each rootstock/scion combination were planted in two different training systems. Four replications of five trees each were planted and trained to the KAC-V perpendicular V system; (DeJong *et al.* 1994) and four replications of four trees each were planted and trained to the standard open vase system (Micke *et al.* 1980). Between-row spacing was the same for all rootstock/scion/training system combination (4.88 m.) but in-row spacing varied according to expectations of final tree size. In-row tree spacing was 1.98 m (1035 trees/ha) for trees on Nemaguard and P-30-135 and 1.83 m (1120 trees /ha) for K-119-50, Alace, Hiawatha, Sapalta, K-145-5, K-146-43 and K -146-44 in the KAC-V system and 4.88m (420 trees/ha) for Nemaguard and P-30-135, 4.27m (480 trees/ha) for K-119-50 Alace, Hiawatha, Sapalta and K-145-5, and 3.66m (560 trees/ha) for K-146-43 and K-146-44 in the open vase systems. Replication of the rootstock/scion combinations were randomized within training system/scion cultivar subplots. In-row tree spacing between replications in the open vase system was the shortest tree distance within the replications plus one-half the spacing difference between the replications. (When a Nemaguard replication was planted adjacent to a K-146-43 replication, the in-row spacing between replicates was 4.27 m).

The soil at the site is a well-drained Handford, fine sandy loam. The trees were flood-irrigated to maintain 100% of potential evapo-transpiration prior to harvest and about 80% after harvest. Fertilizer and pesticides were applied according to standard horticultural practices. Weeds were controlled by mowing the row middles and applying herbicides to maintain a 1.5 wide weed-free strip down the tree rows.

Trees were pruned during midsummer and during the dormant season for the first three years after planting according to standard recommendations for growing the two systems (DeJong *et al.* 1999). Severity of pruning was adjusted according to the growth characteristics of each rootstock/scion combination to optimize crop production while developing/maintaining the desired tree shape. The first significant fruit set occurred in the third leaf and in most of the trees crop load was adjusted for tree size by hand thinning to maintain a minimum spacing between fruit. In addition, a cropload/fruit size study was conducted in the Loadel-KAC-V portion of the plot. For this study, one tree in each of the four, five-tree replications for each rootstock was heavily thinned shortly after bloom to carry an average of 30-45 fruit per tree. Another tree in each rootstock/scion replication was left unthinned while the remaining three trees in each replication were normally thinned to carry an average of 100-150 fruit, depending on tree size. Because patterns of fruit maturity varied somewhat with rootstock, fruit were harvested in several picks but data were combined from all harvests to calculate mean fruit yield, number and weight of individual fruit per tree for each rootstock/scion/training system combination.

3. Results

Rootstock related differences in tree size and vigor were apparent after the first year of growth in the field. Nemaguard was clearly the most vigorous generally followed by K-119-50, P-30-135, Hiawatha, K-145-5, K-146-43, Alace, Sapalta, K-146-44 and Citation, respectively. However, in the fall of the first year in the field several trees of Citation, K-145-5, Alace and Sapalta appeared unhealthy with premature leaf fall and leaf “boating” and “bronzing”. During the subsequent spring several of these trees died while others appeared to recover. By the following fall, additional trees appeared unhealthy and more died. As a

consequence these scion/rootstock combinations were eliminated from the formal experiment and no further data on them was collected. For brevity only tree growth and yield data from the third year of the study are presented.

The six rootstocks left in this trial generally fall into two categories in relation to trunk growth. Trees on Hiawatha, P-30-135 and K-119-50 had trunk cross sectional areas (TCA) between 60 and 80% of Nemaguard while TCA's of trees on K-146-43 and K-146-44 were between 25 and 40% of Nemaguard (Table 1). However the Flavorcrest trees on P-30-135 grew more like trees on Nemaguard during the third year of the study. The weight of wood pruned from the trees during the summer and dormant season followed a pattern similar to that of TCA. (Tables 2 and 3). However, the trees on Hiawatha were intermediate between the slightly dwarfing stocks (K-119-50 and P-30-135) and the more size-controlling stocks (K-146-43 and K-146-44).

Mean fruit yield for each scion/rootstock combination decreased with decreasing tree size (Table 4). The rootstocks that produced smaller trees also tended to have fewer fruits per tree. Trees on all of the rootstocks appeared to produce fruit of size similar to trees on Nemaguard in at least one of the four scion/rootstock/training system combinations but the overall crop yield performance of any rootstock was difficult to evaluate because of differences in crop load between the various treatments. KAC-V trees generally had about one-third the crop load as open vase trees while mean fruit size was generally comparable but quite variable. Crop loads and yields were substantially less with Flavorcrest than Loadel because Flavorcrest is a fresh market cultivar that is harvested earlier than Loadel which is used in the processing industry. Consequently mean fruit size of Flavorcrest was generally larger than Loadel. One rootstock (P-30-135) produced KAC-V trees with particularly large fruit size in both the Loadel and Flavorcrest parts of the experiment.

A cropload/fruit size study conducted within the Loadel/KAC-V part of the experiment appeared to substantiate the tendency for KAC-V trees on P-30-135 to produce larger fruit size (data not shown). Fruit size within the heavy-thinned treatment of this experiment should not have been limited by interfruit competition (Grossman and DeJong 1995) but fruit on trees of P-30-135 produced fruit with 12.5% greater mean size potential than trees on Nemaguard while trees on all the other rootstocks produced fruit with a mean size potential equal to or less than Nemaguard. Interestingly, unthinned trees of P-30-135 tended to have fewer fruit than trees on all the other rootstocks while most of the unthinned trees on the other size-controlling rootstocks produced as many, if not more, fruit than trees on Nemaguard.

4. Discussion

The results of this study indicate that five of the experimental rootstocks involved in this trial have commercial potential as size-controlling rootstocks for peach. While two of the rootstocks (K-119-50, P-30-135) produce trees that eventually grow nearly as large as trees on the standard Nemaguard rootstock, tree water sprout production is less and thus excessive vegetative growth is less. The other three rootstocks (Hiawatha, K-146-43, K-146-44) produce trees that are substantially smaller and less vigorous than current standard rootstocks. Although individual trees on the size-controlling rootstocks produced lower crop yields than trees on standard rootstocks like apples, there is no apparent reason why orchard yield potential cannot be equal to, if not greater than, that obtained on standard rootstock if tree spacings are adjusted appropriately. However, the apparent high potential for fruit set on dwarfing stocks (Table 5) may indicate an increased need for early fruit thinning (Grossman and DeJong 1995) and more precise crop load management.

The incompatibility symptoms observed on three of the rootstocks that were selected after the previous screening experiments is reason for concern since the incompatible rootstocks have similar genetic backgrounds as the five remaining stocks. However a concurrent study involving these stocks planted on the borders of the main experiment presented here indicated no incompatibility symptoms with eighteen other scion cultivars (Firebrite, Flamekist, June Go, May Glo, Rose, Sparkling June, Carson, Haig Arkalian, Cal

Red, Carnival, Elegant Lady, Fay Elberta, Queencrest, Red Top, Spring Lady, Snow Flame, Giant Babcock, Ross) from diverse genetic backgrounds. Thus the five rootstocks remaining in the study appear to have broad compatibility with peach scion cultivars.

Additional studies are ongoing to determine differences in seasonal patterns of vegetative growth induced by the various rootstocks and to develop a hypothesis for the mechanism of dwarfing in these peach systems. Similarly, future studies are planned to validate the fruit growth potential responses observed with the P-30-135 rootstock and develop an understanding of the underlying mechanism involved in that phenomenon.

References

DeJong, T.M., K.R. Day, J.F. Doyle and R.S. Johnson, 1994. The Kearney Agricultural Center Perpendicular "V" (KAC-V) orchard system for peaches and nectarines. HortTech. 4:362-367.

DeJong, T.M., W. Tsuji, H.F. Doyle and Y.L. Grossman, 1999. Comparative economic efficiency of four peach production systems in California. Hortscience 34(1): 73-78.

Grossman, Y.L. and T.M. DeJong, 1995. Maximum fruit growth potential following resource limitation during peach growth. Ann. Bot. 75:561-567.

Micke, W., A.A. Hewitt, J.K. Clark and M. Gerdts, 1980. Pruning Fruit and Nut Trees. University of California Div. of Agric. Sci. Leaflet 21171.

Rom, R.C. and R.F. Carlson, 1987. Rootstocks for fruit crops. Wiley Press, New York. 494p.

Tables

1a. Yearly TCA increment of two-year-old Loadel open vase trees grafted on six different rootstocks (mean and standard error). Different letters indicate that means differ significantly (Tukey $P<0.05$).

	----------Sample date----------		
	March 1 1998	December 1998	
Rootstock	Initial TCA (cm^2)	Final TCA (cm^2)	TCA increment (cm^2)
K-146-44	18.6 (1.91) c	33.3 (4.06) c	14.7 (2.22) c
K-146-43	25.6 (2.03) c	43.2 (2.51) c	17.6 (1.81) c
Hiawatha	54.6 (3.35) b	91.8 (5.38) b	37.2 (2.44) b
P-30-135	59.6 (2.69) b	97.1 (2.31) b	37.5 (1.93) b
K-119-50	56.3 (1.77) b	93.2 (4.12) b	36.9 (2.00) b
Nemaguard	74.0 (2.66) a	131.2 (2.08) a	57.2 (2.05) a

1b. The yearly TCA increment of Flavorcrest open vase system trees growing on six different rootstocks (mean and standard error). Different letters indicate that means differ significantly (Tukey P<0.05).

	Sample date		
	March 1 1998	December 1998	
Rootstock	Initial TCA (cm^2)	Final TCA (cm^2)	TCA increment (cm^2)
K-146-44	24.3 (0.89) c	51.6 (0.60) d	27.4 (0.77) d
K-146-43	28.4 (2.24) c	57.5 (2.98) d	29.0 (2.01) d
Hiawatha	52.4 (5.97) b	100.1 (9.31) c	47.7 (4.40) c
P-30-135	57.6 (2.31) b	127.5 (2.79) ab	70.0 (1.94) a
K-119-50	51.8 (6.05) b	105.8 (8.37) bc	54.0 (2.52) b
Nemaguard	77.4 (2.14) a	152.4 (4.73) a	75.0 (2.83) a

2. Dormant pruning weights (kg fresh weight) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems (mean and standard error) after the third season of growth in the field (January, 1999).

	Loadel		Flavorcrest	
Rootstock	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	13.9 ±1.14	2.7 ± 0.25	17.5 ± 1.48	5.0 ± 0.32
K-119-50	9.8 ± 0.45	2.8 ± 0.24	11.2 ± 0.99	4.4 ± 0.82
P-30-135	8.2 ± 0.59	2.4 ± 0.72	12.3 ± 1.22	3.7 ± 0.78
Hiawatha	5.6 ± 0.51	1.8 ± 0.19	7.8 ± 0.83	2.9 ± 0.53
K-146-43	3.6 ± 0.16	1.6 ± 0.17	5.3 ± 0.41	1.3 ± 0.21
K-146-44	2.4 ± 0.18	1.4 ± 0.06	3.9 ± 0.32	1.3 ± 0.17

3. Summer pruning weight (kg fresh weight) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems (mean and standard error) during the third season growth (August, 1998) in the field.

	Loadel		Flavorcrest	
Rootstock	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	9.6 ± 1.3	6.0 ± 0.95	17.1 ± 1.49	11.3 ± 1.65
K-119-50	5.7 ± 0.41	3.3 ± 0.33	10.0 ± 0.90	6.6 ± 0.89
P-30-135	4.8 ± 0.56	2.9 ± 0.20	11.3 ± 0.80	7.3 ± 1.59
Hiawatha	2.9 ± 0.51	2.6 ± 0.30	9.2 ± 1.07	6.7 ± 0.67
K-146-43	1.6 ± 0.21	1.6 ± 0.20	1.8 ± 0.21	1.4 ± 0.24
K-146-44	0.3 ± 0.11	1.4 ± 0.22	2 .1 ± 0.36	1.6 ± 0.22

4a: Fruit harvest data for the Loadel cultivar on the six different rootstocks (mean and standard error).

Rootstock	VASE			KAC-V		
	Mean Fruit weight/tree (kg)	Mean Fruit number/tree	Mean individual fruit weight (g)	Mean Fruit weight/tree (kg)	Mean Fruit number/tree	Mean individual fruit weight (g)
Nemaguard	71 ± 3.1	506 ± 22.8	141 ± 3.6	18 ± 1.1	145 ± 10.1	125 ± 5.8
K-119-50	66 ± 3.1	518 ± 25.7	129 ± 2.2	15 ± 1.2	125 ± 12.8	124 ± 4.3
P-30-135	59 ± 1.3	447 ± 16.8	134 ± 3.8	17 ± 1.6	125 ± 10.7	138 ± 2.8
Hiawatha	48 ± 3.5	379 ± 24.8	128 ± 3.3	14 ± 1.0	128 ± 12.6	110 ± 3.3
K-146-43	34 ± 2.0	299 ± 18.3	118 ± 2.2	13 ± 0.8	120 ± 8.7	110 ± 3.3
K-146-44	32 ± 1.9	301 ± 19.1	110 ± 3.4	12 ± 0.6	101 ± 7.7	123 ± 3.9

4b. Fruit harvest data for the Flavorcrest cultivar on the six different rootstocks (mean and standard error).

	VASE			KAC-V		
Rootstock	Mean Fruit weight/tree (kg)	Mean Fruit number/tree	Mean individual fruit weight (g)	Mean Fruit weight/tree (kg)	Mean Fruit number/tree	Mean individual fruit weight (g)
Nemaguard	50 ± 2.7	330 ± 21.2	152 ± 1.9	14 ± 0.8	96 ± 6.0	145 ± 2.5
K-119-50	34 ± 3.3	218 ± 15.6	156 ± 2.4	14 ± 0.7	89 ± 5.2	155 ± 2.5
P-30-135	34 ± 8.9	218 ± 15.6	156 ± 2.4	11 ± 1.3	65 ± 8.1	164 ± 3.2
Hiawatha	32 ± 2.0	226 ± 124	143 ± 5.1	9 ± 0.9	62 ± 6.0	155 ± 3.2
K-146-43	19 ± 1.4	142 ± 8.3	133 ± 3.2	9 ± 0.4	62 ± 2.9	138 ± 4.6
K-146-44	17 ± 1.8	138 ± 14.8	125 ± 1.8	6 ± 0.7	46 ± 5.3	135 ± 1.2