Evaluation of Size Controlling rootstocks for California Peach Production

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Over half of the annual production costs for California peaches involve hand labor for pruning, thinning and harvesting which is done on ladders because of the large size of trees. It is widely recognized that production costs could be substantially reduced if the size of the trees could be reduced enough to eliminate the need for ladders in the orchard. The benefit of size-controlling rootstocks has been clearly demonstrated in apples and revolutionized the apple industries in Europe and the U.S.

The primary factor limiting the use of size controlling rootstocks in stone fruit production is the lack of commercial availability of suitable size-controlling 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 in the peach part of this project, we identified 19 potential size controlling rootstock genotypes. In 1993, we selected 8 of the 19 for further testing in a second round of experiments. Most of these sixth leaf trees were 50-80% of the size of trees grown on standard rootstocks. In 1994 we began the current project to further evaluate these eight selected rootstocks in replicated field production trials with Flavorcrest and Loadel scion cultivars. In February, 1996, a four-acre experimental rootstock trial was planted at the Kearney Agricultural Center to evaluate the commercial potential of these rootstocks. The main part of this experiment involved ten different rootstocks and two scions. The ten rootstocks were: 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). The trial contained thirty-six trees of each rootstock/scion combination. Four replications of 5 trees each were planted and trained to the KAC-V perpendicular V system, and 4 replications of 4 trees each were planted and trained to the standard open vase system. In row tree spacings for each rootstock/scion/training system combination varied according to expectations of final tree size.

A secondary part of this experiment involves up to two trees of each of the eight experimental rootstocks budded with the following scion cultivars: Firebrite, Flamekist, Juneglo, Mayglo, Rose, Sparking June, Carson, Haig Arkalian, Cal Red, Carnival, Elegant Lady, Fay Elberta, Queencrest, Red Top, Spring Lady, Snow Flame, Giant Babcock, and Ross. The cultivars were chosen to represent a broad range of genetic backgrounds to test for scion compatibility and growth characteristics on the various rootstocks. These trees were all planted with four feet between trees in the row and were trained to KAC-perpendicular V system. They are on the margins of the plot and can be removed when compatibility studies are complete without compromising the integrity of the main plot.

Trees on six of the ten rootstocks have grown well during twelve seasons with size-controlling characteristics of five of the rootstock/scion combinations clearly apparent. Four rootstocks in the trial (Citation, Alace, Sapalta, K145-5) showed clear signs of scion/rootstock incompatibility with both the Loadel and Flavorcrest scions. These incompatibilities caused tree death during 1998 and 1999 in each rootstock/scion combination and consequently trees on these rootstocks were removed from the plot in 2001.

The best indicator of differences in relative tree size among the various scion/rootstock combinations compared to Nemaguard is the data on trunk circumferences. Trees in each of the 4 or 5 tree replicate subplots were measured after the growing season. Data from December, 2007, are provided in Table 1. Trees on all five of the remaining size-controlling rootstocks had mean trunk circumferences that were smaller than trees on Nemaguard. However, trees on P-30-135 were not significantly different than trees on Nemaguard. Trees on K-119-50, Hiawatha, K-146-43 and K-146-44 were all clearly smaller than trees on Nemaguard.

Prior to the summer of 2003 all of the trees were allowed to attain a tree height that appeared to be in balance with the relative vigor of the rootstocks. Thus, by 2003 post-dormant season pruning heights of trees on the most vigorous trees (Nemaguard, K119-50, P30-135) approached more that fourteen feet. Since the real value of size-controlling rootstocks is foreseen to be in their ability to help manage tree height, in September, 2003, the management strategy was changed and the trees were severely topped at 11 ft. This topping was repeated in September, 2004. To further test the response of the trees on the different rootstocks one-half of the replications of each scion/rootstock/training system replication was topped to 8 ft. in September 2005. This treatment was continued in the fall of 2006. Table 2 indicates the mass of wood that was removed from the trees during the summer in the first full growing season after one-half of the trees had been topped at 8 feet. Table 3 indicates the mass of wood pruned off in the dormant season after the first full growth season after topping. Note the large differences among trees on different rootstocks. There was also a clear tendency for trees topped to a lower height to need more summer and dormant pruning than the taller trees (see the combined pruning weights in Table 4). This was particularly true for the trees on the more vigorous rootstocks and is a clear demonstration of why it is not possible to efficiently lower tree heights only by severe pruning without the use of a size-controlling rootstock. Clearly there is a pruning advantage to using size-controlling rootstocks if a grower is interested in developing an orchard management strategy that involves arbitrarily limiting tree height to less than 11 ft. Dormant pruning weights of trees topped to 8 feet also reflected large differences in tree vigor due to rootstock but the differences among trees on different rootstocks were not as great for trees topped at 11 feet (Tables 3 and 4).

In 2007 we attempted to adjust crop loads on all the trees of a particular system (scion cultivar and pruning system) to similar levels regardless of rootstock and tree height. Crop loads/tree in the KAC-V (Table 5) were much lower that the open vase (Table 6) system. Although there was substantial variation among treatments in many cases crop loads and yields were similar across rootstocks and tree heights for a given system but fruit size on the more size-controlling rootstocks was generally smaller than on the vigorous rootstocks, especially as crop weight per unit trunk cross sectional area increased. In most cases there was no problem in keeping crop loads in the shorter trees as high as in the taller trees. However, interestingly fruit size on the trees topped at 8 feet tended to be larger than fruit on trees topped at 11 feet when crop loads were similar for a given rootstock/scion/training system combination. Cropping efficiency (crop weight /trunk cross sectional area) was always higher in trees on the more size controlling rootstocks within a given scion cultivar and training system combination.

This project clearly shows the potential of size-controlling rootstocks to be used in conjunction with tree topping to maintain the height of trees so that virtually all horticultural operations (pruning, fruit thinning, and harvest) can be conducted from the ground or on very short ladders. However tree planting densities would have to be greater than used in this trial to maintain crop yields comparable to standard, tall orchards. Also since there is the tendency for trees on the most size-controlling rootstocks to produce smaller fruit compared to trees on more vigorous rootstocks it is recommended that growers use the new size-controlling rootstocks (like Controller 5 aka K146-43) only in conjunction with scion cultivars that have a propensity to produce large fruit.

Table 1: Trunk circumferences (cm) of Flavorcrest and Loadel scion cultivars on six rootstocks and two training systems at the end of the twelfth growing season (December, 2007). Values represent the mean (± SE) of measurements of the four replications in the high density "KAC-V" and standard density "open vase" parts of the trial.

ROOTSTOCK	LOADEL		FLAVORCREST	
	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	78.1±0.68	54.6±0.96	90.2±1.97	62.6±1.17
K-119-50	64.1±1.06	46.3±1.58	73.9±3.07	51.7±1.70
P-30-135	72.2±2.11	52.6±2.21	86.3±2.59	63.4±3.75
Hiawatha	63.0±1.28	45.8±1.34	68.7±2.24	49.4±2.31
K-146-43	53.0±0.36	38.1±1.69	61.7±1.18	41.6±0.39
K-146-44	53.2±2.61	52.6±0.93	65.3±1.15	45.8±0.47

Table 2: Summer pruning weights (kg/tree) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems and two topping treatments during the eleventh season of growth in the field (Flavorcrest June 27, 2006 and Loadel July 12, 2006). The 8 foot topping treatment was imposed during the previous September.

ROOTSTOCK		LOADEL		FLAVORCREST	
	Topping Treatment	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	Topped 11’	1.63	0.78	1.03	1.10
	Topped 8’	14.54	6.46	5.00	3.89
K-119-50	Topped 11’	0.93	0.82	0.30	0.42
	Topped 8’	4.88	3.70	3.14	2.42
P-30-135	Topped 11’	0.23	0.59	0.44	0.37
	Topped 8’	5.54	3.38	2.41	0.98
Hiawatha	Topped 11’	0.49	0.30	0.69	0.16
	Topped 8’	3.94	2.77	1.69	1.23
K-146-43	Topped 11’	0.54	0.24	0.25	0.18
	Topped 8’	1.65	1.57	0.96	1.30
K-146-44	Topped 11’	0.28	0.35	0.40	0.14
	Topped 8’	3.40	2.17	2.53	1.80

Table 3: Dormant pruning weights (kg/tree) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems and two topping treatments after the eleventh season of growth in the field (January, 2007). This was the first regular dormant pruning after half of the trees had been topped to 8 feet.

ROOTSTOCK		LOADEL		FLAVORCREST	
	Topping Treatment	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	Topped 11’	8.65	4.99	9.70	4.96
	Topped 8’	13.06	5.60	13.59	7.94
K-119-50	Topped 11’	6.63	3.84	6.37	3.11
	Topped 8’	6.40	3.33	11.37	6.68
P-30-135	Topped 11’	4.99	3.22	6.09	4.32
	Topped 8’	7.38	3.96	8.31	6.84
Hiawatha	Topped 11’	4.65	3.19	5.39	2.60
	Topped 8’	5.91	2.82	8.84	4.55
K-146-43	Topped 11’	5.28	2.71	5.88	3.02
	Topped 8’	5.52	2.28	6.20	3.94
K-146-44	Topped 11’	4.05	2.93	6.63	3.84
	Topped 8’	5.49	2.67	8.65	5.04

Table 4: Combined 2006 summer and 2007 winter (January) dormant pruning weights (kg/tree) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems and two topping treatments.

Rootstock		Loadel		Flavorcrest	
	Topping Treatment	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	Topped 11’	10.28	5.77	10.73	6.06
	Topped 8’	27.60	12.06	18.59	11.83
K-119-50	Topped 11’	7.56	4.66	6.67	3.53
	Topped 8’	11.28	7.03	14.51	9.10
P-30-135	Topped 11’	5.22	3.81	6.53	4.69
	Topped 8’	12.92	7.34	10.72	7.82
Hiawatha	Topped 11’	5.14	3.49	6.08	2.76
	Topped 8’	9.85	5.59	10.53	5.78
K-146-43	Topped 11’	5.82	2.95	6.13	3.20
	Topped 8’	7.17	3.85	7.16	5.24
K-146-44	Topped 11’	4.33	3.26	7.03	3.98
	Topped 8’	8.89	4.84	11.18	6.84

Table 5. Fruit harvest data for the KAC-V Loadel and Flavorcrest trees on six different rootstocks and two topping treatments in 2007. (TCA is trunk cross sectional area)

ROOTSTOCK	Topping Treatment	KAC-V							
		LOADEL				FLAVORCREST			
		Mean crop weight/tree (kg)	Mean fruit weight (gm)	Mean crop load (#fruit/tree)	Fruit weight/TCA (kg/cm^2)	Mean Crop weight/tree (kg)	Mean fruit weight (gm)	Mean crop load (#fruit/tree)	Fruit weight/TCA (kg/cm^2)
Nemaguard	Not topped	59.8	156.0	384	0.25	43.5	138.8	314	0.14
	Topped 8’	58.1	142.2	409	0.24	47.5	132.2	359	0.15
K-119-50	Not topped	58.5	166.6	351	0.34	41.0	126.8	323	0.19
	Topped 8’	63.4	125.5	505	0.37	44.8	134.4	333	0.21
P-30-135	Not topped	55.2	146.0	378	0.25	45.9	124.6	369	0.14
	Topped 8’	57.9	132.0	437	0.26	40.6	128.4	317	0.13
Hiawatha	Not topped	51.6	146.7	352	0.31	29.6	129.5	228	0.15
	Topped 8’	52.0	129.8	400	0.31	37.4	126.4	296	0.19
K-146-43	Not topped	41.6	136.2	305	0.36	42.5	117.8	360	0.31
	Topped 8’	47.7	110.6	432	0.41	39.5	111.7	354	0.28
K-146-44	Not topped	50.8	142.0	358	0.37	39.7	121.5	326	0.24
	Topped 8’	55.84	127.4	438	0.41	38.7	127.3	304	0.23

Table 6: Fruit harvest data (±SE) for the open vase Loadel and Flavorcrest trees on six different rootstocks and two topping treatments in 2007. (TCA is trunk cross sectional area)

ROOTSTOCK	Topping Treatment	OPEN VASE							
		LOADEL				FLAVORCREST			
		Mean crop weight/tree (kg)	Mean fruit weight (gm)	Mean crop load (#fruit/tree)	Fruit weight/TCA (kg/cm^2)	Mean Crop weight/tree (kg)	Mean fruit weight (gm)	Mean crop load (#fruit/tree)	Fruit weight/TCA (kg/cm^2)
Nemaguard	Not topped	117.9	148.4	795	0.24	88.4	143.9	614	0.14
	Topped 8’	88.7	175.2	506	0.18	78.2	146.6	534	0.12
K-119-50	Not topped	97.5	147.2	662	0.30	80.0	129.6	617	0.18
	Topped 8’	108.3	147.2	735	0.33	86.4	126.4	684	0.20
P-30-135	Not topped	102.2	124.9	818	0.25	84.9	116.8	727	0.14
	Topped 8’	85.0	142.5	600	0.20	72.0	113.7	633	0.12
Hiawatha	Not topped	93.13	125.4	742	0.29	85.5	116.1	736	0.23
	Topped 8’	88.56	133.9	661	0.28	74.1	106.6	695	0.20
K-146-43	Not topped	86.76	122.0	711	0.38	83.4	120.5	692	0.27
	Topped 8’	89.09	125.0	713	0.39	61.4	118.6	518	0.20
K-146-44	Not topped	80.68	114.5	705	0.36	92.8	119.0	780	0.27
	Topped 8’	88.87	115.7	768	0.39	76.3	113.3	673	0.22