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, Redtop, 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 the first eleven 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 November, 2006, 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. Table 2 indicates the mass of wood that was removed from the trees during this topping operation. Note the large differences among trees on different rootstocks. It is especially interesting to note that the mass of wood removed from the trees on Nemaguard was much greater than the trees on P-30-135 even though they had similar trunk circumferences (Table 1). Fruit yields in the severely topped treatment were very low in 2006 because most of the fruit wood was removed in the topping treatment and 2006 was a year for fruit wood renewal in the lower parts of the trees.

The trees were dormant-pruned in January, 2006. Pruning weights varied substantially among the various scion/rootstock/topping combinations (Table 3). As observed in previous years the pruning weights the taller (11 ft.) trees of most of the experimental scion/rootstock combinations were substantially less than those of the same scions on Nemaguard. These data indicate that the experimental rootstocks appear to have the capacity to reduce the amount of “excess” vegetative growth of the trees without necessarily having as great of an effect on the structural strength of the trees. Subjectively, the canopies of the trees on the experimental rootstocks have appeared less dense than those on Nemaguard and this years pruning weights are a good quantification of this since the dormant pruning weights represent only the fine pruning that was done subsequent to the

late summer topping. 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 the previous September also reflected differences in tree vigor due to rootstock but the differences among trees on different rootstocks were not as great for tree topped at 11 feet (Table 3). Generally more dormant pruning was required in the Flavorcrest trees compared to the Loadel trees.

Interestingly, summer pruning weights on Loadel trees were much greater than Flavorcrest trees especially in the severely topped treatment (Table 4). The effect of the size-controlling rootstocks was also very apparent in the differences in weights of summer prunings removed from trees on Nemaguard compared to the other rootstocks. It is interesting to note that the amounts of prunings removed from trees on P-30-135 (released as Controller 9) were less than half of those removed from Nemaguard (Table 4) even though the trunk circumferences were very similar for the two rootstocks (Table 1). For trees on rootstocks other than Nemaguard the severity of topping did not have a major effect on the combined pruning weights from both hand prunings (Table 5). The severe topping treatment on Loadel trees on Nemaguard resulted in more pruning than the less severe treatment but the opposite was the case for Flavorcrest trees on Nemaguard. This was apparently a function of the difference in hand pruning done in the dormant vs. the summer on these two scion cultivars (Tables 2 and 3).

Trees topped to 11 feet in both the KAC-V (Table 6) and the open vase (Table 7) systems were cropped normally and thinned to commercial expectations by maintaining a separation between fruit to obtain fruit size. Crop loads and yields were very similar on all the tall KAC-V Flavorcrest trees whereas Loadel trees on the three more size-controlling rootstocks had lower fruit numbers and yield than the larger trees (Table 6). Fruit size was comparable among most of the rootstocks but tended to be smallest on K-146-43. These results are very promising since they indicate that the trees on the smaller rootstocks can yield similarly to trees on more vigorous rootstocks when all trees are managed for height. Crop loads and yields of the severely topped trees were very low because most of the fruiting wood as removed during the topping treatments. Next year's yields should be much more indicative of yield potentials at the reduced tree height.

Although the crop loads and yields per tree in the 11 foot tall open vase system trees were much higher than the KAC-V system, again trees on Nemaguard generally did not yield significantly more than trees on the other rootstocks and mean fruit size of the trees on Nemaguard was not larger than on most other rootstocks (Table 7). Again fruit loads and yields of the trees topped at 8 feet were very low and probably not representative of the yield potential since 2006 was a fruit wood renewal year for this treatment.

The crop load data were divided by the TCA data collected on the trees at the end of the season (November 2006). This factor normalizes crop load by an indicator of tree size (TCA) and indicates that the trees on K146-43 and K146-44 were more heavily cropped relative to their tree size. The 2005 and 2006 yield data subsequent to strong topping indicate the importance of these increased yield efficiencies when tree heights are limited to less than the natural balance of the tree. Under the

11 ft. topping strategy the intermediate vigor rootstocks clearly out-performed trees on Nemaguard with regard to tree yields and fruit size. Next year will give an indication of the efficiency of trees on the size-controlling trees topped to 8 ft. and indicate if trees on the most size-controlling stocks will then have an advantage over trees on both the Nemaguard and the intermediate vigor rootstocks.

During 2006, we concluded corollary projects related to peach tree physiology and size-controlling rootstocks. These corollary projects have clearly documented that at least part of tree size-controlling mechanism involves differences in root hydraulic conductivity and daily water relations among the different rootstocks. We plan to continue physiological studies and develop a computer simulation model of tree growth and physiology of trees on the various rootstocks to further characterize rootstock differences and try to understand if there are likely to be any unanticipated, negative consequences on the performance of these rootstocks over time and in different growing conditions.

Table 1: Trunk circumferences (cm) of Flavorcrest and Loadel scion cultivars on six rootstocks and two training systems at the end of the eleventh growing season (November 2006). 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	75 ± 1.4	53 ± 1.4	87 ± 1.2	61 ± 1.5
K-119-50	63 ± 1.0	45 ± 1.2	72 ± 1.7	50 ± 1.1
P-30-135	71 ± 1.5	51 ± 1.2	84 ± 1.5	61 ± 2.1
Hiawatha	60 ± 0.9	44 ± 0.9	66 ± 1.3	48 ± 1.4
K-146-43	53 ± 0.8	37 ± 1.1	60 ± 1.1	40 ± 1.0
K-146-44	52 ± 1.7	39 ± 0.9	63 ± 1.3	43 ± 0.9

Table 2: Topping pruning weights (kg/tree ± SE) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems after the tenth season of growth in the field (September, 2005). Trees were topped at 8 feet.

ROOTSTOCK	LOADEL		FLAVORCREST	
	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	208.1 ± 2.36	89.8 ± 1.57	168.5 ± 1.68	98.6 ± 1.33
K-119-50	95.3 ± 1.77	59.0 ± 1.31	112.4 ± 1.43	71.5 ± 1.38
P-30-135	99.6 ± 2.12	62.8 ± 1.20	114.8 ± 2.22	78.3 ± 1.47
Hiawatha	65.2 ± 1.45	36.8 ± 1.04	66.1 ± 1.78	35.6 ± 0.82
K-146-43	47.3 ± 1.31	24.4 ± 1.16	42.7 ± 0.92	30.4 ± 1.08
K-146-44	59.0 ± 1.73	35.4 ± 1.25	56.1 ± 1.19	38.3 ± 1.20

Table 3: Dormant pruning weights from hand pruning (kg/tree) of the Flavorcrest and Loadel scion cultivars on six different rootstocks and two training systems and two topping treatments after the tenth season of growth(January, 2006) after the severe (8 ft.) topping had been imposed in September.

ROOTSTOCK		LOADEL		FLAVORCREST	
	Topping Treatment	Open Vase	KAC-V	Open Vase	KAC-V
Nemaguard	Topped 11’	7.36	3.83	9.14	5.43
	Topped 8’	1.50	0.76	2.39	1.38
K-119-50	Topped 11’	6.23	2.50	6.66	4.86
	Topped 8’	1.03	0.32	1.62	0.73
P-30-135	Topped 11’	5.18	2.00	6.86	4.21
	Topped 8’	1.03	0.71	1.11	0.75
Hiawatha	Topped 11’	4.73	1.68	5.52	2.65
	Topped 8’	0.64	0.48	1.27	0.76
K-146-43	Topped 11’	4.43	1.64	6.10	3.74
	Topped 8’	0.94	0.70	1.86	0.61
K-146-44	Topped 11’	2.81	1.92	5.52	3.18
	Topped 8’	0.88	0.61	1.80	1.04

Table 4: Summer 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 (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 5: Combined 2006 winter and summer 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’	8.99	4.60	10.16	6.53
	Topped 8’	16.03	7.22	7.40	5.27
K-119-50	Topped 11’	7.15	3.31	6.96	5.28
	Topped 8’	5.90	4.02	4.75	3.15
P-30-135	Topped 11’	5.41	2.60	7.31	4.58
	Topped 8’	6.57	4.09	3.52	1.73
Hiawatha	Topped 11’	5.21	1.98	5.80	2.81
	Topped 8’	4.58	3.25	2.96	2.00
K-146-43	Topped 11’	4.97	1.88	6.35	3.93
	Topped 8’	2.60	2.28	2.82	1.91
K-146-44	Topped 11’	3.09	2.27	5.91	3.33
	Topped 8’	4.27	2.78	4.33	2.85

Table 6: Fruit harvest data for the KAC-V Loadel and Flavorcrest trees on six different rootstocks and two topping treatments in 2006. (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	Topped 11’	32.2	185.3	174	0.143	26.0	163.4	159	0.088
	Topped 8’	5.9	184.1	32	0.026	6.9	150.4	46	0.023
K-119-50	Topped 11’	33.1	203.3	163	0.207	26.9	172.8	156	0.133
	Topped 8’	9.8	187.6	52	0.061	13.2	167.2	79	0.065
P-30-135	Topped 11’	33.6	189.5	177	0.163	26.6	161.1	165	0.089
	Topped 8’	7.6	191.8	39	0.037	13.2	168.1	78	0.044
Hiawatha	Topped 11’	28.6	205.5	139	0.182	25.7	162.5	158	0.137
	Topped 8’	7.2	204.0	35	0.046	10.58	200.4	53	0.057
K-146-43	Topped 11’	23.2	174.1	133	0.213	24.7	152.4	162	0.195
	Topped 8’	2.6	176.5	32	0.024	8.3	150.1	55	0.065
K-146-44	Topped 11’	27.7	186.4	149	0.224	25.8	164.1	157	0.171
	Topped 8’	7.9	201.9	39	0.064	10.8	173.1	63	0.072

Table 7: Fruit harvest data (±SE) for the open vase Loadel and Flavorcrest trees on six different rootstocks and two topping treatments in 2006. (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	Topped 11’	47.4	169.7	279	0.105	61.4	175.9	349	0.102
	Topped 8’	10.7	186.8	57	0.024	18.8	167.7	112	0.031
K-119-50	Topped 11’	60.3	207.9	290	0.194	62.6	170.2	368	0.152
	Topped 8’	14.9	239.9	62	0.479	19.1	179.3	106	0.046
P-30-135	Topped 11’	43.4	194.9	223	0.109	74.4	163.2	456	0.132
	Topped 8’	15.6	252.3	62	0.039	18.7	173.2	108	0.033
Hiawatha	Topped 11’	39.8	197.0	202	0.137	71.1	164.3	433	0.202
	Topped 8’	16.7	208.1	80	0.058	23.2	192.4	120	0.066
K-146-43	Topped 11’	40.3	189.2	213	0.183	58.6	159.0	368	0.204
	Topped 8’	7.8	174.2	45	0.035	15.2	158.2	96	0.053
K-146-44	Topped 11’	51.6	179.7	287	0.245	57.6	169.1	340	0.183
	Topped 8’	12.3	185.4	66	0.058	18.8	161.7	116	0.060