

2015 FIELD EVALUATION OF PRUNE ROOTSTOCKS

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PROBLEM AND ITS SIGNIFICANCE

The California Prune Industry has historically utilized five rootstocks, Myrobalan seedling, Myro 29C, Marianna 2624, Lovell Peach and some M40. The last statewide organized prune rootstock effort was the “M” series rootstock plots planted in 1987 (Vina Monastery 3/20/87). Since the conclusion of that experiment many more potential rootstocks for prune have been identified. HBOK 50, Krymsk1, Krymsk 86, Citation, Rootpac-R, Viking, Atlas and others.

Three rootstock experiments have been planted in Northern California. One at Wolfskill, planted 1/19/11, a second in Yuba County planted 6/3/11 and a third in Butte County planted 4/28/11. All trees were nursery grafted to the ‘Improved French’ variety.

OBJECTIVES

- 1) Evaluate 29 rootstocks for use in California Prune production.
- 2) Evaluate tree growth and development, trunk cross sectional area (TCSA), suckers per rootstock, stem water potential, vigor, anchorage, rootstock uniformity, canopy spread, yield, and bloom date.

PLANS AND PROCEDURES

Butte County Location

The Butte County location was planted 4/28/11. The wet winter delayed soil preparation resulting in the late planting date. The Butte County soil survey lists the soil as Farwell Clay Adobe alternating with a lighter textured soil described as Nord Loam. Test trees followed almonds on Lovell peach rootstock with no soil treatments prior to planting. Lesion nematodes were isolated from soil samples. The layout is a randomized complete block design with 14 treatments and 5 replicates. There are 6 trees per plot in the original design. Trees were headed at 40 inches on 5/10/2011 and the test planting is drip irrigated. The HBOK 50 rootstock came as potted trees and were delivered 5/4/11 and planted by 5/10/11. Instructions were to remove trees from the pots, do not disturb the root ball, cover with 2 inches of soil and irrigate carefully to keep the small root ball moist. The HBOK 50 were small bush like trees and did not have sufficient trunk growth to head the first year and were left alone. Viking and Atlas were not available in 2011 and were added to the experiment in 2012 and are consequently one year younger. Viking and Atlas were propagated by Dave Wilson nursery, HBOK 50 from Duarte nursery and the remaining trees were propagated by Fowler nursery. Tree mortality was high

during the 2011 season. Missing tree locations were site fumigated with 0.5 pound of chloropicrin on 11/15/11 and replanted 2/10/12. Viking and Atlas were also planted 2/10/12. Many of the Rootpac-R trees did not survive the initial planting and replacement trees were not available. On 2/10/12 the few remaining Rootpac-R were extracted at Butte and replanted in the Yuba plot. The goal was to have one complete set of Rootpac-R at one location. Both the Butte and Yuba locations have mixed tree ages because of the high initial tree mortality. Fumigated replant trees grew well and growth wise caught up with trees planted the first year. So for the 2015 trunk circumference measurements both tree ages are combined. Trunk Measurements include scion circumference measured 12 inches above the graft union using a measuring tape. Trunk circumference is used to calculate trunk cross sectional area.

Yuba County Location

The Yuba County location was planted 6/3/11. The wet winter delayed soil preparation and subsequently delayed planting. Similar to Butte, the plot is a randomized complete block design with 14 treatments and 5 replicates. There are 6 trees per plot in the original design. Rootstocks are the same as the Butte plot with the exception of Rootpac-R which was transplanted from Butte to Yuba and Emphyrean 2 which did not survive in the Yuba location. Tree mortality was high during the first season in the ground. Replants in 2012 replaced missing trees. The Yuba experiment is complete and trees are growing well.

Sucker ranking and anchorage assessment were done in early March, just before bloom. Each tree was given a sucker grade, ranging from 0 (no suckers) to 5 (excessive suckers). Anchorage assessment was done by measuring the degrees from the vertical of the tree trunk before and after horizontal force was applied to the tree at 4' above the soil. The force was delivered by a 200 lb adult male leaning on the tree.

At commercial maturity (less than 4 lbs fruit pressure), fruit from two trees per replicate treatment -- for a total of ten trees per rootstock -- were harvested by hand on Aug 13-14. Fresh fruit from each tree was separately weighed and then a four pound subsample of fresh fruit, made up of equal amounts of fruit from each replicate was dried at the SunSweet Dryers' Live Oak dehydrator. Dry fruit yield per tree was determined from the total fresh fruit weight per tree and ratio of fresh fruit to dry fruit weight ("dry away") from that replicate.

Wolfskill Experimental Orchard

A satellite experiment of prune rootstocks was planted at the UC Wolfskill experimental orchard in Winters, California. The plot contains 15 experimental rootstocks and 3 standard rootstocks (Marianna 2624, Lovell, and Myro 29C) nursery budded to 'Improved French.' This experiment provides an initial evaluation of possible rootstocks that have previously not been tried with prune or have had very little field testing.

The experiment is planted with at least 5 trees of each rootstock and is non-replicated, which limits statistical analysis. The goal was to get a first look at how these rootstocks performed with 'Improved French' scions and identify any defects before commercial planting. 'Improved French' on its own root differs from the others in that trees were grown in the nursery for two

years. Own rooted trees do have a graft union because 'Improved French' was budded on top. Wolfskill rootstock entries are listed in figure 17. Trees were planted 17 feet across the row and 14 feet down the row, which would result in approximately 183 trees per acre.

The Wolfskill site was previously planted to peaches, removed in 2008 and the field left fallow for 3 years with annual winter wheat. The Yolo County soil survey describes the soil as Yolo loam. Nematode samples were taken at four locations within the field at approximately an 18 inch depth, and combined for nematode evaluation (8/29/11). One liter of soil contained, 50 Lesion (*Pratylenchus sp.*), 50 Pin (*Pratylenchus sp.*), and 30 Dagger (*Xiphinema americanum*). There were not enough nematodes to identify the species of either Lesion or Pin nematodes.

The majority of the trees were planted on January 19, 2011. Bare-root trees were planted directly after transportation from the nurseries sawdust box. HBOK 32 and HBOK 10, were potted trees planted on April 25, 2011. At the time of planting, trees were headed at 36 inches. Trees that had not reached heading height were left alone and allowed to grow through 2011 then headed at 36 inches in the following dormant season.

Bloom was recorded on March 14th and day of full bloom was estimated based on number of flower buds open, petal fall, leaf-out, etc by Pope. Harvest occurred August 12th. Harvest weight was a combination of the weight of dropped fruit and shaken fruit. For each of 5 trees, fruit drop was rated as a percent of the heaviest fruit drop in each of the 5 trees (i.e. heaviest drop = 100%, other trees were evaluated as a percent relative to this standard). The drop from the 100% tree was weighed and dropped fruit weights estimates were made for other trees based on this one weight and their % drop relative to the heaviest drop tree. The fruit that remained in the tree was then shaken or hand-picked and the combined weight of the fruit from all 5 trees was taken. An aggregate subsample was dried for 24 hours. Fresh harvest weights were then adjusted based on the subsample % dry weight. Vigor, spread and even-ness of these characteristics were rated by Pope, Sarah Castro and Ted DeJong on October 16th. Vigor and spread were rated 1-5, and five trees were rated as even or variable in these characteristics. Trunk circumference was measured on December 16th at 18" above the soil line.

RESULTS AND DISCUSSION

Butte County location

2015 evaluations for the Butte rootstock experiment includes Stem water potential, sucker ratings, tree vigor, first year dry yield, Canopy spread, tree anchorage and tree uniformity. Stem Water Potential (SWP) was measured for only a single day 7/8/15 (Figure 1). Rootstocks showed little statistical difference in SWP although it appeared as though the more vigorous Atlas and Viking trees demonstrated less moisture stress at -6.32 bars to -6.92 bars compared to -8.68 bars and -8.94 bars for M2624 and M40 respectively. Monthly SWP measurements are planned for the 2016 crop year to verify any rootstock differences in SWP. Rootstock sucker visual ratings are described in Figure 2. Sucker ratings for the Butte experiment suggested M2624 and Myro seedling were the two rootstocks most likely to impart suckering under the Butte growing conditions (Figure 4). Tree vigor ratings are shown in Figure 5. Lovell, 29C, Viking and Atlas imparted the most vigor. HBOK 50, M2624, Myro seedling, M30, M40 and Krymsk 86 were

intermediate with Krymsk 1, M58, Citation and Empyrean 2 as the least vigorous. For the first year yield evaluations (Figure 6), M30 and Krymsk 1 demonstrated the greatest dry yield and HBOK 50, Viking and Atlas imparted the least dry fruit yield. For canopy spread in the Butte plot (Figure 8), Krymsk 86 was the most upright and Krymsk 1 trees had the most spreading growth characteristic. Anchorage measurements for the Butte experiment (Figure 9) suggested good anchorage for Viking, M30, 29C, Atlas, Krymsk 86, M40, Lovell, Myro seedling and M2624. Citation, Empyrean 2, HBOK 50, M58 and Krymsk 1 imparted the greatest amount of lean. Tree uniformity was a visual rating where a “2” represented uniform tree growth per plot compared to a “1” which represented non uniform growth between trees. Atlas, 29C, Viking, M30, M2624, and Lovell rootstocks imparted very good tree growth uniformity. Krymsk 86, M58 and M40 were intermediate with HBOK 50, Myro seedling, Citation, Empyrean 2 and Krymsk 1 with the poorest tree growth uniformity (Figure 11). Figure 13 is the summary table for comparing all 14 rootstocks in the Butte experiment.

Yuba County location

Rootstock sucker information for the Yuba location is summarized in Figure 3. Similar to the butte experiment, Myrobalan seedling demonstrated the most tendency to sucker and Viking, Atlas and HBOK 50 were rated as zero suckering. Prune yield and Dry Ratio (Figure 7) suggested M58 as the rootstock that imparted the greatest first year yield with Myrobalan seedling, HBOK50, Atlas and Viking as the rootstocks with the least dry yield at the first harvest. Dry ratios varied from 2.7 to 3.1 and although differences were not large, dry ratios did show statistical separation between rootstocks. Differences are probably related to fruit load. Krymsk 86 anchored well in the Yuba experiment (Figure 10) and M58 and Krymsk 1 demonstrated poorer anchorage. Differing results suggest how rootstock performance may vary by location. Soils, irrigation and pruning all differ between the Butte and Yuba experiments.

Wolfskill location

At Wolfskill, bloom timing data show bloom can vary by at least a week based on rootstock (Figure 14). Yield was highly variable by rootstock (Figure 15). However, this is in part due to differences in tree size (Figure 16), which could be compensated for with closer spacing. Better conclusions regarding how much yield is influenced by tree size will be possible when trees are older and canopies are more filled in.

Vigor and spread were highly variable for a number of experimental rootstocks: Controller 9, Puente, Krymsk 99, Own Root, Ishtara and Imperial California were variable. This variability indicates these may not be good candidates for commercial planting. M2624 & Myro 29C were also highly variable. Rootstocks that showed low variability in vigor and spread were Krymsk 2, HBOKs 10, 27, and 32, Lovell, WRM 2, Empyrean 1 and 3, Speaker and Fortuna (Figure 17). These vigor ratings are also reflected in the trunk circumference measurements (Figure 17).

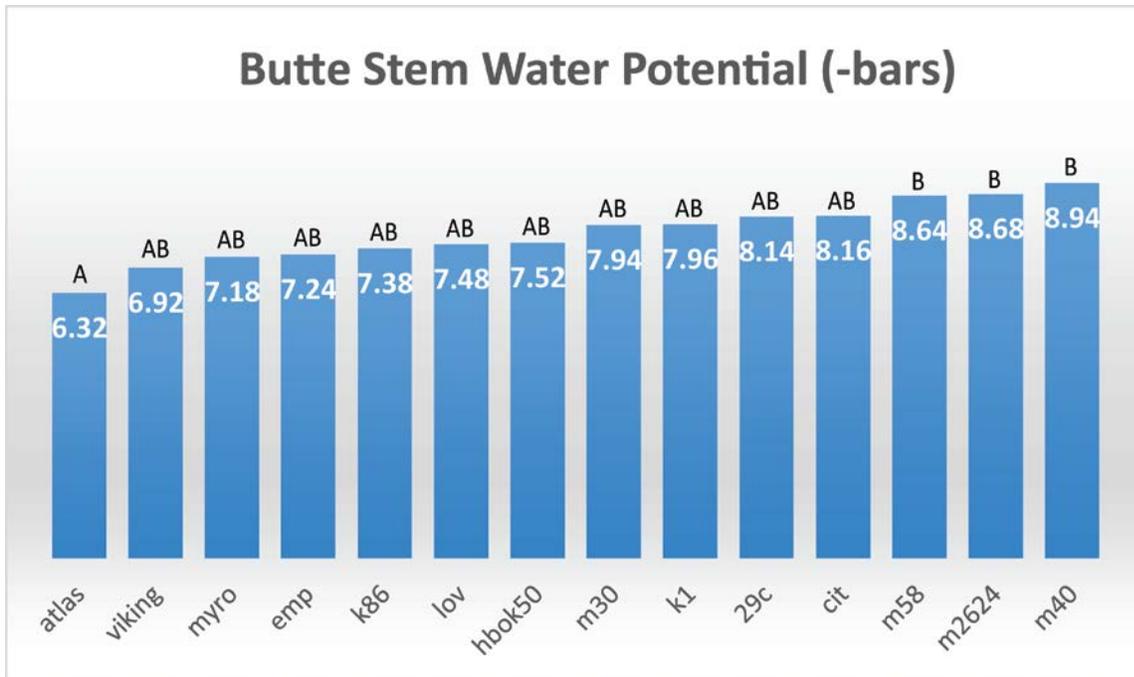


Figure 1. Comparison of Stem Water Potential for the 14 rootstocks in the Butte experiment. Bagged leaves were measured between 12:32 and 2:00 pm 7/8/15. Trees were drip irrigated in the morning and the weather was clear skies with a slight breeze.



Sucker rating 1



Sucker rating 2



Sucker rating 3



Sucker rating 4



Sucker rating 5

Figure 2. Rootstock sucker rating system.

Sucker data, Yuba Co site, March 13, 2015			
<u>Rootstock</u>	<u>ave rating</u>	<u>SE</u>	<u>% trees w/ suckers</u>
Myrobalan	2.55	0.31	90
Myro 29C	0.90	0.27	40
Krymsk 1	0.79	0.26	34
M30	0.78	0.25	30
Rootpack R	0.60	0.16	37
M2624	0.37	0.12	27
M40	0.30	0.12	20
Lovell	0.10	0.07	7
Krymsk 86	0.07	0.05	7
M58	0.07	0.05	13
Citation	0.04	0.04	3
HBOK 50	0.00	0.00	0
Viking	0.00	0.00	0
Atlas	0.00	0.00	0

Figure 3. Comparison of Average Suckers per Rootstock for the Yuba County experiment. Suckers were rated 1 to 5 on 3/13/15 with a rating of 5 as most severe.

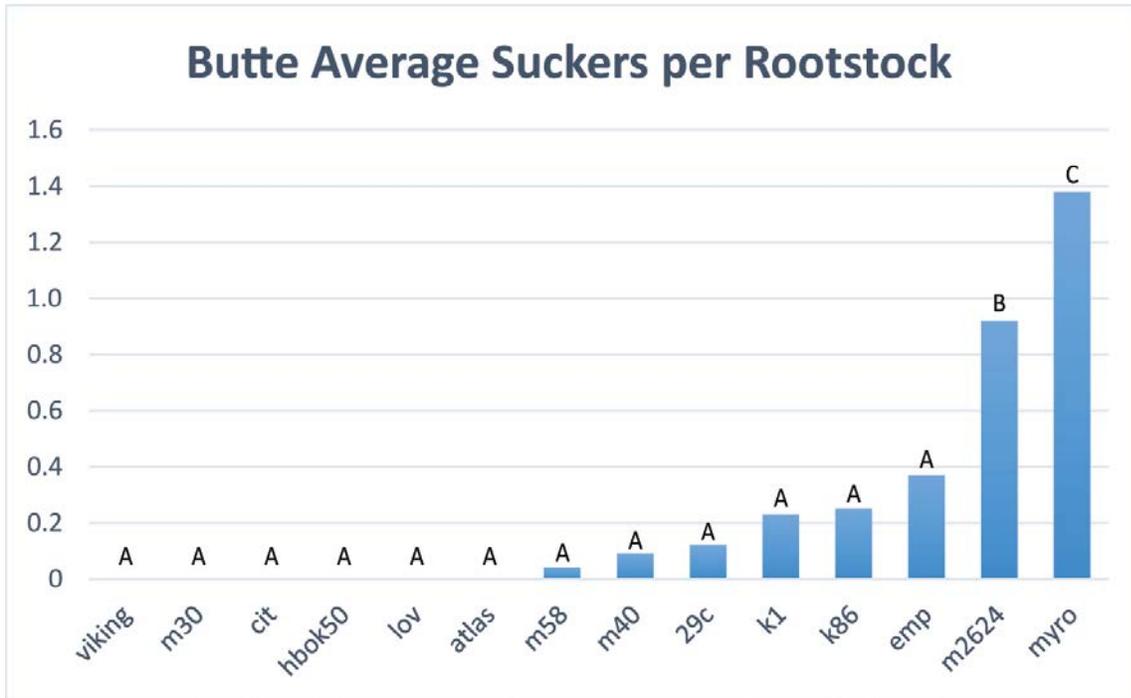


Figure 4. Comparison of Average Suckers per Rootstock for the Butte County experiment. Suckers were rated 1 to 5 on 7/8/15 with a rating of 5 as most severe.

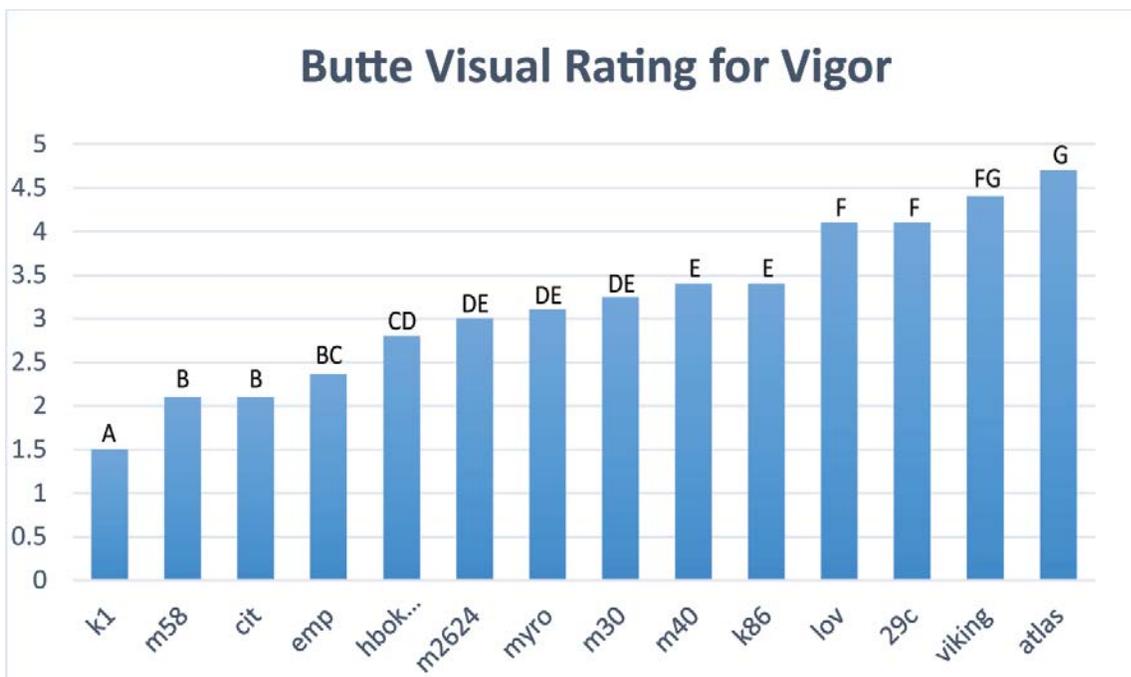


Figure 5. Visual rating on 9/14/15 for tree vigor by rootstock for the Butte experiment. Trees were rated 1-5 with 5 being the most vigorous.

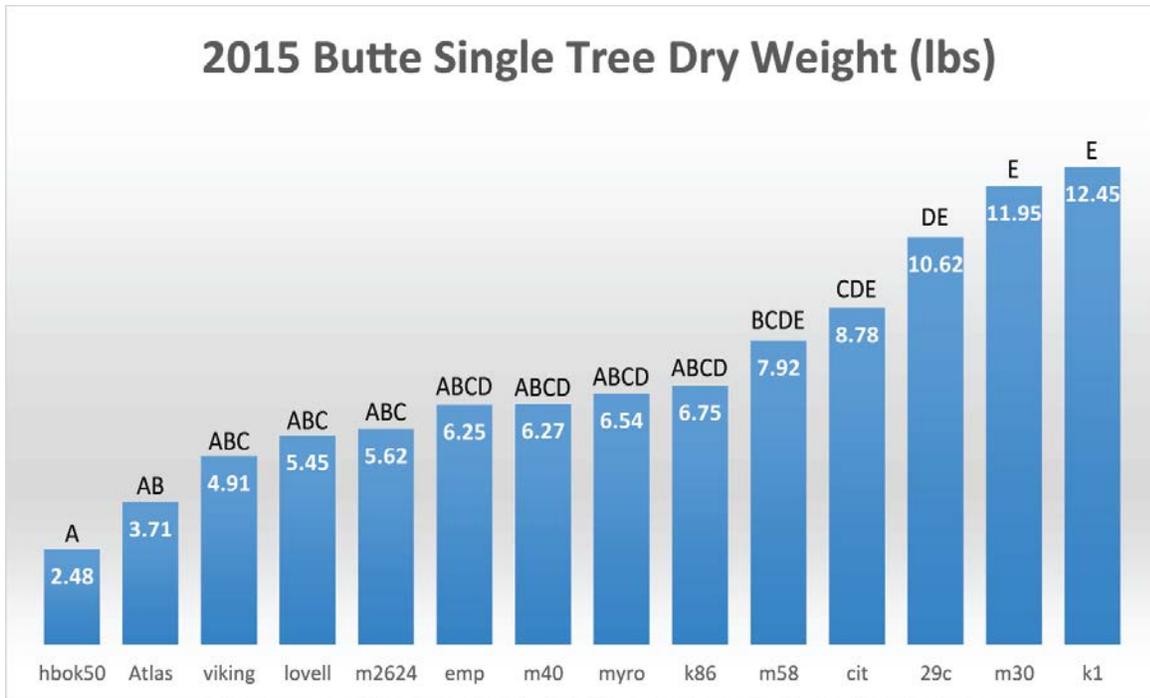


Figure 6. Single Tree Dry Yield by Rootstock for the Butte experiment. Numbers represent the first commercial harvest. 8/13/15. Dry Ratio was 2.84, average flesh pressure 2.77 lbs. and sugar measured 24.1 Brix.

Prune yield & dry away. Yuba Co. 2015.

Rootstock	Mean Yield/tree (lbs. dw)	Median dry away (fw:dw)
Myro seedling	0.98 a	2.8 a
HBOK 50	1.13 ab	3.1 bc
Atlas	1.42 ab	3.1 c
Viking	1.86 abc	2.9 ab
M40	2.50 abc	2.8 a
Rootpac-R	2.54 abc	2.7 a
Krymsk 86	2.59 abc	3.1 c
M2624	2.93 abc	2.8 a
M29C	2.94 abc	2.8 a
M30	3.14 abc	2.9 ab
Lovell	3.36 abc	3.1 c
Citation	3.83 bcd	3.2 c
Krymsk 1	4.56 cd	3.0 abc
M58	7.15 d	2.8 abc

Figure 7. Dry yield by rootstock for the Yuba experiment. Numbers represent the first commercial harvest.

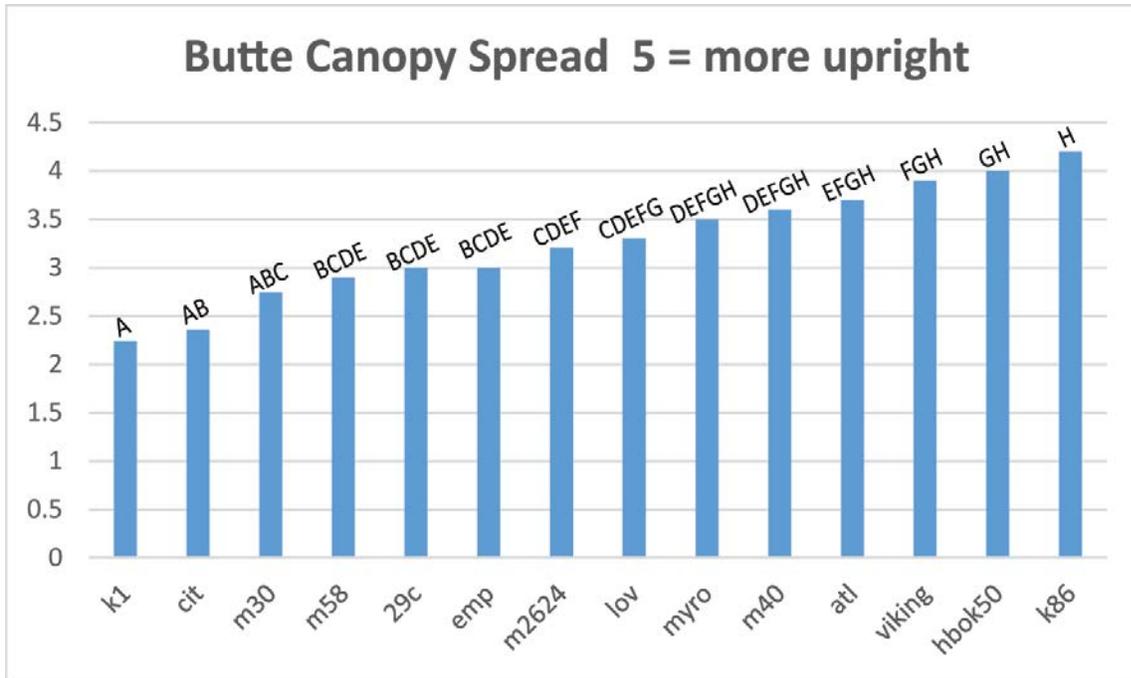


Figure 8. Canopy spread visual ratings for the Butte Rootstock experiment. Ratings were made 9/14/15 using a 1-5 scale where a rating of 5 being more upright.

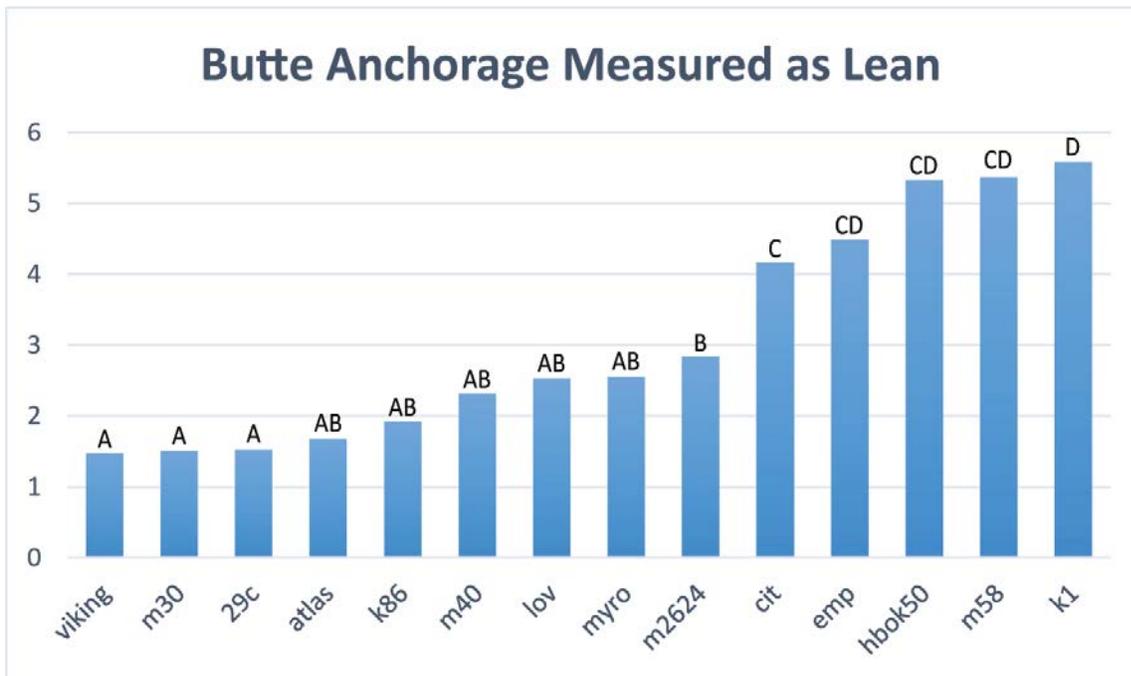


Figure 9. Anchorage measurements for the Butte Rootstock experiment. Lean measurements were made on 7/8/15 by recording the Degrees of Deflection from zero when pushing on the tree trunk.

Prune rootstock anchorage comparison. Median angle of trunk deflection (\pm 95% Confidence Interval). Yuba Co. March 13, 2015

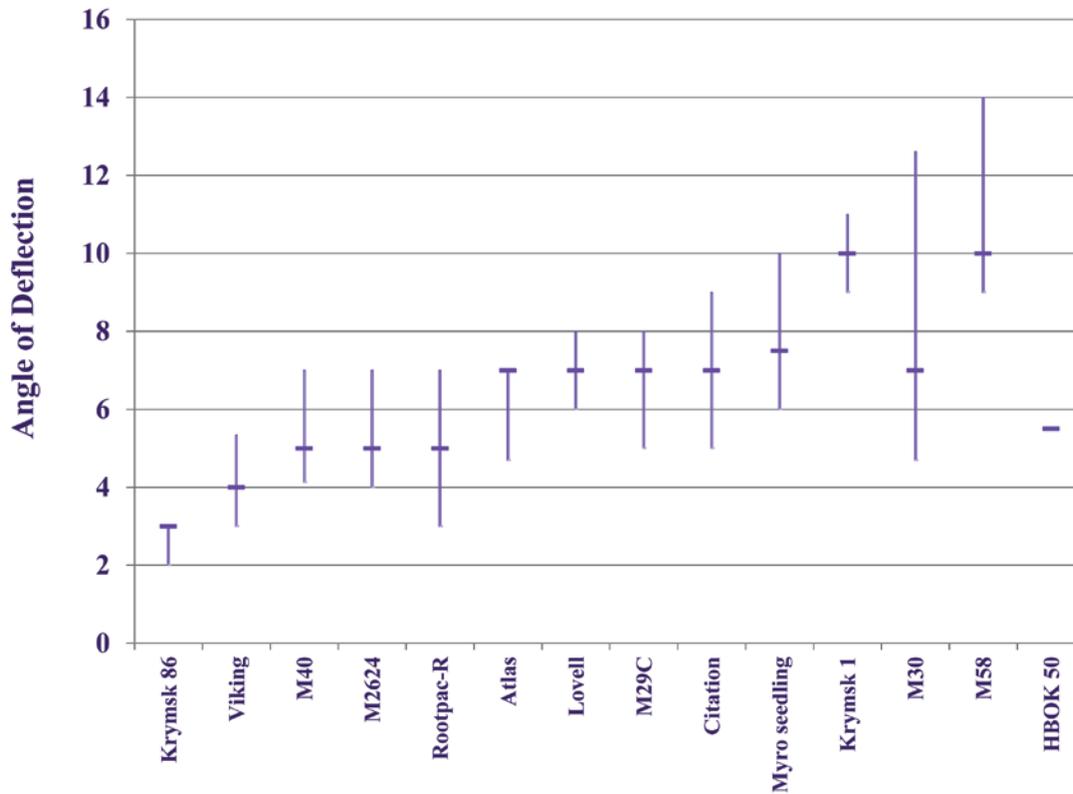


Figure 10. Anchorage measurements for the Yuba rootstock experiment. Data represent the degrees of deflection from zero when pushing on the tree trunk.

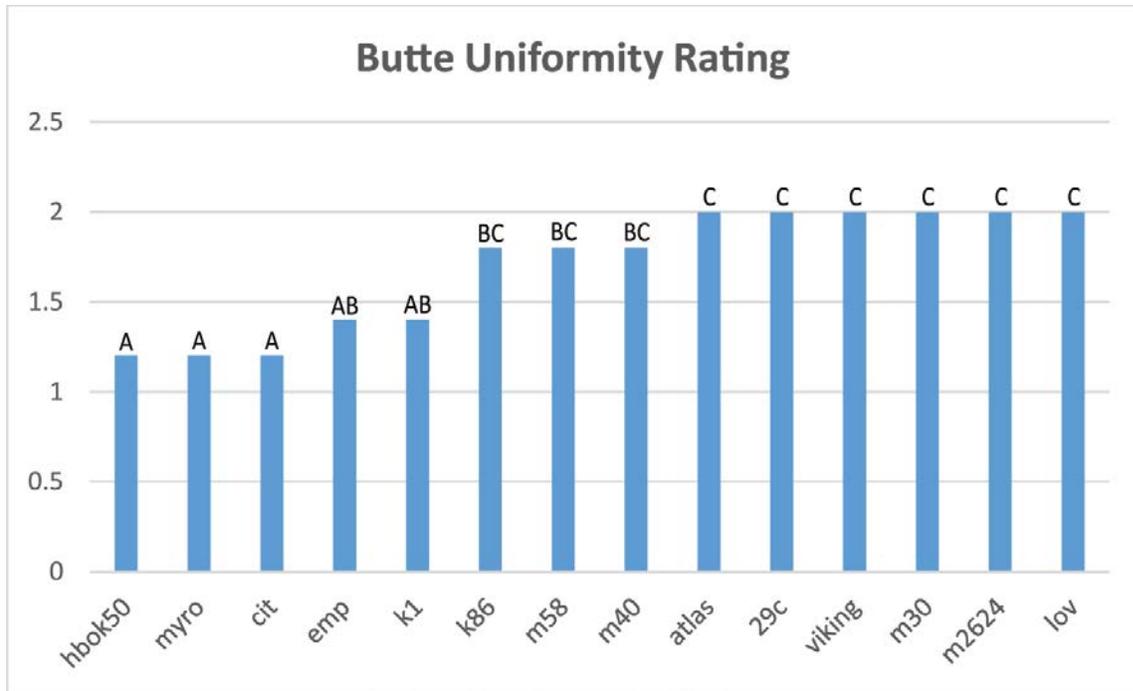


Figure 11. Tree Uniformity by Rootstock for the Butte Rootstock experiment. Plots were visually rated 9/14/15 using a scale of 1 to 2 with a rating of 2 representing good tree to tree uniformity.





Figure 12. Examples of tree growth for the Butte rootstock experiment. Photos taken early October 2015.

LOV = Lovell
M30 = M30
M58 = M58
HB = HBOK 50
K86 = Krymsk 86
29C = Myro 29C
K1 = Krymsk 1



Butte Rootstock Comparison for 2015							
	VIGOR RATING	UPRIGHT RATING	UNIFORM RATING	SUCKER RATING	ANCHORAGE (LEAN)	SWP (BARS)	DRY YIELD (LBS.)
Atlas	4.7	3.7	2.0	0	1.6	6.3	3.7
Viking	4.4	3.9	2.0	0	1.4	6.9	1.9
29C	4.1	3.0	2.0	0.1	1.5	8.1	10.6
Lovell	4.1	3.3	2.0	0	2.5	7.4	5.4
K86	3.4	4.2	1.8	0.2	1.9	7.3	6.7
M40	3.4	3.6	1.8	.09	2.3	8.9	6.2
M30	3.2	2.7	2.0	0	1.5	7.9	11.9
Myro	3.1	3.5	1.2	1.3	2.5	7.1	6.5
M2624	3.0	3.2	2.0	0.9	2.8	8.6	5.6
HBOK 50	2.8	4.0	1.2	0	5.3	7.5	2.4
Emp	2.3	3.0	1.4	0.3	4.4	7.2	6.2
Cit	2.1	2.3	1.2	0	4.1	8.1	8.7
M58	2.1	2.9	1.8	0.04	5.3	8.6	7.9
K1	1.5	2.2	1.4	0.23	5.5	7.9	12.4

Figure 13. 2015 Tree performance comparisons by rootstock for the Butte experiment. Measurements are preliminary and may change as trees mature.

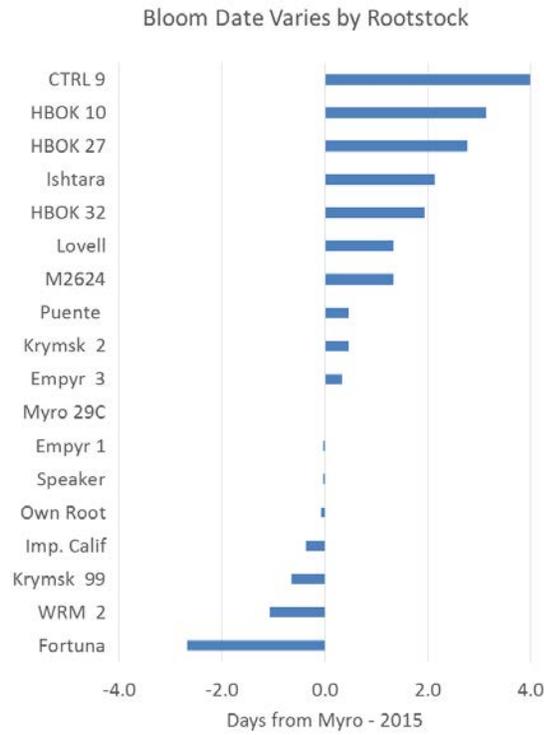


Figure 14. Bloom dates relative to Myro 29C for rootstocks at the Wolfskill location.

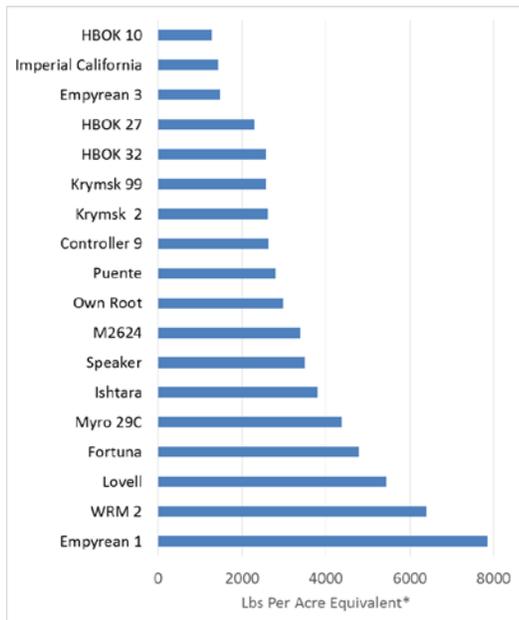


Figure 15. Yield measurements for the Wolfskill location.

Yield is highly correlated with, and largely determined by ($R^2=64\%$) trunk circumference. This indicates that in some cases, low yields per acre could be resolved with closer spacing.

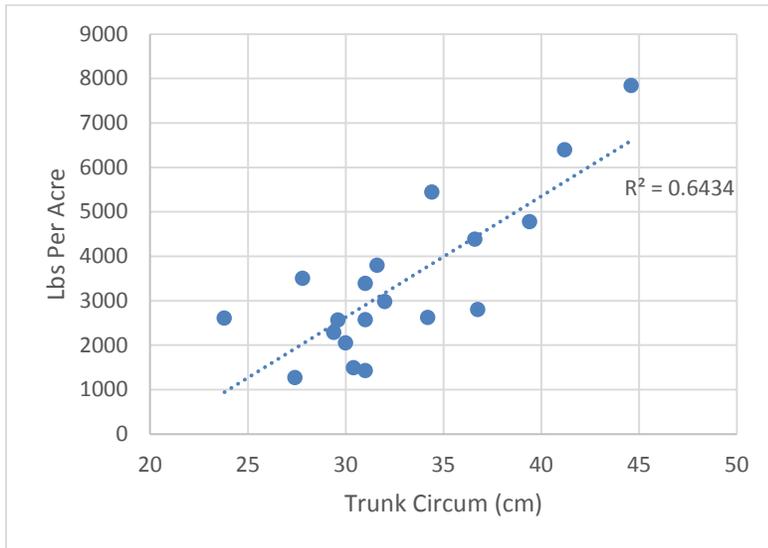


Figure 16. Yield relative to trunk circumference for the Wolfskill location.

Rootstock	Bloom Date (Relative to 3/14/15)	Dry Wt/Acre	Vigor	Spread	Even/Variable	Trunk Circum (cm)
Controller 9		2,052	3	3	V	30
Controller 9	2.9	2,622	3.5	4	V	34
Empyrean 1	-0.8	7,845	5	4	E	45
Empyrean 3	-1.2	1,487	3.5	2	E	30
Fortuna	-3.8	4,777	3	2	E	39
HBOK 10	2.0	1,269	2.5	2	E	27
HBOK 27	1.6	2,285	2	3	E	29
HBOK 32	0.8	2,563	3	3	E	30
Imp'l California	-1.5	1,430	3	3	V	31
Ishtara	1.0	3,799	3.5	2	V	32
Krymsk 2	-0.7	2,611	1	3	E	24
Krymsk 99	-1.8	2,571	2.5	2.5	V	31
Lovell	0.2	5,440	4	3	E	34
M2624	0.2	3,385	3	2.5	V	31
Myro 29C	-1.1	4,382	4	2	V	37
own root	-1.2	2,981	4	2	V	32
Puente	-0.7	2,798	4	3	V	37
Speaker	-1.2	3,501	2	2.5	E	28
WRM 2	-2.2	6,396	4	3	E	41

Figure 17. Rootstock performance for the Wolfskill location.

Rootstock	Pedigree (scientific)	Pedigree (Common)	Other names	Trial	Interest to CA
Atlas	P. persica (Nemaguard) x (Prunus dulcis x Prunus blierianna)	Nemagaurd x(almond x (apricot x plum))		Grower	Bac canker resistant?
Viking	P.persica x (P. amygdalus x P. blireiana (P.cerasifera x P.Mume)	Nemagaurd x(almond x (apricot x plum))		Grower	Bac canker resistant?
Citation	Prunus salicina x Prunus persica	Red Beaut plum x peach	4-G-816	Grower	
Empyrean 2	Prunus domestica	European prune (OP seedling of 'Imperial Epineuse')	Penta	Grower	small tree
HBOK 50	Prunus persica	Harrow Blood X Okinawa		Grower	nematode resistant?
Krymsk 1	Prunus tomentosa x Prunus cerasifera	Plum x plum	VVA1	Grower	grown in Europe
Krymsk 86	Prunus cerasifera x Prunu spersica	Plum/peach hybrid	Kuban 86	Grower	anchorage
M30	Prunu cerasifera x Prunus munsoniana	Plum x wild plum		Grower	
M40	Prunus cerasifera x Prunus munsoniana	Plum x wild plum		Grower	Less suckering
M58	Prunus cerasifera x Prunus munsoniana	Plum x wild plum		Grower	smaller tree?
Myrobalan seedling	Prunus cerasifera	Myrobalan seedlings		Grower	control
Rootpack R	Prunus cerasifera x prunus dulcis	Plum/almond hybrid	Replantpac	Grower	
Lovell	Prunus persica	peach seedling		Grower/Wolfskill	control
M2624	Prunus cerasifera x Prunus munsoniana	Plum x wild plum	Marianna 2624	Grower/Wolfskill	control
Myro 29C	Prunus cerasifera	Myrobalan clone		Grower/Wolfskill	control
Controller 7	Prunus persica	Harrow Blood X Okinawa	HBOCK 32	Wolfskill	
Controller 8	Prunus persica	Harrow Blood X Okinawa	HBOCK 10	Wolfskill	
Controller 9	Prunus salicina X Prunus persica	Plum/peach hybrid	P30-135	Wolfskill	
Empyrean 1	Prunus persica x P. davidana	Peach x Chinese wild peach. Venice, Italy	Barrier	Wolfskill	
Empyrean 3	Prunus domestica	European prune (seedling of Regina Claudia Verde)	Tetra	Wolfskill	sensitive to ORF
Fortuna	Prunus cerasifera x Prunus persica	Plum/peach hybrid		Wolfskill	
HBOCK 27	Prunus persica	Harrow Blood X Okinawa		Wolfskill	
Imperial California	Prunus domestica	plum R/S Italian Origin		Wolfskill	
Ishtara	(P. cerasifera x P.salicina)X (P. cerasifera x P. persica)	peach/plum hybrid (complex hybrid selected by INRA)	Ferciana	Wolfskill	
Krymsk 2	Prunus incana x Prunus tomentosa	wild cherry x Manchu cherry	VSV 1	Wolfskill	
Krymsk 99	P. besseyi x P. salicina	Plum/Plum hybrid (Sand cherry x Japanese plum)		Wolfskill	
Own rooted French	Prunus domestica	European prune		Wolfskill	
Puente	Prunus cerasifera	Plum (from Spain)	Adara	Wolfskill	
Sharpe	Prunus angustifolia x unknown plum	Plum x plum		Wolfskill	
Speaker	No idea scientific name	Plum/peach hybrid	Spicer	Wolfskill	
WRM #2	Prunus cerasifera	Red leaf myroblan type (found in water logged soil)		Wolfskill	

Figure 18. Scientific and common pedigree for the Butte, Yuba and Wolfskill prune rootstock experiments.