Selecting Rootstocks for Utah Peach Orchards

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Peaches are the second most important fruit crop in Utah by acreage. Peach fruit that ripen under our high desert conditions (warm sunny days and cool nights) are valued in the market for their flavor and sugar content. However, peaches are more sensitive than most other fruit crops to our alkaline soil conditions, and often suffer from iron chlorosis.

Commercial peach trees consist of two cultivars or varieties that are grafted together: the scion produces the above ground portion of the tree, and the rootstock forms the roots and the base of the trunk (below ground). The scion variety determines the characteristics of the fruit (size, color, quality) and the flowering and fruit ripening time. The rootstock variety influences tree size and growth habit, productivity, insect and disease resistance, soil adaptability, and may also influence cold hardiness.

Rootstock Characteristics

Rootstocks can be propagated from seed, cuttings or tissue culture. Seed propagation can result in some variability, which is minimized by taking seeds from known parents. Lovell rootstock is an example of a seedling rootstock where seeds are collected from a known parent. Cloning by propagating with cuttings or through tissue culture results in genetically identical plants, and the use of "clonal" peach rootstocks is becoming more common. Characteristics of interest in selecting rootstocks included tree size, yield, alkaline soil tolerance, tree survival, and low root suckering.

Tree size and yield - Size controlling (dwarfing) rootstocks have become an important consideration in apple management systems, where dwarfing precocious (begin fruiting in 2nd and 3rd leaf) rootstocks have facilitated transition to high-density plantings. Peaches tend to be somewhat precocious, and the habit of fruiting on 1-year-old shoots requires vigorous production of new shoots to provide adequate fruit buds. Some highly dwarfing peach rootstocks have such low vigor under Utah conditions that they do not provide adequate fruiting wood.

Alkaline soil tolerance – With Utah's high pH (alkaline) soils, the availability of micronutrients such as iron and zinc can be problematic. Iron chlorosis is a symptom of iron deficiency characterized by interveinal yellowing (Figure 1). In severe cases, the leaf becomes almost white in color and the edges of the leaf brown. If left untreated, iron chlorosis can lead to tree death. Iron chlorosis is often present in stone fruits in Utah, and is typically more severe in peaches than in cherries. The most common remedies are the use of expensive chelated iron fertilizers. Some of Utah's alkaline soils are also relatively saline (high salts), which present an additional challenge in orchard management.

Root suckering - Root suckers are shoots that originate from the roots and from the rootstock shank (trunk below the graft union). Suckers must be removed as they interfere with harvest and weed management, where they prevent the use of systemic herbicides for in-row weed control. Removal adds to overall labor costs. They are often a symptom of poor tree health, and may indicate incompatibility between the rootstock and scion. Root suckering may also be related to soil type and growing condition.

Adaptability to Utah Conditions

Rootstocks vary in their adaptability to different soil conditions, with some being better-suited for Utah soils than others. In addition to peach rootstocks, peach scions can be grafted onto rootstocks from other closely related species such as plum, apricot, almond or a cross of two species (interspecific hybrids). Based on studies conducted in California, Chile, and Spain, some of these non-peach and hybrid rootstocks appear to be more tolerant of alkaline and saline soil conditions than traditional peach rootstocks. To evaluate rootstock performance under Utah conditions, we carried out comparison plantings over more than 10 years in southern Utah County and at the USU Kaysville Research Farm (Table 1).

Study 1

'Redhaven' peach (scion) was grafted onto 16 different rootstocks and tree performance (final tree size, yield, iron chlorosis susceptibility, and root sucker number) evaluated over 10 years at two different sites: the USU Kaysville Research Farm and a commercial orchard in West Payson, Utah County. The Kaysville site has more neutral soil pH, and iron chlorosis is not typically a management concern. The Payson site has more alkaline soil and peaches grown there are prone to iron chlorosis. For the purposes of this study, no applications of chelated iron were applied at either location. Rootstocks included 6 peach, 5 peach hybrids, and 5 plum cultivars (Table 2).

Table 1. Locations and characteristics of three orchard sites where rootstocks were tested in Utah.

Location	Soil Type	pH	Clay (%)	Organic Matter (%)	Elevation	Slope, Aspect
Kaysville	Kidman Fine Sandy Loam	7.5	13	1.7	4383	1 to 3%, W
West Payson	Hiko Peak Stony Sandy Loam	8.5	14	0.75	4740	8 to 15%, N
Goshen	Freedom Silt Loam	8.8	22	0.75	4780	0 to 2%, N

Figure 1. Healthy green peach tree (left) and chlorotic tree (right) are the same scion (variety O'Henry) grafted onto different rootstocks.

Table 2. Rootstock cultivars compared in the 2009 NC-140 trial at 2 Utah sites and their reported species composition.

Rootstock cultivar	Species (hybrids are clonally propagated)
Lovell	Peach seedling
Guardian®	Peach seedling
KV-010123	Peach seedling
KV-010127	Peach seedling
Controller™ 8 (HBOK 10)	Peach (clonal)
[1]Controller™ 7 (HBOK 32)	Peach (clonal)
Bright's Hybrid #5 (BH-5)	Peach x Almond
Krymsk® 86 (Kuban 86)	Peach x Myrobalan plum
Controller™ 5 (K146-43)	Peach x plum
Atlas	Peach, Almond, Myrobalan and Japanese plum
Viking	Peach, Almond, Myrobalan and Japanese plum
Rootpac® R (Replantpac)	Myrobalan plum x Almond
Krymsk® 1 (VVA-1)	Nanking cherry x Myrobalan plum
Prunus americana	American plum seedling
Empyrean® 2 (Penta)	European plum (clonal)
[2]Imperial California	European plum (clonal)

[1]100% mortality at Payson location
[2]Not included in the Payson location

Tree Size - Comparing overall growth of trees grown in a challenging environment (Payson) to trees grown in a good location (Kaysville) allows for comparison of rootstock tolerance to high pH soils. Based on overall tree growth, the rootstocks most tolerant of the alkaline conditions were 'Bright's Hybrid #5', 'Atlas', 'Empyrean® 2', 'Krymsk® 1' and *P. americana*. All of these rootstocks are either interspecific hybrids or plum. Peach rootstocks including the industry standard Lovell were the least tolerant of alkaline soils. Figure 2 shows how tree size was affected when grown in the alkaline soil at Payson compared to the more neutral soil at Kaysville.

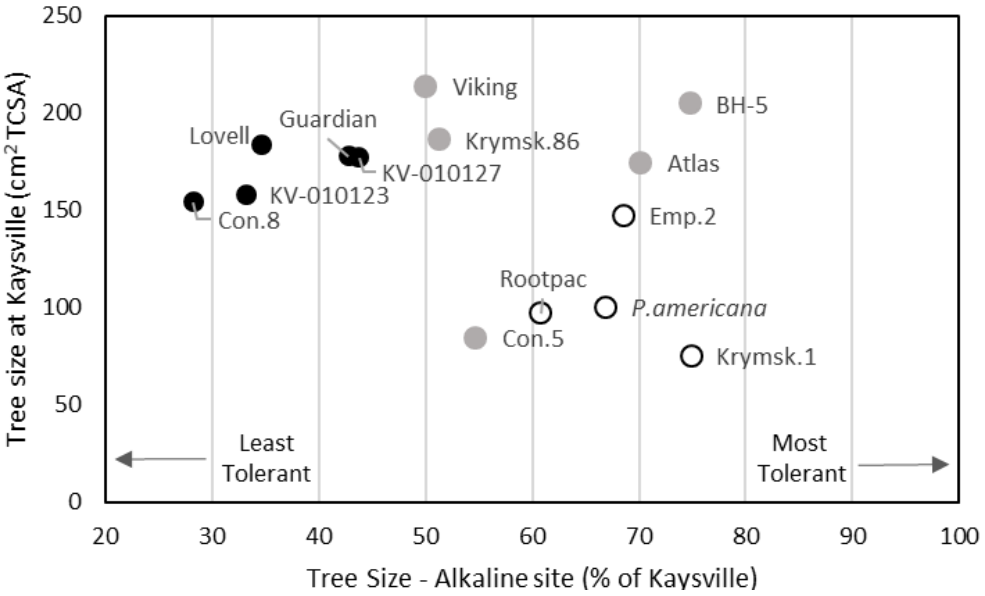

Figure 2. Tree size at Payson relative to tree size at Kaysville. Data symbol shade indicates genetic background of peach (black), hybrid (gray) and other non-peach species (white).

Yield - Cumulative yield for surviving trees was compared (Table 3). Without alkaline soil stress, the highest yielding trees at Kaysville were on 'Viking', KV-010127, and 'Atlas' rootstocks. These all had vigorous growth and were on peach hybrid or peach rootstocks. At the Payson site, the highest-yielding trees were on 'Bright's Hybrid #5', 'Atlas', and 'Rootpac® R' rootstocks (all interspecific hybrids). These data suggest that when grown in a highly alkaline soil, scions grafted to interspecific hybrid rootstocks produce higher yields than peach rootstocks.

Another method to evaluate tree performance is by calculating yield efficiency (total fruit yield per tree divided by final trunk cross-sectional area). Yield efficiency allows for evaluation of how well the tree is partitioning resources to fruit versus wood. Yield efficiency also indicates trees that might be most productive in higher density plantings. Rootstocks with the highest yield efficiency (Table 2) were 'Controller™ 5', *P. americana*, and 'Krymsk® 1', two plum and one peach hybrid.

Leaf Chlorophyll - Measurements of relative leaf chlorophyll content were used to compare tree health by looking at peach leaf color (an indicator of nitrogen and iron content). A handheld device was used to quantify the visible differences in leaf color, which reports results in "chlorophyll content index" or CCI. Healthy vigorous peach leaves typically have a CCI reading >20, and leaves with pronounced visible chlorosis give CCI readings <15. At the Kaysville site, leaves rarely showed signs of chlorosis and there was no significant difference among rootstocks. When grown in the more alkaline soil at the Payson site, 'Rootpac® R' and 'Bright's Hybrid #5' consistently had the highest leaf chlorophyll. The peach rootstocks 'Controller™ 8', KV-010123, Lovell, Guardian®, and KV-010127 were consistently ranked the lowest in relative chlorophyll content.

Root Suckers - Root suckers were also counted as a measure of tree performance. In general, the plum rootstock *P. americana* was the only one that suckered prolifically at both locations, likely indicating compatibility issues with peach. Although some of the other rootstocks did produce suckers on the alkaline soil, none of these were at levels that would be considered particularly problematic. The Kaysville farm typically had a higher number of root suckers than other locations, but the reason for this isn't clear.

Tree survival - differed somewhat with rootstocks, but this did not appear to be related to alkaline soil tolerance, as the rootstocks with poor survival were relatively weak trees coming from the nursery, and most of the trees died in the first few years of the experiment.

Table 3. Tree performance parameters including final tree size, cumulative yield (total yield from 2011 to 2017), yield efficiency (lbs of fruit per cm^2 trunk cross sectional area), iron chlorosis susceptibility (leaf chlorophyll) and root suckers for two Utah sites.

Kaysville	Tree size cm^2	Cum. yield lbs/tree	Yield Eff. lbs/cm2	Root suckers #/tree*
Viking	215	613	2.85	+
BH #5	207	536	2.59	-
Krymsk®86	191	494	2.59	+
Lovell	185	553	2.99	+
Guardian®	180	547	3.04	+++
Imperial CA	179	335	1.87	+
KV-010127	178	597	3.36	+
Atlas	176	562	3.19	-
KV-010123	160	500	3.13	+
Controller™8	155	531	3.43	-
Empyrean®2	150	425	2.84	-
Controller™7	146	522	3.58	-
P. americana	105	410	3.91	+++
Controller™5	86	342	3.97	-
Krymsk®1	76	287	3.77	+++

Payson	Tree Size cm^2	Cum. yield lbs/tree	Leaf chlor. Jul-13	Root suckers #/tree*
BH #5	156	428	19.5	-
Atlas	124	388	17.1	-
Rootpac®R	114	368	19.9	+
Viking	109	348	15.1	-
Empyrean®2	104	300	18.1	+
Krymsk®86	99	309	19.5	+
Guardian®	80	247	14.4	+
KV-010127	78	265	15.1	-
P.americana	70	254	17.2	+++
Lovell	66	247	12.3	-
Krymsk®1	58	223	17.7	+
KV-010123	58	179	14.1	-
Controller™5	51	174	19.5	-
Controller™8	47	231	9.8	-

* Suckers removed: None or very few (-), low to moderate (+), high (+++).

Study 2

For a second trial, the peach cultivar 'O'Henry' was grafted on to 11 rootstocks and the trees were evaluated for growth and iron chlorosis over 12 years on a commercial farm near Goshen, Utah. In addition to a high soil pH (Table 3), this location also has some salinity and sodicity issues with soil EC reaching as high as 6 dS/m in the fall, and a sodium adsorption ratio (SAR) of 3 mmol/L, compared to a soil salinity of 0.7 dS/M and an SAR of 0.3 for Kaysville (Johnson and Roper, unpublished).

Rootstocks included 4 peach cultivars, 4 peach x almond hybrids, and 3 plum and plum hybrids (Table 4). The peach rootstock, Lovell was used as a commercial industry standard.

Tree size - Trunk cross sectional area measurements were used to evaluate final tree size among the cultivars (Figure 3). The largest trees were on 'Monegro', 'Empyrean 1', and 'Nickels' rootstocks. Overall, plum rootstocks were smaller than peach and peach hybrid rootstocks but 'Lovell' the industry standard peach rootstock was the smallest and was likely stunted due to severe iron chlorosis.

Table 4. Rootstocks included in the Goshen study.

Rootstock Cultivar	**Species**
Lovell	peach
Cadaman	peach x David's peach
Empyrean® 1	peach x David's peach
Hansen 536	peach x almond
Garnem	peach x almond
Monegro	peach x almond
Nickels	peach x almond
Paramount	peach x almond
Krymsk® 86	Myrobalan plum x peach
Rootpac® R	Myrobalan plum x almond
Julior	plum hybrid

Leaf Chlorophyll - Chlorophyll readings were compared to determine overall tree health and alkaline soil tolerance (Figure 4). 'Garnem' and 'Paramount' had the highest chlorophyll readings in this study. In general,

peach x almond hybrid rootstocks (green bars, Fig. 3) were more tolerant of alkaline soils than peach and plum rootstocks (yellow bars). Lovell, the industry standard had the lowest leaf chlorophyll of all the rootstocks.

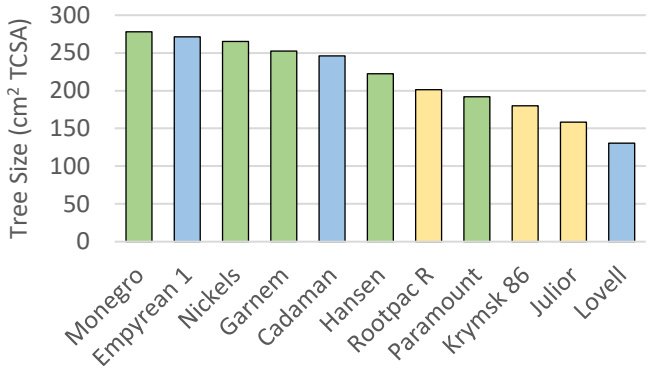

Figure 3. 2019 Tree cross-sectional area comparison among 12 rootstock cultivars grown at Goshen site. Bar colors represent rootstock genetic background (blue=peach, green=peach hybrid, yellow=plum/plum hybrid).

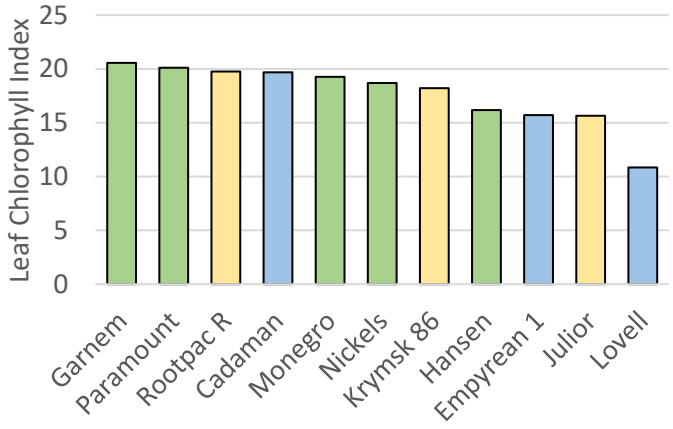

Figure 4. July 1st average (2010, 2015, 2017) leaf chlorophyll of trees at the Goshen site. Bar are color coded by genetic background the same as Figure 3.

Conclusion

When peach trees were grown in alkaline soils, interspecific hybrids generally outperformed peach rootstocks. The industry standard, Lovell grew well at the Kaysville site (neutral soil pH) but was not tolerant of alkaline soil conditions and performed poorly at both the Payson and Goshen sites. Rootstock selection for alkaline soil tolerance has a large effect on overall tree size, yield and chlorosis susceptibility.

Since peaches fruit on 1-year old shoots, consistent yields require adequate new shoot growth each year. On many of Utah's alkaline soils, it proves difficult to maintain adequate vigor for consistent production. At the Payson site, the most productive trees were the largest. In a higher density planting, and on stronger soils, some of the more dwarfing rootstocks such as 'Krymsk® 1', and 'Controller™ 5' might be useful as these had high yield efficiency, and relatively high leaf chlorophyll though 'Controller™ 5' is known to produce slightly smaller fruit.

Many of the rootstocks tested in these experiments are not widely available commercially. Table 5 shows availability of these rootstocks at some nurseries that specialize in peach as of Spring 2020.

Cultivar Descriptions of Widely Available Rootstocks.

Bright's Hybrid #5 *(Peach x Almond):* Self-sterile, nematode resistant, deep rooting and drought tolerant. Needs well-drained soil. Performs well on replant sites. One of the most vigorous, high-yielding trees in our trials. Excellent tolerance to iron chlorosis and low suckering. Likely too vigorous for stronger soils.

Cadaman *(Peach x David's peach):* Tolerant to root-knot nematode, not resistant to lesion nematode. Does not do well in heavy, wet soils. Moderate to good anchorage depending on soil type. Performs well on replant sites. Performed well in our trials with good tree size and tolerance to iron chlorosis.

Hansen 536 *(Peach x Almond):* Excellent anchorage, moderate resistance to root-knot nematode. Needs deep, well-drained soil and only 400-500 hours of chilling. Moderate growth compared to other cultivars at our Goshen site. Below average tolerance to iron chlorosis.

Krymsk® 86 *(Peach x Myrobalan plum):* Excellent growth, uniformity and anchorage. Tolerant of wet and heavy soils. In our trials, Krymsk® 86 was large and vigorous when planted at the lower pH site (Kaysville) but size was reduced when grown in high pH soils, even though leaf chlorophyll readings were relatively high.

Viking *(Peach, Almond, Myrobalan and Japanese plum):* Well-anchored, resistant to root-knot nematode, tolerant of ring nematode and bacterial canker. Tolerant of wet soil conditions. Very large, high yielding tree in our trials. May be too large and vigorous on less

alkaline sites such as Kaysville with moderate tolerance to iron chlorosis and low root suckering.

Rootpac® R *(Myrobalan plum x Almond):* Well-anchored, highly resistant to root-knot nematode, resistant to oak-root fungus and Phytophthora. Susceptible to bacterial canker. Performs well in replant situations. Tolerant of wet, heavy soils. In our trials, Rootpac® R performed well with good vigor and yield. Excellent tolerance to iron chlorosis but had moderate suckering.

Lovell *(Peach):* Currently the industry standard peach rootstock. Good growth and yields on less alkaline soils, with little to no root suckers. Susceptible to crown rot and crown gall. Susceptible to root-knot and root-lesion nematodes and oak-root fungus. Tolerant of wet soils but prefers well-drained soil. Good anchorage. In our trials, Lovell was very small when grown in high pH soils with low yields.

Adapted dwarfing rootstocks

Dwarfing rootstocks can be more "yield efficient" meaning that they are more efficient at preferentially directing resources to fruit instead of branches. Dwarfing rootstocks with high yield efficiency are considered best suited to high density systems. However, since peach production is on one-year-old wood, under Utah conditions there is a risk these rootstocks can be too dwarfing. Of the dwarfing rootstocks included, the following had high yield efficiency and appeared to be best adapted to Utah's alkaline soils.

Controller™ 5 *(Peach x Plum)*: A dwarfing rootstock with 50 to 60% tree vigor of standard rootstocks. Moderately susceptible to root-knot nematode. Excellent tolerance to iron chlorosis in our trials.

Krymsk 1 (*Nanking cherry x Myrobalan plum*): A dwarfing rootstock with 50 to 70% tree vigor of standard rootstocks. Susceptible to bacterial canker sites, but performs relatively well under Rootknot and Lesion nematode pressure. Moderate tolerance to iron chlorosis in our trials.

Disclaimers

Table 5. Rootstock availability from commercial nurseries (with alternative names).

	Agromillora	ANFIC	Burchell	Dave Wilson	Duarte	Fowler	North American	Rich Farm Garden	Sierra Gold	Summit Tree
Atlas				x						
Bright's Hybrid 5 (BH #5)					x	x	x		x	
Cadaman	x		x				x			
Controller™5 (K146-46)			x						x	
Controller™7 (HBOK 32)									x	
Controller™8 (HBOK 10)									x	
Empyrean 1		x							x	
Empyrean 2 (Penta)		x								
Garnem	x									
Guardian® (BY520-9)			x							
Hansen 536			x	x	x	x	x		x	
Krymsk®1 (VVA 1)		x					x	x	x	x
Krymsk®86 (Kuban 86)		x			x	x	x		x	x
Lovell			x	x		x		x	x	x
Nickels						x			x	
P. americana (Am. Plum)			x							
Paramount (GF 677)							x			
Rootpac®R (Mirobac)	x		x	x			x			
Viking				x	x				x	

Sources for Rootstocks

Agromillora
Warmington Road, 9375 N.
E Mc Minnville, OR 97128
503-474-1852
Commercial producers and nurseries

ANFIC
P.O. Box 811
Kallangur, Queensland
Australia 4503

Burchell Nursery
12000 State Highway 120
Oakdale, CA 95361
209-845-8733
Public and commercial producers

Dave Wilson
P.O. Box 439
Hickman, CA 95323
209-871-1821
Commercial producers and nurseries

Duarte
1555 Baldwin Road
Hughson, CA 95326
209-531-0351
Commercial producers and nurseries

Fowler Nurseries, Inc.
525 Fowler Road
Newcastle, CA 95658
919-645-8191
General public

North American Plants
P.O. Box 743
Lafayette, OR 97127
503-474-1852
Commercial producers and nurseries

Rich Farm Garden
P.O. Box 143
Winchester, IN 47394
General public

Sierra Gold
5320 Garden highway
Yuba City, CA 95991
530-674-1145
Public and commercial producers

Summit Tree Sales
37456 Red Arrow Highway
Paw Paw, Michigan 49079
1-800-424-2765
Broker for commercial orchardists