Journal of the American Pomological Society 62(2):46-51 2008

Nursery Performance of Peach Seedling Rootstocks

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Abstract

The nursery performance of a cross-section of both historically important and current commercial peach [*Prunus persica* (L.) Batsch] seedling type rootstocks was studied over three growing seasons at six nurseries serving the southeastern United States peach industry. Many of the 14 rootstock lines tested differed significantly in both their percent germination and growth prior to budding. Tennessee Natural (IR282-2) displayed the best (77%) germination. The commercial bulked seedlot of Guardian™ (BY520-9) being distributed at the time of this study displayed the worst (32%) percent germination. However, since then Guardian's germination percentage has improved dramatically through the identification and utilization of those selections with superior germination. Percent unbuddable seedlings ranged from 1.5 to 6.6% across the rootstock lines. High vigor is desirable. Nemared and Bailey displayed the highest (58.0 cm height) and lowest (35.2 cm height) vigor, respectively. Seedlings with few or no branches on their lower trunks are most desirable for budding. Rutgers Red Leaf and Bailey displayed the lowest (0.7 branches per seedling) and highest (2.4 branches per seedling) number of side branches on the lowest 10 cm of trunk, respectively. Rootstocks differed sufficiently to warrant preferences for increased production efficiency if rootstock-specific site adaptability did not take precedence.

Very little information has been published regarding the comparative nursery performance of peach [*Prunus persica* (L.) Batsch.] seedling rootstocks utilized in the United States (U.S.) or elsewhere. While differences in the germination of different rootstock lines has long been recognized (5, 16), the little information now available is largely based on lab-based tests (17).

To date 21 seedling peach rootstocks have been introduced in North America (2). The number is actually closer to 30 if informally introduced, adapted cultivar materials and research evaluated materials (that in most cases were never, or only briefly, available commercially) are included (8). Some of these have enjoyed wide utilization in the US nursery industry, whereas others were found wanting and abandoned. Reasons varied. Some, like Bailey, Chui Lum Tao, Harrow Blood, Siberian C, and Tzim Pee Tao, were touted as imparting superior cold tolerance to the scion varieties budded onto them. Bailey is currently utilized in Midwest and northeastern nurseries for this reason. Others were found to be useful for addressing specific soil-related issues such as root-knot nematodes (Bokhara, Guardian (BY520-9), Flordaguard, Higama, Okinawa, Nemaguard, Nemared, Rancho Resistant, Red Ran, S-37, S-60, Shalil, and Yunnan), root lesion nematodes (Bailey and Rutgers Red Leaf) or peach tree short life (Lovell, Halford and BY520-9). Guardian (BY520-9) is currently the dominant rootstock for peach in the southeastern U.S. principally because of its resistance to peach tree short life. Other stocks offered the convenience of a red leaf character which made differentiating the scion shoot from rootstock suckers a simple task (Flordaguard, Nemared, Red Ran and Rutgers Red Leaf). Some were not used because of specific shortcomings, e.g. Okinawa for a large percentage of doubles, i.e. 2 seeds within a pit (15) or, in the case of S-37, a reputation (deserved or not) for poor anchorage (19).

Occasionally, rootstock release notices comment on seed germination, subsequent vigor and uniformity, but very little, if any, information is provided as to what they were being compared to or the methods or circumstances of the testing being reported. Nevertheless, anecdotal information from nursery managers indicates that there are significant differences in percent germination and subsequent growth prior to budding. Consequently, nursery managers generally have had clear preferences for particular varieties of peach

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seedling rootstocks if a customer's needs did not dictate other choices.

The purpose of the work reported here was to compare the nursery performance of a group of historically important and currently utilized peach seedling rootstocks.

Materials and Methods

Fourteen different rootstock genotypes, all peach seedling types, were compared in this study (Table 1). Open-pollinated seeds were collected each year from trees growing at the USDA-ARS Southeastern Fruit and Tree Nut Research Lab in Byron, Georgia. After cleaning and air drying, random samples (50 seed) of each of the 14 genotypes were weighed (pit intact), packaged and shipped to six nurseries each fall, typically late September, for direct planting in the field. The following May, just as budding operations commenced, the number of emerged seedlings was counted and the length of each plot measured. In the event of a plot disturbance, such as water erosion, an attempt was made to estimate the length of the disturbed portion and a proportional adjustment was made to the germination estimate for that plot. Seedlings smaller than 25 cm in height are unlikely to be budded (Beckman, personal observation) and these were also counted in each lot. On a sample of (up to) 25 seedlings in each lot, total height and height to first branch were measured and the number of branches on the lowest 10 cm of trunk was counted. Trunk caliper was measured 10 cm above the soil line on Lovell and Nemaguard seedlots only (sample of up to 25 seedlings). Data were analyzed by the General Linear Models (GLM) program of the Statistical Analysis System for personal computers (13). A split plot experimental design was utilized with nurseries as the main plot and rootstock as the split plot. Years were treated as replications.

Results and Discussion

Although we had expected significant main plot (nursery) effects due to differences in management practices and site, very few

Table 1. Peach seedling rootstocks tested in Tennessee nurseries (1994-1996).

Rootstock	Origin	Chill (hr)[z]	Flower type[y]	Flesh color[x]	Flesh type[w]	Pit type[v]	Leaf color[u]	Leaf gland[t]	Ref.
Bailey	Iowa	1000	S	W	M	F	G	E	none
Boone Co.	Iowa	1000	S	W	M	F	G	E	none
Guardian (BY520-9)	Georgia	750	S	W	M	F	G	R	11, 14
Ferris	Iowa	950	S	W	M	F	G	E	none
Flordaguard	Florida	250	S	Y	M	F	R	R	1,15
GF305	France	1000	NS	W	M	F	G	R	1
Halford (2)	California	750	NS	Y	NM	C	G	G	4
Lovell	California	750	NS	Y	M	F	G	G	18
Nemaguard	Georgia	750	S	W	M	C	G	R	4
Nemared	California	650	S	W	M	C	R	R	12
Rutgers Red Leaf	New Jersey	1000	S	W	M	F	R	R	4
Siberian C	Canada	850	S	W	M	F	G	R	4, 9
Tennessee Natural IR282-2	Tennessee	1000	S	W	M	F	G	R	none
Tennessee Natural IR1258-2	Tennessee	1000	S	W	M	F	G	R	none

[z] Estimated hours below 7ºC based on observations at Byron, Ga.
[y] Flower type: showy (S) or nonshowy (NS).
[x] Fruit flesh color: yellow (Y) or white (W).
[w] Fruit flesh type: melting (M) or nonmelting (NM).
[v] Fruit pit type: freestone (F) or clingstone (C).
[u] Leaf color: green (G) or red (R).
[t] Leaf petiolar gland: reniform (R), globose (G) or eglandular (E).

variables differed significantly among nurseries. Additionally, there were no nursery (main plot) by rootstock (split plot) interactions. Nursery managers were clearly hesitant to discuss many of the details of their management program, particularly their fertilizer regimes. Use of pre-plant fumigations was variable. A few nurseries fumigated with methyl bromide every year. Most fumigated every other year and a few used no pre-plant fumigants at all. We observed that 'planting' depth (as noted at time of budding) was fairly uniform across nurseries. Most growers indicated that they planted *ca*. 5-8 cm deep and then hilled soil up on each row another 5 to 8 cm deep. Their intention was to provide sufficient cover to moderate soil freezing and resist soil erosion such that the seed would be *ca.* 5 cm deep in the spring during emergence, much as observed. Likewise seed (planting) density was quite uniform across all nurseries ranging between 18 and 20 seeds per meter of row (data not shown) and was not significantly correlated with seed weight, e.g. size, ($r = -0.13$, $P = 0.08$).

Rootstock lines differed significantly in seed weight, and percent germination (Table 2). Guardian (BY520-9) had the largest seeds and Nemaguard the smallest. The range was well within that previously reported for peach (7). There was only a small non-significant negative linear correlation between percent germination and seed weight ($r = -0.04$, $P=0.56$). Tennessee Natural IR282-2, with the next to smallest seed, had the highest percent germination, while Guardian (BY520-9), with the largest seed, displayed the lowest percent germination.

Most nursery managers indicated that they expected commercial lines to provide at least 60% germination, in agreement with published expectations (10). Most lines tested achieved this standard. The reasons for low germination may not always be related to inherent germination ability of the lot. Growers reported that Nemaguard often emerged from the ground ahead of Lovell and in some years would be subjected to a hard late freeze capable of killing emerged and emerging seedlings, thereby reducing apparent germination. It has been our observation that Flordaguard requires far less time than other rootstock lines in artificial stratification (excised embryo in the lab) to achieve high rates of germination (Beckman, unpublished data). Therefore, Flordaguard's low percent germination could be due to early emergence and subsequent freeze damage, making it unsuitable for fall planting in the Tennessee nursery industry.

Guardian (BY520-9) was released in 1993 and this experiment covered its first three years in commercial use. Pre-release experience with the germination of a wide range of sibling Guardian lines under laboratory conditions (excised embryo) had indicated that they routinely achieved germination percentages similar to other commercial rootstock lines (data not shown). However, initial commercial lots (consisting of seed collected from as many as 60 surviving sibling lines) typically displayed disappointing germination under field conditions. Many of the unemerged seed of Guardian (BY520-9) were still alive and the embryos, if taken back to the lab and excised, were capable of germination and growth (though some would rosette, suggesting inadequate stratification). This may be related to the unusual structural integrity of Guardian pits which appears to delay water penetration (Beckman, unpublished data) and resist splitting along the suture (Beckman, personal observation). The former would delay the uptake of moisture, a key precondition before the stratification process can proceed. The latter would delay or thwart seedling emergence. Through a series of germination evaluations under field conditions, Guardian lines with superior germination potential were selected and propagated for a seed production orchard. At the present time commercial lots of Guardian (BY520-9) routinely achieve 60% (or better) germination under Tennessee nursery conditions (10; and Beckman, unpublished data).

There were small but significant main plot (nursery) effects on percent unbuddable seedlings which ranged from 1.2 to 2.4% ($P < 0.03$, data not shown). It was not clear if this was related to planting/management practices or site specific factors. There were also significant rootstock effects on percent unbuddable seedlings (Table 2) which ranged from 1.5 to 6.6%. In general this did not have a major effect on the percent usable seedlings of each rootstock line, causing only minor reshuffling in the relative order of the rootstock treatments (Table 2). Nevertheless, in some cases this represented a loss of more than 10% of the emerged seedlings for subsequent use in budding. There was a significant negative linear correlation between seed density and percent unbuddable seedlings ($r = -0.27$, $P = 0.0002$) which suggests that closer seed spacing might aid the timely emergence of their neighbors. There was also a significant negative linear correlation between seedling height and percent unbuddable seedlings ($r = -0.56$, $P < 0.0001$) which may only indicate that lower vigor lines tended to have more seedlings fall short of the 25 cm cutoff we imposed.

Rootstocks differed significantly in their vigor (height) prior to budding (Table 2). Nemared displayed the highest vigor and Bailey the lowest. Lovell and Nemaguard did not differ significantly in their trunk caliper, with means of 3.46 mm and 3.78 mm, respectively (LSD, alpha = 0.05). However, numerical differences closely mimicked their grafted performance in field trials, i.e. trees budded on Lovell rootstock are typically 10-15% smaller than the same cultivar budded on Nemaguard (3).

Side branches near the budding site (typically 5 to 10 cm from the soil line) are routinely removed a week or two prior to budding. It is a tedious and time consuming task. Rootstock had a significant effect on the number of side branches on the lowest 10 cm of trunk (Table 2). Interestingly, all three red leaf types (Flordaguard, Nemared and Rutgers Red Leaf) were among the four treatments with the fewest side branches. The number of side branches ranged more than 3-fold with Bailey producing the largest number. There was a significant negative linear correlation between seedling height and number of side branches ($r = -0.23$, $P = 0.0004$) suggesting an interaction of apical dominance and vigor. However, this correlation is largely driven by Nemared, one of the most vigorous and least branched rootstock lines tested. If Nemared is excluded from the analysis, the correlation becomes non-significant, $r = -0.13$, $P = 0.47$.

Height to first branch was also measured as a simpler alternative to counting all branches on the lowest 10 cm portion of the trunk. Height to first branch displayed a significant negative linear correlation with number of branches ($r = -0.64$, $P < 0.0001$). Again all three red leaf types were among the four treatments with the greatest height to first branch (Table 2). There was also a positive linear correlation between seedling height and height to first branch ($r = 0.35$, $P < 0.0001$). However, this correlation was again largely driven by Nemared. If Nemared is excluded, the correlation becomes non-significant, $r = 0.17$, $P=0.33$.

Height to first branch was the only variable, other than percent unbuddable seedlings, in which the main plot treatment (nursery) was significant (data not shown). Although the nurseries with the lowest number of branches also displayed the largest height to first branch, main plot treatments were not significant for the former as they were for the latter. It is not exactly clear what the mechanism of the nursery effect is. However, we noted that those nurseries with a relatively "lush" growth habit (deep green color) also seemed to be associated with more side branches and lower first branches. Hence, it would seem that some optimization of the nutritional program might be possible such that sufficient height could be achieved by the desired time of budding with a minimum number of side branches present.

This relative performance of the rootstock lines tested revealed differences that have value to nursery managers. Both Nemared and Rutgers Red Leaf displayed superior germination and few side branches. Additionally, Nemared showed exceptional vigor, such that it may be budded 1-2 weeks earlier than stan-

Table 2. Seed weight, percent germination and growth characteristics of peach seedling rootstocks tested in Tennessee nurseries (1994-1996).

Rootstock	Seed weight (g)	Plot length (m)	Seed density (no./m)	Germination (%)[z]	Unbuddable (%)[y]	Usable (%)[z]	Plant height (cm)	No. of branches[x]	First branch (cm)[w]
TN IR282-2	2.36 hi	2.73	19.4	76.9 a	3.1 def	73.9 a	41.4 bcd	1.1 defg	11.9 bc
Rutgers Red Leaf	2.52 ghi	2.78	18.4	75.5 ab	6.6 a	68.3 ab	41.4 bcde	0.7 g	13.3 b
Lovell	3.43 bc	2.80	18.4	73.6 ab	5.1 abcd	68.6 ab	41.3 bcde	1.3 def	10.8 bcd
Siberian C	3.57 b	2.81	18.4	68.9 abc	2.4 def	66.6 ab	40.2 bcde	1.2 defg	11.3 bcd
Halford (2)	3.18 cd	2.75	18.8	69.9 abcd	5.9 ab	64.0 abc	38.0 def	1.6 bcd	10.6 bcd
GF305	2.69 efghi	2.76	18.7	68.4 abcd	2.8 def	65.6 ab	44.0 b	0.9 efg	11.8 bcd
Nemared	3.08 cde	2.83	18.6	67.1 abcd	1.5 f	65.4 ab	58.0 a	0.7 fg	17.6 a
Bailey	2.68 fghi	2.73	18.7	66.5 abcd	5.2 abcd	61.3 abcd	35.2 f	2.4 a	7.1 e
Nemaguard	2.33 i	2.93	17.8	62.8 bcde	1.9 ef	60.9 abc	43.1 bc	1.5 cde	9.4 cde
TN IR1258-2	2.40 ghi	2.76	18.6	58.7 cde	5.6 abc	53.1 bcd	37.0 ef	0.7 fg	13.2 b
Boone Co.	2.76 efg	2.78	18.6	52.4 def	4.8 abcde	47.6 cde	37.3 def	2.2 ab	10.5 bcd
Ferris	2.74 efgh	2.71	19.0	49.7 ef	3.1 cdef	46.6 de	37.8 def	2.1 abc	9.6 cde
Flordaguard	2.98 def	2.90	17.8	39.1 fg	3.4 bcdef	35.6 ef	39.2 cdef	0.8 fg	13.2 b
BY520-9	3.98 a	2.63	19.6	32.0 g	3.6 bcdef	28.4 f	37.6 def	1.7 bcd	8.7 de
MSD[v]	0.38	0.39	2.3	14.7	3.1	15.2	4.3	0.6	3.1

[z] Data transformed as arcsin prior to analysis (6). Untransformed means are presented.
[y] Data transformed as square root prior to analysis (6). Untransformed means are presented
[x] Number of branches emerging on lowest 10 cm of trunk
[w] Height from soil line to first branch emerging on trunk
[v] Minimum significant difference, Waller-Duncan K-Ratio = 100

dard commercial stocks such as Nemaguard and Lovell. Earlier budding would provide a longer growing season to produce a finished product. Despite Guardian's inauspicious debut with the nursery industry, it is now the dominant rootstock utilized for the southeastern U.S. peach industry principally because of its superior resistance to peach tree short life. Fortunately, Guardian's seed germination and stand uniformity has improved dramatically in recent years through the selection and utilization of the best-performing lines for the production of the bulked commercial seedlot.

Acknowledgements

The author expresses thanks to the following nursery owners for their help in this work: Dale Bryan (Freedom Tree Farms, Pelham, Tenn.), Dan Farris (Pleasant Ridge Nursery, Huntland, Tenn.), Paul Haley (Haley Nursery Co., Smithville, Tenn.), Phil Pelham (Cumberland Valley Nurseries, McMinnville, Tenn.), Marvin Tieman (Tieman Fruit Trees, Morrison, Tenn.), and Gene and Mike Vaughn (Vaughn Nursery, Smithville, Tenn.). The author also expresses gratitude to Kathy Halat and Raymon Pate for their technical assistance in this work.

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