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# Performance of the 2002 NC-140 Cooperative Peach Rootstock Planting

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## Abstract

In 2002, a peach [*Prunus persica* (L.) Batsch] trial consisting of eight rootstocks was planted at 17 sites in the United States, Canada and Mexico. 'Redhaven' was the scion at ten sites and 'Cresthaven' at the other seven sites. The rootstocks tested were Adesoto 101, Mr.S.2/5, Penta, Krymsk®2 (VSV-1), Krymsk®1 (VVA-1), Pumiselect®, Cadaman® and Lovell. After five years, trees on Cadaman® were similar in size and productivity to Lovell. Pumiselect® and Krymsk®2 exhibited many problems with survival, suckering and fruit weight. Adesoto 101, Mr.S.2/5 and Penta all showed potential as semi-dwarfing rootstocks although mortality and suckering were excessive at some sites. Krymsk®1 showed potential as a dwarfing rootstock with a trunk cross-sectional area 35% of Lovell. Trees on Krymsk®1 rootstock also had fruit weight equal to the more vigorous rootstocks and had the highest yield efficiency.


In recent years, many new rootstocks for peaches have been introduced throughout the world (5, 10). These new selections show promise for improving orchard management efficiency. Some of their reported attributes include dwarfism, increased resistance to pests and diseases, and greater survival under adverse conditions. A thorough testing over many years and in numerous locations is advisable so the strengths and weaknesses of each new rootstock can be determined (1). Often this takes an inordinate amount of time and resources. The NC-140 Rootstock Evaluation Committee was formed to shorten this process and to allow for a more uniform evaluation under many different locations with varying climatic, edaphic and biotic conditions (9). Past reports from this group (8, 11, 12) have provided valuable information about various fruit tree rootstocks.

Having smaller, yet productive trees, has been a major goal of rootstock breeding programs around the world. Size-controlling rootstocks for peach could provide a great boost in production efficiency, similar to that experienced by the apple industry with the introduction of M.9 and other dwarfing rootstocks. This paper reports on growth and fruiting results from the first five years of a planting initiated to test seven experimental peach rootstocks in 17 locations.

## Materials and Methods

In spring 2002, a trial consisting of eight rootstocks was planted at 17 sites (Table 1) under the coordination of the NC-140 Technical Committee. 'Redhaven' was the scion at ten sites and 'Cresthaven' at the other seven sites. The rootstocks tested were Adesoto 101 (6), Mr.S.2/5 (4), Penta (7), Krymsk®2 or VSV-1 (14), Krymsk®1 or VVA-1 (15), Pumiselect®, and Cadaman®, with Lovell as the industry standard (Table 2). Reighard and Loreti (13) provide detailed information on these rootstocks. Trees were propagated by Burchell Nursery, Oakdale, California. Spacing for each orchard site was 5 x 6 m and trees were trained to an open vase system. Irrigation, pest control and fertilization followed local recommendations at each location. Experimental design was a randomized complete block with eight blocks and a single

[1] Authors' locations and institutions appear in Table 1

**Table 1.** NC-140 2002 peach rootstock trial cooperators

| Location code | Scion cultivar | Cooperator | Institution | Site |
|---|---|---|---|---|
| CA | Redhaven | Scott Johnson | Univ. of California | Parlier |
| CO | Cresthaven | Ron Godin<br>Harold Larsen<br>Ramesh Pokharel | Colorado State Univ. | Rogers Mesa |
| GA | Redhaven | Kathryn Taylor<br>Tom Beckman | Univ. of Georgia<br>USDA-ARS | Byron |
| MA | Redhaven | Wesley Autio | Univ. of Massachusetts | Deerfield |
| MD | Redhaven | Michael Newell<br>Chris Walsh | Univ. of Maryland | Queenstown |
| MO | Cresthaven | Martin Kaps<br>Patrick Byers | Missouri State Univ. | Mountain Grove |
| MO | Redhaven | Michele Warmund | Univ. of Missouri | New Franklin |
| MX | Redhaven | Rafael Parra Quezada<br>Carlos Chavez Gonzalez | INIFAP Sierra de Chihuahua<br>Universidad Autonoma<br>de Chihuahua, Mexico | Nuevo Casas Grandes |
| NJ | Cresthaven | Win Cowgill<br>Daniel Ward | Rutgers-NJAES | Bridgeton |
| NY | Cresthaven | Terence Robinson<br>Robert Andersen | Cornell University | Geneva |
| OH | Redhaven | Diane Miller | Ohio State Univ. | Wooster |
| ON | Redhaven | John Cline | Univ. of Guelph | Vineland |
| PA | Redhaven | James Schupp<br>George Greene | Penn State Univ. | Biglerville |
| SC | Redhaven | Gregory Reighard<br>David Ouellette | Clemson Univ. | Clemson |
| TX | Cresthaven | Larry Stein<br>Jim Kamas | Texas Coop Ext. | Fredricksburg |
| UT | Cresthaven | Brent Black<br>Thor Lindstrom | Utah State Univ. | Kaysville |
| WA | Cresthaven | Matthew Whiting<br>David Ophardt | Washington State Univ. | Prosser |

**Table 2.** Rootstocks tests in the NC-140 2002 peach rootstock trial.

| Rootstock | Country of origin | Species |
|---|---|---|
| Adesoto 101 | Spain | *Prunus insititia* L. |
| Mr.S.2/5 | Italy | *Prunus cerasifera* Ehrh. |
| Penta | Italy | *Prunus domestica* L. |
| Krymsk® 2 | Russia | *Prunus incana* (Pall.) Batsch × *P. tomentosa* Thunb. |
| Krymsk® 1 | Russia | *Prunus tomentosa* Thunb. × *P. cerasifera* Ehrh. |
| Pumiselect® | Germany | *Prunus pumila* L. |
| Cadaman® | France | *Prunus persica*(L.) Batsch × *P. davidiana* (Carr.) Franch |
| Lovell | USA | *Prunus persica* (L.) Batsch |

tree of each rootstock per block. Trees were removed after the 2006 season.

The following data were collected each year from each site: survival rate, trunk circumference (used to calculate trunk cross-sectional area), number of root suckers (counted and removed), total yield per tree and weight of a 50 fruit subsample (used to calculate average fruit weight). Data were analyzed with the MIXED procedure of the SAS statistical analysis software (SAS Institute, Cary, NC, USA). 'Redhaven' and 'Cresthaven' sites were analyzed separately for yield, yield efficiency and fruit weight parameters, but combined for tree mortality, number of root suckers and trunk cross-sectional area parameters. Least-squares means, adjusted for missing subclasses, were generated by the analyses. Rootstock and location means were separated by Tukey's HSD ($P = 0.05$).

## Results and Discussion

Although some significant rootstock by location interactions were found, they tended to be due to minor differences in the rank of rootstocks from one location to another. These changes did not appear to have profound biological or practical importance, and therefore, only main effects will be discussed in this paper. Over the five years of this trial, approximately 25% of the trees died. These deaths were due to a wide range of environmental, edaphic, cultural and pest related factors. The standard rootstock, Lovell, was ranked lowest in tree loss (Table 3). Survival of trees on Lovell was 100% at most sites, and the few sites with high mortality showed overall poor survival among all rootstocks. Cadaman® also survived well although half the sites lost at least one tree. The worst performing rootstock was Pumiselect®, which averaged 39% mortality; only one site had no tree deaths. The other five rootstocks had tree mortality values ranging from 19 to 34%. Thus, it is concluded that some of these rootstocks are not well adapted to major peach growing areas of North America.

After the establishment year (2002), on average tree losses rose by 5 to 7% per year (Table 4). However, individual sites showed more episodic changes. For instance, 15% or higher tree deaths per year occurred in the following situations: 2004 – Ohio and Missouri ('Cresthaven'); 2005 – South Carolina, Missouri ('Cresthaven') and New York; 2006 – Georgia and Pennsylvania. Episodic tree loss was often associated with sudden temperature drops, particularly harsh winters,

**Table 3.** Cumulative mortality (%) of peach trees on eight rootstocks at 17 sites (2002-2006).

| | Rootstock | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site | Adesoto 101 | Mr.S.2/5 | Penta | Krymsk®2 | Krymsk®1 | Pumiselect® | Cadaman® | Lovell |
| ***Redhaven*** | | | | | | | | |
| CA | 0.0 | 37.5 | 0.0 | 0.0 | 0.0 | 12.5 | 0.0 | 0.0 |
| GA | 87.5 | 12.5 | 50.0 | 75.0 | 12.5 | 50.0 | 12.5 | 0.0 |
| MA | 0.0 | 12.5 | 25.0 | 0.0 | 12.5 | 50.0 | 0.0 | 0.0 |
| MD | 0.0 | 25.0 | 42.9 | 50.0 | 12.5 | 87.5 | 12.5 | 0.0 |
| MO | 0.0 | 25.0 | 37.5 | 62.5 | 12.5 | 50.0 | 25.0 | 0.0 |
| MX | 20.0 | 0.0 | 40.0 | 60.0 | 40.0 | 60.0 | 20.0 | 20.0 |
| OH | 25.0 | 75.0 | 12.5 | 87.5 | 12.5 | 37.5 | 0.0 | 0.0 |
| ON | 37.5 | 12.5 | 0.0 | 25.0 | 0.0 | 37.5 | 0.0 | 12.5 |
| PA | 0.0 | 75.0 | 12.5 | 12.5 | 25.0 | 0.0 | 25.0 | 0.0 |
| SC | 50.0 | 75.0 | 12.5 | 37.5 | 50.0 | 37.5 | 25.0 | 0.0 |
| ***Cresthaven*** | | | | | | | | |
| CO | 0.0 | 0.0 | 0.0 | 0.0 | 37.5 | 62.5 | 0.0 | 0.0 |
| MO | 100.0 | 50.0 | 50.0 | 71.4 | 25.0 | 37.5 | 0.0 | 12.5 |
| NJ | 62.5 | 50.0 | 50.0 | 0.0 | 25.0 | 12.5 | 12.5 | 12.5 |
| NY | 62.5 | 87.5 | 62.5 | 50.0 | 12.5 | 25.0 | 37.5 | 37.5 |
| TX | 12.5 | 25.0 | 50.0 | 28.6 | 25.0 | 25.0 | 12.5 | 0.0 |
| UT | 0.0 | 0.0 | 0.0 | 12.5 | 12.5 | 62.5 | 0.0 | 0.0 |
| WA | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.5 | 0.0 | 0.0 |
| Mean | 26.9 ab$^z$ | 33.1 a | 26.2 ab | 33.7 a | 18.5 bc | 38.8 a | 10.7 c | 5.6 c |

$^z$ Mean separation by Tukey's HSD ($P$=0.05).

and/or factors that weakened the trees such as poor growth, flooding, wind, or pest damage.

Root suckering varied considerably among rootstocks, but even more among the different locations (Table 5). California, South Carolina, New York and Utah averaged more than 20 root suckers per tree, while Massachusetts, Mexico and Ontario had almost none. To our knowledge, there are almost no scientific studies on external factors influencing suckering

**Table 4.** Cumulative mortality (%) of peach trees on eight rootstocks by site 2002-2006.

| Site | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| ***Redhaven*** | | | | | |
| CA | 0.0 b[z] | 1.5 | 1.5 d | 6.1 ef | 6.3 ef |
| GA | 1.5 ab | 7.8 | 10.9 a-d | 17.0 c-f | 37.5 a-c |
| MA | 0.0 b | 3.0 | 6.1 cd | 9.3 d-f | 12.5 d-f |
| MD | 0.0 b | 9.9 | 22.4 a-c | 25.5 a-e | 28.8 a-e |
| MO | 3.1 ab | 12.4 | 18.6 a-d | 21.6 b-f | 26.6 a-e |
| MX | 7.5 a | 15.0 | 15.0 a-d | 20.0 b-f | 32.5 a-e |
| OH | 0.0 b | 7.6 | 28.0 a | 29.5 a-d | 31.3 a-e |
| ON | 0.0 b | 1.5 | 4.5 cd | 13.9 c-f | 15.6 c-f |
| PA | 1.5 ab | 1.5 | 3.0 d | 3.0 f | 18.8 c-f |
| SC | 4.6 ab | 9.3 | 15.4 a-d | 34.1 a-c | 35.9 a-d |
| ***Cresthaven*** | | | | | |
| CO | 0.0 b | 7.8 | 9.4 b-d | 10.9 d-f | 12.5 d-f |
| MO | 1.5 ab | 1.5 | 26.6 ab | 41.4 ab | 43.3 ab |
| NJ | 0.0 b | 1.5 | 7.6 cd | 17.1 c-f | 28.1 a-e |
| NY | 0.0 b | 0.0 | 6.1 cd | 46.5 a | 46.9 a |
| TX | 1.5 ab | 6.1 | 14.0 a-d | 20.6 b-f | 22.3 b-f |
| UT | 0.0 b | 9.3 | 9.3 b-d | 10.8 d-f | 10.9 ef |
| WA | 0.0 b | 1.5 | 1.5 d | 1.5 f | 1.6 f |
| Mean | 1.2 | 7.2 | 13.3 | 20.7 | 25.6 |

[z] Mean separation within columns by Tukey's HSD ($P$=0.05).

in fruit trees. Other tree species such as aspen (*Populus tremuloides* Michx.) have been studied extensively and many parameters that affect suckering have been identified, including soil temperature, soil moisture, nutrient availability, tree vigor, soil compaction, root damage and weed competition (2). Certainly, factors such as these varied substantially among the 17 sites.

Lovell had almost no suckering even at

**Table 5.** Average number of root suckers per tree in 2005 and 2006 arising from eight rootstocks at 16 sites (suckering data not collected at one site) in the 2002 NC-140 trial.

| | Rootstock | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Adesoto 101 | Mr.S. 2/5 | Penta | Krymsk®2 | Krymsk®1 | Pumiselect® | Cadaman® | Lovell | Mean |
| ***Redhaven*** | | | | | | | | | |
| CA | 61.0 | 25.5 | 5.5 | 59.0 | 12.0 | 21.5 | 7.5 | 1.0 | 23.9 ab[z] |
| GA | 24.0 | 13.0 | 3.5 | 1.5 | 6.5 | 0.5 | 1.5 | 0.0 | 4.8 cd |
| MA | 2.0 | 2.5 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 d |
| MD | 33.0 | 13.0 | 5.0 | 6.0 | 15.0 | 0.0 | 1.0 | 1.0 | 9.2 cd |
| MO | 8.5 | 7.5 | 2.5 | 0.0 | 3.0 | 0.5 | 1.0 | 0.0 | 2.9 d |
| MX | 1.5 | 0.5 | 0.0 | 0.5 | 0.5 | 0.0 | 1.0 | 0.5 | 0.6 d |
| ON | 1.0 | 0.5 | 1.0 | 1.0 | 1.0 | 1.0 | 0.5 | 0.0 | 0.7 d |
| PA | 13.5 | 20.5 | 5.5 | 11.5 | 8.5 | 1.0 | 0.0 | 0.0 | 5.5 cd |
| SC | 47.5 | 24.0 | 23.5 | 33.0 | 22.5 | 3.5 | 0.5 | 0.0 | 21.0 b |
| ***Cresthaven*** | | | | | | | | | |
| CO | 6.0 | 7.0 | 5.0 | 47.5 | 18.0 | 2.5 | 5.5 | 0.5 | 11.5 c |
| MO | --- | 3.5 | 5.0 | 24.0 | 23.0 | 7.5 | 1.0 | 0.0 | 9.1 cd |
| NJ | 6.5 | 1.5 | 3.0 | 3.0 | 3.0 | 0.5 | 0.0 | 0.0 | 1.8 d |
| NY | 46.0 | 70.0 | 42.0 | 17.0 | 8.0 | 4.0 | 18.0 | 1.0 | 25.8 ab |
| TX | 20.0 | 3.0 | 4.0 | 7.0 | 1.0 | 1.0 | 0.0 | 0.0 | 4.5 cd |
| UT | 24.0 | 11.5 | 7.0 | 88.5 | 54.5 | 41.5 | 7.5 | 0.5 | 29.4 a |
| WA | 2.0 | 6.0 | 2.0 | 5.0 | 3.0 | 1.0 | 0.0 | 0.0 | 2.4 d |
| Mean | 18.5 a | 12.9 b | 7.2 cd | 18.9 a | 10.8 bc | 5.4 c-e | 2.8 de | 0.3 e | |

[z] Mean separation by Tukey's HSD ($P$=0.05).

those sites with many suckers on average. Cadaman® also had low suckering in general, although the New York site had an average of 18 suckers per tree. The other rootstocks all had at least two sites with more than 20 suckers per tree. Thus, it appears that all the experimental rootstocks had the potential for substantial suckering as long as conditions were conducive. However, even those stocks showing extensive suckering had some sites with almost no suckers. This suggests it might be possible to suppress the suckering potential by manipulating certain factors. Further research in this area could be very beneficial.

Tree size at the end of this trial, as estimated by trunk cross-sectional area (TCSA), was affected by both location and rootstock (Table 6). In general, trees growing under cooler conditions (higher latitudes and altitudes) were smaller than those under warmer conditions. The main exception to this was the site in Mexico where tree mortality was high and

**Table 6.** Trunk cross-sectional areas (cm²) in 2006 of eight peach rootstocks at 16 sites (data not collected at one site) in the 2002 NC-140 trial.

| Site | Adesoto 101 | Mr.S. 2/5 | Penta | Krymsk®2 | Krymsk®1 | Pumiselect® | Cadaman® | Lovell | Mean |
|---|---|---|---|---|---|---|---|---|---|
| ***Redhaven*** | | | | | | | | | |
| CA | 69.0 | 98.1 | 93.8 | 32.7 | 49.9 | 118.1 | 200.2 | 190.1 | 106.7 c[z] |
| GA | 127.3 | 135.2 | 115.3 | 114.3 | 77.4 | 114.2 | 198.7 | 223.1 | 137.1 a |
| MA | 63.8 | 74.8 | 74.5 | 29.8 | 45.5 | 50.3 | 107.2 | 101.2 | 68.6 de |
| MD | 156.0 | 121.4 | 144.3 | 50.1 | 38.6 | 121.7 | 185.6 | 186.2 | 126.3 a |
| MO | 136.9 | 111.4 | 121.2 | 28.5 | 55.8 | 96.0 | 147.8 | 160.0 | 107.5 bc |
| MX | 26.1 | 27.5 | 22.7 | 13.8 | 14.1 | 68.3 | 71.6 | 42.5 | 35.6 gh |
| ON | 46.2 | 45.3 | 53.2 | 31.2 | 34.1 | 30.7 | 70.1 | 52.4 | 45.1 f-h |
| PA | 90.8 | 74.3 | 87.9 | 31.0 | 51.5 | 81.2 | 105.8 | 95.5 | 77.5 d |
| SC | 124.8 | 75.8 | 137.0 | 35.0 | 75.3 | 127.8 | 219.9 | 212.0 | 126.0 ab |
| ***Cresthaven*** | | | | | | | | | |
| CO | 34.9 | 35.3 | 25.1 | 11.4 | 13.8 | 25.8 | 31.3 | 38.9 | 27.1 h |
| MO | --- | 59.5 | 31.1 | 15.9 | 26.0 | 44.7 | 76.4 | 89.9 | 50.8 e-g |
| NJ | 59.5 | 58.1 | 48.1 | 36.6 | 37.7 | 68.2 | 102.0 | 81.8 | 61.4 d-f |
| NY | 80.6 | 60.6 | 65.2 | 30.3 | 42.5 | 56.0 | 72.9 | 103.3 | 63.9 d-f |
| TX | 65.3 | 91.0 | 64.5 | 27.1 | 32.5 | 62.9 | 101.8 | 85.1 | 66.5 de |
| UT | 48.5 | 53.2 | 56.3 | 14.6 | 14.9 | 51.7 | 54.6 | 56.0 | 43.8 f-h |
| WA | 76.0 | 65.5 | 56.2 | 25.6 | 18.6 | 55.0 | 85.1 | 99.7 | 60.2 d-f |
| Mean | 78.7 b | 74.2 b | 74.9 b | 32.9 c | 39.4 c | 73.7 b | 114.5 a | 113.6 a | |

[z] Mean separation by Tukey's HSD (*P*=0.05).

those that did survive grew poorly. In almost every location, Lovell and Cadaman® were the largest trees and were quite similar in size. The cooperators considered these to be standard, full-sized peach trees. Adesoto 101, Mr.S.2/5, Penta and Pumiselect® all produced semi-dwarfing trees with TCSA about 65-70% of 'Lovell'. However, variability among sites was large (Table 6). For each of these four rootstocks, there was at least one site where tree vigor was almost identical to Lovell. At other sites, the trees were only 50 to 60% the size of those on Lovell. Thus, it may be hard to predict how dwarfing these rootstocks will be at any given location.

Krymsk®2 and Krymsk®1 were definitely dwarfing rootstocks at all sites. Their TCSA was about 30 to 35% of Lovell. Once again there was a lot of variability in TCSA among sites, ranging from 20 to 60% of Lovell. Most cooperators reported that the Krymsk®1 trees were healthy looking while the Krymsk®2 trees appeared weak and showed signs of incompatibility.

Accumulated yields between 2004 and 2006 varied from 18.5 to 81.1 kg/tree among rootstocks (Table 7). Generally, the differences in yield were proportional to tree size so dif-

**Table 7.** Accumulated yield (2004 to 2006), cumulative yield efficiency and average fruit weight of 'Redhaven' and 'Cresthaven' peach trees on eight rootstocks at 17 sites in the 2002 NC-140 trial.

| | Redhaven | | | Cresthaven | | |
|---|---|---|---|---|---|---|
| Rootstock | Yield 2004-06 (kg/tree) | Yield efficiency ($kg/cm^2$) | Fruit weight (g) | Yield 2004-06 (kg/tree) | Yield efficiency ($kg/cm^2$) | Fruit weight (g) |
| Adesoto 101 | 42.2 c[z] | 0.46 d | 160 ab | 41.4 b | 0.72 ab | 211 ab |
| Mr.S. 2/5 | 42.0 c | 0.50 b-d | 152 bc | 41.6 b | 0.73 ab | 206 ab |
| Penta | 46.0 c | 0.48 cd | 153 b | 30.5 b-d | 0.60 b | 200 a-c |
| Krymsk®2 | 19.6 d | 0.60 a-c | 140 d | 18.5 d | 0.81 ab | 179 c |
| Krymsk®1 | 30.2 d | 0.65 a | 160 ab | 21.5 cd | 0.87 a | 199 bc |
| Pumiselect® | 42.8 c | 0.46 d | 141 cd | 31.9 bc | 0.60 b | 180 c |
| Cadaman® | 81.1 a | 0.59 ab | 166 a | 60.1 a | 0.81 ab | 217 a |
| Lovell | 67.5 b | 0.52 b-d | 157 ab | 57.2 a | 0.78 ab | 211 ab |

[z] Mean separation within columns by Tukey's HSD (*P*=0.05).

ferences in yield efficiency were minor. Only 'Redhaven' on Krymsk®1 showed statistical separation from Lovell in yield efficiency. Some sites had very low yields in one or more of these three years due to poor weather conditions (usually frost) in the spring. However, the effect was uniform across all the rootstocks. The sites where yield potential was not limited by weather conditions had abundant flowering and good fruit set so that fruitlet hand thinning was always required on every tree. Therefore, it is concluded that these eight rootstocks all have about the same capacity to bear fruit, in proportion to canopy size. Krymsk®1 shows a tendency to have slightly higher cropping efficiency than the other rootstocks.

Fruit weight differed among rootstocks and between the two cultivars (Table 7). Fruit weight varied greatly among the different sites, especially with 'Cresthaven' (data not shown). Some site/year/rootstock combinations had average fruit weights greater than 300 g. In a companion study, extra 'Cresthaven'/Lovell trees were planted in six of these sites and fruit weight differences were shown to be correlated with weather conditions (3).

Two of the rootstocks, Krymsk®2 and Pumiselect®, significantly reduced fruit size relative to trees on Lovell, regardless of scion cultivar. In many of the sites this reduction in fruit weight was noticeable and considered to be a major drawback for these two selections. The other five experimental rootstocks all produced fruit similar in size to Lovell.

In summary, Cadaman® was similar to Lovell in all parameters measured in this trial. Pumiselect® and Krymsk®2 exhibited many problems with survival, compatibility, suckering and fruit size. They would not be recommended for peach plantings in North America. Krymsk®1 has potential as a dwarfing rootstock for peach and did not exhibit a problem with small fruit size like some other dwarfing rootstocks. Adesoto 101, Mr.S.2/5 and Penta all showed potential as semi-dwarfing rootstocks. However, these latter four stocks would all need to be evaluated carefully as tree survival and excessive suckering could be problems under certain unidentified conditions.

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## HARVEST PARAMETERS FOR 'REINETTE DU CANADA' APPLE

'Reinette du Canada' apple is severely affected by bitter pit during storage, but increasing demand for organic produce requires chemical post-harvest treatments to be replaced with other practices. The optimum stage of fruit maturity to improve the storability of high quality fruit and the incidence of bitter pit in this cultivar were both impacted by seasonal conditions. Harvest maturity also influenced apple quality during storage, with later harvest reducing the development of bitter pit and increasing the soluble solids:titratable acidity ratio. This ratio was a useful parameter for determining optimum harvest maturity. The results also suggested that skin hue angle ($h^o$) may provide a quick and useful index that could replace fruit firmness measurements. Paraphrased from M. Guerra and P. A. Casquero. 2010. J. Hort. Sci. and Biotech. 85: 544-550.