Journal of the American Pomological Society 66(1): 23-27 2012

The Performance of Four Vineland Apple Rootstocks in British Columbia, Canada

Cheryl R. Hampson[1]

Abstract

The horticultural performance of '8S6923' (Aurora Golden Gala™) apple on M.9 EMLA and V.1, V.2, V.3 and V.4 (Vineland) rootstocks was evaluated for 8 years in Summerland, B.C., Canada. The trees were planted in 2003 and trained as vertical axes on a post and wire trellis. Tree vigor fell into three groups based on trunk cross-sectional area, where V.4 > V.1, V.2 > V.3, M.9 EMLA. Trees on V.4 were also significantly taller and had wider canopies than trees on the other rootstocks. No tree mortality occurred. The cumulative number of root suckers on V.1, V.2 and V.3 was significantly lower than on V.4 or M.9 EMLA. Precocity (based on counts of flower clusters in the second leaf) was highest for M.9 EMLA, whilst trees on V.4 had no blossoms at all. The latter finding is noteworthy because the scion cultivar is normally extremely precocious. Cumulative yield was proportional to tree size. Cumulative yield efficiency was highest for V.3 and M.9 EMLA. In comparison to M.9 EMLA, V.3 was similar in most respects, and it produced fewer root suckers, but it did reduce scion fruit size by about 5%. V.1 and V.2 were both semi-dwarfing under the conditions of this trial, and they also reduced fruit size slightly relative to M.9 EMLA.

Since the early 1990s, commercial apple (*Malus* × *domestica* Borkh.) growers in British Columbia (B.C.), Canada, have adopted high density super spindle plantings of new cultivars on dwarf rootstocks. Although M.9 is excellent for this orchard system in most respects, a need remains for a consistent, dwarfing rootstock with greater resistance to fire blight (incited by *Erwinia amylovora* [Burr.] Winslow et al.) and better winter hardiness, combined with M.9's good resistance to *Phytophthora* spp. Fire blight is sporadic but can be severe in a given orchard, because many new cultivars are very susceptible to the disease, and a fire blight strike can quickly reach the trunk on a super spindle tree, causing tree mortality. Root grafting of high density trees on M.9 or M. 26 can spread infections along a row (personal observation).

Budagovsky 9 (B.9) is widely used in interior B. C., but has not been satisfactory in all situations. Wind storms at the research center have broken off supported trees at the graft union on occasion (personal observation). In previous trials at our location, B.9 was usually close to M.26 in vigor control (14), but in the current 2002 and 2003 NC-140 trials and on coarser soils at the research station, trees on B.9 tend to "runt out" after they start to bear and can be smaller than those on M.9. This decline in vigor detrimentally affects annual yield and fruit size.

The Vineland (V) rootstocks are open-pollinated seedlings of 'Kerr', a winter-hardy, fire blight-resistant apple crab from Agriculture Canada in Morden, Manitoba (10). M.9 is the probable pollen parent. The seven V rootstocks all had higher resistance to fire blight than M.26 when directly inoculated as liners, or as trees budded with 'Delicious' as the scion (9). As budded trees, all but V.4 were rated as intermediate to high in resistance in the same study. After two years of severe fire blight epidemics in Ohio, no trees were lost on V.4 or V.7 (11). V.1, V.2 and V.3 had some mortality, varying with the scion, but in general losses were below those for trees on M.9 or M.26. One exception was that tree loss on V.3 was significant with 'Lawspur Rome Beauty' as the scion (12).

Because of their parentage, the V rootstocks are also presumed to be more winter hardy

[1] Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, P.O. Box 5000, Summerland, B.C., Canada. E-mail: cheryl.hampson@agr.gc.ca

than Malling rootstocks, but no published field reports are available to substantiate this assumption. No winters severe enough to produce injury on any of the 16 rootstocks occurred in Missouri during a 10-year trial that included V.1 and V.3 (18). Historically, cold winters in B.C. have regularly damaged apple trees (8). Such incidents are fewer now, perhaps due to climate change or adoption of the practice of recharging the soil water by irrigation in autumn (19), but damage can still occur if Arctic low pressure weather systems flow into the valley in the absence of snow cover (17, 19).

The objective of this study was to test the horticultural performance of Vineland rootstocks relative to M.9 EMLA under the climatic and management conditions typical of interior B.C. Only four of the seven rootstocks (V.1, V.2, V.3 and V.4) were available to test at the time that the trial was established.

Materials and Methods

Virus-free, 10-to-12 mm rootstock liners of M.9 EMLA, V.1, V.2, V.3 and V.4 were obtained from Treco (Woodburn, OR). The dormant liners were fumigated with methyl bromide prior to importation. They were planted in a field nursery at the Pacific Agri-Food Research Centre, Summerland, B.C. (49°34” N, 119°39” W, 454 m elevation) in May, 2001, budded with ‘8S6923’ (13) scion wood in August of 2001, and grown for another year in the nursery.

In 2003, 6 trees on each rootstock were planted in the field abutting the 2003 NC-140 rootstock trial, using the same protocols for tree spacing, training, support, pruning, and data collection (15, 16). In brief, the trees were trained as vertical axes with a post and wire trellis and bamboo support stakes. Rows were oriented north-south and tree spacing was 4.5 m x 2.5 m. The trees were drip-irrigated (one emitter on each side of tree 0.5 m from trunk, each of capacity $4L{\cdot}hr^{-1}$) from May to October and managed according to regional recommendations for fertilization, watering and pest control (7). The soil was a sandy loam, and the site was fumigated with metam sodium in October 2002 according to label instructions. No pollenizers were included, but the trees were immediately adjacent to an apple germplasm collection on one side and to the ‘Golden Delicious’ trees of the 2003 NC-140 trial on two other sides. Fruit were thinned by hand for the first crop, and thereafter with dilute carbaryl (rate 104 $mL{\cdot}100\ L^{-1}$; product Sevin XLR 42.8% [Bayer Crop Science, Calgary, AB]) at the 10-15 mm fruit stage, followed by hand thinning shortly after June drop to achieve single-fruit clusters approximately 15 cm apart.

Trunk diameter at 30 cm above the bud union was measured annually after harvest (average of 2 measurements, across-row and in-row orientations) and converted to trunk cross-sectional area (TCA) for analysis. In 2004 and 2005, the number of flower clusters on each tree was recorded. The trees were de-blossomed after the counts in 2004 to encourage vegetative growth. From 2005 to 2010, the yield, average fruit weight, tree mortality, and number of root suckers were recorded annually. Suckers were removed each year after counting. The apples of each tree were counted during harvest and the total yield was divided by fruit number to obtain average fruit weight. In October 2010, tree height and maximum canopy spread (average of two measurements, in-row and across-row orientation) were measured. Cumulative yield efficiency was calculated as the sum of annual yields divided by final TCA. For average fruit weight, cumulative yield was divided by cumulative number of fruit.

The experimental design was a randomized complete block with single tree replicates per block. Data were analyzed with the SAS procedure MIXED, with rootstocks as a fixed effect and block as a random effect (SAS Institute, Cary NC). Tukey’s HSD test was used for mean separation.

Results and Discussion

Tree growth and survival. Mortality was zero for all trees in this trial. A number of trees (various different scions and rootstocks, including trees on M.9 and M.26) were lost to fire blight on three sides of this trial in adjacent plantings. A few small strikes of fire blight occurred on the trees in the present trial but they were pruned out and did not cause any serious or lasting damage. There were no severe winters during the 8 years of this trial. The extreme minimum winter temperature during the trial was -21.6°C on December 20, 2008 (http://www.climate.weatheroffice.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=BC&StationID=979&dlyRange=1990-06-01|2011-12-04&Year=2008&Month=12&Day=01 accessed December 6, 2011). Therefore the field resistance of the V rootstocks to fire blight or winter cold cannot be ascertained from this planting. Survival of these four V rootstocks has been good in other trials. In the 1994 multi-site NC-140 trial with 'Gala' as the scion, trees on V.1 had very good survival at 18 of 19 sites and V.2 at all 24 sites (15, 16). V.3 was only tested at 9 sites and data were not analyzable statistically, but in most cases tree survival was better than that on M.9 EMLA. In Missouri, windstorms caused some losses of trees on V.3 (18).

After 8 years, trees on V.4 were by far the largest (Table 1). The final TCA of trees on V.4 was about 350% that of those on M.9 EMLA, which is too vigorous for a high density planting. Trees on V.4 also had greater height and canopy spread than any of the other trees in the trial. V.3 resembled M.9 EMLA in vigor control, as judged by TCA, tree height and canopy spread. The other two rootstocks were intermediate in TCA and spread, but similar in height, doubtlessly due to pruning after the trees reached the top of the trellis.

Based on TCA, the trees on V.1 and V.2 here were similar in size to those of 'Golden Delicious' on M.26 EMLA in the adjacent 2003 NC-140 crop load trial (i.e. semi-dwarfing). 'Gala' on V.2 was also similar in TCA to M.26 EMLA in the 1994 NC-140 trial at the B.C. location, but 'Gala' on V.1 was 150% of M.26 EMLA. This suggests that tree size on V.1 may be more inconsistent than that on V.2. Published studies give some support to this conclusion. Tree size on V.2 was similar to that on M.26 EMLA in Ohio (12), Massachusetts (3) and 14 of 18 locations in Marini et al. (16). In contrast, trees on V.1 were reportedly similar in size to those on M.9 EMLA (12), substantially larger than those on M.9 (2, 18), or similar in size to M.26 EMLA (1, 2). At 20 locations analyzed by Marini et al. (15) trees on V.1 were similar in size to those on M.26 EMLA at 13 locations, bigger at 5 locations and smaller at 2 locations.

V.3 has not been tested very widely. It is variously reported as substantially more dwarfing than M.9 EMLA (1, 4, 5, 15) or similar to M.9 (2, 12, 18).

V.1, V.2 and V.3 produced fewer root suckers on average than M.9 EMLA (Table 1). V.4 and M.9 had similar cumulative sucker counts on

Table 1. Tree size and root sucker production for Aurora Golden Gala™ on five rootstocks after eight growing sasons in British Columbia, Canada.[z]

Rootstocks	TCA[y] (cm^2)	Tree height (cm)	Canopy spread (cm)	Cumulative no. of root suckers	Range in cumulative no. of suckers
M.9 EMLA	26.2 c	319 b	194 c	28 a	1 to 46
V.1	43.5 b	319 b	230 b	9 b	0 to 23
V.2	45.0 b	329 b	221 b	12 b	0 to 23
V.3	27.7 c	326 b	208 bc	5 b	0 to 11
V.4	93.4 a	372 a	287 a	39 a	22 to 55

[z] Mean separation within columns by Tukey's HSD (P = 0.05)
[y] TCA, trunk cross-sectional area

average, but all replicate trees of V.4 produced at least 22 suckers, unlike some of the trees on M.9 (Table 1). V.3 has had few or no suckers in other trials (6, 12, 15). V.4 had many suckers in Ohio and Washington (6, 12) and V.1 and V.2 have been variable (15, 16).

Flowering and fruiting. In 2004, floral density on M.9 EMLA exceeded that of all the other rootstocks, and trees on V.4 produced no flowers at all (Table 2). However, because trees were not allowed to crop in their second leaf, this finding may not have practical relevance. In 2005, only V.4 continued to show low precocity. This finding is especially noteworthy because the scion cultivar used in this trial is normally extremely precocious, to the extent of setting fruit in the nursery if allowed to do so. V.4 also showed poor precocity in Washington (6).

Patterns for cumulative yield mirrored those of tree size, with trees on V.4 yielding significantly more than all others (Table 2). Although trees on V.4 had more than triple the TCA of trees on M.9, they yielded only 34% more on average, and their cumulative yield efficiency (CYE) was therefore low. Likely the low CYE of V.4 is due in part to its lack of precocity. V.3 and M.9 EMLA had the highest CYE. The performance of V.3 was similar to M.9 NAKB T337 in 9 of 10 sites in another trial (15) and also similar to M.9 in Missouri (18). The CYE for trees on V.1 and V.2 was intermediate, and very close to that for 'Golden Delicious'/M.26 EMLA in the adjacent NC-140 trial (3.09 kg·cm^{-2}). Productivity, fruit size, and yield efficiency of 'Gala' on V.2 did not differ significantly from those on M.26 EMLA in the 1994 NC-140 planting in B.C. (16).

Trees on the four V rootstocks had similar fruit size (Table 2), and all of them induced a small but statistically significant (5 to 10%) reduction in fruit size relative to M.9 EMLA. Nevertheless fruit size was commercially acceptable for all trees. Autio et al. (3) found V.3 to reduce fruit size with 'McIntosh', but not with some other scions (1, 2). Fruit size reduction may be a drawback for economic reasons, particularly for scions with a tendency for smaller fruit size, such as 'Gala'.

Conclusions

V.4 is not suitable for high density plantings because it produces trees that are too vigorous, produce many suckers, are low in precocity, and have slightly smaller fruit size than trees on M.9. In Ohio trials, tree size on V.4 was comparable to that on M.7 (12). Autio et al. (3) removed the trees on V.4 from their trial due to its excessive vigor.

Trees on V.3 performed as well as those on M.9 in most respects, and had fewer root suckers. V.3 can be recommended for commercial testing in B.C., but with the warning that it may slightly reduce fruit size. Although V.2 is more vigorous than M.9 EMLA, it performed as well as M.26 EMLA in an adjacent trial (Hampson, unpublished data from 2003 NC-140 trial) and in previous trials (16), so it may be of interest where a larger tree

Table 2. Number of blossom clusters, yield, yield efficiency and fruit size for Aurora Golden Gala™ on five rootstocks after eight growing seasons in British Columbia, Canada[z].

Rootstock	Floral density[y] 2004 (no.·cm^{-2} TCA)	Floral density 2005 (no.·cm^{-2} TCA)	Cumulative yield (kg·tree^{-1})	Cumulative yield efficiency (kg·cm^{-2} TCA)	Average fruit weight[x] (g)
M.9 EMLA	6.8 a	25.5 b	129 bc	5.0 a	225 a
V.1	2.0 b	27.9 ab	133 bc	3.2 b	202 b
V.2	0.3 b	27.2 ab	143 b	3.2 b	204 b
V.3	1.3 b	31.2 a	124 c	4.5 a	213 b
V.4	0.0 b	4.2 c	173 a	1.9 c	203 b

[z] Mean separation within columns by Tukey's HSD (P = 0.05)
[y] Floral density in number of blossom clusters per unit TCA, where TCA= trunk cross-sectional area
[x] Average over 6 cropping years

is needed. V.1 appears to be more inconsistent than V.2 in tree size from one trial to another. It may be more subject to genotype-environment interaction, or more affected by scion cultivar.

Acknowledgements

I thank Rob Brownlee for data collection in this trial, and Dr. John Cline for his help in obtaining liners of the Vineland rootstocks. I also thank the Field Services Unit for plot management, pruning, and help with data collection during harvest.

Literature Cited

1. Autio, W.R. and J. Krupa. 2001. Rootstock effects on Ginger Gold apple trees. Fruit Notes 66:50-51. Online at www.umass.edu/fruitadvisor/fruitnotes/rootstockeffectson.pdf <<Accessed 18 June 2011>>
2. Autio, W.R., J. Krupa and J.M. Clements. 2005. 1995 Massachusetts-Maine-Nova Scotia scion/rootstock trial: several rootstocks evaluated with McIntosh, Pioneer Mac, Cortland, and Macoun as scions. Fruit Notes 70:1-5. Online at Online at www.umass.edu/fruitadvisor/fruitnotes/v70n1/fn701-a1.pdf <<Accessed 18 June 2011>>
3. Autio, W.R., J. Krupa and J.M. Clements. 2006. A comparison of Vineland apple rootstocks and M.26 EMLA in the 1996 McIntosh rootstock trial. Fruit Notes 71:5-6. Online at www.umass.edu/fruitadvisor/fruitnotes/v71n1/a2.pdf <<Accessed 18 June 2011>>
4. Barritt, B.H. 1995. New dwarfing rootstocks compared with standards. Good Fruit Grower 46(1):19e-21e, 23, 24.
5. Barritt, B., M.A. Dilley and B.S. Konishi. 1994. Apple rootstocks for high-density orchards. Good Fruit Grower 45(3):20-25.
6. Barritt, B.H., B.S. Konishi and M.A. Dilley. 1995. Performance of three apple cultivars with 23 dwarfing rootstocks during 8 seasons in Washington. Fruit Var. J. 49:158-170.
7. British Columbia Ministry of Agriculture and Lands (BCMAL). 2008. Integrated fruit production guide for commercial tree fruit growers: interior of British Columbia. BCMAL, Victoria, B.C. [publication updated annually]
8. Caprio, J.M. and H.A. Quamme. 1999. Weather conditions associated with apple production in the Okanagan Valley of British Columbia. Can. J. Plant Sci. 79:129-137.
9. Cline, J.A., D.M. Hunter, W.G. Bonn and M. Byl. 2001. Resistance of the Vineland series of apple rootstocks to fire blight caused by *Erwinia amylovora*. J. Amer. Pomol. Soc. 55:218-221.
10. Elfving, D.C., I. Schecter and A. Hutchinson. 1993. The history of the Vineland (V.) apple rootstocks. Fruit Var. J. 47:52-58.
11. Ferree, D.C. 1994. Performance after 8 years of 20 dwarfing rootstocks on 3 cultivars. Compact Fruit Tree 27:32-36.
12. Ferree, D.C., P.M. Hirst, J.C. Schmid and P.E. Dotson. 1995. Performance of three apple cultivars with 22 dwarfing rootstocks during 8 seasons in Ohio. Fruit Var. J. 49:171-178.
13. Hampson, C.R., R.A. MacDonald, H.A. Quamme, D.-L. McKenzie and W.D. Lane. 2005. ‘8S6923’ (Aurora Golden Gala™) apple. HortScience 40:251-253.
14. Hampson, C.R., H.A. Quamme and R.T. Brownlee. 1997. Performance of dwarfing rootstocks in five trials in British Columbia, Canada. Fruit Var. J. 51:183-191.
15. Marini, R.P., J.L. Anderson, W.R. Autio, B.H. Barritt, J. Cline, W.P. Cowgill, Jr., R.M. Crassweller, R.M. Garner, A. Gauss, R. Godin, G.M. Greene, C. Hampson, P. Hirst, M.M. Kushad, J. Masabni, E. Mielke, R. Moran, C.A. Mullins, M. Parker, R.L. Perry, J.P. Privé, G.L. Reighard, T. Robinson, C.R. Rom, T. Roper, J.R. Schupp, E. Stover and R. Unrath. 2006. Performance of ‘Gala’ apple trees on 18 dwarfing rootstocks: ten-year summary of the 1994 NC-140 rootstock trial. J. Amer. Pomol. Soc. 60:69-83.
16. Marini, R.P., B.H. Barritt, G.R. Brown, J. Cline, W.P. Cowgill, Jr., R.M. Crassweller, P.A. Domoto, D.C. Ferree, J. Garner, G.M. Greene, C. Hampson, P. Hirst, M.M. Kushad, J. Masabni, E. Mielke, R. Moran, C.A. Mullins, M. Parker, R.L. Perry, J.P. Privé, G.L. Reighard, T. Robinson, C.R. Rom, T. Roper, J.R. Schupp, E. Stover and R. Unrath. 2006. Performance of ‘Gala’ apple on four semi-dwarf rootstocks: a ten-year summary of the 1994 NC-140 semi-dwarf rootstock trial. J. Amer. Pomol. Soc. 60:58-68.
17. Quamme, H.A. 1987. Low-temperature stress in Canadian horticultural production – an overview. Can. J. Plant Sci. 67:1135-1149.
18. Warmund, M.R. 2004. Vegetative growth and fruiting of ‘Red Fuji’ apple on M.9 clones and other dwarfing rootstocks. J. Amer. Pomol. Soc. 58:152-156.
19. Waterman, P. 2006. Preparation for winter. British Columbia Fruit Grower 4(3):20-21.