

Performance of Geneva® Rootstocks in On-Farm Trials in New York State

T.L. Robinson and S.A. Hoying
Department of Horticultural Sciences
New York State Agric. Exp. Station
Cornell University
630 W. North Street
Geneva, NY 14456
USA

G. Fazio
USDA-ARS, Plant Genetics Resources Unit
630 W. North Street
Geneva, NY 14456
USA

Keywords: *Malus* × *domestica*, yield efficiency, dwarfing, fire blight, fruit size, root suckers

Abstract

Two replicated rootstock trials on growers farms in New York State were begun in 2004 to evaluate the Cornell-Geneva series of apple rootstocks which have been bred for tolerance to fire blight and *Phytophthora* root rot, high yield efficiency and good tree survival. In the 2001 trial with ‘Golden Delicious’ as the scion, the two named Geneva® rootstocks, G.41 and G.11 were dwarfing, had good survival and had high yield efficiency. Other promising un-named dwarf selections include CG.4214, 6006, 5005, 5087 and 5012. Two semi-dwarfing selections similar in size to M.7 showed good survival and high yield efficiency, CG.6969 and 5890. In the 2004 trial with ‘Honeycrisp’ as the scion, the named Geneva® rootstocks, particularly G.11 and G.935 continued to perform very well but we have also identified a group of 4 new dwarfing rootstocks CG.4021, 4210, 5757 and 4214 similar in size as M.9 or B.9 which have high productivity and fire blight resistance. We also identified a group of 6 semi-dwarfing rootstocks, CG.4001, 6969, 5757, 5046, 4004 and 5012 between the size of M.9 and M.7 which have high productivity and fire blight resistance. These rootstocks are free-standing but will need trunk and limb support for the high crops which they produce in the early years. These may be useful in parts of the world where fully dwarfing rootstocks are not adapted. We also identified a group of 4 vigorous rootstocks, CG.6001, 7707, 5890 and 6874, larger than MM.106 which have high productivity and fire blight resistance. These may be useful in the garden center trade.

INTRODUCTION

For many apple growers in North America, New Zealand and Europe, the bacterial disease fire blight is a serious threat to dwarf apple orchards. M.9 and M.26, the most common dwarfing apple rootstocks, are very susceptible to this disease and in some locations this disease limits the planting of dwarfing rootstocks (Norelli et al., 2003; Russo et al., 2007). Outbreaks of the disease in the eastern USA have decimated many dwarf apple orchards. There is a great need for new, highly productive apple rootstocks that are resistant to fire blight and are adapted to the climatic stresses common in apple production.

A number of new apple rootstocks which are fire blight resistant (*Erwinia amylovora*) are rapidly becoming available. The Cornell University apple rootstock breeding project, located at Geneva NY, has developed rootstock genotypes which are resistant to fire blight and crown rot (*Phytophthora* spp.) (Cummins and Aldwinckle, 1983) and some are resistant to apple replant disease (Isutsa and Merwin, 2000). Some elite rootstock genotypes from this program have been tested in second and third level trials within NY state (Robinson and Hoying, 2004) and national trials in the US and Canada, (Robinson et al., 2003, 2004, 2007), France (Masseron and Simard, 2002) and New Zealand (personal communication from Stuart Tustin). In this paper, we report on field performance results from 3 trials in New York State of numerous elite Geneva®

rootstocks.

MATERIALS AND METHODS

In 2001, a replicated field trial of 12 Geneva[®] named and un-named elite rootstocks and 2 Malling rootstocks (M.26 and M.7) as controls was planted at Wolcott, NY (Western part of state) using 'Golden Delicious' as the scion cultivar. The plot was laid out as randomized complete block experiment with 5 replications and with each block containing from 1-6 individual trees of each rootstock. All of the plant material was grown in a common nursery in Geneva, NY. The trees were planted as unbranched whips at a spacing of (2.4×4.8 m) and were headed at 1 m. Trees were managed with the vertical axis system and fertilized annually with nitrogen and potassium according to local recommendations. Trees were supported with a single wire trellis and a metal tube tree stake.

In 2004, a second replicated field trial of 47 Geneva[®] named and un-named elite rootstocks and 3 Malling rootstocks (M.9, M.7 and MM.106) and 1 Budagovsky stock (B.9) as controls was planted at Hilton, NY (Western part of state) using 'Honeycrisp' as the scion cultivar. The plot was laid out as randomized complete block experiment with 5 replications and with each block containing 2 individual trees of each rootstock. All of the plant material was grown in a common nursery in Geneva, NY. The trees were planted as unbranched whips at a spacing of (2.4×4.8 m) and were headed at 1m. Trees were managed with the vertical axis system and fertilized annually with nitrogen and potassium according to local recommendations. Trees were supported with a single wire trellis and a metal tube tree stake.

With both trials, tree survival, number of root sucker and trunk circumference at 30 cm above the graft union were measured annually in November. Fruit number and yield were recorded annually and harvest and fruit size was calculated as the ratio of fruit yield/tree (g) divided by the number of fruit per tree. Data were analyzed by ANOVA using SAS statistical analysis software (SAS Institute, Cary, NC, USA). Significant differences among means were determined by LSD P=0.05.

RESULTS

'Golden Delicious' Trial

After 7 years, all of the rootstocks had high tree survival except CG. 6874 which had 78% survival (Table 1). The trees fell into three vigor classes, dwarf, semi-dwarf and semi-vigorous. In the dwarf group, the smallest trees were on G.11 followed by CG5029, M.26, G.41, CG.4214, CG.6006, CG.5005, CG.5087, CG.5012 and CG.6874. In the semi-dwarf group, the smallest trees were on M.7 followed by CG.6969 and CG.5890. Only one stock, CG.6589 was in the semi-vigorous group and it was much larger than any other stock in the trial. Among the dwarf stocks, CG.6874 had the highest yield followed by CG.5012, CG.5005 and G.41. Among the semi-dwarf stocks, CG.5890 had the highest yield followed by CG.6969 while M.7 had only about 55% of the yield of the other two semi-dwarfing stocks. Among the dwarf stocks, G.41 had the highest yield efficiency followed by CG.5005, CG.5012, CG.5087, CG.6874, G.11 and CG.6006. This group was not statistically different in yield efficiency. Among semi-dwarfing stocks, CG.6969 and CG.5890 were much more yield efficient than M.7 and had similar yield efficiency to the dwarf rootstock group. CG.6589 which was the largest rootstock in the trial had lower yield efficiency than M.7.

Fruit size was largest with M.7 followed by CG.5890, CG.6874, CG.6589 and CG.6969 which were all the more vigorous stocks in the trial (Table 1). Among the dwarf stocks, CG.5005, G.41 and M.26 had the largest size while CG.4214, CG.5087 and CG.6006 had significantly smaller size. Root suckers were highest with M.7 while all of the other stocks had few root suckers (Table 1).

‘Honeycrisp’ Trial

After 6 years, all of the rootstocks had high (>80%) tree survival but CG. 2034, 4088, 4019, 4003, 4288, 5046 and G.16 and G.935 had from 83 to 90% survival (Table 2). Tree vigor ranged from super dwarfing (<10 cm² TCA) to vigorous (>40 cm² TCA) with a continuum between the extremes. Trees smaller than B.9 were CG.4291, 4088, 4021, 4210, 4202, 2034, 4019, 2406, G.11 and 2022. Trees similar to B.9 and M.9 were CG.4003, 2006, 4288, 4292, 5757 and 4214. The trees which were intermediate in size between M.9 and M.7 were CG.6143, 5030, 6969, 4001, 5046, G.16, 6874, 4011, G.935, G.202, 5012, 4814 and G.30. About half of the rootstocks were larger than M.7.

As expected, cumulative yield generally reflected tree size; however, yield efficiency which normalizes yield with tree size (TCA) was generally inversely related to tree size (Table 2). Among those rootstocks smaller than B.9 which had higher yield efficiency than M.9 were CG.4021, 4210 and G.11. Among the group of stocks similar in size to M.9 which had high yield efficiency were CG.5757 and 4214. Among those slightly larger than M.9 and smaller than M.7 which had high yield efficiency were CG.4001, G.935, 6969, 5757 and 5046. Among those similar in size to M.7 which had high yield efficiency were CG.4004, 5012 and G.30. Among those which were larger than MM.106 which had high yield efficiency were CG.6001, 7707, 5890 and 6874.

Fruit size was largest with CG.6001, 7037 and M.9. Fruit size of most stocks did not differ significantly from M.9. Stocks with significantly smaller fruit size than M.9 were CG.2034, 4019, 2406, 4003, 4288 and 6874 (Table 2). Root suckers were low on all of the rootstocks (Table 2). Root suckers were highest with CG.5030 followed by 5046, 6001, M.7 and 4214. All of the other stocks had few root suckers and were not significantly different than zero (Table 2).

DISCUSSION

In the 2001 trial with ‘Golden Delicious’ as the scion, the two named Geneva[®] rootstocks, G.41 and G.11 were dwarfing, had good survival and had high yield efficiency. In the trial with ‘Honeycrisp’ which did not include G.41, G.11 also was a superior rootstock. These data confirm our earlier trials with other scion cultivars which showed that these stocks are similar in dwarfing as M.9, highly yield efficient and are fire blight resistant (Autio et al., 2007; Robinson et al., 2003, 2004, 2005; Robinson and Hoying, 2004). They offer substantial benefits to US apple growers compared to M.9 and are being commercialized rapidly.

Through this project we have identified several new fire blight resistant and dwarfing rootstocks which may have potential. They include CG.4214, 6006, 5005, 5087 and 5012 from the ‘Golden Delicious’ trial and CG.4021, 4210, 5757 and 4214 from the ‘Honeycrisp’ trial. From this group, CG.4214 will likely be released in the near future. It has excellent stoolbed propagation characteristics which may make it easier to introduce quickly.

Among CG stocks similar in size to M.26 rootstock, both of the named Geneva[®] rootstocks G.935 and G.202 have performed better than ‘M.26’ and are being commercialized rapidly. This confirms our earlier work which showed these two stocks to have similar efficiency as M.9 but are similar in vigor to M.26 (Autio et al., 2007; Robinson et al., 2003, 2004, 2005; Robinson and Hoying, 2004). G.202 is resistant to woolly apple aphids while G.935 is not. Through this project we have identified several new semi-dwarfing stocks which may have potential. They include: CG.6969 from the ‘Golden Delicious’ trial and CG.4001, 6969, 5757, 5046, 4004 and 5012 from the ‘Honeycrisp’ trial. From this group, CG.5757, 5087 and 6969 may be released in the near future. These may be excellent stocks for weak growing cultivars like Honeycrisp and MN1914 in northern climates. CG.5087 performs well in northern climates and on sandy soils. CG.6969 may also be useful in medium density orchards grown for a processing market.

We also identified a group of 6 semi-vigorous selections similar in size as M.7 which are free standing, have high productivity and are fire blight resistance. Although

these rootstocks are free-standing, their high precocity will require trunk and limb support for the high crops which they produce in the early years. These may be useful in parts of the world where fully dwarfing rootstocks are not adapted. They include CG.6001, 7707, 5890 and 6874. Of these, CG.5890 may be released in the near future and it may be useful in the garden center trade.

The Geneva stocks which are currently being commercialized in the world are:

- 1) Geneva[®] 11 which is a dwarfing like M.9, fire blight resistant, has good resistance to *Phytophthora* root rot, but it is not resistant to woolly apple aphids or apple replant disease, is being commercialized in North America and Europe. G.11 has good layerbed and nursery characteristics. It is an excellent replacement for M.9. Substantial new stoolbeds have been planted in the USA which should increase production to 300,000 liners in 2011 and 800,000 liners in 2012.
- 2) Geneva[®] 41 is dwarfing like the vigorous clones of M.9, is highly resistant to fire blight, resistant to *Phytophthora*, woolly apple aphids, resistant to cold damage, resistant to apple replant disease and is being commercialized in the USA. In the stoolbed, 'G.41' is a shy rooter and will require specialized rooting techniques or tissue cultured stoolbed mother plants to improve its rooting. It has brittle roots and a brittle graft union similar in strength to M.9. It appears that G.41 will be a good alternative to M.9 in high fire blight prone areas and in woolly aphid prone areas. Substantial new stoolbeds have been planted which should increase production to 100,000 liners in 2011 and 300,000 liners in 2012.
- 3) Geneva[®] 935 is semi-dwarfing like M.26, highly efficient like 'M.9', has wide crotch angles, is highly resistant to fire blight and *Phytophthora*, has tolerance to apple replant disease, resistant to cold damage, but its not resistant to woolly apple aphid. It is being commercialized in the USA. Substantial new stoolbeds have been planted which should increase production to 100,000 liners in 2011 and 300,000 liners in 2012.
- 4) Geneva[®] 202 produces a tree slightly larger than 'M.26', has a high level of resistance to fire blight, good resistance to *Phytophthora*, apple replant disease and to woolly apple aphid and has higher yield efficiency than 'M.26'. It is being commercialized in the USA, Mexico, New Zealand, Chile, Argentina and South Africa. It's production in New Zealand is 300,000 plants, but in all other countries is limited.
- 5) Geneva[®] 30 is similar in vigor to M.7, but much more efficient. It is commercialized only in North America where it continues to have a niche market of 100,000 plants per year. It is most useful in northern growing areas where it shows wide soil adaptation, good winter hardiness and high yields.
- 6) Geneva[®] 16 is a dwarfing stock similar to the vigorous clones of M.9 which has high yield efficiency, is essentially immune to fire blight, highly resistant to *Phytophthora*, but it is not resistant to woolly apple aphids. It is sensitive to one or more latent viruses in scion wood which results in the death of the trees in the nursery or the first year in the orchard if infected scion wood is used. If virus free wood is used, it appears that G.16 is a good alternative to M.9 in high fire blight areas. G.16 also has exhibited very good mid-winter hardiness having survived the 2004 winter freeze event in Northern NY that killed many 'M.9', 'B.9' and 'M.26' trees. However, 'G.16' does appear to have some susceptibility to very early winter freeze events in the nursery (Roger Adams, pers. commun.). This is likely due to its vigorous growth characteristics in the nursery and in the orchard during the first few years where it grows late. It is being commercialized only in the USA where 100,000 plants are produced.

CONCLUSIONS

Our trials have confirmed the value of the top Geneva[®] rootstocks. Both Geneva[®] 41 and Geneva[®] 11 are fire blight resistant, have high yield efficiency and are good alternatives to M.9. They are being commercialized in several countries. Both Geneva[®] 935 and Geneva[®] 202 are fire blight resistant, have high yield efficiency but are slightly more vigorous. These will be useful in countries which have not adopted M.9 style

orchards or with weak growing scion cultivars like ‘Honeycrisp’. We have also identified several new Geneva® rootstock genotypes in the dwarf, semi-dwarf and the semi-vigorous rootstock categories which show promise for future releases.

Literature Cited

- Autio, W., Anderson, L., Barritt, B., Cline, J., Crassweller, R., Embree, C., Ferree, D., Garcia, E., Greene, G., Hoover, E., Johnson, S., Kosola, K., Masabni, J., Parker, M., Perry, R., Reighard, G. and Robinson, T. 2007. Early performance of ‘Fuji’ and ‘McIntosh’ apple trees on several dwarf rootstocks in the 1999 NC-140 rootstock trial. *Acta Hort.* 732:119-126.
- Cummins, J.N. and Aldwinckle, H.S. 1983. Breeding apple rootstocks. p.294-394. In: J. Janick (ed.), *Plant Breeding Reviews*. Westport CT, USA, AVI Publishing.
- Isutsa, D.K. and Merwin, I.A. 2000. *Malus* germplasm varies in resistance or tolerance to apple replant disease in a mixture of New York orchard soils. *HortScience* 35:262-268.
- Masseron, A. and Simard, M.H. 2002. Les porte-greffe du pommier: 20 années d'études en France. 2^e partie. Infos-Ctifl no. 175.
- Norelli, J.L., Holleran, H.T., Johnson, W.C., Robinson, T.L. and Aldwinckle, H.S. 2003. Resistance of Geneva and other apple rootstocks to *Erwinia amylovora*. *Plant Disease*. 8(1):26-32.
- Robinson, T., Anderson, L., Azarenko, A., Barritt, B., Baugher, T., Brown, G., Couvillon, G., Cowgill, W., Crassweller, R., Domoto, P., Embree, C., Fennell, A., Garcia, E., Gaus, A., Granger, R., Greene, G., Hirst, P., Hoover, E., Johnson, S., Kushad, M., Moran, R., Mullins, C., Myers, S., Perry, R., Rom, C., Schupp, J., Taylor, K., Warmund, M., Warner, J. and Wolfe, D. 2003. Performance of Cornell-Geneva apple rootstocks with ‘Liberty’ as the scion in NC-140 trials across North America. *Acta Hort.* 622:521-530.
- Robinson, T.L. and Hoying, S.A. 2004. Performance of elite Cornell Geneva apple rootstocks in long-term orchard trials on growers farms. *Acta Hort.* 658:221-229.
- Robinson, T., Anderson, L., Azarenko, A., Barritt, B., Brown, G., Cline, J., Crassweller, R., Domoto, P., Embree, C., Fennell, A., Ferree, D., Garcia, E., Gaus, A., Greene, G., Hampson, C., Hirst, P., Hoover, E., Johnson, S., Kushad, M., Marini, R., Moran, R., Mullins, C., Parker, M., Reighard, G., Perry, R., Privé, J.P., Rom, C., Roper, T., Schupp, J., Warmund, M., Autio, W., Cowgill, W., Taylor, K. and Wolfe, D. 2004. Performance of Cornell-Geneva rootstocks in multi location NC-140 rootstock trials across North America. *Acta Hort.* 658:241-245.
- Robinson, T., Anderson, L., Autio, W., Barritt, B., Cline, J., Crassweller, R., Cowgill, W., Embree, C., Ferree, D., Garcia, E., Greene, G., Hampson, C., Kosola, K., Parker, M., Perry, R., Roper T. and Warmund, M. 2007. A multi-location comparison of Geneva 16, Geneva 41 and M.9 apple rootstocks across North America. *Acta Hort.* 732:59-66.
- Russo, N., Robinson, T.L., Aldwinckle, H.S. and Fazio, G. 2007. Horticultural performance and fire blight resistance of Cornell-Geneva apple rootstocks and other rootstocks from around the world. *HortScience* 42:1517-1525.

Tables

Table 1. Performance of 10 Geneva[®] apple rootstocks with ‘Golden Delicious’ apple as the scion cultivar over 7 years at Wolcott, NY, USA.

Rootstock ^z	Tree survival (%)	Trunk X-sectional area (cm ²)	Cumulative yield (kg/tree)	Cumulative yield efficiency (kg/cm ² TCA)	Average fruit size (g)	Cumulative root suckers
G.11	100 a ^y	34.3 e	141.9 c	4.16 ab	142 defg	0.1 b
CG.5029	100 a	38.7 de	135.5 d	3.53 bc	147 cdef	2.4 b
M.26	100 a	41.7 cde	124.8 d	3.06 cd	151 abcd	0.3 b
G.41	92 ab	42.2 cde	190.6 b	4.55 a	154 abc	0.7 b
CG.4214	100 a	43.5 cde	148.6 cd	3.57 bc	135 g	2.0 b
CG.6006	92 ab	43.6 cde	175.8 bc	4.06 ab	138 efg	0.0 b
CG.5005	87 ab	44.7 cde	195.4 b	4.42 a	156 abc	0.9 b
CG.5087	100 a	44.8 cde	175.9 bc	4.16 ab	137 fg	0.2 b
CG.5012	100 a	46.7 cd	199.0 b	4.29 ab	149 bcde	0.0 b
CG.6874	78 b	47.5 cd	200.0 b	4.26 ab	160 ab	1.7 b
M.7	100 a	52.0 c	122.5 d	2.56 d	161 a	9.5 a
CG.6969	100 a	53.3 c	207.7 b	3.93 ab	153 abcd	0.2 b
CG.5890	100 a	65.4 b	252.7 a	3.86 abc	160 ab	0.5 b
CG.6589	93 ab	116.4 a	194.0 b	1.67 e	157 abc	0.5 b
LSD	20	11.8	38.2	0.82	12	3.4
P≤0.05						

^zRootstocks ranked by increasing trunk x-sectional area.

^yMean separation by LSD p≤0.05.

Table 2. Performance of 47 Geneva apple rootstocks with ‘Honeycrisp’ apple as the scion cultivar over 6 years at Hilton, NY, USA.

Rootstock ^z	Tree survival (%)	Trunk cross-sectional area (cm ²)	Cumulative yield (kg/tree)	Cumulative yield efficiency (kg/cm ² TCA)	Average fruit size (g)	Cumulative root suckers
CG.4291	100 a ^y	5.5 x	4.7 v	1.1 d-l	260 a-c	1.0 c
CG.4088	83 b	8.1 wx	8.7 s-v	0.8 h-n	238 a-f	0.6 c
CG.4021	100 a	9.3 v-x	20.3 k-v	2.2 a	246 a-e	0.2 c
CG.4210	100 a	10.7 u-w	20.9 j-u	2.2 ab	268 ab	0.8 c
CG.4202	100 a	11.9 t-w	12.6 r-v	1.3 b-i	247 a-e	0.0 c
CG.2034	83 b	12.6 s-w	12.1 r-v	0.9 g-n	214 ef	0.0 c
CG.4019	88 b	13.8 r-v	6.6 t-v	0.4 n	222 c-f	0.0 c
CG.2406	100 a	14.0 r-v	8.2 s-v	0.7 j-n	223 c-f	0.2 c
G.11	100 a	14.5 r-v	22.2 i-t	1.5 b-f	256 a-d	0.2 c
CG.2022	100 a	14.8 r-u	16.7 n-v	1.2 c-k	260 a-c	0.3 c
CG.4003	90 ab	16.8 q-t	14.6 p-v	1.0 f-m	206 f	0.0 c
CG.2006	100 a	17.0 p-t	17.0 m-v	1.0 f-m	247 a-e	0.3 c
B.9	100 a	17.2 p-s	14.2 q-v	0.9 g-n	240 a-f	0.5 c
CG.4288	90 ab	17.5 p-s	6.1 uv	0.4 mn	218 d-f	0.7 c
CG.4292	100 a	17.7 p-s	18.0 l-v	1.0 f-m	239 a-f	0.3 c
CG.5757	100 a	17.9 o-r	23.9 i-s	1.4 b-g	239 a-f	0.3 c
CG.4214	100 a	18.5 o-r	25.7 i-r	1.4 b-h	240 a-f	2.8 b
M.9	100 a	18.7 n-r	28.8 g-q	1.5 b-f	269 a	0.8 c
CG.6143	100 a	20.4 m-q	20.1 k-v	1.0 f-m	251 a-e	1.1 c
CG.5030	100 a	20.8 m-q	21.1 j-u	1.0 f-m	253 a-d	4.5 a
CG.6969	100 a	21.7 l-q	26.5 h-r	1.3 b-j	243 a-f	0.2 c
CG.4001	100 a	21.7 l-q	33.7 d-l	1.6 b-e	242 a-f	0.0 c
CG.5046	100 a	21.8 l-q	27.4 h-r	1.2 c-k	238 a-f	4.4 a
G.16	90 ab	22.3 k-p	14.7 o-v	0.7 k-n	241 a-f	0.0 c
CG.6874	100 a	23.0 j-o	12.9 r-v	0.5 l-n	230 b-f	0.8 c
CG.4011	100 a	23.9 i-n	28.9 g-q	1.2 c-k	249 a-e	0.2 c
G.935	90 ab	24.1 i-m	30.2 e-p	1.3 b-i	263 ab	0.4 c
G.202	100 a	24.2 i-m	26.1 h-r	1.1 d-l	246 a-e	0.5 c
CG.5012	100 a	24.6 h-m	34.6 d-k	1.4 b-g	253 a-d	0.0 c
M.7	100 a	24.7 h-m	29.5 e-q	1.1 c-k	265 ab	2.9 b
CG.4814	100 a	25.2 g-m	23.0 i-s	0.9 g-n	241 a-f	0.1 c
G.30	100 a	25.5 f-m	30.4 e-o	1.2 c-k	248 a-e	0.5 c
CG.4004	100 a	26.4 f-l	43.9 c-g	1.7 a-c	260 a-c	0.2 c
CG.8189	100 a	27.3 f-k	30.1 e-p	1.1 c-l	260 a-c	0.1 c
CG.4049	100 a	27.5 f-j	31.0 d-n	1.1 c-k	259 a-c	1.1 c
MM.106	100 a	28.5 e-i	29.3 f-q	1.0 e-l	255 a-d	0.8 c
CG.5257	100 a	28.6 d-i	32.5 d-m	1.1 c-k	249 a-e	0.0 c
CG.6006	100 a	29.7 d-h	30.8 d-n	1.0 d-l	249 a-e	0.0 c
CG.6879	100 a	30.1 d-g	41.9 c-h	1.4 b-h	253 a-d	0.5 c
CG.7480	100 a	30.5 c-f	36.2 d-j	1.2 c-k	258 a-c	0.0 c
CG.5890	100 a	32.8 b-e	46.3 b-d	1.4 b-g	256 a-d	0.3 c
CG.7707	100 a	33.3 b-e	52.2 a-c	1.6 b-d	241 a-f	0.0 c
CG.6253	100 a	33.6 b-e	34.4 d-k	1.0 e-l	247 a-e	1.0 c
CG.4213	100 a	33.8 b-d	26.7 h-r	0.8 i-n	247 a-e	0.8 c
CG.6001	100 a	35.6 bc	63.9 a	1.8 ab	269 a	3.2 ab
CG.8534	100 a	37.0 b	32.9 d-l	0.9 g-n	239 a-f	0.1 c
CG.6024	100 a	46.0 a	44.7 b-f	1.0 e-l	245 a-e	0.9 c
CG.7037	100 a	47.6 a	37.5 c-i	0.8 i-n	269 a	0.1 c
CG.5463	100 a	48.0 a	45.1 b-e	0.9 g-n	242 a-f	0.6 c
CG.4002	100 a	49.3 a	27.1 h-r	0.5 l-n	258 a-c	0.4 c
CG.6589	100 a	49.8 a	60.1 ab	1.2 c-k	239 a-f	0.3 c
LSD P≤0.05	11	5.3	15.7	0.58	38.3	1.4

^zRootstocks ranked by increasing trunk x-sectional area.

^yMean separation by LSD p≤0.05.

