

Early Performance of ‘Fuji’ and ‘McIntosh’ Apple Trees on Several Semidwarf Rootstocks in the 1999 NC-140 Rootstock Trial

W.R. Autio, B.H. Barritt, J.A. Cline, R.M. Crassweller, C.G. Embree, D.C. Ferree, M.E. Garcia, G.M. Greene, E.E. Hoover, R.S. Johnson, K. Kosola, J. Masabni, M.L. Parker, R.L. Perry, G.L. Reighard, T.L. Robinson, S.D. Seeley, and M. Warmund

Keywords

Malus x domestica, yield efficiency, tree size, fruit size, Cornell-Geneva rootstocks, Pillnitz rootstocks

Abstract

‘Fuji’ and ‘McIntosh’ apple trees (*Malus x domestica* Borkh.) on CG.4184, CG.7707, G.30N (liners from stool beds), M.7 EMLA, M.26 EMLA, and Supporter 4 rootstocks were planted at 19 locations (‘Fuji’ at 9 sites and ‘McIntosh’ at 10 sites) throughout North America as a uniform trial coordinated by the NC-140 Technical Committee. After five growing seasons, the only significant loss was of ‘McIntosh’ trees on CG.7707 (73% survived). Largest ‘Fuji’ trees were on CG.7707 and M.7 EMLA, and smallest were on M.26 EMLA and Supporter 4. Largest ‘McIntosh’ trees were on M.7 EMLA and Supporter 4, and smallest were on CG.4814 and M.26 EMLA. ‘Fuji’ trees on G.30N, CG.7707, and CG.4814 outyielded trees on M.7 EMLA, M.26 EMLA, and Supporter 4. Greatest ‘McIntosh’ yields were from trees on G.30N, and lowest were from trees on M.26 EMLA. The most yield efficient trees of both cultivars were on G.30N and CG.4814, and the least efficient trees were on M.7 EMLA. ‘Fuji’ fruit were largest from trees on G.30N and Supporter 4, and smallest from trees on M.26 EMLA. ‘McIntosh’ fruit were largest from trees on CG.7707 and Supporter 4, and smallest from trees on CG.4814 and M.7 EMLA.

INTRODUCTION

The rootstock is a critical component of any orchard management system. Historically, there have been relatively few rootstock choices for growers interested in free-standing, central-leader systems. All have had low precocity and relatively low yield efficiency. The NC-140 Technical Committee, which began in 1976 with the goal of evaluating rootstocks over a wide variety of North American conditions in uniform trials, has evaluated a number of semidwarf rootstocks, but few have performed better than M.7(NC-140, 1991, 1996). The Cornell-Geneva Apple Rootstock Breeding Program (a cooperative effort between Cornell University and the United States Department of Agriculture) has begun to release rootstocks in a wide variety of size categories including semidwarfs, all reported to be highly productive and disease resistant (Johnson et al., 2001a). Likewise, the Institut für Obstforschung Dresden-Pillnitz released Supporter 4 as a semidwarf apple rootstock, reported to be similar size to trees on M.26 and more productive (Fischer, 2001).

The objective of the 1999 NC-140 Apple Rootstock Trial was to evaluate Cornell-Geneva and Pillnitz rootstocks in comparison to M.7 EMLA and M.26 EMLA, utilizing several locations and uniform plantings.

MATERIALS AND METHODS

In spring, 1999, two trials of semidwarf apple rootstocks were established under the

coordination of the NC-140 Technical Committee. One trial included 'Fuji' apple trees on CG.4814, CG.7707, G.30N (liners from stool beds), M.7 EMLA, M.26 EMLA, and Supporter 4 and was planted in California, Kentucky, North Carolina, Ohio, Pennsylvania (Biglerville), and Washington (Table 1). Partial plantings were initiated in Missouri, South Carolina, and Utah, and some sites included CG.6210 and G.30T (liners from tissue cultured plants). A second trial included 'McIntosh' apple trees on CG.4814, CG.7707, G.30N (liners from stool beds), M.7 EMLA, M.26 EMLA, and Supporter 4 and was planted in Massachusetts, Michigan, Minnesota, Nova Scotia (Canada), New York (Geneva), Ontario (Canada), and Wisconsin (Table 2). Partial plantings were established in New York (Champlain), Pennsylvania (Rock Springs), and Vermont, and some sites included CG.6210, CG.8, and G.30T.

Trees were spaced 4x6m and trained as free-standing central leaders. Water, fertility, and pest control were per local recommendations. The experimental design was a randomized complete block at each site, with six blocks and a single tree representing each rootstock treatment in a block. Trunk circumference at 25cm above the bud union was measured annually in October, and values were transformed to trunk cross-sectional area (TCA). Tree height was measured in October, 2003. Canopy spread was assessed in October, 2003 as the average of the in-row and across-row canopy widths. Root suckers were counted and removed annually in August. Yield per tree was assessed in 2001 through 2003 as total weight of both harvested and dropped fruit. Fruit size was derived from the total weight of harvested fruit divided by the total number of harvested fruit per tree.

Data were analyzed with the MIXED procedure of the SAS statistical analysis software (SAS Institute, Cary, NC, USA). The two trials ('Fuji' and 'McIntosh') were analyzed separately and each treated as a randomized-complete-block-split-plot design, with location as the whole plot and rootstock as the split plot. Least-squares means, adjusted for missing subclasses, were generated by the analyses. Rootstock means were separated by Tukey's HSD ($P = 0.05$).

RESULTS AND DISCUSSION

After five growing seasons, the only significant loss was of 'McIntosh' trees on CG.7707, where only 73% remained. The largest 'Fuji' trees were on CG.7707 and M.7 EMLA, and the smallest were on M.26 EMLA and Supporter 4 (Table 3). The largest 'McIntosh' trees were on M.7 EMLA and Supporter 4 (Table 4), and the smallest were on CG.4814 and M.26 EMLA.

Root suckering was much more prominent with 'Fuji' as the scion cultivar compared to 'McIntosh' (Tables 3 and 4). M.7 EMLA and CG.4814 resulted in the most root suckering with both scion cultivars.

'Fuji' trees on G.30N, CG.7707, and CG.4814 outyielded (cumulatively, 2001-03) trees on M.7 EMLA, M.26 EMLA, and Supporter 4 (Table 3). For 'McIntosh,' the greatest yields were from trees on G.30N, and the lowest were from trees on M.26 EMLA (Table 4).

Rootstock effects on yield efficiency were consistent between the two cultivars (Tables 3 and 4). The most yield efficient trees were on G.30N and CG.4814, and the least efficient trees were on M.7 EMLA.

Effects of rootstock on fruit weight were modest and somewhat inconsistent between the two cultivars (Tables 3 and 4). 'Fuji' fruit were largest from trees on G.30N and Supporter 4 and smallest from trees on M.26 EMLA. 'McIntosh' fruit were largest from trees on CG.7707 and Supporter 4 and smallest from trees on CG.4814 and M.7 EMLA.

The results presented here must be labeled preliminary, since they are based only on the first five growing seasons, but they give an early look at some of the newest and potentially useful semidwarf apple rootstocks from the Cornell-Geneva Rootstock Breeding Program (Johnson et al., 2001a; Robinson et al., 2002) and the Pillnitz Rootstock Breeding Program (Fischer, 2001). Utilizing these data, two of these rootstocks can be categorized based on tree size. G.30N was clearly similar to M.7 EMLA in size controlling, but was significantly more yield efficient. CG.4814 was similar to M.26 EMLA, but also significantly more yield efficient. CG.7707 may result in trees in the M.7 EMLA category or trees between M.26 EMLA and M.7 EMLA, but yield efficiency was similar to M.26 EMLA. Robinson et al. (2004) and Johnson et al. (2001b) presented data suggesting that trees on CG.7707 was similar or larger than those on M.7 EMLA but more yield efficient. Supporter 4 (from the Pillnitz Program) may provide size control similar to M.26 EMLA or M.7 EMLA, but trees were similarly yield efficient to those on M.26 EMLA. Fischer (1997, 2001) suggested that Supporter 4 will result in trees similar in size to M.26 and more efficient.

Acknowledgments

The authors wish to acknowledge the International Dwarf Fruit Tree Association for the significant support provided for the establishment and coordination of this trial. Massachusetts Agricultural Experiment Station Paper 3349.

Literature Cited

- Fischer, M. 1997. The Pillnitz apple rootstock breeding methods and selection results. *Acta Hort.* 451:89-97.
- Fischer, M. 2001. New dwarfing and semidwarfing Pillnitz apple and pear rootstocks. *Acta Hort.* 557:55-61.
- Johnson, W.C., H.S. Aldwinckle, J.N. Cummins, P.L. Forsline, H.T. Holleran, J.L. Norelli, and T.L. Robinson. 2001a. The new USDA-ARS/Cornell University Apple Rootstock Breeding and Evaluation Program. *Acta Hort.* 557:35-40.
- Johnson, W.C., J.N. Cummins, H.T. Holleran, S.A. Hoying, and T.L. Robinson. 2001b. Orchard trial performance of elite Geneva series rootstocks. *Acta Hort.* 557:63-67.
- NC-140. 1991. Performance of 'Starkspur Supreme Delicious' apple on 9 rootstocks over 10 years in the NC-140 Cooperative Planting. *Fruit Varieties J.* 45:192-199.
- NC-140. 1996. Performance of the NC-140 Cooperative Apple Rootstock Planting: I. Survival, tree size, yield and fruit size. *Fruit Varieties J.* 50:6-11.
- Robinson, T., L. Anderson, W. Autio, A. Azarenko, B. Barritt, G. Brown, J. Cline, R. Crassweller, P. Domoto, C. Embree, A. Fennell, D. Ferree, E. Garcia, A. Gaus, G. Greene, C. Hampson, P. Hirst, E. Hoover, S. Johnson, M. Kushad, R. Marini, R. Moran, C. Mullins, M. Parker, R. Perry, J.P. Privé, G. Reighard, C. Rom, T. Roper, J. Schupp, and M. Warmund. 2002. Performance of Cornell-Geneva rootstocks in the North American NC-140 rootstock trials. *Compact Fruit Tree* 35:99-102.
- Robinson, T., L. Anderson, A. Azarenko, B. Barritt, T. Baugher, G. Brown, R. Crassweller, P. Domoto, C. Embree, A. Fennell, E. Garcia, A. Gaus, R. Granger, G. Greene, P. Hirst, E. Hoover, S. Johnson, M. Kushad, R. Moran, C. Mullins, S. Myers, R. Perry, C. Rom, J. Schupp, M. Warmund, and J. Warner. 2004. Performance of Cornell-Geneva rootstocks with 'Liberty' as the scion in NC-140 trials across North America. *Acta Hort.* (In press).

Table 1. Planting locations in the 1999 NC-140 Semidwarf Rootstock Trial – ‘Fuji’.

Site	Planting location	Cooperator	Cooperator Affiliation & Address
California	Parlier	S. Johnson	Kearney Agric. Center, University of California 9240 S. Riverbend Ave., Parlier, CA 93648 USA
Kentucky	Princeton	J. Masabni	Research & Education Center, University of Kentucky P.O. Box 469, Princeton, KY 42445 USA
Missouri	New Franklin	M. Warmund	Dept. Horticulture, University of Missouri I-40 Agriculture Building, Columbia, MO 65211 USA
North Carolina	Fletcher	M. Parker	Dept. Horticulture, North Carolina State University Box 7609, Raleigh, NC 27695 USA
Ohio	Wooster	D. Ferree	Dept. Hort. & Crop Science, Ohio State University OARDC, Wooster, OH 44691 USA
Pennsylvania	Biglerville	G. Greene	Fruit Research & Ext. Cntr., Pennsylvania State Univ. P.O. Box 330, Biglerville, PA 17307 USA
South Carolina	Seneca	G. Reighard	Dept. Horticulture, Clemson University Box 340375, Clemson, SC 29634 USA
Utah	Logan	S.D. Seeley	Plant Science Dept., Utah State University Logan, UT 84321 USA
Washington	Wenatchee	B. Barritt	Tree Fruit Res. & Ext. Cntr., Washington State Univ. 1100 N. Western Ave., Wenatchee, WA 98801 USA

Table 2. Planting locations in the 1999 NC-140 Semidwarf Rootstock Trial – ‘McIntosh’.

Site	Planting location	Cooperator	Cooperator Affiliation & Address
Massachusetts	Belchertown	W. Autio	Dept. Plant, Soil, & Insect Sci., Univ. Massachusetts 205 Bowditch Hall, Amherst, MA 01003 USA
Michigan	Clarksville	R. Perry	Dept. Horticulture, Michigan State University East Lansing, MI 48824 USA
Minnesota	Excelsior	E. Hoover	Dept. Horticultural Sci., University of Minnesota 1970 Folwell Ave, St. Paul, MN 55108 USA
Nova Scotia (Canada)	Kentville	C. Embree	Agriculture & Agri-Food Canada Kentville, NS B4N 1J5 Canada
New York	Williamson	T. Robinson	Dept. Horticultural Science, Cornell University NYS Agric. Experiment Station, Geneva, NY 14456 USA
New York	Peru	T. Robinson	Dept. Horticultural Science, Cornell University NYS Agric. Experiment Station, Geneva, NY 14456 USA
Ontario (Canada)	Simcoe	J. Cline	Dept. Plant Agriculture, University of Guelph Box 587, Simcoe, ONT N3Y 4N5 Canada
Pennsylvania	Rock Springs	R. Crassweller	Dept. Horticulture, Pennsylvania State University 102 Tyson Building, University Park, PA 16802 USA
Vermont	South Burlington	M.E. Garcia	Dept. Plant & Soil Science, University of Vermont 206 Hills Building, Burlington, VT 05405
Wisconsin	Sturgeon Bay	K. Kosola	Dept. Horticulture, University of Wisconsin 1575 Linden Drive, Madison, WI 53706 USA

Table 3. Survival, tree size, number of root suckers, yield, and fruit size of ‘Fuji’ apple trees on various rootstocks through the first five growing seasons (1999-2003) as part of the 1999 NC-140 Semidwarf Rootstock Trial. All values are least-squares means adjusted for missing subclasses and are derived only from California, Kentucky, North Carolina, Ohio, Pennsylvania (Biglerville), and Washington locations.¹

Rootstock	Survival (%)	Trunk cross-sectional area (cm ²)	Tree height (m)	Canopy spread (m)	Cumulative no. root suckers (1999-2003)	Cumulative yield per tree (kg) (2001-03)	Cumulative yield efficiency (kg/cm ² TCA) (2001-03)	Average fruit weight (g) (2001-03)
CG.4814	97 a	40.1 ab	3.2 a	3.2 a	14.2 b	30 a	0.78 a	190 ab
CG.7707	91 a	46.4 a	3.2 a	3.2 a	5.2 bc	33 a	0.73 ab	199 ab
G.30N	97 a	45.1 ab	3.3 a	3.3 a	4.7 bc	38 a	0.84 a	206 a
M.7 EMLA	97 a	45.8 a	3.2 a	2.9 a	31.8 a	21 b	0.53 b	190 ab
M.26 EMLA	89 a	39.8 ab	3.1 a	2.9 a	1.2 c	21 b	0.64 ab	180 b
Supporter 4	86 a	37.0 b	2.9 a	2.9 a	5.8 bc	20 b	0.66 ab	206 a

¹ Mean separation within columns by Tukey’s HSD ($P = 0.05$).

Table 4. Survival, tree size, number of root suckers, yield, and fruit size of ‘McIntosh’ apple trees on various rootstocks through the first five growing seasons (1999-2003) as part of the 1999 NC-140 Semidwarf Rootstock Trial. All values are least-squares means adjusted for missing subclasses and are derived only from Massachusetts, Michigan, Minnesota, Nova Scotia (Canada), New York (Geneva), Ontario (Canada), and Wisconsin locations.¹

Rootstock	Survival (%)	Trunk cross-sectional area (cm ²)	Tree height (m)	Canopy spread (m)	Cumulative no. root suckers (1999-2003)	Cumulative yield per tree (kg) (2001-03)	Cumulative yield efficiency (kg/cm ² TCA) (2001-03)	Average fruit weight (g) (2001-03)
CG.4814	95 a	23.9 c	2.7 c	2.8 cd	5.4 ab	28 b	1.37 a	157 b
CG.7707	73 b	29.0 bc	2.8 c	3.0 bc	1.5 bc	26 bc	0.98 b	172 a
G.30N	94 a	33.8 ab	3.0 bc	3.4 a	2.3 bc	38 a	1.17 ab	160 ab
M.7 EMLA	95 a	35.5 a	3.4 a	3.1 ab	8.0 a	21 bc	0.61 c	157 b
M.26 EMLA	95 a	23.4 c	2.9 c	2.6 d	0.4 c	20 c	0.93 b	162 ab
Supporter 4	86 ab	35.2 a	3.3 ab	3.0 bc	1.5 bc	28 b	0.89 b	166 ab

¹ Mean separation within columns by Tukey’s HSD ($P = 0.05$).