Journal of the American Pomological Society 59(4):192-201 2005

Performance of 'Fuji' and 'McIntosh' Apple Trees After 5 Years as Affected by Several Semidwarf Rootstocks in the 1999 NC-140 Apple Rootstock Trial[1]

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Abstract

'Fuji' and 'McIntosh' apple trees (*Malus x domestica* Borkh.) on CG.4814, CG.7707, G.30N (liners from stool beds), M.7 EMLA, M.26 EMLA, and Supporter 4 rootstocks were planted at six sites with 'Fuji' and seven sites with 'McIntosh' as the scion cultivars throughout North America as a uniform trial coordinated by the NC-140 Technical Committee. Partial plantings were established at three sites per cultivar, and CG.6210 and G.30T (liners from tissue cultured plants) were included in four plantings with each scion cultivar. After five growing seasons, the only significant loss was of 'McIntosh' trees on CG.7707 (73% survived). Trunk cross-sectional area, tree height, and canopy spread were affected by rootstock and allowed partitioning of a portion of the rootstocks in this trial into preliminary size categories. CG.6210, G.30N, and G.30T resulted in semidwarf trees, similar in size to those on M.7 EMLA, but less prone to root suckering, greater yielding, and more yield efficient. CG.4814 resulted in large dwarf trees, similar in size to those on M.26 EMLA, but more prone to root suckering, greater yielding, and more yield efficient. Effects of CG.7707 and Supporter 4 varied with scion cultivar. CG.7707 resulted in semidwarf 'Fuji' trees, similar in size those on M.7 EMLA, with less root suckering, greater yield per tree, and similar yield efficiency. CG.7707 produced large dwarf 'McIntosh' trees, similar in size to those on M.26 EMLA, with slightly more root suckering and similar yield per tree, and similar yield efficiency. Supporter 4 produced large dwarf 'Fuji' trees, similar in size and performance to those on M.26 EMLA, and it resulted in semidwarf 'McIntosh' trees, similar in size to those on M.7 EMLA, with less root suckering, similar yield per tree, and greater yield efficiency.

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 (6, 7). 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 (4). 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 (3).

The objective of this portion 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 uniform plantings at several locations.

[1]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 3351.

Materials & 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' as the scion cultivar, and the other included 'McIntosh'. Core rootstocks were CG.4814, CG.7707, G.30N (liners from stool beds), M.7 EMLA, M.26 EMLA, and Supporter 4. Plantings at four 'Fuji' and four 'McIntosh' sites also included CG.6210 and CG.30T (liners from tissue cultured plants) as rootstock treatments. The 'Fuji' trial was planted in California, Kentucky, North Carolina, Ohio, Pennsylvania (Biglerville), and Washington, with partial plantings in Missouri, South Carolina, and Utah (Table 1). The 'McIntosh' trial was planted in Massachusetts, Michigan, Minnesota, Nova Scotia, New York (Williamson), Ontario, and Wisconsin, with partial plantings in New York (Peru), Pennsylvania (Rock Springs), and Vermont (Table 1).

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 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 the harvested and dropped fruit. Yield efficiency in 2003 was calculated as yield in 2003 divided by TCA in 2003. Cumulative yield efficiency (2001-03) was calculated as cumulative yield (2001-03) divided by TCA in 2003. Fruit size in 2003 was derived from the total weight of fruit harvested per tree in 2003 divided by the total number of harvested fruit per tree. Average fruit weight (2001-03) was calculated as the cumulative yield (2001-03) divided by the cumulative number of fruit.

Data were analyzed with the MIXED procedure of the SAS statistical analysis software (SAS Institute, Cary, NC). The two trials ('Fuji' and 'McIntosh') were analyzed separately. Data from the core rootstocks and sites were analyzed as a randomized-complete-block-split-plot design, with location (L) and block within location (B:L) in the whole plot and rootstock (R) and the associated interactions (RL and RB:L) in the split plot. Rootstock and location were treated as fixed effects, and block was considered random. In general, the interaction of location and rootstock was significant. Additional analyses, therefore, were conducted for each site, including all of the rootstocks at that site. Least-squares means, adjusted for missing subclasses, were generated by the analyses. Rootstock means were separated by Tukey's HSD ($P = 0.05$).

Results

Rootstock Effects Across the Core Sites

After five growing seasons, rootstock did not affect survival of 'Fuji' trees, but 'McIntosh' trees on CG.7707 had significantly lower survival than did comparable trees on CG.4814, G.30N, M.7 EMLA, or M.26 EMLA (Table 2).

Based on TCA, the largest 'Fuji' trees were on CG.7707 and M.7 EMLA, and the smallest were on Supporter 4 (Table 2). The largest 'McIntosh' trees were on M.7 EMLA and Supporter 4, and the smallest were on CG.4814 and M.26 EMLA. Neither height nor canopy spread of 'Fuji' trees was affected by rootstock, but the tallest 'McIntosh' trees were on M.7 EMLA and Supporter 4, and the shortest were on M.26 EMLA, CG.7707, and CG.4814 (Table 2). The largest 'McIntosh' canopy spread was of trees

Table 1. Planting locations in the 1999 NC-140 Semidwarf Rootstock Trial.

Site	Planting location	Cooperator	Cooperator Affiliation & Address
			'Fuji'
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-87 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	Clemson	G. Reighard	Dept. Horticulture, Clemson University, Box 340319, 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
			'McIntosh'
Massachusetts	Belchertown	W. Autio	Dept. Plant, Soil, & Insect Sci., Univ. Massachusetts, 205 Bowditch Hall, Amherst, MA 01003 USA
Michigan	Traverse City	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	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	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 2. Survival, tree size, yield, and fruit size of 'Fuji' and '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. 'Fuji' data were derived only from California, Kentucky, North Carolina, Ohio, Pennsylvania (Biglerville), and Washington locations. 'McIntosh' data were derived only from Massachusetts, Michigan, Minnesota, Nova Scotia, New York (Williamson), Ontario, and Wisconsin locations

Rootstock	Survival (%)	Trunk cross-sectional area (cm^2)	Tree height (m)	Canopy spread (m)	Cumulative no. root suckers (1999-2003)	Yield per tree (kg)		Yield efficiency (kg/cm^2 TCA)		Fruit weight (g)	
						2003	Cumulative (2001-03)	2003	Cumulative (2001-03)	2003[2]	Average (2001-03)
						'Fuji'					
CG.4814	97 a[1]	40.1 ab	3.2 a	3.2 a	14.2 b	13.8 bc	30 a	0.37 a	0.78 a	191 b	190 ab
CG.7707	91 a	46.4 a	3.2 a	3.2 a	5.2 bc	18.4 ab	33 a	0.41 a	0.73 ab	198 ab	199 ab
G.30N[3]	97 a	45.1 ab	3.3 a	3.3 a	4.7 bc	20.0 a	38 a	0.45 a	0.84 a	223 a	206 a
M.7 EMLA	97 a	45.8 a	3.2 a	2.9 a	31.8 a	13.7 bc	21 b	0.36 a	0.53 b	192 b	190 ab
M.26 EMLA	89 a	39.8 ab	3.1 a	2.9 a	1.2 c	12.0 c	21 b	0.39 a	0.64 ab	182 b	180 b
Supporter 4	86 a	37.0 b	2.9 a	2.9 a	5.8 bc	11.0 c	20 b	0.40 a	0.66 ab	204 ab	206 a
						'McIntosh'					
CG.4814	95 a	23.9 c	2.7 c	2.8 cd	5.4 ab	16.4 b	28 b	0.77 a	1.37 a	154 b	157 b
CG.7707	73 b	29.0 bc	2.8 c	3.0 bc	1.5 bc	16.5 b	26 bc	0.61 ab	0.98 b	170 a	172 a
G.30N[3]	94 a	33.8 ab	3.0 bc	3.4 a	2.3 bc	22.4 a	38 a	0.66 ab	1.17 ab	160 ab	160 ab
M.7 EMLA	95 a	35.5 a	3.4 a	3.1 ab	8.0 a	13.6 b	21 bc	0.36 c	0.61 c	153 b	157 b
M.26 EMLA	95 a	23.4 c	2.9 c	2.6 d	0.4 c	12.4 b	20 c	0.54 bc	0.93 b	161 ab	162 ab
Supporter 4	86 ab	35.2 a	3.3 ab	3.0 bc	1.5 bc	16.5 b	28 b	0.49 bc	0.89 b	169 ab	166 ab

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] Fruit weight of 'Fuji' in 2003 was affected by crop load, and therefore least-squares means were adjusted to account for crop load.

[3] G.30N was originally propagated from stool beds.

on G.30N and the smallest was of trees on M.26 EMLA (Table 2).

Root suckering was much more prominent with 'Fuji' as the scion cultivar compared to 'McIntosh' (Table2). M.7 EMLA and CG.4814 resulted in the most root suckering with both scion cultivars, and M.26 EMLA resulted in the least root suckering.

In 2003, 'Fuji' trees on G.30N and CG.7707 yielded significantly more than those on M.26 EMLA and Supporter 4 (Table 2). Cumulatively, 'Fuji' trees on CG.4814, CG.7707 and G.30N yielded more than those on M.7 EMLA, M.26 EMLA, or Supporter 4 (Table 2). 'McIntosh' trees on G.30N yielded more than trees on all other rootstocks in 2003 and cumulatively (Table 2). Lowest cumulative yields of 'McIntosh' were harvested from trees on M.26 EMLA.

In 2003, rootstock did not affect yield efficiency of 'Fuji', but 'McIntosh' trees on CG.4814 were more efficient in 2003 than those on M.7 EMLA, M.26 EMLA, or Supporter 4 (Table 2). Cumulatively, rootstock effects on yield efficiency were consistent between the two cultivars, with the most yield efficient trees on G.30N and CG.4814, and the least efficient trees on M.7 EMLA (Table 2).

Effects of rootstock on fruit weight were modest and somewhat inconsistent between the two cultivars (Table 2). In 2003, G.30N resulted in larger 'Fuji' fruit than did CG.4814, M.7 EMLA, or M.26 EMLA. Averaged across years, G.30N and Supporter 4 resulted in larger 'Fuji' fruit than did M.26 EMLA. In 2003 and on average, CG.7707 resulted in larger 'McIntosh' fruit than did CG.4814 or M.7 EMLA.

Interaction of Rootstock and Site

Significant loss of 'Fuji' trees occurred during the first 5 years of this trial in MO, with complete loss of trees on G.30N and Supporter 4 (Table 3). This loss was the result, primarily, from breakage caused by severe winds. In MI, 'McIntosh' trees on CG.7707 had significant lower survival than did trees on CG.4814, G.30N, M.7 EMLA, M.26 EMLA, or Supporter 4. In MN, 'McIntosh' trees on Supporter 4 were lost to the greatest degree, primarily from fireblight infection.

Although rootstock and site interacted significantly to affect TCA (Table 4), little important variation existed from the overall rootstock effects shown in Table 2. The only notable difference was that 'Fuji' trees on M.7 were smaller than expected in WA.

As with TCA, the relative effects of rootstock on cumulative yield were mostly consistent from site to site (Table 5). The only deviations of note include the following: 'Fuji'/CG.4814 yielded less than expected in KY, 'McIntosh'/M.7 EMLA yielded less than expected in MN, and 'McIntosh'/Supporter 4 yielded less than expected in NY-W. With cumulative yield efficiency (Table 6), rootstock effects were relatively consistent, except that 'McIntosh'/CG.4814 were more efficient than expected in MA.

Average fruit weight was not affected by rootstock at most sites (Table 7); however, in UT, M.26 EMLA resulted in larger 'Fuji' fruit than did CG.4814. Also, G.30N resulted in larger 'McIntosh' fruit than did M.7 EMLA in MN, CG.7707 resulted in the largest 'McIntosh' fruit in WI, and Supporter 4 resulted in larger 'McIntosh' fruit than did M.26 EMLA in NY-P.

CG.6210 and G.30T

G.30T and CG.6210 were included in four 'Fuji' and four 'McIntosh' plantings. Trees on G.30T performed comparably in all respects to those on G.30N with both cultivars (Tables 3-7). Generally, performance of trees on CG.6210 was similar to that of trees on M.7 EMLA with both scion cultivars (Tables 3-7). One exception was that 'McIntosh' trees on CG.6210 in NY-W were smaller than those on M.7 EMLA (Table 4). Also, 'McIntosh' trees on CG.6210 in MN yielded more per tree (Table 5), were more

Table 3. Survival (%) of 'Fuji' and 'McIntosh' apple trees by location 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.[1]

Rootstock	CA	KY	NC	OH	PA-B	WA	MO	SC	UT	
					'Fuji'					
CG.4814	100 a	80 a	100 a	100 a	100 a	100 a	67 ab	80 a	100 a	
CG.7707	100 a	60 a	100 a	83 a	100 a	100 a	83 a	-	100 a	
G.30N[2]	100 a	99 a	100 a	99 a	100 a	83 a	0 b	-	100 a	
M.7 EMLA	100 a	100 a	100 a	83 a	100 a	100 a	67 ab	-	100 a	
M.26 EMLA	100 a	83 a	100 a	50 a	100 a	100 a	33 ab	100 a	67 a	
Supporter 4	100 a	50 a	100 a	67 a	100 a	100 a	0 b	75 a	-	
CG.6210	100 a	-	100 a	100 a	-	100 a	-	-	-	
G.30T[2]	100 a	-	100 a	100 a	-	100 a	-	-	-	
	MA	MI	MN	NS	NY-W	ON	WI	NY-P	PA-R	VT
					'McIntosh'					
CG.4814	100 a	100 a	100 a	100 a	100 a	67 a	100 a	-	-	67 a
CG.7707	100 a	33 b	33 ab	83 a	75 a	83 a	100 a	-	-	100 a
G.30N[2]	100 a	100 a	83 ab	100 a	100 a	100 a	75 a	-	-	100 a
M.7 EMLA	100 a	100 a	67 ab	100 a	100 a	100 a	100 a	100 a	100 a	100 a
M.26 EMLA	100 a	100 a	67 ab	100 a	100 a	100 a	100 a	100 a	100 a	-
Supporter 4	100 a	100 a	17 b	100 a	100 a	83 a	100 a	100 a	100 a	100 a
CG.6210	-	60 ab	80 ab	-	100 a	-	-	-	-	100 a
G.30T[2]	-	80 ab	60 ab	-	100 a	-	-	-	-	100 a

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] G.30N was originally propagated from stool beds, and G.30T originally came from tissue cultured plants.

yield efficient (Table 6), and had larger fruit (Table 7) than those on M.7 EMLA.

Discussion

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 (4, 8) and the Pillnitz Rootstock Breeding Program (2, 3).

After 5 years, the rootstocks included in this trial did not separate into size categories as cleanly as those in the dwarf portion of the 1999 NC-140 Rootstock Trial (1), but these are only preliminary allocations, since relative differences may change somewhat in the remaining years of this trial. Trees on CG.6210, G.30N, and G.30T were similar to those on M.7 EMLA in tree size and fruit size, but were less prone to root suckering, yielded more, and were more yield efficient. Trees on CG.4814 were similar in size to trees on M.26 EMLA, and yielded more per tree, were more yield efficient, and had similar fruit size. Also, trees on CG.4814 had more root suckering than those on M.26 EMLA.

Table 4. Trunk cross-sectional area (cm^2) of 'Fuji' and 'McIntosh' apple trees by location 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.[1]

Rootstock	CA	KY	NC	OH	PA-B	WA	MO	SC	UT
					'Fuji'				
CG.4814	72.1 ab	40.7 a	38.1 a	41.8 a	29.3 ab	19.7 bc	53.3 a	67.4 a	36.6 b
CG.7707	74.5 ab	48.3 a	50.4 a	40.8 a	33.0 ab	31.0 abc	56.0 a	-	47.5 ab
G.30N[2]	71.5 ab	45.5 a	47.1 a	36.0 a	29.6 ab	40.4 a	-	-	52.6 ab
M.7 EMLA	72.0 ab	41.2 a	50.2 a	48.3 a	39.7 a	24.9 bc	52.2 a	-	60.6 a
M.26 EMLA	88.5 ab	31.2 a	41.2 a	37.3 a	23.0 b	18.1 c	40.5 a	82.9 a	41.0 b
Supporter 4	63.8 b	17.6 a	45.9 a	31.3 a	30.6 ab	33.2 ab	-	63.5 a	-
CG.6210	111.6 a	-	57.3 a	54.6 a	-	26.1 abc	-	-	-
G.30T[2]	71.7 ab	-	49.7 a	46.4 a	-	38.8 a	-	-	-

	MA	MI	MN	NS	NY-W	ON	WI	NY-P	PA-R	VT
					'McIntosh'					
CG.4814	13.1 b	23.3 a	33.5 a	16.1 b	24.7 c	30.9 a	25.5 b	-	-	22.5 a
CG.7707	16.7 b	20.4 a	30.4 a	22.3 ab	34.8 bc	43.2 a	35.3 ab	-	-	24.3 a
G.30N[2]	31.5 a	26.1 a	31.0 a	22.2 ab	45.3 ab	42.2 a	38.4 ab	-	-	27.3 a
M.7 EMLA	30.6 a	28.9 a	32.5 a	24.1 a	55.7 a	39.9 a	36.9 ab	37.1 a	70.3 a	22.6 a
M.26 EMLA	15.3 b	20.0 a	19.9 a	16.9 b	27.9 c	36.1 a	27.3 b	21.6 b	50.5 b	-
Supporter 4	29.7 a	24.6 a	29.0 a	21.9 ab	43.6 ab	51.2 a	47.3 a	31.9 a	73.2 a	28.7 a
CG.6210	-	23.7 a	31.5 a	-	33.6 bc	-	-	-	-	24.7 a
G.30T[2]	-	30.9 a	21.6 a	-	40.0 bc	-	-	-	-	32.6 a

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] G.30N was originally propagated from stool beds, and G.30T originally came from tissue cultured plants.

'Fuji' trees on CG.7707 were similar in size to comparable trees on M.7 EMLA, with less root suckering, greater yield per tree, similar yield efficiency, and similar fruit size. 'McIntosh' trees on CG.7707, however, were smaller than those on M.7 EMLA and similar to trees on M.26 EMLA, with slightly more root suckering and similar yield per tree, yield efficiency, and fruit size. Robinson et al. (9) and Johnson et al. (5) presented data suggesting that trees on CG.7707 were similar or larger than those on M.7 EMLA but more yield efficient.

Supporter 4 was likewise variable in its effects. 'Fuji' trees on Supporter 4 were smaller than those on M.7 EMLA and similar to trees on M.26 EMLA. Root suckering, yield per tree, yield efficiency, and fruit size of 'Fuji' trees on Supporter 4 were similar to trees on M.26 EMLA. 'McIntosh' trees on Supporter 4 were larger than trees on M.26 EMLA and similar to those

Table 5. Cumulative (2001-03) yield (kg) per tree of 'Fuji' and 'McIntosh' apple trees by location 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.[1]

Rootstock	CA	KY	NC	OH	PA-B	WA	MO	SC	UT	
					'Fuji'					
CG.4814	41 a	41 b	45 ab	1 a	37 ab	11:00 AM	29 a	83 a	42 a	
CG.7707	31 ab	58 ab	47 ab	1 a	43 a	14 a	25 a	-	42 a	
G.30N[2]	35 a	82 a	53 ab	3 a	37 ab	16 a	-	-	37 a	
M.7 EMLA	25 b	47 ab	27 ab	1 a	17 b	11:00 AM	14 a	-	27 a	
M.26 EMLA	25 b	37 b	30 ab	1 a	21 ab	9 a	18 a	73 a	29 a	
Supporter 4	34 ab	36 b	24 b	1 a	20 ab	5 a	-	59 a	-	
CG.6210	32 ab	-	27 ab	5 a	-	11:00 AM	-	-	-	
G.30T[2]	41 a	-	60 a	4 a	-	12:00 AM	-	-	-	
	MA	MI	MN	NS	NY-W	ON	WI	NY-P	PA-R	VT
					'McIntosh'					
CG.4814	37 ab	11 ab	30 a	35 a	34 ab	23 a	24 abc	-	-	50 ab
CG.7707	29 bc	9 ab	35 a	32 a	34 ab	24 a	18 bc	-	-	35 ab
G.30N[2]	53 a	16 a	32 a	44 a	59 a	27 a	36 a	-	-	49 ab
M.7 EMLA	30 bc	6 ab	3 b	27 a	46 ab	20 a	15 c	16 a	44 a	24 b
M.26 EMLA	19 c	4 b	18 ab	30 a	29 b	15 a	25 abc	16 a	39 a	-
Supporter 4	32 bc	13 ab	25 ab	45 a	25 b	25 a	30 ab	25 a	60 a	37 ab
CG.6210	-	14 ab	35 a	-	31 ab	-	-	-	-	43 ab
G.30T[2]	-	16 a	27 ab	-	44 ab	-	-	-	-	58 a

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] G.30N was originally propagated from stool beds, and G.30T originally came from tissue cultured plants.

on M.7 EMLA in size, with less root suckering, similar yield per tree, greater yield efficiency, and similar fruit size. Fischer (3, 4) suggested that Supporter 4 will result in trees similar in size to M.26 and more efficient.

Additional years of study should allow better placement of these rootstocks into appropriate performance categories.

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Table 6. Cumulative (2001-03) yield efficiency (kg/cm² TCA) of 'Fuji' and 'McIntosh' apple trees by location 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.[1]

Rootstock	CA	KY	NC	OH	PA-B	WA	MO	SC	UT	
					'Fuji'					
CG.4814	0.60 a	1.05 a	1.20 a	0.03 a	1.24 a	0.54 a	0.58 a	1.22 a	1.16 a	
CG.7707	0.44 ab	1.23 a	0.94 a	0.03 a	1.31 a	0.43 a	0.42 a	-	0.90 ab	
G.30N[2]	0.51 ab	1.75 a	1.11 a	0.08 a	1.17 a	0.41 a	-	-	0.81 ab	
M.7 EMLA	0.37 ab	1.29 a	0.59 a	0.02 a	0.47 b	0.43 a	0.26 a	-	0.44 b	
M.26 EMLA	0.30 b	1.28 a	0.79 a	0.02 a	0.91 ab	0.53 a	0.41 a	0.87 b	0.77 ab	
Supporter 4	0.55 a	2.01 a	0.57 a	0.02 a	0.65 ab	0.15 a	-	0.91 b	-	
CG.6210	0.29 b	-	0.47 a	0.09 a	-	0.43 a	-	-	-	
G.30T[2]	0.58 a	-	1.22 a	0.08 a	-	0.31 a	-	-	-	
	MA	MI	MN	NS	NY-W	ON	WI	NY-P	PA-R	VT
					'McIntosh'					
CG.4814	2.82 a	0.48 ab	0.93 ab	2.21 a	1.42 a	0.74 a	0.98 a	-	-	2.03 a
CG.7707	1.73 b	0.42 ab	1.18 a	1.45 ab	0.97 ab	0.56 a	0.52 bc	-	-	1.53 a
G.30N[2]	1.71 b	0.66 a	1.01 a	1.90 ab	1.32 ab	0.67 a	0.97 a	-	-	1.72 a
M.7 EMLA	0.96 b	0.20 b	0.10 b	1.14 b	0.87 ab	0.55 a	0.42 c	0.42 a	0.64 a	0.91 a
M.26 EMLA	1.23 b	0.20 b	0.93 ab	1.82 ab	1.06 ab	0.40 a	0.90 ab	0.75 a	0.83 a	-
Supporter 4	1.12 b	0.52 ab	0.84 ab	1.99 a	0.63 b	0.50 a	0.64 ab	0.79 a	0.83 a	1.31 a
CG.6210	-	0.63 ab	1.09 a	-	0.94 ab	-	-	-	-	1.63 a
G.30T[2]	-	0.56 ab	1.24 a	-	1.04 ab	-	-	-	-	1.70 a

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] G.30N was originally propagated from stool beds, and G.30T originally came from tissue cultured plants.

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Table 7. Average (2001-03) weight (g) of fruit harvested from 'Fuji' and 'McIntosh' apple trees by location on various rootstocks through the first five growing seasons (1999-2003) as part o□the 1999 □□-1□0 □e□i □war□□ootstock □rial□ □llvalues are least-s□uares □eans a□□ste□ □or□issing subclasses□

Rootstock	CA	KY	NC	OH	PA-B	WA	MO	SC	UT
					□□□i□				
CG.4814	198 a	164 a	202 a	157 a	200 a	221 a	211 a	177 a	171 b
CG.7707	197 a	198 a	203 a	139 a	215 a	239 a	206 a	-	193 ab
G.30N[2]	195 a	199 a	207 a	174 a	204 a	260 a	-	-	193 ab
M.7 EMLA	187 a	177 a	180 a	127 a	206 a	262 a	219 a	-	206 a
M.26 EMLA	204 a	179 a	192 a	104 a	201 a	201 a	208 a	180 a	185 ab
Supporter 4	200 a	161 a	204 a	227 a	193 a	248 a	-	186 a	-
CG.6210	195 a	-	190 a	235 a	-	235 a	-	-	-
G.30T[2]	199 a	-	250 a	198 a	-	249 a	-	-	-

	MA	MI	MN	NS	NY-W	ON	WI	NY-P	PA-R	VT
					□□c□nosh□					
CG.4814	154 a	180 a	138 ab	138 ab	157 a	167 a	164 b	-	-	166 a
CG.7707	168 a	192 a	146 ab	150 a	178 a	166 a	204 a	-	-	173 a
G.30N[2]	169 a	185 a	150 a	119 b	171 a	161 a	163 b	-	-	168 a
M.7 EMLA	163 a	186 a	111 b	141 ab	174 a	165 a	163 b	154 ab	211 a	166 a
M.26 EMLA	168 a	189 a	139 ab	137 ab	180 a	173 a	152 b	146 b	213 a	-
Supporter 4	169 a	197 a	146 ab	152 a	169 a	154 a	174 b	170 a	213 a	173 a
CG.6210	-	173 a	147 a	-	174 a	-	-	-	-	158 a
G.30T[2]	-	199 a	126 ab	-	170 a	-	-	-	-	165 a

[1] Mean separation within column and cultivar by Tukey's HSD (P = 0.05).

[2] G.30N was originally propagated from stool beds, and G.30T originally came from tissue cultured plants.

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