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Performance of 'Gala' Apple on Four Semi-dwarf Rootstocks: A Five-year Summary of the 1994 NC-140 Semi-dwarf Rootstock Trial

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Abstract

In 1994, trees of 'Gala' apple (*Malus x domestica* Borkh.) on 4 semi-dwarf rootstocks were planted at 24 sites in North America according to the guidelines established for cooperative testing by the North Central Regional Cooperative Project (NC-140). The four rootstocks were P.1, V.2, G.30, and M.26 EMLA. Tree losses were greatest for G.30 and M.26 EMLA. Trunk cross-sectional area was generally largest for trees on P.1 and smallest for trees on G.30. Tree height was usually greatest for P.1 and tree spread was usually smallest for M.26 EMLA. Although results were not consistent for all sites, yield and yield efficiency (YE) tended to be highest for G.30 and lowest for P.1. When adjusted for number of fruit per tree, fruit size was influenced by rootstock at only 7 sites. Trees on P.1 produced the smallest fruit at 5 of those 7 sites.

Introduction

During the past 30 years, North American apple producers have gradually increased the number of trees planted per hectare. This transition has required size-controlling rootstocks. Although recent rootstock testing has emphasized dwarfing rootstocks, there is still a place for semi-dwarfing rootstocks. Some growers question the profitability of intensive orchards on dwarfing rootstocks, with high establishment costs, especially for processing cultivars. Semi-dwarf rootstocks may also be desirable for weak-growing or spur-type cultivars, especially on non-vigorous or replant sites.

There are currently three widely used semi-dwarf rootstocks, but all three have serious faults. MM.111 produces trees that are nearly as large as seedling rootstocks; it produces burrknots, and is non-precocious. M.7 produces an abundance of root suckers, and is relatively non-precocious. Trees of many cultivars on M.7 tend to lean, especially on windy sites. M.7 may also lack adequate cold tolerance in northern climates. MM.106 is usually the most dwarfing and most productive of the semi-dwarf rootstocks, but its use is restricted due to unacceptably high tree mortality caused by collar rot (Phytophthora sp.) and brown line necrosis (1, 6). MM.106 performs best on well-drained soils. A series of precocious semi-dwarf rootstocks, providing a range of vigor, and tolerant to biotic and abiotic stresses is needed.

Previous regional rootstock trials have included both dwarf and semi-dwarf rootstocks with a wide range of vigor planted at the same spacing at all sites. Results from such trials may have been biased because the growth and productivity of a tree were influenced by size of adjacent trees. These research plantings also are difficult to manage because trees varying in size and productivity require different chemical thinning programs, different sprayer nozzling, and different amounts of prun-

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Table 1. Location and cooperators in the 1994 semi-dwarf rootstock trial.

Location	Cooperator	Planting Location
(AR) Arkansas	Curt R. Rom	Fayetteville
(BC) British Columbia	Cheryl Hampson	Summerland, Canada
(GA) Georgia	Stephen Myers, Joseph Garner	Blairsville
(IA) Iowa	Paul A. Domoto	Ames
(IL) Illinois	Mosbah M. Kushad	Urbana
(IN) Indiana	Peter Hirst	West Lafayette
(KY) Kentucky	Gerald R. Brown	Princeton
(ME) Maine	James R. Schupp	Monmouth
(MI) Michigan	Ronald L. Perry	Clarkesville
(NB) New Brunswick	Jean-Pierre Privé	Bouctouche, Canada
(NJ) New Jersey	Winfred P. Cowgill, Jr.	Pittstown
(NC) North Carolina	Michael Parker, Richard Unrath	Fletcher
(NYG) New York	Terence Robinson	Geneva
(NYH) New York	Edward Stover, Terence Robinson	Highland
(OH) Ohio	David C. Ferree	Wooster
(ONT) Ontario	John Cline	Simcoe, Canada
(OR) Oregon	E. Mielke	Hood River
(PA) Pennsylvania	George M. Greene	Biglerville
(SC) South Carolina	Gregory L. Reighard	Clemson
(TN) Tennessee	Charles A. Mullins	Crossville
(UT) Utah	J. Lamar Anderson	Farmington
(VA) Virginia	Richard P. Marini	Blacksburg
(WA) Washington	Bruce H. Barritt	Wenatchee
(WI) Wisconsin	Teryl Roper	Sturgeon Bay

ing, irrigation, and fertilizer. Inappropriate tree spacing may have influenced growth and productivity of trees at some locations. Tree size varied with location (10, 11). Therefore, trees were spaced too closely at some sites and required severe pruning to prevent tree crowding. Trees growing at less vigorous sites may not have filled their space and therefore required minimal pruning. Pruning severity can greatly influence the size and productivity of young trees (7).

In this study four semi-dwarf rootstocks were evaluated at 24 sites representing a wide range of growing conditions. Additionally, trees were planted at spacings appropriate for the site. Reported here are the results after five growing seasons.

Materials and Methods

TRECO, INC., Woodburn, OR, propagated all trees and the scion was 'Treco Red Gala #42.' Trees were planted at 24 sites during the late winter or spring of 1994. Cooperators and locations are listed in Table 1. Trees were planted in a randomized complete block design at each site. Trees were assigned to blocks on the basis of trunk diameter measured before planting. Because trunk size was confounded with block, trunk size was considered to be a treatment. Most sites had 10 trees of each of four rootstocks, but four sites did not receive trees on P.1. Each cooperator planted 10 pollinizer trees on M.26 EMLA, but the cultivars were not the same at all sites. Each cooperator had a choice of two spacings: 4.0 x 6.0 m could be selected for low-vigor sites and 5.0 x 7.0 m for high-vigor sites. Trees were planted with the bud unions 5 cm above the soil surface. Trees were supported to a height of about 2.1 m and were managed as vertical axes (5). Pest, fertility, and water management followed local recommendations.

Trunk circumference or diameter of each tree was measured each fall and trunk cross-sectional area (TCSA) was calculated. Tree height and canopy spread were

Table 2. Survival (% alive) of 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks after five growing seasons. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	100	100	90	100	100	90 a	100
V.2	100	100	100	100	100	80 a	100
G.30	80	100	90	100	90	10 b	100
M.26 EMLA	80	100	70	100	100	50 ab	100
P-value	0.129	1.000	0.082	1.000	0.786	0.001	1.000
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	100	90	90 a	100	90 a	100	100
V.2	100	100	100 a	100	70 ab	100	100
G.30	100	80	50 b	100	90 a	100	100
M.26 EMLA	100	100	90 a	100	50 b	100	100
P-value	1.000	0.273	0.001	1.000	0.001	1.000	1.000
	PA	SC	TN	UT	VA	WI	
P.1	100	90 a	90 ab	90 a	100 a	90	
V.2	90	80 a	90 ab	100 a	90 a	100	
G.30	90	80 a	100 a	60 b	40 b	100	
M.26 EMLA	80	50 b	70 b	70 ab	80 a	100	
P-value	0.418	0.014	0.024	0.008	0.001	0.786	
	KY	NB	NYH	WA			
V.2	90	100	100	100			
G.30	90	100	80	100			
M.26 EMLA	10	100	90	100			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test (P = 0.05).

measured during the fall of 1998. Some cooperators harvested fruit in 1995, and all cooperators harvested fruit in 1996. The total number of fruit per tree and yield (kg/tree) were recorded each year and used to calculate average fruit weight (FW). Rootsuckers were counted and removed each fall.

The cooperator from Virginia organized data collection and performed statistical analyses. The experimental design and data analyses are were the same as for the 1994 NC-140 dwarf apple rootstock planting, where they are described in detail (6).

Results and Discussion

Tree survival. No tree mortality occurred at 8 sites, whereas 10 sites lost at least 30% of the trees on one or more rootstocks (Table 2). At least 70% of the trees on P.1 and V.2 survived at all sites. Eleven sites reported no tree losses for G.30 and M.26 EMLA. However, at least 50% mortality was reported for G.30 in AR, NJ, VA and at least 50% mortality was reported for M.26 EMLA in IN, OH, SC and KY. In previous rootstock trials, tree mortality was also greater for M.26 EMLA than for P.1 or V.2 (2, 4, 10). The cause of tree death is not known for most sites. Cooperators reporting causes of tree death indicated that the primary cause of mortality for G.30 and M.26 EMLA was from breakage at the bud union during windstorms. At some sites (OH) tree loses on M.26 EMLA were due to fireblight.

Tree size. TCSA varied greatly from one site to another (Table 3). Sites with the smallest TCSA included BC, ME, ONT, WA, WI, KY, and NB, whereas the largest TCSA was produced in AR, NJ, UT, and VA. There was a strong site x rootstock in-

Table 3. Trunk cross-sectional area (cm^2) after five growing seasons for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	98.1 a	17.8	48.7 a	65.8 a	47.0 a	39.1	25.6
V.2	55.9 b	16.3	46.5 a	40.1 b	37.9 ab	40.7	22.2
G.30	40.7 c	24.7	36.0 ab	35.4 b	30.6 b	26.6	28.0
M.26 EMLA	64.2 b	16.6	33.7 b	41.0 b	39.8 ab	35.9	21.4
P-value	0.001	0.196	0.001	0.001	0.005	0.531	0.421
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	60.9 a	38.4 a	68.9 a	49.9 a	54.4 a	40.9 a	68.1 a
V.2	43.7 b	41.9 a	57.1 ab	37.8 b	44.8 ab	33.8 ab	47.1 b
G.30	31.8 b	35.9 ab	44.0 b	34.1 b	39.1 b	34.1 ab	47.8 b
M.26 EMLA	41.8 b	24.2 b	59.7 a	40.9 ab	44.6 ab	27.9 b	43.7 b
P-value	0.001	0.001	0.005	0.001	0.001	0.038	0.001
	PA	SC	TN	UT	VA	WI	
P.1	57.2 a	48.9	46.1 a	59.6 a	62.4 a	31.6	
V.2	34.4 b	39.0	35.2 ab	41.2 ab	52.8 ab	27.5	
G.30	32.7 b	37.1	27.4 b	36.9 b	43.8 b	31.2	
M.26 EMLA	33.5 b	42.9	37.6 ab	47.3 ab	54.1 ab	28.6	
P-value	0.001	0.066	0.001	0.001	0.011	0.754	
	KY	NB	NYH	WA			
V.2	31.9	25.3	---	21.6			
G.30	35.3	28.7	---	24.1			
M.26 EMLA	29.4	24.8	---	16.7			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

teraction; TCSA was not significantly influenced by rootstock at IN, ME, and WI. At 16 of 20 sites, trees on P.1 had the largest TCSA and trees on G.30 had the smallest TCSA at 13 of the 20 sites. M.26 EMLA, P.1 and V.2 were included in a rootstock trial with 3 cultivars in Washington (3). Depending on cultivar, TCSA for P.1 was 40% to 70% larger than for M.26 EMLA. TCSA for V.2 was similar to M.26 EMLA for 'Golden Delicious' and 'Delicious,' but was 48% larger than M.26 EMLA for 'Granny Smith.' In Ohio (4), TCSA was greatest for P.1, smallest for M.26 EMLA and intermediate for V.2. When P.1 and M.26 EMLA were compared after five years at nine sites, TCSA of P.1 was 20 to 40% greater than for M.26 EMLA (3).

Tree height was influenced ($P = 0.05$) by rootstock at 12 of the 19 sites reporting data (Table 4). In general, P.1 produced taller trees than the other rootstocks. Of the 19 sites reporting data, rootstock influenced canopy spread at only 10 sites (Table 5). At most sites, trees on M.26 EMLA had the smallest spread. Tree height and spread were greater for P.1 than for M.26 EMLA in the 1984 NC-140 rootstock trial (10). In Ohio trials, 'McIntosh' and 'Delicious' tree height and spread were similar for P.1, V.2, and M.26 EMLA, but for 'Rome' V.2 was smaller than the other two rootstocks (4). The rootstock G.30 has not been widely tested outside of New York. In two of five trials with 'Empire' as the scion, trees on G.30 were slightly larger than trees on M.7 and in three trials trees on G.30 were slightly smaller than trees on M.7 (12).

Fruit production. Eight of the 23 sites reported no yield in 1995 and three sites re-

Table 4. Tree height (cm) after five growing seasons for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	473 a	302 ab	411 a	475 a	380 a	406	337
V.2	405 a	281 b	405 ab	370 b	353 ab	439	348
G.30	353 b	333 a	389 ab	416 b	330 b	408	355
M.26 EMLA	412 a	276 b	358 b	378 b	324 b	415	314
P-value	0.001	0.005	0.031	0.001	0.007	0.202	0.098
	MI	**NC**	**NJ**	**NYG**	**OH**	**ONT**	**OR**
P.1	443 a	362	480	---	351 a	420 ab	472 a
V.2	404 ab	352	460	---	350 a	432 ab	394 b
G.30	362 b	354	430	---	321 ab	449 a	429 ab
M.26 EMLA	370 b	328	439	---	298 b	384 b	385 b
P-value	0.001	0.292	0.107	---	0.034	0.003	0.001
	PA	**SC**	**TN**	**UT**	**VA**	**WI**	
P.1	418 a	337	---	454 a	424	319	
V.2	355 b	355	---	408 ab	419	305	
G.30	362 b	364	---	384 b	386	320	
M.26 EMLA	356 b	338	---	421 ab	409	311	
P-value	0.003	0.397	---	0.022	0.614	0.835	
	KY	**NB**	**NYH**	**WA**			
V.2	---	---	---	323			
G.30	---	---	---	320			
M.26 EMLA	---	---	---	266			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

ported no yield in 1996 (data not shown). Highest cumulative yields were reported for AR, IA, IL, SC, VA and KY, whereas those sites with low yields included GA, ME, PA, and NB (Table 6). Cumulative yield was not significantly ($P = 0.05$) influenced by rootstock at AR, GA, IN, ONT, SC, or VA. Trees on V.2 were most productive at some sites, but at most sites G.30 was most productive and P.1 was least productive. Cumulative YE was highest at BC, IA, IL, MI, SC, WI, KY, and WA, whereas low values were reported for AR, IN, ME, NC, NJ, PA, and NB (Table 7). Cumulative YE was not influenced by rootstock at GA, IN, ONT, and VA. Of the 14 sites where rootstock influenced yield, G.30 was most productive at 13 sites and P.1 was least productive at 13 sites.

Average fruit weight (FW) was greatest at BC, MI, NJ, ONT, UT, and WA, and lowest at IN, NC, PA, TN, and NB, but was influenced by rootstock at only NJ, OH, and VA (Table 8). Two analyses of covariance were performed to determine if the number of fruit harvested per tree influenced FW. For the first analysis, fruit/tree was added to the model as the covariate; the site x number of fruit interaction term was included to evaluate the hypothesis that the linear relationship between FW and fruit/tree was the same for all sites. The interaction was significant ($P = 0.001$), indicating that this relationship was not the same for all sites, so means for FW could not be adjusted for number of fruit/tree. The second analysis involved the addition of fruit/tree and the interaction of fruit/tree x rootstock. Because the interaction was significant ($P = 0.025$), the linear relationship between FW and fruit/tree varies for different rootstocks, and analysis of co-

Table 5. Average canopy diameter (cm) after five growing seasons for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	368	149 b	289 ab	384 a	328	314	289 b
V.2	368	136 b	301 a	335 b	338	299	327 ab
G.30	342	196 a	270 ab	365 ab	324	344	354 a
M.26 EMLA	376	148 b	254 b	340 ab	316	293	296 b
P-value	0.259	0.001	0.041	0.008	0.564	0.505	0.001
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	356 a	242 b	451	---	336	366 a	386 a
V.2	332 ab	290 a	456	---	339	362 a	356 ab
G.30	324 ab	289 a	440	---	325	364 a	343 ab
M.26 EMLA	311 b	221 b	437	---	312	310 b	338 b
P-value	0.040	0.001	0.654	---	0.547	0.001	0.012
	PA	SC	TN	UT	VA	WI	
P.1	358	304	---	394 a	357	287	
V.2	341	301	---	365 ab	359	295	
G.30	356	302	---	370 ab	359	319	
M.26 EMLA	322	266	---	342 b	345	289	
P-value	0.131	0.242	---	0.038	0.846	0.158	
	KY	NB	NYH	WA			
V.2	---	---	---	265			
G.30	---	---	---	291			
M.26 EMLA	---	---	---	211			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

variance could not be used to adjust the FW LSmeans for varying crop loads. When averaged over all 30 sites in the 1984 NC-140 trial, yield/tree, YE, and FW did not differ for P.1 and M.26 EMLA (11). In Ohio, yield and YE were similar for 'McIntosh' and 'Delicious' on V.2, P.1 and M.26 EMLA, but 'Rome' yield was greatest for M.26 EMLA, and least for V.2 (4). In Washington trials, yield for 'Golden Delicious' and 'Delicious' were similar for trees on P.1, V.2, and M.26 EMLA, but V.2 was most productive with 'Granny Smith' (3). For 'Golden Delicious' and 'Delicious' V.2 had the highest YE and P.1 tended to have the lowest YE. 'Granny Smith' YE was similar for all three rootstocks. Averaged over 9 sites, the yield and YE of 'Gala' trees were 10% and 37% greater for M.26 EMLA than for P.1, respectively (2). Trials with 'Empire' in New York indicate that G.30 is substantially more productive and has higher YE than M.7 (12).

Conclusions

At low vigor sites, rootstocks tended to have little influence on tree size. Thus, choice of rootstock may be not be critical at locations where poor tree growth is expected. Of the four semi-dwarf rootstocks evaluated in this trial, P.1 tended to produce the largest trees and the lowest yields and yield efficiencies. At most locations V.2, G.30, and M.26 EMLA produced trees of similar size, but G.30 tended to have the highest yields and yield efficiencies

Literature Cited

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Table 6. Cumulative yield (Kg/tree) after five growing seasons for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	48.0	29.7 b	14.2	52.3 b	47.0 c	35.8	5.6 b
V.2	56.4	30.0 b	26.1	61.0 a	72.4 b	24.6	20.5 ab
G.30	38.9	65.2 a	17.8	69.9 a	85.3 a	58.7	31.9 a
M.26 EMLA	64.3	33.2 b	19.0	61.6 a	61.2 bc	32.2	11.8 b
P-value	0.063	0.001	0.238	0.020	0.001	0.148	0.001
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	39.2 b	12.4 b	10.4 b	36.8 b	70.6 a	29.3	31.0 b
V.2	47.6 a	34.4 a	37.4 a	47.2 a	64.3 a	33.4	34.5 b
G.30	60.9 a	41.3 a	31.7 a	49.7 a	49.8 b	28.2	48.4 a
M.26 EMLA	42.9 b	17.2 b	13.3 b	36.4 b	54.2 b	26.8	39.0 b
P-value	0.001	0.001	0.001	0.001	0.001	0.666	0.012
	PA	SC	TN	UT	VA	WI	
P.1	4.8 b	52.8	16.5 b	33.9 b	50.5	30.0	
V.2	17.9 a	55.9	28.7 ab	57.8 a	60.7	43.4	
G.30	20.0 a	65.9	31.9 a	46.1 a	56.8	61.3	
M.26 EMLA	14.6 a	47.1	30.0 a	37.3 b	64.1	39.1	
P-value	0.001	0.067	0.041	0.001	0.131	0.001	
	KY	NB	NYH	WA			
V.2	48.3	11.0	37.9	26.7			
G.30	51.0	8.1	50.1	41.2			
M.26 EMLA	85.3	4.9	32.3	26.9			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

Table 7. Cumulative yield efficiency (Kg/cm^2) after five growing seasons for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	0.49 b	1.60 c	0.29	0.80 c	1.00 c	0.97	0.23 c
V.2	0.82 a	1.82 bc	0.56	1.52 b	1.93 b	0.63	0.91 ab
G.30	0.33 b	2.63 a	0.48	2.03 a	2.62 a	0.69	1.14 a
M.26 EMLA	0.83 a	2.04 b	0.53	1.50 b	1.58 b	0.65	0.54 b
P-value	0.023	0.001	0.446	0.001	0.001	0.322	0.001
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	0.65 b	0.52 b	0.20 b	0.75 b	0.63	0.79	0.46 b
V.2	1.06 b	0.81 ab	0.62 a	1.26 a	0.66	1.00	0.75 ab
G.30	1.93 a	1.23 a	0.71 a	1.49 a	0.50	0.83	1.01 a
M.26 EMLA	1.00 b	0.64 b	0.24 b	0.91 b	0.33	0.96	0.91 a
P-value	0.001	0.001	0.004	0.001	0.410	0.581	0.007
	PA	SC	TN	UT	VA	WI	
P.1	0.08	1.04 b	0.37 b	0.61 b	0.83 b	0.97	
V.2	0.50	1.42 ab	0.81 a	1.40 a	0.82 b	1.58	
G.30	0.64	1.63 a	1.15 a	0.94 a	1.41 a	1.99	
M.26 EMLA	0.50	1.10 b	0.74 a	0.68 b	1.09 ab	1.40	
P-value	0.013	0.004	0.001	0.001	0.087	0.001	
	KY	NB	NYH	WA			
V.2	1.55	0.45	- - -	1.39			
G.30	1.42	0.28	- - -	1.83			
M.26 EMLA	2.79	0.20	- - -	1.77			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

Table 8. Mean fruit weight (g/fruit) for 1997 and 1998 for surviving 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks. All values are least squares means, adjusted for missing cells. The interaction of rootstock and site was significant. Least squares means are presented for KY, NB, NYH and WA, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	AR	BC	GA	IA	IL	IN	ME
P.1	140	159 c	124 b	147	151	109	128 b
V.2	143	170 bc	141 ab	136	143	124	146 a
G.30	147	185 a	144 a	151	146	116	134 ab
M.26 EMLA	126	175 ab	140 ab	145	145	127	139 ab
P-value	0.146	0.001	0.016	0.093	0.556	0.219	0.016
	MI	NC	NJ	NYG	OH	ONT	OR
P.1	156	127	140	144 ab	150 ab	157	160
V.2	157	119	148	132 b	167 b	157	173
G.30	157	133	147	141 ab	138 ab	168	173
M.26 EMLA	160	130	151	150 a	132 a	163	165
P-value	0.969	0.096	0.338	0.034	0.005	0.142	0.075
	PA	SC	TN	UT	VA	WI	
P.1	114	138 b	117	162	140	156	
V.2	131	147 ab	114	158	146	139	
G.30	142	142 ab	118	158	132	142	
M.26 EMLA	142	155 a	107	159	151	143	
P-value	0.072	0.781	0.451	0.782	0.166	0.172	
	KY	NB	NYH	WA			
V.2	142	102	149	159			
G.30	149	110	147	165			
M.26 EMLA	137	106	151	157			

[z]*P*-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Least squares means within a site were compared with Tukey's test ($P = 0.05$).

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