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Performance of 'Gala' Apple on Four Semi-Dwarf Rootstocks: A Ten-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 20 locations 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. Four of the locations did not receive trees on P.1 rootstock. Tree losses were greatest for G.30. Trunk cross-sectional area (TCSA) was generally largest for P.1 and smallest for G.30. TCSA was most variable for M.26; at some sites, trees on G.30 had larger trunks than trees on M.26. 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 tended to be highest for G.30 and lowest for P.1. Although the effect of rootstock was not consistent, cumulative yield efficiency tended to be lower for G.30 than for M.26 or V.2. Trees on P.1 and G.30 produced the most root suckers.

The North American apple industry has been increasing plantings of high density orchards utilizing dwarf rootstocks. However, for several reasons, some apple producers are still planting trees on semi-dwarfing rootstocks. The vigor of semi-dwarf rootstocks may be desirable with weak-growing cultivars or on replant sites. Some growers are reluctant to plant processing cultivars on dwarfing rootstocks because establishment costs for high tree numbers plus the cost of support systems are high. Some growers are also concerned about the fire blight susceptibility of widely available dwarf rootstocks.

The most widely planted semi-dwarf rootstocks include MM.111, M.7, and MM.106, but they all have problems. None of these rootstocks have the precociousness or the high yield efficiency associated with the more popular dwarf rootstocks (1, 13, 14, 15). In addition, MM.111 provides little vigor control and is prone to burrknot development, whereas M.7 produces an abundance of root suckers and when budded to certain cultivars, trees may lean (11). MM.106 is the most dwarfing and most productive of the semi-dwarf rootstocks, but its use is limited due to high tree mortality associated with collar rot and brown line necrosis (1, 9). There is a need for rootstocks in the semi-dwarf class that provide a range of vigor and tolerance to biotic and abiotic stresses.

In this study four semi-dwarf rootstocks were evaluated at 20 locations representing a wide range of growing conditions. Reported here are the results after 10 growing seasons; a five-year summary was previously published (8).

Materials and Methods

All trees were propagated by TRECO, Inc., Woodburn, OR and the scion was 'Treco Red Gala #42'. Trees were planted at 21 locations during the spring of 1994. Cooperators and

[1] We gratefully acknowledge the support of TRECO Nursery, Woodburn, Oregon for growing the trees and IDFTA for financial support.

[2] For locations, see Table 1.

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 in block, trunk size was considered 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 pollinizing cultivars were not the same at all sites. Each cooperator had a choice of two spacings: 4.0 x 6.0 m for low-vigor sites and 5.0 x 7.0 m for high-vigor sites. Trees were planted with the bud union at 5 cm above the soil surface. Trees were supported to a height of about 2.1 m and were managed as vertical axe (5). Pest, fertility, and water management were per local recommendations.

Trunk circumference of each tree was measured each fall at 25 cm above the soil line and trunk cross-sectional area (TCSA) was calculated. Tree height and canopy spread were measured during the fall of 2003. Some locations harvested fruit in 1995, and all sites harvested fruit in 1996. Average fruit weight (FW) and yield (kg/tree) were reported each year. Cumulative yield efficiency (CYE) was calculated for each tree by dividing the cumulative yield by the TCSA. Root suckers were counted and removed each fall by some cooperators. In 2003, the percentage of rootstock circumference above ground covered with burrknots was visually estimated for each

Table 1. Location and cooperators originally participating 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	W. Lafayette
(KY) Kentucky	Gerald Brown, Joseph Masabni	Princeton
(ME) Maine	James R. Schupp, Renae Moran	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, Jim Schupp	Highland
(OH) Ohio	David C. Ferree	Wooster
(ONT) Ontario	John Cline	Simcoe, Canada
(OR) Oregon	E. Mielke	Hood River
(PA) Pennsylvania	George Greene, Robert Crassweller	Biglerville
(SC) South Carolina	Gregory L. Reighard	Clemson
(TN) Tennessee	Charles A. Mullins	Crossville
(VA) Virginia	Richard Marini	Blacksburg
(WA) Washington	Bruce H. Barritt	Wenatchee
(WI) Wisconsin	Teryl Roper	Sturgeon Bay

tree by six cooperators. Each tree was visually evaluated for scion rooting and those trees that were scion rooted were deleted from the data set. Most cooperators reported the cause of tree mortality. Fifteen locations received all four rootstocks and data were subjected to statistical analyzes. Four locations (KY, NB, NYH, and WA) did not receive P.1, so data were not included in the analysis, but means are presented for comparison. TCSA data from WA were not reported for the tenth year, so means for TCSA and YE are not reported for WA.

The cooperator from Virginia organized data collection from all cooperators and performed the statistical analyses. Because the experimental design was a replicated randomized complete block, the error term used to test location was block nested in location. Data were subjected to analysis of variance (ANOVA) using SAS's Mixed Procedure; block was considered a random effect and rootstock and location were considered fixed effects. The Slice Option was used to compare least-squares means (LSmeans) for rootstocks within each site (6). The site x rootstock interaction was significant for all response variables. Because SAS does not support a method of performing a multiple comparison with the Slice Option, a macro was written to compare rootstocks within each site with Tukey's HSD (P = 0.05) (7). The Tukey's test was computed using the variances and covariances associated with a specific rootstock within a site. Four sites did not have P.1 and those sites with open cells could not be included in the statistical analyses. To generate LSmeans for those sites, a second ANOVA was performed for each response variable with data from all sites and, for comparative purposes, the LSmeans for those sites are presented in the tables.

Results and Discussion

Tree survival. Five locations had no tree mortality, whereas 6 locations lost at least 50% of the trees on one or more rootstocks (Table 2). Five locations reported no tree mortality, and at most locations tree survival was best on P.1. No mortality was reported for P.1 in 10 of the 15 locations with P.1. Tree mortality was greatest with G.30; at least one tree was lost at 14 of the 19 locations with G.30. Tree loss was due primarily to wind breakage at the bud union. Tree survival was at least 90% on V.2 and M.26 at 14 and 11 locations, respectively. For M.26, tree losses were due primarily to fire blight.

Tree size. TCA varied greatly from one location to another (Table 3). Locations with the smallest trunks were BC, ME, KY, and NB, whereas locations with the largest trunks included IA, MI, IL, NJ, NYG, and VA. At most locations trees on P.1 had the largest trunks and those on G.30 had the smallest trunks. However at the six locations with the smallest average TCA, the trunks of trees on G.30 were as large, or larger, than trees on M.26. Similar results were reported after five years (8). To show this graphically, TCA of trees on G.30 were plotted against TCA of trees on M.26 (Fig. 1). If trees on both rootstocks had the same TCA, all points would lie along the line of unity. Only six points were located below the line, indicating that trees on G.30 had larger trunks than trees on M.26 and all six of these locations had smaller than average TCA. The relative vigor of G.30 seems more consistent across a wide range of growing conditions than M.26 because TCA of M.26 varied by a factor of more than 4 (33.4 cm^2 in BC to 139.9 cm^2 in VA), whereas G.30

Figure 1. Scatter plot of mean trunk cross-sectional area (cm^2) of 'Gala' trees on M.26 EMLA vs. G.30 at 18 locations after 10 years of growth.

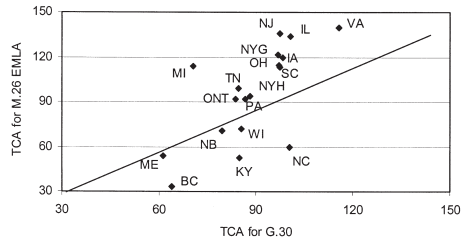

Table 2. Survival (% alive) of 'Gala' trees on P.1, V.2, G.30 and M.26 EMLA rootstocks after ten growing seasons. All values are least-squares means, adjusted for missing values. The interaction of rootstock and site was significant. LSmeans are presented for KY, NB, NYH, and WA but because these sites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

Rootstock	BC	IA	IL	ME	MI	NC
P.1	100	100	100	100	100	90
V.2	100	100	100	100	100	90
G.30	100	100	90	100	100	90
M.26 EMLA	100	100	100	100	100	90
P-value	*1.000*	*1.000*	*0.827*	*1.000*	*1.000*	*1.000*

	NJ	NYG	OH	ONT	PA	SC
P.1	80	100	100 a	100	90	90 a
V.2	100	100	70 b	100	80	80 ab
G.30	50	90	80 ab	90	90	60 bc
M.26 EMLA	80	100	40 c	100	80	50 c
P-value	*0.652*	*0.808*	*0.001*	*0.881*	*0.829*	*0.033*

	TN	VA	WI
P.1	100	100 a	50 b
V.2	100	90 a	80 a
G.30	100	30 b	40 b
M.26 EMLA	100	80 a	50 b
P-value	1.000	0.001	0.048

	KY	NB	NYH	WA
V.2	90	90	90	70
G.30	90	80	70	80
M.26 EMLA	20	90	70	80

[z]P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within site by Tukey's test (P = 0.05).

varied by a factor of only 1.9 (61.1 cm^2 in ME to 115.9 cm^2 in VA).

Tree height and spread are functions of pruning and site vigor, as well as rootstock vigor. Tree height was significantly affected by rootstock at less than half of the locations (Table 4). The tallest trees were located in IA, NJ, and NYG and the widest trees were in NJ, NYG and VA (Table 5). The shortest trees were in BC and KY, and the narrowest trees were in BC. Rootstock did not consistently affect tree height, but P.1 produced the tallest trees at about half the locations. Tree spread was significantly affected by rootstock at 12 locations and the highest values for tree spread were reported for P.1 at 10 locations, whereas spread was most often smallest for trees on M.26 (Table 5).

Fruit Production. Cumulative yield (CY)) was significantly affected by rootstock at half

Table 3. Trunk cross-sectional area (cm^2) after ten 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 values. The interaction of rootstock and site was significant. LSmeans are presented for KY, NB, and NYH, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	BC	IA	IL	ME	MI	NC
P.1	37.7 b	206.7 a	165.5 a	84.4 a	141.3 a	123.1 a
V.2	34.5 b	104.9 b	139.4 ab	59.7 b	105.9 b	117.7 b
G.30	63.8 a	98.3 b	100.9 b	61.1 b	70.5 c	100.5 b
M.26 EMLA	33.4 b	119.8 b	134.1 ab	53.8 b	113.6 b	59.6 c
Mean	42.4	132.4	135.0	64.8	107.6	100.2
P-value	0.009	0.001	0.001	0.020	0.001	0.001
	NJ	NYG	OH	ONT	PA	SC
P.1	198.7 a	151.0 a	143.1 a	100.4 a	193.9 a	107.2
V.2	145.0 b	113.6 b	105.4 b	89.8 ab	91.9 b	89.5
G.30	97.5 c	96.9 b	97.1 b	83.8 b	86.6 b	97.4
M.26 EMLA	136.0 c	121.4 b	114.6 b	92.2 ab	91.9 b	113.3
Mean	144.3	120.7	115.0	91.5	116.1	101.8
P-value	0.001	0.001	0.001	0.452	0.001	0.254
	TN	VA	WI	KY	NB	NYH
P.1	134.8 a	170.3 a	124.2 a	- - -	- - -	- - -
V.2	93.5 ab	130.9 bc	90.0 ab	88.8	70.4	92.7
G.30	84.6 b	115.9 c	85.4 b	84.9	79.6	88.3
M.26 EMLA	98.8 ab	139.9 b	72.2 b	52.9	70.8	93.6
Mean	102.9	139.2	92.9	- - -	- - -	- - -
P-value	0.001	0.001	0.004	- - -	- - -	- - -

[z] P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within site by Tukey's test (P = 0.05).

the locations (Table 6). Locations with high yields included IA, IL, MI, NYG, and VA, whereas locations with low yields included BC, ME, PA, TN, UT, NC, NB and WA. Rootstock affected cumulative yield inconsistently, but at most locations V.2 was more productive than M.26. Although the difference was usually not significant, G.30 had higher cumulative yield than M.26 at 13 of 18 locations. In previous trials, P.1 was consistently less productive than M.26 (2, 3, 4), but in this trial CY was similar for P.1 and M.26 at many locations. Cumulative yield efficiency was highest in BC, IA, and SC and lowest in ME, NC, NJ, TN, NB and VA (Table 7). CYE was significantly affected by rootstock at only seven locations. Although the effect of rootstock was not consistent, CYE tended to be lower for G.30 than for M.26 or V.2. These results do not agree with results after the first five years of this trial. Earlier, G.30 generally had the highest CYE and P.1 had the lowest CYE (8). These conflicting results indicate that G.30 is very efficient in the early years but may be no more efficient than M.26 over a 10-year period. These results also indicate

Table 4. Tree height (cm) after ten 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 values. The interaction of rootstock and site was significant. LSmeans are presented for KY, NB, and NYH, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	BC	IA	IL	ME	MI	NC
P.1	300 b	604 a	342	393	461	387 a
V.2	308 ab	462 b	324	379	437	405 a
G.30	343 a	475 b	310	361	432	378 a
M.26 EMLA	283 c	489 b	316	359	434	336 b
Mean	308	508	323	373	441	377
P-value	*0.002*	*0.001*	*0.359*	*0.162*	*0.257*	*0.022*
	NJ	NYG	OH	ONT	PA	SC
P.1	557	510	395	390	455 a	377 b
V.2	539	495	382	426	400 b	396 b
G.30	497	499	386	388	421 ab	513 a
M.26 EMLA	503	496	346	419	385 b	421 b
Mean	524	500	377	406	415	427
P-value	*0.92*	*0.797*	*0.330*	*0.995*	*0.001*	*0.001*
	TN	VA	WI	KY	NB	NYH
P.1	403	393	447 a	- - -	- - -	- - -
V.2	371	384	391 b	340	376	382
G.30	374	403	397 b	390	420	360
M.26 EMLA	336	376	350 b	262	360	352
Mean	371	389	396	- - -	- - -	- - -
P-value	*0.991*	*0.706*	*0.003*	- - -	- - -	- - -

[z]P-values were generated with the Slice Option of SAS to test equality of rootstocks within a site. Mean separation among rootstocks within sites by Tukey's test (P = 0.05).

that rootstock recommendations should not be developed with only five years of data.

Mean fruit weight (FW) was high in IL, ONT, and low in IA, MI, NC, NYG, OH, TN, VA, and NB (Table 8). FW was significantly affected by rootstock in only three locations and G.30 produced the largest fruit at two of those locations. FW is often negatively related to yield. When number of fruit per tree or crop density was used as covariates in a previous multi-location rootstock trial, analysis of covariance indicated that there was an interaction between location, rootstock and the covariate (10). At three of the four locations in that study, M.26 produced smaller fruit than M.9. Analysis of covariance for the present data also indicate a three-way interaction, so determining the true effect of rootstock on FW in 16 locations will be complicated.

Root suckers. In previous trials, the cumulative number of root suckers per tree was often reported (8, 13). However, in this study many cooperators did not report root suckers every year, so data are presented for only 2003 (Table 9). As in previous multi-location rootstock trials, root sucker production varied

Table 5. Average canopy diameter (cm) after ten 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. LSmeans are presented for KY, NB, and NYH, but because these sites did not have P.1 they were not included in the statistical analyses.[z]

Rootstock	BC	IA	IL	ME	MI	NC
P.1	192 b	479 a	449 a	376 a	384 a	360 a
V.2	217 ab	367 b	418 ab	343 b	368 ab	334 a
G.30	293 a	371 b	388 b	357 ab	328 b	329 a
M.26 EMLA	196 b	404 a	418 ab	323 b	343 b	262 b
Mean	224	405	530	350	356	321
P-value	*0.001*	*0.001*	*0.026*	*0.001*	*0.001*	*0.021*
	NJ	NYG	OH	ONT	PA	SC
P.1	553	471 a	403 a	323	483 a	381 b
V.2	561	427 b	374 ab	311	396 b	373 b
G.30	529	419 b	370 ab	283	417 b	428 a
M.26 EMLA	532	445 ab	339 b	302	391 b	385 b
Mean	544	440	372	305	422	392
P-value	*0.314*	*0.013*	*0.032*	*0.997*	*0.001*	*0.028*
	TN	VA	WI	KY	NB	NYH
P.1	415	466	470 a	- - -	- - -	- - -
V.2	358	446	395 bc	367	436	308
G.30	310	448	420 b	348	447	311
M.26 EMLA	328	456	368 c	205	426	302
Mean	353	454	413	- - -	- - -	- - -
P-value	*0.944*	*0.643*	*0.001*	- - -	- - -	- - -

[z]P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within site by Tukey's test (P = 0.05).

greatly from one location to another (8). Large numbers of root suckers were produced in only IL, NJ, PA, and VA, and root sucker production was significantly affected by rootstock in five locations. In most locations the number of root suckers per tree was lowest for M.26, highest for P.1 and G.30, and intermediate for V.2.

Burrknots. Burrknot severity was reported for only six locations (Table 10). The severity of burrknots was greatest in BC, which was also the only location where rootstock affected burrknot development. In BC, P.1 and V.2 produced the most burrknots. In a previous trial where seven rootstocks were compared, the scions of 'Gala' trees on P.1 and O.3 had the most burrknots and tress on M.27 produced the fewest burrknots (12).

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Table 6. Cumulative yield (Kg/tree) after ten 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 values. The interaction of rootstock and site was significant. LSmeans 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	BC	IA	IL	ME	MI	NC
P.1	107.5 b	314.2	231.9 b	119.4	424.9	91.3 b
V.2	125.9 ab	265.5	322.6 a	139.0	450.8	151.7 a
G.30	216.9 a	287.6	215.9 b	149.1	438.5	130.4 ab
M.26 EMLA	122.1 ab	284.6	300.9 ab	127.9	407.4	47.1 c
Mean	118.2	295.2	268.8	134.5	430.1	105.4
P-value	0.014	0.631	0.009	0.868	0.682	0.010
	NJ	NYG	OH	PA	SC	TN
P.1	211.1 a	291.6 ab	287.7 ab	103.2	242.9	52.0
V.2	153.2 b	349.6 a	364.3 a	162.4	233.2	108.2
G.30	114.4 c	231.0 b	238.1 b	197.4	228.0	101.2
M.26 EMLA	223.0 a	274.2 ab	165.7 c	147.9	189.0	84.4
Mean	178.2	287.1	263.6	151.8	223.2	86.2
P-value	0.007	0.016	0.001	0.089	0.609	0.457
	VA	WI	KY	NB	NYH	WA
P.1	423.1 a	166.2 b	- - -	- - -	- - -	- - -
V.2	395.2 a	258.8 a	334.9	151.6	332.9	70.1
G.30	152.4 c	194.2 ab	454.9	128.5	279.2	97.7
M.26 EMLA	316.9 b	157.7 b	265.4	140.3	233.2	72.7
Mean	321.8	194.2	- - -	- - -	- - -	- - -
P-value	0.001	0.032	- - -	- - -	- - -	- - -

[z] P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within sites by Tukey's test (P = 0.05).

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Table 7. Cumulative yield efficiency (kg/cm^2) after ten 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 vlaues. The interaction of rootstock and site was significant. LSmeans 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	BC	IA	IL	ME	MI	NC
P.1	5.3	4.1	3.0 b	2.2	2.8	2.0 ab
V.2	5.2	4.3	3.9 a	2.7	3.5	2.4 a
G.30	5.5	4.2	2.6 b	2.9	3.5	1.9 bc
M.26 EMLA	5.8	4.6	3.8 a	2.6	3.3	1.5 c
Mean	5.4	4.3	3.3	2.6	3.3	2.0
P-value	*0.181*	*0.351*	*0.001*	*0.126*	*0.062*	*0.004*
	NJ	NYG	OH	ONT	PA	SC
P.1	1.6	3.3 a	3.2 a	3.2	2.5	4.7
V.2	1.3	2.3 b	2.8 ab	3.3	3.0	4.6
G.30	1.5	2.4 b	2.6 ab	3.1	3.0	4.1
M.26 EMLA	1.7	2.8 ab	1.9 b	3.3	3.0	4.2
Mean	1.5	2.7	2.6	3.2	2.9	4.4
P-value	*0.638*	*0.017*	*0.001*	*0.973*	*0.273*	*0.230*
	TN	UT	VA	WI		
P.1	2.2	1.6	2.5 a	2.7 b		
V.2	2.6	2.0	2.4 a	3.4 a		
G.30	2.4	1.5	1.5 b	2.2 b		
M.26 EMLA	2.7	1.8	2.3 a	2.6 b		
Mean	2.5	2.2	2.7			
P-value	*0.418*	*0.480*	*0.011*	*0.005*		
	KY	NB	NYH	WA		
V.2	3.9	2.4	3.7	2.9		
G.30	3.7	2.4	3.2	3.0		
M.26 EMLA	4.9	2.2	3.3	3.0		

z P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within sites by Tukey's test (P = 0.05).

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Table 8. Mean fruit weight (g/fruit) for all fruiting years 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 values. The interaction of rootstock and site was significant. LSmeans 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	BC	IA	IL	ME	MI	NC
P.1	131 b	137	163	143 a	129	132
V.2	144 b	136	156	132 ab	133	133
G.30	164 a	135	147	120 b	123	127
M.26 EMLA	148 b	138	159	119 b	136	136
Mean	147	136	156	128	130	132
P-value	*0.003*	*0.984*	*0.274*	*0.018*	*0.456*	*0.930*
	NJ	NYG	OH	ONT	PA	SC
P.1	156	131	134 ab	165	148	138
V.2	165	129	117 b	169	154	153
G.30	147	134	147 a	180	152	150
M.26 EMLA	162	135	135 ab	171	156	158
Mean	158	132	133	171	152	150
P-value	*0.569*	*0.893*	*0.017*	*0.361*	*0.834*	*0.246*
	TN	VA	WI			
P.1	123	137	155			
V.2	135	120	142			
G.30	125	136	145			
M.26 EMLA	137	126	142			
Mean	130	130	146			
P-value	*0.343*	*0.169*	*0.383*			
	KY	NB	NYH	WA		
V.2	157	84	138	163		
G.30	158	90	139	158		
M.26 EMLA	138	88	154	169		

[z] P-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within sites by Tukey's test (P = 0.05).

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Table 9. Number of root suckers per tree in 2003 for surviving '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 values. The interaction of rootstock and site was significant. LSmeans 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	BC	IA	IL	ME	MI	NC
P.1	2	10 a	53 a	5	5	2
V.2	2	9 a	26 b	1	3	1
G.30	8	13 a	52 a	8	10	1
M.26 EMLA	0	0 b	1 c	0	0	1
Mean	3	8	33	4	5	1
P-value	*0.204*	*0.016*	*0.001*	*0.328*	*0.156*	*0.985*
	NJ	NYG	OH	ONT	PA	SC
P.1	24 a	3	1	3	21 b	9
V.2	5 b	1	1	3	16 b	5
G.30	23 a	3	8	5	60 a	0
M.26 EMLA	1 b	0	0	0	1 c	0
Mean	13	2	3	3	24	4
P-value	*0.001*	*0.875*	*0.861*	*0.687*	*0.001*	*0.160*
	TN	VA	WI	KY	NB	NYH
P.1	1	42 b	11	- - -	- - -	- - -
V.2	0	46 ab	1	2	2	2
G.30	1	56 a	8	4	6	3
M.26 EMLA	0	9 c	0	0	0	0
Mean	1	38	5			
P-value	*0.996*	*0.001*	*0.158*	- - -	- - -	- - -

zP-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within site by Tukey's (P = 0.05).

Table 10. Percentage of the circumference of the rootstock covered with burrknots in 2003 for surviving '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 values. The interaction of rootstock and site was significant. LSmeans 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	BC	IA	KY	ME	TN	VA
P.1	17 a	4	- - -	1	0	5
V.2	17 a	2	0	0	0	1
G.30	6 b	3	0	0	1	1
M.26 EMLA	9 b	1	0	1	1	2
P-value	*0.006*	*0.909*	*1.000*	*0.999*	*0.986*	*0.710*

zP-values were generated with the Slice Option of SAS to test the equality of rootstocks within a site. Mean separation among rootstocks within site by Tukey's (P = 0.05).