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Performance of 'Gala' Apple on 18 Dwarf Rootstocks: Five-year Summary of the 1994 NC-140 Dwarf Rootstock Trial

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Abstract

In 1994, trees of 'Gala' apple (*Malus x domestica* Borkh.) on 18 dwarf rootstocks were planted at 26 sites in North America according to the guidelines established for cooperative testing by the North Central Regional Cooperative Project (NC-140). Rootstocks for this trial included six selections of M.9, two from the Budagovski (B) series, three stocks from the Polish (P) series and two from the Vineland (V) series. M.27 EMLA, B.491, P.16 and P.22 produced the smallest trees, whereas V.1, M.26 EMLA, M.9 RN29 and M.9 Pajam2 produced the largest trees. M.9 EMLA, M.9 Pajam1, B.9, O.3, P.2, Mark, B.469, V.3, M.9 Fleuren56, and M.9 NAKBT337 produced intermediate-size trees. Among the most dwarfing rootstocks, cumulative yields were greatest for P.16 and P.22, whereas M.27 EMLA had the lowest yields. All rootstocks in the intermediate size class produced similar yields. Among the most vigorous rootstocks, Pajam2 had the lowest yields and V.1 had the highest yields. Yield efficiency (YE) was low at CO, IN, NB, NC NJ, OH, SC, and ME and high at AR, OR, WA, and WI. Rootstocks significantly influenced YE at 19 of the 26 locations. Among the most dwarfing rootstocks, P.16 had the highest YE. Among the rootstocks in the intermediate size class, O.3, Mark, and M.9 NAKBT337 had the highest YE M.26 EMLA had the lowest YE for the most vigorous stocks.

Introduction

The North American apple industry is in a transition from relatively low-density plantings, with semi-dwarfing rootstocks, to higher density plantings, requiring dwarfing rootstocks. The economic success of high-density orchards requires rootstocks that control tree size, that are precocious and remain productive for the life of the orchard, that produce large high-quality fruit, and that survive biotic and abiotic stresses. The four most widely planted dwarfing rootstocks include M.9, M.26, Mark and B.9. Although these rootstocks provide a range of vigor, all of these rootstocks are susceptible to fireblight (7, 8, 9). Mark sometimes lacks sufficient vigor to fill its allotted space and may be sensitive to water stress (4, 7).

The regional project NC-140 was initiated in 1976 to evaluate promising rootstocks at many locations. Results from previous uniform trials have been published (7, 8, 9). New dwarfing rootstocks recently released from breeding programs in Canada, Europe, and the United States have not been tested widely in North America. The Vineland (V.) rootstocks originated at the Horticultural Research Institute of Ontario, Vineland Station, as open-pollinated seedlings of 'Kerr' apple-crab. The two primary objectives of the breeding program were cold hardiness and size control (2). The first extensive testing of five of the V. selections occurred in Washington and Ohio, where V.1 and V.3 looked promising in comparison to M.9 EMLA (1, 3). The Polish (P.) rootstocks

[1]Appreciation is extended to TRECO, Inc., Woodburn, OR 97071 for propagating the trees and to the International Dwarf Fruit Tree Association for providing financial assistance for data summarization. Special thanks are extended to Klaus Hinkelmann and Marvin Lentner for assisting with the experimental design and data analysis and to Michele Marini for writing a SAS macro for multiple comparisons.

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

Location	Cooperator	Planting Location
(AR) Arkansas	Curt R. Rom	Fayetteville
(BC) British Columbia	Cheryl Hampson	Summerland, Canada
(CO) Colorado	Alvan Gaus	Hotchkiss
(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
(ME) Maine	James R. Schupp	Monmouth
(MA) Massachusetts	Wesley R. Autio	Belchertown
(MI) Michigan	Ronald L. Perry	Clarkesville
(NB) New Brunswick	Jean-Pierre Privé	Bouctouche, Canada
(NC) North Carolina	Michael Parker, Richard Unrath	Fletcher
(NJ) New Jersey	Winfred P. Cowgill, Jr.	Pittstown
(NY) New York	Terence Robinson	Geneva
(NY) New York	Edward Stover, Terrence Robinson	Highland
(OH) Ohio	David C. Ferree	Wooster
(ONT) Ontario	John Cline	Simcoe, Canada
(OR) Oregon	E. Mielke	Hood River
(PAB) Pennsylvania	George M. Greene	Biglerville
(PARS) Pennsylvania	R. M. Crassweller	Rock Springs
(SC) South Carolina	Gregory I. 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

originated at the Research Institute of Pomology, Skierniewice, Poland, and the objective of the program was to provide dwarfing rootstocks with improved tolerance to severe winter cold (10). Trials in Poland indicated that all three clones tested in this trial were very dwarfing. The Budagovski (B.) rootstock clones originated at Micurin College of Horticulture, Russia, and were selected for tolerance to severe winter cold.

This report summarizes results from the first five years of a uniform rootstock trial involving 18 dwarfing rootstocks at 26 North American locations, where new rootstocks are compared to commercially used rootstocks which are considered to be standards.

Materials and Methods

All trees were propagated by TRECO, Inc., Woodburn, OR with the scion 'Treco Red Gala #42.' Trees were planted at 26 sites during the late winter and 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. All sites had 10 trees of each of 14 rootstocks, but several sites did not receive trees on P.22, B.469, M.9 Fleuren 56, and/or V.3. Pollinizer trees consisted of one tree each of 'Liberty,' 'Starkspur Supreme Delicious,' and 'Fuji' on M.26 EMLA per block. Each cooperator had a choice of two spacings: 2.5 x 4.5 m could be selected for low-vigor sites and 3.5 x 5.5 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 man-

Table 2. Survival (% alive) of 'Gala' trees on 18 dwarfing rootstocks after five growing seasons. All values are least-squares means, adjusted for missing cells. The interaction of rootstock and site was significant (P = 0.001). LSmeans are presented for P.22, B.469, M.9 Fleuren 56, and V.3, but because these rootstocks were not planted at every site they were not included in the statistical analysis.[z]

Rootstock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NB	NC	NJ
M.27	90 ab	100	100	70 ab	80 ab	90	100	100	90	100	90 a	90 ab	100
B.491	80 ab	100	100	70 ab	70 ab	80	90	100	100	90	100 a	80 ab	100
P.16	70 ab	100	100	90 ab	90 ab	90	100	90	100	100	80 a	80 ab	100
T337	90 ab	100	100	40 c	90 ab	100	100	100	100	100	90 a	70 ab	100
Mark	80 ab	100	100	80 ab	90 ab	100	100	70	100	100	100 a	60 b	100
P.2	100 a	100	100	80 ab	90 ab	100	100	90	100	100	70 ab	100 a	100
O.3	90 ab	100	100	70 ab	80 ab	100	100	100	100	100	50 b	80 ab	100
B.9	70 ab	100	100	90 ab	60 b	100	100	90	90	100	100 a	100 a	100
M.9	90 ab	100	100	70 ab	90 ab	100	100	90	100	90	70 ab	80 ab	100
Pajam1	100 a	100	100	90 ab	100 a	100	100	100	100	100	100 a	100 a	100
Pajam2	90 ab	100	100	60 bc	100 a	100	100	100	90	100	100 a	80 ab	100
RN29	90 a	100	100	70 ab	80 ab	100	100	100	100	100	100 a	80 ab	100
M.26	50 b	100	100	60 bc	100 a	100	90	100	100	100	100 a	90 ab	100
V.1	90 ab	100	100	100 a	100 a	100	100	80	100	100	90 a	100 a	100
P.22	90	100	100	60	90	100	100	90	100	100	- - -	80	100
B.469	60	100	100	50	90	90	100	100	100	100	- - -	30	100
Fleuren56	100	100	- - -	90	- - -	- - -	100	90	100	90	- - -	60	100
V.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	100	- - -	90	100
LSmean	**84**	**100**	**100**	**74**	**87**	**97**	**99**	**94**	**98**	**98**	**89**	**85**	**100**
P-value	***0.001***	***1.00***	***1.00***	***0.001***	***0.007***	***0.871***	***0.999***	***0.224***	***0.997***	***0.999***	***0.001***	***0.001***	***1.00***
	NYG	**NYH**	**OH**	**ONT**	**OR**	**PAB**	**PARS**	**SC**	**TN**	**UT**	**VA**	**WA**	**WI**
M.27	100	90	80	90	90	90	100	90 a	50 bc	100	100	100	100
B.491	100	100	90	100	90	100	100	100 a	90 a	100	100	100	100
P.16	100	100	30	100	100	100	100	50 bc	70 ab	100	90	90	100
T337	100	100	20	100	100	100	100	20 cd	70 ab	100	100	100	100
Mark	90	100	20	100	100	100	100	70 a	40 c	100	90	100	100
P.2	90	100	80	100	100	100	100	10 d	100 a	100	100	90	100
O.3	100	100	10	100	80	90	90	80 ab	100 a	100	90	100	100
B.9	100	100	90	100	100	100	100	50 bc	100 a	100	100	100	100
M.9	100	100	20	100	100	100	100	40 cd	90 a	100	100	90	100
Pajam1	100	100	0	100	100	100	100	10 d	90 a	100	100	100	100
Pajam2	100	80	20	100	100	100	100	90 a	90 a	100	90	100	100
RN29	100	90	30	80	100	100	100	70 abc	80 ab	100	100	100	100
M.26	100	100	20	100	90	100	100	50 bc	90 a	100	80	100	100
V.1	100	100	90	100	90	100	100	100 a	100 a	100	100	100	100
P.22	100	- - -	60	100	- - -	90	100	- - -	- - -	100	100	90	100
B.469	100	90	100	100	- - -	100	100	20	- - -	100	90	100	90
Fleuren56	100	- - -	40	80	- - -	100	- - -	- - -	- - -	- - -	90	100	- - -
V.3	90	- - -	70	90		100	- - -	- - -	- - -	- - -	100	90	- - -
LSmeans	**99**	**97**	**43**	**98**	**96**	**99**	**99**	**59**	**84**	**100**	**96**	**98**	**100**
P-value	***0.999***	***0.831***	***0.001***	***0. 602***	***0.691***	***0.999***	***0.999***	***0.001***	***0.001***	***1.00***	***0.866***	***0.973***	***1.00***

[z]Least squares means for rootstocks within site were compared with Tukey's test (P = 0.05).

Table 3. Trunk cross-sectional area (cm^2) of surviving 'Gala' trees on 18 dwarfing rootstocks after five growing seasons. P.22, B.469, M.9 Fleuren 56, and V.3 were not planted at all locations and were not included in the analysis. The interaction of rootstock and site was significant ($P = 0.001$). All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NB	NC	NJ
M.27	6.2 f	5.8 bc	5.4 b	13.1 d	8.3 e	10.6 de	6.8 e	6.8 de	6.2 c	10.3 c	14.4bc	8.1 c	13.8 e
B.491	12.1 ef	5.6 bc	6.0 b	7.8 d	9.7 e	13.9 de	10.8 cde	9.1 de	7.4 c	13.6 c	13.6c	11.5 c	17.4 e
P.16	11.0 ef	4.0 c	6.9 ab	6.3 d	14.5 e	15.6 de	7.6 d	11.4 d	7.7 c	12.9 c	13.6c	8.9 c	18.6 de
T337	29.0 abcd	7.9 ab	9.0 ab	17.8 bcd	25.0 de	34.1 ab	25.0 bcd	21.6 bc	11.6 bc	32.4 ab	16.9abc	20.9 bc	36.9 cd
MARK	14.5 ef	11.0 ab	12.0 ab	16.5 d	22.1 de	20.5 cd	20.7 bcd	20.1 bc	17.8 ab	27.3 b	29.4a	23.1 b	32.2 cd
P.2	24.4 cde	11.9 abc	9.5 ab	14.0 d	18.6 de	23.2 cd	15.9 bcd	24.0 bc	12.6 bc	25.7 b	21.4ab	24.1 b	25.2 cd
O.3	27.5 bcd	9.8 bc	10.3 ab	22.8 bcd	27.9 cd	28.2 abc	19.5 bc	22.9 bc	13.7 bc	32.1 b	24.5a	28.0 b	38.4 cd
B.9	18.9 de	10.8 bc	15.3 a	16.5 cd	18.6 de	22.2 cd	18.9 bcd	18.7 cd	16.7 ab	26.2 b	20.4abc	25.4 b	31.4 cd
M.9	32.8 abc	8.6 bc	11.1 ab	16.7 bcd	28.7 bcd	33.8 ab	26.2 ab	25.0 bc	13.2 abc	40.0 ab	19.8 abc	21.6 b	39.5 c
Pajam1	34.0 ab	9.4 bc	10.9 ab	15.0 d	25.9 d	32.2 ab	22.3 ab	28.0 b	13.1 bc	36.7 ab	22.5a	22.5 b	42.0 bc
Pajam2	35.0 ab	12.5 abc	13.4 ab	23.2 bcd	33.6 abc	30.4 abc	24.9 ab	34.3 b	17.7 ab	42.5 ab	25.7a	27.8 b	45.6 abc
RN29	35.6 ab	11.9 abc	13.3 ab	25.4 bc	28.6 cd	33.2 ab	28.4 ab	30.2 b	19.1 ab	38.8 ab	26.4a	24.6 b	48.5 abc
M.26	31.9 abc	14.1 ab	14.8 ab	26.6 b	37.0 ab	38.2 a	24.6 ab	37.6 a	23.3 a	43.4 a	22.8a	27.6 b	53.3 a
V.1	38.8 a	19.2 a	14.0 ab	35.4 a	39.0 a	36.3 a	29.8 a	39.8 a	21.0 ab	42.8 a	26.9a	42.3 a	53.2 ab
P.22	11.1	4.8	4.4	6.5	6.9	10.5	7.5	6.0	5.5	10.7	- - -	11.7	9.2
B.469	14.2	7.6	11.0	14.2	15.3	15.1	14.5	12.8	10.3	17.8	- -	17.0	23.0
Fleuren56	26.6	7.7	- - -	16.4	- - -	- - -	16.5	19.2	- - -	31.3	- -	16.6	34.6
V.3	29.2	7.9	- - -	18.1	- - -	- - -	- - -	- - -	- - -	19.7	- - -	16.2	23.3
LSmean	**25.2**	**10.2**	**10.8**	**18.1**	**42.1**	**26.6**	**20.1**	**23.6**	**14.4**	**30.4**	**21.0**	**22.4**	**35.6**
P-value	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***
	NYG	**OH**	**ONT**	**OR**	**PAB**	**PARS**	**SC**	**TN**	**UT**	**VA**	**WA**	**WI**	
M.27	8.8 f	7.1	6.3	17.1 e	4.5 e	7.1 g	2.2 e	8.3 d	13.3 c	8.3 d	8.9 c	10.3 c	
B.491	9.4 f	13.4	16.6	18.9 df	9.4 de	11.7 a	10.2 e	12.8 cd	14.3 c	12.6 d	7.2 c	12.3 bc	
P.16	12.8 ef	4.4	17.9	14.4 e	11.2 de	12.2 fg	8.0 e	11.3 d	22.0 bc	11.4 d	15.4 b	14.9 bc	
T337	23.6cde	5.7	30.9	27.4 cd	25.6 bcd	24.4 cd	22.5 cde	21.5 bc	36.5 ab	26.1 bc	28.9 a	20.4 b	
Mark	20.8 de	1.4	26.5	25.4 d	15.2 d	22.5 d	10.6 de	27.9 b	21.6 bc	22.7 c	21.1 ab	26.1 ab	
P.2	27.8 abc	24.6	24.4	35.2 b	24.4 cd	21.4 df	19.3 de	18.5 c	32.8 b	26.6 bc	24.0 ab	26.0 ab	
O.3	25.3 bcd	3.8	- - -	38.5 b	29.9 bc	30.4 bcd	32.2 cd	28.3 b	30.1 b	31.7 b	28.0 a	20.7 b	
B.9	26.1 bcd	26.6	19.3	33.6 b	16.7 d	21.6 d	10.8 de	23.2 bc	23.7 bc	22.3 c	18.0 b	23.0 ab	
M.9	26.2 bcd	5.8	6.7	30.3 cd	30.6 bc	26.5 cd	33.6 cd	21.2 c	36.0 ab	30.4 bc	28.1 a	27.1 a	
Pajam1	29.8 abc	- - -	- - -	33.2 ab	29.6 bc	34.7 abc	37.9 cd	24.3 bc	39.8 a	33.0 b	29.9 a	24.6 ab	
Pajam2	32.0 ab	8.3	11.0	37.6 b	32.8 bc	37.6 ab	36.2 cd	27.4 b	43.8 a	34.6 b	30.8 a	32.2 a	
RN29	32.8 ab	7.9	11.8	34.8 b	31.5 bc	33.8 abc	39.6 bc	31.1 a	46.7 a	36.1 b	29.0 a	29.0 a	
M.26	33.5 ab	6.6	8.6	40.9 b	34.9 b	41.5 a	40.2 ab	46.1 a	41.1 a	46.2 ab	33.3 a	32.6 a	
V.1	38.2 a	35.5	21.2	43.3 a	46.8 a	42.6 a	41.8 a	27.4 b	42.3 a	50.5 a	38.2 a	30.4 a	
P.22	10.7	5.2	33.7	- - -	7.6	5.7	- - -	- - -	10.2	7.3	6.2	6.5	
B.469	16.1	20.6	19.8	- - -	14.9	14.2	7.5	- - -	20.2	18.2	14.2	13.4	
Fleuren56	21.3	8.5	14.7	- - -	24.7	- -	- - -	- - -	- - -	21.9	23.4	- -	
V.3	23.9	14.2	20.2	- - -	22.8	- - -	- - -	- - -	- - -	21.8	19.4	- - -	
LSmean	**24.8**	**11.6**	**16.8**	**30.8**	**24.5**	**26.3**	**24.5**	**23.5**	**31.7**	**28.0**	**24.3**	**23.6**	
P-value	***0.001***	**- - -**	**- - -**	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	

[z]Least squares means for rootstocks within site were compared with Tukey's test ($P = 0.05$).

aged as vertical axes (Lespinasse, 1981). Pests, fertility, and water were managed per 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 measured during the fall of 1998. Some cooperators harvested fruit in 1995, but 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). Root suckers were counted and removed each fall. After defoliation in 1998, cooperators at nine sites evaluated each tree for scion rooting, and scion-rooted trees were eliminated from the data set. The height of the bud union above ground and the percentage of the trunk circumference covered with burrknots were recorded for each tree.

The cooperator from Virginia organized data collection and analyses. The experimental design was a split-plot, where initial trunk sizes (blocks) within each site were the whole-plots, rootstocks were the split-plots, and sites were the replicates. Although all factors in the model were fixed and the GLM Procedure of SAS would provide valid F-tests from an analysis of variance (ANOVA), the Mixed Procedure was used to take advantage of the Slice Option to compare least squares means (LSmeans) for rootstocks within each site (6). The site x rootstock interaction was significant ($P = 0.0001$) for all response variables. In the past when interactions were significant, ANOVAs were usually performed for each site and a multiple comparison was performed to compare rootstocks within a given site (7, 9) and additional ANOVAs were performed for each rootstock to compare sites within each rootstock. Such an approach to evaluating interaction loses most of the information, because each analysis is performed on a small subset of data. The Slice Option uses the entire data set to generate a P-value for each site to test the hypothesis that all rootstocks within that site are equal. If desired, another set of P-values may be generated to evaluate the equality of sites within each rootstock. 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 using Tukey's HSD ($P = 0.05$) (M. C. Marini, personal communication). The Tukey's test is computed using the variances and covariances associated with a specific rootstock within a site. Several sites did not receive P.22, B.469, M.9 Fleuren 56, or V.3. Because the lack of those rootstocks created open cells, they could not be included in the statistical analyses. To generate LSmeans for those rootstocks, a second ANOVA was performed for each response variable with data from all 18 rootstocks and, for comparative purposes, the LSmeans for those sites are presented in the tables.

Results and Discussion

Data interpretation. LSmeans, or population marginal means, are the values of treatment means that would be expected for a balanced experiment. However, at some sites poor tree survival resulted in an extremely unbalanced experiment and the LSmeans may not be reliable and should be interpreted with caution.

The multiple comparisons are not as easily interpreted as usual. With balanced experiments, the mean square error (MSE) from the analysis of variance provides an estimate of the pooled variance. The pooled standard error (SE) is estimated as the square root of the MSE divided by the number of replicates per treatment. The critical value w is calculated by multiplying the SE by a value obtained from a table of studentized values, with the appropriate error degrees of freedom. If two means differ by more than the value of w, the two means are considered to be significantly different. Therefore, in balanced experiments all possible pairs of means are compared with the same value of w. Comparison of LSmeans in unbalanced experiments is much more complicated. A multiple comparison of 14 rootstocks within a site requires 91 pair-wise comparisons. Within each site there are many

Table 4. Tree height (cm) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant (P = 0.001). All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NC
M.27	173 c	141 b	191 b	211 b	210 c	256 b	222 bc	194 c	192 b	254 b	197 c
B.491	234 bc	148 b	200 b	172 bc	245 bc	295 ab	278 b	224 c	220 b	270 b	247 bc
P.16	212 bc	142 b	207 b	165 b	274 bc	289 ab	239 bc	248 bc	220 b	312 b	219 bc
T337	332 ab	187 ab	246 ab	270 cd	325 ab	342	346 ab	313 b	259 b	388 a	267 b
Mark	221 bc	187 ab	238 ab	250 bcd	290 ab	286 b	300 ab	269 b	294 a	345 b	243 bc
P.2	274 b	196 ab	273 a	226 bcd	280 b	311 ab	304 a	341 b	241 b	360 b	273 b
O.3	313 ab	198 ab	243 ab	270 d	336 ab	322 a	313 a	337 ab	264 ab	350 b	292 ab
B.9	280 b	204 ab	311 a	257 bcd	289 ab	313 ab	319 a	313 b	328 a	391 a	274 ab
M.9	331 ab	190 ab	250 ab	227 bcd	336 ab	361 a	332 a	342 b	299 a	424 a	280 ab
Pajam1	348 a	190 ab	255 a	230 bcd	337 a	328 a	350 a	351 ab	260 b	408 a	269 b
Pajam2	331 ab	207 a	261 a	293 acd	363 a	350 a	364 a	383 a	302 a	446 a	274 ab
RN29	343 ab	188 ab	268 a	282 acd	328 ab	340 a	336 a	371 ab	300 a	413 a	273 b
M.26	330 ab	216 a	277 a	294 acd	348 ab	353 a	327 a	381 ab	325 a	390 a	287 ab
V.1	354 a	234 a	281 a	338 a	350 a	358 a	350 a	408 a	322 a	426 a	334 a
P.22	202	136	196	167	205	241	241	189	199	257	230
B.469	211	183	252	208	256	301	272	260	252	330	238
Fleuren56	320	183	- - -	240	- - -	- - -	314	321	- - -	401	262
V.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	331	264
LSmean	**291**	**188**	**250**	**250**	**308**	**321**	**313**	**320**	**273**	**370**	**260**
P-value	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

	NJ	OH	ONT	OR	PAB	PARS	SC	UT	VA	WA	WI
M.27	274 c	181	181	262 c	200 c	218 c	140 c	267 c	210 cd	181 d	211 c
B.491	358 b	243	252	342 ab	271 b	274 c	258 b	267 c	238 cd	212 cd	270 bc
P.16	370 b	247	292	277 bc	252 bc	266 c	252 b	343 ab	244 cd	263 c	264 bc
T337	462 a	271	345	316 bc	356 ab	344 b	402 a	411 a	294 bc	358 ab	305 ab
Mark	388 b	249	311	259 c	266 b	336 b	229 b	291 bc	272 bc	261 c	305 ab
P.2	383 b	295	304	353 ab	330 b	330 b	223 b	337 b	288 bc	274 c	332 a
O.3	444 a	380	- - -	386 ab	348 ab	367 b	352 a	345 ab	310 b	299 bc	285 a
B.9	442 a	337	263	389 ab	318 b	354 b	264 b	342 ab	275 bc	308 bc	327 ab
M.9	468 a	280	182	355 ab	393 a	382 ab	361 a	420 a	316 b	349 b	340 a
Pajam1	474 a	- - -	- - -	370 ab	384 a	386 ab	393 a	418 a	334 b	344 b	324 ab
Pajam2	489 a	339	245	380 ab	395 a	407 ab	384 a	405 a	329 b	346 b	344 ab
RN29	478 a	232	235	377 ab	378 ab	387 ab	373 a	424 a	344 ab	358 ab	335 a
M.26	482 a	270	208	389 ab	387 ab	386 ab	374 a	419 a	370 ab	394 ab	351 a
V.1	481 a	356	311	401 ab	407 a	433 a	358 a	400 a	394 a	413 a	337 a
P.22	256	199	384	- - -	247	237	- - -	217	206	180	193
B.469	263	259	344	- - -	297	310	168	308	244	232	267
Fleuren56	450	298	265	- - -	380	- - -	- - -	- - -	286	330	- - -
V.3	400	240	286	- - -	320	- - -	- - -	- - -	289	293	- - -
LSmean	**429**	**283**	**261**	**347**	**335**	**348**	**312**	**363**	**301**	**312**	**309**
P-value	***0.001***	*- - -*	*- - -*	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

[z]Least squares means for rootstocks within site were compared with Tukey's test (P = 0.05).

possible values of w_i because the value of w will vary depending on the variance, the number of replicates, and the error degrees of freedom associated with any specific pair of LSmeans. As an example of what may happen, assume we are comparing three rootstocks (R_1, R_2, and R_3), and the LSmeans for tree height of these rootstocks is 200, 250, and 250 cm, respectively. It is possible that R_1 may differ significantly from R_2, but not from R_3. This could happen if the number of trees is smaller and the variance is larger for the difference of R_1 and R_2 than for the difference of R_1 and R_3. In addition to the magnitude of the difference between two rootstocks, one also must consider the magnitude of the variance, the number of trees per rootstock, and the error degrees of freedom associated with that particular difference. In some cases the variance of the difference between two rootstocks within a site varied by more than 40%.

Tree survival. Sites with no tree mortality included BC, CO, NJ, and UT, whereas the sites with the most mortality included OH, SC, TN, GA, and NC (Table 2). Only eight cooperators indicated the cause of tree death. At most sites, regardless of rootstock, the major cause of tree death was fire blight or vole injury (data not shown). In a previous NC-140 trial, tree mortality was highest for TN, MO, IN, KS, and MN (8). In this trial, no rootstock had 100% survival at all sites. Rootstocks with less than 70% survival for at least three sites included M.26 EMLA, Mark, and P.22. Results from this study do not agree very well with previous reports, possibly because this is the first rootstock trial where 'Gala,' which is very susceptible to fireblight, was used as the scion. When three scion cultivars were grown on 22 dwarfing rootstocks in Ohio, tree survival for P.22 and M.26 EMLA was generally less than for V.3, V.1, M.9 EMLA, M.9, and P.2 (3). In a similar experiment in Washington, where three cultivars were grown on 23 rootstocks, tree survival was high for Mark, M.9, V.1, M.26 EMLA, and V.2, and survival was poorest for B.9, P.2, and P.22 (1). In a uniform planting with 15 rootstocks at 30 sites, tree survival was relatively poor for P.22, P.16, and P.2 (8).

Tree size. As with most response variables in this study, TCSA was influenced by a strong interaction between site and rootstock, so it is difficult to draw general conclusions (Table 3). Sites that tended to have the smallest trunks included BC, OH and ONT, whereas sites with big trunks included AR, IL, MI, NJ, UT and VA. For the M.9 clones, NAKBT337 seemed to be about the same size as M.9 EMLA, whereas M.9 RN29, Pajam1 and Pajam2 were larger than M.9 EMLA.

Tree growth. Because the numerical values for TCSA varied considerably from site to site, rootstock LSmeans within each site were ranked and the sums of the ranks were used to help interpret this complex data set (data not shown). Based on the rank sums, TCSA separated out into three fairly distinct groups. The group with the smallest trunks (M.27 size class) included M.27 EMLA, B.491, P.16, and P.22. Rootstocks producing the largest trunks (M.26 size class) included V.1, M.26 EMLA, M.9 RN29, and M.9 Pajam2. The other rootstocks were intermediate in vigor (M.9 size class). The overall ranking of TCSA for the five M.9 clones planted at all 23 locations was RN29 > Pajam2 > M.9 EMLA > Pajam1 > NAKBT337. M.9 Fleuren56 was planted at only 13 locations, and it usually produced the smallest trunks of all the M.9 clones. In a previous NC-140 trial TCSA was similar for P2, P.16, and P.22, but tree height was about 1.3 times higher for P.2 than for P.22 (8). Averaged over three cultivars in Washington, the ranking for TCSA was M.26 EMLA > O.3 > B.9 > V.1 > M.9 EMLA > P.2 > M.9 > P.22 > V.3 > Mark > P.16 > M.27 EMLA (1). After eight years of growth with 'Cox's Orange Pippin' as the scion, the rank for TCSA, crown volume and tree weight was M.9 EMLA > B.9 > P.16 > P.2 > M.27 EMLA > P.22 (10). Ferree et al. (3) reported a strong interaction for cultivar and rootstock on TCSA. In general M.27-size trees included P.16, P.22, and Mark; M.9-size included B.9, V.1, V.3, P.22, and M.9 EMLA; and M.26 and V.2 were similar in

size. Twenty-four clones of M.9 recently were compared with 'Cox's Orange Pippin' as the scion (11), but only three of those clones were included in our trial. They found that compared to M.9 EMLA, crown volume was 94 and 62% as large for M.9 RN.29 and M.9 NAKBT337, respectively, and tree weight was 103 and 71% as large, respectively.

Tree height varied greatly with location (Table 4). Locations with the tallest trees (several rootstock means were > 400 cm) included MI, UT, and NJ, whereas locations with the shortest trees (no more than one mean > 300 cm) included BC, CO, NC, GA, OH, and OR. The rank sums for tree height separated into three distinct groups. Rootstocks that produced the shortest trees included M.27, B.491, P.16, and Mark, whereas V.1, M.9 Pajam2, M.26, and M.9 RN29 produced the tallest trees. Ranking for the five M.9 clones grown at all sites was Pajam2 > RN 29 > M.9 EMLA > Pajam1 > NAKBT337. NAKBT337 was taller than Fleuren56 at eight of the 13 sites where both were grown.

Most rootstocks produced canopies with a spread of less than 200 cm at BC, NC, OH, and ONT, whereas many trees had a spread exceeding 300 cm at IL, MI, NJ, and PAB (Table 5). Rank sums indicated that M.27 EMLA, P.16, and B.491 produced the smallest canopies, whereas V.1, M.9 Pajam2, M.26 EMLA, and M.9 RN29 produced the largest canopies.

The prevalence of rootsuckers seemed to be influenced primarily by site, but there was a very strong site by rootstock interaction (Table 6). Very few rootsuckers were reported for ME, NC, TN, and WI, whereas rootsuckers were most abundant at AR, CO, IA, MA, ONT, PARS, UT, and WA. M.9 EMLA, M.26 EMLA, M.27 EMLA, and P.2 produced few rootsuckers, whereas P.16, M.9 RN29, M.9 Pajam2, and Mark produced the most rootsuckers. In an Ohio study the prevalence of suckers varied with cultivar, but rootstocks that were relatively non-suckering included M.27 EMLA, B.9, V.3, and M.9 EMLA, whereas MARK, P.16 and M.9 produced suckers on at least one cultivar (3). Twelve cooperators reported the height of the bud union relative to the soil surface. When the height of the bud union above ground was used as a covariate, the analysis of covariance indicated that the number of rootsuckers per tree increased linearly with the amount of the rootstock above ground.

The percentage of trunk circumference covered with burrknots varied with location and rootstock (Table 7). Trees at TN, NB, MA, and OR, produced few burrknots, whereas burrknot development was greatest at CO, IA, NYH, PAB, and WI. Burrknot severity was influenced by rootstock at 9 of the 20 sites reporting data. At most sites Mark produced the most burrknots, but incidence was also high for M.27 EMLA. When the height of the bud union above ground was used as a covariate, the site by rootstock interaction was significant. This indicates that the percentage of the circumference of the rootstock covered with burrknots was linearly related to the amount of rootstock above ground, but the relationship varied for different sites.

Yield and fruit size. Cumulative yield was greatly influenced by location (Table 8). CO, GA, NB, NC, and ME had low yields, where trees on most rootstocks averaged < 15 kg per tree. High yields, often exceeding 40 kg per tree, were reported for AR, IA, IL, MI, NYG, OR, UT, VA, WA, and WI. Rootstock did not significantly influence yield at most of the locations with low yields (CO, NB, and ME). For the most dwarfing rootstocks, P.16 generally had the highest yields followed by B.491 and M.27 EMLA. P.22 had yields similar to M.27 EMLA. For the high-vigor rootstocks, V.1 usually produced the highest yields, M.9 Pajam2 had the lowest yields, and M.26 EMLA and M.9 RN29 were intermediate. In an Ohio study yield was similar for Mark, M.9 and M.9 EMLA; P.22 out-yielded M.27 EMLA; and V.2 out-yielded M.26 EMLA (3). Yields of 'Cox's Orange Pippin' were similar on 22 selections of M.9 (11). Of the very dwarfing rootstocks, P.16 produced more than twice the yields of M.27 EMLA and P.22,

Table 5. Canopy diameter (cm) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.3, B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant. All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NC
M.27	123 cd	66 a	107abc	112 cd	147 a	217 b	117 a	134 b	157 a	150 bc	124 b
B.491	212 a	87 a	123 a	118 a	193 b	230 b	177 b	182 a	216 a	198 a	158 c
P.16	179 a	64 a	158 a	80 a	240 b	267 b	143 b	190 a	192 ab	209 a	144 ab
T337	267 a	105 b	174 c	170 ab	294 ab	322 ab	270 a	274 b	245 d	305 c	183 bc
Mark	180 a	136 a	183 abc	163 ab	242 b	275 ab	218 b	215 ab	281 a	254 bc	167 ab
P.2	235 cd	138 a	151 a	141 ab	242 b	263 ab	189 b	280 a	244 a	249 a	197 a
O.3	269 a	139 b	181 d	203 b	293 a	300 a	254 a	266 b	265 c	282 c	210 a
B.9	227 acd	116 a	202 ac	153 ab	244 b	278 b	240 b	230ab	279 a	262 a	186 a
M.9	269 ad	105 b	187 a	183 cd	298 a	300 b	259 a	284 ab	268 ab	302 ab	185 a
Pajam1	276 a	121 a	171 abc	156 ad	299 a	311 b	254 a	290 b	241 ab	306 bc	188 b
Pajam2	294 a	134 a	209 ac	202 cd	323 a	314 ab	275 a	314 ab	297 b	315 ab	211 ab
RN29	281 bd	132 a	208 bc	201 ad	298 a	319 ab	259 c	298 b	317 ab	316 c	204 bc
M.26	288 b	138 a	196 a	192 cd	302 ab	315 ab	253 ab	319 a	302 ab	308 ab	204 a
V.1	285 a	150 a	162 a	233 a	311 b	306 b	266 b	327 a	318 a	318 a	254 a
P.22	177	63	91	83	132	196	- - -	120	139	171	145
B.469	188	95	160	127	209	245	135	204	197	221	169
Fleuren56	264	111	- - -	- - -	- - -	- - -	209	258	- - -	308	173
V.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	244	180
LSmean	**241**	**116**	**172**	**164**	**267**	**287**	**227**	**257**	**259**	**270**	**187**
P-value	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

	NJ	OH	ONT	OR	PAB	PARS	SC	UT	VA	WA	WI
M.27	193 abc	145	127	206 b	120 bc	206 ab	72 b	161 ab	139 ab	122 b	168 ab
B.491	248 a	215	231	222 a	206 a	296 a	178 bc	202 d	190 a	130 a	200 b
P.16	252 a	190	264	191 a	215 a	280 a	156 c	239 d	181 ab	200 a	220 abc
T337	276 b	291	315	262 a	315 bc	413 b	304 a	302 bc	264 d	280 b	273 cd
Mark	288 ab	183	283	233 a	224 a	375 a	161 ab	216 d	231 d	225 a	267 abc
P.2	245 a	259	288	281 a	266 a	364 ab	192 bc	287 d	254 a	220 a	279 ab
O.3	295 c	256	- - -	289 a	334 bc	441 b	273 d	281 a	270 e	264 b	279 d
B.9	279 ac	263	258	316 a	248 ac	402 ab	171 bc	246 d	228 a	246 a	279 ab
M.9	318 a	279	160	258 b	325 bc	427 a	283 bc	308 c	280 c	261 a	305 ab
Pajam1	291 ab	- - -	- - -	275 b	331 bc	470 a	300 ab	289 ab	292 ab	274 b	289 c
Pajam2	300 abc	324	212	313 b	345 bc	489 ab	311 b	297 bc	269 bc	270 a	317 ab
RN29	312 bc	271	218	282 a	334 bc	467 ab	320 a	314 ab	296 a	281 b	310 abc
M.26	313 a	250	181	291 b	334 abc	482 a	292 bc	290 cd	309 c	284 a	310 ab
V.1	308 a	336	270	311 a	371 a	500 a	304 bc	304 d	342 ab	351 a	327 ab
P.22	154	148	344	- - -	148	238	- - -	145	126	99	119
B.469	251	218	271	- - -	234	326	123	237	207	191	199
Fleuren56	284	310	233	- - -	306	- - -	- - -	- - -	248	271	- - -
V.3	- - -	218	263	- - -	280	- - -	- - -	- - -	242	214	- - -
LSmean	**280**	**250**	**234**	**266**	**283**	**401**	**235**	**266**	**253**	**244**	**273**
P-value	***0.001***	**- - -**	**- - -**	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

[z]Least squares means for rootstocks within site were compared with Tukey's test ($P = 0.05$).

Table 6. Cumulative rootsuckers per tree after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant (P = 0.0001). All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	CO	IA	IL	MA	ME	NC	NJ	NYG
M.27	0.9 b	6 .9ab	0.9 b	1.7 b	3.0 ab	0.0	0.1	1.2 b	1.5 b
B.491	0.2 b	8.3 ab	4.8 ab	0.6 b	3.0 ab	1.3	0.7	1.8 b	9.5 b
P.16	14.4 ab	15.6 a	12.9 ab	22.5 a	14.8 a	1.8	0.2	20.8 a	28.1 a
T337	3.0 ab	12.6 ab	5.0 b	3.3 b	4.6 ab	0.0	2.5	3.5 b	4.3 b
Mark	2.6 ab	13.0 ab	13.3 a	24.2 a	7.5 ab	0.0	0.7	8.7 b	4.3 b
P.2	0.7 b	1.6 b	1.3 ab	0.0 b	2.0 ab	0.0	0.7	0.2 b	2.2 b
O.3	2.2 b	8.3 ab	9.4 ab	6.2 b	9.6 ab	0.0	0.1	2.0 b	1.6 b
B.9	0.4 b	1.3 ab	5.0 ab	6.1 b	3.4 ab	0.0	1.1	5.8 a	1.4 b
M.9	4.3 ab	3.7 ab	2.2 ab	0.1 b	4.1 ab	0.0	0.5	0.4 b	0.3 b
Pajam1	13.5 ab	7.6 ab	10.6 ab	1.2 b	7.2 ab	0.0	2.8	1.9 b	0.5 b
Pajam2	2.0 a	7.6 ab	12.9 ab	3.3 b	12.6 ab	0.0	2.7	6.6 b	1.7 b
RN29	14.6 a	9.5 ab	5.5 ab	0.5 b	5.4 ab	0.0	6.1	2.4 b	0.5 b
M.26	1.2 ab	4.2 ab	0.3 b	0.5 b	1.0 b	0.1	0.1	1.4 b	0.7 b
V.1	9.9 a	4.2 ab	5.1 ab	4.3 b	4.6 ab	0.0	0.3	5.6 b	0.6 b
P.22	0.9	6.0	1.2	1.6	2.9	- - -	0.0	0.8	3.1
B.469	1.0	5.7	2.9	2.2	3.4	0.0	0.0	2.3	1.9
Fleuren56	6.1	- - -	- - -	- - -	9.4	0.1	0.2	9.4	0.7
V.3	- - -	- - -	- - -	- - -	- - -	- - -	0.5	2.1	0.0
LSmean	**6.1**	**6.5**	**6.8**	**5.3**	**5.9**	**0.2**	**1.3**	**4.4**	**4.1**
P-value	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***1.000***	***0.990***	***0.001***	***0.001***

	ONT	PAB	PARS	SC	TN	UT	WA	WI
M.27	4.0	0.6	1.6 b	2.8 ab	0.0	3.6 b	7.1 bc	1.4
B.491	1.7	1.1	7.2 b	3.8 ab	0.0	10.7 b	19.7 bc	0.9
P.16	19.3	5.8	38.0 a	25.4 a	2.3	17.5 a	43.2 a	6.4
T337	2.1	6.0	8.3 b	6.1 ab	0.0	2.6 a	4.7 bc	0.7
Mark	20.3	9.6	15.4 b	1.9	2.0	9.1	13.3 bc	0.8
P.2	6.8	2.5	0.2 b	0.1 b	1.1	0.8 b	4.6 bc	0.0
O.3	- - -	0.9	16.4 b	3.8 ab	0.8	12.0 b	15.8bc	0.4
B.9	8.4	1.4	7.2 b	0.6 ab	0.0	6.4 b	8.9 bc	0.0
M.9	1.6	1.1	0.0 b	0.6 b	0.0	0.3 b	4.3 bc	0.1
Pajam1	- - -	2.1	9.4 b	1.5 ab	0.3	9.1 b	13.8 b	0.5
Pajam2	5.7	4.7	28.5 b	10.0 ab	0.2	2.6 b	21.3 b	0.4
RN29	6.6	3.0	19.2 b	6.3 ab	0.1	10.1 b	21.9 b	0.3
M.26	17.9	0.1	0.2 b	0.5 ab	0.0	1.1 b	0.4 c	0.0
V.1	8.4	3.3	7.0 b	6.9 ab	0.0	9.3 b	14.6 bc	0.3
P.22	5.5	0.9	9.8	- - -	- - -	8.9	8.4	0.6
B.469	3.4	1.6	6.2	8.2	- - -	2.8	7.7	1.9
Fleuren56	- - -	6.7	- - -	- - -	- - -	- - -	17.2	- - -
V.3	5.9	2.0	- - -	- - -	- - -	- - -	7.2	- - -
LSmean	**8.6**	**3.0**	**11.3**	**5.0**	**0.5**	**6.8**	**13.8**	**0.9**
P-value	**- - -**	***0.404***	***0.001***	***0.001***	***1.000***	***0.001***	***0.001***	***0.988***

[z]Least squares means for rootstocks within site were compared with Tukey's test (P = 0.05).

Table 7. Burrknots (% of trunk circumference) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.3, B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant ($P = 0.001$). All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	BC	CO	GA	IA	MA	ME	MI	NB	NC	NYG
M.27	4	6 c	30 b	10	0	2	4 b	8	0	7 ab	4 ab
B.491	14	1 c	16 b	7	12	1	9 a	10	0	9 a	6 ab
P.16	0	0 c	1 c	0	28	0	5 ab	0	1	5 ab	10 a
T337	4	4 c	32 b	1	14	21	13 a	6	0	1 b	6 ab
Mark	6	46 a	62 a	4	34	3	10 a	28	8	3 b	13 a
P.2	2	4 c	1 c	8	---	0	1 b	3	0	10 a	3 b
O.3	3	0 c	10 b	0	8	1	3 b	4	0	13 a	0 b
B.9	2	3 c	6 c	6	3	6	3 b	2	0	6 ab	1 b
M.9	2	0 c	11 c	2	12	1	2 b	2	0	3 b	3 b
Pajam1	1	3 c	15 bc	2	0	0	10 a	4	0	8 ab	0 b
Pajam2	3	1 c	8 c	1	19	0	2 b	0	0	5 ab	0 b
RN29	3	2 c	14 bc	2	---	1	2 b	1	1	7 ab	1 b
M.26	12	24 b	25 bc	1	15	1	12 a	16	0	3 b	0 b
V.1	14	7 c	10 b	2	15	0	1 b	11	0	2 b	2 b
P.22	4	1	28	11	14	1	9	12	---	8	0
B.469	12	2	2	0	---	2	3	6	---	1	0
Fleuren56	3	5	---	4	---	0	---	3	---	4	0
V.3	---	---	---	---	---	---	---	13	---	5	2
LSmean	**5**	**7**	**17**	**3**	**14**	**1**	**5**	**7**	**1**	**6**	**4**
P-value	***0.063***	***0.001***	***0.001***	***0.762***	***0.054***	***0.999***	***0.050***	***0.978***	***0.518***	***0.001***	***0.001***

	NYH	ONT	OR	PAB	PARS	SC	TN	UT	VA	WI
M.27	19 ab	9	2	24 ab	2	2	0	13 ab	8	24 a
B.491	14 ab	0	0	17 a	1	8	0	5 ab	8	2 b
P.16	19 ab	9	0	9 a	0	1	0	0 b	1	19 a
T337	13 b	4	0	7 b	3	0	0	9 ab	1	16 ab
Mark	35 a	4	0	5 b	12	5	0	20 a	0	14 a
P.2	12 b	1	0	3 bc	1	5	0	9 ab	3	6 ab
O.3	9 bc	---	0	0 c	0	2	0	1 ab	1	8 ab
B.9	4 c	4	0	3 bc	2	0	0	7 ab	1	10 ab
M.9	3 c	10	0	17 ab	1	3	0	0 b	2	5 b
Pajam1	7 bc	---	0	8 ab	2	4	0	4 ab	1	7 ab
Pajam2	9 bc	16	0	4 bc	0	0	0	0 b	3	8 ab
RN29	1 c	1	0	5 bc	1	3	0	0 b	1	4 b
M.26	7 bc	0	0	9 ab	3	0	0	5 ab	8	8 ab
V.1	6 bc	4	0	7 b	0	7	0	6 ab	1	7 ab
P.22	15	4	0	9	1	9	---	4	3	5 b
B.469	---	10	---	17	1	---	---	7	3	---
Fleuren56	---	1	---	5	---	---	---	---	1	---
V.3	---	2	---	19	---	---	---	---	0	16
LSmean	**11**	**5**	**0**	**8**	**2**	**3**	**0**	**6**	**3**	**9**
P-value	***0.001***	---	***1.000***	***0.001***	***0.592***	***0.855***	***1.000***	***0.001***	***0.765***	***0.001***

[z]Least squares means for rootstocks within site were compared with Tukey's test (P = 0.05).

Table 8. Cumulative yield (kg/tree) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.B.469, M.9 Fleuren 56 and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant ($P = 0.0001$). All values are least-squares means, adjusted for missing cells.[z]

Rootstock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NB	NC	NJ
M.27	17.2 b	14.2 b	2.8	1.9 b	12.0 c	19.6 b	9.1 b	10.2 a	2.9	18.9 b	4.9	6.0 c	13.5 b
B.491	33.2 bc	17.3 b	4.1	3.1 ab	14.3 c	26.2 ab	9.8 ab	19.1 a	6.1	20.6 ab	3.2	6.1 bc	10.8 b
P.16	32.3 bc	13.8 b	3.7	2.5 ab	23.9 c	36.7 ab	13.3 ab	20.7 a	4.6	36.0 ab	6.4	4.6 b	24.0 ab
T337	56.7 bc	27.2 ab	4.7	5.8 ab	36.2 abc	31.6 ab	10.8 ab	38.7 ab	9.3	36.8 ab	5.5	9.5 abc	14.5 ab
Mark	30.2 bc	27.4 ab	4.4	10.9 ab	33.0 b	39.3 a	25.2 ab	28.3 ab	13.6	56.3 ab	11.8	21.2 ab	42.5 a
P.2	55.3 c	28.8 ab	6.2	5.3 ab	29.4 c	34.6 ab	14.7 ab	26.2 ab	9.3	38.8 ab	5.0	14.8 b	6.4 b
O.3	75.6 a	29.8 ab	6.9	15.3 ab	46.0 b	51.8 a	27.0 ab	46.8 b	14.3	62.0 ab	4.6	20.8 a	26.6 ab
B.9	47.7 c	30.7 ab	7.5	9.7 ab	27.9 c	41.9 a	23.8 a b	29.1 ab	10.3	44.8 ab	5.9	19.5 b	24.6 ab
M.9	75.4 a	27.8 ab	8.5	8.5 ab	75.0 a	39.5 ab	18.4 ab	30.4 ab	10.2	47.8 ab	6.2	15.1 ab	16.3 b
Pajam1	70.1 a	27.3 ab	2.8	6.0 ab	39.1 b	36.0 ab	12.6 ab	38.8 b	8.9	45.4 ab	10.6	14.4 b	20.4 b
Pajam2	71.1 a	36.5 a	10.3	12.3 ab	52.1 b	39.9 a	21.6 ab	55.0 ab	14.9	57.4 ab	15.1	18.8 ab	18.2 b
RN29	79.6 a	37.7 a	10.7	13.0 ab	46.9 b	36.4 ab	18.6 ab	46.5 b	18.3	53.5 ab	16.5	15.7 bc	18.6 b
M.26	78.8 a	29.7 ab	6.0	16.3 ab	43.9 b	35.7 ab	24.0 a	36.9 ab	10.2	52.7 ab	3.6	15.1 ab	20.6 b
V.1	84.1 a	36.9 a	4.5	20.1 a	40.5 b	40.4 a	24.2 ab	41.5 b	15.6	69.1 a	13.3	28.9 a	26.1 b
P.22	28.8	11.6	2.3	2.9	8.7	19.7	12.4	11.4	2.2	25.7	---	8.1	9.8
B.469	32.3	23.8	5.4	5.8	19.2	32.4	16.8	25.9	7.7	34.4	---	18.7	19.1
Fleuren56	49.9	25.8	---	8.2	---	---	7.0	34.7	---	45.8	---	11.2	11.2
V.3	---	---	---	---	---	---	---	---	---	39.6	---	9.4	13.6
LSmean	**57.7**	**27.5**	**5.8**	**9.3**	**37.2**	**36.4**	**18.2**	**35.6**	**10.7**	**46.2**	**8.0**	**15.0**	**20.2**
P-value	***0.001***	***0.001***	***0.975***	***0.028***	***0.001***	***0.001***	***0.003***	***0.001***	***0.129***	***0.001***	***0.228***	***0.002***	***0.001***
	NYG	**NYH**	**OH**	**ONT**	**OR**	**PAB**	**PARS**	**SC**	**TN**	**UT**	**VA**	**WA**	**WI**
M.27	23.0 c	6.7 b	13.6	8.0	41.2 c	7.0 c	5.9 b	3.1 c	1.4 b	16.0 b	8.1 b	20.7 b	24.2 b
B.491	31.5 c	15.8 b	11.5	16.6	44.8 c	13.1 bc	8.7 b	19.1 bc	10.6 bc	25.4 b	16.5 bc	22.3 b	34.0 b
P.16	47.1 b	11.2 b	12.3	16.8	48.4 c	22.9 bc	13.7 b	17.2 c	10.7 bc	48.6 ac	20.0 bc	46.1 c	52.1 c
T337	62.3 abc	18.4 ab	6.7	20.9	66.5 abc	23.5 abc	17.3 ab	23.5 abc	30.0 abc	50.5 abc	36.7 abc	78.5 ac	62.3 abc
Mark	68.3 b	22.6 b	12.2	36.2	69.0 b	26.8 b	29.5 a	15.9 c	23.9 c	38.0 bc	38.8 c	49.5 c	76.4 ac
P.2	57.2 b	18.8 b	31.2	22.9	86.5 ab	27.3 b	19.4 b	17.3 bc	16.8 bc	46.9 ac	40.2 c	48.4 c	60.4 c
O.3	75.0 ab	40.5 a	8.0	---	90.8 a	47.2 ac	38.2 a	56.7 a	36.1 ac	58.1 ac	54.7 a	70.8 ac	77.5 ac
B.9	64.2 b	27.6 a	30.4	25.6	95.1 a	25.2 bc	20.9 b	19.4 bc	17.7 bc	44.3 c	29.1 c	46.8 c	66.8 c
M.9	76.1 ab	27.0 ab	10.2	10.2	74.3 ab	31.8 ab	18.4 b	29.0 b	24.2 ac	63.4 ac	46.3 ac	68.2 ac	75.6 ac
Pajam1	76.1 ab	21.8 ab	---	---	75.9 b	32.6 ab	27.1 a	43.0 b	33.3 ac	56.2 ac	51.8 a	77.7 ac	70.4 ac
Pajam2	80.0 a	28.7 a	15.9	19.8	90.2 a	36.3 ab	30.0 a	43.6 b	35.4 ac	67.2 a	49.8 a	73.7 ac	87.0 a
RN29	88.0 a	38.4 a	12.5	12.7	87.9 a	33.7 ab	34.2 a	35.7 b	29.4 ac	75.0 a	50.1 a	81.2 a	86.5 a
M.26	72.3 ab	29.3 a	11.3	12.6	77.7 ab	31.6 ab	21.7 b	47.0 ab	44.5 a	56.8 ac	54.9 a	60.5 c	76.8 ac
V.1	74.3 ab	39.2 a	41.3	19.3	85.9 ab	48.7 ab	41.2 a	62.9 a	34.8 ac	52.3 ac	65.1 a	79.1 a	70.5 ac
P.22	21.4	13.4	13.7	29.8	---	10.7	1.4	---	---	---	10.0	15.8	17.3
B.469	43.2	---	34.2	21.8	---	25.4	17.6	6.2	---	---	23.0	39.7	40.6
Fleuren56	58.1	---	25.3	---	---	28.1	---	---	---	---	38.9	62.6	---
V.3	61.8	---	23.0	22.8	---	34.7	---	---	---	---	27.2	52.8	---
LSmean	**64.2**	**24.8**	**16.7**	**18.5**	**73.9**	**29.4**	**23.6**	**30.9**	**24.9**	**49.9**	**40.2**	**59.9**	**65.7**
P-value	***0.001***	***0.001***	---	---	***0.001***	***0.001***	***.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

[z]Least squares means for rootstocks within site were compared with Tukey's test ($P = 0.05$).

Table 9. Fruit weight (g/fruit) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant (P = 0.0001). All values are least squares means, adjusted for missing cells.[z]

Root-stock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NB	NC	NJ
M.27	103 a	156 a	132 ab	162	140 ab	111 a	108 a	122 a	125	150 b	111	123 b	147 ab
B.491	115 b	180 c	128 a	155	141 ab	131 a	115 ab	139 a	134	170 a	106	107 ab	131 a
P.16	102 a	163 ac	147 ab	164	140 ab	154 b	117 ab	147 b	127	150 ab	110	96 a	138 ab
T337	156 ab	198 abc	141 ab	173	159 ab	141 ab	136 ab	165 ab	139	166 ab	110	97 ab	175 b
Mark	82 a	168 ac	114 a	152	128 a	161 b	112 ab	142 a	131	129 b	125	96 a	144 ab
P.2	122 b	189 bc	137 ab	155	138 ab	142 ab	122 ab	146 ab	126	157 a	119	106 ab	145 ab
O.3	118 b	201 bc	126 a	157	147 ab	174 b	118 ab	148 b	134	144 ab	112	112 ab	135 ab
B.9	105 b	190 bc	147 ab	151	132 a	165 b	114 ab	154 b	143	153 a	98	111 ab	144 ab
M.9	116 b	187 bc	150 ab	159	159 ab	146 ab	126 ab	168 b	140	166 a	100	106 ab	139 ab
Pajam1	129 b	195 bc	145 ab	162	160 b	143 ab	133 b	167 b	135	159 a	114	115 ab	141 ab
Pajam2	125 b	193 bc	141 ab	163	161 b	145 ab	118 ab	164 b	148	162 a	116	114 ab	139 ab
RN29	125 b	204 b	153 b	156	159 b	138 a	116 ab	166 b	139	157 a	113	108 ab	140 ab
M.26	114 b	192 bc	134 ab	158	152 ab	138 a	125 ab	156 b	140	157 a	114	112 ab	149 ab
V.1	121 b	200 bc	148 ab	159	145 ab	135 a	115 ab	174 b	135	152 ab	103	118 ab	133 ab
P.22	106	161	117	165	125	111	116	116	123	132	--	102	137
B.469	105	181	115	157	132	148	119	137	113	140	---	93	145
Fleuren56	160	193	--	155	---	---	133	167	---	157	---	96	146
V.3	---	---	--	---	---	---	---	---	---	159	---	116	138
LSmean	**115**	**187**	**139**	**160**	**147**	**145**	**120**	**154**	**135**	**155**	**111**	**109**	**143**
P-value	***0.005***	***0.001***	***0.441***	***0.896***	***0.001***	***0.006***	***0.001***	***0.004***	***0.026***	***0.001***	***0.947***	***0.009***	***0.001***
	NYG	**NYH**	**OH**	**ONT**	**OR**	**PAB**	**PARS**	**SC**	**TN**	**UT**	**VA**	**WA**	**WI**
M.27	130 a	129 a	146	139	164 ab	110 ab	127	126 b	113	79 c	153 ab	156 b	131 ab
B.491	132 ab	143 ab	125	161	168 ab	128 ab	135	149 ab	120	104 b	162 a	157 b	144 ab
P.16	132 ab	135 ab	134	155	166 ab	114 ab	134	142 ab	114	134 a	152 ab	187 a	141 ab
T337	141 ab	150 ab	142	163	170 ab	137 ab	139	169 ab	118	136 ab	168 ab	205 ab	142 ab
Mark	121 ab	114 ab	130	161	153 a	107 b	129	123 b	119	124 ab	139 b	152 b	122 ab
P.2	145 ab	136 ab	141	163	165 ab	123 ab	134	132 ab	117	132 a	156 ab	182 a	146 ab
O.3	132 ab	144 ab	147	---	161 ab	125 ab	130	147 ab	118	138 a	155 ab	178 a	133 a
B.9	145 ab	141 ab	147	162	176 b	120 ab	133	125 b	123	124 ab	154 ab	175 a	144 ab
M.9	138 ab	143 ab	142	161	175 ab	131 ab	133	152 ab	106	143 a	159 ab	193 a	148 b
Pajam1	147 b	154 b	---	---	174 ab	134 b	140	162 a	126	136 a	159 ab	200 a	145 ab
Pajam2	141 ab	141 ab	138	160	175 ab	134 b	141	151 ab	120	152 a	157 ab	186 a	141 ab
RN29	148 b	150 ab	129	164	174 ab	135 b	140	158 a	121	153 a	162 a	196 a	144 ab
M.26	143 ab	138 ab	140	158	172 ab	129 ab	140	156 a	118	138 a	158 ab	198 a	147 ab
V.1	140 ab	145 ab	123	158	164 ab	126 ab	131	148 ab	130	132 a	157 ab	187 a	145 ab
P.22	123	---	123	158	---	108	131	--	---	70	152	145	127
B.469	125	---	126	140	---	125	130	147	---	112	149	172	133
Fleuren56	145	---	130	157	---	135	--	---	---	---	156	183	--
V.3	145	---	119	172	---	130	---	---	---	---	161	190	---
LSmean	**139**	**140**	**137**	**159**	**168**	**125**	**135**	**147**	**119**	**130**	**157**	**182**	**141**
P-value	***0.025***	***0.001***	---	---	***0.001***	***0.001***	***0.566***	***0.001***	***0.430***	***0.001***	***0.030***	***0.001***	***0.004***

[z]Least squares means for rootstocks within site were compared with Tukey's test (P = 0.05).

Table 10. Cumulative yield efficiency (Kg/cm² TCSA) after five growing seasons for surviving 'Gala' trees on 18 rootstocks planted in 1994. P.22, V.B.469, M.9 Fleuren 56, and V.2 were not planted at all sites and were not included in the analysis. The interaction of rootstock and site was significant ($P = 0.0001$). All values are least-squares means, adjusted for missing cells.[z]

Root-stock	AR	BC	CO	GA	IA	IL	IN	MA	ME	MI	NB	NC	NJ
M.27	2.8 a	2.2 b	0.5	0.4	1.3 b	1.8 ab	1.4 a	1.6 ab	0.5	2.0 c	0.4	0.7	1.0 ab
B.491	2.7 ab	3.1 a	0.7	0.3	1.5 b	2.0 a	1.0 ab	2.1 a	0.8	1.6 bc	0.2	0.5	0.6 a
P.16	2.7 ab	3.3 a	0.5	0.3	1.7 b	2.4 a	1.7 a	1.8 ab	0.6	2.8 a	0.5	0.5	1.3 a
T337	2.0 b	3.3 a	0.5	0.3	1.4 b	1.0 b	0.5 b	1.8 ab	0.8	1.2 b	0.4	0.4	0.4 ab
Mark	2.1 ab	2.4 b	0.3	0.6	1.5 b	1.9 ab	1.3 a	1.8 ab	0.8	2.2 ac	0.4	0.9	1.4 a
P.2	2.3 ab	2.4 b	0.6	0.4	1.5 b	1.5 b	1.1 ab	1.1 b	0.7	1.5 bc	0.2	0.6	0.3 b
O.3	2.8 a	3.0 a	0.6	0.5	1.7 b	1.9 ab	1.4 ab	2.1 ab	1.0	2.0 c	0.2	0.6	0.7 a
B.9	2.6 ab	2.9 a	0.5	0.6	1.4 b	1.9 ab	1.3 a	1.6 ab	0.6	1.8 bc	0.3	0.8	0.8 ab
M.9	2.4 ab	3.1 a	0.6	0.5	2.7 a	1.3 b	0.7 b	1.4 ab	0.7	1.3 bc	0.3	0.6	0.4 a
Pajam1	2.1 ab	2.8 a	0.3	0.3	1.6 b	1.1 b	0.6 b	1.4 b	0.7	1.3 bc	0.4	0.6	0.5 ab
Pajam2	2.1 ab	2.9 a	0.8	0.4	1.6 b	1.3 b	0.9 b	1.6 ab	0.8	1.4 bc	0.6	0.5	0.4 b
RN29	2.3 ab	3.2 a	0.8	0.5	1.7 b	1.2 b	0.7 b	1.6 ab	1.0	1.4 bc	0.6	0.6	0.4 ab
M.26	2.5 ab	2.2 b	0.4	0.4	1.2 b	1.0 b	1.0 ab	1.1 b	0.4	1.3 bc	0.2	0.5	0.4 b
V.1	2.2 ab	1.9 b	0.3	0.6	1.0 b	1.1 b	0.8 b	1.0 b	0.8	1.6 bc	0.5	0.7	0.5 b
P.22	2.4	2.4	0.5	0.2	1.0	1.8	1.7	1.9	0.4	2.4	- - -	0.6	1.1
B.469	1.6	3.0	0.5	0.2	1.0	1.9	1.2	2.0	0.7	2.0	- - -	0.4	0.9
Fleuren56	1.9	3.3	- - -	0.5	- - -	- -	0.4	1.8	- - -	1.5	- - -	0.5	0.3
V.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	1.9	- - -	0.5	0.6
LSmean	**2.4**	**2.8**	**0.5**	**0.5**	**1.5**	**1.5**	**1.0**	**1.6**	**0.7**	**1.7**	**0.4**	**0.6**	**0.7**
P-value	***0.001***	***0.001***	***0.440***	***0.969***	***0.001***	***0.001***	***0.001***	***0.001***	***0.329***	***0.001***	***0.674***	***0.811***	***0.001***
	NYG	**NYH**	**OH**	**ONT**	**OR**	**PAB**	**PARS**	**SC**	**TN**	**UT**	**VA**	**WA**	**WI**
M.27	2.8 ab	2.3 ab	1.5	1.2	2.5 a	1.7 ab	0.8 bc	1.3 b	0.3 ab	1.2 ab	1.0	2.7 ab	2.4 c
B.491	3.4 ab	2.8 ab	0.9	1.0	2.4 ab	1.5 ab	0.8 ab	1.9 ab	0.9 ab	1.8 ab	1.3	3.1 ab	2.8 bc
P.16	3.7 ab	2.4 a	1.0	1.0	3.3 a	2.0 b	1.1 ab	2.1 ab	1.1 b	2.3 a	1.7	3.3 a	3.6 ab
T337	2.8 ab	2.3 ab	0.3	0.7	2.4 b	1.7 ab	0.7 c	1.0 a	1.4 ab	1.5 ab	1.4	2.8 a	3.1 abc
Mark	3.3 ab	2.5 ab	0.8	1.4	2.7 ab	1.7 ab	1.3 abc	1.6 ab	0.7 ab	1.8 ab	1.7	1.7 b	2.9 bc
P.2	2.2 b	2.1 ab	1.2	0.9	2.4 ab	1.5 ab	0.9 c	1.0 ab	0.8 a	1.5 ab	1.5	2.2 b	2.4 c
O.3	3.0 ab	3.1 ab	0.4	- - -	2.4 ab	1.6 ab	1.3 ab	1.7 a	1.3 ab	1.9 ab	1.7	2.6 ab	3.8 ab
B.9	2.6 a	3.1 ab	1.1	1.3	2.9 ab	1.6 ab	1.0 abc	1.6 ab	0.8 ab	1.9 ab	1.3	2.8 ab	2.9 bc
M.9	3.0 ab	2.4 ab	0.4	0.8	2.4 b	1.0 a	0.6 c	0.9 a	1.1 ab	1.8 ab	1.5	2.5 ab	2.8 bc
Pajam1	2.7 ab	2.6 ab	- - -	- - -	2.3 b	1.1 ab	0.7 bc	1.1 a	1.2 a	1.4 ab	1.6	2.6 ab	2.9 bc
Pajam2	2.5 ab	2.3 ab	0.6	1.0	2.4 b	1.1 ab	0.8 bc	1.2 a	1.3 ab	1.6 ab	1.4	2.4 b	2.8 c
RN29	2.8 ab	2.6 ab	0.5	0.8	2.5 b	1.1 ab	1.0 c	0.9 ab	0.9 ab	1.6 ab	1.5	2.8 ab	3.0 bc
M.26	2.3 ab	2.5 b	0.5	0.6	1.9 b	1.0 ab	0.5 abc	1.2 ab	1.0 ab	1.5 ab	1.2	1.8 b	2.4 c
V.1	2.0 ab	2.3 b	1.0	0.8	2.0 b	1.1 ab	0.9 abc	1.5 ab	1.0 a	1.2 b	1.3	2.1 b	2.4 c
P.22	1.9	2.0	1.5	0.9	- - -	1.4	0.9	- - -	- - -	1.4	1.3	0.8	2.7
B.469	2.3	- - -	1.7	1.0	- - -	1.8	1.2	0.2	- - -	1.5	1.1	1.9	2.8
Fleuren56	2.2	- - -	0.6	0.8	- - -	1.2	- - -	- - -	- - -	- - -	1.6	2.4	- - -
V.3	2.5	- - -	1.0	1.0	- - -	1.6	- - -	- - -	- - -	- - -	1.2	2.4	- - -
LSmean	**2.8**	**2.5**	**0.8**	**1.0**	**2.5**	**1.4**	**0.9**	**1.3**	**1.0**	**1.6**	**1.4**	**2.6**	**2.9**
P-value	***0.001***	***0.001***	**- - -**	**- - -**	***0.001***	***0.001***	***0.013***	***0.001***	***0.001***	***0.001***	***0.126***	***0.001***	***0.001***

[z]Least squares means for rootstocks within site were compared with Tukey's test ($P = 0.05$).

which had similar yield (10). Cumulative yields for B.9, Mark and P.2 were 84, 61, and 60% those of M.9 EMLA (10).

Average fruit weight was influenced by location (Table 9). Fruit weight was lowest at AR, NB, and NC and highest at BC and WA. Fruit weight was significantly influenced by rootstock at 19 of the 26 locations and was probably influenced by crop load. To account for crop load, analyses of covariance were performed using number of fruit per tree as the covariate. Interaction terms for site x number of fruit or rootstock x number of fruit were included in the models to determine if the relationship was similar for all rootstocks and for all sites. In order to use analysis of covariance to adjust means for the covariate, it is assumed that the relationship between the covariate and the response variable is linear and that the slopes are homogenous for all levels of the non-continuous variables. In this case the non-continuous variables are site and rootstock. Because both interactions were significant ($P = 0.001$), fruit weight was influenced differently by crop load at different locations and for different rootstocks. Analysis of covariance could therefore not be used to adjust the means for crop load.

Yield efficiency was low at CO, GA, IN, ME, NB, NC, NJ, OH, PARS, and TN, and high at AR, BC, NYG, NYH, OR, WA and WI (Table 10). Rootstock did not significantly affect yield efficiency at CO, GA, ME, NB, NC, and VA. Among the most dwarfing rootstocks, P.16 had the highest yield efficiency; the moderately dwarfing stocks with high yield efficiencies included O.3, Mark, and B.9. Among for the most vigorous rootstocks M.26 EMLA tended to have the lowest yield efficiencies. Yield efficiency is generally highest for the most dwarfing rootstocks (1, 3). 'Cox's Orange Pippin' on P.16, Mark and B.9 had yield efficiencies similar to M.9 EMLA (10), and M.9 RN.29 had lower efficiency than trees on M.9EMLA (11). In Ohio, M.27 EMLA was generally less efficient than P.22, and M.26 EMLA was less efficient than V.1 (3).

Conclusions. Results from this trial should be interpreted cautiously, because data are for only the first five years. It is impossible to make general statements about rootstocks because rootstock performance varied greatly from one location to another. At some locations, all rootstocks produced trees of similar size and productivity, so choice of rootstock is not very important. At other locations rootstock had a large influence on tree size and productivity, but the superior rootstocks varied for different locations. However, there may be some rootstocks that perform better than the Malling rootstocks currently being planted. In the very dwarf category, P.16 was generally more productive than M.27 EMLA; in the moderate vigor class O.3 was most productive at most locations, whereas M.9 NAKTB337 was least productive; in the high vigor class M.9 Pajam2 was usually more productive than M.26 EMLA. This is the first trial in North America where several selections of M.9 have been compared. There is a wide range of vigor among these selections. M.9 RN29 and M.9 Pajam2 produced trees about the same size as M.26 EMLA; M.9 NAKBT337 and M.9 Fleuren56 were more dwarfing than M.9 EMLA, but trees on M.9 EMLA produced higher yields than on the other M.9 selections in its size class.

At the nine sites where V.3 was planted, it had similar TCSA and slightly lower yields per tree, but higher YE than M.9 EMLA. Because V.3 survived better than M.9 EMLA in Ohio, it may have more resistance to fireblight. These data indicate that V.3 may be a good candidate for continued testing.

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Call for Wilder Medal Nominations

The Wilder Medal Committee of the American Pomological Society (APS) invites nominations for the 2000 Wilder Silver Medal Award. All active members of APS are eligible to submit nominations. The Wilder Medal was established in 1873 in honor of Marshall P. Wilder, the founder and first President of the Society. The award consists of a beautifully engraved medal which is presented to the recipient at the annual meeting of APS, held during the ASHS Annual Meeting.

The Wilder Medal is conferred on individuals or organizations which have rendered outstanding service to horticulture in the area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious fruit cultivars. Individuals associated with either commercial concerns or professional organizations will be considered if their introductions are truly superior and have been widely planted.

Significant contributions to the science and practice of pomology other than through fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or noteworthy publications in any of the above subjects.

To obtain nomination guidelines, contact committee chairperson, Desmond R. Layne, Dept. of Horticulture, Clemson University, Clemson, SC 29634-0375; phone: 864-656-4960; fax: 864-656-4960; e-mail: dlayne@clemson.edu. Nominations must be submitted by **1 May 2000.**

Mites on Strawberries

All 13 cultivars were susceptible to two-spotted spider mite. Most of the cultivars were moderately infested similar to 'Senga Senguna' used as the standard. Cultivars similar to the controls were ' Kama,' 'Dukat,' 'Syriusz,' 'Real,' 'Honeyoe,' 'Gerida,' 'Cortina' and 'Redgauntlet.' The higher numbers of mites were on 'Kent,' 'Dana,' 'Marmolada' and 'Elsanta.' In bad years mite control was needed for all cultivars.. From: Labanowska and Chelbowska. 1998. J. Fruit and Orn. Plant Res. VI(1):129-137.