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Performance of Plum Rootstocks with 'Stanley', 'Valor', and 'Veeblue' as the Scion in the 1990 NC-140 Multi-Site Plum Trial

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Abstract

In 1990, a multi-site replicated plum (*Prunus domestica* L.) rootstock trial was established by the Cooperative Regional Pome and Stone Fruit Project (NC-140), using 'Stanley', 'Valor', or 'Veeblue' as the scions. The trial compared vigorous and semi-vigorous peach and plum rootstocks to identify rootstock selections with improved performance for the various production areas in the United States. Marianna GF8-1 and Marianna 4001 rootstocks generally had the best survival, highest cumulative yield and cumulative yield efficiency, largest fruit size, the greatest trunk cross-sectional areas and highest numbers of root suckers, irrespective of the scion. The Oregon site was the most productive with 100% tree survival for all rootstocks, the largest trunk cross-sectional areas, the highest cumulative yields and some of the largest fruit sizes for all rootstock/scion combinations. None of the three putative dwarfing or semi-dwarfing stocks, Citation, Pixy and St. Julien A performed well in the eastern USA sites. Citation rootstock had the lowest tree survival, trunk cross-sectional area, and fruit size, at the 3 sites in the eastern USA. St. Julien A and Pixy rootstocks followed closely after Citation in low tree survival at the eastern USA sites. In contrast at Oregon, Citation had high survival and the highest yield efficiency coupled with large fruit size. No significant differences were observed between 'Valor' and 'Veeblue' scions for most variables although both had larger fruit size than 'Stanley' regardless of the rootstock. We were not able to identify any dwarfing rootstocks with the desired characteristics.

European plums (*Prunus domestica* L.) are primarily grown commercially along the west coast and in the Great Lakes region of the USA. However, they are widely adapted and can be grown in nearly all locations in the USA. Plums offer the potential for many fruit producers to diversify their operations, but poor rootstock adaptability, especially to the poorly drained clay soils found in many regions of the United States, has limited production in these areas.

Myrobalan 29C is the predominant plum rootstock used in the eastern USA while Marianna 2624 is the predominant stock in California (14). Myrobalan 29C is vigorous and not adaptable to high density plantings (7, 12). Another important problem with this rootstock is brown line decline caused by tomato ringspot virus (5, 6). Plum tree losses due to this disease have been highest with Myrobalan and peach rootstocks (5). Several important scions such

as 'Stanley', 'Iroquois', and 'Richard's Early Italian' are known to be susceptible to tomato ringspot virus on Myrobalan. The susceptibility of other scion varieties is unclear. Dr. Dave Rosenberger (plant pathologist, Cornell University, personal comm., 2002) reported that he was unable to obtain brown line on either 'Shiro' or 'Methley' on Myrobalan in a trial in New York State. Infected trees can die from a hypersensitivity reaction at the graft union. The rootstock may become infected in the nursery or after planting by a nematode vector which moves the virus from a natural reservoir in orchard weeds. Orchard sites which have recently had peaches often are infested with the virus.

Marianna 2624 is also a vigorous rootstock but it is resistant to the root-knot nematode that vectors tomato ringspot virus (11). Like Myrobalan, it is tolerant of heavier soils than other *Prunus* rootstocks; however, it suckers profusely (14).

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The tree size of both Myrobalan and Marianna 2624 is well suited to the shake-and-catch methods of mechanical harvest used in many processing plum districts. However, many plum growers would prefer a rootstock that confers dwarfing and higher precocity, especially for fresh market orchards where fruit thinning by hand is utilized to achieve increased fruit size. Desirable characteristics of a new rootstock include tolerance to poorly drained clay soils, cold hardiness, dwarfing, precocity, high yield efficiency, low root suckering, and pest resistance (7, 13). These desirable characteristics are seldom found in a single rootstock. Several new plum rootstocks from France, England, and the USA, including improved selections of Myrobalan and Marianna, may offer improved tree performance for American plum growers (7, 12).

There have been few comparative reports of plum rootstock performance in the USA (7), but several reports of plum rootstock comparisons from Europe (2, 3, 4) were reviewed by Wertheim in 1998 (12). In North America, a committee of researchers from the United States, Canada, and Mexico has undertaken the evaluation of fruit tree rootstocks using multi-site coordinated trials. This committee (named NC-140) has previously evaluated several plum rootstocks with peach as the scion (8, 9). However, this is the first report of a multi-site comparison of plum rootstocks using plum scions by the NC-140 group.

Materials and Methods

In 1990, a multi-site plum rootstock trial was planted at 5 sites (Table 1) across the United States (Indiana, IN; Kentucky, KY; Michigan, MI; New York, NY; and Oregon,

OR) with 'Stanley', 'Valor', and 'Veeblue' (all *Prunus domestica* L.) scions. Trees on 14 test rootstocks (Table 2) were produced by Newark Nurseries (Hartford, MI) and distributed to cooperators for each planting. Not all sites had all 3 scions and, due to limitations in plant material, not all sites received all 14 rootstocks. The rootstocks varied in tree vigor from dwarf to vigorous and were of several *Prunus* species or hybrids of *Prunus* species (Table 3).

At each site, trees were planted in a randomized complete block design at a spacing of 4.9 m within rows and 6 m between rows. There were 7 single tree replicates of each rootstock at KY, MI, NY, and OR, but only 6 replicates at IN. Soil management consisted of a 2 m herbicide strip centered beneath the tree rows, with mowed sod alleyways. Trees were trained and pruned to the multi-leader vase system according to a uniform protocol across all sites, but fertilization, irrigation, and fruit thinning were conducted according to local recommendations. The MI site was terminated after the 4th year and the IN site after the 8th year. The KY, OR, and NY sites were continued through year 9.

Data collected included tree survival, trunk circumference (converted to cross-sectional area TCA, cm²) measured at the end of the experiment 30 cm above the soil line, cumulative yield, cumulative yield efficiency, fruit size (measured annually on a sample of 50 fruits per tree) and number of root suckers counted at the end of the experiment.

Data for each site and scion cultivar were analyzed separately since the scion and rootstock combinations varied between sites. A second analysis pooling data across sites was done using data at the end of year 8 only with

Table 1. NC-140 1990 plum rootstock trial cooperators.

State	Cooperators	Institution	Site
Indiana	P. Hirst, R. Hayden	Purdue University	West Lafayette
Kentucky	J. Masabni, D. Wolfe, G. Brown	University of Kentucky	Princeton
Michigan	R. Perry	Michigan State University	Clarksville
New York	R. Andersen, J. Freer, T. Robinson	Cornell University	Geneva
Oregon	A. Azarenko, B. McCluskey	Oregon State University	Corvallis

Table 2. Rootstocks and scions at the test sites for the 1990 NC-140 plum rootstock trial.

Rootstock	Scions				
	Indiana (8 years of data)	Kentucky (9 years of data)	Michigan (4 years of data)	New York (9 years of data)	Oregon (9 years of data)
Brompton	Stanley, Valor	Stanley	Valor	Stanley	Stanley
Citation	Stanley	Stanley	Stanley, Valor	Stanley	Stanley
Damas GF1869				Stanley	
GF-677			Stanley	Stanley	
Lovell seedling	Stanley, Veeblue	Stanley	Stanley	Stanley	Stanley
Marianna GF8-1	Stanley, Veeblue	Stanley	Stanley, Valor	Stanley	Stanley
Marianna 2624			Stanley, Valor	Stanley	
Marianna 4001	Stanley	Stanley	Stanley, Valor	Stanley	Stanley
Myrobalan 29C	Stanley	Stanley	Stanley	Stanley	
Myrobalan GF31	Valor	Stanley	Stanley, Valor	Stanley	
Myrobalan Seedling	Stanley, Valor, Veeblue	Stanley	Stanley, Valor	Stanley	Stanley
Pixy	Stanley, Valor	Stanley	Stanley, Valor	Stanley	Stanley
St. Julien A		Stanley	Stanley, Valor	Stanley	Stanley
Texas				Stanley	

‘Stanley’ for 4 sites (IN, KY, NY, and OR) with 7 rootstocks common at each site. A third analysis using pooled data across sites was done using data at the end of year 4 to evaluate the early performance of rootstocks at all 5 sites for the 6 rootstocks common at all sites. These data were analyzed using PROC GLM (SAS Institute, Cary, NC) for the analysis of variance and the Fisher’s least significant difference (LSD) for mean separation.

Results

Tree survival was highest at OR where all trees were alive at the end of 9 years (Table 4). Tree survival was also high at MI but the trial was ended after only 4 years and thus this may not reflect long term survival in a northeastern growing site. At the other three sites in the eastern US (IN, KY, and NY), rootstocks varied significantly in survival. The range of tree survival was greatest in NY (from 14-100%) and to a lesser extent at IN and KY. Citation had the lowest survival rates, followed by St. Julien A with significant losses at KY and

non-significant losses at NY. Other rootstocks with significant tree loss in NY were Damas GF1869, GF-677, Lovell seedling, and Texas. Tree survival at IN was only 50% for ‘Veeblue’ on Myrobalan or Lovell Seedling and ‘Valor’ on Pixy. However, the variability was so high that this was not significantly different from 100%. Pixy rootstock had higher survival rates when grafted with ‘Stanley’ (83-100%) than with ‘Valor’ (50%). Considering all rootstock-scion combinations over all sites, Marianna GF8-1, Marianna 4001, Myrobalan GF31, and Marianna 2624 had the highest survival rates irrespective of site or scion, ranging from 83-100%.

Tree size among rootstocks differed at each site except at IN with ‘Valor’ or ‘Veeblue’ as the scions (Table 5). Trees in OR were the largest followed by IN, KY, and NY with the smallest trees. Tree size rankings within each site for each scion generally allowed categorization of tree size into three groups (large, intermediate, and small). Three rootstocks, Marianna GF8-1, Myrobalan 29C, and

Table 3. Characteristics of plum rootstock evaluated in the 1990 NC-140 multi-site trial^z.

Rootstock	Species ^y	Origin	Degree of dwarfing	Relative tolerance to waterlogging	Disease susceptibilities	Susceptibility to root knot nematode	Suckering	Known scion incompatibilities	Propagation methods
Brompton	<i>P. domestica</i>	England	semidwarf	medium	bact. canker, Sharka carrier	resistant	slight	some prunes	hardwood cuttings, layers
Citation	Plum x Peach hybrid	California	dwarf	low	^x		none	none	cuttings (easy to root)
Damas GF1869	<i>P. spinosa</i> x <i>P. domestica</i>	France	semidwarf	high			profuse		
GF-677	Peach x Almond hybrid	France	vigorous	low		susceptible			
Lovell seedling	<i>P. persica</i>	USA	vigorous	low	prune, brownline, oak, root rot, Sharka, collar rot	susceptible	few to none	Lombard, German Prune, Grand Duke, Stanley Prunes	seed
Marianna GF8-1	<i>P. cerasifera</i> x <i>P. munsoniana</i>	France	vigorous	high	Silver leaf	resistant	none	Reine Claude	cuttings (easy to root)
Marianna 2624	<i>P. cerasifera</i> x <i>P. munsoniana</i>	California	semidwarf	medium	bact. canker	resistant	medium	none	cuttings
Marianna 4001	<i>P. cerasifera</i> x <i>P. munsoniana</i>	California	vigorous				medium	none	cuttings
Myrobalan 29C	<i>P. cerasifera</i>	USA	vigorous	medium	prune, brownline, bact. canker	resistant	medium	none	cuttings
Myrobalan GF31	<i>P. cerasifera</i>	France	vigorous	medium	prune, brownline, bact. canker			Reine Claude	cuttings (easy to root)
Myrobalan seedling	<i>P. cerasifera</i>	Europe	vigorous	medium	prune, brownline	susceptible	few	Stanley, Green Gage, President	seed
Pixy	<i>P. insititia</i>	England	semidwarf		brownline		slight		hardwood cuttings, layers
St. Julien A	<i>P. insititia</i>	England	semidwarf	medium			moderate	none	hardwood cuttings, layers
Texas		USA	semidwarf						

^z Compiled from Okie (1987) and Wertheim (1998)^y Genus name abbreviated for *Prunus*^x Missing value () indicate no information is available for that rootstock

Table 4. Plum tree survival (%) as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley					Valor		Veeblue
	IN (8 yrs.)	KY (9 yrs.)	MI (4 yrs.)	NY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	MI (4 yrs.)	IN (8 yrs.)
Brompton	100 a ^z	100 a	.	86 ab	100	100	100 a	.
Citation	0 b	29 c	100	14 d	100	.	100 a	.
Damas GF1869	.	.	.	53 bc	.	.	.	.
GF-677	.	.	100	50 c	.	.	.	.
Lovell seedling	100 a	100 a	100	57 bc	100	.	.	50
Marianna GF8-1	100 a	100 a	100	100 a	100	.	100 a	100
Marianna 2624	.	.	100	100 a	.	.	100 a	.
Marianna 4001	100 a	100 a	100	100 a	100	.	100 a	.
Myrobalan 29C	100 a	100 a	100	75 abc	.	.	.	.
Myrobalan GF31	.	100 a	100	86 ab	.	83	100 a	.
Myrobalan seedling	100 a	71 ab	100	86 ab	100	83	100 a	50
Pixy	83 a	100 a	100	100 a	100	50	50 b	.
St. Julien A	.	57 bc	100	86 ab	100	.	100 a	.
Texas	.	.	.	56 bc	.	.	.	.
LSD (0.05)	17	31	NS	34	NS	NS	30	NS
P-value	0.001	0.001	0.999	0.001	0.999	0.217	0.005	0.296

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values (.) indicate that variety/rootstock combination was not planted at that site.

Marianna 2624 were in the largest tree group at all sites regardless of the scion. Marianna 4001 was also in the largest group at all sites except OR where it was in the intermediate size group. Myrobalan seedling was in the largest tree size group at all sites except KY where it was in the intermediate size group. Myrobalan GF31, GF-677 and St. Julien A were in the large group at NY but were in the intermediate group at IN and KY. Pixy was in the large group at NY, in the intermediate group at IN and KY, and in the small group at OR but all of the trees at OR including those on Pixy were larger than any of the trees in the eastern sites. Lovell seedling was in the intermediate group, except at OR where it was in the small group. Brompton was in the intermediate group at IN with ‘Stanley’ but in the small group at KY, NY and OR. The smallest trees were with Citation at the three sites where it was planted (KY, NY, OR). With ‘Stanley’, the TCA of Citation was only 30-50% of the

largest trees at any site. Tree size ranking from the MI plot at the end of 4 years was generally similar to the final rankings from the other sites at the end of 8 or 9 years, except that Lovell seedling was in the large size group rather than the medium or small group and St. Julien A was in the small group rather than in the intermediate or large groups.

Cumulative yield per tree differed among stocks at all sites with ‘Stanley’ as the scion (Table 6). Rankings of cumulative yield within each site for each scion generally allowed categorization into three yield groups (high, intermediate, and low). With ‘Stanley’ as the scion, Marianna GF8-1, and Marianna 4001 were in the top yielding group at all sites. St. Julien A was in the high yielding group at KY and OR but in the intermediate group at NY. Myrobalan 29C was in the high yielding group at IN but in the intermediate group at KY and NY. Conversely, Lovell seedling was in the intermediate group at IN but in the high

Table 5. Trunk cross-sectional area (cm²) of surviving plum trees as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley					Valor		Veeblue
	IN (8 yrs.)	KY (9 yrs.)	MI (4 yrs.)	NY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	MI (4 yrs.)	IN (8 yrs.)
Brompton	138 bc ^z	74 d	.	80 def	247 bc	138	18 de	.
Citation	.	52 d	31 e	51 f	221 c	.	32 bcd	.
Damas GF1869	.	.	.	75 ef	.	.	.	.
GF-677	.	.	47 ed	100 abcde	.	.	.	.
Lovell seedling	132 bc	138 bc	73 a	99 bcde	252 bc	.	.	132
Marianna GF8-1	176 a	174 a	66 a	131 ab	324 a	.	67 a	200
Marianna 2624	.	.	63 ab	123 abc	.	.	53 ab	.
Marianna 4001	175 a	165 ab	55 bc	136 a	273 b	.	48 bc	.
Myrobalan 29C	180 a	177 a	70 a	103 abcde	.	.	.	.
Myrobalan GF31	.	130 c	38 de	120 abc	.	152	35 cd	.
Myrobalan seedling	157 ab	128 c	44 d	134 a	338 a	173	30 d	201
Pixy	119 c	140 bc	47 cd	106 abcde	253 bc	157	11 e	.
St. Julien A	.	120 c	32 e	113 abcd	255 b	.	29 d	.
Texas	.	.	.	89 cde	.	.	.	.
LSD (0.05)	36	28	11	35	43	NS	17	NS
P-value	0.009	0.001	0.001	0.001	0.001	0.377	0.001	0.130

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values "." indicate that variety/rootstock combination was not planted at that site.

group at KY, NY, and OR. Myrobalan seedling was in the high yielding group at KY and OR but in the intermediate group at IN and NY. The least productive rootstock was Citation at the three eastern USA sites (IN, KY, and NY) but it was in the high yielding group in OR. Pixy was in the high yielding group at KY, in the intermediate group at IN and NY, and in the low yielding group at OR. Marianna 2624, planted only at NY and MI, was in the high yielding group while GF-677 was in the intermediate group and Damas GF1869 was in the low yielding group. The yields from MI, which represent only 4 years, show that Lovell seedling, Myrobalan seedling, Myrobalan 29C and GF-677 were the most precocious while Marianna 4001, Marianna 2624, St. Julien A and Pixy were the least precocious. No significant differences in cumulative yield were observed among any of the rootstocks with either 'Valor' or 'Veeblue' as the scion (Table 6).

Cumulative yield efficiency (CYE) differed significantly among rootstocks at each site except at IN with 'Veeblue' as the scion (Table 7). Rankings of CYE within each site for each scion generally allowed categorization into three yield efficiency groups (high, intermediate, and low). Of the rootstocks which were planted at 3 or more sites, only Myrobalan GF31 and St. Julien A were in the top yield efficiency group at all 3 sites. Myrobalan seedling was in the top group at 3 of 5 sites while Citation, Marianna 4001, Marianna GF8-1 and Lovell seedling were in the top group at 2 of 4 sites. Brompton, Pixy, Damas GF1869, and Texas were never in the top group while the remaining stocks were in the top group at only one of the sites. Citation had the highest yield efficiency at KY and OR but had the lowest yield efficiency at IN and NY. Although the CYE for Citation in KY (1.4 kg·cm⁻²) is high, the trees were extremely weak and not of commercial size (see Table 5). At

Table 6. Cumulative yield (kg/tree) of surviving plum trees as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley					Valor		Veeblue
	IN (8 yrs.)	KY (9 yrs.)	MI (4 yrs.)	NY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	MI (4 yrs.)	IN (8 yrs.)
Brompton	117c ^z	80 d	.	93 efg	152 bc	98	4	.
Citation	22 d	71 c	12 bcd	23 h	211 ab	.	12	.
Damas GF1869	.	.	.	66 gh	.	.	.	.
GF-677	.	.	13 abc	144 bcde	.	.	.	.
Lovell seedling	124 c	149 ab	19 a	133 cdef	206 ab	.	.	214
Marianna GF8-1	219 ab	161 ab	10 cd	202 ab	266 a	.	11	369
Marianna 2624	.	.	5 de	174 abc	.	.	9	.
Marianna 4001	190 ab	173 a	3 e	224 a	231 a	.	5	.
Myrobalan 29C	236 a	137 b	14 abc	101 defg	.	.	.	.
Myrobalan GF31	.	149 ab	8 cde	167 abc	.	140	8	.
Myrobalan seedling	181 b	152 ab	17 ab	156 bcd	232 a	129	6	171
Pixy	114 c	142 ab	6 de	123 cdefg	139 c	63	0	.
St. Julien A	.	144 ab	6 de	150 bcde	230 a	.	3	.
Texas	.	.	.	83 fg	.	.	.	.
LSD (0.05)	50	34	7	58	64	NS	NS	NS
P-value	0.001	0.001	0.001	0.001	0.003	0.086	0.089	0.102

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values “.” indicate that variety/rootstock combination was not planted at that site.

IN, Myrobalan 29C and Myrobalan seedling were in the high yield efficiency group while Marianna GF8-1, Marianna 4001, Pixy, and Lovell seedling were in the intermediate group and Brompton and Citation were in the low yield efficiency group. At KY, Citation, Myrobalan GF31, Myrobalan seedling and St. Julien A were in the high yield efficiency group while Marianna 4001 and Lovell seedling were intermediate and Pixy, Brompton, Marianna GF8-1, and Myrobalan 29C were in the low yield efficiency group. At NY, Marianna 4001, Marianna GF8-1, Myrobalan GF31, GF-677, Marianna 2624, Lovell seedling, and St. Julien A were in the high yielding group, while Brompton, Myrobalan seedling, Myrobalan 29C, and Pixy were in the intermediate group and Damas, Texas, and Citation were in the low yield efficiency group. At OR there were only 2 yield efficiency groups with Citation, St. Julien A, Marianna GF8-1, Lovell seedling, and Marianna 4001 in the high yield-

ing efficiency group and Myrobalan seedling, Brompton, and Pixy in the low yield efficiency group. At IN with ‘Valor’ as the scion, Myrobalan GF31 and Myrobalan seedling were the most yield efficient, while Brompton was intermediate and Pixy had low yield efficiency. No significant differences were observed for CYE for ‘Veeblue’ at IN.

Fruit size differed significantly among rootstocks with ‘Stanley’ as the scion but not with ‘Valor’ or ‘Veeblue’ as the scion (Table 8). At IN, the fruit of trees on all stocks was similar in size, except Pixy, which was smaller. At KY, the largest fruits were on Myrobalan 29C, Lovell seedling, Myrobalan GF31, Marianna GF8-1, Myrobalan seedling, and St. Julien A. Citation at the KY site had both the smallest fruit size and the lowest yields (Tables 6 and 8). Fruit size with ‘Stanley’ among 3 eastern USA sites was largest at KY regardless of rootstock, except for Citation. In contrast, at OR, Citation had the largest fruits (41 g). Marianna

Table 7. Cumulative yield efficiency (kg·cm⁻² TCA) of surviving plum trees as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley					Valor		Veeblue
	IN (8 yrs.)	KY (9 yrs.)	MI (4 yrs.)	NY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	MI (4 yrs.)	IN (8 yrs.)
Brompton	09 ef ²	1.0 bc	.	1.2 bcd	0.6 cd	0.7 b	0 d	.
Citation	0.7 d	1.4 a	0.4 ab	0.6 e	1.0 a	.	0.4 a	.
Damas GF1869	.	.	.	0.9 de	.	.	.	.
GF-677	.	.	0.3 abc	1.4 abc	.	.	.	.
Lovell seedling	0.9 de	1.1 b	0.3 bcd	1.3 abc	0.8 abc	.	.	1.7
Marianna GF8-1	1.2 ab	1.0 bc	0.2 bdef	1.5 ab	0.8 abc	.	0.2 bc	1.9
Marianna 2624	.	.	0.1 ef	1.4 abc	.	.	0.2 bc	.
Marianna 4001	1.1 bcd	1.1 b	0.0 f	1.6 a	0.8 abc	.	0.1 cd	.
Myrobalan 29C	1.3 a	0.8 c	0.2 cde	1.1 cd	.	.	.	.
Myrobalan GF31	.	1.2 ab	0.2 cdef	1.4 abc	.	0.9 a	0.3 b	.
Myrobalan seedling	1.2 ab	1.2 ab	0.4 a	1.2 bcd	0.7 bcd	0.8 ab	0.2 bc	1.0
Pixy	1.0 cde	1.0 bc	0.1 def	1.1 cd	0.5 d	0.4 c	0 d	.
St. Julien A	.	1.2 ab	0.2 cdef	1.3 abc	0.9 ab	.	0.1 cd	.
Texas	.	.	.	0.9 de	.	.	.	.
LSD (0.05)	0.2	0.3	0.1	0.4	0.2	0.2	0.1	NS
P-value	0.001	0.013	0.001	0.002	0.011	0.001	0.001	0.238

² Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values “.” indicate that variety/rootstock combination was not planted at that site.

4001, Marianna GF8-1, and Lovell seedling also had large fruit size at OR. Fruit size data were not collected at MI or NY.

Root suckering varied by site with KY having the most root suckers followed by OR and IN (Table 9). Citation and Lovell seedling rootstocks had the fewest root suckers across all trials, while Marianna GF8-1 and Myrobalan Seedling had the most. Suckering of trees on Brompton, Marianna 4001, Pixy, and Myrobalan 29C was highly variable depending on the site. Among scion cultivars at IN, the number of root suckers with ‘Valor’ was higher than with ‘Stanley’ while ‘Veeblue’ was intermediate.

When the data for ‘Stanley’ were pooled after year 4 and analyzed across all 5 sites, we observed that among the 6 rootstocks common to all sites, Citation and Marianna 4001 were the only stocks with tree survival significantly less than 100% (Table 10). Citation also had the smallest TCA. Marianna GF8-1 and Mari-

anna 4001 had the highest TCA, followed by Myrobalan seedling, Lovell seedling, and Pixy. Marianna 4001 had higher cumulative yield than any of the others. No significant differences were observed in yield efficiency among the 6 stocks.

When the data for ‘Stanley’ were pooled after year 8 and analyzed across all 4 available sites, we observed that among the 7 rootstocks common to all sites, Citation was the only rootstock with significantly less than 100% tree survival (Table 11). Marianna GF8-1 had the highest TCA and cumulative yield, followed by Myrobalan seedling, Marianna 4001, Lovell seedling, Pixy, and Citation, while Brompton had the smallest TCA and cumulative yield. CYE was not significantly different for the rootstocks evaluated after 8 years. This data suggest that TCA is proportional to yield (yield = $-19.4 + 0.87 \cdot \text{TCA}$, and $r^2 = 0.86$).

Table 8. Average fruit size (g) on surviving plum trees as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley			Valor	Veeblue
	IN (8 yrs.)	KY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	IN (8 yrs.)
Brompton	34 a ^z	39 cd	33 c	47	.
Citation	36 a	34 d	41 a	.	.
Lovell seedling	33 a	46 ab	35 bc	.	39
Marianna GF8-1	35 a	45 ab	35 bc	.	44
Marianna 4001	34 a	42 bc	36 b	.	.
Myrobalan 29C	35 a	47 a	.	.	.
Myrobalan GF31	.	45 ab	.	50	.
Myrobalan seedling	35 a	44 ab	33 c	49	44
Pixy	29 b	41 bc	33 c	49	.
St. Julien A	.	44 ab	34 bc	.	.
LSD (0.05)	4	5	3	NS	NS
P-value	0.05	0.002	0.001	0.680	0.057

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values "." indicate that variety/rootstock combination was not planted at that site.

Table 9. Average number of root suckers on surviving plum trees as influenced by rootstock, cultivar and site in the 1990 NC-140 multi-site trial.

Rootstock	Stanley			Valor	Veeblue
	IN (8 yrs.)	KY (9 yrs.)	OR (9 yrs.)	IN (8 yrs.)	IN (8 yrs.)
Brompton	7 ab ^z	7 cd	12 ab	42 a	.
Citation	0 c	1 d	0 c	.	.
Lovell seedling	2 bc	3 d	0 c	.	8 b
Marianna GF8-1	5 abc	47 a	29 a	.	17 a
Marianna 4001	2 bc	13 cd	4 c	.	.
Myrobalan 29C	2 bc	21 bc	.	.	.
Myrobalan GF31	.	4 d	.	8 b	.
Myrobalan seedling	8 a	35 ab	27 a	13 b	8 ab
Pixy	2 bc	15 cd	26 ab	18 b	.
St. Julien A	.	4 d	3 c	.	.
LSD (0.05)	5	14	15	21	10
P-value	0.041	0.001	0.001	0.018	0.038

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$). Missing values "." indicate that variety/rootstock combination was not planted at that site.

Table 10. Average performance of 6 plum rootstocks with 'Stanley' as the scion at 5 sites across North America (IN, KY, MI, NY, and OR) after 4 years in the 1990 NC-140 multi-site trial.

Rootstock	Tree survival (%)	Trunk cross-sectional (cm ²)	Cumulative yield (kg)	Cumulative yield efficiency (kg·cm ⁻² TCA)
Marianna GF8-1	100 a z	80 a	31 b	0.56
Myrobalan Seedling	100 a	68 ab	27 b	0.55
Pixy	97 ab	58 b	22 b	0.51
Lovell seedling	94 abc	71 ab	33 b	0.54
Citation	88 bc	38 c	24 b	0.79
Marianna 4001	84 c	75 a	47 a	0.74
LSD (0.05)	11	15	14	NS

^z Means followed by common letters do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$).

Discussion

Citation rootstock was the poorest performer across all sites, except at OR. Citation with 'Stanley' scions at OR were larger than all rootstocks at the other sites but Citation was still the smallest tree at the OR site. It appears that Citation is suited to the climate of OR (milder winters, and cooler and drier summers) but is not suited to the more extreme climates of the other sites (colder winters, and hotter and wetter summers). This was especially evident at KY where Citation had both the smallest fruit size and the lowest yields.

At IN, Myrobalan 29C, Myrobalan seedling, Marianna GF8-1, and Marianna 4001 were the best rootstocks considering yield, fruit size, and tree mortality when 'Stanley' was the scion. With 'Valor' or 'Veeblue' as the scions, there were no differences between rootstocks for any measured variables except CYE with 'Valor'. A comparison of 'Valor' and 'Veeblue' with 'Stanley' on similar rootstocks indicates that 'Valor' was similar to 'Stanley', while 'Veeblue' outperformed 'Stanley' in TCA, cumulative yield, CYE, and fruit size, but not tree survival. The MI trial also showed similar performance between 'Valor' and 'Stanley'. In general, 'Valor' and 'Veeblue' plums were larger than 'Stanley' plums.

At KY, Marianna GF8-1, Marianna 4001, and Lovell seedling were the best rootstocks

considering yield, fruit size, and tree mortality. The three Myrobalan stocks and Pixy were intermediate. St. Julien A showed good yield efficiency but intermediate survival. Brompton had low yield and low tree survival.

At NY, Marianna 4001, Marianna GF8-1, and Marianna 2624 were the best rootstocks considering yield, CYE and tree mortality. Citation, Damas GF1869, Lovell seedling, GF-677, and Texas had poor survival and are of questionable value for northern climates. The three Myrobalan stocks had slightly lower survival than the Marianna stocks but Myrobalan GF-31 had similar yield efficiency. St. Julien A and Brompton showed good yield efficiency but intermediate survival. In NY, Marianna 2624 and Damas GF1869 with 'Stanley' had severe suckering, defined as > 15 suckers per tree (Jay Freer, Research Support Specialist, Cornell University, personal communication, 1999).

At OR, since all trees had good survival, the best stocks in each vigor class were Marianna GF8-1 in the vigorous category, St. Julien A, Lovell seedling, and Marianna 4001 in the intermediate vigor category, and Citation in the dwarf category. Pixy and Brompton were poor performers in OR.

In general, it appears that Marianna GF8-1 and Marianna 4001 are the best rootstocks for the eastern production areas but they are vigor-

Table 11. Average performance of 7 plum rootstocks with 'Stanley' as the scion at 4 sites across North America (IN, KY, NY, and OR) after 8 years in the 1990 NC-140 multi-site trial.

Rootstock	Tree survival (%)	Trunk cross-sectional (cm ²)	Cumulative yield (kg)	Cumulative yield efficiency (kg•cm ⁻² TCA)
Brompton	96 a ^z	110 c	77 d	0.71
Citation	38 b	138 bc	114 abc	0.85
Lovell seedling	92 a	149 abc	112 bc	0.79
Marianna 4001	100 a	172 ab	136 ab	0.83
Marianna GF8-1	100 a	185 a	142 a	0.85
Myrobalan seedling	88 a	179 ab	135 ab	0.84
Pixy	96 a	144 abc	88 cd	0.69
LSD (0.05)	15	42	31	NS

^z Means within a column followed by a common letter do not differ significantly ($P \leq 0.05$, $n = 7$ except IN where $n = 6$).

ous. Early reports by Hatton (2, 4) and Glenn (2) categorized Marianna as intermediate in vigor. However, it is unclear which clone of Marianna they used. Our data show that the selected clones of Marianna are as vigorous as Myrobalan. It appears they were selected for increased tree vigor (12). These newer clones of Marianna did not appear to be significantly different from the more common Marianna 2624 in performance or survival in NY. In general, they may offer a small advantage over Myrobalan seedling which is currently the most commonly planted rootstock. Only at IN did the Myrobalan stocks perform as well as the Marianna stocks. The peach/almond hybrid rootstock GF-677 had good yield but poor survival at NY. It has good tolerance to high pH soils and may be a good option for sites that do not have cold winters, but it does not appear to be well suited to northern growing areas. None of the semi-dwarfing or dwarfing stocks we tested was better than Myrobalan or Marianna stocks in the east while Citation appears to be quite promising as a dwarfing rootstock for OR. Lovell seedling, a semi-dwarfing peach rootstock, performed well at IN and KY but its poor survival in NY indicates a vulnerability to cold winters, which is also a problem when it is used as a rootstock

for peaches (9). Damas GF1869, which was only tested at NY, did not have good survival or yield.

The identification of productive, precocious and dwarfing plum rootstocks which are well adapted to eastern growing conditions was not successful with these trials and will have to wait for the next generation of new plum rootstocks. Ishtara from France has shown promise as a dwarfing plum rootstock (10). Researchers at the Univ. of California and the USDA recently named two new dwarfing stocks, Controller 5 (50% the size of seedling) and Controller 9 (90% the size of seedling), which may have promise as rootstocks for plums since they are both peach/plum hybrids (1). Controller 5 has shown much better cold hardiness than Lovell seedling with peach scions in NY (Terence Robinson, unpublished data). Hiawatha is another new stock that may have potential as a plum rootstock (1). It was bred in South Dakota as a scion variety which tolerates the prairie states' winters. It has shown considerable promise in California as a peach rootstock that is intermediate in dwarfing between Controller 5 and Controller 9 (1). In addition, California researchers plan to introduce a new Marianna rootstock (M 40) in the near future (Ted DeJong, Univ. of Cali-

fornia, personal communication). This stock is reported to be very similar to Marianna 2624 but with many fewer suckers. Lastly a plum hybrid (*P. tomentosa* × *P. cerasifera*) from Russia, VAA-1, has also shown good hardiness in NY (Terence Robinson, unpublished data) and may have potential as a plum rootstock.

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TOWARDS THE BEST DISINFECTANT FOR USE ON SHEARS WHEN PRUNING FIRE BLIGHT

The authors' objective was to determine the best disinfectant against *Erwinia amylovora* (the causative agent of fire blight) on secateurs, considering efficacy, corrosivity and phytotoxicity. A culture media test was used to screen five disinfectants in two concentrations: ethanol (70 and 96%), Menno Florades™ (1 and 4%), Arekina (5 and 10%), Pera Safe™ (0.81 and 1.62%), Virkon® (1 and 5%) and three time durations of disinfection: 20 s, 10 s, 1 s (a rapid dip). For practical use the disinfectant should offer complete rapid sterilization, be non-corrosive and non-phytotoxic. A new statistical measure for evaluating disinfectant efficacy was used. Taking into account the joint effect of efficacy, corrosivity and phytotoxicity, Pera Safe™ (0.81%) was closest to the ideal; it worked fast, was non-corrosive and non-phytotoxic. It was followed by ethanol (70%) which required a longer period for disinfection, and Pera Safe™ (1.62%) which was slightly phytotoxic. See Celar et al. 2007. Evaluating the efficacy, corrosivity and phytotoxicity of some disinfectants against *Erwinia amylovora* (Burrill) Winslow et al. using a new statistical measure. *J. Plant Diseases and Protection* 114(2):49-53.