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Performance of Plum Rootstocks with 'Stanley', 'Valor', 'Veeblue' and 'Santa Rosa' as the Scions in the 1991 NC-140 Multi-State Plum Trial

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Abstract

In 1991, a multi-site replicated plum rootstock trial was established by the Cooperative Regional Pome and Stone Fruit Project (NC-140) at Indiana (IN), New York (NY), Oregon (OR) and South Carolina (SC), using 'Stanley', 'Valor', 'Veeblue', or 'Santa Rosa' plums as the scions. The trial compared vigorous and semi-dwarfing plum rootstocks to identify improved rootstocks and rootstock/scion combinations best suited to the various production areas in the United States. Trees on Mariana 2624 and Mariana 4001 rootstocks generally had the best tree survival, cumulative yields, trunk cross-sectional areas, cumulative yield efficiencies, and fruit sizes but had the most root suckers, irrespective of the scion or location. Trees on Pixy rootstock had the smallest trunk cross-sectional area, lowest cumulative yield, and cumulative yield efficiency, and smallest fruit size. Trees on Eruni had similar survival, tree size, yield, and yield efficiency as the Mariana stocks but fewer root suckers. It may be a good alternative to the Mariana and Myrobalan rootstocks. No significant differences were observed between rootstocks with 'Valor' and 'Veeblue' scions for most variables. The Oregon site had the largest trunk cross-sectional areas, but the NY site had the highest yield and yield efficiency. Stanley used as a rootstock (only tested in Oregon) had high yield efficiency, and a low number of root suckers but also high vigor.

European plums (*Prunus domestica* L.) and Oriental plums (*Prunus salicina* L.) are widely adapted and offer the potential for fruit producers to diversify their operations. However, poor rootstock adaptability, especially to the poorly drained clay soils found in many regions of the United States, and lack of dwarfing have limited production in these areas.

Desirable characteristics of a new plum rootstock include tolerance to poorly drained clay soils, cold hardiness, high yield efficiency, low root suckering, and pest resistance (11, 19). Dwarfing has not been a high priority for plums since many European plums are harvested mechanically for processing. However, greater interest in the fresh market has generated significant interest in dwarfing rootstocks and high density plantings (1, 12).

Myrobalan 29C is the predominant plum rootstock used in the eastern USA while Mariana 2624 is the predominant stock in California (20). Myrobalan 29C is vigorous and not adaptable to high density plantings (11, 20). Another important problem with this rootstock is Brown Line decline caused by tomato ringspot virus (6). Plum tree losses due to this disease have been highest with Myrobalan and peach rootstocks (10). 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. Susceptible rootstocks which become infected serve as a reservoir of the virus for the nematode vectors which move the virus from tree to tree. Orchard sites which have recently been planted with peaches are often infected with the virus.

Mariana 2624, a commonly planted vigorous rootstock in California, is resistant to the root-knot nematode which is a vector for tomato ringspot virus (16). Like Myrobalan, it is tolerant to heavier soils than other *Prunus* rootstocks however it suckers profusely (20).

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Several new plum rootstocks from Sweden, England, and the USA, including improved selections of Myrobalan and Mariana, may offer improved tree performance for plum growers (11, 18).

There have been few reports of plum rootstock performance in the USA (7), compared to Europe (2, 3, 4, 5, 8, 9, 12, 14, 18). In North America, a committee of researchers, (the NC-140 committee) undertook the evaluation of plum rootstocks using multi-site coordinated trials planted in 1990 and 1991. This article reports on the second experiment planted in 1991 and serves as a companion paper for a similar study established in 1990 (7).

Materials and Methods

In 1991, a multi-state plum rootstock trial was planted at 4 locations in the US [Indiana (IN), Oregon (OR), New York (NY) and South Carolina (SC)] with 'Stanley', 'Valor', 'Veeblue', or 'Santa Rosa' as the scions (Table 1). 'Stanley', 'Valor' and 'Veeblue' are European plum cultivars, and 'Santa Rosa' is an Oriental plum cultivar. Trees on seven rootstocks (Eruni, Mariana 2624, Mariana 4001, Myrobalan 2-5, Myrobalan 20-2, Pixy, Stanley and Texas) were produced by Newark Nurseries, Inc. (Hartford, MI) and distributed to the cooperators for each planting. Due to limitations in plant material, not all sites received all seven rootstocks. Similarly, scions also varied among sites (Table 2). 'Stanley' was planted at 3 sites (IN, NY and OR), 'Valor' and 'Veeblue' were planted only at NY and 'Santa Rosa' was planted only at SC. The rootstocks varied in tree vigor from semi-dwarf to vigorous and were of several *Prunus* species or hybrids of *Prunus* species (Table 3).

Table 1. NC-140 1991 plum rootstock trial cooperators.

State	Cooperators	Institution	Site
Indiana	Peter Hirst, Richard Hayden	Purdue University	West Lafayette
New York	Robert Andersen, Jay Freer, Terence Robinson	Cornell University	Geneva
Oregon	Anita Azarenko, Becky McCluskey	Oregon State University	Corvallis
South Carolina	Greg Reighard	Clemson University	Columbia

Table 2. Rootstocks and scions at the test sites for the 1991 NC-140 plum rootstock trial.

	Scions			
Rootstock	Indiana (8 years of data)	New York (9 years of data)	Oregon (9 years of data)	South Carolina (5 years of data)
Eruni	Stanley	Stanley, Valor	Stanley	Santa Rosa
Mariana 2624	Stanley	Stanley, Valor	Stanley	Santa Rosa
Mariana 4001	Stanley	Stanley, Valor, Veeblue	Stanley	Santa Rosa
Myrobalan 2-5	Stanley	Stanley	.	.
Myrobalan 20-2	Stanley	Stanley	.	.
Pixy	Stanley	Stanley, Valor, Veeblue	Stanley	Santa Rosa
Stanley	.[z]	Veeblue	Stanley	.
Texas	.	.	.	Santa Rosa

[z] Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

Table 3. Characteristics of plum rootstocks evaluated in the 1991 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
Eruni	*P. domestica*	Sweden	Semidwarf	Medium	.[x]	.	moderate	none	Layering and hardwood cuttings
Mariana 2624	*P. cerasifera X P. munsoniana*	California	Vigorous	Medium	Bact. canker[w]	Resistant	high	none	cuttings
Mariana 4001	*P. cerasifera X P. munsoniana*	California	Vigorous	.	Bact. canker	.	high	none	cuttings
Myrobalan 2-5	*P. cerasifera*	USA	Vigorous	Medium	Prune brownline	Resistant	medium	none	cuttings
Myrobalan 20-2	*P. cerasifera*	USA	Vigorous	Medium	Prune brownline	.	medium	none	cuttings
Pixy	*P. insititia*	England	Semidwarf	Susc. to drought	.	.	slight	.	hardwood cuttings, layers
Stanley	*P. domestica*	USA	Vigorous	Medium	.	.	moderate	none	hardwood cuttings, layers
Texas	*P. americana*	USA	Semidwarf	.	.	.	.	.	.

[z] Compiled from Okie (1987) and Wertheim (1998)
[y] Genus name abbreviated for *Prunus*
[x] Missing value (.) indicates that no information is available for that rootstock
[w] *Pseudomonas syringae*

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 6 single-tree replicates of each rootstock at the IN, OR and SC sites, and 8 replicates at the NY site with 'Stanley' but only 4 replicates with 'Valor' and 'Veeblue'. Soil management consisted of a 2 m herbicide strip centered under the trees, 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 trees were headed at 60 cm above the ground shortly after planting, which produced 3-5 shoots per tree during the first growing season. At the beginning of the second year, each of the shoots was headed again and the resulting shoots were allowed to grow over the next 3 years without heading. Cropping began in the third year. Tree height was limited to 4 m by topping each of the multiple leaders beginning in the fifth or sixth year. The SC site was terminated after the 5th year and the IN site was terminated after the 8th year. Trees at the NY and OR sites were continued through 9 years.

Data collected included tree survival, trunk circumference (converted to cross-sectional area, TCA, cm^2) measured at 30 cm above the soil line and the number of root suckers measured at the end of the experiment. Except for SC, trees were also evaluated for cumulative yield, cumulative yield efficiency (kg yield/cm^2 TCA). Cumulative yield data for 'Valor' and 'Veeblue' scions at NY is the sum of only seven and five years, respectively, due to mistakes in collecting yield data in some years. At SC no yield was recorded due to high tree mortality. At IN and OR fruit size was measured annually on a sample of 50 fruits per tree.

Data for each site and scion cultivar were analyzed separately since the scion and rootstock combinations varied between sites. The

Table 4. Plum tree survival (%) as influenced by rootstock, cultivar and site in the 1991 NC-140 multi-site trial.

	Stanley				Valor	Veeblue	Santa Rosa
Rootstock	IN (8 years)	NY (9 years)	OR (9 years)	Avg. survival of 4 rootstocks common at IN, NY and OR	NY (9 years)	NY (9 years)	SC (5 years)
Eruni	100 a[z]	100 a	100 a	100 a[y]	100 a	.	83 a
Mariana 2624	100 a	100 a	100 a	100 a	100 a	.	50 a
Mariana 4001	83 a	100 a	100 a	94 a	100 a	100 a	20 a
Myrobalan 2-5	100 a	100 a	.	.	.	.	.
Myrobalan 20-2	100 a	63 b	.	.	.	.	.
Pixy	100 a	100 a	100 a	100 a	100 a	75 b	33 a
Stanley	.	.	100 a	.	.	100 a	.
Texas	.	.	.	.	.	.	67 a
LSD (0.05)	NS	22	NS	NS	NS	20	NS
P-value	0.44	0.005	>0.999	0.398	>0.999	0.001	0.388

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$). For 'Stanley', n = 8 for NY and n = 6 for IN and OR; for 'Valor' and 'Veeblue', n = 4; for 'Santa Rosa', n = 6). Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

[y] Average survival means are Least Squares Means

Table 5. Trunk cross-sectional area (cm^2) of surviving plum trees as influenced by rootstock, cultivar and site in the 1991 NC-140 multi-site trial.

	Stanley				Valor	Veeblue	Santa Rosa
Rootstock	IN (8 years)	NY (9 years)	OR (9 years)	Avg. TCA of 4 rootstocks common at IN, NY and OR	NY (9 years)	NY (9 years)	SC (5 years)
Eruni	124 b[z]	90 b	186 a	127 a[y]	89 a	.	33 b
Mariana 2624	118 b	107 ab	207 a	139 a	102 a	.	61 a
Mariana 4001	110 b	99 ab	191 a	129 a	98 a	118 a	77 a
Myrobalan 2-5	124 b	117 a	.	.	.	.	.
Myrobalan 20-2	161 a	98 ab	.	.	.	.	.
Pixy	102 b	86 b	148 b	108 a	114 a	121 a	19 b
Stanley	.	.	201 a	.	.	139 a	.
Texas	.	.	.	.	.	.	72 a
LSD (0.05)	32	20	26	NS	NS	NS	25
P-value	0.02	0.05	0.001	0.157	0.44	0.27	0.01

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$). For 'Stanley', n = 8 for NY and n = 6 for IN and OR; for 'Valor' and 'Veeblue', n = 4; for 'Santa Rosa', n = 6). Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

[y] Average TCA means for 4 rootstocks are Least Squares Means

data were analyzed using the procedure GLM (SAS Institute, Cary, NC) for the analysis of variance and Fisher's least significant difference (LSD) for the mean separation. A second analysis, pooling data across sites was done using data from the end of year five (to evaluate early tree performance) and at the end of year eight (IN) or nine (NY and OR) with 'Stanley' for the 4 rootstocks common at each of the three sites. These data were analyzed by the MIXED procedure (SAS Institute, Cary, NC) for analysis of variance and the interaction of rootstock and site was evaluated. Differences among Least Squares Means were evaluated by Tukey's HSD test.

Results

Tree survival. Almost all trees of the European plum cultivars at all sites had survived to the end of the study except 'Stanley' trees on Myrobalan 20-2 and 'Veeblue' trees on Pixy in NY which had 63% and 75% survival, respectively (Table 4). Eruni, Mariana 2624, and Myrobalan 2-5 had 100% tree survival at all sites with European plum scions. Though not statistically significant, tree death at SC with the oriental plum 'Santa Rosa' varied widely from 80% for trees on Mariana 4001 to only 17% for trees on Eruni. We attributed tree death to bacterial canker (*Pseudomonas syringae* pv. *syringae* (Pss)).

Average tree survival across three sites (IN, NY and OR) showed no significant differences in survival among the four rootstocks common at each site with 'Stanley' as the scion (Table 4).

Tree size. Trunk cross-sectional area among rootstocks with 'Stanley' as the scion differed at each site (Table 5). However, there were no significant differences in tree size with 'Valor' or 'Veeblue' as the scions at NY. At IN, trees on Myrobalan 20-2 were significantly larger than all other rootstocks but there was no significant difference in tree size between the other rootstocks. At NY, trees with Myrobalan 2-5 rootstock were the largest, but they did not differ significantly from those with Mariana 2624, Mariana

Table 6. Cumulative yield (kg/tree) of surviving plum trees as influenced by rootstock, cultivar and site in the 1991 NC-140 multi-site trial.

	Stanley				Valor	Veeblue
Rootstock	IN (8 years)	NY (9 years)	OR (9 years)	Avg. cum. yield of 4 rootstocks common at IN, NY and OR	NY (9 years)	NY (9 years)
Eruni	109 ab[z]	127 bc	158 ab	129 a[y]	75 a	.
Mariana 2624	106 ab	175 a	137 ab	143 a	69 a	.
Mariana 4001	101 b	149 ab	114 bc	126 a	67 a	12 a
Myrobalan 2-5	98 b	152 ab	.	.	.	.
Myrobalan 20-2	141 a	118 bc	.	.	.	.
Pixy	77 b	98 c	93 c	90 b	51 a	23 a
Stanley	.	.	167 a	.	.	.
Texas	.	.	.	.	.	8 a
LSD (0.05)	38	32	30	20	NS	NS
P-value	0.05	0.001	0.002	<0.001	0.22	0.27

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$). For 'Stanley', n = 8 for NY and n = 6 for IN and OR; for 'Valor' and 'Veeblue', n = 4). Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

[y] Average cum. yield means for 4 rootstocks are Least Squares Means

4001, or Myrobalan 20-2. Only Pixy and Eruni were significantly smaller than Myrobalan 2-5. At OR, neither of the Myrobalan rootstocks were planted. The trees on Mariana 2624 were the largest but they did not differ significantly from Eruni, Mariana 4001, or Stanley as a rootstock. However, trees on Pixy were significantly smaller than the other stocks. At SC, with the oriental plum 'Santa Rosa', trees on Texas and the two Mariana rootstocks were the largest while Eruni and Pixy were significantly smaller after the 5 years of this trial.

Average 'Stanley' tree size across three sites (IN, NY and OR) with the four rootstocks common at the three sites, was not significantly different (Table 5). However, there was a trend for trees on Pixy to be the smallest while trees on Mariana 2624 tended to be the larger. Eruni and Mariana 4001 were intermediate in tree size.

Cumulative yield. Cumulative yield per tree with 'Stanley' differed among rootstocks at each site but with 'Valor' and 'Veeblue' as the scions there were no significant differences among rootstocks (Table 6). At IN, Myrobalan 20-2 had the highest yield but did not differ significantly from Eruni and Mariana 2624. Pixy, Myrobalan 2-5 and Mariana 4001 all had significantly lower yield than Myrobalan 20-2. At NY, Mariana 2624 had the highest yield but did not differ significantly from Myrobalan 2-5 and Mariana 4001. Pixy had the lowest yield while Eruni, and Myrobalan 20-2 were intermediate in cumulative yields. At OR, 'Stanley' on Stanley rootstock had the highest yield but did not differ significantly from Eruni or Mariana 2624. Pixy had the lowest yield while Mariana 4001 had intermediate yields. At SC, 'Santa Rosa' yields were not recorded.

Average cumulative yield across three sites (IN, NY and OR) with the four rootstocks common at each site with 'Stanley' as the scion, was highest with Mariana 2624 followed by Eruni, Mariana 4001 and Pixy (Table 6). Among the four rootstocks, cumulative yield was significantly lower only for

Table 7. Cumulative yield efficiency (kg/cm² trunk cross-sectional area) of surviving plum trees as influenced by rootstock, cultivar and site in the 1991 NC-140 multi-site trial.

	Stanley					Valor	Veeblue
Rootstock	IN (8 years)	NY (9 years)	OR (9 years)	Early cum. yield eff. (yrs 1-5) of 4 rootstocks common at IN, NY and OR	Avg. cum. yield efficiency of 4 rootstocks common at IN, NY and OR	NY (9 years)	NY (9 years)
Eruni	0.87 a[z]	1.43 ab	0.79 ab	0.56 a	1.11 a[y]	0.85 a	.
Mariana 2624	0.89 a	1.63 a	0.66 bc	0.65 a	1.13 a	0.97 a	.
Mariana 4001	0.92 a	1.53 a	0.60 c	0.71 a	1.09 a	1.09 a	0.34 a
Myrobalan 2-5	0.77 a	1.27 bc	.	.	.	.	.
Myrobalan 20-2	0.86 a	1.21 bc	.	.	.	.	.
Pixy	0.72 a	1.17 c	0.63 bc	0.54 a	0.89 a	0.97 a	0.81 a
Stanley	.	.	0.84 a	.	.	.	0.22 a
Texas	.	.	.	.	.	.	.
LSD (0.05)	NS	0.21	0.21	0,21	NS	NS	NS
P-value	0.12	0.001	0.03	0.321	0.177	0.23	0.34

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$). For 'Stanley', n = 8 for NY and n = 6 for IN and OR; for 'Valor' and 'Veeblue', n = 4). Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

[y] Average early yield efficiency and average cumulative yield efficiency means for 4 rootstocks are Least Squares Means.

trees on Pixy.

Cumulative yield efficiency. Cumulative yield efficiency with 'Stanley' varied among rootstocks at NY and OR but not at IN (Table 7). With 'Valor' and 'Veeblue' there were no significant differences in cumulative yield efficiency among rootstocks. Trees at NY had higher cumulative yield efficiency than either IN or OR. At NY, trees on Mariana 2624 had the highest cumulative yield efficiency but the did not differ significantly from Mariana 4001 or Eruni. Pixy had the lowest cumulative yield efficiency while Myrobalan 2-5 and Myrobalan 20-2 were intermediate. At OR, 'Stanley' on Stanley rootstock had the highest cumulative yield efficiency bud did not differ significantly from Eruni. At the same site, Mariana 2624 and Pixy were intermediate while Mariana 4001 had the lowest yield efficiency.

Average cumulative yield efficiencies of 'Stanley' across three sites (IN, NY, and OR) with the four rootstocks common at the three sites, were not significantly different (Table 7). Nevertheless there was a trend for Mariana 2624 to have the highest yield efficiency

Table 8. Average fruit size (g) of surviving 179 Stanley plum trees as influenced by rootstock and site in the 1991 NC-140 multi-site trial.

Rootstock	IN (8 years)	OR (9 years)
Eruni	33 c[z]	35 a
Mariana 2624	34 bc	36 a
Mariana 4001	34 bc	35 a
Myrobalan 2-5	36 a	.
Myrobalan 20-2	36 a	.
Pixy	32 c	36 a
Stanley	.	34 a
LSD (0.05)	2.5	NS
P-value	0.02	0.67

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$, n = 6). Missing values (.) indicate that a variety/rootstock combination was not planted at that site.

Table 9. Number of root suckers in the final year on surviving plum trees as influenced by rootstock, cultivar and site in the 1991 NC-140 multi-site trial.

	Stanley				Valor	Veeblue	Santa Rosa
Rootstock	IN (8 years)	NY (9 years)	OR (9 years)	Avg. number of root suckers of 4 rootstocks common at IN, NY or OR	NY (9 years)	NY (9 years)	SC (5 years)
Eruni	3.7 b[z]	2.6 b	21.0 ab	8 c[y]	3.0 c	.	0.0 c
Mariana 2624	25.1 a	19.1 a	33.0 a	25 a	18.0 b	.	7.3 a
Mariana 4001	18.2 a	15.3 a	20.0 ab	18 b	36.0 a	10.7 a	0.0 c
Myrobalan 2-5	5.3 b	1.3 b	.	.	.	.	.
Myrobalan 20-2	0.5 b	4.8 b	.	.	.	.	.
Pixy	3.4 b	2.6 b	5.0 c	4 c	6.0 c	3.0 a	0.0 c
Stanley	.	.	8.0 bc	.	.	0.0 a	.
Texas	.	.	.	.	.	.	3.5 b
LSD (0.05)	9	7	2	7	11	NS	3.3
P-value	0.001	0.001	0.01	<0.001	.0001	0.39	0.001

[z] Means within a column followed by the same letter do not differ significantly ($P \leq 0.05$). For 'Stanley', n = 8 for NY and n = 6 for IN and OR; for 'Valor' and 'Veeblue', n = 4; for 'Santa Rosa', n = 6). Missing values (.) indicate that the variety/rootstock combination was not planted at that site.

[y] Average number of root sucker means for 4 rootstocks are Least Squares Means

followed by Eruni, Mariana 4001 and Pixy (Table 7). Yield efficiency over the first five years (which is an indication of precocity) was not significantly different among the four rootstocks. The ranking of the rootstocks at the end of year 5 for yield efficiency compared to the ranking at the end of the experiment showed only a minor reversal of the ranking between Mariana 4001 which was highest at the end of year 5 and Mariana 2624 which was highest at the end of year 8 or 9.

Fruit size. Fruit size was measured only at IN and OR. Average fruit size varied among rootstocks at IN but not at OR (Table 8). At IN, Myrobalan 2-5 and Myrobalan 20-2 had significantly larger fruits than all other stocks followed by Mariana 2624 and Mariana 4001. Pixy and Eruni had the smallest fruit size.

Root suckers. The number of root suckers differed among rootstocks at all sites except with 'Veeblue' at NY (Table 9). At both IN and NY, Mariana 2624 and Mariana 4001 had significantly more root suckers than the other stocks. At OR, Mariana 2624 had the greatest number of root suckers but it did not differ significantly from Mariana 4001 or Eruni. Pixy and Stanley as rootstocks had lower numbers of root suckers. With 'Valor' at NY, Mariana 4001 had a high number of root suckers. Mariana 2624 had an intermediate number and Pixy and Eruni had low numbers of root suckers. At SC, with 'Santa Rosa' only Mariana 2624 and Texas rootstocks had any root suckers.

The average number of root suckers produced by 'Stanley' trees across three sites (IN, NY and OR) with the four rootstocks common at the three sites, was highest with Mariana 2624 followed by Mariana 4001 (Table 9). Pixy had the lowest number of root suckers while Eruni was intermediate.

Discussion

All of the rootstocks evaluated in this study had good survival and production ef-

ficiency in northern climates with *P. domestica* as scions, but tree loss in SC with the *P. salacina* scion 'Santa Rosa' was severe due to bacterial canker. For northern production areas, Mariana 2624 was the best stock overall (considering yield, fruit size and tree mortality) followed closely by Mariana 4001 and Eruni. There was no significant difference between the two Mariana clones (2624 and 4001). This is in agreement with our earlier trial (7) in which there was no significant difference between 3 Mariana clones (2624, 4001 and GF8-1). The greatest disadvantage of the Mariana rootstocks in this trial was their tendency to produce large numbers of root suckers.

For areas with severe bacterial canker risk like SC, neither of the Mariana rootstocks can be recommended but rather Eruni appears to be a preferable stock in terms of tree survival.

Eruni rootstock from Sweden (15) was not evaluated in the companion 1990 rootstock trial (7). In this trial Eruni exhibited a semi-dwarfing characteristic at IN and NY and had relatively high yield efficiency and few root suckers at all sites. However it was not significantly different from the Mariana stocks in any of the other variables except that it produced smaller fruit size than the two Myrobalan stocks at IN and had fewer root suckers at 3 of the 4 locations. Nevertheless its performance in this trial indicates that it is a good alternative to the Marianas for commercial plum production.

The Myrobalan rootstocks were not statistically different from the Marianas or Eruni except that they were slightly more vigorous and had somewhat lower yield efficiency. On the positive side the Myrobalans had fewer root suckers than the Marianas. The primary problem with the commercial use of Myrobalans is their susceptibility to tomato ringspot virus and brown line decline (6,10). Thus although the Marianas produce more root suckers, they are preferable to Myrobalans in areas with tomato ringspot virus.

Stanley when used as a rootstock (tested only at OR) was quite vigorous but had high yield efficiency and few root suckers. J. Cummins (personal communication, 2000) has suggested that 'Stanley' on its own roots is tolerant of tomato ringspot virus-induced brown line at the graft union. Thus, Stanley as a rootstock appears to be a good choice for OR, however, it is vigorous and not suitable for high density plantings.

There were few significant differences in performance of rootstocks with either 'Valor' or 'Veeblue' scions. This was primarily due to low replication (n=4) with those scions. Nevertheless the trends in rootstock performances were similar with 'Stanley' except that there was a trend for Pixy to induce early bearing of 'Veeblue' compared to either Mariana 4001 or Stanley as a rootstock. The reported cumulative yields of 'Valor' and 'Veeblue' were lower than 'Stanley' due to the fewer years of reliable yield data included in the cumulative yield for 'Valor' (7 years) and 'Veeblue' (5 years) than for 'Stanley' (8 or 9 years).

From a practical perspective, this project did not identify a superior dwarfing rootstock with increased precocity and good survivability that could replace Myrobalan 29C or Mariana 2624 in commercial plum production. Dwarfism and precocity are keys to future high density plum production (12). Although Pixy was more dwarfing than either of the Marianas or Eruni, it had low yield efficiency and did not improve precocity during the first 5 years. This result is similar to a companion 1990 plum rootstock trial conducted by NC-140 (7).

The previous trial identified Citation as a well adapted dwarfing rootstock for OR, but it performed poorly in the eastern USA (7). Identification of productive, precocious and dwarfing plum rootstocks which are well-adapted to eastern growing conditions requires further testing of newly identified rootstocks. These new stocks include, Ishtara from France, which has shown promise as a semi-dwarfing plum rootstock (3, 13), Jaspi

from France, which has shown promise as a semi-dwarfing plum rootstock (3), Controller 5 and Controller 9 from the Univ. of California, which may have promise as rootstocks for plums since they are both peach/plum hybrids (1), Hiawatha, which was bred in South Dakota as a scion variety which tolerates the prairie states' winters (1), Wavit, a dwarfing plum rootstock from Germany (3,17), a new Mariana clone from California (M 40) which was suggested to produce fewer suckers (Ted DeJong, personal communication), and VAA-1, which is a plum hybrid (*P. tomentosa X P. cerasifera*) from Russia which has shown good hardiness (12).

For the moment, the Mariana rootstocks (2624, 4001 and GF8-1) still appear to be the best option for plum growers. Their main limitations are lack of dwarfing and excessive root sucker production.

Literature Cited

1. DeJong, T.M., R.S. Johnson, J.F. Doyle and D. Ramming. 2005. Labor costs may be reduced. Research yields size-controlling rootstocks for peach production. California Agriculture 59:80-83.
2. Glenn E.M. 1961. Plum rootstock trials at East Malling. J. Hort. Sci. 36:28-29.
3. Hartmann, W., H.D. Beuschlein, J. Kosina, D. Ogasanovic and D. Paszko. 2007. Rootstocks in plum growing: Results of an international rootstock trial. Acta Hort. 734:141-148.
4. Hatton, R.G. 1921. Stocks for stone fruits. J. Pomology 2:209-245.
5. Hatton, R.G. 1936. Plum rootstock studies. J. Pomology 14:97-136.
6. Kommineni, K.V., J.M. Gillett and D.C. Ramsdell. 1998. A study of tomato ringspot virus and prune brown line resistance in twenty-five rootstock-scion combinations. HortTechnology 8:349-353.
7. Masabni, J.G., R. Andersen, A. Azarenko, G. Brown, J. Freer, R. Hayden, P. Hirst, B. McCluskey, R. Perry, T. Robinson and D. Wolfe. 2007. Performance of plum rootstocks with 'Stanley', 'Valor', and 'Veeblue' as the scion in the 1990 NC-140 multi-location plum trial. J. Amer. Pomol. Soc. 61:196-207.
8. Meland, M. and M.E. Moe. 2007. Early performance of four plum rootstocks with six European plum cultivars growing in a northern climate. Acta Hort. 734:235-241
9. Mezzetti, B. and F. Sottile. 2007. Mi.P.A.F. Targeted project for evaluation of European and Japanese plum rootstocks in Italy: Results of six years of observations. Acta Hort. 734:149-155.
10. Mircetich, S.M. and J.W. Hoy. 1981. Brownline of prune trees, a disease associated with tomato ringspot virus infection of Myrobalan and peach rootstocks. Phytopathology 71:30-35.
11. Okie, W.R. 1987. Plum rootstocks. Pp. 320-360. In: Rom, R.C and R.F. Carlson R.F. (eds.) Rootstocks for fruit crops. John Wiley and Sons, New York.
12. Peppelman, G., H. Kemp, J.M.T. Balkhoven-Baart and M.J. Groot. 2007. Towards high density plum growing - agronomic and economic performance of plum (*Prunus domestica* L.) on 182 VVA-1 rootstock. Acta Hort. 734:225-234
13. Renaud, R., R. Bernhard, C. Grasselly and F. Dosba. 1988. Diploid plum x peach hybrid rootstocks for stone fruit trees. HortScience 23:115-117.
14. Rozpara, E. and Z.S. Grzyb. 2007. Growth, yield and fruit quality of eighteen plum cultivars grafted on two rootstocks. Acta Hort. 734:157-161.
15. Trajkovski, V. and G. Anderson. 1988. BPr 32 Eruni, a plum rootstock produced at Balsgard. Sveriges Lantbruksuniversitet, Balsgard, Verksamhetsberattelse 1986-87:25-26.
16. Uyemoto, J.K. and S.W. Scott. 1992. Important diseases of *Prunus* caused by viruses and other graft-transmissible pathogens in California and South Carolina. Plant Disease 76:5-11.
17. Wavit plum rootstock. 2009. http://www.cdb-rootstocks.com/english/e_produkte_pflaume_wavit.htm
18. Wertheim, S.J. 1998. Rootstock guide apple, pear, cherry, European plum. Fruit Research Station, Wilhelminadorp, The Netherlands. 144 pp.
19. Westwood, M.N. 1993. Temperate zone pomology: physiology and culture, third edition. Timber Press, Portland, Oregon.
20. Yoshikawa, F.T., D.W. Ramming and J.H. LaRue. 1989. Rootstocks. Pp. 9-11. In: LaRue, J.H. and R.S. Johnson (eds). Peaches, plums and nectarines: growing and handling for fresh market. Publ. 3331. Cooperative Extension, Univ. of California, Oakland.