

THE 'NORTHERN SPY' APPLE

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Growth, Yield, Survival, and Leaf Nutrient Concentrations of Plums on Various Rootstocks

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Abstract

Effects of seedling rootstocks Lovell, Halford, Nemaguard, and Nemared and asexually propagated rootstocks St. Julien A and Pixy on tree growth, yield, survival and leaf nutrient concentration of 2 plum cultivars was studied. Yields did not differ among rootstocks for 'AU-Producer' or 'AU-Amber'. Cumulative yield efficiency (CYE) did not differ among rootstocks grafted with 'AU-Amber,' but was significantly lower for Pixy rootstock grafted with 'AU-Producer' compared to Lovell, Halford, Nemaguard, Nemared and St. Julien rootstocks. St. Julien and Pixy dwarfed scions, resulting in smaller canopy widths and trunk cross-sectional areas (TCA). Their effect on bloom dates was inconsistent, delaying bloom in some years but not in others. The only rootstock-by-year interactions for foliar nutrient levels were for Mn, Fe, and B with 'AU-Producer'. Nutrient levels and multiple regression results indicated that Mg was a positive predictor for canopy width and TCA while Zn and Mn were negatively related to TCA. Attempts to predict tree survival rates in 1994 and 1995 with 1993 and 1994 leaf nutrient levels, respectively, indicated that survival in 1994 was positively predicted with K and negatively with Mn with an R^2 of 0.143. There was no predicted model for 1995 survival based on 1994 nutrient data. Survival in 1995 was negatively predicted with 1995 Zn levels with an R^2 of 0.277.

Introduction

A number of different rootstocks are available for plum production. Rootstocks can affect scions in a number of ways, including bloom and harvest dates, growth characteristics, yields, and survivability (8, 10, 12, 16).

Rootstocks are often regionally adapted. In a trial at Harrow, Ontario, Canada, the best rootstocks for peach were Siberian C, Halford, Bailey, and Lovell (14). The plum, peach x almond, and self-rooted trees all had high mortality rates. Dozier et al. (8), by contrast, found Siberian C

to be an unacceptable peach rootstock for the southeastern United States.

'Redhaven' peach on Lovell rootstock flowered and fruited later than 'Redhaven' on Halford, Bailey, Siberian C and cuttings of GF677 (peach x almond), GF655-2 (*Prunus insititia* L.), Damas 1869 (plum) and 'Redhaven' seedlings (3). Adesoto 101 (*P. insititia*), a new rootstock for stone fruit, advanced fruit maturation by 3-7 days (15).

Yield and fruit size are also been shown to be influenced by rootstock. When European plums were grown in Norway on Eruni, Pixy, and St. Julien A rootstocks,

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those on Eruni produced higher yields than on St. Julien A, but the fruit were consistently smaller. Yields of trees on Pixy were less than on St. Julien A rootstock (23). In a French study, 'Damson' plum yields were higher when grafted on GF 655-2 than on W 61, St. Julien 2/51, or Pixy rootstocks, but fruit size was unaffected (17).

In a study characterizing the roots of dwarfing rootstock VVA-1 (a hybrid of *Prunus tomentosa* and *P. cerasifera*) it was found they had greater branching of scaffold roots which tended to be thinner and they had an overall greater amount of fibrous roots than *P. cerasifera* seedlings.

Rootstock effect on tree size and vigor has been studied and exploited in fruit production, most notably apples. There are several rootstocks known to have a dwarfing effect on plum scions, but there is no consensus on recommending a specific rootstock. In fact, rootstocks such as St. Julien have been characterized as both dwarfing and too vigorous in the literature. Boyhan et al. (4) found that St. Julien suppressed shoot growth particularly during the first few years of growth. Wertheim (21), on the other hand, declared St. Julien too vigorous for plum production. In the former case this rootstock was studied with Japanese plums

and in the latter with European plum. These differences in describing St. Julien rootstocks may also be due to differences in origin. Koppers (13) describes at least 3 different types of St. Julien all having a different origin.

Pixy (*P. insititia*) is another dwarfing plum rootstock similar to St. Julien A, but producing smaller trees than St. Julien A (18). Pixy is not suitable in all cases as a dwarfing rootstock because the growth suppression is accompanied by reduced fruit yield. This reduced cropping per unit of growth does not occur with some vigorous plum cultivars such as 'Ontario,' 'Reine Claude d'Altham,' and 'Warwickshire Drooper' (22).

The search for suitable dwarf rootstocks continues. Webster and Wertheim (19) studied species and hybrid rootstocks and found that 'Victoria' plum trees on the French hybrid rootstock Ferlenain were smaller than 'Victoria' plum trees on Pixy rootstock while yields remained the same or were greater. In another study 'Victoria' on P 2038 (*Prunus besseyi* Bailey x *P. cerasifera* Ehrh.) had the highest yields and the smallest trees compared to 'Victoria' on either Pixy or St. Julien A (22).

Although there has been much work devoted to rootstocks for plum, most of

Table 1. Plum yield results from 1992 to 1995.

Rootstock	Yield (kg/tree)				Cumulative yield ² efficiency (kg·cm ⁻²) 1992-95
	1992	1993 ¹	1994	1995	
<i>AU-Amber</i>					
Lovell	0.4 ^x	—	38.1	9.0	0.13
Halford	0	—	31.9	1.5	0.14
Nemaguard	3.7	—	61.5	1.5	0.22
Nemared	3.2	—	21.9	12.1	0.06
St. Julien	0.3	—	4.2	11.5	0.05
Pixy	0	—	15.7	0	0.17
<i>U-Producer</i>					
Lovell	3.8	1.1	50.9	11.4	0.36ab
Halford	4.8	1.0	47.2	9.1	0.30b
Nemaguard	4.5	0.9	61.8	16.6	0.54a
Nemared	4.2	1.7	54.7	17.5	0.45a
St. Julien	2.2	0.6	22.1	0	0.37ab
Pixy	1.0	0	9.4	9.6	0.13c

²Cumulative Yield Efficiency = $\Sigma(\text{Yields } 1992-1995)/\text{TCA } 1995$

¹Snow on March 14, 1993 with freezing temperatures resulting in no yields for 'AU-Amber.'

^{*}Means followed by the same letter within a column for a cultivar are not significantly different by Fisher's Protected LSD at P20.05.

this work has concentrated on the European plums. This study was undertaken to evaluate rootstocks as to growth, survival, yield, and leaf nutrient concentration for Japanese plums grown in the southeastern United States.

Materials and Methods

One-year-old trees from Cumberland Valley Nursery, McMinnville, Tenn. were established in February of 1989 at the Chilton Area Horticulture Substation, Thorsby, Ala. The site had a Rustin fine sandy loam and was prepared according to Alabama Agricultural Experiment Station System (AAESS) recommendations (1). The original experiment consisted of 4 cultivars, AU-Amber, AU-Producer, AU-Rosa, and AU-Rubrum and 6 rootstocks, Lovell, Halford, Nemaguard, Nemared, St. Julien A, and Pixy. Experimental results of 'AU-Amber' and 'AU-Producer' on the 6 rootstocks are reported. Not all combinations of scions and rootstocks were included therefore scion x rootstock interactions were not addressed. The experiment was arranged in a randomized complete block design of 6 single-tree-replications with an in-row spacing of 3 m and a between row spacing of 6.1 m. Trees were trained to an open-center and were fertilized each year according to AAESS recommendations. Pruning was done each year in late winter according to standard practices. Crop load was not thinned in this study.

Data collected from the experiment included bloom date (50% flowers open), yield, tree height and canopy width, trunk circumference, mortality, and weight of 10 ripe fruit per tree.

Fruit were harvested from each tree when ripe and weighed to determine yield. A random sample of 10 fruit from each tree was also weighed to determine the average fruit weight.

Canopy width, tree height, and trunk circumference were measured in the fall of 1994 and 1995. The canopy width per tree was measured at the widest point within the canopy perpendicular to the row. Trunk circumference was measured

30 cm above the ground and trunk cross-sectional area (TCA) was calculated.

Dead trees were noted each year when measurements were taken. To minimize cultural practices bias, dead trees were not counted in 1990. Consequently each scion/rootstock combination began the study with 100% survival.

Mature leaves from the midpoint of current year's growth were collected in mid-August 1993, 1994, and 1995 from each tree. These samples were analyzed for total nitrogen by a modified micro-Kjeldahl method with a selenium catalyst (2). Phosphorus, potassium, calcium, magnesium, manganese, iron, boron and zinc were determined using an inductively coupled argon plasma spectrophotometer (7).

Two different approaches to predicting tree survival were attempted (Table 6). In one approach leaf nutrient concentrations from the previous year were used as regressor variables to predict survival in the following year. The second approach used the current year's leaf nutrient concentrations to predict the current year's survival.

Statistical analysis was conducted using Systat 5.2.1. Multiple linear regression with survival, canopy spread, TCA, and cumulative yield efficiency (Yields

Table 2. Plum canopy width and trunk cross-sectional area (TCA) from 1994-1995.

Rootstock	Canopy width 1995 (m)	TCA 1995 (cm ²)
<i>AU-Amber</i>		
Lovell	4.6a	330a
Halford	4.4a	330a
Nemaguard	4.8a	284a
Nemared	4.1a	284a
St. Julien	2.6b	133b
Pixy	2.5b	100b
<i>AU-Producer</i>		
Lovell	3.3a	198ab
Halford	3.4a	245a
Nemaguard	2.8ab	203ab
Nemared	3.4a	205ab
St. Julien	1.8b	123bc
Pixy	1.7b	100c

^aMeans followed by the same letter within a column for a cultivar are not significantly different by Fisher's Protected LSD at P20.05.

Table 3. Plum bloom dates, 1992-1993.

Rootstock	1992	1993	Bloom Dates 1994	1995	1996
<i>AU-Amber</i>					
Lovell	28 Feb. b ^z	17 Feb. c	22 Feb.	11 Mar.	29 Feb. a
Halford	28 Feb. b	17 Feb. c	22 Feb.	12 Mar.	28 Feb. b
Nemaguard	28 Feb. b	18 Feb. c	22 Feb.	14 Mar.	1 Mar. a
Nemared	28 Feb. b	22 Feb. bc	22 Feb.	12 Mar.	1 Mar. a
St. Julien	28 Feb. b	25 Feb. ab	22 Feb.	11 Mar.	28 Feb. b
Pixy	3 Mar. a	4 Mar. a	24 Feb.	10 Mar.	29 Feb. a
<i>AU-Producer</i>					
Lovell	2 Mar.	9 Mar. a	28 Feb. a	15 Mar.	6 Mar.
Halford	2 Mar.	4 Mar. c	28 Feb. a	16 Mar.	6 Mar.
Nemaguard	2 Mar.	4 Mar. c	1 Mar. a	12 Mar.	7 Mar.
Nemared	2 Mar.	5 Mar. bc	27 Feb. a	14 Mar.	5 Mar.
St. Julien	2 Mar.	13 Mar. a	26 Feb. b	18 Mar.	5 Mar.
Pixy	1 Mar.	8 Mar. ab	1 Mar. a	16 Mar.	4 Mar.

^zMeans followed by the same letter within a column for a cultivar are not significantly different by Fisher's Protected LSD at P20.05.

1992-1995)/TCA 1995) as the dependent variables and N, P, K, Ca, Mg, Mn, Fe, B, and Zn as the independent variables was conducted. The multiple linear regression analysis was done in a forward stepwise fashion with the probability to enter or remove a predictor set to 0.05 and the tolerance set to 0.01 (23).

Results

There were no yield differences between rootstocks for 1992-1995 with

'AU-Amber' or 'AU-Producer' (Table 1). There were no differences in cumulative yield efficiency (CYE) for 'AU-Amber' on these rootstocks. However, with 'AU-Producer,' yield efficiency was significantly lower on Pixy (Table 1). Additionally, CYE was significantly higher on Nemaguard and Nemared compared to Halford. There were no differences within 'AU-Amber' or 'AU-Producer' for fruit size on the various rootstocks (data not shown).

Table 4. Rootstock effect on foliar nutrient content of plum cultivars (1993-1995).

Rootstock	Dry Wt (%)					Dry Wt (ppm)			
	N	P	K	Ca	Mg	Mn	Fe	B	Zn
<i>AU-Amber</i>									
Lovell	2.34	0.14	2.47	2.05	0.63a	79b	360	33	17
Halford	1.85	0.14	2.88	1.86	0.64a	71b	327	38	20
Nemaguard	2.01	0.15	2.90	1.98	0.60a	68b	253	37	18
Nemared	1.84	0.15	2.93	1.91	0.55ab	76b	303	42	26
St. Julien	2.28	0.19	3.11	1.87	0.47bc	191a	255	28	21
Pixy	2.20	0.22	3.18	1.64	0.43c	139ab	258	27	20
<i>AU-Producer</i>									
Lovell	2.22	0.16b	2.44	1.79	0.55a	—	—	—	20c
Halford	2.00	0.17b	2.48	1.94	0.52a	—	—	—	19c
Nemaguard	2.07	0.16b	2.51	2.11	0.60a	—	—	—	43ab
Nemared	1.83	0.16b	2.54	2.06	0.59a	—	—	—	19c
St. Julien	1.91	0.21b	3.11	1.97	0.51ab	—	—	—	49a
Pixy	2.05	0.26a	3.13	1.73	0.44b	—	—	—	24bc

^zMeans followed by the same letter within a column for a cultivar are not significantly different by Fisher's Protected LSD at P20.05.

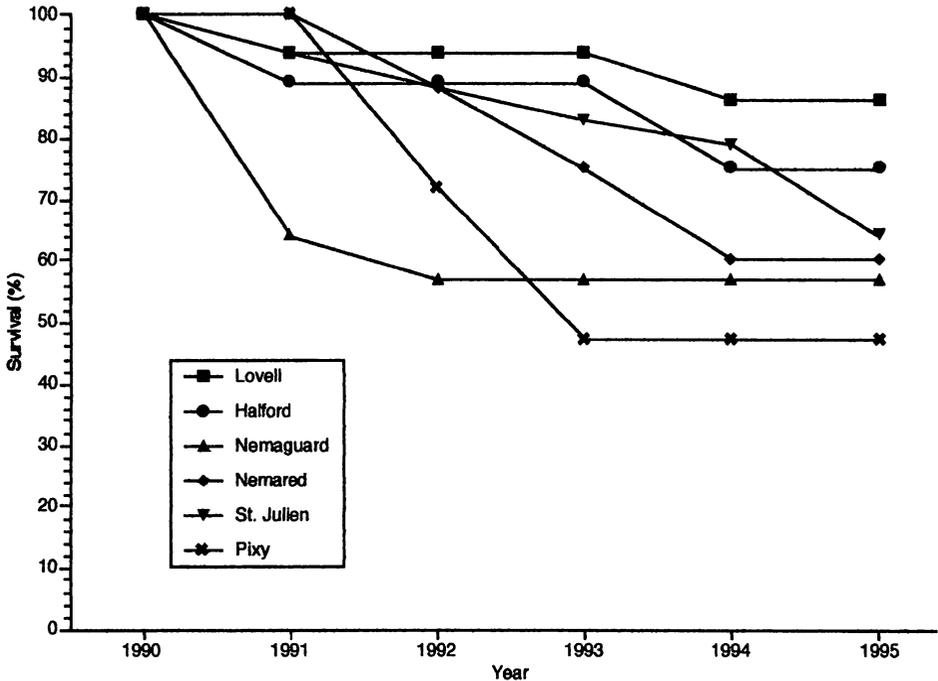


Figure 1. Tree survival by rootstocks. Data from 1990-1993 previously published and shown here for clarity (4).

There was no difference in tree height for any of the rootstocks for either scion (data not shown). This is to be expected, because all trees were pruned each year with height control as one of the criteria. There was no difference in canopy width between rootstocks for 'AU-Amber' in 1994 (data not shown). However, canopy width in 1995 was significantly smaller for St. Julien and Pixy compared to Lovell, Halford, Nemaguard, and Nemared (Table 2). With 'AU-Producer,' trees on St. Julien and Pixy rootstocks had smaller canopy widths compared to Nemared, Halford, and Lovell in 1995. Results were similar in 1994.

TCA for 'AU-Amber' was smaller with St. Julien and Pixy compared to Lovell, Halford, Nemaguard, and Nemared. TCA for 'AU-Producer' was smaller with Pixy compared to Lovell, Halford, Nemaguard, and Nemared. Results for 'AU-Amber' grafted trees was similar except that, 'AU-Producer' on St. Julien rootstock did not

differ from the other rootstocks except for Halford.

The bloom dates in 1992 were 4 days later for 'AU-Amber' on Pixy rootstock compared to Lovell, Halford, Nemaguard, Nemared, and St. Julien (Table 3). This trend continued and was accentuated in 1993 where 'AU-Amber' on Pixy rootstock was later than on Lovell, Halford, Nemaguard, and Nemared by as much as 2 weeks. 'AU-Amber' on St. Julien in 1993 was also \approx 1 week later than on Lovell, Halford, or Nemaguard. There were no differences in bloom dates between rootstocks for 'AU-Amber' in 1994 or 1995. In 1996 'AU-Amber' on Halford and St. Julien was 1-2 days earlier than 'AU-Amber' on the other rootstocks.

Bloom dates among rootstocks for 'AU-Producer' did not vary in 1992. However, in 1993 on Pixy it was later by 4 days than 'AU-Producer' on Halford, or Nemaguard. 'AU-Producer' on St. Julien in 1993 was also later by \approx 1 week than

Table 5. Rootstock effect on AU-Producer for boron, manganese and iron for 1993-95.

Rootstock	Dry Wt (ppm)								
	Mn			Fe			B		
	1993	1994	1995	1993	1994	1995	1993	1994	1995
Lovell	50b ²	91b	75c	80b	708a	118	43	25a	26
Halford	45b	101b	63c	101b	689a	116	48	13b	24
Nemaguard	67b	237a	104b	86b	721a	105	42	9b	22
Nemared	60b	143a	122b	101b	757a	150	53	8c	22
St. Julien	69ab	235a	291a	291a	372b	152	35	3d	20
Pixy	99a	148a	118b	109b	712a	136	41	1d	20

²Means followed the same letter within a column are not significantly different by Fisher's Protected LSD p20.05.

'AU-Producer' on Halford, Nemaguard, or Nemared. This contrasts with 1994 where bloom dates for 'AU-Producer' on St. Julien were up to 3 days earlier than 'AU-Producer' on the other rootstocks. There were no differences in bloom dates for 'AU-Producer' in 1995 or 1996.

There were no differences for leaf N, P, K, and Ca for 'AU-Amber' on any of the rootstocks (Table 4). For 'AU-Producer' there was no differences between rootstocks for N, K, and Ca. Phosphorus levels with 'AU-Producer' were higher with Pixy rootstocks compared to Lovell, Halford, Nemaguard, Nemared, and St. Julien. All of the values for these nutrients were within the normal range for plums except for elevated K levels with 'AU-Amber' and 'AU-Producer' on St. Julien and Pixy rootstocks. The normal range for K in plums is 1.60-3.00% (11).

Magnesium levels with 'AU-Amber' were significantly lower with St. Julien and Pixy rootstocks compared to 'AU-Amber' on Lovell, Halford, or Nemaguard. Leaf Mg levels for 'AU-Producer'

on Pixy rootstock was significantly lower than 'AU-Producer' on Lovell, Halford, Nemaguard, and Nemared.

Leaf Mn levels were higher in 'AU-Amber' on St. Julien than 'AU-Amber' on Lovell, Halford, Nemaguard, or Nemared. There were no differences with 'AU-Amber' on any of the rootstocks for Fe, B, or Zn. 'AU-Producer' on Nemaguard and St. Julien had significantly higher Zn levels than 'AU-Producer' on Lovell, Halford, or Nemared.

Rootstock-by-year interactions with 'AU-Producer' were significant for Mn, Fe, and B. Therefore, these results are shown separately for each year (Table 5). On Pixy rootstock in 1993 Mn levels were higher than on Lovell, Halford, Nemaguard, or Nemared rootstocks. In 1994 the Mn level of 'AU-Producer' on Pixy remained significantly higher than on Lovell and Halford but was not different from Nemaguard and Nemared. In 1995, the Mn level of 'AU-Producer' on Pixy continued to be significantly higher than Lovell and Halford. The highest Mn level

Table 6. Multiple regression results of foliar nutrient concentration as predictors of vigor, yield (1992-1995), cumulative yield efficiency, and survival.²

Variable	Coefficient of determination (R ²)
Survival 1994 = 0.247 K - 0.281 Mn (Nutrients 1993)	0.143
Survival 1995 = No model predicted (Nutrients 1994)	—
Survival 1995 = -0.011 Zn (Nutrients 1995)	0.277
Average canopy spread (1994-1995) = 0.495 Mg	0.245
TCA 1995 = 0.465 Mg 0.304 Zn - 0.360 Mn	0.631
Cumulative yield efficiency = 0.245 Mg - 0.414 K	0.240

²Equations are adjusted so the constant (y-intercept) equals 0.

in 1995 was with 'AU-Producer' on St. Julien rootstock with 291 ppm which was significantly higher than on any other rootstock and was outside the sufficiency range of 40-160 ppm for plums (11).

In 1993, levels of Fe were significantly higher (291 ppm) in leaves of 'AU-Producer' grafted on St. Julien rootstock (Table 5). This contrasts with 1994 when 'AU-Producer' on St. Julien was significantly lower than 'AU-Producer' on other rootstocks. 'AU-Producer' on all rootstocks in 1994 had Fe levels greater than the sufficiency range of 100-250 ppm (11). There were no differences in Fe levels between rootstocks with 'AU-Producer' in 1995.

Boron levels between rootstocks with 'AU-Producer' scions did not differ in 1993 and 1995. However, in 1994 'AU-Producer' on Lovell rootstock was significantly higher than on the other rootstocks. Foliar B levels in 1994 with 'AU-Producer' on all rootstocks, with the exception of Lovell, were below the sufficiency range of 25-60 ppm (11).

Tree survival in 1994 was positively related to 1993 leaf K levels and negatively related to 1993 leaf Mn levels with an $R^2 = 0.143$. There was no equation predicted for the 1995 survival based on 1994 leaf nutrient levels. Using the 1995 nutrient levels to predict 1995 survival rates, Zn was negatively related to survival with an R^2 value of 0.277.

Magnesium was found to be a positive predictor of average canopy spread (1994-1995). Sixty-three percent of TCA was predicted by Mg, Zn, and Mn. Magnesium is a positive predictor of TCA while Zn and Mn are negative predictors. Cumulative yield efficiency is predicted by an increase in foliar Mg and a decrease foliar K levels.

The survival of trees on Lovell rootstock dropped from 94% in 1993 to 86% in 1995 (Figure 1). Trees on Halford rootstock also dropped from 89% to 75%. Trees on Nemaguard remained at 57% survival from 1993 to 1995 and trees on Nemared dropped from 75% to 56% survival during the same period. Trees on St.

Julien dropped from 83% survival in 1993 to 64% survival while trees on Pixy remained the same at 47% survival from 1993 to 1995. There were no statistical differences in survival of trees on the various rootstocks in 1995. This contrasts with 1993 when Lovell and Halford rootstocks had significantly better survival compared to Nemaguard and Pixy (4).

Discussion

An important primary concern in fruit production is increasing fruiting wood and therefore harvestable fruit per unit area. In plum production in the southeastern United States this is particularly important because of uneven production from one year to the next. Dwarfing rootstocks would be useful in increasing yields by increasing the number of trees per area.

Two rootstocks in this study, St. Julien and Pixy, exhibited strong dwarfing characteristics. Previous work had shown that trees on these rootstocks had less shoot growth as well as less increase in TCA (4). This trend was observed in this study with smaller canopy widths as well as smaller TCAs for these rootstocks.

Yields, rarely stellar in the southeastern United States, were acceptable with the dwarf rootstock St. Julien compared to Lovell, Halford, Nemaguard and Nemared, whereas yields on the dwarf rootstock Pixy were variable. The CYEs overall were low. The highest CYE was 0.54 for 'AU-Producer' on Nemaguard which contrasts with Layne (14) reporting 0.95 as the lowest CYE for 'Redhaven' peach on GF1869 rootstock. Devyatov (6) also reported higher CYE with a range of 0.57-1.05 for the three rootstocks tested.

Bloom dates are a particular problem for plums in the southeastern United States. In many years blooming and pollination is disrupted by late frosts and freezes which are probably the single most limiting factor to consistent plum production. For 'AU-Amber,' a particularly early blooming plum, Pixy rootstock delayed bloom in 2 of 5 years while St. Julien delayed bloom 1 of 5 years. For

'AU-Producer,' St. Julien and Pixy delayed bloom 1 of 5 years. Although Pixy and St. Julien delayed bloom in some years, in other years, there were no differences. In some cases trees actually bloomed earlier. Without consistent significant delay in bloom, these rootstocks are not practically suited for this purpose.

There were no differences among primary nutrients for either 'AU-Amber' or 'AU-Producer' except for a higher P level with 'AU-Producer' on Pixy rootstock (Table 4). The 'AU-Producer'/Pixy combination also had higher P levels in the previous evaluation (4) and appears to be an anomaly of this combination with no other apparent significance.

Foliar Mg levels on Pixy and St. Julien rootstocks, although not always significantly so, were lower than on other rootstocks. This trend was also evident in the previous evaluation (4). The association of low Mg levels with dwarfing was evident in the multiple regression analysis (Table 6). Lower Mg levels were related to smaller average canopy spread. Additionally, the TCA, which was generally greater on non-dwarf rootstocks, was positively related to Mg. Interestingly, TCA in dwarf rootstocks was negatively affected by both Zn and Mn. Zinc is often recommended as a foliar spray to prevent deficiency, particularly in the nursery, but can cause premature defoliation (5). This affect may suggest that high Zn levels may play a role in dwarfing trees.

There was no consistent specific leaf nutrient level which could predict survival particularly when using the previous year's leaf nutrient concentration as predictors for the following year's survival (Table 6). It is interesting to note that the current year's Zn level was negatively related to tree survival which as mentioned earlier is associated with tree defoliation (5). It should be noted that except for B levels with 'AU-Producer' on Nemaguard, Nemared, St. Julien, and Pixy in 1994 none of the measured leaf nutrient levels were deficient (20) (Tables 4-5).

Although there were no differences in survival of the various rootstocks in 1995,

many of these survival rates are unacceptable. Minimizing root diseases, insuring adequate moisture, especially during the first year, and minimizing herbicide damage are some of the measures that may help improve rootstock survivability. The reasons for high mortality among these rootstocks is unclear however other researchers have found that both Nemared and Nemaguard are highly susceptible to ring nematode [*Criconebella xenoplax* (Raski) Luc and Raski] which is known to occur at this site (9).

Rootstocks can play an important part in solving problems with plum production in the southeastern United States. Dwarfing, disease resistance, and delaying bloom are desirable characteristics rootstocks can impart. However, at this juncture peach seedling rootstocks such as Lovell and Halford continue to be the best option for growers in the southeastern United States.

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