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# Importance of Scion Cultivar in Peach Tree Short Life

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**Abstract**

In the southeastern United States peach [*Prunus persica* (L.) Batsch] trees planted on sites previously planted with peaches often suffer from Peach Tree Short Life (PTSL) syndrome, in which ring nematode [*Mesocriconema xenoplax* (Raski) Loof & de Grisse], cold injury, and bacterial canker (*Pseudomonas syringae* pv. *syringae* van Hall) combine to kill the scion in the spring. Rootstock plays an important role; where PTSL is present, trees on Guardian® 'BY520-9' rootstock survive better than those on Lovell and much better than those on Nemaguard. Little is known about the role of scion cultivar in susceptibility to PTSL. Previous studies looking at the role of cultivar showed ambiguous results. This study, done in both South Carolina and Georgia, suggests that environmental variability associated with the plantings makes it difficult to reliably separate most commercial cultivars into susceptibility classes. Cultivar susceptibility in the previous experiments were not well correlated with the results of this test, nor with each other. More replications are needed for reliable screening of commercial scion cultivars.

In the southeastern United States, peach [*Prunus persica* (L.) Batsch] trees often die from Peach Tree Short Life (PTSL) syndrome, to which they are predisposed by feeding of ring nematode [*Mesocriconema xenoplax* (Raski) Loof & de Grisse] (9). Cultural practices such as fall pruning and inadequate liming of the soil can also increase PTSL (14). However, the actual causes of scion death in the spring are thought to be either cold injury or bacterial canker (*Pseudomonas syringae* pv. *syringae* van Hall), or a combination of both (14). Generally tissue death extends to the soil line, below which the tree remains alive, hence the frequent occurrence of suckers from below ground. Use of Guardian® 'BY520-9' rootstock dramatically decreases PTSL in comparison to trees budded on Nemaguard (11, 13). As a result BY520-9 is now the predominant rootstock in the Southeast.

Since it is the scion that usually dies from PTSL, it is possible that scion genotype could affect PTSL disease progression. However, the effect of the scion cultivar on susceptibility of a scion/rootstock combination to PTSL has been insufficiently studied. Most PTSL trials reported to date have tested a range of rootstocks budded with only a single scion cultivar; only occasionally have multiple scions been compared (13, 14). In South Carolina (13) the survival of 'Cresthaven', 'Harvester', and 'Redglobe' on Lovell was similar; no difference in 'Springcrest' and 'Redhaven' on several stocks was noted in a second trial. In the 1976 S-97 rootstock planting (5), "there was a tendency for 'Redhaven' trees to be more susceptible to PTSL than 'Loring'" although their Table 1 shows this scion effect varied widely from location to location, and between rootstocks, to the point of even being reversed in some situations. Yadava and Doud (16) reported no differences in survival between 'Correll', 'Derby', 'Hamlet', and 'Winblo' on several different rootstocks. A report from Florida (15) showed a range in PTSL susceptibility among peach scion genotypes budded on Flordaguard seedling rootstock. However, tree numbers were small as these were observations from breeding test blocks. A preliminary study designed to look at the role of cultivar in PTSL using a highly diverse array of germplasm budded on Nemaguard seedling rootstock suggested a significant scion influence on PTSL incidence (1). In a follow-up trial using the best and worst performing (for PTSL) rootstocks and scions, there were again some differences, but not consistent with the first report (2). Based on these limited reports the significance of scion cultivar on incidence of PTSL remains un-

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clear. The purpose of this trial was to compare commercial peach cultivars for their reaction to PTSL across two locations to see if there were significant differences between cultivars, and if previous results could be corroborated.

## Materials and Methods

Trees of 20 peach cultivars commonly grown in the southeastern United States were obtained from commercial nurseries. Most were propagated using virus-indexed scions on Nemaguard rootstock (PTSL susceptible), with 'FlordaKing', 'Jefferson', and 'Rubyprince' cultivars also propagated on BY520-9 rootstock (PTSL resistant). Trees were planted 1 Feb 2000 at the Southeastern Fruit and Tree Nut Research Laboratory in Byron, GA on a site where peaches had grown the previous four years and where PTSL had occurred. The Magnolia sandy loam soil had a pH ranging from 5.3-5.7. An estimate of the preplant presence of ring nematode was determined on 7 July 2000 from six soil cores (2.5 cm in diameter x 30 cm deep) collected from within each block throughout the test site. 'Rubyprince' was monitored as a host for ring nematode population density during the experiment. *Mesocriconema xenoplax* population density was determined on 18 December 2001 and 21 February 2003 from four soil cores collected within the drip line (2 probes on either side of the tree) of the 'Rubyprince'/Nemaguard and 'Rubyprince'/BY520-9 trees. The four soil cores were composited, and nematodes were extracted from a 100 $cm^3$ subsample by elutriation (3) and centrifugation (8) and then counted. Trees were arranged in a randomized complete block design with 20 blocks and single-tree plots within the block. Tree spacing was 1.2 m in the row and 6 m between rows. To enhance PTSL, trees were pruned each December using a tractor-mounted sickle-bar hedger. Trees were maintained following commercial recommendations (7), with the exceptions of not raising the soil pH and time of pruning. Trees were evaluated late each spring through 2007 for scion death caused by PTSL (11). Trees dying of PTSL are notable in that the below-ground portion of the tree remains alive and often produces suckers.

A similar planting was established at the Clemson University Sandhills Research and Education Center in Pontiac, SC. The site had been planted in peach orchards for more than 30 years, with ring nematode present and a history of PTSL. The soil type was a Lakeland fine sand with a pH of 5.3. Trees were planted 23 Feb 2000 in non-fumigated soil in a randomized complete block design, arranged in 5 blocks with cultivars in 4-tree plots. Certain cultivars had limited tree numbers and were only planted at one location. Trees were trained to the perpendicular-V system (4) and were spaced 1.2 m in the row and 6 m between rows. Trees were maintained as noted for the Byron, GA planting except they were pruned in January most years. PTSL-related deaths were recorded in April each year through 2006.

Trees identified as off-type based on bloom or fruit characters, or dying from causes other than PTSL, such as oak root rot [*Armillaria tabescens* (Scop.) Dennis *et al*.], were excluded from data analysis.

Data were summarized as mean survival percentage over blocks, as well as mean tree life span (years) over blocks. Although these parameters are obviously correlated, cultivars with similar survival rates could have different life spans, if one tended to die younger than the other. Data were analyzed by rootstock with Proc GLM using LSMEANS (Version 9, SAS Institute, Cary, NC) using a model with cultivar and block as fixed effects. Cultivar means are presented as least square means (lsmeans) adjusted for block effects because of missing values (6). Mean separation was calculated using Tukey-Kramer HSD. Spearman rank correlations were also done using lsmeans to remove block effects. Nematode data were analyzed using ANOVA with the same model as above. Longevity data was analyzed using Proc Lifetest (Version 9, SAS Institute, Cary, NC) to generate Kaplan-Meier survival functions and associated statistics. This approach compensates for the fact that the experiment

was terminated before all trees died.

## Results and Discussion

In the GA site, the mean initial population density of *M. xenoplax* was 77/100 $cm^3$ soil (range 0 to 330), indicating that the ring nematode was present throughout the majority of the test site, except in two blocks where it went undetected. In Dec 2001 (22 months after orchard establishment), no differences in *M. xenoplax* populations were detected between the two peach rootstock treatments (31 and 36 nematodes per 100 $cm^3$ soil, respectively for Nemaguard and BY520-9). However, 36 months after planting (Feb 2003), nematode populations were greater ($P \leq 0.05$) in 'Rubyprince'/Nemaguard plots than in 'Rubyprince'/BY520-9 plots (160 and 70 nematodes per 100 $cm^3$ soil, respectively). The host reaction of Nemaguard vs. BY520-9 rootstock to *M. xenoplax* in the current study supports previous reports (10). The rootstock host reaction of BY520-9, supporting lesser populations of ring nematode than Nemaguard rootstock, may partially explain why trees on BY520-9 survive longer on PTSL sites than trees on Nemaguard rootstock.

PTSL development was more extensive at the SC site (45% survival) than the GA site (86% survival), which was expected given the histories of the two sites. After two growing seasons (Oct 2001), ring nematode counts in SC averaged 336 nematodes per 100 $cm^3$ soil, substantially higher than in GA (33 nematodes per 100 $cm^3$ soil). On both sites PTSL variability within the field was high, a reflection of the complex of factors that influence progression of PTSL. A highly significant block effect explained substantial variability in SC, with block means (for scions on Nemaguard) ranging from 25 to 67%. One area of the SC planting encompassing parts of several blocks suffered little PTSL, which is typical in orchards afflicted with ring nematode, as its distribution is not uniform within the soil. In addition, other causes of death such as oak root rot (present in the GA planting) are also likely to be spatially irregular in their distribution. The role of viruses such as Prunus necrotic ringspot is unknown, but could influence survival in some cases.

The Log-Ratio and Wilcoxon rankings (Table 1) compare the survival curves of each cultivar to that of the overall population. Negative values indicate better than expected survival rates while positive values reflect lower survival rates. Chi-square tests for homogeneity of survival curves for both measures were highly significant for both plantings, indicating the cultivars differed in survival curves. These rankings are better estimators of survival than the mean lifespan.

Spearman rank correlation coefficients between adjusted mean life span and mean survival were high in both GA ($r=0.94$, $P<0.0001$) and SC ($r=0.97$, $P<0.0001$), as might be expected if trees of each cultivar died at similar ages. Rank correlation between cultivars across locations was not very high for survival ($r=0.62$, $P<0.01$) or for life span ($r=0.69$, $P<0.001$). Only cultivars with large differences in survival or lifespan were significantly different (Table 1). 'Juneprince', 'Springprince' and 'Summerprince' survived poorly in SC but were not in the GA planting; 'Autumnprince' survived poorly in GA only. 'Redglobe' survived relatively poorly at both locations. On the other hand, 'Bounty' and 'Harvester' ranked better for survival in GA than in SC. Cultivars surviving best in SC ('Loring', 'Goldprince' and 'Sunprince') were less well replicated due to initial tree loss, and surviving trees tended to be in a few blocks. Previous research (1, 12) had proposed a possible correlation between chilling requirement and PTSL susceptibility. These correlations were insignificant in the current test. As expected, trees on BY520-9 generally survived better than those on Nemaguard (Table 1).

Results also correlated poorly with previous tests (Table 2). The 1994 trial reported survival after the 6$^{th}$ spring and consisted of 20 single-tree replications (1). Only the commercial cultivars (except Agua 6-4 and Flordaguard) from this trial are shown in Table 2 for comparison to other trials (33 other exotic and feral

**Table 1.** Mean survival percentage and life span, and Log-Rank and Wilcoxon statistics for survival for peach scions budded on Nemaguard or BY520-9 rootstock in Byron, GA and Pontiac, SC. Survival and life-span values are adjusted means of 20 single-tree replicates in Byron after 7 years and adjusted means of five blocks with 4-tree plots in Pontiac after 6 years (some plots missing). Log-Rank and Wilcoxon rankings based on deviations from population survival curve.

| | Georgia | | | | South Carolina | | | |
|---|---|---|---|---|---|---|---|---|
| Scion | Survival | Life | Log-Rank | Wilcoxon | Survival | Life | Log-Rank | Wilcoxon |
| Cultivar | % | (years) | (dev) | (dev) | (%) | (years) | (dev) | (dev) |
| | | *Nemaguard rootstock* | | | | | | |
| Juneprince | - | - | - | | 10 a[z] | 3.1 a[z] | 6.72 | 1923 |
| Autumnprince | 48 a[z] | 5.8 a[z] | 2.67 | 794 | - | - | - | - |
| Harvester | 82 abc | 6.2 a | 0.40 | 155 | 23 ab | 3.3 a | 6.91 | 2324 |
| Springprince | - | - | - | - | 25 ab | 3.9 ab | 3.00 | 571 |
| Bounty | 100 c | 7.0 a | -3.00 | -950 | 33[y] | 4.0[y] | -1.29 | -352 |
| Summerprince | - | - | - | - | 35 abc | 4.3 ab | 1.33 | 151 |
| Redglobe | 60 ab | 5.7 a | 4.73 | 1488 | 35 abc | 4.1 ab | 1.93 | 316 |
| Empress | 77 abc | 6.2 a | 1.40 | 451 | 35 abc | 3.9 ab | 2.49 | 813 |
| Redskin | 77 abc | 6.4 a | 1.27 | 374 | 35 abc | 3.8 ab | 3.52 | 1122 |
| Blazeprince | 83 abc | 6.5 a | 0.15 | 43 | 37 abc | 4.2 ab | 2.65 | 565 |
| Winblo | 83 abc | 6.2 a | 0.62 | 237 | 40 abc | 4.1 ab | 1.79 | 595 |
| Contender | 90 abc | 6.5 a | -0.76 | -204 | 44[y] | 4.5[y] | -1.55 | -503 |
| Surecrop | 69 abc | 6.1 a | 3.24 | 1006 | 45 abc | 4.3 ab | -0.27 | -23 |
| Junegold | 95 abc | 6.9 a | -1.97 | -639 | 47 abc | 4.4 ab | -0.98 | -241 |
| Rubyprince | 88 abc | 6.5 a | -0.67 | -186 | 50 abc | 4.5 ab | -1.10 | -325 |
| Jefferson | 85 abc | 6.3 a | 0.29 | 114 | 50 abc | 4.4[y] | -0.88 | -239 |
| Redhaven | 85 abc | 6.4 a | 0.23 | 82 | 50 abc | 4.3 ab | -1.10 | -70 |
| Sureprince | 68 abc | 6.0 a | 1.73 | 543 | 55 abc | 4.9 b | -3.27 | -1146 |
| FlordaKing | 99 bc | 7.0 a | -2.63 | -850 | 60 bc | 5.0 b | -5.02 | -1704 |
| Flameprince | - | - | - | - | 73 c | 4.9 b | -3.57 | -730 |
| Loring | 100 bc | 7.0 a | -2.69 | -850 | 80 c | 5.4 b | -5.75 | -1551 |
| Flordaguard | 105 c | 7.2 a | -1.58 | -500 | - | - | - | - |
| Sunprince | 96 abc | 7.0 a | -1.37 | -454 | 100[y] | 6.0[y] | -2.74 | -748 |
| Goldprince | 94 abc | 6.9 a | -2.00 | -654 | 100[y] | 6.0[y] | -2.77 | -748 |
| | | *BY520-9 rootstock* | | | | | | |
| FlordaKing | 100 | 7.1 | - | - | 100 | 6.0 | - | - |
| Jefferson | 99 | 6.9 | - | - | 100 | 6.0 | - | - |
| Rubyprince | 78 | 6.4 | - | - | 100 | 6.0 | - | - |

[z] Means within a column having the same letters are not significantly different (P=0.05) based on Tukey-Kramer HSD for lsmeans.

[y] Unadjusted mean. Lsmeans unable to be calculated due to insufficient replication

cultivars were also tested in the 1994 trial). Cultivar groups were statistically split at 40% and 62% survival, meaning the group that included 'Redhaven' had significantly lower survival than the group containing 'Springcrest', 'Cresthaven' and 'Redglobe'. However in the 2002 trial, which was rated after 6 years (2), these cultivars are not significantly different. 'Loring' was one of the better survivors in the current trial in SC (90% survival), compared to 29% survival in the 1994 trial, which placed it in the worst grouping. The rank correlation coefficient between means in the 1994 and 2002 trials was near zero (r=-0.12). Rank correlation between scions in the 1994 trial and the current SC planting (compared because of its more severe PTSL) was also negative (r = -0.52). Despite this lack of agreement in general, Flordaguard (a peach rootstock developed by University of Florida) performed very well as a scion in the 1994 and current trial, as did Agua 6-4 (a local canning peach selection from Aguascalientes, Mexico) in the 1994 and 2002 trials (Table 2).

*Conclusion.* Within the group of commercial peach cultivars that have been tested for scion resistance to PTSL, it has proved difficult to verify differences between cultivars, despite statistically significant differences in some tests. It appears most of these within-test differences can be attributed to experimental variability rather than genetic differences. While the superior survival of Agua 6-4 and Flordaguard as scions on PTSL sites may in fact be a result of genetic resistance to PTSL, these lines are not commercial scion cultivars

**Table 2.** Comparison of scion performance (% survival) for Peach Tree Short Life survival after 6-7 years across four trials in Georgia (GA) and South Carolina (SC), USA. Trials in 1994 and 2002 were previously published by Beckman et al. (1) and Beckman et al. (2), respectively. All trees were on Nemaguard rootstock unless otherwise indicated (Lov=Lovell). Means for current trial are adjusted means (Lsmeans). Means of 20 single-tree replicates (1994, 2002, GA) or five 4-tree blocks (SC) with some plots missing.

| | 1994 | 2002 | Current trial | |
|---|---|---|---|---|
| Scion | GA | GA | GA | SC |
| Agua 6-4 | 85 | 90 | - | - |
| Cresthaven | 41 | 40 | - | - |
| Dixired | 22 | - | - | - |
| Durbin | 20 | - | - | - |
| Elberta | 47 | - | - | - |
| Fireprince | 60 | - | - | - |
| Flordaguard | 85 | - | 100 | - |
| Flavortop | 44 | - | - | - |
| Junegold | 26 | - | 95 | 47 |
| Loring | 29 | - | 100 | 80 |
| Mayflower | 16 | - | - | - |
| Redglobe | 61 | 33 | 60 | 35 |
| Redhaven/Lov | 58 | 22 | - | - |
| Redhaven | 25 | 48 | 85 | 50 |
| Reliance | 59 | - | - | - |
| Springcrest | 50 | 47 | - | - |
| Sunland | 39 | - | - | - |

and not directly useable as such. They might be useful as parents in developing PTSL-resistant scions, if an efficient screening method could be developed. Large-scale screening tests need more replication than previously used to allow repeatable results. However, the potential statistical benefit of increased replication may be offset by the increased variability introduced by the larger area required for the experiment. In conclusion, apparent differences between commercial peach cultivars for scion influence on PTSL should be interpreted with caution due to the variability associated with an individual test.

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