Effect of Winter Root-zone Temperature on Root Regeneration of Peach Rootstocks

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Abstract. Roots of dormant peach trees can grow when soil temperatures are >7 °C, which commonly occurs in the southeastern U.S. during the winter. In our tests, root growth on 1-year-old nursery trees was minimal at 7 °C, and increased with temperature up to at least 16 °C, but rootstocks varied greatly in their regeneration at a given temperature. Trees on seedling rootstocks of ‘Guardian™’, ‘Halford’ and ‘Lovell’ regenerated roots more slowly than those on ‘Nemaguard’ at soil temperatures >7 °C. The regeneration rates mirrored the relative susceptibility of these rootstocks to peach tree short life syndrome in the southeastern U.S., which is associated with parasitism by ring nematode.

Peach trees in the southeastern United States often die from peach tree short life (PTSL) syndrome, in which parasitism by ring nematode [*Mesocriconema xenoplax* (Raski) Loof & de Grisse] predisposes scions to cold injury and bacterial canker (*Pseudomonas syringae* pv *syringae* van Hall) or both in the spring (Ritchie and Clayton, 1981). Rootstock also affects the likelihood of tree death; trees on ‘Guardian™’ brand BY520-9’ outlive those on ‘Lovell’ or ‘Halford’, which are usually longer-lived than those on ‘Nemaguard’ where *M. xenoplax* is present (Okie et al., 1994; Sharpe et al., 1989). Although ‘Nemaguard’ is a slightly better host for ring nematode than ‘Lovell’ and ‘Guardian™’ rootstocks, the differences appear inadequate to explain the increased predisposition to PTSL, nor is the rootstock usually killed when the scion dies from PTSL. Presumably the nematode parasitism causes physiological differences in the rootstocks that differentially affect the scion.

Ring nematodes prefer to feed on young feeder roots, but it is not known if feeding is affected by time of year and soil temperature. Peach roots can apparently grow anytime during the winter that soil temperatures and moisture are adequate (Crider, 1928), in contrast to apple roots that require some chilling for growth (Young and Werner, 1984). Anecdotal information from a commercial nurseryman suggested dormant trees on ‘Nemaguard’ being held by the nursery after digging were quicker to produce new roots compared to those on ‘Lovell’. We hypothesized that the increased availability during the winter of new feeder roots could play a role in predisposing the scion to PTSL in the spring.

Temperature tank studies on dormant peach trees showed no new root growth at 7 or at 35 °C; optimum regeneration occurred at 18 °C (Nightengale, 1935). Winter soil temperatures

in the Southeast are often above 7 °C (Table 1). The only published comparison of temperature effects on peach rootstocks used actively growing seedlings rather than dormant trees. ‘Siberian C’ was better able to tolerate 10 °C soil temperature than ‘Halford’, for those seedlings that were able to survive it (Young, 1980). It is not known if peach rootstocks differ in their ability to grow at a given soil temperature during winter, nor how this root growth might affect scion physiology in the spring. This report describes the root regeneration of dormant peach rootstocks at different root temperatures. A preliminary report has been published (Okie and Nyczepir, 1987).

Materials and Methods

Experiments were conducted in winters 1986–87, 1987–88, 1988–89, and 1999–2000 using June-budded trees with certified virus-free scions (Table 2). All the rootstocks were seed-propagated. Trees were obtained from a commercial nursery in early winter and graded for uniformity. Tops were pruned to 50 cm above the graft union, except for the last trial, which was unpruned. All roots <1 mm in diameter were removed. Larger roots were pruned so that the root system would fit into a 15-cm-diameter polyethylene bag.

Table 2. Materials and Methods for chilling experiments on peach at Byron, Ga.

Test	Scion	Rootstock	Nursery grade (cm ht)	Stem caliper (mm) ²	Root temp (°C)	Duration (d)
1987	Redhaven	Bailey	90–120	65	7,10,13,16	35, 50
		Halford		56		
		Lovell		45		
		Nemaguard		61		
		Tzim Pee Tao		55		
1988	Redhaven	Lovell	75–90	7.7	7,11,16	69
		Nemaguard		7.7		
1989	Loring	Lovell	60–75	11.6	7,11,16	43
		Nemaguard		12.0		
2000	Blazeprince	Guardian	30–45	9.9	13	63
		Halford	45–60	11.8		
		Nemaguard	45–60	12.6		

²Mean estimated volume (mL) of root system for 1987.

Bags were filled with 2 L of a moist 50 sand : 50 vermiculite (by volume) mixture and tied around the shank of the tree. In the 1987 test, 10 to 15 bagged trees of each rootstock were randomly arranged in each of 4 cold rooms (Table 2). The 1988 and 1989 tests used a single cold room (7 °C) so that all trees received identical scion temperatures and so all scions remained dormant. Bagged trees were placed in insulated wooden boxes containing no heating pad (7 °C) or a thermostatically controlled heating pad (>7 °C) to produce the desired root-zone temperature. Additional dry vermiculite was packed around the bags up to the graft union, so roots were maintained at the desired temperature. Temperatures were monitored using thermometers and a Squirrel temperature logger (Science/Electronics, Dayton, Ohio) connected to thermistors in each box. The 1988 and 1989 tests used 10 trees per rootstock randomly arranged in each box (temperature treatment). There was no replication of cold rooms except over years. In 2000, 20 trees per stock were held in 13 °C cold room with the same temperature for roots and scion. In that year ‘Halford’ was used instead of ‘Lovell’ because commercial seed shortages have reduced availability of ‘Lovell’ in recent years in the eastern United States.

At the end of the test, trees were carefully removed from the bags, and all new roots removed and weighed. In 1987, volume of established roots was estimated by volume displacement in water. Trunk caliper was measured at the graft union in 1988, 1989, and 2000. In 1987–89 trunk cambial resistance was measured twice each on the main root, at the graft union, and on the stem using a Shigometer (Osmos, Buffalo, N.Y.). Number of rootstock suckers (vegetative buds on the shank below the graft union that sprouted) was recorded.

In 1988, after root measurement, trees were

Table 1. Number of days in January that maximum daily soil temperature exceeded 7 or 13 °C for 10 and 20 cm depths at Byron, Georgia, 1985–89.

Year	Max daily soil temp (°C)			
	>7		>13	
	10 cm	20 cm	10 cm	20 cm
1985	24	19	4	5
1986	29	27	13	3
1987	28	26	9	1
1988	26	19	11	3
1989	31	31	22	16

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sectioned above the graft union and 1 cm long segments exposed to temperatures of 4, -4, -8, -12, and -20 °C to gauge trunk hardiness, using a refrigerated water-bath filled with anti-freeze. Stem segments were placed in a submerged test tube and exposed to the treatment for 4 h. After exposure, 20 mL distilled water was added to each tube, which was then shaken overnight. After conductance was measured, tubes were autoclaved and conductance remeasured. Initial electrolyte leakage was estimated as a percentage of the total electrolytes released.

Results and Discussion

Root regeneration increased with root

zone temperature (Figs. 1–4). At 7 °C little regeneration occurred except in 1988, which was a longer duration test. Regeneration for roots of ‘Nemaguard’ at 16 °C was less in 1989 compared to 1987 probably due to the use of smaller trees. Differences in nursery conditions, scion cultivar, or chamber conditions could also be factors. In 1988 and 1989 root regeneration varied linearly with temperature within our test conditions (Table 3). In all cases except the 7 °C treatment in 1988, fresh weight of new roots were greater on Nemaguard than Lovell at every temperature (Figs. 1–5). The interaction of temperature and rootstock was significant each year ($P > 0.01$) indicating the slopes (Figs. 1–4, Table 3) were different for

Lovell and Nemaguard. A quadratic term for temperature was significant only in 1987. In the 1987 test, only a single tree on ‘Bailey’ produced any roots (and it only two small roots) regardless of temperature. However, these trees grew normally when transplanted to the field after the test was completed.

Mean tree size was similar between rootstocks within a test. Within a rootstock in a single test, size was not correlated with root regeneration. There was considerable variation in root regeneration within a rootstock, particularly in the warmer treatments. It is not clear whether this variability results from variability within the cold chamber, from genetically determined regeneration potential of a given seedling, or from physiological causes.

Rootstock suckers were much more common on Nemaguard than Lovell or the other rootstocks tested (Table 3), which agrees with our observations from field plantings. Number of sprouts was variable and not correlated with root regeneration, although it tended to increase with root temperature (data not shown).

Shigometer readings of cambial electrical resistance have been correlated with trunk dormancy in peach (Nyczepir, et al., 1987; Wisniewski et al., 1985). As trees emerge from dormancy, increased cambial activity should produce lower Shigometer readings. In our tests, rootstock and temperature effects on cambial resistance were inconsistent.

Comparison of stem hardiness based on percent electrical conductance after freezing showed ‘Redhaven’ was significantly more cold-hardy on ‘Lovell’ than on ‘Nemaguard’ after exposure to temperatures below -4 °C for the 16 °C root treatment (Fig. 6). Trees from the 7 and 11 °C root temperatures showed less difference between rootstocks.

Our results show that “dormant” peach rootstocks differ markedly in their ability to regenerate roots when exposed to temperatures typical of those in winter soil in the southeastern U.S. ‘Nemaguard’ consistently regenerated more roots than the other stocks tested. At the other extreme, ‘Bailey’ regenerated very few roots, albeit in a single trial. Another rootstock developed for use in the northern U.S., ‘Tzim Pee Tao’, also regenerated slowly relative to others tested. Neither ‘Bailey’ nor ‘Tzim Pee Tao’ are recommended for the Southeast. Possibly their root regeneration patterns are more suitable for colder climates with much colder winter soil temperatures.

When this research was initiated, ‘Lovell’ was the preferred rootstock for PTSL sites. The subsequent release of ‘Guardian™’ and its superior survival compared to ‘Lovell’ have made it the current preferred stock. Although it is a putative relative of ‘Nemaguard’, the winter root regeneration rate seems to be quite different. In our final test it regenerated slower even than ‘Lovell’ at cool soil temperatures, supporting the hypothesis that winter root growth potential may be involved in PTSL susceptibility. The relationship of winter root growth on *M. xenopanax* ecology and subsequent trunk physiology needs to be studied further. However, the slow regeneration of ‘Tzim Pee Tao’ and ‘Bailey’ roots suggests they would act

Fig. 1. Mean root regeneration (fresh weight $\pm$ SE) for dormant peach trees held at cold temperatures (°C) for 35 d, 1987, Byron, Ga.

Fig. 2. Mean root regeneration (fresh weight $\pm$ SE) for dormant peach trees held at cold temperatures (°C) for 50 d, 1987, Byron, Ga.

Fig. 3. Mean root regeneration (fresh weight $\pm$ SE) for dormant peach trees held at cold temperatures ($^{\circ}$ C) for 69 d, 1988, Byron, Ga.

Fig. 4. Mean root regeneration (fresh weight $\pm$ SE) for dormant peach trees held at cold temperatures ($^{\circ}$ C) for 43 d, 1989, Byron, Ga.

Table 3. Mean number of suckers and estimates of linear and quadratic effects of temperature on fresh weight of regeneration of peach roots after exposure to different soil temperatures at Byron, Ga.

Year	Rootstock	Mean suckers ($\pm$ SE)	Temp effect on root wt	
			Linear term	Quadratic term
1987	Bailey	0	NS	NS
	Halford	0	0.015**	NS
	Lovell	0.13 $\pm$ 0.09	-0.012**	0.0054**
	Nemaguard	0.46 $\pm$ 0.15	-0.879*	0.049**
	Tzim Pee Tao	0.07 $\pm$ 0.07	-0.141*	0.0073**
1988	Lovell	0.2 $\pm$ 0.20	0.071*	NS
	Nemaguard	4.7 $\pm$ 0.63	0.320**	NS
1989	Lovell	0.7 $\pm$ 0.34	0.061**	NS
	Nemaguard	3.8 $\pm$ 0.77	0.162**	NS
2000	Guardian	4.0 $\pm$ 2.96		
	Halford	2.3 $\pm$ 1.69		
	Nemaguard	7.1 $\pm$ 3.68		

NS,*,** Nonsignificant or significant at the 5% or 1% level, respectively.

Fig. 5. Mean root regeneration (fresh weight $\pm$ SE) for dormant peach trees held at 13 °C for 63 d, 2000, Byron, Ga.

Fig. 6. Cold hardness (electrical conductance of solution) of stem pieces of 'Redhaven' on 'Lovell' versus 'Nemaguard' rootstock after root exposure to 16 °C for 69 d followed by 4 h stem exposure to temperature on x-axis.

more similar to 'Guardian', but 'Tzim Pee Tao' in particular has survived poorly in the Southeast (Okie et al., 1994). However other factors may be responsible for its poor survival.

In conclusion, it is clear that there is substantial genetic variability in winter root regeneration patterns of peach rootstocks. It is likely these patterns are a factor in determining suitability of a rootstock to a particular climatic and edaphic environment, and could be exploited in the development of improved rootstocks.

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