Evaluation of Rootstocks for Tolerance to Bacterial Canker, Orchard Replant Conditions and Size-Controlling in California

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Abstract

The objective of this project was to select rootstocks that are tolerant or resistant to the canker disease caused by the bacterium *Pseudomonas syringae.* In February 2000, twenty-three rootstocks, including the two controls, Nemaguard (susceptible) and Lovell (tolerant), grafted with the 'Ross' scion were planted in a commercial orchard near Escalon, CA. This orchard had very coarse, sandy soil and a history of bacterial canker problems. Symptoms of canker started to show on some of the rootstocks in 2003. Generally, the symptoms started to be apparent in late March and were more pronounced in mid April. Tree death due to canker disease and ratings of springtime canker infections from 2003 through 2009 indicated that trees on several rootstocks were not significantly affected by bacterial canker. These rootstocks were Guardian, Viking, *P. mira*, Flordaguard, HBOK 15, HBOK 1, and HBOK 17. Data from samples of soils and roots, from which live ring (*Criconemoides xenoplax*), root-knot (*Meloidogyne* sp.) and root-lesion *(Pratylenchus vulnus*) nematodes were extracted, showed that the highest numbers of ring nematodes were found on Nickels, K119-50, Hansen 536, Hiawatha, *P. subhirtella,* P30-135, Nemaguard and K146-43 rootstocks. These data, generally, correlated with the data of tree mortality, i.e., rootstocks that harbored high numbers of ring nematodes also showed high numbers of tree mortality. Dormant pruning weights indicated that growth of trees on K146-43, St. Anthony, P30-135, K119-50, Weeping Peach and Compass were the most size controlling rootstocks. Trees on Hansen 536, *P. ferganensis*, HBOK 15, HBOK 1, HBOK 17 and Nickels were similar to, or larger than the Nemaguard control. St. Anthony, Cadaman, Guardian and the Nemaguard control had the highest number of suckers (2.3 to 4.1 suckers per tree). The rest of the rootstocks had zero to one sucker per tree. Trees on the majority of the rootstocks tested were similar to the control with regard to the traditional measure of yield efficiency (Yield/Trunk Sectional Area). Yield efficiencies of trees on the Weeping peach, HBOK 1, Cadaman, HBOK 17, Atlas, K119-50, K146-43, and Lovell rootstocks were higher than the control. Trees on the Nickels rootstock had lower efficiency than the control. In general, all tested size controlling rootstocks were susceptible to bacterial canker.

INTRODUCTION

Loss of peach trees to the "bacterial canker" disease is a serious problem, particularly in second generation orchards planted in the sandy soils of the San Joaquin Valley of California. This problem appears to be related to the susceptibility of the current peach rootstocks to feeding by ring nematode as well as a complex of several other factors. The problem is similar to the malady termed PTSL (Peach Tree Short Life) in the southeast of the United States. Researchers in Georgia and South Carolina have reported that "Guardian" seedling rootstocks have reduced susceptibility to PTSL in the Southeast (Nyczepir et al., 2006). When early selections of these rootstocks were tested under bacterial canker conditions in California, they failed to perform any better than current California rootstocks (unpublished data). However the fact that certain rootstocks appear to confer some benefit in PTSL conditions in the Southeast indicated that it would be beneficial to screen a broad range of rootstock genotypes for potential tolerance to bacterial canker conditions in California. Identification of rootstocks that are more tolerant to bacterial canker conditions may also be beneficial for use where the more general "orchard replant problem" (McKenry, 1999) exists, as use of soil fumigants become more limited.

In addition, several rootstocks have recently been identified that confer varying degrees of size-control on the peach scion cultivars propagated on them (DeJong et al., 2004; Reighard et al., 2001). Availability of these rootstocks for commercial purposes could significantly reduce grower costs by decreasing pruning costs and reducing orchard ladder work. However, none of these rootstocks have been previously tested for tolerance/susceptibility to "bacterial canker" or "orchard replant" conditions in California.

The goal of this project was to evaluate a range of *Prunus* species that come from various parts of the world along with several inter-specific hybrid genotypes that have backgrounds that may confer some unique tolerance characteristics to bacterial canker. Several of the genotypes tested have been reported to impart varying degrees of size-control on the scion and thus we were interested in also assessing their effect on tree growth and yield characteristics.

MATERIALS AND METHODS

In February 2000, trees on a broad range of rootstocks (Table 1) grafted with Ross cling peach were planted in a field site near Escalon, CA, about 1 km from the Stanislaus River. This site had very coarse sandy soil and a history of bacterial canker problems with previous peach plantings. The trees were planted on low berms and flood irrigated regularly to replace water loss due to evapotranspiration. The trees were planted at a spacing of 1.83 m in the row and 4.88 m between rows and trained to the "KAC Perpendicular V" system (DeJong et al., 1994). Trees were planted in randomized replicated blocks with five tree replications of each rootstock in each block. Most rootstocks were represented by 40 or 20 trees at the beginning of the experiment but several had fewer trees because of lack of tree availability at the time of planting. Whenever there were not enough trees to complete a 5-tree replication trees on Lovell rootstock were planted to complete the replication but data was not taken on these substitute trees. Dormant pruning was done early in the winter season to enhance the likelihood of canker disease infection. Dormant pruning weights were recorded immediately after pruning. The crop was harvested in one pick in each year (usually in the first or second week of August). In 2006, the harvest occurred in the third week of August. Tree yield data were taken on five tree replicates of each rootstock. Soil and root samples taken from under each tree in the plot in October 2006 and live ring (*Criconemoides xenoplax*), root-knot (*Meloidogyne* sp.) and root-lesion (*Pratylenchus vulnus*) nematodes were extracted and counted (Ferris et al., 1981).

RESULTS AND DISCUSSION

Symptoms of bacterial canker started to show on some of the rootstocks in spring of 2003. Generally, the symptoms started to show in late March and became more pronounced in mid April. Data on the percentages of dead trees on each rootstock from 2003 through 2009 are shown in Table 2. A few rootstocks apparently conveyed enough resistance to avoid tree death due to canker. These were Guardian, Nemaguard, Viking, *P. mira*, Compass, Flordaguard, HBOK15, HBOK 1, HBOK 17 and Weeping peach. Trees on the *P. subhirtella*, Nickels and P30-135 rootstocks were badly affected and trees on *P.*

mira, Lovell, Compass, HBOK32, Flordaguard, HBOK15, HBOK1, Weeping peach and HBOK17 were not significantly affected by bacterial canker in 2006.

Soil and root samples were taken from under each tree in October 2006 and live ring, root-knot and root lesion nematodes were extracted and counted (Table 3). The highest numbers of ring nematodes were found in soil under Nickels, K119-50, Hansen 536, Hiawatha *P. subhirtella*, P30-135, Nemaguard and K146-43. Except for Nemaguard, this was consistent with the percentage of trees killed by bacterial canker (Table 2), i.e., rootstocks that harbored high numbers of ring nematodes also tended to have high percentages of trees that died from bacterial canker. However soil associated with *P. ferganensis* had the lowest numbers of ring nematodes but was still affected by the disease.

Tree size and vigor as gauged by trunk cross sectional area (TCA) and dormant pruning weights varied substantially among the trees on different rootstocks (Table 4). Fruit yields also tended to correlate with tree size and vigor with the smaller trees producing less fruit. Unfortunately, the trees on the more size-controlling rootstocks tended to be more susceptible to bacterial canker, but there were a few vigor-inducing rootstocks that were also susceptible such as Nickels, Hansen 536, Atlas and *P. ferganensis.*

CONCLUSIONS

Several rootstocks in the trial appeared to impart some resistance to bacterial canker disease in this trial. However, since the performance of the current standard rootstocks used in canker-prone sites in California (Lovell and Nemaguard) performed nearly as well as the rootstocks that showed the least susceptibility in the trial, it is difficult to conclude that any of these rootstocks (Flordaguard, Guardian, *P. mira*, HBOK 1, HBOK 15 and HBOK 17) are truly more resistant to the disease than current standard rootstocks. More commercial-scale trials are needed to make recommendations about which rootstocks should be used. This trial does indicate that it will likely be very difficult to find peach rootstocks that are both size-controlling and resistant to bacterial canker disease.

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Tables

Table 1. List of the rootstocks that were tested. RKN = Root-knot nematode; LN = Root-Lesion nematode.

Prunus Species	Parents	Vigor
P. ferganensis		very vigorous
P. subhirtella		vigorous
P. mira		vigorous
	Inter-Specific Hybrids	
St. Anthony	*P. besseyi* × *P. salicina*	size controlling, resistant of RKN*
Compass	*P. besseyi* × *P. hortulana*	size controlling, resistant of RKN
K119-50	*P. salicina* × *P dulcis*	size controlling
P30-135	*P. salicina* × *P. persica*	size controlling, resistant of RKN, tolerant to LN**
K146-43	*P. salicina* × *P. persica*	size controlling, some susceptibility to RKN & LN
Nickels	*P. persica* × *P. dulcis*	vigorous, resistant to RKN & LN
Hansen 536	*P. persica* × *P. dulcis*	vigorous, resistant to RKN & tolerant to LN
Cadaman	*P. persica* × *P. davidiana*	Vigorous, resistant to RKN & LN, tolerant to high soil pH
Hiawatha	*P. besseyi* × *P. salicina*	size controlling, resistant to RKN & LN
Viking	*Inter-specific of peach, plum & apricot*	very vigorous, may have resistance to RKN & LN
	Prunus persica	
Lovell	control	vigorous, susceptible to RKN& LN
Nemaguard	control	vigorous, resistant to RKN & tolerant to LN
Flordaguard	(low chill Florida Stock)	vigorous, resistant to RKN & tolerant to LN
Guardian	(PTSL Georgia stock)	vigorous, tolerant to peach short life, resistant to RKN
HBOK 1	Okinawa × Harrow Blood	size controlling, resistant to RKN
HBOK 15	Okinawa × Harrow Blood	size controlling, resistant to RKN
HBOK 17	Okinawa × Harrow Blood	size controlling, resistant to RKN
HBOK 32	Okinawa × Harrow Blood	size controlling, resistant to RKN & tolerant to LN
Weeping Peach	Seedling of ornamental weeping peach	size controlling, resistant to RKN
Atlas		resistant to RKN & LN

Table 2. Bacterial canker ratings in 2006 (sixth year after planting and a year of relatively high disease incidence) and the percentage of the total trees on each rootstock that died from 2003 to 2009. Canker rating ranged from 1 (no signs of disease) to 5 (tree killed by bacterial canker). Note that the number of trees on each rootstock (number in parentheses) varied.

Genotype	2006 Canker rating	2006 Canker rating % control	Significance	Total % mortality
P. subhirtella* (29)	3.6	171	a	34.5
Nickels* (20)	3.5	166	ab	55.0
P30-135* (34)	3	146	abc	76.5
Atlas* (34)	3	145	abc	11.8
St. Anthony* (40)	2.9	139	abcd	27.5
Hiawatha * (40)	2.8	134	bcde	32.5
Hansen 536* (19)	2.7	131	cde	15.8
K146-43* (38)	2.6	126	cdef	36.8
K119-50* (40)	2.5	120	cdef	32.5
*P. ferganensis** (27)	2.3	111	cdefg	7.4
Guardian (38)	2.3	112	cdefg	0
Nemaguard (40)	2.3	110	cdefg	0
Viking (38)	2.2	107	defg	0
Compass (18)	2.1	100	defgeh	22.2
HBOK 32* (34)	2.1	100	efgeh	14.7
Lovell (control) (45)	2.1	100	defgeh	2.2
P. Mira (10)	2.1	104	defgeh	0
Cadaman* (37)	2	98	efgeh	2.7
Flordaguard (39)	1.8	88	fgeh	0
HBOK 15 (10)	1.6	78	gh	0
HBOK 1 (19)	1.6	77	gh	0
Weeping peach (5)	1.4	68	h	40.0
HBOK 17 (4)	1.4	65	h	0

Table 3. Number live ring (*Criconemoides xenoplax*), root-knot (*Meloidogyne* sp.) and root-lesion (*Pratylenchus vulnus*) nematodes extracted from 250 cc of soil, with occasional roots, of the tested rootstocks.

Rootstock	Ring	Root-knot	Root lesion
P. ferganensis	66	153	4
Viking	163	1	14
HBOK 1	163	0	61
HBOK 15	171	0	434
Lovell	215	12	101
Compass	249	5	172
P. mira	272	0	5
Guardian	275	67	3
Atlas	281	18	106
HBOK 32	413	5	108
St. Anthony	463	50	27
Cadaman	521	0	4
Flordaguard	587	0.1	107
K146-43	656	161	82
Nemaguard	676	0.8	218
P30-135	860	125	38
P. subhirtella	895	426	12
Hiawatha	937	4	35
Hansen 536	1239	0.3	148
K-119-50	1347	165	6
Nickels	1704	11	24

Table 4. Mean (±SE) trunk cross-sectional area, fresh crop weight and dormant pruning weight data for 2006.

Genoytpe	TCA (cm^2)		Dormant pruning weight (kg/tree)		Crop (kg/tree)	
Nickels	228	±10.9	20.1	±1	87.8	±3.4
Guardian	190	±9.3	14.3	±0.6	99	±2.7
Nemaguard	188.6	±10.4	16.6	±0.9	108.5	±4.6
Viking	186.3	±7.2	14.6	±0.4	102	±3.4
P. ferganensis	182.6	±5.6	17.1	±0.8	102.5	±2.8
Hansen 536	179.9	±8.5	17.8	±1.2	96.6	±2.1
HBOK 15	177.3	±3.7	15.8	±0.3	113.6	±1.2
Flordaguard	163.9	±8.3	12.1	±0.4	103.6	±4
Lovell	163.2	±5.3	12.7	±0.7	115.3	±3.2
P.mira	154.6	±4.5	13.9	±0.1	101.9	±2.6
Cadaman	151.5	±6.5	14	±0.4	121.8	±3
HBOK 17	150.6	±6.4	11.8	±0	115.4	±0
HBOK 1	145.5	±5.7	11.4	±0.4	130.2	±2
Atlas	143.6	±6.9	13.9	±0.5	102	±5.8
P. subhirtella	136.1	±9	8.1	±0.5	69.1	±2.1
Compass	122.5	±5.6	7.6	±0.3	78.4	±2.2
P30-135	94.6	±7	5.8	±0.3	46.9	±3.2
K119-50	76.2	±5.2	6.4	±0.6	53.7	±5
Weeping peach.	73.7	±1.4	6.7	±0	74.9	±0
St. Anthony	70.6	±4.3	3.8	±0.3	36.5	±2.5
K146-43	61.4	±3.8	3.3	±0.2	37.5	±2.4