Reduced Incidence of Lesser Peachtree Borer and *Leucostoma* Canker in Peach-Almond Hybrids

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Abstract. Damage by lesser Peachtree borer (LPB) (*Synanthedon pictipes* Grote & Robinson) and *Leucostoma* canker that had accumulated during 6 (Orchard A) and 8 (Orchard B) years were compared in peach (*Prunus persica* L.) and peach-almond [*P. amygdalus* (Mill.) D. A. Webb] hybrids. Afterward, the main trunk and scaffold limbs of the trees received 10 wounds 26 mm in diameter and a subset of these trees in Orchard A had wounds inoculated with *Leucostoma persoonii* Hohn. Before wounding, *Leucostoma* canker infection and LPB infestations that had accumulated for 6 to 8 years on peach-almond hybrids was $\approx 60\%$ and 98% less than on peach in Orchard A and B, respectively. One month after wounding the trees, no significant differences in *Leucostoma* canker infection and LPB infestations were found among the peach-almond hybrids, treated or not treated with *L. persoonii*, or untreated peach. Yet, *Leucostoma*-treated and untreated peach-almond hybrids had 33% and 25% less *Leucostoma* canker and LPB, respectively, when compared with *Leucostoma*-treated peach. Ten months after wounding, peach-almond hybrids treated with *L. persoonii* still had significantly less *Leucostoma* canker (60%) and LPB (25%) when compared with *Leucostoma*-treated peach. Wound gumming and wound closure rates seemed to influence the degree of LPB infestation and *Leucostoma* canker. Based on these data, peach-almond hybrids could be valuable sources of resistance to LPB and *Leucostoma* canker.

Lesser Peachtree borer (LPB) is indigenous to the United States, where it is a serious pest of peach and other *Prunus* spp. Wounds made by farmimplements, disease, cold injury, hail, sunscald, split crotches, or cracked bark are necessary for LPB to initiate an infestation (Reilly et al., 1987). Once entering the wound, LPB feeds on the cambium surrounding the wound. Such feeding eventually can enlarge wounds to the extent that limbs are girdled. *Leucostoma* canker (formerly *Cytospora* canker), caused by the fungi *Leucostoma persoonii* and *L. cincta* (Fr. ex Fr.) Hohn is a major disease of peach. *Leucostoma persoonii* is the only species known to cause *Leucostoma* canker in West Virginia (Biggs, 1989). Infection is initiated through injured tissue or cracks in the bark from many causes (cold injured tissue, pruning cuts, leaf scars, shade-weakened twigs), after which gumming cankers form that can girdle limbs and weaken the tree (Willison, 1936). LPB and *Leucostoma* canker share a close relationship. *Leucostoma* canker or peach gum from fresh wounds are major ovipositional attractants for LPB (Reed et al., 1988). Moreover, *Leucostoma* canker predisposes peach trees to LPB attack by producing wounds that are favorable entry sites for LPB larvae (Swift, 1986).

Low degrees of resistance to *Leucostoma* canker have been found in open-pollinated peach (Chang et al., 1989a, 1989b; Dhanvantari and Dirks, 1983; Scorza and Pusey, 1984). There are no known chemical treatments or cultural methods that can prevent or eliminate *Leucostoma* canker (Biggs, 1989). Resistance is positively correlated with cold hardiness (Chang et al., 1989b) and rate of suberin formation in wounds (Biggs and Miles 1988). No literature could be found on evaluating *Prunus* spp. resistance to LPB. In 1991, G.J.P. noted that peach-almond hybrids planted in two peach orchards showed almost no sign of LPB infestation or *Leucostoma* infection. In this study, we quantified LPB infestations and *Leucostoma* canker in two orchards containing peach and peach-almond hybrid trees.

Materials and Methods

Two orchards containing mixed plantings of peach and peach-almond hybrids were planted in a completely randomized design. Orchard A was a 6-year-old orchard that contained 70 trees and Orchard B was an 8-year-old orchard that contained 225 trees. Both orchards contained peach seedlings that originated from several open-pollinated parents known to be susceptible to *Leucostoma* canker. Orchard A contained peach-almond hybrids that were segregating F, progeny of a single parentage and Orchard B contained peach-almond hybrids of diverse parentages. The peach-almond hybrids in Orchard A consisted of two distinct phenotypes, almond-like and peach-like, based on the appearance of their leaves, fruit, and bark. Orchard A was subjected to a low-pesticide spray program for disease and insect control, while Orchard B was not sprayed for insects or diseases for 6 years before this study. Tree spacing in Orchard A was 3.5 m between rows and 2.0 m within rows, while tree spacing in Orchard B was 4.0 m between rows and 3.0 m within rows. These orchards were pruned moderately each year.

The abundance of LPB was monitored using two wing-traps (no. 1C Pherocon; Sentry, Buckeye, Ariz.) baited with pheromone (Century; Sentry) so that wound treatments and evaluations of infestations could be timed properly. LPB infestation and *Leucostoma* canker in the peach and peach-almond hybrids were quantified on 1 July 1991. Wounds that contained fresh frass from actively feeding LPB larvae or empty pupal cases left behind by LPB adults were considered infested. *Leucostoma* canker was diagnosed by necrotic wounds that actively flowed dark amber gum, while noncancerous wounds showed little necrosis and flowed clear gum (Swift, 1986). The identity of LPB was confirmed using the morphological characteristics of the mandible described by Stehr (1987). Data for the peach-almond populations were partitioned into peach-like and almond-like hybrids. Afterward, the main trunk and scaffold limbs of peach ($n = 36$), peach-like hybrids ($n = 7$), and almond-like hybrids ($n = 20$) received 10 wounds each from a 26-mm hole punch driven through the bark by hammer; then the circular piece of bark that remained was removed. The wound sites had been cleaned with a cloth

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soaked in 70% ethyl alcohol before being wounded. In Orchard A, randomly chosen subsets of peach (n = 7) and almond-like hybrids (n = 10) had wounds inoculated with 1.0 g of gum homogenate that contained the causal agent of *Leucostoma* canker, *L. personii*, using a method described by Swift (1986). The homogenate was made from dark amber gum that was collected from active *Leucostoma* cankers on 'Redhaven' peach trees. The concentration of *L. personii* conidia was 5×10^5 /ml, based on haemocytometer counts taken from a diluted gum sample. The presence of *L. personii* in the gum was verified by plating a diluted gum sample on yeast-maltose agar and identifying the pathogen using morphological traits of the colonies as described by Willison (1936).

The number of wounds with active *Leucostoma* canker, wounds with LPB, wounds with *Leucostoma* canker and LPB, and degree of gumming were evaluated 1 month after wounding (1 Aug. 1991). Degree of gumming was determined using a 1 to 6 rating

system: 1 = no gumming; 2 to 5 = 25% increments of the wound area filled with gum; 6 = wound area overflowing with gum. Data were taken on the number of LPB infested wounds, wounds with *Leucostoma* canker, and degree of wound closure in Orchard A 10 months after wounding (12 May 1992). The degree of wound closure was determined by measuring the length of the wound across its horizontal and vertical planes and calculating the area of the wound. Data analyses consisted of analyses of variance (PROC GLM) and treatment means were separated using the least significant difference method (SAS Institute, 1988).

Results

Peach and peach-almond hybrids were evaluated 1 July 1991, ≈ 3 weeks after overwintering second-generation LPB adult flight activity had peaked. The frass left by overwintering second-generation larvae and empty pupal cases left by the adults that had emerged were most evident at this time. Peach trees in Orchard B had four times as many wounds as those in Orchard A; whereas, peach-almond hybrids in both orchards had nearly the same number of wounds (Table 1). Most of the wounds found on peach and peach-almond hybrids had actively gumming *Leucostoma* canker. Many of these infected wounds in Orchard A were infested with second-generation LPB larvae, while, in Orchard B, there was a much lower percentage of infected wounds that had LPB. There were substantially fewer LPB infestations and *Leucostoma* cankers in peach-almond hybrids than in peach in both orchards. In Orchard A, peach-like hybrids had an intermediate number of wounds, *Leucostoma* canker, and LPB infestations relative to almond-like hybrids and peach.

On 1 Aug. 1991, 1 month after the trees were wounded, peach treated with *L. personii* had significantly more wounds with *Leucostoma* canker than untreated peach in Orchard A (Table 2, Fig. 1). The wounds were evaluated at the peak of first-generation LPB adult flight activity, before they mated and began ovipositing, so that wounds were infested only with first-generation LPB larvae. The number of LPB did not differ significantly between these two treatments for peach. The incidence of wounds that were gumming or had *Leucostoma* canker, LPB, or *Leucostoma* canker

Table 1. Natural damage (evaluated on 1 July 1991) from *Leucostoma* canker and lesser peachtree borer (LPB) to peach and peach-almond hybrid trees that had accumulated 6 years after planting Orchard A and 8 years after planting Orchard B.

Type of seedling ²	Mean no./tree		Wounds ³ (total)
	Canker	LPB	
<i>Orchard A</i>			
Peach (n = 42)	7.3 a	5.6 a	7.6 a
Peach-like hybrid (n = 7)	2.5 b	1.5 b	2.6 b
Almond-like hybrid (n = 18)	0.5 c	0.4 b	0.6 c
LSD ($\alpha \leq 0.05$)	1.4	1.5	1.4
<i>Orchard B</i>			
Peach (n = 9)	30.4 a	15.7 a	33.6 a
Almond-like hybrid (n = 9)	0.6 b	0.1 b	0.6 b
LSD ($\alpha \leq 0.05$)	19.1	8.5	18.9

²Peach-almond hybrids in Orchard A were separated into peach- and almond-like based on the appearance of leaves bark and fruit. Orchard B had only almond-like hybrids.

³Total number of wounds with or without LPB or *Leucostoma* canker.

Table 2. Mean number of wounds gumming, *Leucostoma* canker, and lesser peachtree borer (LPB) infestations on 1 Aug. 1991, 1 month following mechanical wounding of peach and peach-almond hybrid trees.

Type of seedling	<i>Leucostoma</i> treatment	n	Wounds ^z				Gumming rating ^x
			Gumming	With canker	With canker plus LPB	Total infested with LPB ^y	
<i>Orchard A</i>							
Peach	Yes	7	10.0 a	9.4 a	8.9 a	9.4 a	5.5 a
	No	29	7.3 b	6.2 b	5.8 ab	7.7 ab	5.2 a
Peach-like hybrid	No	7	5.7 b	5.7 b	4.9 b	5.2 b	3.7 b
Almond-like hybrid	Yes	10	6.3 b	6.3 b	5.1 b	6.3 b	2.8 c
	No	10	4.5 b	4.5 b	4.4 b	7.3 ab	3.1 c
LSD ($\alpha \leq 0.05$)			2.9	2.9	3.0	2.8	0.8
<i>Orchard B</i>							
Peach	No	9	8.1 a	7.9 a	8.0 a	9.0 a	5.0 a
Peach-almond hybrid	No	9	3.4 b	2.0 b	2.0 b	6.2 b	2.8 b
LSD ($\alpha \leq 0.05$)			2.0	2.2	1.4	1.9	0.5

²Mean number of wounds per tree damaged, infected, or infested out of 10 wounds per tree.

³Total number of LPB determined by summing the number of LPBs in wounds with canker, gumming without canker, and no gumming.

⁴1 = No gumming; 2 = 1% to 25%, 3 = 25% to 50%, 4 = 50% to 75%, and 5 = 75% to 100% of the wound filled with gum; 6 = wound overflowing with gum.

Fig. 1. (A) Peach seedling 1 month after *Leucostoma* treatment. Note the *Leucostoma* infection and profuse gumming from the wounds. Mean gumming rating for this tree was 5.0. (B) Peach-almond hybrid 1 month after *Leucostoma* treatment. Note the progressive wound closure and lack of infection. Mean gumming rating for this tree was 1.2.

plus LPB was similar among the various peach-almond hybrids, treated or not treated with *L. personii*, or untreated peach in Orchard A. However, the various peach-almond treatment combinations had significantly fewer wounds that were gumming or had *Leucostoma* canker, LPB, or *Leucostoma* canker plus LPB than *Leucostoma*-treated peach. These significant differences also occurred between the peach-almond hybrids and peach not treated with *Leucostoma* canker in Orchard B. Gum ratings for peach, treated or not treated with *L. personii*, were significantly higher than for the peach-almond hybrids, either treated or untreated, in both orchards. The almond-like hybrids, whether treated with *L. personii* or not, gummed significantly less than the peach-like hybrids in Orchard A.

On 12 May 1992, 10 months after wounding and *L. personii* inoculations, overwintering second-generation LPB larvae had pupated and begun to emerge. Significant differences in LPB infested wounds and canker infections still occurred between peach and the peach-almond hybrids (Table 3). Almond-like hybrids not treated with *L. personii* had significantly lower levels of *Leucostoma* canker than untreated peach, while the level of canker was intermediate in peach-like hybrids. The number of first-generation of LPB in the various peach-almond hybrids also was significantly lower than in peach. The wounds of *Leucostoma*-treated peach were significantly larger than those of untreated peach. Treated and untreated almond-like hybrids had

wound areas that were similar; however, their wound areas were significantly smaller than those of peach treated or not treated with *Leucostoma*. Wound areas of the untreated peach-like hybrids were similar to those of untreated almond-like hybrids.

Discussion

The incidence of LPB and *Leucostoma* canker in both orchards was significantly less in peach-almond hybrids than in peach (Table 1). Before being wounded, almond-like hybrids had 92% to 98% fewer open wounds than peach. Most of these wounds appeared to be related to cracks in the bark and limb crotches. Many of these wounds had *Leucostoma* canker and LPB, although the almond-like hybrids had 92% to 99% fewer cankers and LPBs than peach. Our data from mechanically wounding and inoculating the wounds with *Leucostoma* suggest that the reduced incidence of canker and LPB in peach-almond hybrids has a biological basis (Tables 2 and 3). Peach-like hybrids showed intermediate levels of canker before (Table 1) and after wounding (Table 2), a result indicating that resistance to *L. personii* may be associated with almond trans. The size of wound areas suggests that almond-like hybrids are resistant to *Leucostoma* infection, because the wounds of such hybrids inoculated with *Leucostoma* closed normally, compared with the untreated control, and closed faster than in peach (Fig. 1).

Table 3. Degree of lesser peachtree borer (LPB) infestation, *Leucostoma* canker, and wound area on 12 May 1992, following mechanical wounding on 1 July 1991, Orchard A.

Type of seedling	<i>Leucostoma</i> treatment	n	Wounds ^a		Wound area (mm ²)
			Infested with LPB ^a	With canker ^y	
Peach	No	29	5.6 a	6.8 a	503 b
	Yes	10	5.0 a	6.0 ab	578 a
Almond-like hybrid	Yes	10	2.0 b	4.5 bc	346 d
	No	8	0.3 b	1.3 d	378 cd
Peach-like hybrid	No	7	1.6 b	4.0 c	414 c
LSD ($\alpha \leq 0.05$)			2.0	1.9	85

^aMean number out of 10 wounds per tree.

Unlike almonds, which have not been reported to be an LPB host, peach-almond hybrids can serve as hosts but may be less suitable than peach because there are fewer sites (wounds) for oviposition. The strong association between LPB and *Leucostoma* canker was particularly evident 1 month after the trees were artificially wounded and inoculated with *L. personii* (Table 2). Our study supports other research demonstrating that LPB infestations are largely attributed to *Leucostoma* canker (Swift, 1986) because infected wounds become perennial cankers that remain open and, thus, provide sites for LPB larvae to enter the tree. *Leucostoma* canker also has been shown to be a major ovipositional attractant for LPB (Reed et al., 1988). We found that wounds inoculated with *Leucostoma* gummed 50% less in almond-like hybrids compared with peach (Table 2), a result suggesting that gumming degree may be an important factor in LPB resistance. Wound closure was greater in peach-almond hybrids than in peach (Table 3), a result suggesting that this could be another important factor contributing to the reduced LPB infestations and *Leucostoma* canker.

The low incidence of *Leucostoma* canker and LPB in peach-almond hybrids before wounding suggests that there were additional factors influencing this damage before our intervention. Distinct physiological and biochemical differences likely exist between peach-almond hybrids and peach. Reduced cold injury has been found to be an important factor related to lower LPB infestations (Smith, 1952). Data on the cold hardiness of peach-almond hybrids is lacking, but Chang et al. (1989b) found one peach-almond hybrid to be more cold hardy and, consequently, have less *Leucostoma* canker than most peach genotypes. Among the biochemical differences between peach and the hybrids may be two compounds associated with the wound site—prunacin and suberin. Prunacin, a cyanogenic glucoside, is the primary biochemical factor that prevents LPB from attacking uninjured peach bark (Reilly et al., 1987). Suberin, an aliphatic compound with a high phenolic component, creates a physical and biochemical barrier to pathogens, and its accumulation rate at the wound site is correlated to *Leucostoma* susceptibility in peach (Biggs and Miles, 1988). The role of these compounds in limiting the infestation of LPB and *Leucostoma* infection in peach-almond hybrids deserves close scrutiny.

Based on our results, peach-almond hybrids could be valuable sources of resistance to LPB and *Leucostoma* canker. Future research on the inheritance of *Leucostoma* and LPB resistance, linkage to almond traits, and the mechanism of wound resistance to *Leucostoma* infection is necessary to determine the value of this resistance.

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