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Almond trunk injury treatment following bark damage during shaker harvest

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SUMMARY – Injury to almond tree trunks during mechanical shaker harvest quickly attracts several insect vectors of the *Ceratocystis fimbriata* fungus. The American plum borer, *Euzophera semifuneralis*, a known *Ceratocystis* fungus vector, prefers to attack young, injured, or weakened trees wherever callous tissue has formed. When the insect bores through the trees wound-healing zone it could be an important means of introducing *Ceratocystis* spores long after a mechanical injury occurs. Trimming back crushed, torn, or loosened bark to well attached bark and treating the wound with an insecticide-paint or copper-oil reduces the number of plum borer strikes compared to untreated wounds. The number of *Ceratocystis* cankers that subsequently occur are also reduced by these treatments and the copper-oil treatment may provide benefits for several years.

Key words: American plum borer, *Ceratocystis*, *Euzophera*, *Prunus dulcis*, *Prunus amygdalus.*

RESUME – *"Traitement des dommages causés à l'écorce des troncs d'amandiers pendant la récolte par secouage". Les dommages causés aux troncs d'amandier pendant la récolte mécanique par secouage attirent rapidement plusieurs insectes vecteurs du champignon* Ceratocystis fimbriata*. Le foreur américain du prunier,* Euzophera semifuneralis*, un vecteur connu de* Ceratocystis*, préfère attaquer les arbres jeunes, blessés, ou affaiblis partout où un tissu dur s'est formé. Quand l'insecte perce la zone de guérison de l'arbre, il pourrait présenter des moyens importants d'introduire des spores de* Ceratocystis *longtemps après que des dommages mécaniques se produisent. Tailler l'écorce écrasée, déchirée, ou détachée jusqu'au point où l'ecorce est bien attachée et traiter la blessure avec un insecticide-peinture ou une huile-cuivre réduit le nombre d'attaques de foreurs du prunier en comparison aux blessures non traitées. Le nombre de chancres de* Ceratocystis *qui se produisent plus tard sont également réduits par ces traitements et le traitement a l'huile-cuivre peut fournir des avantages pendant plusieurs années.*

Mots-clés : *Foreur américain du prunier,* Ceratocystis, Euzophera, Prunus dulcis, Prunus amygdalus*.*

Introduction

Injury to almond tree trunks during mechanical shaker harvest results in serious damage to tree vigour, health, and longevity. Injuries where bark is crushed or torn from the trunk immediately attract a variety of insects, several of which are known vectors of *Ceratocystis fimbriata* fungus spores. When insect feeding and establishment of *Ceratocystis* cankers compound these trunk injuries, premature tree losses may occur. The fungus grows well on exposed cambium where bark has been stripped off. It grows even more vigorously under bark that has been crushed or loosened (DeVay *et al*., 1965). Crushed or loosened bark provides an attractive environment where insects that vector *C. fimbriata* can multiply.

The major insects implicated in the transmission of *C. fimbriata* include a nitidulid beetle, *Carpophilus freemani*, a drosophilid fly, *Chymomyza procnemoides*, and to a lesser extent the American plum borer, *Euzophera semifuneralis* among others (Moller and DeVay, 1968). They also found that total exclusion of insects from bark injuries prevented infection by *C. fimbriata*. Bostock (1983) found that trunk injuries on 'Nonpareil' almond became resistant to *C. fimbriata* infection after 8 to 10 days due to natural wound healing mechanisms if initial infection was avoided.

The situation may be different when the American plum borer is present. Their feeding greatly

enlarges the wound size after a primary mechanical bark injury has taken place. In addition, when a plum borer larva feeds in the cambium tissue it bores through the trees wound-healing zone and could be an important means of introducing *C. fimbriata* spores long after a mechanical injury occurs. Plum borer larvae prefer to attack young, injured, or weakened trees wherever callous tissue has formed (Van Steenwyk *et al.,* 1986).

In September and October we observed plum borer larvae actively feeding in the callous tissues associated with wound healing in bark injuries that occurred during August trunk shaker harvest operations. Our objective was to treat these bark injuries to control future plum borer feeding and thus reduce the likelihood of subsequent *Ceratocystis* canker development.

Materials and methods

A commercial orchard that sustained many trunk injuries during shaker harvest in August was selected for this trial. Sixty 'Nonpareil' almond trees with bark wounds were identified and treated in October. Twenty replications of three different treatments, each applied to single trees, were arranged in the orchard using a randomized complete block design. All wounds were initially treated the same. Injured bark was removed and wound edges were cleanly trimmed using a hammer and chisel to cut back to healthy, well attached bark at least 2.5 cm beyond any signs of *C. fimbriata* infection.

The three treatments implemented on these cleaned wounds in mid-October included an untreated control, diazinon combined with diluted white interior latex paint, and cupric hydroxide combined with boiled linseed oil. The interior white latex paint was diluted, 1 part paint: 3 parts water, with insecticide added at a rate of 90 g Diazinon 50W per liter of dilute paint. This mixture was spray applied using an average of 118.3 ml of solution per treated wound. The cupric hydroxide-linseed oil mixture was prepared using Kocide 101® (77% cupric hydroxide) added to boiled linseed oil at a rate of 222.7g Kocide 101® per liter of linseed oil. This mixture was brush applied using an average of 31.6 ml per treated wound.

American plum borer flight activity in the orchard was monitored during the growing season for two years following the wound treatments using Trece® Inc. Pherocon® sticky traps baited with American plum borer female sex pheromone lures. American plum borer larvae produce characteristic orange-red frass piles as they feed in the cambium. Treatment effectiveness relative to American plum borer control was gauged by counting the number of active frass piles per wound at 5 weeks and 7 months after treatment. There was no plum borer activity observed at later sampling dates. The treatment effect on subsequent *Ceratocystis* canker occurrence was measured by counting the number of distinct gumming cankers at the edges of treated tree wounds. Counts were made: in July, 9 months after treatment; in January, 15 months after treatment; and in October, 5 years after treatment.

We relied on naturally occurring pest populations to produce results in this trial. Both insect and disease pressure was not distributed uniformly over all replications. Statistical analysis of plum borer data excluded all replicates with no insect populations where the replicate mean for frass piles was equal to zero. Statistical analysis of *Ceratocystis* canker data excluded all replicates with minimal disease pressure including only those replicates where the mean was greater than 1 canker per replicate. Data were analyzed using analysis of variance and Duncan's multiple range test.

Results and discussion

Pheromone trap monitoring indicated that there was some level of plum borer activity occurring in the orchard throughout the entire growing season. This observation is supported by Flint (2002a) who suggests that plum borers have 3 to 4 generations per year with each generation taking 4 to 6 weeks for the insect to develop from egg to adult. They overwinter in sheltered locations in the tree as mature larvae in cocoons with the majority of moths emerging in April and May. Although the flight activity was greatest in April during both years monitored during this trial, the number of moths per trap per night was much higher in the second season (Fig. 1).

In November, five weeks after treatment, both chemical treatments significantly reduced the number of plum borer strikes compared to the untreated treatment (Table 1). The insecticide

combined with diluted white latex paint provided complete control. By the following May, 7 months after treatment, neither the copper nor the diazinon treatment differed significantly from the control. This is consistent with results found by Van Steenwyk *et al.* (1986) that insecticide-paint combinations provided nearly complete control initially but that control began to break down two to three months after application.

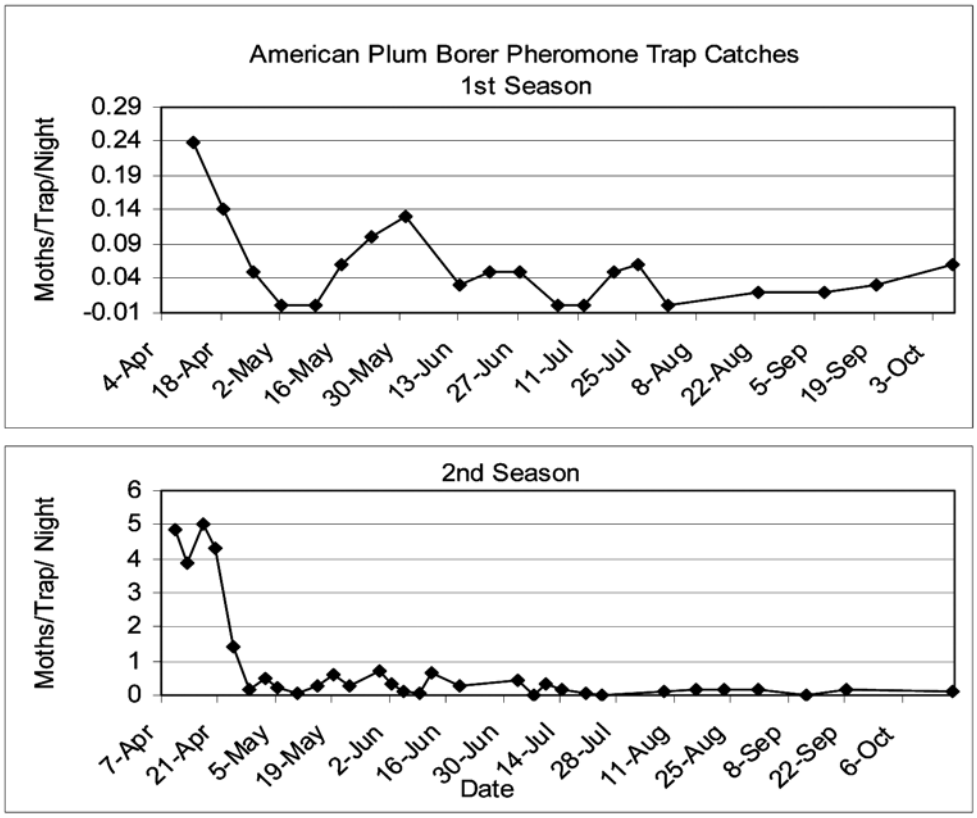

Fig. 1. American plum borer, *Euzophera semifuneralis*, male flight activity throughout the two growing seasons following the application of tree wound treatments.

Table 1. American plum borer larvae visibly feeding at the edges of treated tree wounds as evidenced by the presence of orange-red frass piles

Wound treatment[†]	Rate	Number of frass piles per wound[††]	
		November 5 weeks after treatment	May 7 months after treatment
Untreated	–	2.5 a	1.1 ab
Kocide 101/boiled linseed oil	222.7 g/l	1.3 b	2.9 a
Diazinon 50W/dilute white latex paint	90 g/l	0.0 b	0.4 b

[†]All wounds were initially treated the same. Injured bark was removed and wound edges were trimmed to well attached bark cut back 2.5 cm beyond any signs of *C. fimbriata* infection.
[††]Values followed by the same letter are not significantly different at P = 0.05.

Both the copper-oil and diazinon-paint treatments significantly reduced the number of *Ceratocystis* cankers per wound compared to the untreated treatment at 9 months after application (Table 2). At fifteen months following treatment there were no differences between the treatments. Five years after the trial began, the copper–oil treatment had significantly fewer cankers than the untreated treatment. By this time the diazinon-paint treatment did not differ from either the untreated treatment or the

copper-oil treatment (Table 2). According to Flint (2002b), some *Ceratocystis* cankers apparently become inactive and heal after two or three growing seasons. Thus, trees that are consistently damaged by harvesters year after year are the most severely affected by this canker.

Table 2. Distinct *Ceratocystis* cankers established at the edges of treated tree wounds as evidenced by the presence of amber colored gum exuding from the bark

Wound treatment[†]	Rate	Number of cankers per wound[††]		
		July 9 months after treatment	January 15 months after treatment	October 5 years after treatment
Untreated	–	2.9 a	2.3	3.4 a
Kocide 101/boiled linseed oil	222.7 g/l	1.0 b	1.3	0.4 b
Diazinon 50W/dilute white latex paint	90 g/l	1.4 b	2.2 ns	2.0 ab

[†] All wounds were initially treated the same. Injured bark was removed and wound edges were trimmed to well attached bark cut back 2.5 cm beyond any signs of *C. fimbriata* infection.
[††] Values followed by the same letter are not significantly different at P = 0.05.

Cleaning up injuries by removing damaged bark and treating these trunk wounds is costly in terms of both time and labor. By far, the best way to avoid *Ceratocystis* cankers and subsequent tree loss is to provide good training to mechanical shaker operators and to regularly maintain harvesting equipment to avoid bark injuries in the first place.

Conclusions

Trimming back crushed, torn, or loosened bark to well attached bark and treating the wound with an insecticide-paint or copper-oil does reduce the number of plum borer strikes compared to untreated wounds. The number of *Ceratocystis* cankers that subsequently occur are also reduced by these treatments and the copper-oil treatment may provide benefits for several years.

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