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Using Apple Bolts to Test Insecticide Efficacy Against Ambrosia Beetles

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Summary

Insecticide tests against ambrosia beetles entails an effective induction of beetle attack in artificially stressed plants, which is laborious and costly. Here we report a 3-year study using 30-cm-long Fuji apple bolts (3-4 cm diam.) to test the efficacy of several insecticides against ambrosia beetles in Lexington and Princeton, KY. Even though, fresh cut bolt technique is not a substitution for trees in ambrosia beetle and insecticide efficacy studies, it facilitates to a large extent the ambrosia beetle research. Pyrethroids and double mode of action insecticides and biopesticides were tested. The pyrethroid ζ-cypermethrin was the most effective for two weeks out of the three pyrethroids tested, followed by λ-cyhalothrin and β-cyfluthrin, whereas the dual mode of insecticide Leverage® (+β-cyfluthrin+ imidacloprid) was tested only in 2020 and was effective for the same period. All insecticide treated bolts were attacked at the of the experiments in 2019 and 2020.

INTRODUCTION

Invasive ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) occasionally cause severe damage to nursery, landscape and fruit trees in spring. In Kentucky, the granulate ambrosia beetle, *Xylosandrus crassiusculus,* is the dominant species that attacks landscape and nursery trees and shrubs (Viloria et al. 2019; Viloria et al. 2021).

Physiological stressed plants mediate the beetle attacks due to the emission of stress volatiles, mainly ethanol. It is very difficult to foresee any ambrosia beetle attack; therefore, preventative application of insecticides is the most appropriate management practice. Artificial induction of ambrosia beetle attacks is needed to test efficacy of insecticide in healthy plants, however the application of flood stress technique (Ranger et al., 2016,) or aqueous ethanol irrigation (Ranger et al.,2018) are arduous and expensive approaches.

The use of ethanol infused bolts (Reding and Ranger, 2020) and bolts with a drilled ethanol reservoir are feasible alternatives to screen insecticides, evaluate damage, identify beetle responsible of attacks, and study insecticide residual effect (Mayfield and Hanula, 2012; Brown et al., 2020; Reding and Ranger, 2020; Jones and Pine, 2018). Thus far, pyrethroids are the recommended insecticides to control ambrosia beetles. The main objective of this study was to assess the efficacy of three pyrethroids, a double mode of action insecticide (pyrethroid + imidacloprid), and two biopesticides against ambrosia beetles using freshly cut apple bolts baited with ethanol.

MATERIALS AND METHODS

Apple bolts

Branches (3-4 cm in diameter) from healthy apple (*Malus domestica* 'Fuji') trees were cut into 30 cm long bolts a day before setting up the experiment. A cavity was drilled at one end of each bolt to make an ethanol reservoir (0.79 cm diam and 4-5 cm deep). The hollowed end was wrapped with sealing film (Parafilm®), thereafter both ends were immersed for few seconds in melted wax to reduce water loss through the cut surface.

Experiments

In 2018 spring, May 9-May 23, a nine-bolt bundle was immersed in Baythroid® XL (ß-cyfluthrin), Mustang® Maxx (ʐ-cypermethrin), or vinegars (croton or wood vinegar). In a wooden lot, air dried bolts were hung to trees and suspended about 1m above the ground, keeping a minimum separation distance of about 3 m. After hanging the bolts, three-mL syringe was used to inject 3-4 mL 95% ethanol into the reservoir. Ethanol refill was completed weekly. After ethanol injection the hole was taped to reduce ethanol evaporation. Two control treatments were included: apple bolt with and without ethanol. In 2019, the pesticide test was carried out in Lexington, Fayette Co., Kentucky (April 29-May 20) and Princeton, Caldwell Co. Kentucky (April 23- May 13).

Apple bolts were set in wooden lots, on trees close to the edges. Chemical tested were: ß-cyfluthrin, ʐ-cypermethrin, Warrior® II with Zeon Technology (λ-cyhalothrin), hardwood vinegar at 20% and 40%, and control with no pesticide. To facilitate apple bolt deployment and sampling as well as ethanol refill, bolts were hung on a wire that was set at the edge of the woods at approximately 1m above the ground. Every 1m a wire loop was attached to the wire to hang and keep the bolts fixed. Tested insecticides were Leverage®360 (ß-cyfluthrin+ Imidacloprid), ʐ-cypermethrin and λ-cyhalothrin and 20% hardwood vinegar.

Chemical concentrations and rates are listed in Table 1. All these insecticides were compared with water plus surfactant as a control treatment.

Table 1. Trade and chemical names and rates of tested insecticides in the spring of 2018, 2019, and 2020.

Treatments	Rates	2018	2019	2020
Baythroid® XL (β-cyfluthrin)	2.8 fl oz/10 gal	X	X	
Mustang® Maxx (ζ-cypermethrin)	4.0 fl oz/10 gal	X	X	X
Leverage® 360 (β-cyfluthrin + imidacloprid)	2.4 fl oz/10 gal			X
Warrior II® Zeon® Tech. (λ-cyhalothrin)	2.56 fl oz/10 gal		X	X
Hardwood vinegar	20, 40%	X	X	X
Croton vinegar	20%	X		
Control	-	X	X	X

Evaluations of Ambrosia Beetle Attacks

Damage caused by ambrosia beetles were recorded as total number entries/bolt, percentage of superficial entries/bolt and percentage of attacked bolts. In 2018, nine bolts per treatment were removed and placed in a bucket (18.93 L), with a net as a lid. Eight weeks later, granulate ambrosia beetles, camphor shot borer and black stem borer were counted (data not presented). In 2019, five bolts/treatment were removed at 10 and 20 days after spray, whereas bolt removal was completed at day 7, 14 and 21 days after spray in 2020. In the last two years, bolts were placed individually in 2 or 4L containers to evaluate beetle emergence (data not presented).

RESULTS AND DISCUSSION

Ambrosia beetle attacks were successfully induced by keeping a permanent source of ethanol emission from apple bolts through a weekly refill of 95% ethanol. In 2018, the experiment was completed in late spring, at that moment the actively flying ambrosia beetle populations were low in western Kentucky (Viloria et al., 2021). However, the numbers of entries/bolt were below 5 in most of the treatments, except Mustang® Maxx, which totally protected apple bolts from ambrosia beetle attacks (Figure 1).

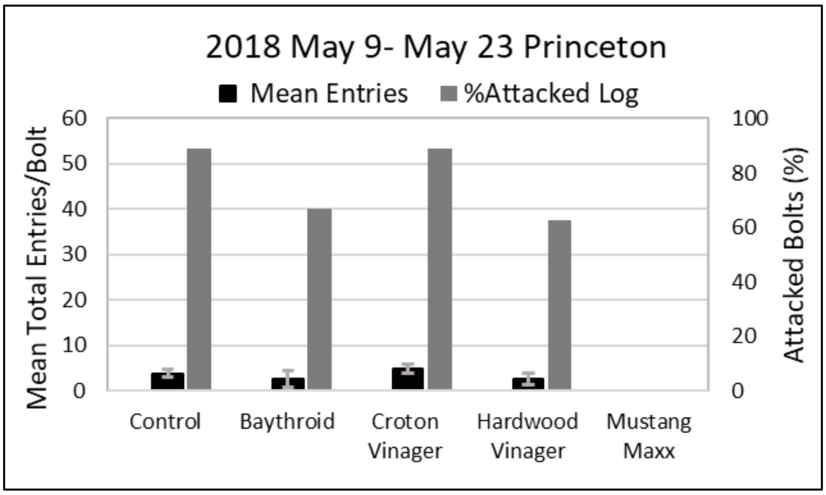

Figure 1. Efficacy of pyrethroid and botanical insecticides in preventing ambrosia beetle attacks to apple bolts in 2018 spring.

Control and croton vinegar showed the highest percentages of attacked bolts (>80%). Vinegar based biopesticides had been reported effective insecticide for a variety of pests (Omulo et al., 2017), nonetheless there is lack of evidence of their effects on borer insects. Neither croton nor hardwood vinegar reduced ambrosia beetle attacks at solution concentrations of 20 and 40%.

The efficacy test completed in two locations in 2019 (Figure 2) showed a considerably higher number of ambrosia beetle attacks for untreated bolts and vinegar treatments at 10 d, and for all treatments at 20 d in Lexington compared with Princeton.

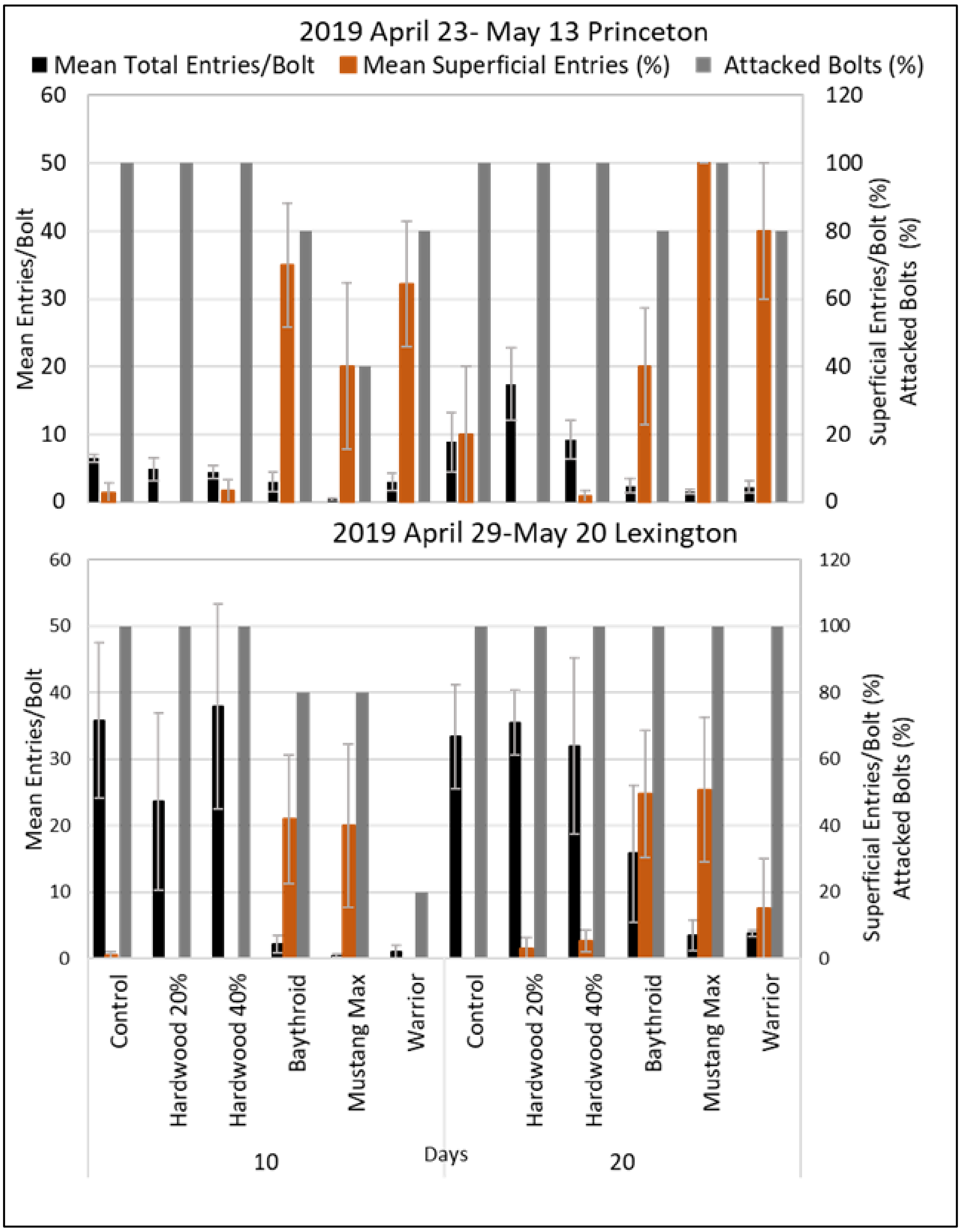

Figure 2. Efficacy of pyrethroid and botanical insecticides in preventing ambrosia beetle attacks to Fuji apple bolts in 2019 spring in Lexington and Princeton, Kentucky.

However, the trend of pesticide efficacy was similar. Pyrethroids reduced significantly the number of entries/bolt. Furthermore, a high percentage of these entries were superficial (<2mm deep). It is likely that tested pyrethroids affect somehow the beetles' capability to bore into the hardwood and stablish a colony in treated bolts. Mustang® Maxx significantly reduced the number of entry holes for 10 d in both locations. This insecticide was still effective in deterring ambrosia beetle attacks for 20 d, at this time its effect was similar to Warrior II® with Zeon Technology. Baythroid XL showed similar effect as non-treated bolts. In a previous study, permethrin, a commonly used pyrethroid against ambrosia beetles, reduced significantly the number of beetle attacks in tree bolts, but did not fully prevent damage (Brown et al., 2020).

The double mode of action insecticide, Leverage® 360, reduced the number of entries/bolt at 7 and 21 d in the 2020 spring (Figure 3); the systemic compound (imidacloprid) of this insecticide might has been curtailed since translocation was interrupted in cut bolts. Imidacloprid reduced of *Euwallacea* sp survival when it was soil drenched (Jones and Paine, 2018). At day 14, Warrior®II showed the lowest % attacked bolts, with similar entry numbers and % superficial entries to those recorded in Mustang®Maxx. At day 21, all apple bolts showed signs of ambrosia attacks, non-treated bolts showed the highest number of entries. Hardwood vinegar had inconsistent results comparing 2019 vs 2020, the number of entries/bolt were similar to untreated bolts in 2019 for the two sites, however in 2020 the number of entries were significant lower in 20% wood vinegar compared to control.

The high incidence of superficial entries suggests a potential use of these insecticides for landscape plants or fruit trees, since the ambrosia fungi are not established, only physical damage remains that may heal to become an undetectable scar. In the nursery crop case, minor damage caused by ambrosia beetles makes trees unmarketable, therefore it is necessary to avoid any attack.

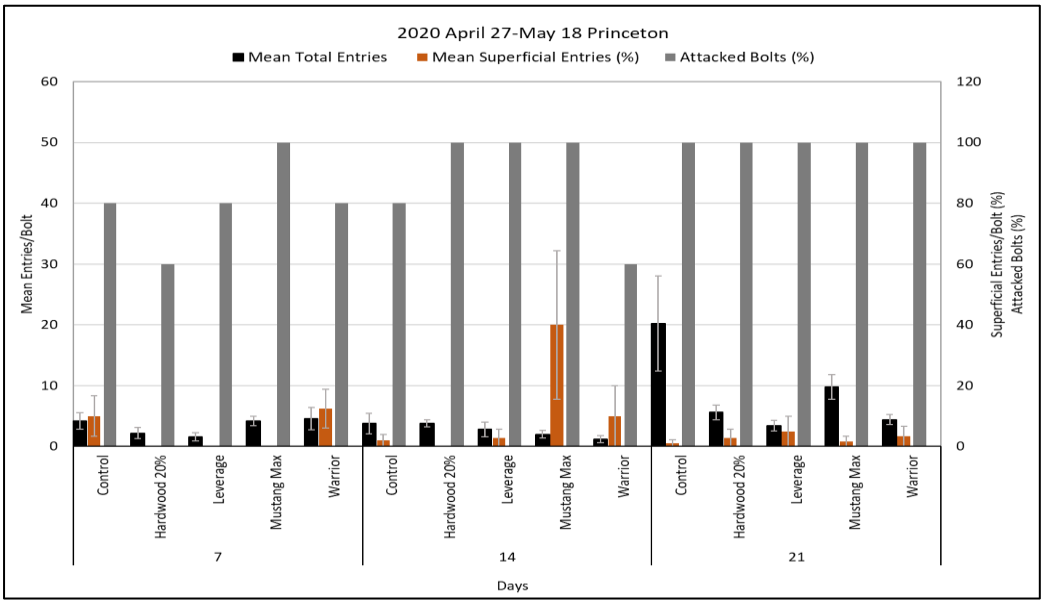

Figure 3. Ambrosia beetle attacks to Fuji apple bolts after a single application of pyrethroids, double mode of action pesticide and hardwood vinegar application in a three-week period of 2020 spring.

CONCLUSIONS

A single application of either ζ-cypermethrin (Mustang®Maxx) or λ-cyhalothrin (Warrior®II) consistently reduced the number of entries for three weeks in low or high ambrosia beetle populations, but the percentages of attacked bolts remained high (80-100%). Whereas β-cyfluthrin (Baythroid®XL) did not show uniform results in Princeton and Lexington in 2019 and Leverage®360 tested only in 2020 was as effective as ζ-cypermethrin and λ-cyhalothrin. Wood and croton vinegars did not deter ambrosia beetle attacks.

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