Wintergreen Oil Improves the Effectiveness of the Odor-Baited Trap Tree Approach for Plum Curculio Monitoring and Attract-and-Kill

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Field studies conducted by UMass researchers and collaborators for the last 20 years revealed that benzaldehyde (BEN) in combination with grandisoic acid (GA) acted in synergy. This discovery led to the development of a monitoring strategy termed the odor-baited trap tree approach. By baiting the perimeter row trees with the synergistic lure and monitoring those trap trees, improved IPM decisions for the entire orchard can be made. While the effectiveness of the trap-tree approach has been validated multiple times throughout New England, the high cost of the lure (>$20 per trap tree) and degradation of commercial BEN lures by UV light and heat have contributed to limited grower adoption. Thus, the identification of an alternative plant volatile to replace the BEN lure is needed.

During the spring and summer of 2020 and 2021 we conducted field-scale research aimed at testing the attractiveness of wintergreen oil to adult PCs in terms of both trap captures using black pyramid traps and fruit injury levels using odor-baited trap trees. The active ingredient of wintergreen oil is methyl salicylate (MES), a volatile compound that is emitted by many plant species. MES is cheaper than BEN, and more stable, chemically speaking. Therefore, we were very interested in determining whether MES could replace BEN. The 2020 and 2021 studies yielded positive results. Here, we are presenting the research results of 2022 filed evaluations of MES, either alone or in combination with GA to PC, when compared against that of the binary combination of BEN + GA. We also sought to determine whether the level of injury received by odor-baited trap trees extend to neighboring trees potentially resulting in spill-over effects.

Materials and Methods

The field experiment was conducted at five different orchards in Massachusetts (University of Massachusetts Cold Spring Orchard (Belchertown, MA), Breezeland Orchard (Warren, MA), Red Apple Farm (Phillipston, MA), Clarkdale Fruit Farm (Deerfield, MA), Sholan Farms (Leominster, MA) and one in New Hampshire (Poverty Lane Orchards, Lebanon, NH).

This study involved lures deployed within the canopies of perimeter-row trees. The treatments were: (1) 1 methyl salicylate (MES dispenser, (2) 1 MES dispenser + 1 GA dispenser, (3) 4 BEN dispensers + 1 GA dispenser, and (4) unbaited. The treatment involving 4 BEN dispensers + 1 GA dispenser is the standard lure concentration based on previous studies. Each treatment was replicated 27 times throughout the six participant orchards. The number of replications differed among the orchards based on the availability of blocks large enough to contain the treatments. Perimeter-row trap trees were baited with the above-mentioned lure combinations during early bloom (6-10 May). Each treatment

dispenser was placed inside an inverted red plastic cup to provide additional protection from rainfall and degradation by UV light and suspended evenly from branches at head height within the tree canopy. MES, BEN, and GA dispensers were replaced once every four weeks.

Fruit injury assessments were conducted to evaluate the attractiveness of the treatments to PCs. The assessments were conducted once between 28 May and 8 June, 2022. The total number of fruits with PC oviposition scars based on a random sample of 30 fruits per treatment trap tree was recorded. In all, 3,240 fruits were inspected for PC injury. To quantify any potential spillover effect to the trees immediately adjacent to the treatment trap trees, a sample of 30 fruits per tree was inspected for PC oviposition scars from two adjacent trees (right and left) to the odor-baited trap trees and the control unbaited trap trees. In addition, 30 fruits from two trees behind the odor-baited trap (i.e., located in rows 2 and 3) trees were inspected, as well as unbaited trap trees (Figure 1).

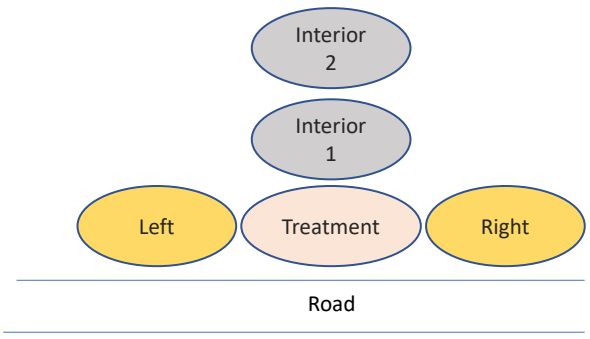

Figure 1. Diagram showing the fruit-sampling scheme in 2022. Treatment trees represent odor-baited trees or unbaited (control) trees. Adjacent left and right unbaited are referred to as neighboring trees (results present the average of both trees). Interior trees: two unbaited trees located behind the treatment tree (i.e., located in rows 2 and 3).

Results

Attractiveness of methyl salicylate to PC. Across all orchards, the average level of PC injured fruit on baited trap trees was greatest for 1 MES dispenser + 1 GA dispenser and with 4 BEN dispensers + 1 GA dispenser, both showing identical levels of PC injury (17.7%). Both types of odor-baited trees received significantly more injury than unbaited trap trees (5%) (Figure 2). MES tested singly (= 1 MES dispenser) showed an intermediate PC injury-aggregation effect with an average level of fruit injury of 9.7% (Figure 2).

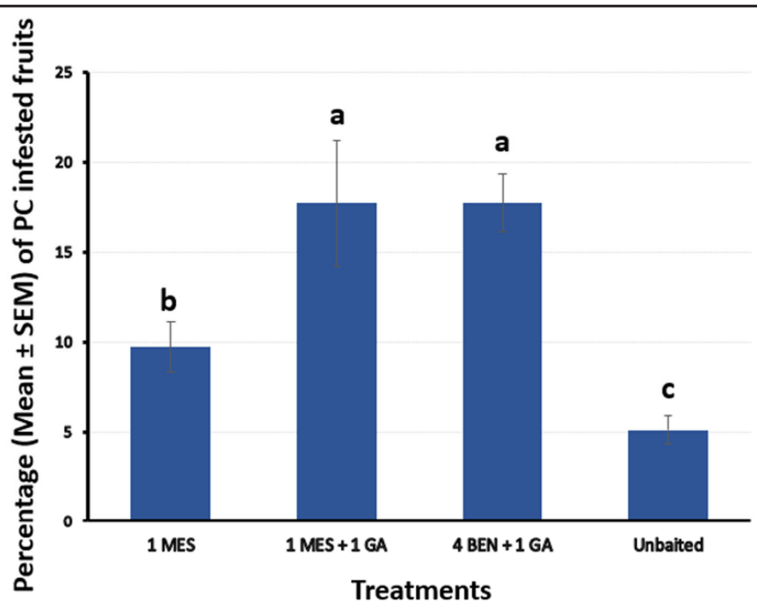

Figure 2. Percentage (mean ± SEM) of plum curculio-infested fruits on trap trees baited with three olfactory treatments versus unbaited trees. MES= Methyl salicylate; GA= grandisoic acid (PC pheromone), BEN= Benzaldehyde. Bars superscribed by the same letter are not significantly different at odds 1:19.

Assessment of spillover effect onto adjacent trees. Overall, results showed no spillover effects. The average level of fruit being injured by PC on trap trees baited with 1 MES dispenser alone (9.8%) was significantly greater than that recorded on the neighboring trees (left and right trees combined) (5.5%), the first interior trees (4.3%), and the second interior trees (2.9%) ($P < 0.05$) (Figure 3A). There were non-significant differences in the level of PC injured fruits among neighbor trees, the first interior trees, and the second interior trees (Figure 3A).

The average level of fruit being injured by PC on trap trees baited with 1 MES dispenser + 1GA dispenser (17.7%) was significantly greater than that recorded on the neighboring trees (6.9%), the first interior trees (5%), and the second interior trees (3%) (Figure 3B). The average level of PC injured fruit

on trap trees baited with 4 BEN dispensers + 1 GA dispenser (17.7%) was significantly greater than that recorded on the neighboring trees (8%), the first interior trees (5%), and the second interior trees (3%) (Figure 3C). Moreover, the average level of PC injured fruit on neighboring trees was not significantly greater than that recorded on the first interior trees but was significantly greater than those recorded on the second interior trees (Figure 3C). It was also observed that there were non-significant differences in the average levels of PC injury to fruit between the first interior trees and the second interior trees (Figure 3C).

The average level of PC injured fruits on unbaited trap trees (5.1%) was not significantly different from that recorded on the neighboring trees (4.7%), and the first interior trees (3.7%) but was significantly greater than the level observed on the second interior trees (1.6%) (Figure 3D).

In terms of costs of lures, the 1 MES dispenser + 1 GA dispenser combination is less expensive than the standard lure consisting of 4 BEN dispensers + 1 GA lure per trap tree. The cost of 1 MES dispenser is ca. $3, and 1 GA dispenser is ca. $8. Therefore, the total cost for 1 MES dispenser + 1 GA dispenser would be half of the cost of 4 BEN dispensers + 1 GA dispenser which is greater than $20. In addition to its relatively high cost, BEN lure is unstable, and it converts to benzoic acid under high UV light and heat (Leskey et al. 2005). In contrast, MES lure was found to continue to emit odor two months after initial deployment. The PC season typically lasts 6 weeks, therefore a single MES dispenser is expected to last the entire period of PC activity.

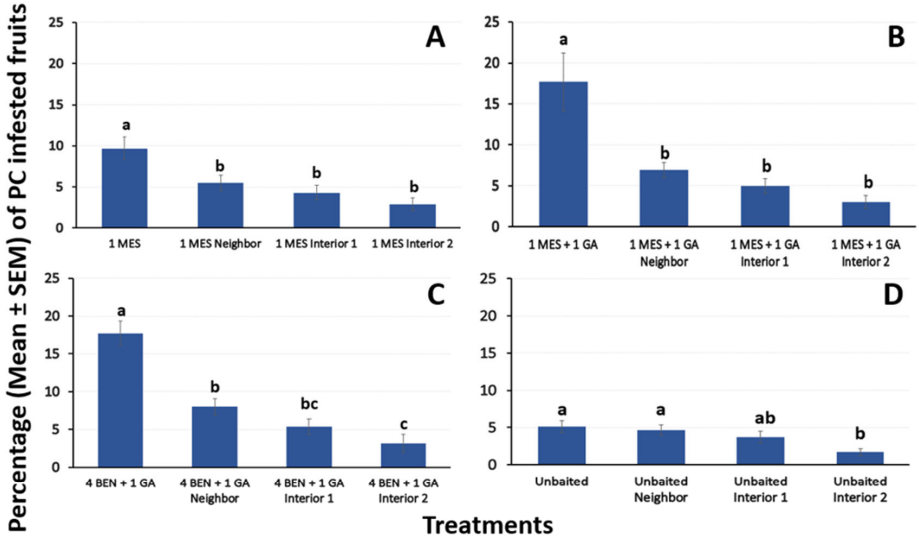

Figure 3. Mean percent (± SEM) injury by PC to fruit sampled from treatment trees, neighboring trees, and interior-row trees: (A) trap tree baited with 1 MES, (B) trap tree baited with 1 MES + 1 GA, (C) trap tree baited with 4 BEN+ 1 GA, and (D) unbaited trap tree. For a description of the fruit-sampling scheme, see figure 1. For each chart, bars superscribed by the same letter are not significantly different at odds 1:19.

Conclusions

Our collective findings showed that 1 MES + 1 GA is as attractive to PCs as the standard synergistic lure composed of 4 BEN + GA. These findings could increase the likelihood of adoption of the trap-tree approach for monitoring and also for reduced insecticide sprays against PC in New England apple orchards.

Acknowledgments

We thank Ajay Giri, Heriberto Godoy-Hernandez, Jaelyn Kassoy, Zoe Robinson, and Dorna Saadat for assistance. We thank growers from Massachusetts (Tom and Ben Clark, Keith Arsenault, Al Rose, Joanne DiNardo, Shawn Mcintire, Mark Tuttle, and Elizabeth Vaughan) and New Hampshire (Steve Wood) for allowing us to work at their orchards. he USDA National Institute of Food and Agriculture, Crop and Pest Management program, funded this work through project 2019-70006-30445. Additional funding stemmed from the New England Tree Fruit Growers Committee.

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