Devising an Attractive Bait to Monitor the Seasonal Course of Plum Curculio Immigration into Apple Orchards using Traps

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To reduce insecticide use against plum curculio (PC), management strategies should consider the time of first appearance of PCs on host trees after overwintering in woods, as well as the peak and the end of immigration. One approach to tracking the seasonal course of PC immigration is the use of a trap baited with a lure that is highly attractive to PCs. In the 2000 issue of *Fruit Notes*, we reported that both panel and pyramid traps baited with benzaldehyde (BEN) in combination with PC pheromone called grandisoic acid (GA) were very good indicators of the seasonal course of immigration into apple orchards when deployed in close proximity to woods. In that study, we also found that ethyl isovalerate (EIV) and limonene (LIM), in combination with GA, showed some degree of attractiveness to PCs, but to a lesser extent when compared to the high luring power of BEN+GA.

Here, we report on two field studies performed in Massachusetts in 2001 and 2002 using panel and pyramid traps. The 2001 study was aimed at evaluating the three most attractive fruit odors (BEN, EIV, and LIM) found in our 2000 study to confirm the high attractiveness of the combination BEN+GA to PCs. The 2002 study was performed to evaluate PC response to four different amounts of BEN (the most attractive fruit odor found in the 2001 study) and two different amounts of GA to determine the amount of each odor needed to maximize the performance of monitoring traps.

Materials & Methods

Both studies were conducted in an unsprayed section of a commercial apple orchard at the UMASS Cold Spring Orchard Research & Education Center (Belchertown, MA). As in 2000, traps evaluated in 2001 and 2002 were clear Plexiglas panels (2 x 2 feet, with the woods-facing side coated with Tangletrap) and black pyramid traps (24 inches wide at base x 48 inches tall) (Figure 1). Whereas panel traps capture mainly PCs in flight (particularly on warm days), pyramid traps capture primarily crawling PCs (mostly during cool days or at night).

2001 Study. This study was undertaken from April 30 to June 30, 2001. Host plant odors evaluated were benzaldehyde (BEN), ethyl isovalerate (EIV), and limonene (LIM), all purchased from Sigma-Aldrich Chemical Co. (Milwaukee, WI). Three different groups of odor treatments were arranged, each involving a single host volatile alone, GA alone, a combination of host volatile and GA, and a no-odor (control) treatment. By testing each fruit odor alone and in combination with GA, we sought to determine the extent to which each of the synthetic host plant volatiles tested enhanced PC responsiveness to GA. There were four replicates for each trap type and odor combination.

BEN was released from 1-ml low-density white polyethylene vials in order to prevent polymerization of this chemical by UV light (as found in 2000 when using high-density clear polyethylene vials). Because this problem was not found for EIV and LIM, these two chemicals were tested (as in 2000) using 400¼l high-density clear polyethylene vials. A white vial filled with 1 ml of BEN released ~2.5 mg/day of BEN. Only one vial of this type was used per trap. Two vials containing LIM and three vials containing EIV were needed per trap to accomplish a release rate of ~10 mg/day of each chemical. Each pheromone dispenser released ~1 mg/day of GA.

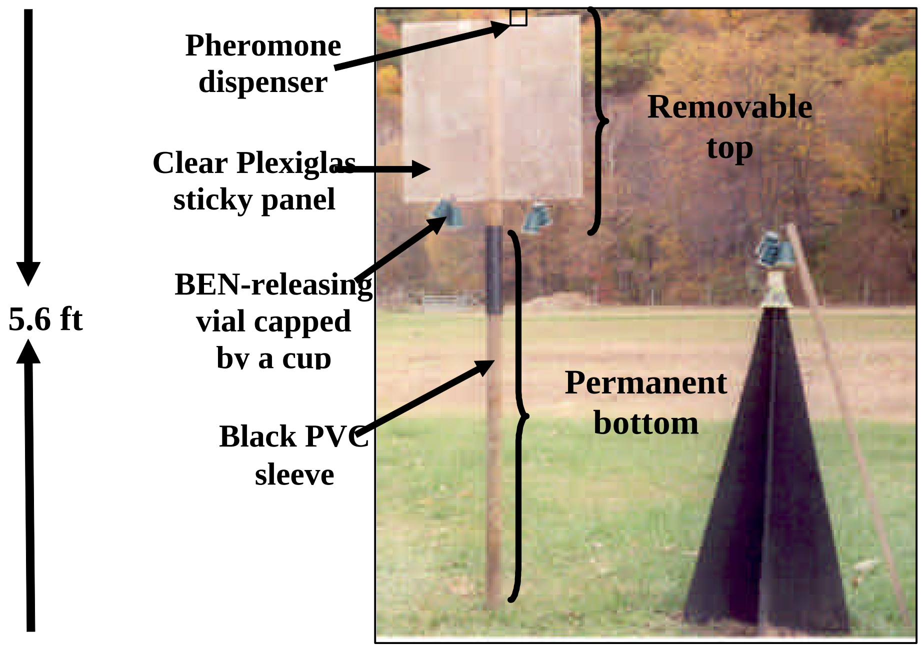

Figure 1. View of a panel and a pyramid trap used in the 2001 and 2002 studies to evaluate synthetic odors for attractiveness to PCs. Traps were deployed in pairs in close proximity (~1m) to woods to intercept immigrating PCs.

Vials containing fruit volatiles were attached to the lower edge of a panel using binder clips, whereas one GA dispenser was attached to the upper edge of a panel. For pyramid traps, both fruit volatile- and GA-releasing dispensers were placed inside a boll weevil trap top. Vials containing BEN were replaced every 2 weeks to maintain a consistent release rate. Vials containing EIV and LIM, along with GA dispensers, were replaced twice (3 and 6 weeks after trap deployment).

2002 Study. In 2002, we evaluated four different amounts of BEN (0, 2.5, 10, and 40 mg/day), hereafter referred to as no-BEN, low, medium, and high release rates, respectively, and two amounts of GA (1 and 2 mg/day), hereafter referred to as low and high release rates, respectively. The low release rate of BEN (~2.5 mg/day) was achieved by filling 1-ml low-density white polyethylene vials with 1 ml of BEN (1 vial/trap), as in 2001. The medium release rate (~10 mg/day) was achieved by using one 15-ml low-density white polyethylene vial filled with 15 ml of BEN (1 vial/trap). The high release rate (~40 mg/day) was achieved by using four such 15-ml vials per trap. Since each pheromone dispenser released ~1 mg of GA per day, the high release rate of GA (2 mg/day) was achieved by using two GA dispensers per trap. In total, eight treatments were evaluated. Each was replicated six times for each trap type.

In 2002, besides using white vials to protect BEN from UV light, we employed green 266-ml plastic cups to provide additional protection against UV light and rainfall. Each vial containing BEN was hung by its neck from a wire and positioned inside a plastic cup. For use with pyramid traps, cups were hung in inverted position from the end of a wooden pole (buried in the ground at a 45° angle) in such a way that bases of cups were ~ 4 inches above pyramid trap tops (see Figure 1). Depending on the treatment, either one or four cups were attached to each pole. Cups holding BEN-dispensing vials were attached to the bottom edge of panels using wire and steel binder clips. GA dispensers were attached to the upper edge of panels using binder clips, or were placed inside the inverted screen funnel capping pyramid traps. All vials releasing BEN and all GA dispensers were replaced once (four weeks after initial trap deployment).

Trap deployment. In both years, panel and pyramid traps were deployed in pairs (1 yard apart) along the periphery of the apple orchard, in close proximity (~1 yard) to woods. This approach allowed traps to intercept PC adults presumably immigrating into the orchard after overwintering in the woods. Each pair of traps was baited with the same odor combination and spaced 10 yards from other trap pairs on either side. Traps were inspected for PC captures on a daily basis, although for the purposes of this article, results for each year show PC captures by panel or pyramid traps across the entire period of immigration. In both years, traps were baited during the tight cluster stage of apple tree phenology (on April 29 in 2001 and on April 16 in 2002).

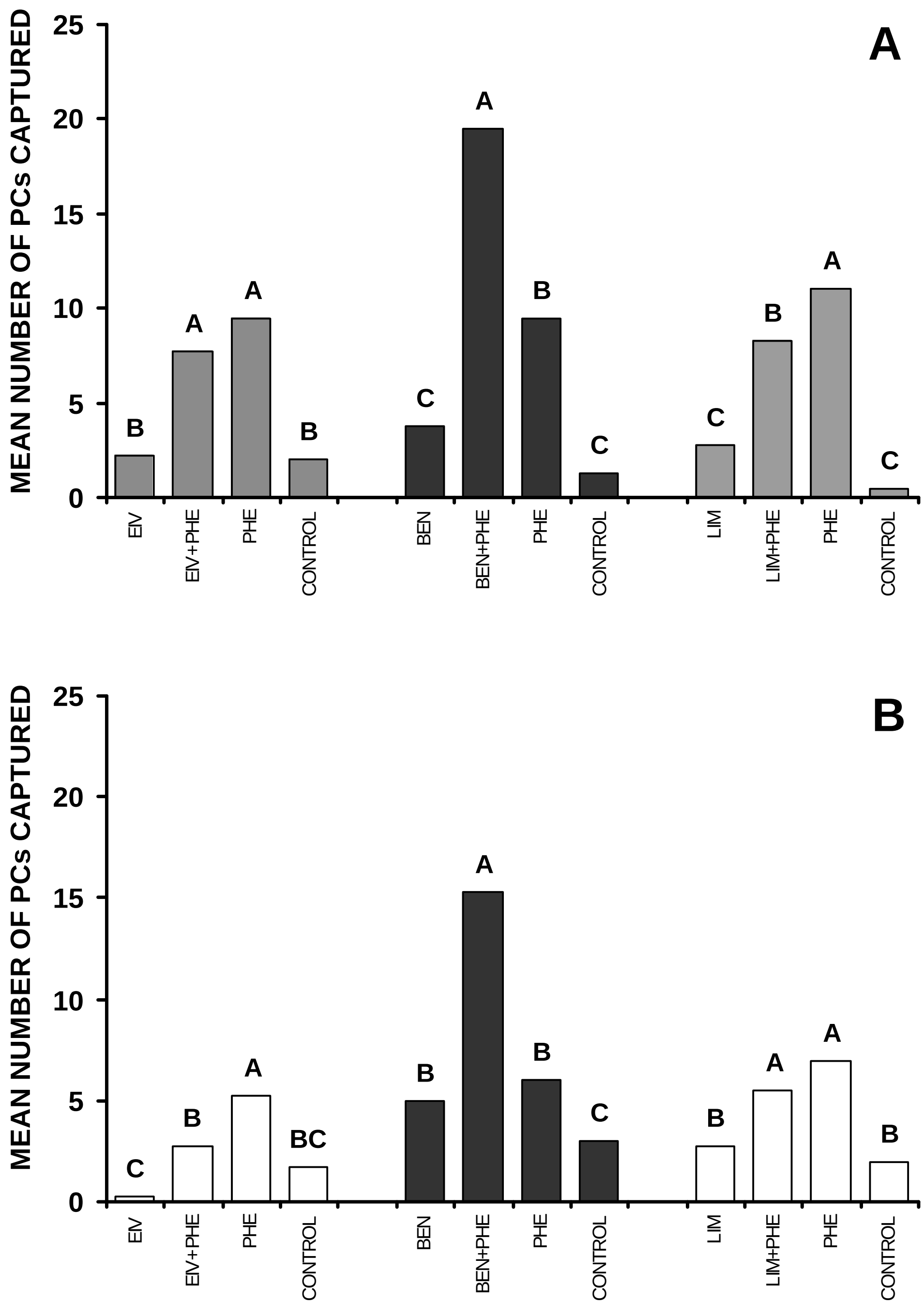

Figure 2. PC captures by A) panel traps and B) pyramid traps in the 2001 study. For each graph, bars in each group not superscribed by the same letter are significantly different at odds of 19:1.

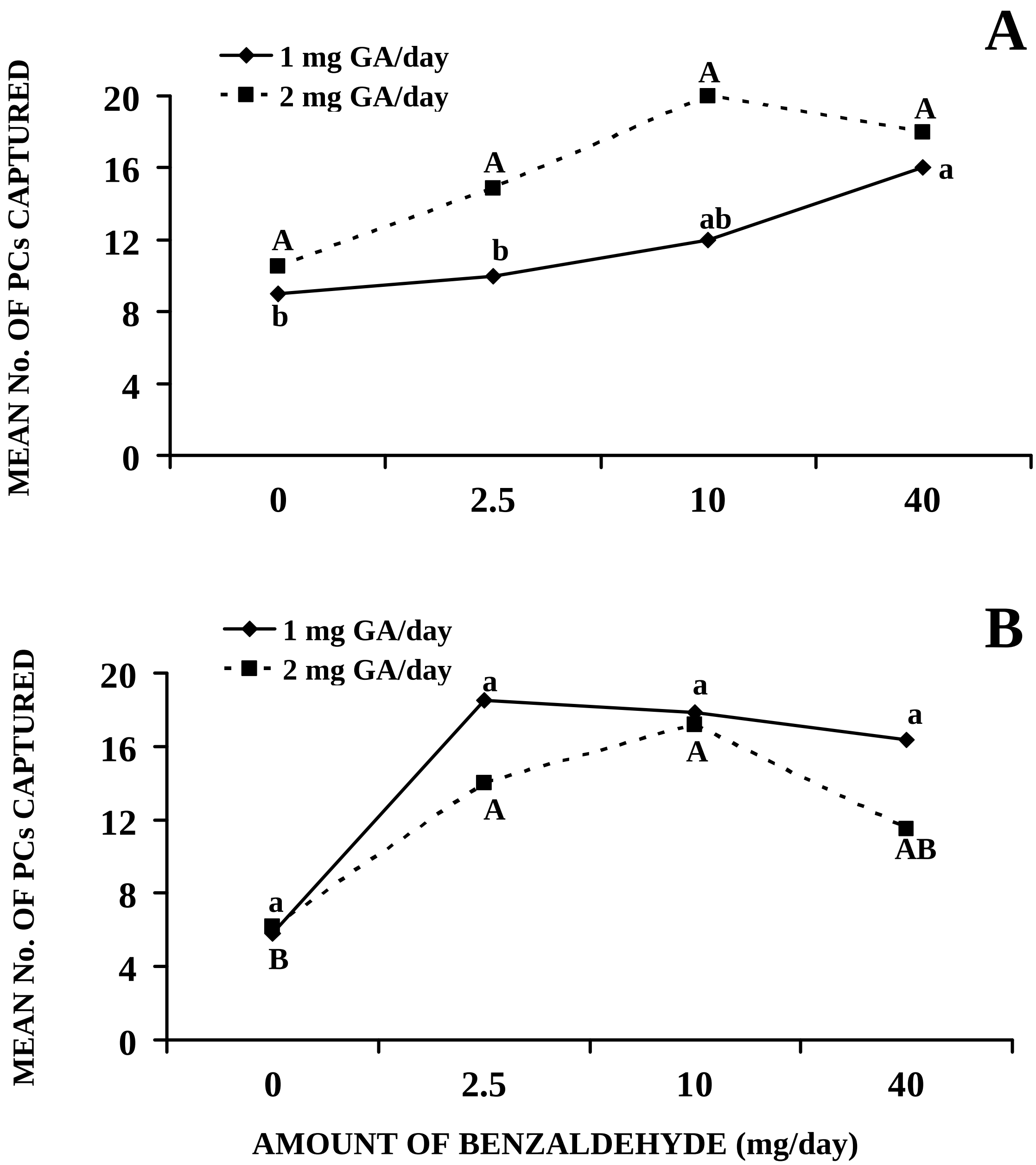

Figure 3. PC captures by A) panel traps and B) pyramid traps in the 2002 study as a function of amounts of BEN (benzaldehyde) and GA (grandisoic acid) used. For each graph, points in each line not superscribed by the same letter are significantly different at odds of 19:1.

Results

2001 Study. Overall, 538 PCs were captured by traps (312 PCs by panels and 226 PCs by pyramids) over the period of 62 days that encompassed the PC season in 2001 (April 30–June 30).

In 2001, BEN was the only host volatile that for both trap types significantly enhanced the response of PCs to GA. To illustrate, panel traps baited with BEN+GA captured 15 times more PCs than unbaited traps of the same type, and captured twice as many PCs as traps baited with GA alone (Figure 2A). Panel traps baited with GA alone captured more PCs than panel traps baited with BEN alone or unbaited traps. Pyramid traps baited with BEN+GA captured 5 times more PCs than unbaited pyramid traps and 2.5 times more PCs than pyramid traps baited with GA alone. Pyramid traps baited with BEN alone or GA alone captured more PCs than unbaited pyramid traps (Figure 2B).

For both trap types, the presence of EIV or LIM did not enhance the attractiveness of GA to PCs (Figure 2A and B). Also, for both trap types, consistently more PCs were captured by traps baited with GA alone than by traps baited with EIV alone, LIM alone, or unbaited traps. In no case did EIV or LIM alone significantly enhance adult response above that to control traps.

2002 Study. In all, 1,305 PCs were captured by traps (662 PCs by panels and 643 PCs by pyramids) over the period of 82 days that comprised the PC season in 2002 (April 17 – July 8).

Figure 3A shows PC captures by panel traps according to amounts of BEN and GA evaluated. Overall, panel traps baited with the high release rate of GA captured about 35% more PCs than panel traps baited with the low release rate of GA. When we examined PC captures by panel traps baited with the low release rate of GA, we found a significant positive linear relationship between the amount of BEN and the extent of captures. As depicted in Figure 3A, increases in the amount of BEN released corresponded to increases in captures by panel traps, with the maximum number of PCs captured corresponding to the high release rate of BEN (40 mg/day). For panel traps baited with the high release rate of GA, we found that the most attractive release rate of BEN was again 40 mg/day, although differences among BEN treatments were only numerical.

Figure 3B presents PC captures by pyramid traps according to amounts of BEN and GA used. Pyramid traps captured similar numbers of PCs regardless of the amount of GA used. For pyramid traps baited with the low release rate of GA, we found that the mere addition of BEN, regardless of the dose, enhanced PC captures relative to traps baited with GA alone (Figure 3B). For pyramid traps baited with the high release rate of GA, we found an increase in captures as the amount of BEN released increased but only up to a maximum of 10 mg/day. Beyond that amount, BEN did not enhance, but rather decreased the attractiveness of GA.

Conclusions

Our results from the 2001 study indicate that, among all odor combinations evaluated, BEN in association with GA was the most attractive bait for PCs. Results from the 2002 study, as well as an assessment of cost of both BEN (as formulated by us) and GA (obtained from Great Lakes IPM), indicate that a high release rate of BEN (40 mg/day/trap) in association with a low release rate of GA (1 mg/day/trap) seems to be the most cost-effective bait combination to be used for panel as well as pyramid traps. With our approach, BEN provided sustained attractiveness to PCs across the entire period of immigration (82 days in 2002). Placement of BEN-releasing vials outside of trap tops (for pyramid traps) appeared to preclude the kind of close-range repellency found in previous studies in which BEN-releasing vials had been positioned inside the tops of pyramid, Circle, or cylinder traps.

We conclude that BEN (at 40 mg/day of release) in association with GA (at 1 mg/day of release) constitutes a powerful lure that may greatly improve the effectiveness of monitoring traps for PC.

Acknowledgments

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