Using Odor-baited Trap Trees as Indicators of Need and Timing of Insecticide Spray Against Plum Curculio in the Northeast: Validation Studies 2004-2005

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For many decades, apple growers in the Northeast faced the problem of accurately monitoring plum curculio (PC) activity in orchard trees as a way of determining need and timing of insecticide applications until the late Ron Prokopy conceived and evaluated in the field the odor-baited 'trap tree' approach. Intensive research conducted during 2002-2003 (see main results in the 2002-2004 Winter Issues of *Fruit Notes*) clearly demonstrated that baiting branches of a single perimeter-row apple tree with the synthetic host plant odor benzaldehyde (= BEN) plus the synthetic PC pheromone grandisoic acid (= GA) led to significant aggregation (14-15 fold on average) of ovipositional injury by PC in perimeter-row trap trees compared to unbaited trees. This behavioral observation resulted, for the first time in Massachusetts apple orchards, in accurate and simple monitoring of the seasonal course of injury to fruit by PC. In addition, because trap trees are also sprayed with insecticide, they serve as excellent indicators of the extent to which insecticide residue remains effective against PC.

Further investigations indicated that the decision whether or not to spray insecticide to peripheral-row trees only after the whole-block petal-fall spray could be based on a pre-set threshold of 1 fresh egglaying scar out of 25 fruit sampled on a trap tree. Using this threshold, not only were economically-acceptable low levels (0.77% on average) of orchard-wide injury to fruit by PC recorded at harvest in the 9 commercial orchard blocks evaluated in Massachusetts in 2003, but also important reductions in insecticide use were achieved when compared with the conventional approach involving three whole-block sprays. Combined findings from these and other studies conducted during 2004 clearly demonstrated that the establishment of odor-baited trap trees on perimeter rows of apple orchards to determine need and timing of post-petal-fall insecticide applications against PC is an efficient, inexpensive and practical method of preventing economic injury to apple fruit. However, the potential for using this monitoring approach in other NE states under a variety of conditions (e.g., weather, type of orchard management) remained to be tested.

Here, we report results of a 2004-2005 study aimed at validating the effectiveness of a trap- tree approach to determine need and timing of insecticide use against PC in comparison with existing approaches based on calendar-driven sprays and heat-unit-accumulation models. This work was conducted as part of a multi-state project funded to the late Ron Prokopy with the main objective of validating and demonstrating the efficacy and the economic viability of bio-based methods for managing PC and apple maggot fly (results to be published soon in *Fruit Notes*) in apple orchards throughout New England and New York.

Materials & Methods

Study sites. In 2004, evaluations took place in 24 orchard blocks located in 7 states: 14 in MA, 2 each in NH, VT, NY, and RI, and 1 each in CT and ME. In 2005, 20 blocks (11 in MA, 2 each in NH, VT, NY, and RI, and 1 each in CT and ME) were used for this study.

Description of experimental blocks. Each orchard block was about 3 acres in size, with at least 300 yards of perimeter-row and 9 rows of trees. The perimeter row of each block bordered open field, hedgerow, or woods. Each block was divided into three similar-sized plots, which were adjacent to each other in nearly all sites. All three plots within a block had trees of similar size and similar border habitat adjacent to the perimeter row. Cultivar type may have varied among rows within a plot, but the cultivar arrangement was the same for all three plots within the block. Table 1 shows that the cultivars most commonly present in the test blocks were McIntosh (> 52%), followed by Empire and Cortland.

Pruning style was also similar for all plots within a block. The type of insecticide sprayed against PC was also the same (either Guthion or Imidan in most cases, or Avaunt in a few instances) for each of the 3 plots within a block. Even though the materials used may have had a slightly different toxicity profile and residual activity against PC, we accommodated our test design to existing grower practices. Application rates were in general as recommended by the NEAPMG or the Cornell guidelines. In those blocks that received thinning sprays before the initiation of the study or fungicide during the PC season, all plots within a block received the same spray.

Treatments evaluated. Each plot within a block was assigned a particular treatment (i.e., PC management strategy) (Figure 1). Each treatment was randomized in location within a block.

1. ***Treatment A (grower control).*** In this treatment, PC was managed through the conventional approach currently used in Massachusetts, comprising three calendar-driven sprays of organophosphate insecticide applied to all trees within the plot. The first spray was applied within a few days after petal fall. Two additional whole-

Table 1. Apple cultivars present in the orchard blocks evaluated in 2004 and 2005 combining all orchard blocks in the 7 northeast participating states.

Cultivar	Fruit sampled in 2004[1]	2004 (%)	Fruit sampled in 2005[1]	2005 (%)
McIntosh	32,900	56.9	25,470	52.8
Empire	5,900	10.2	5,300	11.0
Cortland	4,300	7.4	5,630	11.7
Gala	3,600	6.2	900	1.9
Rome	1,800	3.1	1,800	3.7
Braeburn	1,500	2.6	0	0.0
Red Del	1,300	2.2	1,440	3.0
Macoun	1,200	2.1	1,950	4.0
Other[2]	5,400	9.3	5,710	11.9
TOTAL	57,900	100.0	48,200	100.0

[1] Harvest sample only. The same amount of fruit was also sampled 7 weeks after petal fall.
[2] For example, Honeycrisp, IdaRed, Golden Del, Red Mac, Jonagold.

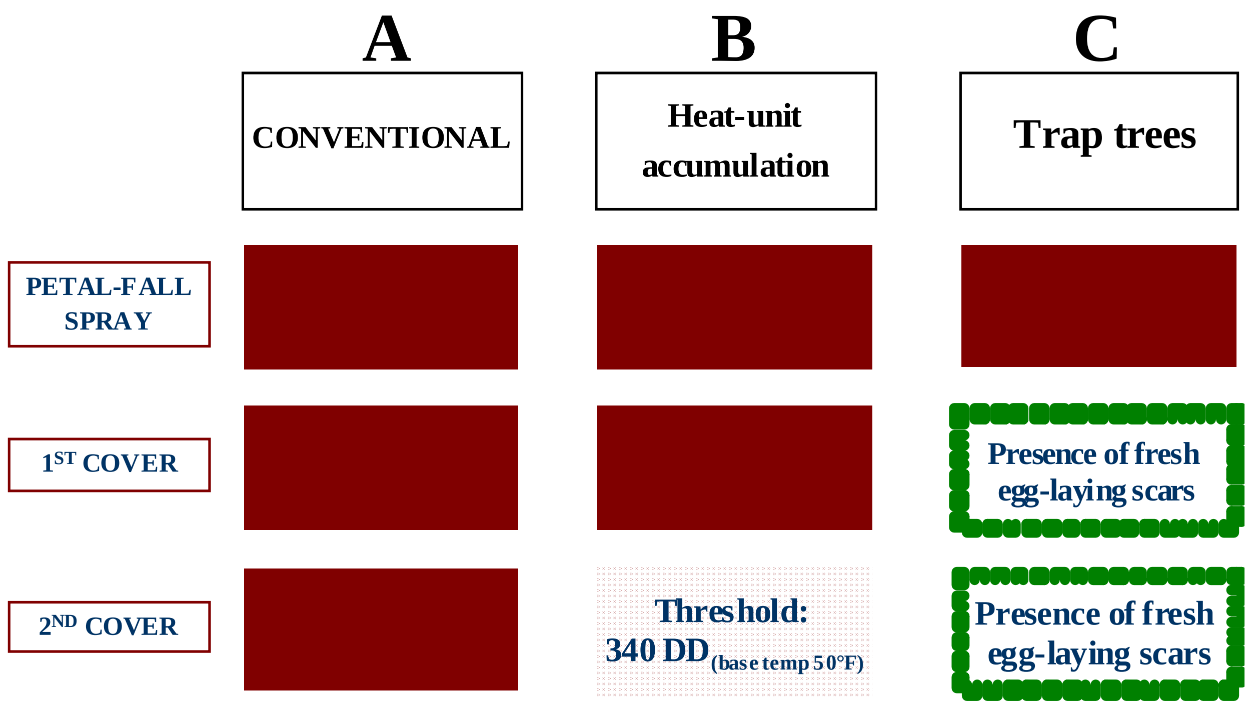

Figure 1. Schematic representation of the treatments associated with 3 different PC management strategies evaluated in the northeast in 2004 and 2005. Each of the three treatments received a whole-plot insecticide spray by the time of petal fall. Treatment A (conventional approach) received two more calendar-based whole-plot insecticide sprays (= first and second covers). Treatment B (current IPM approach) received a first whole-plot cover spray, and the second cover was sprayed only if the date of accumulation of 340 DD occurred more than 10-14 days after the first cover spray. In Treatment C, post-petal fall sprays (if needed) were restricted to peripheral-row trees depending on the occurrence of fresh PC egg-laying scars on fruit sampled on a trap tree.

plot sprays were applied 10-14 and 20-28 days after petal fall. The length of these intervals depended primarily on the amount of rainfall.

2. ***Treatment B (heat-unit accumulation).*** This treatment represented the current IPM approach, as suggested by Cornell University for managing PC in NY: the first, second and third (if needed) whole-plot sprays against PC were the same as for treatment A, except that the need and timing of the last (third) spray was determined on the basis of the heat accumulation model developed by H. Reissig & J. Nyrop in Geneva. This approach indicates that the last spray against PC should have sufficient residual activity for effective PC control until 340 degree days (base 50°F) have accumulated since petal fall. Thus, the third full-plot spray against PC took place ONLY if rainfall and cool temperatures suggested that the second application would lose efficacy before 340 DD base 50 had accumulated since petal fall. To gather day-degree information, Skybit, Orchard Radar (or equivalent) or Hi-Low thermometers were used.

3. ***Treatment C (new bio-based trap-tree approach).*** As in treatments A and B, a first whole-plot insecticide spray was applied by petal fall, to kill any PC that had overwintered within the plot or immigrated in previously from overwintering sites. Succeeding sprays (if needed) were applied only to peripheral-row trees, and were dependent on the appearance of fresh PC egglaying scars on fruit sampled (see details below) from a single odor-baited trap tree tree deployed at the center of the perimeter row of this plot. If this threshold was reached, the grower was advised to spray, within 24 hours, all perimeter-row trees including the trap tree. Efforts were made to restrict the perimeter-row sprays to both sides of row 1 trees and perimeter-facing side of row 2 trees in those

treatment C plots where rows ran parallel to the border habitat. For plots where rows ran perpendicular to border habitat, applications targeted the perimeter-facing side of trees.

a. *Baiting the trap trees.* During full bloom, each perimeter-row trap tree was baited with 1 dispenser releasing GA at a rate of 1 mg per day plus 4 dispensers releasing BEN at a rate of about 40 mg per day. BEN-releasing vials were placed inside inverted colored plastic cups to protect against degradation by UV light, and were evenly distributed among branches near the tree center and hung from chest to head height. GA dispensers were deployed at the center of the tree. In MA, GA dispensers were replaced four weeks after deployment while BEN dispensers were left in place for the reminder of the PC season. All GA dispensers were purchased from Great Lakes IPM, whereas BEN was formulated by UMass personnel.

b. *Fruit sampling on the trap trees.* Beginning when fruit reached ¼ inch in diameter (i.e., about one week after petal fall), 35 fruit clusters were designated on each trap tree using flagging tape and numbered using a non-toxic, water-resistant Sharpee pen. Each king fruit within each cluster was selected as the fruit to be inspected for occurrence of fresh PC egglaying scars throughout the season. Only king fruit in clusters 1-25 were used for making a threshold decision. King fruit in clusters 26-35 were checked on each visit and the damage circled, but they were not counted toward the threshold, because they were considered as potential replacements in the event a designated king fruit fell off. Fruit sampling on the trap tree took place twice per week (e.g., Mondays and Thursdays in MA orchards in 2004) for about six weeks. During sampling, a tight circle was drawn using a sharpee around each fresh PC scar detected and data for each labelled fruit were recorded on a data sheet.

c. *Threshold triggering insecticide sprays.* Growers were advised to spray an insecticide against PC to all perimeter-row trees whenever the threshold of 1 fruit with fresh egglaying scars out of the 25 sampled fruit on a trap tree was reached. Fruit sampling resumed 4-7 days after an insecticide spray took place. A representative example of insecticide applications being triggered by trap tree sampling is presented in Fig. 2 for the 14 blocks monitored in MA (2004 data). As shown here, some orchard plots (e.g., E and H) experienced very low PC pressure, which resulted in ZERO post-petal fall sprays based on the sampling results, whereas other plots (e.g., D) were subject to high PC pressure and thus required multiple perimeter-row insecticide sprays after petal fall. It is important to note that injury detected after growers were alerted may have occurred after sampling, but before the actual application of insecticide.

Assessment of treatment efficacy. The efficacy of each method for managing PC was assessed at two distinct time periods: during early July (i.e., 6-7 weeks after petal fall) and also about one week before harvest. For each of these two time periods and for each of the three plots within a block, 10 random fruit were inspected for PC egglaying scars on each of 10 trees in 9 rows (= 900 fruit per plot, 2,700 fruit per orchard block). Rows selected for sampling depended on the number of rows included in a plot. If the block had large (M.7) trees, all 9 rows were sampled. If trees were on M.26 or M.9 rootstocks, the 9 rows sampled were distributed as evenly as possible among all the rows in the plot, including the most interior row. An additional 50 fruit were sampled on the odor-baited trap tree in Plot C to determine the extent of aggregation of PC damage on trap trees. In all, 115,800 fruit (combining the first survey and the harvest survey) were inspected for PC injury in 2004, and 96,400 fruit (53,600 on each sampling occasion) in 2005. Only data collected during the harvest survey samplings are presented in the 'Results' section.

Results

This study was conducted in 24 orchard blocks in 2004 and in 20 blocks in 2005 in 7 northeastern states. However, results presented below exclude data from some blocks (4 in 2004 and 2 in 2005) because of exceedingly high levels of PC pressure and/or logistical problems involving timing and coverage of insecticide applications.

Some of the results presented below will be

ORCHARD	05/20	05/24	05/27	05/31	06/03	06/07	06/10	06/14	06/17	06/21	06/24	06/28
A	0	0	0	0	0	0	1	1	0	0	0	0
B	0	0	0	0	0	1	0	2	0	2	0	0
C	0	1	0	1	0	0	0	0	0	0	0	0
D	0	1	1	3	2	0	0	2	1	1	0	0
E	0	0	0	0	0	0	0	0	0	0	0	0
F	1	1	0	0	0	0	0	0	0	1	0	0
G	0	1	0	0	0	1	1	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0	0	0
I	1	0	0	0	0	0	5	2	0	0	1	0
J	0	0	0	0	0	0	0	0	0	0	1	0
K	0	0	0	1	0	0	0	0	1	0	0	0
L	0	2	0	1	0	0	0	0	0	0	0	0
M	0	1	0	0	0	0	0	2	0	0	0	0
N	---	---	---	---	0	0	1	0	0	0	0	0

Figure 2. Example of sampling data collected twice per week (Tue & Thu) in the trap-tree plots (Treatment C) for the 14 orchard blocks in MA in 2004. Fruit was sampled on each trap tree 12 times across the entire PC season from late May to late June, except for the block denoted with the letter 'N'. Boxes in light gray represent presence of fruit having fresh PC egg-laying scars, numbers indicate total number of fruit injured (of the 25 sampled). Dark gray indicates when growers were alerted for need for an insecticide spray against PC.

illustrated using only the orchard blocks located in MA for 3 reasons: (1) some data (e.g., incidence of injury to fruit by other insects) was collected exclusively in MA blocks, (2) in both years most blocks evaluated were located in MA (58% and 50% of the total in 2004 and 2005, respectively), and (3) MA blocks have been used for several years to conduct IPM research on PC and thus the history of these blocks in terms of PC management was well known.

Weather conditions prevailing in 2004 and 2005. Weather data taken at Cold Spring Orchard (Belchertown, MA) indicate that both 2004 and 2005 were years with atypical weather prevailing for at least the orchards located in MA. As a consequence, many apple growers experienced problems in managing PC both years, even using the most conservative approach. In 2004, PC immigration was characterized in most MA orchards by cool and rainy weather during May and June, leading to a prolonged PC egg-laying period. This resulted in some injury still occurring through early July. In 2005, May and June temperatures were lower than in 2004, and there was also more rainfall compared with 2004. This again resulted in some PC injury still taking place in early July in some MA orchard blocks.

Overall efficacy of each management strategy. As shown in Figure 3, in 2004 the most blocks achieving relatively low levels (£ 1.5%) of PC damage at harvest were those managed using the conventional approach (95%), which involved calendar-based whole-plot applications of insecticide (i.e., treatment A), followed by the trap-tree approach (i.e., Treatment C) (75% of blocks), and lastly the heat-unit accumulation method (i.e., Treatment B) (65% of blocks). This trend was

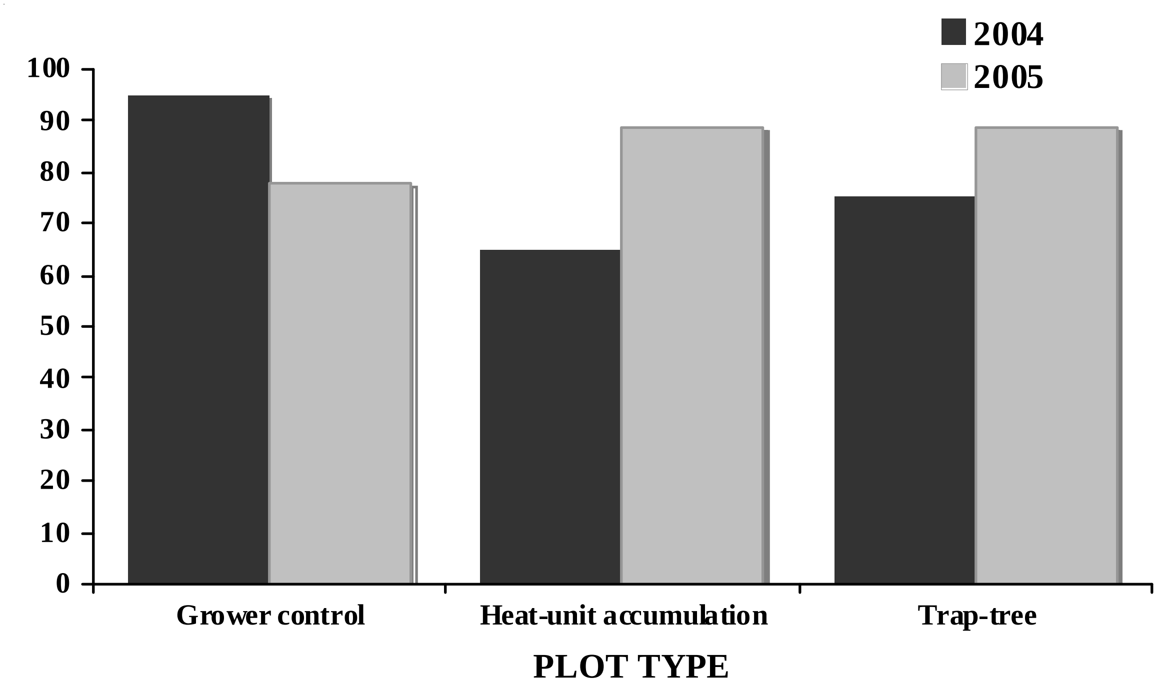

Figure 3. For each of the two years and for each of the three different PC management methods, percentage of orchard blocks in which whole-plot injury by PC to fruit sampled at harvest was less than or equal to 1.5%. Data from all 24 blocks evaluated in 2004 and all 20 blocks evaluated in 2005 are included.

reversed in 2005, when 89% of the blocks achieved this low level of PC damage at harvest using either the heat-unit accumulation approach or trap trees, compared with 78% of the plots that used the conventional approach. In general, the trap tree approach was shown to be either more effective than (2004) or as effective as (2005) the heat-unit accumulation approach in achieving this designation of relatively low PC fruit injury.

Whole-plot injury by PC according to tree size.

Table 2. For each of the three plots associated with a different PC management strategy, whole-plot incidence (% of total) of injury to fruit by other insect pests and diseases in fruit sampled at harvest in 14 orchard blocks in MA in 2004 and 2005. Sample size: 900 fruit per plot/orchard (N=14).

	––––––––––2004----------------			–––––––––-2005-------––––-		
Insect/disease	Grower control (Trt A)	Heat-unit accumulation (Trt B)	Trap tree (Trt C) Grower control	(Trt A) Heat-unit accumulation	(Trt B) Trap	tree (Trt C)
Tarnished plant bug	3.16	6.88	6.51	0.96	1.46	1.22
European apple sawfly	0.03	0.08	0.01	0.00	0.00	0.00
Leaf rollers (1st + 2nd generations)	0.01	0.06	0.02	1.62	2.79	2.15
Codling moth	0.02	0.02	0.05	0.12	0.12	0.15
Lesser apple worm	0.00	0.02	0.01	0.00	0.15	0.04
Sooty blotch	0.00	0.00	0.13	0.30	0.82	1.72
Flyspeck	0.44	1.09	4.81	0.72	2.68	3.91
Apple scab	0.13	0.25	0.39	0.47	0.57	0.86

The size of the trees influenced to a different extent the effectiveness of the three PC management methods. For each of the two years, in those orchard blocks composed of large (M.7 rootstock) trees the amount of whole-plot PC fruit injury was relatively low (less than 1%) and statistically similar ($P > 0.05$) in each of the three treatment plots (Figure 4A, B). For blocks composed of medium-sized (M.26 rootstock) trees, PC fruit injury at harvest in 2004 was significantly greater (1.6%) in the heat-unit accumulation plots than in either the conventional (0.7%) or trap-tree (0.8%) plots (Figure 4A). In 2005, also for medium-sized trees, similar

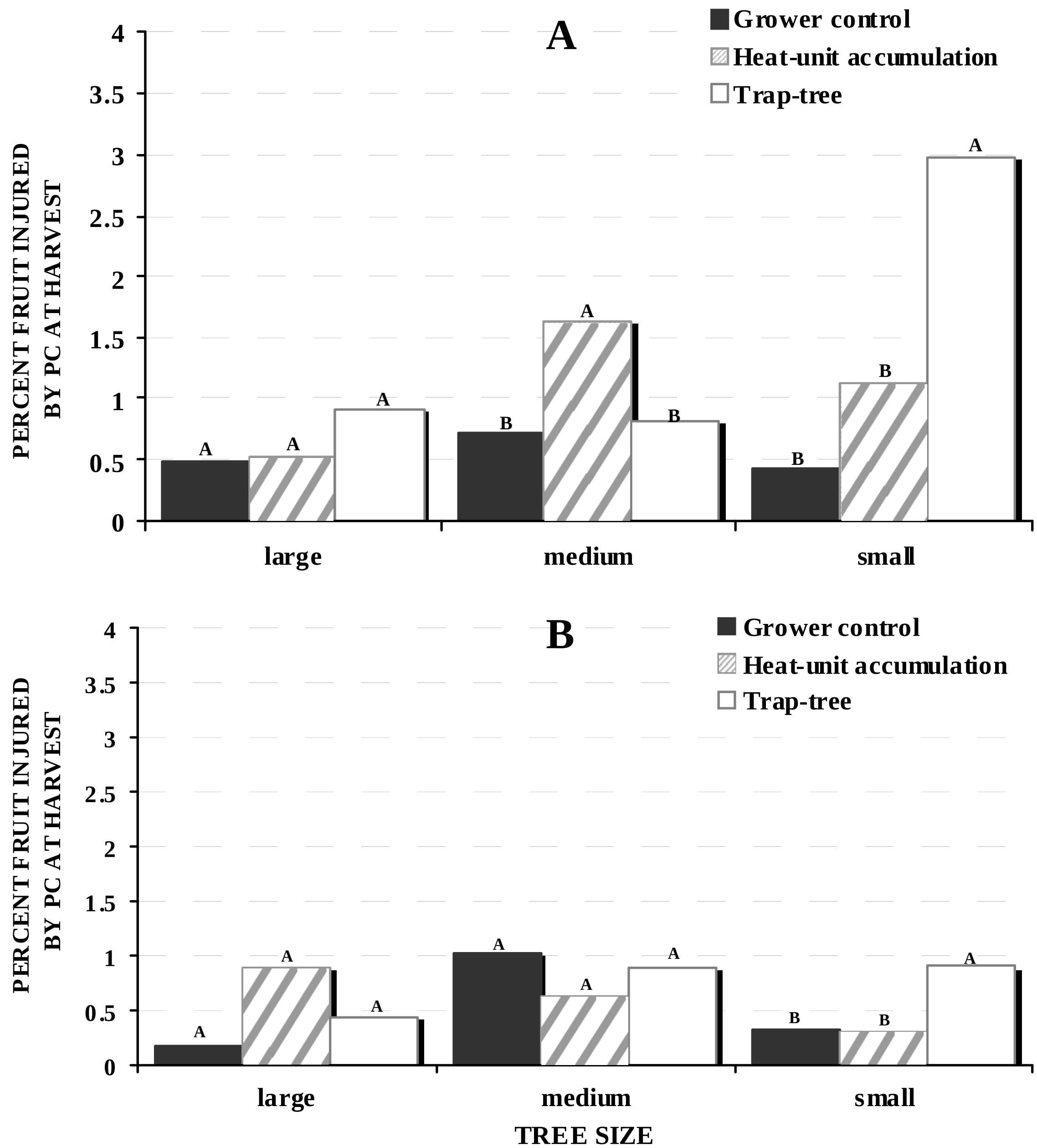

Figure 4. For each of the three different PC management methods, percent whole-plot injury to fruit sampled at harvest in (A) 2004 and (B) 2005 according to the size of trees present in the experimental blocks. Data exclude 4 (2004) and 2 (2005) blocks. Within each category of tree size, columns superscribed by different letters are different ($P = 0.05$). Data from 20 (of 24) blocks evaluated in 2004 and from 18 (of 20) blocks evaluated in 2005 are included.

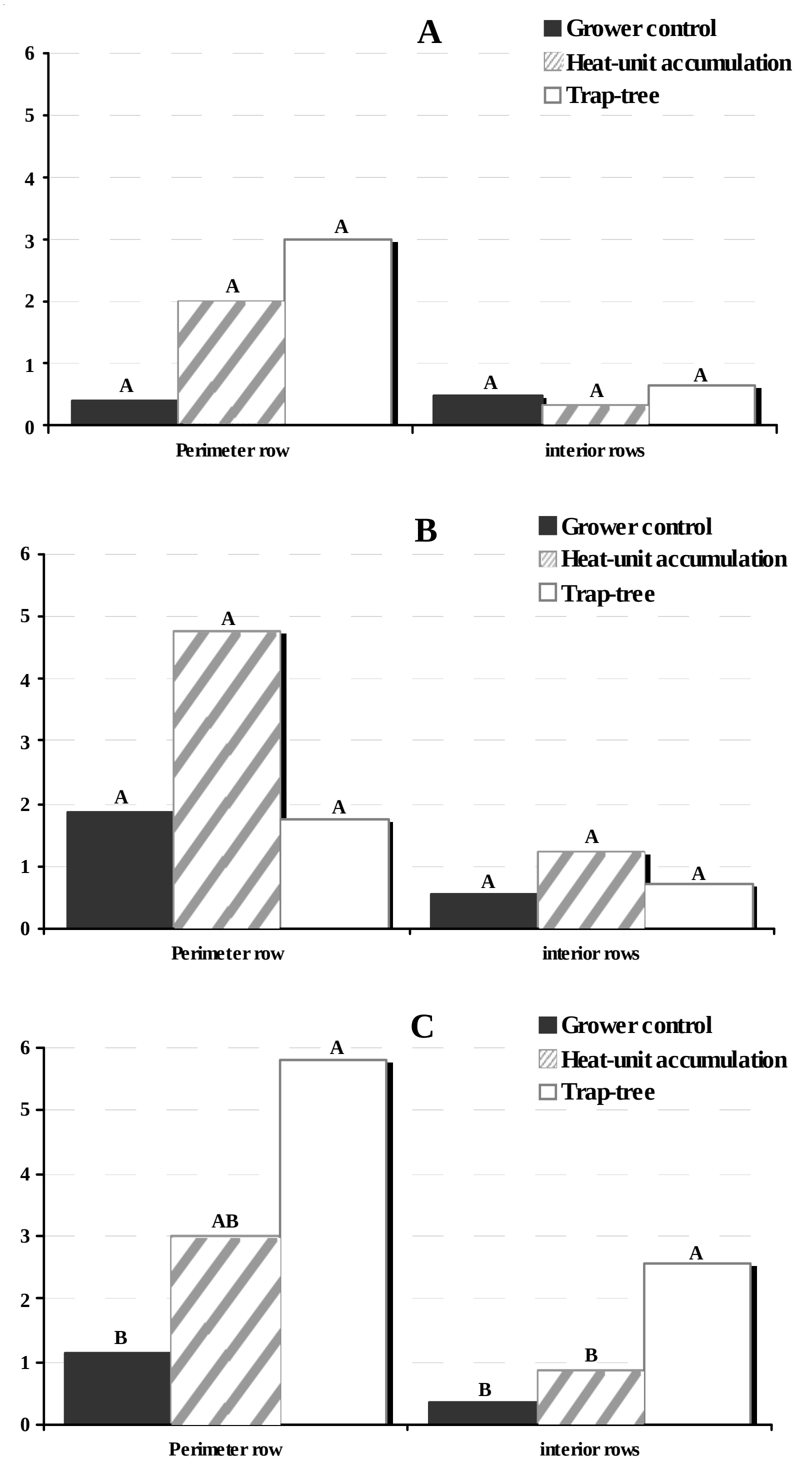

Figure 5. For each of the three different PC management methods, percent of perimeter-row or interior-row injury to fruit sampled at harvest in 2004 for orchard blocks composed of either (A) large trees (B) medium-size trees) or (C) small trees. Within each of the 2 types of injury (perimeter or interior), columns superscribed by different letters are different (P = 0.05). Data from 20 (of 24) blocks evaluated in 2004 and from 18 (of 20) blocks evaluated in 2005 are included.

amounts of fruit were injured in each of the three plots (Figure 4B). In contrast, in both 2004 and 2005 those blocks composed of small (M.9 rootstock) trees received significantly more whole-plot injury in trap-tree plots (3.0% in 2004 and 0.9% in 2005) than in the other two plots. Treatments A and B received similar low levels of injury to fruit by PC in both years (Figure 4 A, B).

Perimeter-row versus interior-row PC injury. Because the applications of insecticide after petal fall were restricted to perimeter-row trees only in the trap-tree plots, it is of interest to consider the level of PC fruit injury at harvest in perimeter-row versus interior-row trees.

Figure 5 shows that, in 2004, the level of perimeter-row and interior-row PC injury to fruit did not differ among plots in blocks of either large or medium-sized trees. However, for blocks of small trees, injury to fruit in perimeter-row trees was significantly greater in treatments B and C than in treatment A, which was managed under the conventional approach. The level of fruit injury in interior trees was also significantly greater in treatment C than in treatments A and B. Overall, in blocks of large or medium-sized trees, the percent fruit injured at harvest was consistently greater in perimeter-row trees than in interior trees, regardless of the PC management technique.

In contrast, in 2005, there were no differences among the three treatments in amount of PC fruit injury in perimeter-row trees, regardless of tree size (Figure 6). Similarly, each of the three PC management tactics resulted in comparatively low levels (less than 1%) of PC injury to interior trees, regardless of tree size.

Injury by other insect pests and diseases. The amount of injury to fruit by each of the five different species of insect pests recorded in MA was in general low in both years, except for tarnished plant bug (TPB). In 2004, fruit injury by TPB in both the heat-accumulation and trap tree plots was substantially greater than that recorded in the conventionally managed plot (Table 2). In 2005, TPB fruit injury was similar in each of the 3 treatments. In both years, the lack of whole-orchard sprays after the petal fall spray

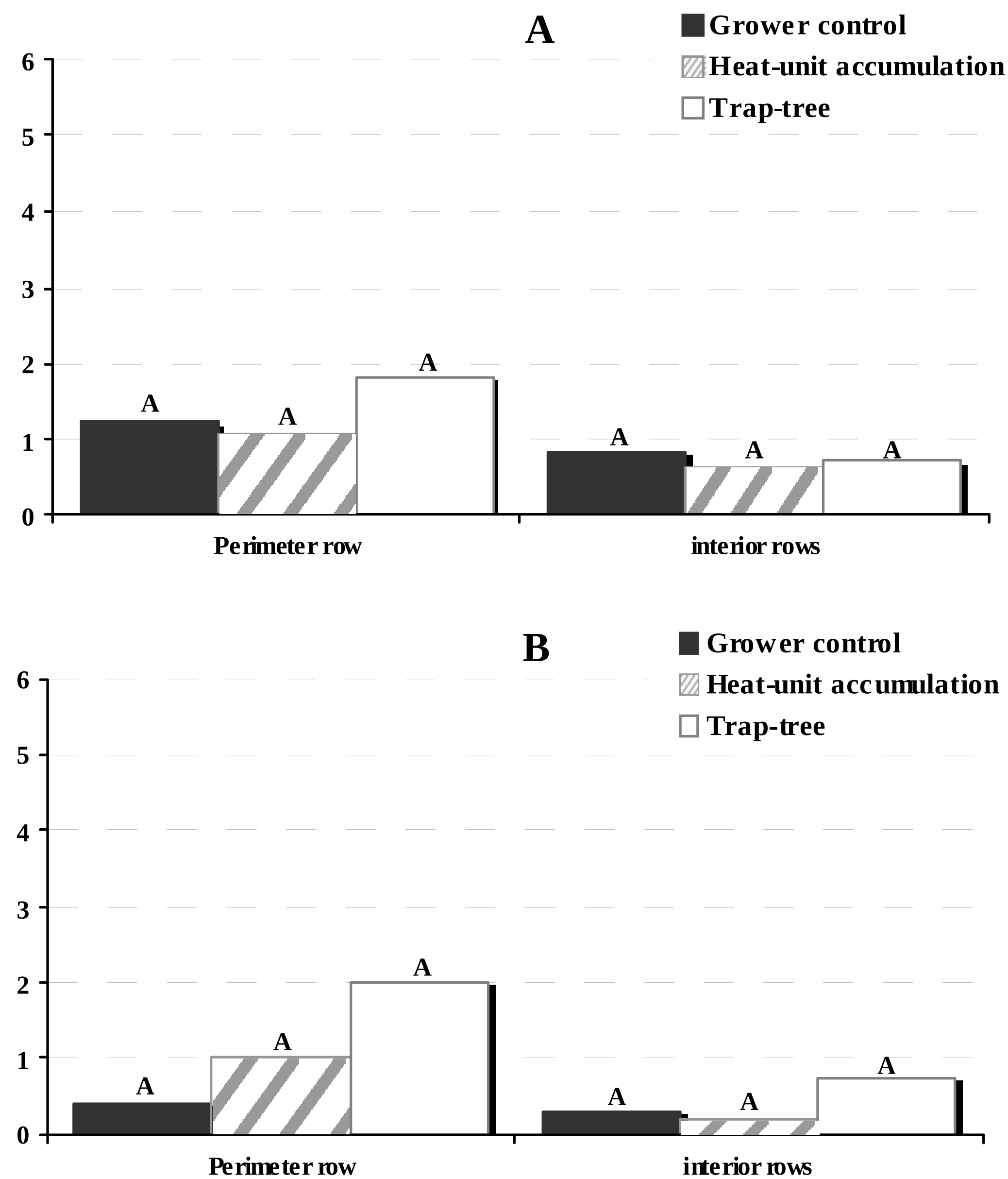

Figure 6. For each of the three different PC management methods, percentage of perimeter-row or interior-row injury to fruit sampled at harvest in 2005 for orchard blocks having composed of (A) large or medium-size trees (data combined) or (B) small trees. Within each of the 2 types of injury (perimeter or interior), columns superscribed by different letters are different (P = 0.05). Data from 20 (of 24) blocks evaluated in 2004 and from 18 (of 20) blocks evaluated in 2005 are included.

in the treatment C plot did not result in a buildup of European apple sawfly, leafrollers, codling moth, or lesser appleworm. Regarding diseases, only flyspeck showed differential fruit infection levels, being substantially higher in treatment C than in the other two treatments in both years (Table 2). The reasons for these differences are not known. The substantial amount of fruit injured by TPB in 2004 was not restricted to the trap-tree plots, thus lack of post-petal fall insecticide in the interior trees did not seem to be a significant factor here.

Insecticide use 2004-2005. Data collected in seven orchard blocks in MA in the 2004 season indicate that in terms of number of applications of insecticide, the trap-tree plots (treatment C) received fewer sprays (average of 1.9) than the plot subject to conventional PC management (Treatment A, average of 2.9 sprays) and than the heat-unit accumulation plots (Treatment B, average of 2.3 sprays). The above frequency of insecticide applied in the trap-tree plots in 2004 is only slightly above the frequency of sprays (1.44 on average) reported by R.J. Prokopy and collaborators in the nine orchard blocks evaluated in MA in 2003 using the trap-tree approach.

In 2005, spray events were converted to dosage equivalents (DE) by dividing the actual rate used by the manufacturer's recommended field rate (MRFR) in order to adjust for the wide range of field rates used by growers. This type of data was obtained for 13 of the 20 blocks evaluated in 2005 (6/11 in MA, and 6/9 in the other 6 states). Application of thinning agents (e.g., carbaryl) was excluded from this estimation unless the selected thinning agent replaced an insecticide application for the petal-fall spray. When data from all these 13 orchards are combined, the total PC insecticide dosage equivalents used were 39.1 for Treatment A (calendar sprays), 30.8 for Treatment B (heat-unit-accumulation), and 19.7 for Treatment C (trap tree approach) indicating that less insecticide was sprayed in plot associated with Treatment C compared to the other two approaches.

Conclusions

Our results indicate that the trap tree approach was more effective than (2004) or as effective as (2005) the heat-unit accumulation approach in terms of the number of blocks with < 1.5% PC-injured fruit at harvest. When compared with the conventional approach (i.e., grower control plots), the trap-tree plots were shown to be less effective in 2004, but more effective than the conventional approach in 2005.

One concern prior to the start of this study was that the lack of whole-plot sprays after the petal fall spray in the treatment C plot could invite the buildup of TPB, leafrollers, codling moth, oriental fruit moth and lesser appleworm, all of which can injure fruit in apple orchards. Here, we showed in the MA orchards that even though TPB was the second most important insect pest species, the injury it caused was similar in Treatments B and C in 2004 and among all 3 treatments in 2005. Ron Prokopy had already shown that by using bio-based approaches for controlling PC and apple maggot, such a buildup did not reach economically injurious proportions over 4 years of study (1991-1994) in several MA orchards, nor over a 20-year period (1981-2000) in Prokopy's own commercial orchard in Conway.

Main factors affecting the efficacy of trap trees. Each of the three management strategies is affected by different factors, such as prevailing weather conditions during the period of PC egg-laying activity. Based on our results, the prolonged PC egg-laying period observed in 2004 as a consequence of cool, rainy weather during May and June seems to have impacted the effectiveness of the heat-unit accumulation model more than that of the trap-tree approach, which not only allows for directly monitoring late-season PC egg-laying activity, but also for accurately determining when petal fall insecticide residues lose effectiveness against PC as a consequence of rainfall, etc.

In addition to the prevailing spring weather, other factors (discussed below) could have influenced the effectiveness of trap trees. In those cases where fruit injury in the trap-tree plots was above 1-2 %, possible causes could have included intense PC pressure (by PCs that may have either immigrated or overwintered inside the plots), planting arrangement of very small apple trees, or a missed insecticide spray.

(1) Level of PC pressure: Orchard blocks with exceedingly high PC population levels may experience substantial injury to interior trees, owing to less insecticide being used on these trees after petal fall. Under such conditions, more trap trees per plot might be needed.

(2) Tree size: In this study, more PC injury occurred on fruit in interior-row trees of blocks with small trees than those with large trees. We have previously reported that PCs are more likely to penetrate into the interior of blocks composed of small trees than those with large trees, which would allow them to elude the insecticide sprays that are restricted to the perimeter-row trees after petal fall. How to overcome this problem? One possibility would be to also apply the first cover to the entire block, so that all the PCs present inside the block after petal fall are killed. The second cover could then be confined to perimeter-row trees only. Another possibility would be to use 2 or more odor-baited perimeter-row trap trees in blocks with small trees, to increase the chances that immigrating PCs would be directed to these trap trees. As discussed by Leskey et al. (2007), there is also the need of developing even more powerful attractants within tree canopies so as to increase aggregation of PCs and potentially reduce the number of trap trees required. More research is needed in this direction.

(3) Timing of insecticide sprays: For the new bio-based management strategy to be efficient, spray applications should be made in a timely manner, preferably within 24 hours of growers being made aware that fruit are susceptible to PC attack. This did not occur in some orchard blocks. There were a couple of cases in which a delay in the timing of insecticide spray after notification resulted in more PC-injured fruit at harvest. This underscores the critical need to spray a PC insecticide to perimeter-row trees as soon as possible after detecting a fresh egg-laying scar, to minimize injury to the otherwise unprotected fruit. Inspecting 25 fruit on a trap tree takes little time (< 5 min). Because PC oviposition can take place very rapidly once fruit is unprotected, more frequent trap tree fruit monitoring (e.g., three times per week as in our 2003 studies, rather than two times per week as in this study) would result in more precise timing of insecticide applications.

Overall, our 2004-2005 results validate the conclusions drawn from previous studies and demonstrate that, in most situations, an odor-baited trap tree can be used as a sentinel to monitor the seasonal course of egglaying by PC, thereby determining the need and timing of insecticide sprays. After a whole-orchard application of insecticide to apple trees shortly after petal fall, subsequent applications of insecticide against plum curculio can be confined to peripheral-row trees driven by the threshold used here. However, results from this and other studies suggest that PC management might be more effective using trap trees **in orchard blocks that have large trees, with low to moderate PC pressure, and employing more frequent examination of the designated fruit.** Considering the little time a grower has to invest in setting up one trap tree per 1-acre plot, the associated low cost of materials involved (less than $ 15), the straightforward sampling procedure that allows for accurate and simple monitoring of egg-laying activity, the excellent value that trap trees offer as direct indicators of insecticide residue longevity, and the relatively low cost and ease of monitoring a trap tree throughout the PC season, we are hopeful that this monitoring technique might be of use to some commercial growers in the NE .

Acknowledgments

Special thanks go to Isabel Jácome, Everardo Bigurra, Suzanne O'Connell, Paul Appleton, and Marina Blanco for excellent assistance. We are very grateful to all growers in the seven northeastern states who allowed us the use of their orchard blocks for this study (especially after the sudden death of RJP), and who conscientiously made the effort to respond rapidly to our advice for timing an insecticide treatment using different approaches (heat accumulation model and fruit sampling). Funds for this work were provided by a USDA Northeast Regional IPM Grant, a USDA Northeast Regional SARE Grant, a Hatch Grant, and the New England Tree Fruit Research Committee.

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