This trial was conducted in mixed plantings of fresh and processing apples on two commercial farms in Wayne County, NY, in cooperation with researchers overseeing and additional 22 similar plots in the six New England states as part of a Univ. of Massachusetts USDA NE Regional IPM project initiated by Ron Prokopy in 2003. The field trials conducted in 2004 constituted the first year of a 2-year validation and demonstration of the effectiveness of the following advanced-level IPM tactics in commercial orchards:

1 - For plum curculio (PC), an optimal trap tree approach to determine need and timing of insecticide use against PC in comparison with existing approaches based on calendar-driven sprays or heat-unit accumulation models.

2 - For apple maggot (AM), an orchard-architecture-based ranking system for deploying odor-baited pesticide-treated spheres for direct control of AM in comparison with existing approaches to AM control based on calendar-driven sprays or monitoring-trap-capture-driven sprays.

**Materials & Methods**

Three non-replicated treatments were set up in plots 1.3–1.9 A in size at each of two commercial farms in the following varieties: Rome and Ida Red (Peters, Williamson); and Empire (Perkins, N. Rose). Plots were chosen so as to be adjacent or in proximity to a woods or hedgerow along at least one border. Plot A was designated as the "Conventional" treatment, Plot B as "1st-Level IPM", and Plot C as "Advanced-Level IPM". Treatment protocols were as follows:

Plot A: For PC, a petal fall plus two cover sprays of phosmet to the entire plot on a 10–14-day schedule. For AM, 3 applications of phosmet to the entire plot at mid-July, early August and mid-August.

Plot B: For PC, a petal fall application of phosmet to the entire plot followed by 2 more applications, the first 10–14 days after petal fall; and the second based on the heat-unit accumulation model of Reissig et al. (1998) requiring insecticide protection until 340 DD (base 50°F) after petal fall.

Plot C: For PC, a petal fall application of phosmet to the entire plot followed by subsequent applications of phosmet only to perimeter-row trees, contingent on incidence of fresh PC oviposition injury on an odor-baited "trap tree" located in the middle of the perimeter row closest to the woods or hedgerow area adjacent to the plot. For AM, deployment of odor-baited pesticide-treated spheres on perimeter trees of all four sides of the plot, as a substitute for insecticide sprays. Distance between the pesticide-treated spheres on the perimeter rows was determined for each orchard based on an 'AM damage potential' index that ranks 4 environmental factors: tree size, quality of pruning, varietal susceptibility, and nature of bordering habitat.

All insecticide sprays were applied by the grower cooperators. Each of the PC trap trees was baited by hanging 4 vials containing benzaldehyde (a component of ripening fruit shown to be
attractive to PC) and one membrane dispenser containing grandisoic acid (a component of the boll weevil mating pheromone shown to be attractive to PC) within 30" of the center of the tree canopy, within 3 days of petal fall. On the same date, 25 fruit clusters on each trap tree containing a king and 4 lateral fruits were tagged with flagging tape and numbered so as to facilitate repeated inspections of the same fruits for evidence of fresh PC oviposition injury. These inspections were conducted twice per week for 5 weeks until 23 June, or slightly past the 340 DD cutoff date. On 8 July, final midsummer PC injury was assessed in all plots by inspection of 10 fruits on each of 10 trees in each of the first 9 rows of each plot from the woods edge.

For AM, pesticide-treated spheres (PTS) were hung in the perimeter rows of Plot C at each farm on 7–8 July. Each PTS consisted of an apple-red hollow plastic sphere approximately 8.2 cm (3 1/4") in diameter with a contoured compressed top cap paraffin wax and wire mesh matrix containing sugar (as a feeding stimulant) and spinosad as the toxicant. This was designed so that any significant rain or dew would produce a coating of the sphere by the sugar+spinosad mixture, to lure and kill any AM flies entering the orchard from outside sources. To determine the inter-sphere distance along the perimeter, the following index was calculated by summing the values (1, 2, or 3, respectively) for each of the following parameters: tree size (large, medium, small); quality of pruning (poor, fair, good); varietal susceptibility to AM damage (high, moderate, low); and bordering habitat (woods, hedgerow, open field or adjacent sprayed orchard). For each site in this study, the index resulted in a total value of:

\[2 \text{ ('medium' tree size) + 2 ('fair' pruning) + 3 ('low' susceptibility) + 1 (woods border) = 8}\]

According to the guidelines previously established by field research of these parameters, this value when applied to the protocol would thus require a distance of 11 m (36 ft) between spheres. The number of PTS used in the individual Plot C's was 37 at Peters and 32 at Perkins; each was deployed together with a vial containing a standard 5-component blend of fruit odor volatiles, affixed to the same hanger wire and above the sphere.

To monitor AM flight progress into the center of the plots, 4 unbaited red sphere traps were hung in trees along a transect through the middle 2 rows of each of the 3 plots at both sites; these were inspected twice weekly and cleaned of any AM and non-target flies, from 20 July to 16 Sept.

Immediately before the respective harvest dates at the two sites (23 Sept., Perkins; 11 Oct., Peters), final fruit damage was assessed by randomly picking 100 fruits per row (10 fruits from each of 10 trees) in each of the first 9 rows of each plot, and visually inspecting them for damage caused by plum curculio, apple maggot, obliquebanded leafroller, and tarnished plant bug. Mean percent damage levels were transformed by arcsine square root and treatment means separated using ANOVA and Fisher's lsd test ($P = 0.05$).

**Results**

**Plum Curculio:** No PC oviposition damage was found on any of the tagged fruits on the trap trees at either farm for the entire 5 weeks of fruit inspection after petal fall; therefore, no additional insecticide sprays were advised beyond the petal fall application. The 8 July assessment of PC damage gave the following values:

<table>
<thead>
<tr>
<th></th>
<th>Peters</th>
<th>Perkins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot A</td>
<td>0.1% ab</td>
<td>0.7% ab</td>
</tr>
<tr>
<td>Plot B</td>
<td>0.0% a</td>
<td>0.6% a</td>
</tr>
<tr>
<td>Plot C</td>
<td>0.8% b</td>
<td>1.6% b</td>
</tr>
</tbody>
</table>
**Apple Maggot:** Adult trap captures on the unbaited red sphere traps hung inside each of the plots were extremely low during the summer. Only one AM adult was caught on one of the traps at the Perkins site during the entire trapping period, on 11 August (in Plot C). At the Peters site, single adult catches were recorded on the following dates: 30 July (Plot B), 6 August (one each in Plots A and C), and 13 August (Plot C).

**Harvest Evaluations:** Insect damage was very low in all plots at both sites (Table 1). Apple maggot injury was only nominal overall, and there were no significant differences across any of the treatments. For Plum Curculio, no damage was found at the Peters site, and a small amount at Perkins; in this case, the damage in Plot B (using the DD oviposition model) was significantly higher than in the other two plots. Tarnished plant bug and late-feeding obliquebanded leafroller damage was uniformly low across all treatments at Peters. At Perkins, TPB was significantly higher in the Conventional plot, and late OBLR was higher in the 1st-Level IPM plot. Overall levels of clean fruit were statistically comparable at Peters, and slightly lower in the 1st-Level IPM plot at Perkins.

**Table 1. Fruit Harvest Damage Evaluations**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Peters (Avg. % damaged fruits*)</th>
<th>Perkins (Avg. % damaged fruits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM PC TPB Late Clean</td>
<td>AM PC TPB Late Clean</td>
</tr>
<tr>
<td>A (Conventional)</td>
<td>0.0 a 0.0 a 0.0 a 2.0 a 98.0 a</td>
<td>0.1 a 0.1 a 2.2 a 0.0 a 97.7 ab</td>
</tr>
<tr>
<td>B (1st-Level IPM)</td>
<td>0.0 a 0.0 a 0.1 a 1.1 a 98.8 a</td>
<td>0.0 a 2.6 b 0.4 b 0.7 b 96.3 a</td>
</tr>
<tr>
<td>C (Advanced IPM)</td>
<td>0.7 a 0.0 a 0.0 a 2.1 a 97.2 a</td>
<td>0.0 a 0.0 a 0.8 ab 0.6 ab 98.7 b</td>
</tr>
</tbody>
</table>

(*Values within a column followed by the same letter not significantly different; \(P=0.05\) [Fisher's Protected lsd]).

**New England Locations:** Population pressure for both AM and PC was substantially greater in the New England field sites than was observed in NY, although there was high variability from one site to the next (Fig. 1). Among the trends noted in these locations were the following:

- The "Advanced-Level IPM" plots usually exhibited the higher fruit damage readings at harvest.

- A definite edge effect was noted in the incidence of pest injury, with worse damage occurring generally nearer to the non-orchard habitats adjacent to the plots.

- Because it was not always possible to set up all the plots in plantings of the same variety, a varietal effect was also apparent in several cases; increasing pest susceptibility was seen in the progression from: McIntosh, Red Mac, Cortland, Jonamac, Mutsu, Liberty, to Redfree.

In at least two cases, the Plot C (Advanced-Level IPM) was set up in plantings where there was evidently an indigenous apple maggot population in the orchard. This would explain the poor performance of the pesticide treated spheres in controlling this pest, as a behavioral tactic of this nature would not be expected to be effective in such a case.

**Acknowledgments**

Thanks are due to Jim Peters and Robert Perkins for the use of their farms; Gowan Co. and Dow AgroSciences for the donation of insecticide products; Starker Wright for providing the pesticide treated spheres; and Jaime Piñero, Kathleen Leahy, Glen Koehler, Heather Faubert, Lorraine Los and Glenn Morin for all of their collaborative advice and guidance.
Fig. 1. Mean fruit damage levels caused by plum curculio and apple maggot in conventional (Calendar), 1st-Level IPM (Ovipositional Model or Trap Threshold), and Advanced-Level IPM (Trap Tree or Pesticide Treated Spheres) plots in 22 commercial farms in New England and New York, 2004. Experiment-wise averages are given for each treatment across all sites.