Commercial Orchard Evaluation of Pesticide-treated Spheres for Apple Maggot Control in 2001

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In the 2000 issue of Fruit Notes, we described results of year-2000 orchard trials of pesticide-treated spheres (PTS) for controlling apple maggot flies (AMF). These trials involved evaluation of biodegradable sugar/flour PTS as well as wooden PTS topped with a disc composed of sugar and wax. We found that neither type of PTS approached optimal efficacy. Sugar/flour PTS suffered progressive loss of toxicant under rainfall as well as progressive loss of sphere integrity due to consumption of spheres by rodents and other mammals. Wooden PTS maintained a high level of residual toxicant throughout the summer of 2000, but the top caps did not retain enough sugar to stimulate consistent feeding of AMF on the sphere surface after 4-5 inches of rainfall and, like sugar/flour spheres, were vulnerable to consumption by rodents and other mammals.

In the preceding article in this issue of Fruit Notes, we describe recent laboratory research that gave rise to an improved type of sugar/wax disc for placement atop a wooden PTS. Here, we describe commercial orchard trials conducted in 2001 comparing the effectiveness of wooden PTS topped by improved sugar/wax discs with the effectiveness of standard sugar/flour PTS and sticky-coated spheres for controlling AMF.

Materials & Methods

The improved sugar/wax discs had the following properties: a size of 2 inches diameter by 3/4 inch tall; a composition of 85% sucrose and 15% paraffin wax (50 grams total mass); a top surface into which eight shallow reservoirs were pressed to permit retention of a small amount of water that could percolate through the slightly porous body of the disc; a hardness that resulted from compression under 20 tons of hydraulic pressure; and an embedded wire guard surrounding the disc to protect it from consumption by rodents. Red vegetable dye was mixed with the sucrose to color each disc red. The dye was absorbed by the sugar. As the amount of sugar diminished under rainfall or dew, so also did the color of the disc change from red to pink and eventually white. This allowed visual assessment of the relative amount of sugar remaining in the disc. A disc was positioned atop each 3.25-inch wooden PTS by unscrewing the metal shaft holding the sphere, pushing the shaft through the small hole at the center of the disc and then reattaching the shaft to the sphere. The sphere received a coat of black latex paint containing 4% (a. i.) imidacloprid (Provado). Water containing 20% sucrose was sprayed on each wooden PTS just before deployment.

Sugar/flour spheres likewise were 3.25 inches diameter, coated with black latex paint containing 4% (a. i.) imidacloprid (Provado) and were purchased from FruitSphere Inc. (Peoria, Illinois). Except for substitution of black for red latex paint and an increase in amount of imidacloprid from 2 to 4% a. i., sugar/flour spheres were the same as those we evaluated in orchard trials in 2000.

Sticky spheres were 3.25 inches in diameter, red in color, and coated with Tangletrap to capture alighting AMF.

Spheres were evaluated in six commercial orchards in MA, each of which contained four small plots of apple trees (~ 49 trees per plot). Three of the plots received no insecticide after mid-June and were surrounded by either wooden PTS, sugar/flour PTS, or sticky spheres placed about 5 yards apart on perimeter trees during the first week of July. Each sphere was baited with a vial of butyl hexanoate. The fourth plot received two or three sprays of phosmet to control AMF. Discs atop wooden spheres and all sugar/flour spheres were replaced at mid-season (after 6 weeks of field exposure) with fresh versions of each. Treatment effectiveness was judged by comparing numbers of feral AMF captured on interior unbaited monitoring traps (four traps on central trees of each plot) and percent injury to fruit in samples taken every other week from July to September.

In addition to measurements of whole-plot treatment effectiveness, we assessed the structural durability of each PTS bi-weekly from July to September. For these assessments, we recorded the percentage of spheres impacted by feeding of rodents or other mammals on discs atop wooden spheres or on the body of sugar/flour spheres. For each of four sample sites, we also recorded the amount of rainfall accumulated during each bi-weekly period as a factor potentially leading to premature breakdown of sphere effectiveness (through wash-off of sugar and/or toxicant).

At the mid-point (6 weeks of sphere exposure) and end (12 weeks of sphere exposure) of our trial, we retrieved two randomly-chosen but intact PTS of each type from each orchard and returned them to the laboratory for testing. We directly assessed the fly-killing power of each retrieved PTS by exposing 10 AMF to the sphere. Each PTS was tested twice: soon after return from the field (with no supplemental feeding stimulant applied to the sphere), and again after application of a 20% sucrose solution to stimulate fly feeding. Residence time on spheres and condition (alive or dead) at 72 hours post-exposure were recorded for each fly.

Results

Treatment Effectiveness. As indicated by captures of AMF on unbaited monitoring spheres on interior trees of each plot, the numbers of AMF that penetrated into plots surrounded by wooden PTS were substantially fewer (~ 30% fewer) than the numbers that penetrated into plots surrounded by sugar/flour PTS or sticky spheres and were only about 3% greater than the number that penetrated into insecticide-treated plots (Table 1). Very few sampled fruit were injured by AMF in plots surrounded by wooden PTS (0.13%) or sticky spheres (0.13%) or in plots sprayed with insecticide (0.17%), whereas a greater percentage was injured in plots surrounded by sugar/flour spheres (0.58%) (Table 1).

Structural Integrity. Data in Table 2 show that after 6 weeks of field exposure from early July until mid-August, 37% of sugar/flour PTS but only 10% of sugar/wax discs atop wooden PTS had lost 20% or more of their surface area to feeding by rodents or other mammals. All of the feeding on sugar/wax discs occurred in a single orchard and was perpetrated by raccoons, which were observed to be numerous in that orchard. All sugar/flour PTS and all discs atop wooden PTS were replaced at mid-August. By mid-September (4 weeks later), 47% of sugar/flour PTS but 0% of discs atop wooden PTS had lost 20% or more of their surface area due to feeding by vertebrates.

Residual Sugar. As depicted in Figure 1, the amount of sugar remaining in sugar/wax discs atop wooden

Table 1. Captures of feral AMF on unbaited monitoring traps and percent injury to fruit by AMF in 24 plots of apple trees in six commercial orchards in 2001.

Treatment*	No. AMF captured per plot**	Fruit injury per plot (%)***
Wooden PTS	38.1	0.13
Sugar/flour PTS	54.5	0.58
Sticky Spheres	53.0	0.13
Insecticide Sprays	36.9	0.17

* Within columns, differences among treatments were nonsignificant at odds of 19 to 1.
** Based on four unbaited spheres per plot.
*** Based on 100 fruit sampled per plot on each of five bi-weekly sampling dates from July to September.

Table 2. Percentage of sugar/wax discs atop wooden PTS and percentage of sugar/flour PTS having greater than 20% estimated damage by feeding of rodents or other mammals, based on visual inspection (bi-weekly) of 120 discs or spheres.

	Spheres damaged by feeding (%)*	
Weeks of field exposure	Discs atop wooden PTS	Sugar/flour PTS
2	9	16
4	10	28
6	10	37
All sugar/wax discs and all sugar/flour spheres were replaced at mid-season (after week 6)		
2	0	46
4	0	47

* Loss of 20% or more of mass (discs) or surface area (sugar/flour PTS).

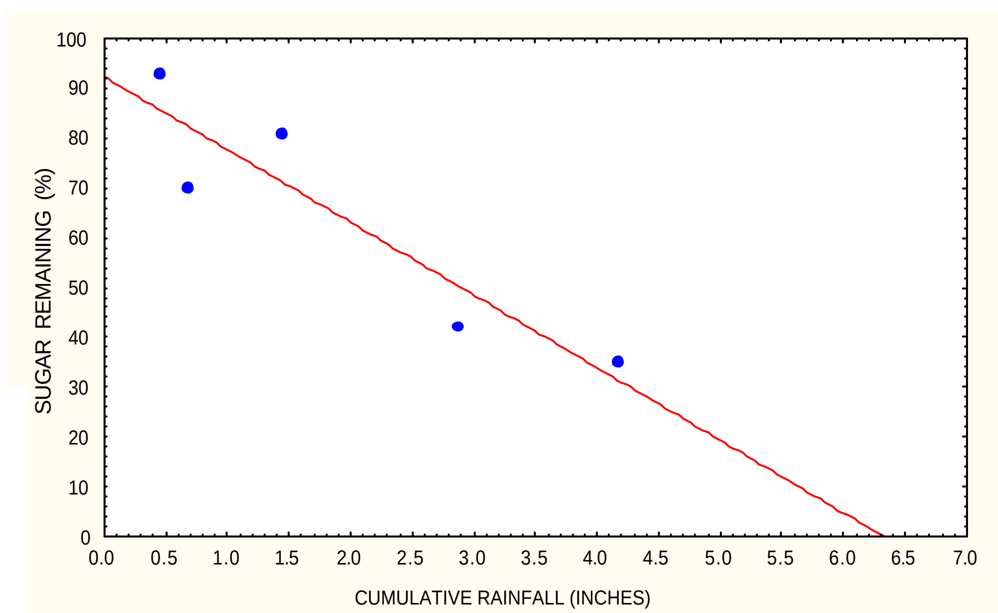

Figure 1. Visually estimated percent of original sugar remaining in sugar/wax discs atop wooden PTS after exposure to rainfall in commercial apple orchards. Visual estimates were based on color of discs, which range from red (no sugar loss) to white (complete sugar loss).

PTS (as assessed by color of discs) declined in concert with the amount of rainfall to which discs were subjected during their 6-week exposure period in commercial orchards. The relationship between amount of remaining sugar and amount of rainfall appears to be approximately linear and suggests that very little sugar would remain after 6 inches of rainfall. Besides rainfall, droplets of dew accumulating in reservoirs of sugar/wax discs also result in release of sugar onto the surface of wooden PTS. This is advantageous to sphere performance during periods of dry weather.

Residual Toxicity. After the first 6 weeks of field exposure under 4.17 inches (on average) of cumulative rainfall, wooden PTS killed 37% of alighting AMF compared with 69% kill of alighting AMF by sugar/flour PTS (Table 3).

After 12 weeks of field exposure of wooden PTS (accompanied by replacement of sugar/wax discs at 6 weeks), 39% of alighting AMF died (Table 4). Total rainfall averaged 3.14 inches during weeks 7-12 and 7.31 inches over the entire 12 weeks of sphere exposure. In addition to 39% mortality of alighting AMF, another 14% of AMF, though alive, were unable to fly 72 hours after contact with wooden PTS. When a 20% sugar solution was applied to 12-week-

Table 3. Mortality of AMF after exposure to PTS. All evaluated PTS were placed in commercial orchards during the first week of July and retrieved after 3 or 6 weeks of field exposure. AMF were exposed individually to each PTS and allowed to forage freely on it for up to 10 minutes.

Weeks of PTS orchard exposure	Average amount of rainfall (inches) per orchard during each interval	AMF mortality (%) 72 hours after exposure*		
		Wooden PTS	Sugar/flour PTS	Spheres without insecticide
3	2.02	38	72	0
6	2.15	37	69	2

* Each value is based on sphere exposure to 120 AMF (10 AMF per sphere x 2 spheres per orchard x 6 orchards).

Table 4. Mortality of AMF after exposure to PTS. All evaluated PTS were retrieved from commercial orchards at the end of the season: for wooden PTS, 12 weeks of field exposure after deployment in early July accompanied by replacement of sugar/wax discs in mid-August; for sugar/flour PTS, 6 weeks of field exposure after deployment in mid-August. AMF were exposed individually to each PTS and allowed to forage freely on it for up to 10 minutes.

Weeks of PTS orchard exposure	Average amount of rainfall (inches) per orchard during each interval	AMF mortality (%) 72 hours after exposure*		
		Wooden PTS	Sugar/flour PTS	Spheres without insecticide
9	0.56	68	-	2
12	2.58	39	-	3
12**	-	100	-	0
3	0.56	-	77	3
6	2.58	-	58	2
6**	-	-	87	0

* Each value is based on sphere exposure to 120 AMF (10 AMF per sphere x 2 spheres per orchard x 6 orchards).
** 20% sugar solution applied to sphere surface prior to fly exposure.

exposed wooden PTS, 100% of AMF died (Table 4). This result indicates that the 4% (a.i.) amount of imidacloprid in latex paint on the surface of wooden PTS remained highly effective in killing AMF after 12 weeks of exposure to sunlight and 7.31 inches of rainfall.

After 6 weeks of field exposure from mid-August until late-September, sugar/flour PTS that were deployed in mid-August killed 58% of alighting AMF (Table 4). When a 20% sugar solution was applied to these spheres, 87% of AMF died (Table 4).

Conclusions

Populations of AMF were substantially greater in 2001 than in 2000 in commercial apple orchards in Massachusetts. In 2000, wooden PTS topped by fluted-type sugar/wax discs were slightly superior to sugar/flour PTS in controlling AMF in commercial orchards. In 2001, as described here, wooden PTS topped by reservoir-type sugar/wax discs were substantially better in preventing AMF penetration of commercial orchard blocks and preventing injury to fruit than were sugar/flour PTS. Indeed, wooden PTS were just as effective as 2-3 sprays of insecticide in providing effective AMF control in 2001.

In 2001, sugar/flour PTS experienced about the same level of damage by rodents and other mammals as they did in 2000: 35-47% of sugar/flour PTS received 20% or more damage by such vertebrates after 6 weeks of orchard exposure. Even though our residual toxicity tests suggest that intact sugar/flour PTS killed at least 58-69% of alighting AMF during 6 weeks of orchard deployment, the fact that more than a third of such spheres were not substantially intact by the end of 6 weeks probably accounts for the lesser degree of AMF control provided by sugar/flour PTS.

In 2000, 20-31% of sugar/wax discs atop wooden PTS experienced 20% or more damage by vertebrates after 6 weeks of field exposure. In 2001, only 0-11% of our new-version discs (protected by embedded wire) experienced 20% or more damage by vertebrates after a similar amount of field exposure, and all of the observed damage was caused by raccoons in a single orchard. No damage occurred from rodents. The level of kill of alighting AMF by wooden PTS (37-39%) after 6 weeks of sugar/wax disc exposure, coupled with an average of 14% of survivors that were unable to fly, gave rise to 51-53% incapacitated AMF that alighted on wooden PTS. This level was less than the kill afforded by intact sugar/flour PTS (58-69%), but apparently was sufficiently great to have provided excellent protection of fruit against injury by AMF.

For the future, we plan to focus on optimizing the size of sugar/wax discs atop wooden PTS so that a single disc might provide a sufficient supply of sugar to the sphere surface to last for the entire 12-week season of AMF activity in commercial orchards. We know from 2001 results reported here that the 4% a.i. level of imidacloprid in latex paint on the surface of a wooden PTS is sufficient to kill all alighting AMF, even after 12 weeks of orchard exposure. We also know from results reported here that little or no sugar is likely to remain in sugar/wax discs atop wooden PTS after about 6 inches of rainfall. Our challenge thus lies not in preserving the residual activity of insecticide, but in ensuring a residue of sugar on wooden PTS.

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