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Source: Florida Entomologist, 86(2) : 206-210

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/0015-4040(2003)086[0206:COBPAW]2.0.CO;2

COMPARISON OF BIODEGRADABLE, PLASTIC AND WOODEN IMIDACLOPRID-TREATED SPHERES FOR CONTROL OF *RHAGOLETIS MENDAX* (DIPTERA: TEPHRITIDAE) FLIES

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ABSTRACT

In experiments comparing biodegradable, plastic and wooden imidacloprid-treated spheres for control of *Rhagoletis mendax* Curran, the mean number of flies caught on plexiglas panes below each sphere type was not significantly different for the entire season. However, the mean time spent by *R. mendax* flies alighting on biodegradable imidacloprid-treated spheres was significantly greater (2.6×) than plastic imidacloprid-treated spheres. During 2001, significantly fewer larvae were found in blueberries harvested from bushes that had wooden imidacloprid-treated spheres hung within the canopy compared with bushes where biodegradable and plastic imidacloprid-treated spheres were deployed. There was no significant difference between the number of larvae found in berries picked from bushes where biodegradable or plastic spheres were deployed. All imidacloprid-treated sphere treatments were found to significantly reduce blueberry maggot larval infestation in fruit compared with the control.

Key Words: attractant, imidacloprid-treated sphere, blueberry maggot

RESUMEN

En experimentos comparando las esferas de plástico y de madera biodegradable y tratadas con imidacloprid para el control de *Rhagoletis mendax* Curran, el promedio del número de las moscas atrapadas sobre la superficie de “plexiglas” debajo cada clase de esfera no fué significativamente diferente para la estación completa. No obstante, el promedio del tiempo pasado por mosca de *R. mendax* encima de las esferas biogradables tratadas con imidacloprid fué significativamente mayor (2.6 veces) que en las esferas plasticas tratadas con imidacloprid. Durante 2001, fueron significativamente encontradas menos larvas sobre las moras (*Vaccinium* sp.) cosechadas de arbustos que tenian las esferas de madera tratadas con imidacloprid colgadas dentro del dosel comparados con arbustos donde pusieron esferas de plástico biodegradable y tratadas con imidacloprid. No habia una diferencia significativa entre el número de larvas encontradas en la frutas cortadas de los arbustos donde habian puestas las esferas de plástico biodegradable y tratadas con imidacloprid. Se encontraron que todos los tratamientos de las esferas tratadas con imidacloprid redujieron significativamente la infestación de larvas en las frutas comparados con el control.

The potential for using a lure and toxicant system to control fruit flies has been examined by several researchers. Hanotakis et al. (1991) combined a food attractant, a phagostimulant, a male sex pheromone, a female aggregation pheromone, a hygroscopic substance (glycerin), and two insecticides (deltamethrin and dichlorvos) with a trap to control the olive fruit fly, *Bactrocera oleae* (Gmelin). Duan and Prokopy (1995) and Hu et al. (2000) tested dimethoate, abamectin, phloxine B, diazinon, imidacloprid, azinphosmethyl, methomyl, tralomethrin, malathion, fenvalerate, and carbaryl on wooden spheres and found that only dimethoate, malathion and imidacloprid were viable candidates for incorporation into spheres to suppress apple maggot, *Rhagoletis pomonella* (Walsh), activity. Dimethoate, malathion, and imidacloprid did not reduce the time of visitation by *R. pomonella* flies on treated spheres in field cage studies.

Recently, Ayyappath et al. (2000) evaluated thiamethoxam at 2-4% AI in sugar/starch spheres and found this insecticide to be significantly less effective than spheres treated with 2% AI imidacloprid. Wright et al. (1999) determined that regardless of trap design and pesticide incorporation, several conditions must exist for spheres to become a viable alternative for control of *Rhagoletis* flies. Spheres must be: 1) easy and safe to deploy, 2) as effective as insecticide sprays, 3) able to endure throughout the growing season, and 4) maintain fly-killing power with a very low dose of toxicant.

A recent trap design is a biodegradable sphere consisting of water, gelatinized corn flour, corn syrup, sugar, cayenne pepper, and sorbic acid (Liburd et al. 1999; Stelinski & Liburd 2001). The biodegradable sphere is coated with a mixture of 70% paint, 20% sucrose solution (wt:vol), 4% imidacloprid (AI), and 6% water. Biodegradable spheres were developed as alternatives to broad-spectrum insecticides for management of key *Rhagoletis* spp. in the northeastern United States. The benefits of using insecticide-treated spheres include the reduction of pesticide residues on crops as well as reduced environmental and worker hazards.

The purpose of this study was to compare biodegradable, plastic, and wooden imidacloprid-treated spheres to determine the most efficacious sphere type for preventing blueberry maggot injury. All previous trap designs, with the exception of the biodegradable sphere, had focused on using wooden spheres brush painted with enamel paint mixed with an insecticide. Using a plastic sphere, either dipping it into an insecticide/sugar solution or coating it with a mixture of paint and insecticide presents a third alternative to previous designs.

Materials and Methods

Research plots were located in Rhode Island and Michigan. In Rhode Island plots were located at two locations during 2000, a 0.5 ha highbush blueberry, *Vaccinium corymbosum* L., planting of 'Patriot', 'Blueray', and 'Jersey' located in North Kingstown and a 2 ha planting of 'Berkley' and 'Collins' located in West Kingston. In 2001, research was conducted at a 0.3 ha planting of 6 cultivars; 'Bluecrop', 'Bluetta', 'Darrow', 'Earliblue', 'Herbert' and 'Lateblue' in Kingston, RI and at a 2 ha planting of 'Jersey' located in Holland, MI.

Sphere preparation (2000)

Biodegradable spheres were obtained from the USDA, National Center for Agricultural Utilization Research Laboratory in Peoria, Illinois and prepared as described in Liburd et al. (1999). Spheres were brush painted with a mixture containing 70% enamel paint (Shamrock Green 197A111, ACE Hardware, Kensington, IL.), 20% (wt:vol) sucrose solution, 2% (AI) imidacloprid (Provado 1.6 F, Bayer, Kansas City, MO), and 8% water.

Plastic spheres (Great Lakes IPM, Vestaburg, MI) were dipped in a solution containing 946 ml water, 28 g of Merit 75 WP (imidacloprid) (Bayer, Kansas City, MO), 189 ml of 20% sucrose solution (wt:vol), and 22 ml (2 ml of product in 20 ml water) finished additive of Turbo spreader (Bonide, Yorkville, NY). This mixture represents 81.6% water, 2.4% Merit 75WP (1.8% AI imidacloprid), and 16% (wt:vol) sucrose solution. Spheres were dipped a total of three times during the growing season.

2000

Three treatments were evaluated in two highbush blueberry plantings for control of *R. mendax* in a completely randomized block design with four replicates. Each block consisted of ten 9-cm diameter green biodegradable imidacloprid-treated spheres (treatment 1), ten 9-cm diameter green plastic imidacloprid-treated spheres (treatment 2), and a section of the block consisting of 30 bushes was left untreated (treatment 3, control). Spheres, approximately one per three bushes, were hung about 15-cm from the uppermost bush, which is the most effective position (Liburd et al. 2000), and baited with ammonium acetate (1 g in 4 ml of water) in a 5 ml scintillation vial (National Diagnostics, Atlanta, GA). A 45 cm × 45 cm square of plexiglas spray-coated with Tangletrap (The Tanglefoot Co., Grand Rapids, MI) was hung 30 cm beneath each of the imidacloprid-treated spheres and supported by four tie-wires (Liburd et al. 1999).

During each sampling period, *R. mendax* flies that landed on treated spheres were observed for 30 minutes; a total of 54 flies were observed. *R. mendax* flies captured on plexiglas panes were counted and removed twice weekly. In addition to monitoring fly populations with Plexiglas panes, *R. mendax* fly populations were also monitored twice weekly using 9-cm diameter unbaited green plastic spheres coated with Tangletrap. Towards the end of the season, an 8-liter sample of 'Patriot' and 'Blueray' was taken on July 13 and 'Blueray' and 'Jersey' taken on July 27 from North Kingstown, RI and placed on screens (0.5 cm mesh) over clear plastic containers to determine the number of maggots in fruit (Liburd et al. 1998). The number of maggots collected into the containers was counted twice a week to determine the effectiveness of the sphere treatments. Fruit was not sampled from West Kingston, RI because deer had damaged the majority of the biodegradable spheres.

Sphere preparation (2001)

During 2001, sphere preparation methods differed from those used in 2000 because additional research data were available on the deployment of insecticide-treated spheres.

Biodegradable imidacloprid-treated spheres were prepared as described in 2000. However, the active ingredient (AI) was increased to 4% because Stelinski et al. (2001) had shown that the effectiveness of field-exposed imidacloprid-treated spheres with 2% AI was significantly reduced over a 12 wk period whereas spheres treated with 4% AI were not significantly affected.

Plastic imidacloprid-treated spheres were first painted with a mixture of 26 ml Provado 1.6F (4% AI imidacloprid) (Bayer, Kansas City, MO), 87 ml 'Bell Pepper' paint (Pittsburgh Paints, Pittsburgh, PA) and 20 ml sucrose solution (5.5 g per 20 ml water = ca. 4.8% of the total mixture). In addition, a newly developed sucrose cap (Prokopy et al. unpublished data) was attached to the spheres to act as a feeding stimulant.

2001

In Rhode Island, the same three treatments (biodegradable and plastic imidacloprid-treated spheres and control) evaluated in 2000 were re-evaluated in 2001. In Michigan, a fourth treatment, wooden imidacloprid-treated spheres, was included in the experimental design. Wooden imidacloprid-treated spheres (9-cm) were brush painted with a mixture of DevFlex latex green paint (ICI Paints, Cleveland, OH) (70%), sucrose feeding stimulant (20%), water (6%), and imidacloprid (4% AI). Like plastic spheres, wooden spheres had the sucrose cap attached to act as a feeding stimulant.

The experimental design was similar to 2000 and consisted of randomized block with four replicates. The placement and position within the canopy of imidacloprid-treated spheres were the same as 2000. However, spheres were baited with polycon dispensers containing 5 g of ammonium carbonate (Great Lakes IPM, Vestaburg, MI). The dispensers were attached to the strings used for hanging spheres. Flies were monitored using the same Plexiglas pane system used in 2000.

In Michigan, four samples of 100 berries per replicate (totaling 400 berries per treatment) were taken July 31 and August 1, 3, and 8. Berries were then placed over 0.5 cm mesh hardware cloth to allow larvae to exit the fruit and drop into containers filled with vermiculite (Liburd et al. 1998). The vermiculite was then sifted and blueberry maggot fly puparia were collected and counted to quantify fruit infestation.

Statistical Analysis

Data were analyzed by analysis of variance. (SAS Institute 1989).

RESULTS

2000

The population of *R. mendax* flies at the North Kingstown, RI site was small, and captures on plexiglas panes for biodegradable and plastic imidacloprid-treated spheres were not significantly different, except on July 18th (Fig. 1). However, Plexiglas panes placed under biodegradable spheres consistently captured more flies than panes placed beneath plastic spheres. The time spent by *R. mendax* flies on biodegradable imidacloprid-treated spheres (62.6 ± 12.0 sec) was significantly greater ($F = 32.5$, df = 26, 53; $P < 0.01$) than the time spent by flies on dipped plastic spheres (24.2 ± 24.2 sec).

Data collected using 9-cm diameter, unbaited, green plastic sticky spheres coated with Tangletrap indicated that peak flight activity occurred on July 4th. No maggots were found in 32 liters of berries harvested on July 13th and 27th from any of the treatment blocks including the control. The data at the West Kingston, RI site could not be analyzed due to the high incidence of deer damage.

2001

In Rhode Island, the mean number of flies collected on plexiglas panes below plastic (35.6 ±

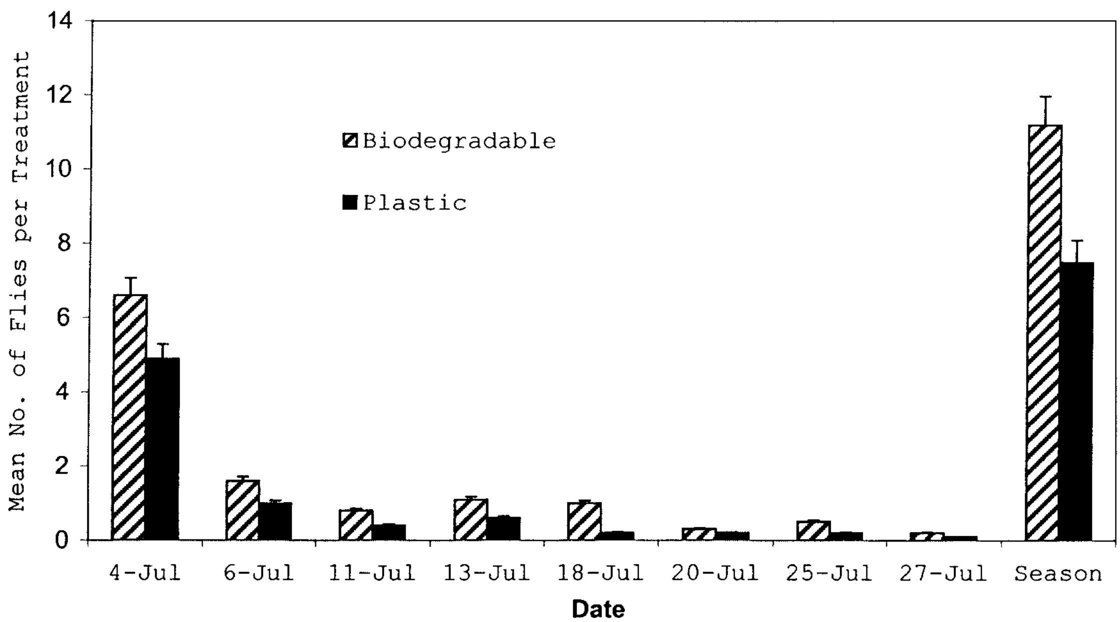

Fig. 1. Mean number of *R. mendax* flies trapped on plexiglas panes beneath imidacloprid-treated biodegradable and plastic spheres, North Kingston, RI July 4-27, 2000.

16.0) and biodegradable (24.6 ± 11.0) imidacloprid-treated spheres was not significantly different for the entire season. Similarly, in Michigan the mean number of flies collected on Plexiglas panes below biodegradable (33.8 ± 2.98), wooden (31.3 ± 4.71), and plastic (26.0 ± 9.06) spheres was not significantly different for the entire season. Again, plexiglas panes placed below biodegradable spheres consistently captured more *R. mendax* flies than plastic and wooden spheres.

In our fruit infestation counts, significantly fewer (F = 24.63, df = 3,6, P < 0.01) larvae were collected from berries that had wooden spheres deployed in blocks compared with plastic and biodegradable spheres (Fig. 2). Overall, the mean number of larvae found in berries treated with biodegradable, plastic, or wooden spheres was significantly lower (F = 24.63, df = 3,6, P < 0.01) than untreated checks. Berries collected from untreated (control) plots had 1.8 times as many larvae compared with other treated plots (Fig. 2). Six biodegradable imidacloprid-treated spheres were lost to deer feeding during the 6 weeks of experimentation in Michigan. Peak flight activity for *R. mendax* occurred on July 24 as measured with yellow unbaited sticky boards.

Discussion

Experiments comparing the effectiveness of biodegradable, wooden, and plastic imidacloprid-treated spheres showed no significant differences in the number of flies trapped on Plexiglas panes. This is the first study showing the effectiveness of plastic imidacloprid-treated spheres for suppression of *R. mendax*. Previous studies have focused on the efficacy of wooden and biodegradable insecticide-treated spheres. Currently, wooden spheres are not commercially available. Also, production of wooden and biodegradable spheres may be prohibitive since the cost may range between $2-4 per sphere for either sphere type. In blueberries, depending on infestation of *R. mendax*, it may take as many as 100 spheres per hectare for effective control.

The variation in sphere preparation throughout 2000 and 2001 was done to optimize insecticide concentration and formulation as well as to further develop the feeding stimulant system so that flies will alight for longer time on treated spheres. Our data showed that flies spent much longer time on biodegradable imidacloprid-treated spheres compared with plastic imidacloprid-treated spheres. However, the fact that larval infestation was not significantly affected between sphere types may indicate that the duration of stay on treated spheres to deliver a lethal dose may not be as important as previously thought. Insecticide compatibility with treated spheres and susceptibility of the insect may be the key factors regulating the effectiveness of insecticide-treated spheres.

Because data from our green sticky sphere monitoring traps indicated that *R. mendax* flies were active throughout the season and flies were trapped continuously with our Plexiglas trapping device, it was rather surprising that no larvae were found in treated and untreated plots at our North Kingston, Rhode Island site. However, because the plots were relatively small, it is possible

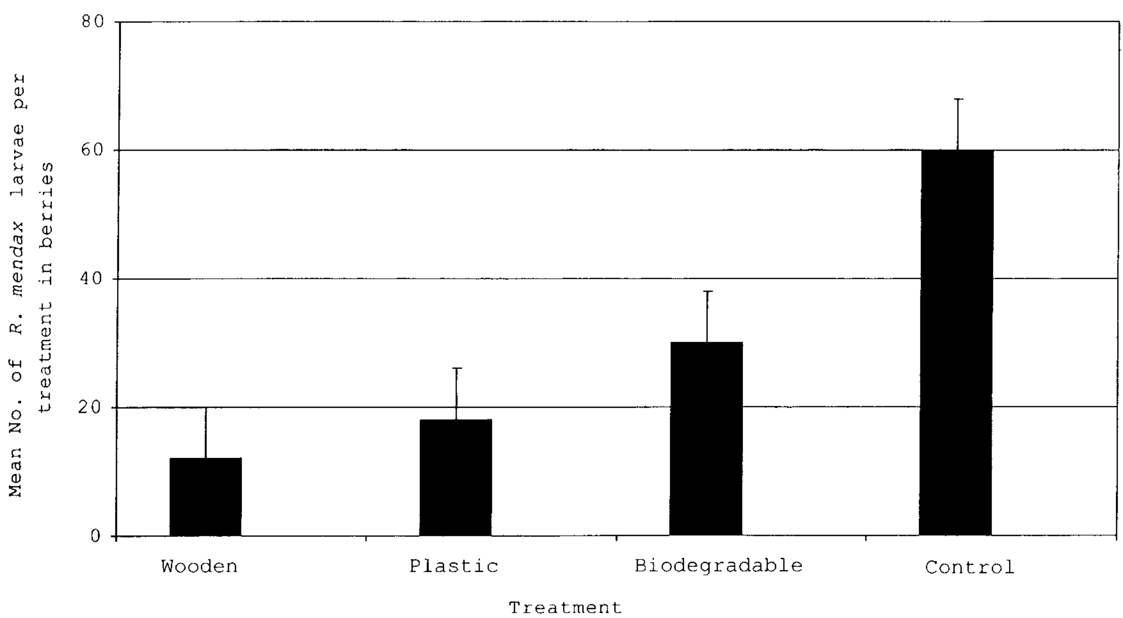

Fig. 2. Mean number of maggots in four samples of 100 berries, Holland, MI (2001).

that the ammonium acetate attractant used for baiting imidacloprid-treated spheres may have attracted flies from treated and untreated areas resulting in a high mortality and subsequently preventing infestation in both treated and untreated plots. Liburd et al. (1999) also found that ammonium lures were effective in attracting *R. mendax* flies from within a 5 m radius to insecticide-treated sphere traps.

The biodegradable imidacloprid-treated spheres used in our study may be more appealing to growers than the plastic spheres used in 2000. Biodegradable spheres did not require additional maintenance after initial deployment in the field. However, some of these spheres needed to be replaced because rodents and deer frequently ate them. As Stelinski et al. (2001) stated, prevention of deer feeding and inhibition of mold growth are needed before these spheres can be recommended to growers.

The plastic spheres used in 2000 needed successive dipping in pesticide solution to maintain their effectiveness in killing *R. mendax* flies. Depending on the insecticide used, the risks of repeated exposure to the applicator may not justify the use of plastic spheres in this manner. The sucrose caps (Prokopy et al. unpublished) used on plastic and wooden spheres in 2001 may make these spheres more appealing to growers.

Wooden pesticide-treated spheres deployed with a sucrose cap may be another alternative. We noted that the resulting fruit injury from plots treated with wooden imidacloprid-treated spheres was lower than plastic and biodegradable spheres. The major problem with wooden spheres is that they are no longer commercially available; a problem that can be rectified if their usefulness in the cropping system exceeds production costs.

The sucrose cap included in our experiments in 2001 was designed to last for a longer duration in the field compared with earlier versions of sucrose caps. An increase in the duration of available sugar may have lead to an increase in fly kill over time. As Stelinski et al. (2001) noted, pesticide-treated spheres require a constant supply of sugar to act as a feeding stimulant and be effective.

Further research is needed to determine how many spheres are needed to treat different fields possessing varying fly densities. Our results show that plastic spheres may be a viable option to control blueberry maggot. However, there should be a system for releasing a constant supply of sugar such as the sugar caps used in 2001. In addition plastic spheres must maintain the residual efficacy of the pesticide.

ACKNOWLEDGMENTS

We thank Charles Dawson, Marsha Browning, Jason Koopman, Rhiannon O'Brien, and Erin Finn for assistance in collection of data. We also thank Lukasz Stelinski (Michigan State University) for critical review of the manuscript. In addition we would like to thank David Bloomberg (Fruitspheres, Inc., Macomb, IL) for providing biodegradable spheres. This research was supported by USDA-CSREES Grant No. 721495612. This manuscript is Florida Agricultural Experiment Station Journal Series R-09081.

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