**Title:** DEVELOPING A BIOCOMPATIBLE MANAGEMENT STRATEGY FOR ONION MAGGOT FLIES

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**Abstract:**

The current goal of our research is to develop a biocompatible management strategy for onion maggot flies that would replace the use of foliar applications of broad-spectrum pesticides. Foliar sprays are used in an attempt to kill onion maggot flies before they lay eggs in onion fields. However, there is no evidence that this strategy is worthwhile and there are multiple disadvantages. As an alternative, insecticide-baited devices could be used in onion fields to “attract and kill” onion maggot flies. In 2006, we evaluated the efficacy of spinosad-baited spheres in a commercial onion production area near Elba, NY. These spheres, which were nearly the same size and color as a softball, contained either 0.5 to 1.0% concentration of the insecticide active ingredient spinosad plus sugar. Spheres were hung about 18 inches from the ground and placed along onion field edges for either 1, 2, 3 or 4 months. Because spinosad does not kill flies quickly, mortality of flies encountering the spheres had to be estimated. Spheres were removed from the field and taken to the laboratory and placed singly into cages. Twenty onion maggot flies (1:1 sex ratio) were released into each cage and mortality was recorded over 72 hr. Fly mortality was not affected by the concentration of spinosad, indicating that the lower concentration is sufficient for these devices. Similarly, mortality of female flies was not affected by the duration that the spheres were hung in the field (range in mortality: 45 to 60%). In contrast, mortality of males tended to decline as the duration of spheres hung in the field increased (64% down to 50%). Overall mortality of males and females over the course of the season averaged 55%. We also predicted that one spinosad-baited sphere would kill approximately 182 flies (147 males and 36 females) during the onion-growing season. Onion growers are keenly interested in this tactic because onion maggot is becoming more difficult to control and this tactic will be safe and easily integrated into existing management practices.

**Background and Justification:**

Onion maggot, *Delia antiqua* (Meigen), is a major pest of onion and populations are becoming more difficult to control due to insecticide resistance. In onion fields where onion maggot infestations are particularly difficult to manage, foliar applications of organophosphate, carbamate and pyrethroid insecticides are used in an attempt to control flies before they lay eggs in the field. This tactic is used early in the season to enhance onion maggot control provided by the insecticide application at-planting and again late in the season to prevent maggots from infesting bulbs at harvest. The major limitation of using foliar sprays to kill flies is that flies must be contacted directly with the spray. Therefore, sprays must be timed when flies are active within onion fields, which is difficult because flies spend only brief periods within onion fields — primarily during dawn and again at dusk when they are laying eggs. Also problematic is that
flies often disperse away from the spray rig as it approaches, reducing the number of flies contacted by the toxicant. A potential unintended side effect of this strategy also may occur such as mortality of beneficial insects, which may reduce natural mortality of onion maggot populations. Developing biocompatible control measures for insect pests such as the onion maggot that minimizes environmental, health and economic risks ranks high among the IPM and NY onion industry research priorities.

To circumvent the limitations associated with foliar sprays, onion maggot could be targeted with an insecticide bait that would “attract and kill” flies. An example is to deploy pesticide-treated sphere traps. This approach has significantly reduced damage by blueberry maggot in blueberries and apple maggot in apples. In principle, pesticide-treated sphere traps consist of (1) a reusable base tailored to the visual cues (e.g., color, shape, and size) used by the target pest, and (2) a sustained-release cap of feeding stimulant (sucrose) and toxicant. Linking the toxicant to a feeding stimulant allows maximum lethality at a minimum dose by increasing the likelihood of pest exposure to the toxicant. In current trap designs, the feeding stimulant and toxicant are dissipated under rainfall or heavy dew and they are replaced by dissolution from a source on top of the trap. In apple orchards, spinosad (Entrust)-bearing spheres were active against apple maggot for 12 weeks, despite 10 inches of cumulative rainfall.

During 2005, we conducted several preliminary studies to assess the efficacy of spinosad against onion maggot and to identify the most attractive color, shape and size of trap. Spinosad was active against onion maggot flies and large, white traps were the most attractive; shape did not matter. However, we prefer to use sphere-shaped bait dispensers because they are already commercially available through Pest Management Innovations, LLC. These spheres could be placed along onion field edges where onion maggot flies are most active and where they would not interfere with normal onion growing practices (e.g., spraying, cultivation, etc.) (see Figure 1). Our preliminary results suggest that spinosad-treated spheres will be an excellent alternative to foliar insecticide sprays for managing onion maggot flies.

**Figure 1.** Proposed placement of “attract and kill” spinosad-baited spheres in onion fields.

We realize that any efficacy afforded by this technique would not be a stand-alone method to combat onion maggot in high-infestation production areas. Ultimately however, when combined with other techniques such as insecticide seed treatments, an environmentally friendly and sustainable production system can be approached.
OBJECTIVES:
1) Determine the optimum rate of spinosad to use in baited spheres for onion maggot fly control
2) Assess the efficacy of spinosad-baited spheres over the course of the growing season
3) Evaluate performance of project through discussions with the NY onion industry as well as with other extension entomologists who work with onion maggot

PROCEDURES:

Objectives 1 and 2. Both objectives will be addressed in the same experiment. The optimum rate of spinosad to incorporate into baited spheres that will provide the highest level and greatest duration of lethality against onion maggot (16 weeks) will be identified. Based on preliminary results, we will use large, white, spinosad-baited spheres. Spheres will be hung 18 inches above the ground and placed along field edges. This experiment will be conducted in commercial onion fields in western and eastern NY known to have high onion maggot pressure. Two rates of spinosad-baited spheres (0.5 and 1.0% spinosad) and a sphere containing no insecticide (control) will be examined. This rate range was chosen based on a considerable amount of previous research with onion maggot. Spheres will be deployed in mid May and remain for either 1, 2, 3 or 4 months. This experiment will be designed as a factorial with spinosad (2 rates plus control) and duration in field (1, 2, 3 or 4 months) as main plot factors (3 x 4 = 12 treatments) each replicated 6 times (72 spheres total).

To assess lethality, each sphere collected from the field will be placed into a screen-meshed cage containing 20 seven-day old flies (1:1 sex ratio). All cages will include a protein/sugar diet source and water will be provided. Mortality will be recorded after 72 hours (time that best represents final mortality in previous research). Onion maggot flies from a colony established from field-collected maggots in 2006 will be used. Rainfall levels will be recorded at each site as well.

Although the procedure described above will provide information on lethality of the spheres against onion maggot flies through the season, it does not provide direct evidence of how many naturally occurring flies may be killed in the field using this technology. Past studies have attempted to address this question by placing sticky boards underneath the sphere to “retrieve” the dead flies. Unfortunately, spinosad lacks quick knock down activity; flies that ingest a lethal dose may not die for hours or even days later. Alternatively, white sticky cards (same area as baited spheres) will be placed in the field and we can infer that all flies stuck to the spheres would have fed on the bait. Mortality then can be estimated by multiplying the number of onion maggot flies captured on the spheres by the % mortality of flies for each collection period.

Objective 3. Results of this project will be discussed frequently with onion growers, CCE educators, other onion industry personnel and extension entomologist colleagues who work with onion maggot. These discussions will occur informally as well as at onion twilight meetings, onion industry council meetings, NY Fruit &Veg EXPO and in Extension newsletters.
RESULTS AND DISCUSSION

Spinosad-baited spheres killed onion maggot flies and this novel management tool could be deployed to reduce fly populations in commercial onion fields. Mean percent fly mortality (both sexes combined) was not affected by either concentration of spinosad or by the duration spheres were placed in the field (Figure 1). Pooling results across all spinosad treatments, the season average mortality for flies visiting one sphere was estimated to be 55%.

Figure 1. Onion maggot fly mortality after exposure to insecticide-baited spheres deployed using a rate of 0.5% or 1.0% spinosad in spheres placed along onion field edges for up to 4 months in Elba, NY.

Separating mortality by sex indicated that although females were not affected by duration spheres were placed in onion fields, males were affected (Figure 2). Mortality of males was greatest after 1 and 3 months of exposure in the field (Figure 2).

Figure 2. Onion maggot female and male mortality after exposure to spinosad-baited spheres that were hung along onion fields for up to 1 to 4 months.
We noticed that mortality of flies exposed to treated spheres that had been in the field for two months was numerically lower for females and significantly lower for males than the other time periods (Figure 2). A likely explanation for this observation is that there was a lot of rain during the second month (Figure 3). According to the manufacturer of these treated spheres, a reduction in efficacy may occur after treated spheres are exposed to 5 inches of cumulative rainfall. Similar observations have been observed with other fly species. During the second month of our study, 5 inches of rainfall had accrued (Figure 3). According to the manufacturer, mortality of flies encountering these spheres will increase again after this drop because the toxicant eventually becomes more available. We observed this trend in our study (Figure 2).

Figure 3. Total amount of rainfall in Elba, NY in 2006.

The total number of female and male onion maggot flies captured on white sticky cards (same color and area as sphere) was greatest during the second month of the study compared with any of the other months (Figure 4). More males were attracted to the cards than females (Figure 4).

Figure 4. Mean number of onion maggot flies captured per sticky card.
This information then was multiplied by the percent mortality of flies exposed to spheres during each time period to estimate the mean number of onion maggot flies that would be killed by a single spinosad-baited sphere during an onion-growing season (Figure 5). We predict that a single sphere would kill a total of 182 flies (81 percent males and 19 percent females).

**Figure 5.** Estimated mean number of onion maggot flies killed by a single spinosad-baited sphere during the 2006 growing season.

Spinosad-baited spheres appear to be an excellent alternative to spraying broad-spectrum insecticides for onion maggot fly control. This management tactic is safe to the user and environment and each sphere dispenses only a small quantity of a bio-based insecticide. Potentially, this technology could replace the use of a broad-spectrum insecticide on over 1,000 acres of onions in New York alone. Although we do not anticipate that this technology would replace all insecticide use targeting the onion maggot, it could supplement the at-plant insecticide that is used for maggot control in fields where this pest is a severe problem. We also suspect that these spheres will control seedcorn maggot flies, *Delia platura*, a sporadic pest of onion.

Results from this experiment have been presented to Cornell Cooperative Extension Educators at the New York Food and Agriculture In-Service Vegetable Session in Ithaca, NY, the Pacific Northwest onion industry at the Pacific Northwest Vegetable Association Annual Meeting in Pasco, WA and to the onion industry in Quebec at a regional vegetable growers annual meeting in St. Remi, Quebec.

The next phase of this project requires demonstration that deployment of these spheres can reduce onion maggot damage to onion plants in the field. Our intention is to answer this question in 2007. Demonstration of onion maggot damage reduction will be important for this technology to be accepted by onion growers and for the manufacturer to market them.
**Useful Photographs:**

Spinosad-baited spheres after various periods of exposure in a commercial onion field in Elba, NY in 2006.

[Image of Spinosad-baited spheres after various periods of exposure]

- **1 month** (mid May to mid June)
- **2 months** (mid May to mid July)
- **3 months** (mid May to mid August)
- **4 months** (mid May to mid Sept)

Onions killed by onion maggot, *Delia antiqua*.

[Image of onions killed by onion maggot]

Onion maggot larvae.
Onion Maggot Life Cycle

*37 - 60+ days total

Adult - Lives 2 to 4 weeks

Egg - Lays hundreds of eggs
   - Hatch in 2 to 5 days

Puparium - In soil for 2 to 4 weeks

Larva - Feeds for 2 to 3 weeks