Final Project Report to the NYS IPM Program, Agricultural IPM 2002-2003

TITLE: ONION MAGGOT AND SEED MAGGOT MANAGEMENT IN ONION USING INSECTICIDE-TREATED SEED

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TYPE OF GRANT: Pheromones; biorationals; microbials; conventional pesticides

PROJECT LOCATIONS: Research is applicable to locations where onion is grown.

ABSTRACT:

Novel seed treatment chemistries that provide a high level of onion maggot and seed maggot control in onion were investigated. Laboratory experiments were conducted to evaluate how well seed treatments protected the onion plant from onion maggot when plants were infested at varying ages with varying densities of maggots. Younger onion plants tended to be more likely to be killed or damaged by onion maggots than older ones. Plants also were more likely to be killed at onion maggot densities of 5 and 10 eggs per plant than at a density of 2 eggs per plant. With the exception of cyromazine (Trigard), all seed treatments reduced the overall percentage of onion plants killed by onion maggot. Although spinosad (SpinTor) and fipronil (Icon or Mundial) were not effective against onion maggot when plants were 2-weeks old, they reduced the percentage of plants killed by maggots when plants were older (4 to 8 weeks). Thiamethoxam (Cruiser) provided the best protection from onion maggots when plants were young (2 to 4 weeks old), but efficacy waned as plants got older. All of these chemistries were effective against seed corn maggots, although cyromazine was the weakest. In the field, spinosad, fipronil and GUS-I (experimental product) provided the best protection of the onion crop from onion maggots, whereas cyromazine and thiamethoxam also provided an acceptable level of control. Onion maggot control using cyromazine failed in laboratory, but worked well in the field. Thus, more research is needed to identify the factors and mechanisms responsible for this disparity. Commercially applied formulations of fipronil provided excellent control of onion maggot in three major onion-growing areas in NY, indicating that fipronil will be an effective tool for onion maggot control when it becomes commercially available. Additional studies are required to evaluate fipronil and other seed treatments for controlling seed maggot infestations.

BACKGROUND AND JUSTIFICATION:

Onion maggot, *Delia antiqua*, constrains onion production in New York because infestations are likely to cause significant economic injury if not controlled, and control has become unpredictable due to insecticide resistance. Onion maggot will commonly reduce stands of untreated onions by 20 to 60%, and levels above 90% in portions of fields have been reported. Seed maggots, which include the seedcorn maggot, *Delia platura*, and bean seed maggot, *D. florilega*, infest onion only sporadically, but can be devastating to the crop. Onion maggot and seed maggot may feed on several seeds and/or plants during its lifetime. Seed maggots can be present in the soil feeding on organic matter or cull onions before the crop is planted. In New York, there are three generations of onion maggot and 2-3 generations of seed maggot per season. Onion maggot and seed maggot adults become active in May and late April, respectively, and the first generation of each pest is the most damaging. High infestations of onion maggot often occur in non-rotated onion fields, whereas high seed maggot infestations often are associated with conventionally managed fields in which organic material is actively decaying (e.g., green or animal manure). Thus, the risk of a severe onion maggot infestation can be minimized by rotating onion to fields at least one mile from fields planted to onion the previous year, while seed maggot infestations can be reduced by not planting the crop into fields that have recently had animal manure amendments or after cover crops have been incorporated. However, rotation is not always possible and damaging populations of seed maggot also occur when weather conditions are cool and wet and the soil is poorly drained. In these commonly encountered situations, the risk of losing the crop to either onion maggot or seed maggot infestations is minimized using an insecticide in-furrow at planting or planting cyromazine-treated seed.

The only products labeled for controlling onion maggot in New York onion fields include chlorpyriphos (organophoshate) and cyromazine (triazine), whereas only chlorpyriphos is recommended for seed maggot control. Organophosphates may not be available in the near future as a result of FQPA. Moreover, there is concern about the effects that existing levels of organophosphate usage in vegetable crops have on human health and the environment. Therefore, it is not only important to identify biorational insecticides that are effective for onion maggot and seed maggot control, but an alternative approach for managing seed maggot that requires less active ingredient. The emerging technology of pelleting or film-coating seed with small quantities of a biorational product appears to be a solution. For example, onion seed treated with cyromazine (an insect growth regulator) reduced the amount of insecticidal-active ingredient required to control onion maggots by 85%. Currently, a significant portion of the onion acreage in New York is planted with cyromazine-treated seed. Yet, it is perceived that cyromazine is not effective for controlling seed maggots. As a result, many onion fields are also treated with chlorpyriphos in-furrow at planting. This management approach will likely accelerate resistance development in onion maggot populations to both products.

The goal of this research is to evaluate novel insecticide seed treatments for controlling onion maggots and seed maggots in onion. Information concerning how survival of onion plants are affected by maggot density and plant age at which time plants are attacked is critical for understanding the advantages and limitations of insecticide seed treatments.

OBJECTIVES:

1. To determine the duration of efficacy of novel insecticides used as seed treatments for control of onion maggot and seed maggot in the laboratory.
2. To evaluate efficacy of novel insecticides used as seed treatments for control of onion and seed maggots in the field.
3. To evaluate this project, the most effective seed treatments will be evaluated on a large scale in commercial fields.

PROCEDURES:

Experiments were conducted separately for onion maggot and seed maggot. For laboratory experiments, onion maggot and seedcorn maggot colonies were established from feral populations originating from Potter, NY (2001) and Ontario, Canada (2001), respectively. In the field, only experiments with onion maggots were conducted. For all experiments, onion seeds (var. 'Millenium') were treated with insecticides using a film-coating technique.

Objective 1. Experiment 1. Survival of onion plants infested by onion maggots was evaluated when plants where infested at varying ages with varying densities of maggots. A single, untreated onion seed was planted in a 2 in. x 2 in. plastic pot (=experimental unit) filled with muck soil from a nearby commercial farm. When seedlings were 2, 4, 6 and 8 weeks old, they were infested one time with either 2, 5 or 10 eggs per plant. The experiment was designed as a 4 (seedling age) x 3 (egg density) factorial arranged in a RCBD replicated 20 times. Plants were recorded as live, dead or damaged within 8-9 d after infestation. Data were analyzed using an ANOVA procedure for binomial data (PROC GENMOD of SAS at $P<0.05$).

Experiment 2. Protection of the onion plant from onion maggots using insecticide seed treatments was evaluated when plants were infested at varying ages. Seed treatments included spinosad (SpinTor 2SC), fipronil (Mundial or Icon), thiamethoxam (Adage or Cruiser), a experimental product (GUS-I), and the industry standard, cyromazine (Trigard 75WP). Lorsban 4E was the only non-seed treatment evaluated and it was applied in each pot as a drench in furrow during planting at a rate of 1.1 fl oz/1,000 row-ft. Plants were grown as described above. When seedlings were 2, 4, 6 and 8 weeks old, they were infested one time with 2 eggs per plant. The experiment was designed as a 4 (seedling age) x 5 (insecticide treatment) factorial plus an untreated control arranged in a RCBD replicated 20 times. Data were collected and analyzed as described above.

Experiment 3. Survival of onion plants grown from insecticide-treated seed was evaluated after plants were infested with seed corn maggots. Seed treatments were similar to those evaluated in Experiment 2, but included imidacloprid (Gaucho 600). Plants were grown as described above. When seedlings were 2 weeks old, they were infested one time with 10 eggs per plant. The experiment had 8 treatments plus an untreated control arranged in a RCBD replicated 16 times. Data were collected and analyzed as described above.

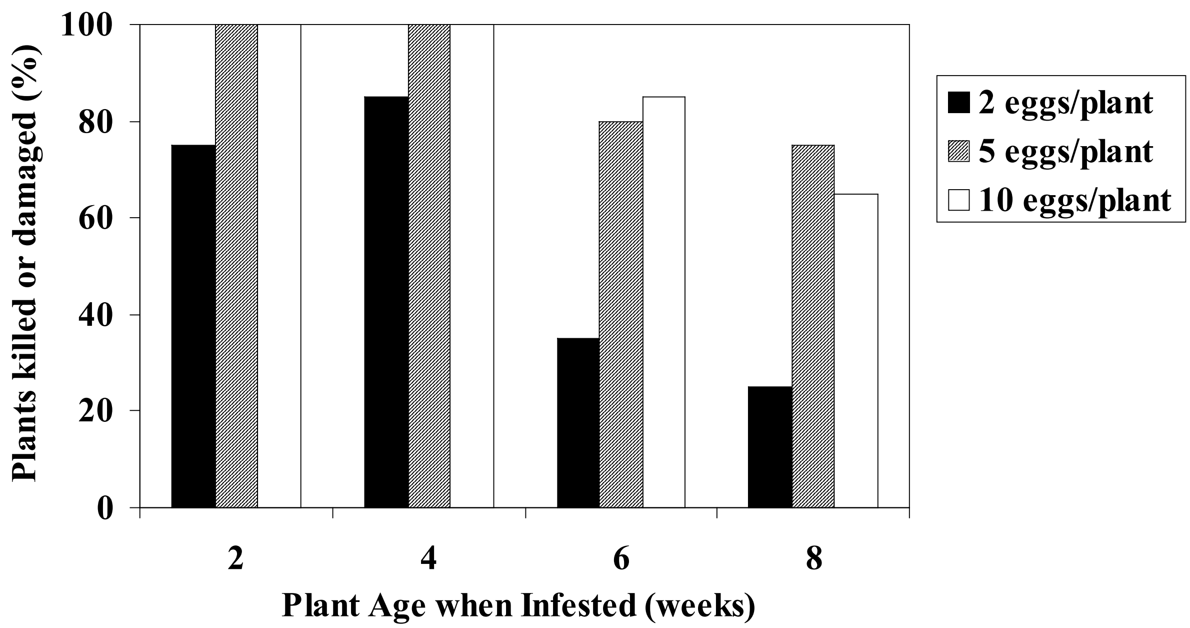
Objective 2. Experiment 4. This study was conducted in a commercial onion field in Yates Co. and in Orange Co., NY. Each plot was a single 20-ft-long row spaced from other rows by approximately 15 inches. There were 5 to 7 seed treatments and an untreated control arranged in a RCBD replicated 6 times. Number of plants in each plot was recorded periodically to identify 100% plant stand. Seedlings containing maggot larvae or those clearly damaged by maggots (but larva not present) were recorded as damaged and then removed from the plot. Sampling for damage ceased when the first larval generation was completed in late June to early July. Maggots were collected periodically from onions during the season, reared to adult and then identified to ensure that maggots encountered were onion maggots.

Objective 3. Experiment 5. This study was designed to evaluate commercial formulations of fipronil-treated onion seed to control onion maggot. Identification of the best formulation will lead to a formulation that will be commercialized for use in NY. Experiments included a number of varieties and formulations **(see Table 3)** that were evaluated in commercial onion fields in Orleans, Oswego and Orange Counties. Plot size, data collection and analyses were identical to the experiments described in Objective 2.

RESULTS AND DISCUSSION:

Experiment 1. The percentage of untreated onion plants killed or damaged by onion maggots was affected by an interaction between egg density and the age at which time plants were infested (χ^2 = 5.51; df= 1; P=0.0189) **(Figure 1).** Percentage of untreated plants killed or damaged by onion maggots decreased as plant age at the time of infestation increased. The percentage of plants killed by onion maggot tended to be greater at densities of 5 and 10 eggs per plant than at a density of 2 eggs per plant. These results indicate that the onion plant becomes inherently more resistant to attack by onion maggot as it becomes older, but that this defense may be overcome when onion maggot pressure is high.

FIGURE 1. Mean percentage of untreated onion plants killed or damaged by onion maggots, *Delia antiqua*, in a laboratory assay in 2002. Plants varied in age at the time they were infested with varying densities of eggs (n = 20 plants).

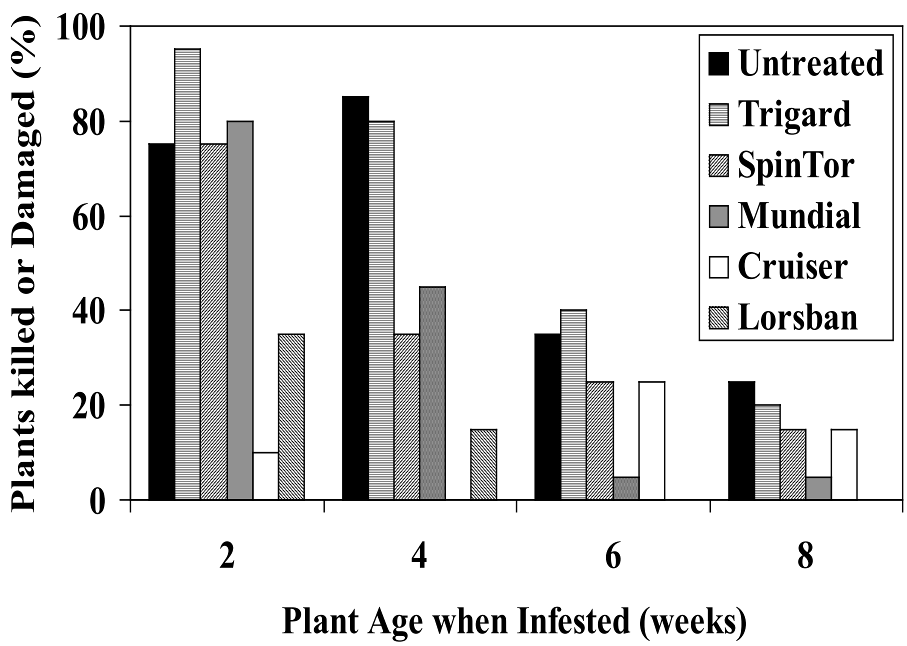


Experiment 2. The percentage of onion plants killed or damaged by onion maggots was affected by an interaction between the insecticide treatment and plant age at which time plants were infested (χ^2 = 28.13; df= 5; P<0.0001) **(Figure 2).** In general, the percentages of plants killed or damaged in all treatments, except Cruiser, decreased as the age of the plant at the time it was infested increased. The percentage of dead or damaged plants did not differ between plants grown from untreated seed and Trigard-treated seed, regardless of plant age at time of infestation. This trend was initially similar for SpinTor- and Mundial-treated seed (2-week old plants,) but plant death and damage in these seed treatments was significantly lower than that

observed in the untreated control for plants > 2 weeks old. Plants damaged in the Lorsban treatment decreased considerably as plant age at the time of infestation increased. In contrast, percentages of plants killed or damaged by maggots in the Cruiser treatment were much lower than all other treatments when plants were infested at 2 to 4 weeks old. This level of control by Cruiser waned when plants were infested at 6 to 8-weeks old.

Overall, there was a greater level of plant mortality and damage in this laboratory experiment than in field experiments. Perhaps, densities of onion maggot eggs in our lab studies were too high. Alternatively, survival of neonates may be much greater in the laboratory than in the field. Results from this experiment indicate that Trigard would not be an effective seed treatment for managing onion maggot. Yet, this product is highly effective in the field. More research is needed to understand the factors and mechanisms responsible for Trigard's effectiveness in the field and not in the laboratory. SpinTor and Mundial protected the onion plant when plants were infested beyond 2-weeks, whereas Cruiser was the most effective early (first 4 weeks). Perhaps, the high solubility and systemic activity of Cruiser was responsible for the results. The efficacy of Lorsban appeared to improve as the age of the plant at which time plants were infested increased. The population of onion maggots used in this experiment is partially resistant to Lorsban, explaining why it did not provide better protection.

FIGURE 2. Mean percentage of onion plants grown from insecticide-treated seed that were killed or damaged by onion maggots, *Delia antiqua*, in a laboratory assay in 2002. Plants varied in age at the time they were infested with 2 eggs per plant (n = 20 plants).



Experiment 3. All insecticide treatments reduced the percentage of onion plants killed by seed corn maggots **(Table 1)**. Only 0 to 6% of plants were killed in the Lorsban, Gaucho, Adage, GUS-I, SpinTor and Mundial treatments, whereas more were killed in the Trigard treatment (19%). Trigard is not believed to control seed maggot infestations in commercial onion fields. Trigard appears to have activity against seed corn maggots in the laboratory, but infestation levels in the field may be too high for this product to be effective. More research is needed to identify the best seed treatments for controlling seed maggot infestations in the field.

TABLE 1. Mean percentage of onion seedlings grown from insecticide-treated seed that were killed by seed corn maggots, *Delia platura*, in a laboratory assay in 2001 (n= 16 plants).

Treatment	Chemical name	Rate	% Plants Killed by Maggots
Lorsban 4E	chlorpyriphos	1.1 oz product/ 1,000 ft	6
Trigard 75WP	cyromazine	50 g [a.i.]/ kg of seed	19
Gaucho 600	imidacloprid	50 g [a.i.]/ kg of seed	0
Adage	thiamethoxam	50 g [a.i.]/ kg of seed	0
GUS-I	experimental	10 g [a.i.]/ kg of seed	6
GUS-I	experimental	30 g [a.i.]/ kg of seed	6
SpinTor 2SC	spinosad	25 g [a.i.]/ kg of seed	6
Mundial	fipronil	25 g [a.i.]/ kg of seed	0
Untreated		-	81

Experiment 4. In Yates Co. the onion maggot infestation level was very high, while the one in Orange Co. was moderate. All seed treatments protected the onion crop from onion maggot infestations **(Table 2)**. In Yates Co., all seed treatments provided significantly better control of onion maggot than the standard organophosphate insecticide, Lorsban. The standard practice of using both Lorsban and Trigard was effective in managing onion maggots. The onion maggot population at this location was partially resistant to Lorsban, explaining why it was not more effective. In both locations, SpinTor, Icon and GUS-I protected the crop from onion maggot as good or significantly better than Trigard and Cruiser.

TABLE 2. Mean cumulative percentage of onion seedlings killed by onion maggots, *Delia antiqua*, in commercial onion fields in Yates Co and in Orange Co. New York in 2002.

			Mean Cumulative % Plants Killed by Maggots[1]	
Treatment	Chemical	Rate	Yates Co.	Orange Co.
Untreated	-	-	57.4 a	18.8 a
Lorsban 4E	chlorpyriphos	1.1 oz product/ 1,000 ft	27.6 b	-
Cruiser	thiamethoxam	50 g [a.i.]/ kg of seed	9.5 c	5.5 b
Trigard 75WP	cyromazine	50 g [a.i.]/ kg of seed	6.8 c	3.0 bc
Trigard + Lorsban 4E	cyromazine + chlorpyriphos	50g [a.i.]/ kg of seed + 1.1 oz product/ 1,000 ft	3.6 cd	-
GUS-I	experimental	50 g [a.i.]/ kg of seed	3.2 cd	1.4 c
SpinTor 2SC	spinosad	25 g [a.i.]/ kg of seed	1.1 d	1.8 c
Icon	fipronil	25 g [a.i.]/ kg of seed	1.1 d	1.6 c

[1] Means within a column followed by the same letter are not significantly different ($P > 0.05$; Fisher's Protected LSD). Data were transformed by either an arc sin square root or a square root function before analysis, but untransformed means are presented.

Experiment 5. Onion maggot pressure was very high in Oswego Co. (over 50% loss in untreated plots), high in Orleans Co. (about 30% loss in untreated plots) and low in Orange Co. (< 10% loss in untreated plots). Fipronil applied in different coatings, formulations and proximity to the seed provided good control in Orleans (3% loss due to onion maggot – average of all Fipronil treatments) and Orange Counties (< 1% – average of all Fipronil treatments) **(Table 3)**. Under the severe maggot pressure in Oswego, there was 10% loss due to onion maggot – average of all Fipronil treatments. Further research is warranted on Fipronil for control of onion maggot, especially under high pressure. For comparison, ICON film coated treatments from Taylor's lab in 2002 from multiple locations had only 1% damage due to onion maggot.

Table 3. Mean cumulative percentage of onion plants killed by onion maggots, *Delia antiqua*, in commercial onion fields in Oswego Co., Orleans Co. and Orange Co., New York in 2002.

Coating with treatment[1]	Mean Cumulative % Plants Killed by Onion Maggots		
T-Coat	**Oswego**	**Orleans**	**Orange**
1. Pro-Gro	61	27	7
2. Icon next to seed	10	7	1
3. Icon next to seed w/ Celgard film coat	6	2	0
4. Mundial next to seed	6	3	0
5. Icon layered in pellet	13	4	3
6. Mundial layered in pellet	22	0	4
Red Racer			
7. Pro-Gro	56	39	12
8. Icon next to seed	4	5	1
9. Icon next to seed w/ Celgard film coat	4	2	0
10. Mundial next to seed	2	3	0
Prism			
11. Pro-Gro	53	24	5
12. Icon next to seed	18	2	1
13. Icon next to seed w/ Celgard film coat	14	3	1
14. Mundial next to seed	17	1	1
Film Coat			
15. Pro-Gro	63	32	4
16. Icon next to seed	11	4	0
17. Mundial next to seed	7	2	0

[1] Icon or Mundial applied at 25 g ai / kg seed by STI (Sun Seeds) in Salinas, CA.
All treatments received Pro-Gro at the labeled rate of 20 g ai / kg seed.