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

TITLE: A New Approach for Detecting Insecticide Resistance in Onion Maggot Populations

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TYPE OF GRANT: Monitoring, forecasting, and economic thresholds

PROJECT LOCATIONS: Research was conducted in several of the major onion growing regions in NY; therefore, results are applicable throughout NY and perhaps the eastern US.

ABSTRACT:

The goal of this research is to develop a rapid assay for identifying insecticide resistance in onion maggot populations. Development of an assay in which larvae can be tested for resistance to insecticides ultimately will be used to predict controllability of onion maggot infestations in the field. In 2002, chlorpyriphos (Lorsban) was evaluated for managing onion maggot infestations in 12 commercial onion fields, which represented regions in eastern, central and western New York. Control differed considerably among fields in each of these regions. Lorsban tended to provide acceptable onion maggot control only when infestation levels were low to moderate (<20% plants killed in untreated control). Although populations have not yet been tested for Lorsban resistance using the new assay, we suspect that high infestations of onion maggot (>20% plants killed in untreated control) are resistant to Lorsban based on limited data using the old assay (target adults). Additionally, results from field experiments in 2001 and 2002 suggest that if an onion maggot infestation in a non-rotated onion field is not controlled effectively using Lorsban, then it is unlikely that Lorsban will effectively control it the following season. For this reason, we believe that onion maggot populations are relatively localized.

BACKGROUND AND JUSTIFICATION:

Onion maggot, *Delia antiqua*, continues to be a major pest of most onion fields in New York. Perennial use of insecticides, especially chlorpyriphos (Lorsban 4E), in onion fields will increase the likelihood that onion maggot populations will become resistant to this important crop protectant. Because Lorsban and cyromazine (Trigard 75WP) are the only labeled products for onion maggot control, the loss of either product to resistance makes long-term management of this pest increasingly difficult. In general, rotating insecticides belonging to different classes

of chemistry will likely delay resistance development and make onion maggot control more reliable. Monitoring the susceptibility of onion maggot populations to insecticides will enable an effective product to be selected. Because selection of an insecticide must be made before planting, the onion maggot population will have to be evaluated for susceptibility to insecticides the preceding year. For this approach to work, onion maggot populations must be relatively localized in onion fields such that the level of control can be predicted the preceding year.

In the early 1990s, an assay was developed in Canada and later modified to detect Lorsban resistance in onion maggot adults. This assay requires female flies to be treated with a dose of Lorsban that will kill most susceptible individuals while allowing most resistant ones to survive. Although this assay works, there are operational constraints. The procedure is quite labor-intensive, time consuming and requires a high level of expertise to perform the experiments. The assay is designed for use only with adults; however, the larval stage is the stage that is targeted in the field. Perhaps most importantly, it is not known how accurately the results from this assay can be used to predict control of onion maggot infestations in the field. Thus, the goal of this project is to develop an assay in which larvae rather than adults can be tested for resistance to Lorsban and that the assay can be used to predict field-level control.

OBJECTIVES:

1. To identify insecticide dose-larval mortality relationships for chlorpyriphos and onion maggot populations using a laboratory assay.

2. To determine field-level control of these onion maggot populations.

3. To relate larval mortality in the laboratory assay to mortality in the field to predict field-level control using the laboratory assay.

4. To evaluate this project, the predictability of resistance in onion maggot populations will be evaluated in commercial onion fields.

MATERIALS AND METHODS

Objective 1. Experiment 1**.** (Research is in progress). Log dose-larval mortality relationships will be determined for seven onion maggot populations collected in 2002 and for a known Lorsban-susceptible colony. To do this, 7-d old larvae (2^{nd} instars) will be subjected to a range of doses of Lorsban using a dip assay. Ten larvae will be submerged into a solution containing the Lorsban for 1 minute after which time they will be placed into a plastic cup containing a small amount of artificial, wheat-germ-based diet. The number of live and dead larvae will be recorded after 24 h. Data will be analyzed using Polo to describe the log dose – mortality relationships. From these results, a discriminating dose of Lorsban that kills 99% of the susceptible insects will be identified.

Objective 2. Experiment 2. Control of onion maggot infestations using Lorsban was evaluated in 12 commercial fields in 2002. Three to six fields were selected in each of three major onion-growing regions in New York (East: Orange Co.; Central: Yates, Wayne and Oswego Cos.; West: Orleans and Livingston Cos.). Fields with and without a history of high onion maggot pressure were selected. Within these fields, small plots were established with the following treatments: Lorsban 4E, cyromazine-treated seed (Trigard 75WP) plus Lorsban (=standard practice) and fipronil-treated seed (Icon). The experiment included 3 treatments plus

an untreated control and was arranged as a RCBD replicated 4 times. Lorsban was applied as a drench in furrow during planting at a rate of 1.1 fl oz/1,000 row-ft. The number of seedlings killed by onion maggot was recorded weekly until the first generation was completed. Colonies of maggots were established from seven of these fields for experiments described in Objective 4.

Experiment 3. Control of onion maggot infestations using Lorsban was evaluated in the same three non-rotated commercial onion fields in 2001 and 2002. The procedure described above was followed.

Experiment 4. Onion maggot colonies were set up from the same field in Yates Co. in 2001 and again in 2002 and examined for resistance to Lorsban using an assay targeting adults (old assay). Only females were used in the study and groups of 10 flies were subjected to a topical application of Lorsban at rates of 250 and 500 ppm using the Potter Spray Tower. Mortality of flies was recorded after 24 h. Adults were considered susceptible if more than 60% died at the 250 ppm dose and many more died at the 500 ppm dose. In contrast, adults were considered resistant if less than 60% died at the 250 ppm dose and some survive at the 500 ppm dose. Mortality in Lorsban treatments was adjusted for low levels of mortality in the untreated control using Abbott's (1925) formula.

Objectives 3 and 4. Experiment 5. In order to use results from the larval assay to predict field-level control of onion maggot infestations using Lorsban, the relationship between level of mortality in the lab bioassay and control in the field must be described. This will be achieved using linear and/or non-linear regression analysis. The predictability of resistance in onion maggot populations to chlorpyriphos using the assay will be evaluated. Because maggot populations are localized, maggots will be tested in the fall to predict controllability in the spring.

RESULTS AND DISCUSSION

The larval assays are currently underway, so only results from Experiments 2, 3 and 4 will be discussed. In all field experiments, onion maggot was responsible for the plant damage.

Experiment 2. There was a wide range in percentage of untreated plants killed by onion maggot in commercial fields (0 to 57% of plants killed) **(Table 1).** Two fields had no reduction in plant stand by onion maggots. One of these fields is isolated by over 60 miles from other onion fields and no cull piles are located near the field. The other field has been recently rotated with potato. Fields with high onion maggot damage have not been rotated within > 5 yr. These results indicate that onion maggot pressure can vary among fields, even within the same growing region.

Plant stand loss in Lorsban-treated plots also varied among fields and correlated positively with stand loss in untreated plots ($R^2 = 0.81$). Percentage reduction of plant stand using Lorsban was as high as 91% (low maggot pressure) and as low as 21% (high maggot pressure). Trigard only/Trigard plus Lorsban and Icon significantly reduced the percentage of plants killed by onion maggot, regardless of the level of onion maggot pressure. Correlations between percentage of plants killed in untreated plots and those treated with either Trigard only/Trigard plus Lorsban or Icon were weakly positive ($R^2 = 0.52$ and 0.30, respectively). These results suggest that Lorsban does not provide acceptable control of onion maggot when infestation levels are moderate to high (>20% plants killed in untreated control). Moreover, high infestations of onion maggot also appear to be resistant to Lorsban.

Table 1. Mean cumulative percentage of onion seedlings killed by onion maggot, *Delia antiqua*, in commercial fields in New York in 2002.

		Mean Cumulative Plant Stand Loss (%)[1]			
Region	**Location**	**Untreated**	**Lorsban 4E**	**Lorsban 4E + Trigard**	**Icon**
East	**Orange-1**	32.6 a	25.0 a	4.5 b	2.5 b
	Orange-2	19.5 a	4.7 b	1.2 b	0.9 b
	Orange-3	11.7 a	6.5 ab	1.6 b	0.6 b
Central	**Yates**	57.4 a	27.6 b	3.6 c	1.1 c
	Wayne-1	46.6 a	24.4 b	11.0 c	1.5 d
	Oswego-1	33.8 a	26.7 a	8.4 b	0.2 c
	Oswego-2	19.3 a	8.2 ab	2.4 bc	0.6 c
	Oswego-3	14.5 a	1.3 b	0.1 c	0.0 c
	Wayne-2	0	0	0	0
West	**Orleans-1**	22.6 a	10.7 ab	1.8 b	1.7 b
	Orleans-2	20.3 a	4.7 b	3.5 b	1.1 b
	Livingston	0	0	0	0

[1] Means within a row followed by the same letter are not significantly different ($P > 0.05$; LSMEANS).

Experiment 3. Plant stand loss as a result of onion maggot feeding in untreated plots in commercial onion fields in Yates and Oswego Counties was similar in 2001 and 2002 (**Table 2**). In Wayne Co., seedling loss in 2002 was greater than in 2001. Although the use of Lorsban significantly reduced damage by onion maggots in all but one field, the level of control using Lorsban was not economically acceptable in the Yates Co. and Oswego Co. fields in 2001 or 2002. In contrast, Lorsban was effective in the Wayne Co. field in 2001, but not in 2002. These results may have resulted from use of Lorsban in 2001 and again in 2002. Trigard, with or without Lorsban, and Icon effectively controlled onion maggot in all fields in both years. Based on these results, if an onion maggot infestation in a non-rotated onion field is not controlled effectively using Lorsban, then it is unlikely that Lorsban will effectively control it the following season. These results also suggest that onion maggot populations are relatively localized between seasons.

Table 2. Mean cumulative percentage of seedlings killed by onion maggot, *Delia antiqua*, in the same three commercial fields in New York in 2001 and 2002.

Location	Mean Cumulative Plant Stand Loss (%)[1]					
	Yates - 2001	Yates- 2002	Oswego - 2001	Oswego - 2002	Wayne- 2001	Wayne- 2002
Untreated	53.7 a	57.4 a	31.1 a	33.8 a	25.6 a	46.6 a
Lorsban 4E	20.4 b	27.6 b	11.2 b	26.7 a	4.4 b	24.4 b
Trigard ± Lorsban 4E[2]	5.8 c	3.6 c	2.5 c	8.4 b	3.4 b	11.0 c
Icon	3.0 c	1.1 c	2.0 c	0.2 c	-	-

[1] Means within a column followed by the same letter are not significantly different ($P > 0.05$; LSMEANS)
[2] Trigard 75WP only was used in 2001, whereas Lorsban 4E was added in 2002.

Experiment 4. Mortality of onion maggot adults from the Yates Co. population was low after treatment with both rates of Lorsban in both years, indicating that flies from this population are resistant **(Table 3)**. These results indicate that the ineffective control of onion maggot in 2001 and 2002 **(Table 2)** was due to Lorsban resistance. Our results also support those mentioned earlier that onion maggot populations are likely localized.

Table 3. Mortality of onion maggot adults subjected to a topical application of Lorsban 4E.

		2001		2002	
Location	**Dose (ppm)**	**Mean % mortality**	**Classification**	**Mean % mortality**	**Classification**
Lab colony[1]	250	95	Susceptible	100	Susceptible
	500	100	Susceptible	100	Susceptible
Yates Co.[2]	250	47	Resistant	35	Resistant
	500	62	Resistant	41	Resistant

[1] Colony initiated in the 1970s from an organically grown onion field in Michigan.
[2] Colony initiated from the same onion field near Potter, NY.