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Resistance of *Thrips tabaci* to pyrethroid and organophosphorus insecticides in Ontario, Canada

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Abstract: Onion thrips, *Thrips tabaci* Lindeman, were collected from commercial onion fields in 2001, 2002 and 2003 to assess resistance to lambda-cyhalothrin, deltamethrin and diazinon. In 2001, six of eight adult populations were resistant to lambda-cyhalothrin, with resistance ratios (RR) ranging from 2 to 13.1 and four of these were also resistant to deltamethrin, with RR ranging from 19.3 to 120. Three of four adult populations were resistant to diazinon with RR ranging from 2.5 to 165.8. In 2002, four of seven nymphal populations and three of six adult populations were resistant to deltamethrin, with RR ranging from 4.3 to 72.5 and 9.4 to 839.2, respectively. Only one of six nymphal populations and one of five adult populations were resistant to diazinon, with RR of 5.6 and 2.3, respectively. In 2003 diagnostic dose bioassays, 15 of 16 onion thrips populations were resistant to lambda-cyhalothrin and all were resistant to deltamethrin. Eight of the 16 were resistant to diazinon. These results indicate that insecticide resistance is widespread in onion thrips in commercial onion fields in Ontario.

Keywords: *Thrips tabaci*; onions; insecticide; resistance; pyrethroid; organophosphate

1 INTRODUCTION

Onion thrips, *Thrips tabaci* Lindeman, are economic pests of onions, leeks, garlic and shallots worldwide.[1] In Ontario, Canada, onion thrips control has often been secondary to onion maggot, *Delia antiqua* (Meigen), control. More recently, however, the use of soil insecticides that target the larval lifestage of the onion maggot, coupled with effective adult onion maggot monitoring strategies has reduced and/or eliminated foliar sprays previously required for maggot control. Although the concept has not been empirically tested, many growers believe that foliar sprays targeting onion maggots provided ancillary control of onion thrips and that the reduction in foliar sprays has resulted in a subsequent increase in onion thrips numbers, especially during dry, hot growing seasons. As thrips numbers increased, growers initiated foliar sprays to control onion thrips. Today, growers in problem areas have moved from two to three sprays per year to upwards of eight to ten.

Nymphs, the predominant life stage throughout the growing season, congregate deep within the axils of onion leaves and are well protected from chemical control agents applied to the foliage.[2,3] Globally, this behaviour, coupled with very rapid increases in numbers under favourable conditions, is a frustration to growers.[3,4] Research on the economic impact of onion thrips damage in Canada has shown that, in the absence of any control measures, onion thrips infestations of yellow onions resulted in 43% and 34.5% yield losses during two climatically different years.[5] In the USA, research on white onions has shown that as few as 10 thrips per plant during the bulbing stage can lead to a 2–3% bulb reduction (by weight) under field conditions and up to 7% reduction under greenhouse conditions.[2]

In Ontario, four foliar insecticides are recommended for thrips management: (1) cypermethrin (Ripcord® 400EC, Cymbush® 250EC); (2) deltamethrin (Decis® 5EC); (3) lambda-cyhalothrin (Matador® 120EC) and (4) naled (Dibrom®).[6] One additional insecticide, diazinon (Diazinon® 500E), while not currently recommended, is legally registered for use on onions in Canada and is often used instead of naled by growers.

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In recent years control failures have led Ontario growers to question the efficacy of these registered insecticides.[7] Although there are no published reports of insecticide resistance in onion thrips in Ontario, resistance to pyrethroid and organophosphorus (OP) insecticides has been documented elsewhere.[8–12]

Our objective was to determine the current susceptibility of onion thrips in Ontario to lambda-cyhalothrin, deltamethrin and diazinon. To facilitate this objective, preliminary screening and diagnostic dose bioassays were performed on populations collected from various onion-growing regions across the province.

2 MATERIALS AND METHODS

2.1 Field collections

During 2001, 2002 and 2003, 36 thrips populations were collected from different onion-growing regions in Ontario and tested for insecticide resistance (Table 1; Fig 1). Every effort was made to collect populations from fields managed by the same growers every year. Unfortunately, this was not always possible. One reason for this was that all growers did not plant onions each year. For instance, in 2001, three Thedford populations, 1, 2 and 3, were collected and tested. In 2002, Thedford 2 was not tested because the grower rotated out of onions into potatoes. However, another population, Thedford 4 was collected from a grower's field who reported control failures in 2001. Population collection was also entirely dependent on grower cooperation and, unfortunately, one year cooperation did not guarantee successive year cooperation. Finally, in 2001, time constraints meant that populations could not be collected from Bradford Marsh. In 2002 and 2003, cooperation with extension staff and growers allowed for the collection and testing of populations from Bradford and Keswick Marshes.

At each site, 25–30 heavily infested onions were identified and individually pulled. Infested tops were cut from the bulb, trimmed to a length of 20 cm, placed in a labelled plastic 4.0-litre bucket and covered with a screened lid. Collections were returned to the laboratory for vial bioassay (see Section 2.4) within 24 h.

2.2 Colony strains and maintenance

In 2001, a laboratory culture (London 1) was established using adult and nymphal thrips collected from bulb onions grown at the Southern Crop Protection and Food Research Centre—Agriculture and Agri-Food Canada in London, Ontario.

Individual cylindrical acetate cages (42 × 30 × 35 cm) contained three fibre trays (27 × 16.5 × 8.5 cm; Kord Products Ltd, Bramalea, Ontario). Each tray contained approximately 7 cm of Pro Mix® growing medium (Premier Horticulture Ltée, Rivière-du-Loup, Quebec), planted with three rows of set bulb onions which were grown to a height of 30 cm under insect restrictive cover in a greenhouse. Trays of onions were then transferred to controlled environment cabinets. The trays were rotated bi-weekly through the cages; on each date the oldest tray was removed and replaced with a new tray of onions. Growth cabinets were maintained at 28 (±1)°C, 40 (±5)% RH and 16:8 h light:dark photoperiod.

In September 2001, a second laboratory culture was established from a thrips population collected from Spanish onions grown in a commercial field near Chatham, Ontario (Chatham 1 in Table 1). This colony was renamed Chatham L and maintained using the method described above.

Table 1. Locations and collection dates for onion thrips populations in Ontario during 2001, 2002 and 2003

Population[a]	Municipality	Type of farm	Collection date
2001			
Thedford 1	Lambton County	Commercial	31 July
Thedford 2	Lambton County	Commercial	15 August
Thedford 3	Lambton County	Commercial	15 August
Chatham 1	Kent County	Commercial	08 August
Chatham 2	Kent County	Commercial	08 August
Chatham 3	Kent County	Commercial	08 August
Chatham 4	Kent County	Commercial	08 August
London 1	Middlesex County	Research	30 July
Chatham L[b]	Kent County	Commercial	05 September
2002			
Thedford 1	Lambton County	Commercial	26 August
Thedford 3	Lambton County	Commercial	26 August
Thedford 4	Lambton County	Commercial	26 August
Chatham 4	Kent County	Commercial	20 August
Chatham 5	Kent County	Commercial	20 August
Chatham 6	Kent County	Commercial	20 August
Bradford 1	York Region	Commercial	26 August
Bradford 2	York Region	Commercial	26 August
Bradford 3	York Region	Commercial	26 August
Bradford 4	York Region	Commercial	26 August
London 1	Middlesex County	Research field	20 August
2003			
Thedford 1	Lambton County	Commercial	30 July
Thedford 2	Lambton County	Commercial	04 August
Thedford 3	Lambton County	Commercial	30 July
Thedford 5	Lambton County	Commercial	04 August
Thedford 6	Lambton County	Commercial	06 August
Chatham 7	Kent County	Commercial	19 August
Chatham 8	Kent County	Commercial	19 August
Chatham 9	Kent County	Commercial	19 August
Bradford 1	York Region	Commercial	27 August
Bradford 4	York Region	Commercial	27 August
Bradford 5	York Region	Research	27 August
Bradford 6	York Region	Commercial	27 August
Bradford 7	York Region	Commercial	27 August
Bradford 8	York Region	Commercial	27 August
Bradford 9	York Region	Commercial	27 August
Keswick	York Region	Commercial	27 August

[a] Populations with the same name and number were collected from fields managed by the same growers.
[b] Collected from CHATHAM 1 and returned to the laboratory to be reared as a laboratory standard.

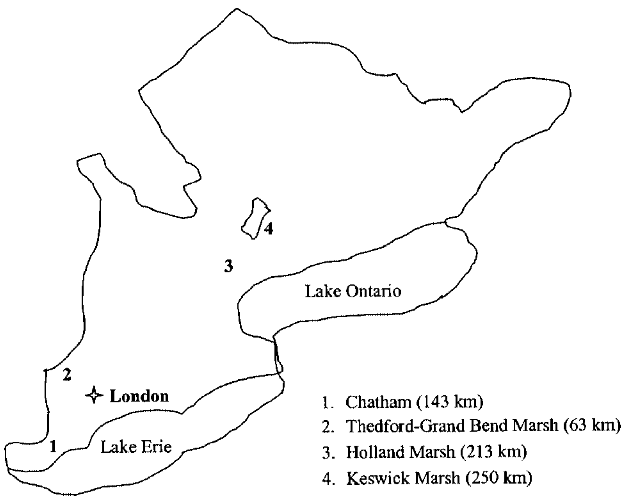

Figure 1. Map illustrating the location of four onion-growing regions in Ontario where onion thrips populations were collected for insecticide resistance testing. Distances from the London research station to each region are provided.

2.3 Insecticides

Three technical grade insecticides were evaluated: (1) lambda-cyhalothrin (98% purity, Syngenta Crop Protection Canada, Inc, Guelph, Ontario), (2) deltamethrin (99% purity, Aventis CropScience Canada, Regina, Saskatechewan) and (3) diazinon (95% purity, Syngenta Crop Protection Canada, Inc, Guelph, Ontario). Insecticides were dissolved in acetone to establish stock solutions for later dilution. In 2001, five concentrations of each of lambda-cyhalothrin (1.0×10^{-3}–5.0 mg litre^{-1}), deltamethrin (0.1–500.0 mg litre^{-1}) and diazinon (0.1–500.0 mg litre^{-1}) were tested. In 2002, five concentrations of deltamethrin (0.1–500.0 mg litre^{-1}) and diazinon (1.0×10^{-3}–100.0 mg litre^{-1}) were tested.

In preliminary resistance screening, five concentrations of each insecticide were used to determine the LC_{50}. In diagnostic dose assays, each field-collected population was exposed to the LC_{95} of the Chatham L population for each insecticide. This response level was chosen for comparison because the same level had been used for selection of discriminating and/or diagnostic doses in other resistance detection studies.[13–15]

2.4 Vial bioassays

Two types of vial bioassay were performed: (1) preliminary screening; (2) diagnostic dose screening.

Preliminary screening was performed using a technique modified from that described by Broadbent and Pree.[16] For testing, 0.5-ml aliquots of desired concentrations dissolved in acetone, were pipetted into 20-ml glass scintillation vials (Fisher Scientific, Unionville, Ontario). Control vials were treated with acetone only. Vials were rotated on mechanical rollers (APW Wyott, Dallas, Texas) to enhance evaporation and to ensure even insecticide deposition on the inner surface. Treated vials not used within 2 h were tightly capped and stored at −10 °C until needed. During this trial, all vials were used within two weeks of preparation. Prior to use, treated vials were removed from the freezer and allowed to equilibrate at room temperature for 2 h.

Dose-responses of the Chatham L population to lambda-cyhalothrin, deltamethrin and diazinon were used to identify diagnostic doses for resistance monitoring. Vials containing the diagnostic dose were prepared as described earlier. Diagnostic doses tested were 0.08, 7.55 and 68.50 mg litre^{1} for lambda-cyhalothrin, deltamethrin and diazinon, respectively. Fifty to 70 adult thrips were exposed to the diagnostic dose for each insecticide.

Bioassays were completed as follows. Approximately 10 thrips (adults or nymphs) were aspirated into each vial with three replicates tested per concentration for preliminary screening and five to seven replicates per insecticide for diagnostic dosages. Vial lids, prepared by removing and replacing the foil inner lining with a 2.2-cm diameter circle of No 3 Whatman filter paper (Fisher Scientific, Unionville, Ontario) moistened with 25 µl of reverse-osmosis water, were used to seal each vial. Vials were maintained at 24 (±)°C, 80 (±5)% RH and 12:12 h light:dark photoperiod. To reduce build-up of radiant energy inside vials, all bioassays were covered with a sheet of brown paper. Mortality was assessed after 24 h.

2.5 Analysis of data

Data were corrected for natural mortality (<10% for all cases) using Abbott's correction.[17] Regression lines, LC_{50} and 95% fiducial limits were calculated for each insecticide using PROC PROBIT (SAS V8, Cary, North Carolina). Differences in response between populations were not significant if the 95% confidence limit of the resistance ratio (RR) at the LC_{50} bracketed 1.0.[18]

3 RESULTS

3.1 Preliminary screening bioassays

3.1.1 2001 studies

Prior to collection of field populations from commercial fields in 2001, a population was collected from bulb onions grown at Southern Crop Protection and Food Research Centre and established in the laboratory as described in Section 2.2 (London 1). Since onions had been grown at this site for over 15 years with no application of insecticides for control of either onion thrips or onion maggot, it was felt that this population would serve as an insecticide-susceptible population with which other populations could be compared. However, when field populations were collected and tested, the London 1 population was not the most susceptible (Table 2), probably as a result of introduction of onion thrips on onion bulbs purchased annually from commercial producers on the Thedford–Grand Bend Marsh. As a result RR were determined using Chatham 1 for lambda-cyhalothrin and deltamethrin.

Table 2. Susceptibility to various insecticides of adult onion thrips collected from Ontario onion fields, 2001

Population	n	Slope (±SEM)	LC_{50} (mg litre^{-1})^a	95% Fiducial limits (mg litre^{-1})^b	RR^{c,d}
Lambda-cyhalothrin					
Chatham 1	153	1.2 (±0.2)	1.0	0.0–1.1	1.0
Chatham 4	142	0.5 (±0.2)	0.1	3.0×10^{-2}–0.3	0.1
Chatham 2	140	1.0 (±0.2)	2.0	0.8–6.0	2.0*
Thedford 2	140	0.8 (±0.2)	4.0	6.8–20.0	4.0*
Thedford 3	144	1.2 (±0.2)	8.0	3.8–14.5	8.0*
Chatham 3	160	1.2 (±0.2)	12.5	6.1–22.9	12.5*
Thedford 1	140	1.6 (±0.3)	13.0	8.9–20.2	13.0*
London 1	351	1.8 (±0.3)	13.1	0.8–29.8	13.1*
Deltamethrin					
Chatham 1	140	0.6 (±0.1)	10.7	3.1×10^{-2}–100.0	1.0
Chatham 2	142	0.5 (±0.1)	5.4	7.9×10^{-2}–50.0	0.5
Thedford 3	142	0.8 (±0.2)	9.9	5.9×10^{-2}–80.0	0.9
Chatham 3	141	0.7 (±0.2)	17.6	0.2×10^{-1}–90.0	1.6
Chatham 4	141	1.0 (±0.2)	207.0	30.0–590.0	19.3*
London 1	160	1.1 (±0.1)	313.0	86.1–514.2	29.5*
Thedford 2	142	0.8 (±0.4)	615.0	260.0–1237.0	57.5*
Thedford 1	148	1.2 (±0.2)	1284.0	560.0–2602.0	120.0*
Diazinon					
Thedford 1	144	0.7 (±0.2)	1.9	3.8×10^{-3}–11.0	1.0
Thedford 3	153	0.6 (±0.2)	4.8	7.2×10^{-2}–20.0	2.5*
Thedford 2	140	0.6 (±0.1)	193.8	28.0–600.0	102.0*
London 1	175	0.7 (±0.1)	315.0	130.2–623.9	165.8*

^{a,b} Lambda-cyhalothrin ($\times 10^{-3}$ mg litre^{-1}); deltamethrin and diazinon ($\times 10^{-2}$ mg litre^{-1}).
^{c} Resistance ratios (RR) calculated by dividing the LC_{50} for test strain by LC_{50} of the reference strains: Chatham 1 (lambda-cyhalothrin and deltamethrin) or Thedford 1 (diazinon).
^{d} RR followed by
* are significantly different from the reference strain.

Assay results in 2001 indicated resistance in thrips populations to lambda-cyhalothrin, deltamethrin and diazinon (Table 2). Two Chatham and all Thedford populations were significantly more resistant to lambda-cyhalothrin than Chatham 1. The most resistant population, London 1 was 13× more resistant than Chatham 1.

Significant resistance to deltamethrin also was identified. Thedford 1, 2, Chatham 4 and London 1 were all less susceptible to deltamethrin than Chatham 1.

Because of the limited availability of onion thrips for bioassay, susceptibility to diazinon was measured for only four populations. Thedford 1 was the most susceptible. All other populations were significantly more resistant to diazinon.

3.1.2 2002 studies

In 2002, a number of field-collected thrips populations were exposed to deltamethrin and diazinon (Table 3).

Significant differences in susceptibility of nymphs to deltamethrin were identified in four of seven populations tested. Bradford 3 and all Chatham populations were significantly more resistant to deltamethrin than Chatham L. Bradford 1 and 2 were significantly more susceptible to deltamethrin than Chatham L.

Significant differences also were identified in adult susceptibility to deltamethrin. Thedford 3, 1, 4 and Bradford 4 were 3.6×, 9.4×, 23.1× and 839× more resistant, respectively, to deltamethrin than Chatham L.

Only Bradford 3, one of the six field populations of nymphs screened with diazinon, was significantly more resistant than Chatham L. LC_{50} values less than that of the standard population were recorded for three populations. Similarly, only one adult population, Thedford 1, was resistant to diazinon while London 1 and Bradford 4 demonstrated LC_{50} values lower than the standard population. With Chatham L having higher LC_{50} values than some of the field populations, it may not be the most acceptable standard for diazinon testing.

3.2 Diagnostic dose bioassays

Field populations of onion thrips were considered resistant when mortality at the diagnostic dose of LC_{95} was $\leqslant$90%. Pree *et al*[13] used the same benchmark of resistance in their studies.

Bradford 9 was susceptible to lambda-cyhalothrin with 90% mortality at the LC_{95} (Fig 2). Mortalities for all other populations tested were less than 70% with Bradford 4, 5 and 8 having 0% mortality.

As mortality at the LC_{95} for deltamethrin was less than 90% for all populations tested, all were classified as resistant (Fig 2).

Eight of 16 populations exposed to the diagnostic dose of diazinon had greater than 90% mortality at

Table 3. Susceptibility to deltamethrin and diazinon of onion thrips collected from Ontario onion fields, 2002

Lifestage	Population	N	Slope (±SEM)	LC_{50} (mg $litre^{-1}$)	95% Fiducial limits (mg $litre^{-1}$)	$RR^{a,b}$
Deltamethrin						
Nymphs	Chatham L	210	1.9 (±0.4)	1.26	0.9–1.8	1.0
	Bradford 1	141	0.5 (±0.2)	0.04	1.6×10^{-3}–0.7	0.03
	Bradford 2	142	0.7 (±0.2)	0.26	3.8×10^{-3}–2.0	0.2
	Bradford 3	146	1.6 (±0.3)	5.42	2.5–9.6	4.3*
	Chatham 5	176	0.8 (±0.2)	12.04	1.4–149.4	9.6*
	Chatham 4	164	0.8 (±0.1)	62.74	25.4–148.4	49.8*
	Chatham 6	165	0.9 (±0.2)	91.38	22.8–213.8	72.5*
Adults	Chatham L	349	2.1 (±0.3)	1.40	0.9–1.7	1.0
	London 1	148	1.0 (±0.2)	2.34	0.3–6.8	1.7
	Thedford 3	164	1.6 (±0.4)	5.09	0.7–13.8	3.6
	Thedford 1	146	1.0 (±0.2)	13.10	2.8–31.0	9.4*
	Thedford 4	145	0.8 (±0.2)	32.35	8.5–77.5	23.1*
	Bradford 4	142	1.5 (±0.8)	1175.00	682–2024.0	839.2*
Diazinon						
Nymphs	Chatham L	225	1.7 (±0.5)	0.09	1.1×10^{-2}–0.8	1.0
	Bradford 1	151	0.9 (±0.2)	0.03	2.0×10^{-3}–0.1	0.3
	Chatham 4	150	0.8 (±0.2)	0.05	3.8×10^{-3}–0.2	0.6
	Chatham 6	150	1.0 (±0.2)	0.06	1.8×10^{-2}–0.2	0.7
	Bradford 2	149	1.5 (±0.4)	0.12	2.5×10^{-2}–0.3	1.3
	Chatham 5	152	0.9 (±0.2)	0.16	9.0×10^{-2}–0.6	1.8
	Bradford 3	149	0.8 (±0.2)	0.50	0.1–1.4	5.6*
Adults	Chatham L	345	1.4 (±0.5)	0.35	2.2×10^{-3}–1.3	1.0
	London 1	146	1.7 (±0.6)	0.10	1.2×10^{-3}–0.2	0.3
	Bradford 4	151	0.8 (±0.1)	0.14	3.7×10^{-2}–0.4	0.4
	Thedford 4	245	0.7 (±0.1)	0.53	0.1–1.5	1.5
	Thedford 3	256	0.8 (±0.1)	0.71	2.6×10^{-3}–16.6	2.0
	Thedford 1	148	0.9 (±0.2)	0.80	0.1–2.7	2.3*

a — Resistance ratios (RR) calculated by dividing the LC_{50} for test strain by LC_{50} of the reference strain — Chatham L
b — RR followed by
* are significantly different from the reference strain

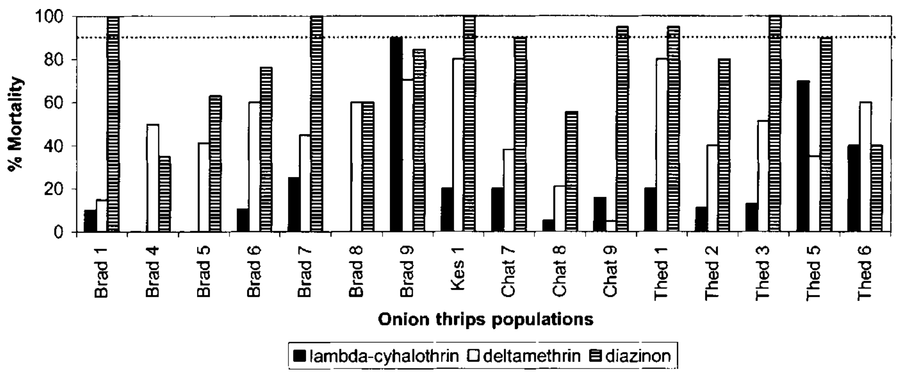

Figure 2. Mortality of onion thrips exposed to a diagnostic dose of lambda-cyhalothrin, deltamethrin or diazinon collected from Ontario onion fields, 2003. Dotted line indicates 90% mortality.

the LC_{95} (Fig 2). Bradford 4 and Thedford 6 had less than 50% mortality.

Bioassays conducted using the LC_{99} of each insecticide resulted in similar responses within populations.[19]

4 DISCUSSION AND CONCLUSIONS

Resistance management programs aim to slow the development of resistance through monitoring, modification of pesticide use, implementation of different control tactics and the preservation of susceptible genes.[20]

Our monitoring data in 2001, 2002 and 2003 showed that onion thrips have developed resistance to pyrethroid (lambda-cyhalothrin and deltamethrin) and OP (diazinon) insecticides in the major onion-growing regions of Ontario. Preliminary screening bioassays revealed significant RR ranging from 2.0 to 13.1 for lambda-cyhalothrin, 3.6 to

839 for deltamethrin and 2.3 to 165 for diazinon. Diagnostic dose bioassays revealed high survival in many populations tested with both deltamethrin and lambda-cyhalothrin substantiating the high RR previously observed in dose-response bioassays. Although screening at the diagnostic dose showed less evidence of resistance to diazinon, resistant populations were identified. It is important to note that the onion thrips populations used as a susceptible reference strain in 2001, 2002 and used to determine the diagnostic dose had been exposed to insecticides in the field. Therefore, resistance may actually be higher than observed since the reference strain may have resistance alleles due to prior selection pressure.

On a number of occasions, a given population displayed very different susceptibilities to the two pyrethroids tested. While all pyrethroids act upon the voltage-gated membrane sodium channel,[21] they are categorized into two distinct groups (type I and II) based on their poisoning symptoms.[22] Deltamethrin and lambda-cyhalothrin are both type II pyrethroids and structurally very similar, thus raising the question of why some populations had different susceptibilities. Burr and Ray[23] hypothesized that the type II syndrome was a result of action on the calcium-independent voltage-gated chloride channel. Their research found that only some of the type II pyrethroids acted on the chloride channel while none of the type I pyrethroids acted there. Deltamethrin was the most efficient pyrethroid tested in opening the chloride channels, while no significant difference in channel opening was observed between pre- and post dose in lambda-cyhalothrin treatments. These results indicate that while structurally similar, there are structure-activity differences in the way that these two pyrethroids work which may aid in explaining differences in susceptibility within a given population.

Differences also appear in bioassay data from one year to the next for a given population. It is important to note that population numbers (ie Thedford 1) indicate that populations were collected from fields managed by the same grower, not necessarily from the same field. It is, therefore, not surprising that geographically separated populations, while managed by the same grower, have different susceptibilities to the same insecticides.

Unfortunately, since only two chemical classes of insecticides are currently recommended for thrips control in Ontario, modification of pesticide use through insecticide rotation or application of mixtures is not feasible. Continued use of these insecticides will result in further selection of more resistant populations, exacerbating current control problems.

Crop rotation also can be an issue for onion growers attempting to implement a resistance management program. In Ontario, onion crops are rotated annually with carrots, celery, potatoes and Asian vegetables. In the major growing regions, however, geographical constraints limit separation of onion fields in succeeding growing seasons. Populations of onion thrips thus have continuing ready assess to onions and continuing access to the same selective agents.

Another tenet of resistance management is the dilution of resistance genes through mating of resistant with susceptible individuals. Onion thrips undergo thelotoky parthenogenesis in many parts of the world including Ontario.[24–27] Therefore, population growth is promoted by all-female offspring and not limited by the availability of males, reducing the likelihood of gene dilution and ensuring that resistant females usually produce resistant progeny.

With limited availability of management options, this research emphasizes the need for continuous monitoring for thrips resistance. Research in Central America and New York State has demonstrated that insecticide resistance can rapidly increase within a given population over the growing season.[12] Monitoring for resistance prior to application of an insecticide would enable growers to make informed decisions about which products would be more effective. With the advent of the Thrips Insecticide Bioassay System, carrying out *a priori* resistance monitoring is now a feasible option for American growers.[11,28] Evaluation of this technology under Ontario conditions would be a most useful extension of our research.

In addition to monitoring thrips populations for resistance to registered insecticides, it is important to continue monitoring to establish baseline sensitivity to future thrips control products.

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