FRESH VEGETABLE GROWERS OF ONTARIO

FINAL RESEARCH REPORT

An investigation determining the efficacy of registered and reduced-risk insecticides on tarnished plant bug in celery in southern Ontario

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This project was made possible with the support of Canada and the Province of Ontario under the Canada Ontario Research & Development (CORD) program, an initiative of the federal-provincial-territorial Agricultural Policy Framework designed to position Canada’s Agri-food sector as a world leader. The Agricultural Adaptation Council administers the CORD program on behalf of the province.
SUMMARY

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beavois) is an economically important agricultural pest in North America. It is polyphagous and is known to feed on more than 300 species of vegetables, fruits, greenhouse and field crops. In Ontario, it has been estimated that TPB damages approximately 5% of the annual fruit and vegetable crops, which is equivalent to a $12 million crop loss. Although TPB is a sporadic pest, it is present in Ontario throughout the growing season and in recent years has become an increasing problem in celery. The objectives of this study were to: 1) acquire much needed information about the biology of TPB on celery in southern Ontario; and, 2) conduct laboratory and small plot field insecticide screening to determine the efficacy of currently registered and reduced risk control products on TPB in celery.

To acquire information on TPB biology on celery, numbers were monitored in commercial celery fields during the 2007 growing season. Monitoring was initiated in late May when the first celery seedlings were transplanted into the field. Numbers were extremely low until the end of July when populations reached a threshold of 0.1 – 0.2 TPB/plant (OMAFRA 2006). Two weeks later numbers fell well below threshold and did not rise again for the remainder of the season. In laboratory and small cage studies, revealed lambda-cyhalothrin was the most efficacious product tested on both adults and nymphs, and provided the highest mortality in the shortest amount of time in both whole plant and leaf dip bioassays. Metaflumizone was the slowest acting insecticide and plants treated with it had damage levels similar to those on untreated celery plants. Thiamethoxam and endosulfan were intermediate in effectiveness. Lambda-cyhalothrin was highly effective, acting quickly, preventing TPB from seriously damaging celery plants.
INTRODUCTION

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beavois) is an economically important agricultural pest in North America. It is a sporadic pest and is present in Ontario throughout the growing season. It has a wide host range, feeding and reproducing on more than 300 species of vegetables, fruits, greenhouse and field crops, and a number of weeds and native species of Ontario (Howard et al. 1994, Broadbent et al. 2002). In Ontario, it has been estimated that TPB damages approximately 5% of the annual fruit and vegetable crop, which is equivalent to a $12 million crop loss (Broadbent et al. 2002). Adult and immature stages pierce plant tissues with their mouthparts, introduce digestive enzymes and pump out the liquefied contents (Tingey and Pillemer 1977). Damage to host plants includes deformation of leaves, and scarring or discoloration of stems or leaf petioles (Nielsen 1983). On celery, early season damage symptoms may appear as a yellowing or wilting of leaflets, “tipburn-like” symptoms on new growth or small lesions along the stalks. Tarnished plant bug damage on celery is often complicated by secondary bacterial infections which lead to larger necrotic lesions along the stalks and/or soft rot symptoms in the heart of the plant (OMAFRA 1998). Damage on celery can be variable but if left untreated, TPB damage can cause up to 80% loss. In recent years, Ontario growers have reported increasing problems with TPB on celery. There are few data available to indicate whether TPB populations in Ontario are increasing in general or if currently registered control products are no longer efficacious. Presently there are only 2 insecticides registered in Canada for TPB control on celery: 1) endosulfan (Thiodan® 50 WP or Thiodan® 4 EC or Thionex® 50 WP); and 2) acephate (Orthene® 75 SP). These insecticides may not be available to growers for much longer and it is important to identify alternative insecticides (e.g., metaflumizone (Alverde® SC), thiamethoxam (Actara® 25WG) or lambda-cyhalothrin (Matador® 120EC) which could
replace older chemistries in the next 3-5 years.

The objectives of this study were to: 1) acquire much needed information about the biology of TPB on celery in southern Ontario; and, 2) conduct insecticide screening studies in the laboratory and in small plot field trials to determine the efficacy of currently registered and reduced-risk control products.

MATERIALS AND METHODS

Insect Monitoring

During the 2007 growing season, TPB were monitored in a number of celery fields in Simcoe, Hamilton-Wentworth and Lambton counties. Monitoring was initiated in May and continued into August. Tarnished plant bugs (adults and nymphs) were monitored by sampling 5 plants at 50 sites throughout the field (250 plants/field). Plants were gently tapped into a collection dish and TPB were counted.

Insect Rearing

In October 2006, a TPB culture was established at the University of Guelph (U of G) using adults obtained from the Southern Crop and Food Research Centre (SCFRC) – Agriculture and Agri-Food Canada (AAFC) in London, Ontario. The original SCFRC TPB culture was established from specimens collected from vegetable fields in the London area 10 years ago. The U of G TPB colony was reared in 4 L ice cream buckets (Fig. 1a). Organic romaine lettuce and green beans were used as food sources (Fig. 1b, c) and sprouted potatoes (Fig. 1c) were used as the ovipositional (egg laying) substrate. Rearing cages were maintained in 2 growth chambers set at 24°C ± 2°C, 20-30% RH and 16:8 hr L:D. Fresh lettuce and green beans were rinsed in a 2.5% solution of bleach and added to rearing cages 3
times weekly. A 30 dram snap bottle filled with deionized water and fitted with a cotton dental wick extending through the cap was provided as a water source.

![Figure 1](image)

**Figure 1.** (a) Tarnished plant bug rearing cage; (b) Cage showing the food sources - romaine lettuce and green beans; (c) Ovipositional material – sprouted potatoes.

**Contact Toxicity Bioassay**

Contact toxicity of 5 insecticides (endosulfan, acephate, lambda-cyhalothrin, metaflumizone and thiamethoxam) was evaluated on adult TPB using a glass vial bioassay developed by Snodgrass (1996) and modified by MacIntyre Allen (2004). Stock solutions were prepared from technical grade insecticides (>95% purity) dissolved in acetone. For testing, 0.5 ml samples of the appropriate concentrations were added to 20 ml glass scintillation vials (Fig. 2a); control vials were treated with 0.5 ml of acetone. Untreated vials also were included in each bioassay to account for natural mortality. To ensure even deposition on the inner surface, the vials were rotated on a mechanical roller (APW Wyott, Dallas Texas) until dry (Fig. 2b,c). Treated vials not used within 2 h were capped and stored in a freezer at -4°C until needed. Vials stored in the freezer were allowed to equilibrate to room temperature for at least 2 h prior to use.
Two adult TPB were added to each vial (Fig. 3a, b). To prevent insect escape a cotton ball was inserted into the neck of each vial (Fig. 3b). Vials were stored upright in a growth chamber set at 24 ± 2°C and 16:8 hr L:D (Fig. 3c). All bioassay vials were covered with a sheet of brown paper to reduce build up of radiant energy (MacIntyre Allen 2004). Mortality counts were made after 24 h.

Initially, screening tests were completed using 5 to 6 concentrations of each insecticide (0.001; 0.01; 0.1; 1.0; 10; 100 ppm). From those results, 5 to 6 concentrations were chosen to determine the LC_{50} for each insecticide. Each bioassay was replicated 3x with 10 insects/replicate (5 vials with 2 adults/vial).
Data Analysis

Abbott’s formula (Abbott, 1925) was used to correct for natural mortality (<15%). Statistical analyses were performed using SAS (version 8.02 SAS Institute, Cary NC). The probit procedure was used to determine the medial lethal concentration (LC$_{50}$), 95% Fiducial limits and $X^2$ goodness of fit for each insecticide tested.

Field Microplot Trials

Commercial celery seedlings were transplanted in 2-row microplots (2.25 m long x 0.9 m wide) containing organic soil at the SCPFRC-London Research Farm. Three seedlings/row were transplanted for a total of 6 plants/plot on July 13. Due to transplant shock, dying or dead seedlings were removed and replaced with new transplants on July 24. Four insecticide treatments (Table 1) and an untreated control were replicated 3x in a randomized complete block design. Treatments were applied to the foliage of the seedlings in 300 L/ha on August 1. Following treatment, individual paper plates were placed around the base of each seedling to act as a collection device for dead or dying TPB. Once plates were installed, 3 cages were installed over each microplot dividing the plot into 3 sections, each section or cage contained 2 plants (Fig. 4). Once cages were fully installed, one side of each cage was lifted and 10 adult TPB were aspirated into each cage. Mortality assessments were made on August 2, 3 and 8. Due to the cryptic behavior of TPB we experienced difficulty in finding released adults in the individual cages. As a result, a decision was made to modify the technique and conduct these bioassays under laboratory conditions.
TABLE 1. List of products evaluated on celery for tarnished plant bug control.

<table>
<thead>
<tr>
<th>Insecticides</th>
<th>Product</th>
<th>Rate (a.i./ha in g)</th>
<th>Rate (product/ha)</th>
<th>Amt. Product/Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambda-cyhalothrin</td>
<td>Matador 120EC</td>
<td>10</td>
<td>83 ml</td>
<td>0.05ml in 182ml water</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>Thiodan 4EC</td>
<td>800</td>
<td>2.0 L</td>
<td>1.2ml in 182ml water</td>
</tr>
<tr>
<td>Metaflumizone</td>
<td>Alverde SC</td>
<td>280</td>
<td>1.17 L</td>
<td>0.70ml in 182ml water</td>
</tr>
<tr>
<td>Thiamethoxam</td>
<td>Actara 25WG</td>
<td>38.7</td>
<td>155 g</td>
<td>0.093g in 182ml water</td>
</tr>
</tbody>
</table>

Figure 4. Tarnished plant bug field cages in microplots at SCPFRC-AAFC London.

Leaf Dip Bioassays

Leaves from celery plants were harvested and cut into equal sizes using a 1.5 cm circular leaf cutter. Individual leaf discs were dipped into each of the 4 insecticide treatments (Table 1) or the control for 10 s, removed and allowed to dry. Once dry, 2 leaf discs were placed into each plastic well of a 20 well tray (Fig. 5). A piece of filter paper disc was placed into each well prior to the addition of leaf discs to absorb excess moisture. Each treatment was replicated 4x for a total of 8 leaf discs/treatment. Tarnished plant bug nymphs were placed into the refrigerator for approximately 45 min prior to experiment initiation to facilitate transfer into the plastic wells. Once the leaf discs were added, 5 nymphs were transferred into each well using a paintbrush and the well was sealed with a perforated plastic
cover and stored in a growth chamber maintained at 24 ± 2°C and 16:8 hr L:D. Mortality was assessed after 24, 48, and 72 h.

Figure 5. Leaf dip bioassays.

**Whole Plant Bioassays**

Six transplants from each of the 4 insecticide treatments (Table 1) and the control were harvested from the microplots, replanted into pots, labeled and returned to the laboratory (Fig. 6). On August 10, each respective set of potted transplants (6 plants) was treated with one of the 5 treatments. All treatments were applied as a foliar spray in 300 L/ha. Four of the 6 treated transplants for each treatment were placed into individual screened cages within a growth chamber maintained at 24 ± 2°C and 16:8 hr L:D (Fig. 7). Ten adult TPB were aspirated into each cage. Mortality assessments were made on August 11, 12 and 18. Damage assessments were made on August 18. Damage assessments were made using a scale of 0-2; 0 = no damage, 1 = leaf discolouration, 2 = leaf necrosis.
RESULTS AND DISCUSSION

Insect Monitoring

Tarnished plant bugs started appearing in the monitored fields in early June at very low levels. Populations at all sites reached a threshold of 0.1 – 0.2 TPB/plant by the end of July. By mid-August, population numbers had dropped below threshold at all sites.

Contact Toxicity

Lambda-cyhalothrin was significantly more toxic to adult TPB than any of the other insecticides tested (Table 2). Thiamethoxam was 1.8x more toxic to adult TPB than the industry standard endosulfan at the LC$_{50}$ however; the differences in toxicity were not significant (Table 2).
Acephate provided extremely variable and unpredictable results in laboratory assays and its inclusion in the study was terminated. Metaflumizone was ineffective even at the highest rate tested after 24 h; however, this chemical is known to be a slow acting stomach poison.

### Field Microplot Trials

Due to the difficulty in locating the released TPB within the individual cages, this part of the study was modified to include leaf dip and whole plant laboratory bioassays with formulated products.

### Leaf Dip Bioassays

Twenty four h after exposure to treated leaf discs, 95-100% TPB nymph mortality was observed in the lambda-cyhalothrin, endosulfan and thiamethoxam treatments (Fig. 8). Forty-eight h after exposure, 100% mortality was recorded in all 3 treatments. Metaflumizone was the only treatment causing < 20% mortality after 48 h; however by 72 h, it also caused 100% mortality.

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<table>
<thead>
<tr>
<th>Insecticide</th>
<th>n¹</th>
<th>Slope (± SEM)</th>
<th>X²</th>
<th>LC₅₀²(95% FL₄)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endosulfan</td>
<td>50</td>
<td>2.67 (±0.72)</td>
<td>13.87</td>
<td>3.05 (1.74 – 3.99)</td>
</tr>
<tr>
<td>Thiamethoxam</td>
<td>55</td>
<td>1.89 (±0.43)</td>
<td>19.14</td>
<td>1.63 (0.92 – 2.24)</td>
</tr>
<tr>
<td>Lambda-cyhalothrin</td>
<td>50</td>
<td>2.60 (±0.83)</td>
<td>9.77</td>
<td>0.08 (0.00 – 0.16)</td>
</tr>
</tbody>
</table>

¹ Total number of TPB adults tested per concentration.
² Concentrations are expressed as ppm.
Whole Plant Bioassays

One day after treatment, 80% of the TPB adults exposed to plants treated with lambda-cyhalothrin were dead while only 40-50% mortality was recorded on plants treated with either thiamethoxam, endosulfan or metaflumizone (Fig. 9). Two days after treatment, more than 85% of the adults exposed to lambda-cyhalothrin were dead, while all other treatments caused < 55% mortality. Seven days after treatment, TPB mortality had increased to more than 85% and 70% in the thiamethoxam and metaflumizone cages, respectively. Adult mortality was still < 50% in the endosulfan cage a week following treatment.
Damage assessments also were completed 7 d after treatment. Most of the insecticide treatments caused leaf yellowing, deformation and/or necrosis (Fig. 10 and 11).

With thiamethoxam, 3 plants had some leaf yellowing but no necrosis while the endosulfan treatment had some leaf yellowing and 1 plant with leaf necrosis (Table 3). All plants treated with metaflumizone displayed some level of damage with 3 of the 4 plants...
showing extensive necrosis. No damage was observed on any of the plants treated with lambda-cyhalothrin.

Table 3. Impact of insecticides applied to celery plants on damage caused by tarnished plant bug adults.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant 1</th>
<th>Plant 2</th>
<th>Plant 3</th>
<th>Plant 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>lambda-cyhalothrin</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>endosulfan</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>thiamethoxam</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>metaflumizone</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>untreated control</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

* 0 = no damage; 1 = leaf yellowing/deformation; 2 = leaf necrosis

CONCLUSIONS

All 4 of the insecticides provided some degree of activity against TPB by direct contact and/or foliar treatment. Metaflumizone was the slowest acting of the insecticides and plants treated with it had damage levels similar to those on untreated celery plants.

Thiamethoxam and endosulfan – the current industry standard – was intermediate in effectiveness. Overall, at the application rates tested, lambda-cyhalothrin was highly effective, acting quickly, thus preventing TPB from causing serious damage to celery plants.
REFERENCES


