2021 Pest Management Research Report
(PMRR)
2021 Growing Season

2021 Rapport de recherches sur la lutte dirigée
(RRLD)
pour la saison 2021

English

2021 PEST MANAGEMENT RESEARCH REPORT

Prepared by: **Pest Management Centre, Agriculture and Agri-Food Canada**
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The Official Title of the Report

2021 Pest Management Research Report - 2021 Growing Season: Compiled by Agriculture and Agri-Food Canada, 960 Carling Avenue, Building 57, Ottawa ON K1A 0C6, Canada.
April, 2022.Volume 60[1]. 50 pp. 14 reports.
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[1] This is the 22nd year that the Report has been issued a volume number. It is based on the number of years that it has been published. See history on page iii.

This annual report is designed to encourage and facilitate the rapid dissemination of pest management research results, particularly of field trials, amongst researchers, the pest management industry, university and government agencies, and others concerned with the development, registration and use of effective pest management strategies. The use of alternative and integrated pest management products is seen by the ECIPM as an integral part in the formulation of sound pest management strategies. If in doubt about the registration status of a particular product, consult the Pest Management Regulatory Agency, Health Canada, at 1-800-267-6315.

This year there were 14 reports. Agriculture and Agri-Food Canada is indebted to the researchers from provincial and federal departments, universities, and industry who submitted reports, for without their involvement there would be no report. Special thanks are also extended to the section editors for reviewing the scientific content and merit of each report.

Suggestions for improving this publication are always welcome.

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Procedures for the 2022 Annual PMR Report will be sent in fall, 2022. They will also be available from Benjamin Houle.

Pest Management Research Report History.

1961 - The National Committee on Pesticide Use in Agriculture (NCPUA) was formed by its parent body, the National Coordinating Committee of Agricultural Services. It had three main duties: to define problems in crop and animal protection and to coordinate and stimulate research on pesticides; to establish principles for drafting local recommendations for pesticide use; and to summarize and make available current information on pesticides.

1962 - The first meeting of the NCPUA was held, and recommended the Committee should provide an annual compilation of summaries of research reports and pertinent data on crop and animal protection involving pesticides. The first volume of the Pesticide Research Report was published in 1962.

1970 - The NCPUA became the Canada Committee on Pesticide Use in Agriculture (CCPUA).

1978 - Name was changed to the Expert Committee of Pesticide Use in Canada (ECPUA).

1990 - The scope of the Report was changed to include pest management methods and therefore the name of the document was changed to the Pest Management Research Report (PMRR). The committee name was the Expert Committee on Pest Management (1990-1993) and the Expert Committee on Integrated Pest Management since 1994.

2006 - The Expert Committee on Integrated Pest Management was disbanded due to lack of funding.

2007 - Agriculture and Agri-Food Canada agreed temporarily to take over responsibility for funding and compilation of the Pest Management Research Report until an organisation willing to assume permanent responsibility was found.

The publication of the Report for the growing season 2021 has been assigned a Volume number for the 22nd year. Although there was a name change since it was first published, the purpose and format of the publication remains the same. Therefore, based on the first year of publication of this document, the Volume Number will be Volume 60.

An individual report will be cited as follows:
Author(s). 2021. Title. 2021 Pest Management Research Report - 2021 Growing Season. Agriculture and AgriFood Canada. April 2022. Report No. x. Vol. 60: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2021

Préparé par: **Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada**
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Titre officiel du document
2021 Rapport de recherches sur la lutte dirigée - pour la saison 2021. Compilé par Agriculture et Agroalimentaire Canada, 960 avenue Carling, Ed. 57, Ottawa ON K1A 0C6, Canada
Avril 2022 volume 60[1]. 50 pp. 14 rapports.
Publié sur Internet à http://phytopath.ca/publication/pmrr/

[1]Ce numéro est basé sur le nombre d'année que le rapport a été publié. Voir l'histoire en page iv.

La compilation du rapport annuel vise à faciliter la diffusion des résultats de la recherche dans le domaine de la lutte antiparasitaire, en particulier les études sur la terrain, parmi les chercheurs, l'industrie, les universités, les organismes gouvernementaux et tous ceux qui s'intéressent à la mise au point, à l'homologation et à l'emploi de stratégies antiparasitaires efficaces. L'utilisation de produits de lutte intégrée ou de solutions de rechange est perçue par Le Comité d'experts sur la lutte intégrée (CELI) comme faisant partie intégrante d'une stratégie judicieuse en lutte antiparasitaire. En cas de doute au sujet du statut d'enregistrement d'un produit donné, veuillez consulter Santé Canada, Agence de réglementation de la lutte antiparasitaire à 1-800-267-6315.

Cette année, nous avons donc reçu 14 rapports. Les membres du Comité d'experts sur la lutte intégrée tiennent à remercier chaleureusement les chercheurs des ministères provinciaux et fédéraux, des universités et du secteur privé sans oublier les rédacteurs, qui ont fait la révision scientifique de chacun des rapports et en ont assuré la qualité.

Vos suggestions en vue de l'amélioration de cette publication sont toujours très appréciées.

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Des procédures pour le rapport annuel de 2022 seront distribuées à l'automne 2022. Elles seront aussi disponibles via Benjamin Houle.

Historique du Rapport de recherche sur la lutte dirigée

Le Comité national sur l'emploi des antiparasitaires en agriculture (CNEAA) a été formé en 1961 par le Comité national de coordination des services agricoles. Il s'acquittait d'un triple mandat: cerner les problèmes touchant la protection des cultures et des animaux et coordonner et stimuler la recherche sur les pesticides; établir des principes pour l'élaboration de recommandations de portée locale sur l'utilisation des pesticides; synthétiser et diffuser l'information courante sur les pesticides.

À la première réunion du CNEAA, en 1962, il a été recommandé que celui-ci produise un recueil annuel des sommaires des rapports de recherche et des données pertinentes sur la protection des cultures et des animaux impliquant l'emploi de pesticides. C'est à la suite de cette recommandation qu'a été publié, la même année, le premier volume du Rapport de recherche sur les pesticides.

En 1970, le CNEAA est devenu le Comité canadien de l'emploi des pesticides en agriculture. Huit ans plus tard, on lui a donné le nom de Comité d'experts de l'emploi des pesticides en agriculture. En 1990, on a ajouté les méthodes de lutte antiparasitaire aux sujets traités dans le rapport, qui est devenu le *Rapport de recherche sur la lutte dirigée*. Par la suite, le nom du comité a changé deux fois: Comité d'experts de la lutte antiparasitaire de 1990 à 1993 puis, en 1994, Comité d'experts de la lutte antiparasitaire intégrée.

En 2000, on a commencé à attribuer un numéro de volume au rapport annuel. Même si ce dernier a changé de titre depuis sa création, sa vocation et son format demeurent les mêmes. Ainsi, si l'on se reporte à la première année de publication, le rapport portant sur la saison de croissance de 2009 correspond au volume 48.

En 2006, le Comité d'experts de la lutte antiparasitaire intégrée a été dissous en raison du manque de financement.

En 2007, Agriculture et Agroalimentaire Canada assume temporairement la responsabilité du financement et de la compilation du Rapport de recherche sur la lutte dirigée jusqu'à ce qu'une organisation désireuse d'assumer la responsabilité pour ce rapport sur une base permanente soit déterminée.

Modèle de référence:
Nom de l'auteur ou des auteurs. 2021. Titre. 2021 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. Avril, 2022. Rapport n° x. vol. 60: pp-pp.

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2021 PMR REPORT # 01 **SECTION B: VEGETABLES and SPECIAL CROPS – INSECT PESTS**

CROP: Garlic (*Allium sativum* L.)
PEST: Leek moth (*Acrolepiopsis assectella* Zeller)

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TITLE: FIRST ATTEMPT WITH ROW COVER AND IDENTIFYING A POTENTIAL TRAP CROP FOR CONTROL OF LEEK MOTH IN NOVA SCOTIA

MATERIALS: WONDERMESH® STANDARD INSECT NETTING

METHODS: Row cover – wondermesh® standard insect netting (1.3 mm) was obtained from Wondermesh (www.wondermesh.co.uk) and used to cover two sections (each 30 m long x 2 m wide with 4 planted lines) of garlic (multiple varieties) located at Stratton Farms (5777 Highway 1, Annapolis Royal, NS). The row cover was installed on 20 April 2021 concurrent with the 1st capture of leek moth on a white delta trap baited with leek moth pheromone (Trécé Inc., USA). Netting was suspended over the plants using metal supports (45 cm high x 15 cm wide) placed every 60 cm along each edge of the section and held down with sandbags. A third section of garlic was left uncovered to serve as a control. On 20 May the netting was removed to facilitate weeding, then replaced over one section on 8 June and removed again on 24 June. These timings created three treatments: covered 1x, covered 2x and not covered. Timings were chosen to coincide with adult flights based upon previous years of survey at nearby sites. Field surveys for evidence of larval feeding occurred on 29 June during scape production. Each 30 m long section was divided into six equal areas and eight plants (chosen at random) within each area were examined. Mean number of plants with leek moth damage were compared among treatments using analysis of variance.

Trap crops – a section of garlic measuring 15 m long x 6 m wide located at Twisted Brook Farm (7809 Hwy 201, South Williamston, Lawrencetown, NS) was used to evaluate potential for different *Allium* species to attract leek moth. Species used were: onion (*A. cepa* var. Toyko Long Neck) – grown from seed at Kentville Research and Development Centre (KRDC), leek (*A. porrum*) and onion (*A. cepa* var. Dakota Tears) – individual plants provided by Twisted Brook Farm, and chives (*A. schoenoprasum*) – a clump taken from a home garden near Kentville and divided into 4 equal portions. All plants (other than those sown) were transplanted into pots (15 cm diameter) on 10 March and maintained at the KRDC until moved to the field. In the field, pots were randomized (one replicate of each type) and placed along each side of the garlic section for four replicates. Pots were dug into the ground on 21 April 2021 and removed on 21 May and taken to KRDC for examination. Plants were examined for evidence of leek moth: eggs, larvae and pupae. Mean numbers of larvae and pupae per pot and percentage of damaged leaves were compared between treatments using analysis of variance.

RESULTS: Row cover data are presented in Table 1.Trap crop data are presented in Table 2.

CONCLUSIONS: Covering of garlic sections did reduce damage from leek moth, although not significant in our study. Row covers show some potential to reduce impact by leek moth if used in combination with a degree day model to identify the best time to cover the crop. Of the four *Alliums* tested, all were equally as attractive to leek moth for oviposition and larval survival, and all experienced high levels of damage. The *Alliums* tested showed significant differences for number of pupae, but this could be attributed to timing of oviposition in relation to our examination. While eggs were observed on some plants these were not considered a reliable indicator of leek moth preference. Selection of an *Allium* species for use as a trap crop to divert oviposition and damage away from garlic requires further study.

ACKNOWLEDGEMENTS: The authors gratefully acknowledge the support of Stratton Farms and Twisted Brook Farms to allow us access to their garlic plantings for this work.

Table 1. Mean (± SE) percentage of plants showing damage from leek moth at Stratton Farms when covered with a row cover, 2021.

Treatment	Mean leek moth damage	Statistics
Control (no cover)	10.4 (5.9)	$F_{2,15} = 2.97$, $P = 0.09$
Covered 1x	0.0 (0.0)	
Covered 2x	0.0 (0.0)	

Table 2. Mean (± SE) number of leek moth larvae and pupae per pot and percentage of plant stems within each pot showing damage when placed around a garlic planting at Twisted Brook Farms, 2021.

Treatment	Larvae	Pupae	Damage (%)
Onion (var. Toyko Long Neck)	12.0 (3.5)	1.7 (0.3)	87.6 (7.9)
Onion (var. Dakota Tears)	7.0 (2.0)	0.0 (0.0)	67.1 (8.3)
Leek	7.7 (2.6)	0.7 (0.3)	88.7 (6.6)
Chives	11.7 (3.4)	2.7 (1.1)	76.8 (5.5)
	$F_{3,11} = 0.5$, $P = 0.7$	$F_{3,11} = 9.1$, $P = 0.003$	$F_{3,11} = 2.3$, $P = 0.14$

2021 PMR REPORT # 02 **SECTION B: VEGETABLES and SPECIAL CROPS – INSECT PESTS**

CROP: Garlic (*Allium sativum* L.), Leek (*Allium porrum* L.)

PEST: Leek Moth (*Acrolepiopsis assectella* (Zeller))

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TITLE: **MONITORING OF LEEK MOTH POPULATIONS IN ONTARIO, 2021**

MATERIALS: DELTA 1 Pheromone trap, lure #40AS009

METHODS: DELTA 1 pheromone traps with a leek moth lure #40AS009 (Distributions Solida, Montreal, QC) were set up in 14 locations in nine counties in Southwestern Ontario from 11 April to 25 May, 2021. Counties surveyed include Brant, Chatham-Kent, Essex, Grey, Huron, Oxford, Perth, Renfrew and Wellington. Two traps were hung on wooden stakes approximately 40 cm above the ground in every field monitored. Thirteen of the fields surveyed were planted with garlic and one field in Perth County was planted with leek. At the Perth location growing garlic, traps were moved to nearby onion fields when garlic was harvested. Sticky cards were changed weekly, and pheromone lures were changed every two weeks during the duration of the study. Specimens were counted visually without extracting genitalia. Traps were left in all fields after garlic harvest to capture the third flight of the season. In the leek field, the traps were left in the field until 31 August.

RESULTS: As outlined in Figures 1, 2, 3 and 4.

CONCLUSIONS: Leek moth were detected at all locations surveyed during the 2021 field season except at the Essex field site (Figure 1). Physical damage of plants was observed at both Perth field sites, with damage observed in leeks, garlic and onions. Peak leek moth counts were below an average of 14 moths/trap/week or 2 moth/trap/day in the majority of the locations. Several of the fields monitored in 2021 were also monitored in 2020, 2019 and 2018. Most field sites had three distinct population spikes between May and September. A spike of 22 leek moths was observed at a single location in Grey county on 8 July which was the same week a spike of 16, 40 and 38 moths were observed in the same area in 2020, 2019, and 2018 respectively **(**Figure 2**)**. With the use of an exclusion net and insecticides applied, the number of captured leek moths did not change significantly in Renfrew county (Figure 3). At a field site in Huron county, garlic was planted >10km from the previous year's location each year and no insecticide applications targeting leek moth were applied in 2018, 2019, 2020 and 2021. (Figure 4). Results suggest that leek moth can be managed by insecticides if they are applied timely after peak trap capture or by planting next years crop an adequate a distance away.

ACKNOWLEDGEMENTS: Thank you to Hannah Fraser, Dennis Van Dyk, Meagan Stager, Alexandra Switzer and Tyler Ykema for their help throughout the growing season.

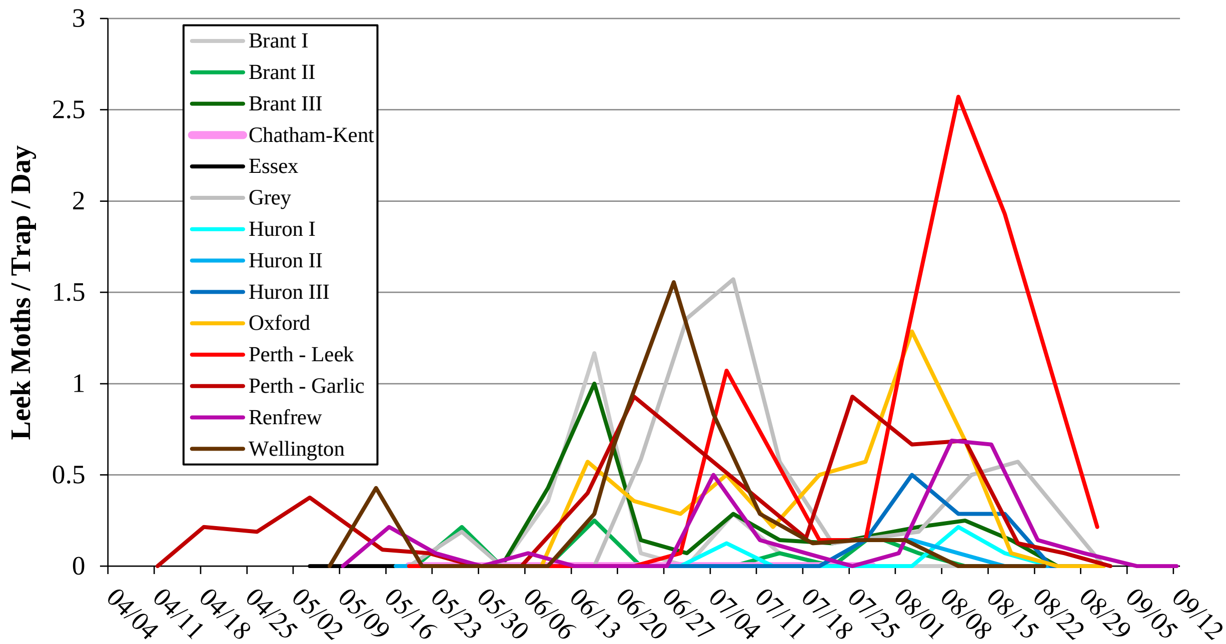

Figure 1. Average number of leek moths per sticky trap per day at 13 garlic fields and one leek field within the surveyed counties of Brant, Chatham-Kent, Grey, Huron, Oxford, Perth, and Renfrew, 2021. No leek moths were observed in Essex County.

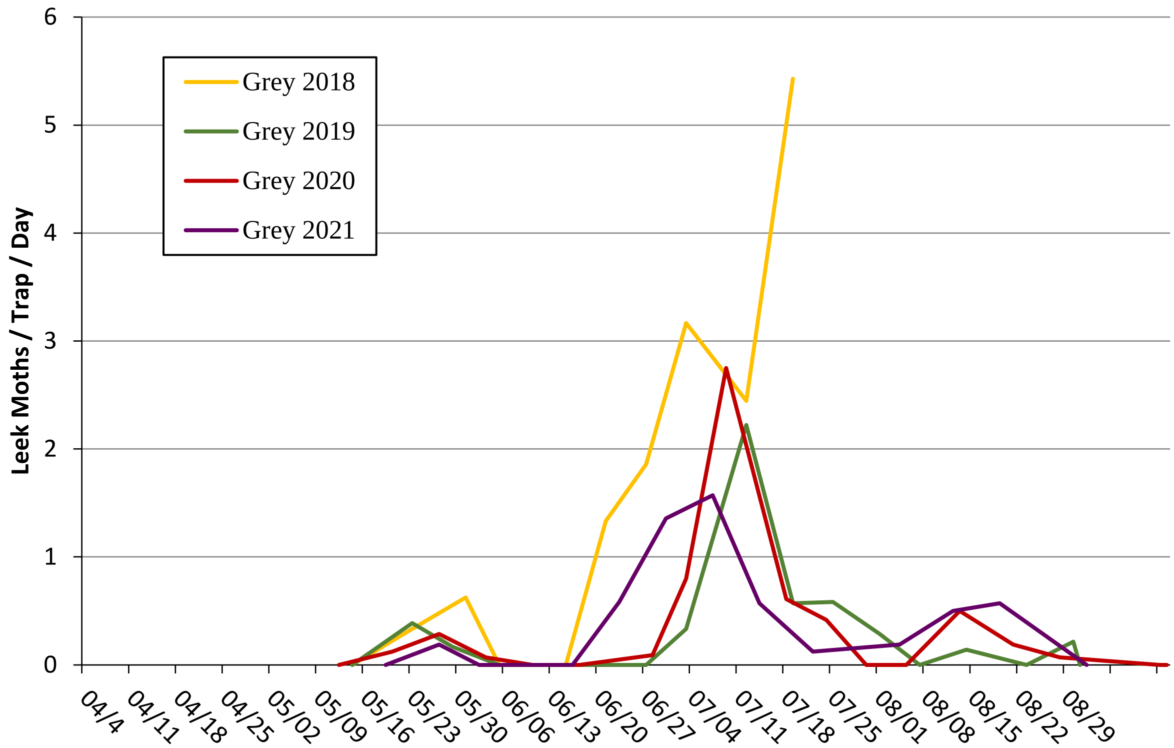

Figure 2. Leek moth counts in Grey County in 2021 (purple), 2020 (red), 2019 (orange), and 2018 (yellow) with two insecticide applications following the second peak each year. Monitoring stopped in 2018 following garlic harvest, however, it was continued until September in 2019-2021.

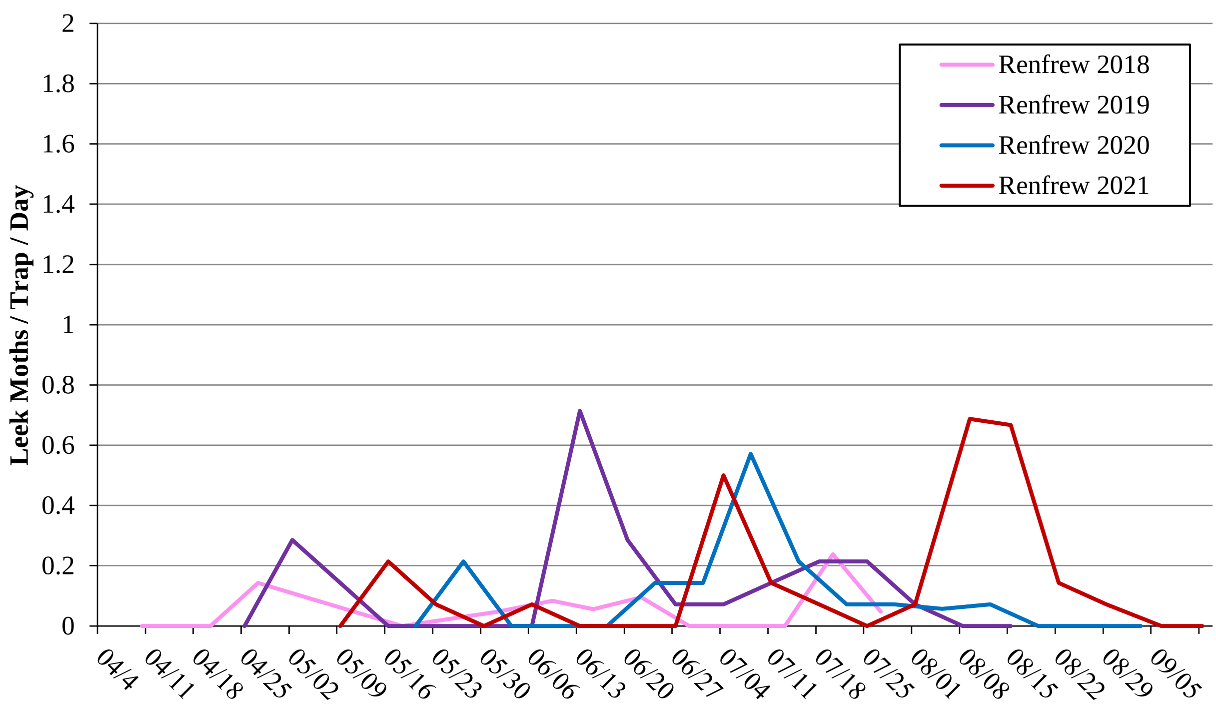

Figure 3. Leek moth counts in Renfrew County in 2021 (red), 2020 (blue), 2019 (purple), and 2018 (pink). No insecticides were applied 2018-2021, however, exclusion nets were implemented in 2021.

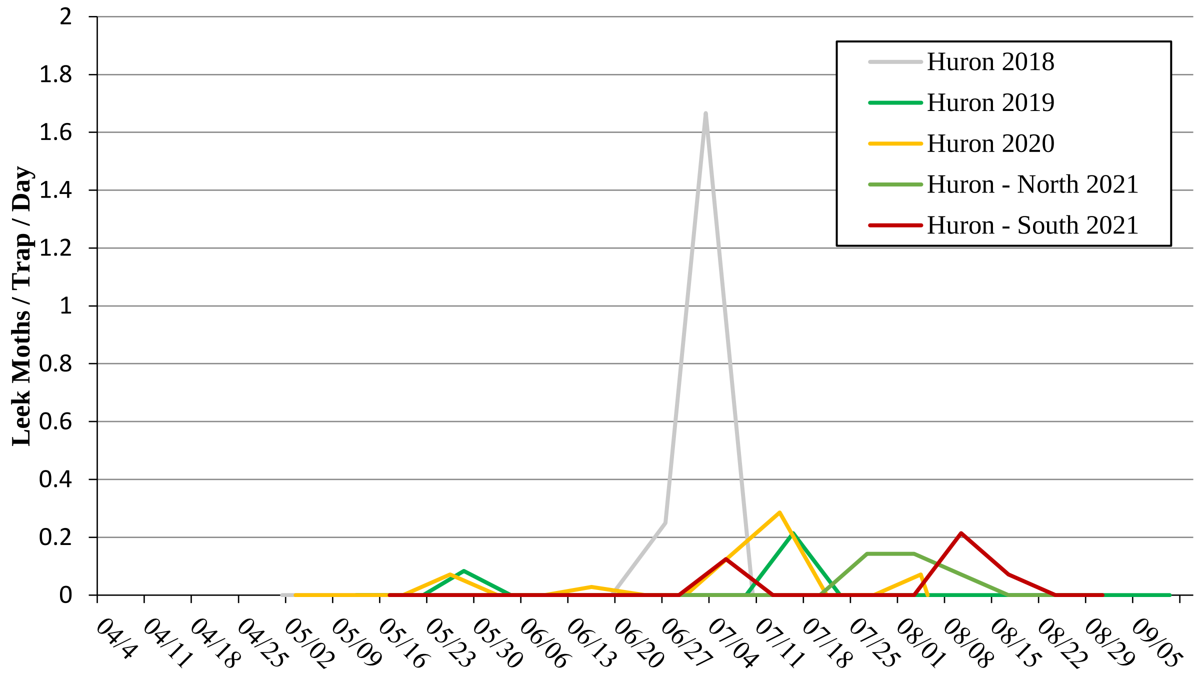

Figure 4. Leek moth counts at several field sites within 20 km of each other in Huron County in 2021 (orange and red) in 2020 (purple), 2019 (dark green), and 2018 (light green). Garlic fields were moved >10 km from the previous years location with no insecticide applications targeting leek moth

2021 PMR REPORT # 03 **SECTION C: POTATOES – INSECT PESTS**

CROP: *Solanum tuberosum* L. var. Yukon Gold
PEST: Colorado potato beetle (Leptinotarsa decemlineata) (Coleoptera:Chrysomelidae)

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TITLE: FIELD EVALUATION OF FIVE INSECTICIDES AGAINST COLORADO POTATO BEETLE ON POTATO

MATERIALS: ADMIRE (Imidacloprid 240 g/L), CORAGEN (Chlorantranilirole 200g/L), CORMORAN (Acetamiprid 80 g/L, Novaluron 100 g/L), SIVANTO PRIME (Flupyradifurone 200 g/L), SUCCESS (Spinosad 480 g/L)

METHODS: Seed potatoes (var. Yukon gold) with at least three eyes were planted at Harrington, PEI (46.342449, -63.155750) on June 03, 2021 in four-row plots with plant spacing of 0.3 m within rows and 0.9 m between rows. Plots were arranged in a randomized complete block design with six treatments, and four replications per treatment. The plots were 3.1 m in length and 3.7 m in width. They were separated from each other within a replication by a 1.8 m width of bare soil, and there was a 3.1 m bare-soil pathway between replications.
After planting a standard pre-emergence application of Sencor at 1.1 kg AI/ha was applied to plots for weed control. Throughout the summer, plots received a recommended blight prevention scheduled application of (Orondis, Reason, Double Nickel, or Luna Tranquility), commencing July 07, 2021. Starting July 8, weekly counts of the numbers of CPB adults (spring and summer), egg masses, early-instars (L1-L2), and late-instars (L3-L4) on five whole plants per plot were done. The CPBE threshold was calculated and used to determine timing for insecticide application. Insecticides were applied twice July 12 and 29, except for Admire, at the following rates: Admire @ 9.8 ml of product/100 m of row in furrow at planting, Sivanto prime 1000ml/ha, Cormoran @700ml/ha, Coragen @500ml/ha, Success 125ml/ha. Each plot was rated weekly for the percentage of defoliation by the CPB. After each treatment application, signs of plant toxicity was noted.
The plants were top killed by two half-rate applications of Reglone on Sept 08 and 13, 2021. Tubers from the center two rows of each plot were harvested on September 17, 2021, and total and marketable (wt.>41.5 g, <510 g) yields were recorded. Analyses of variance (ANOVA) was performed on the yield data and TukeyHSD was used to separate the means. Percent defoliation was transformed to sqrt (arcsine(prop)) before analysis. Untransformed means are presented.

RESULTS: As outlined in Figures 1-2 and Table 1.

CONCLUSIONS: All the insecticides significantly reduced the Colorado potato beetle population (Figure 1), reduced plant defoliation (Figure 2) and increased yields (Table1) when compared to the untreated control, however there was no significant differences among the insecticides.
The insecticide Cormoran appeared to give the best protection from Colorado potato beetle feeding, followed by Admire, Coragen, Sivanto Prime and Success.

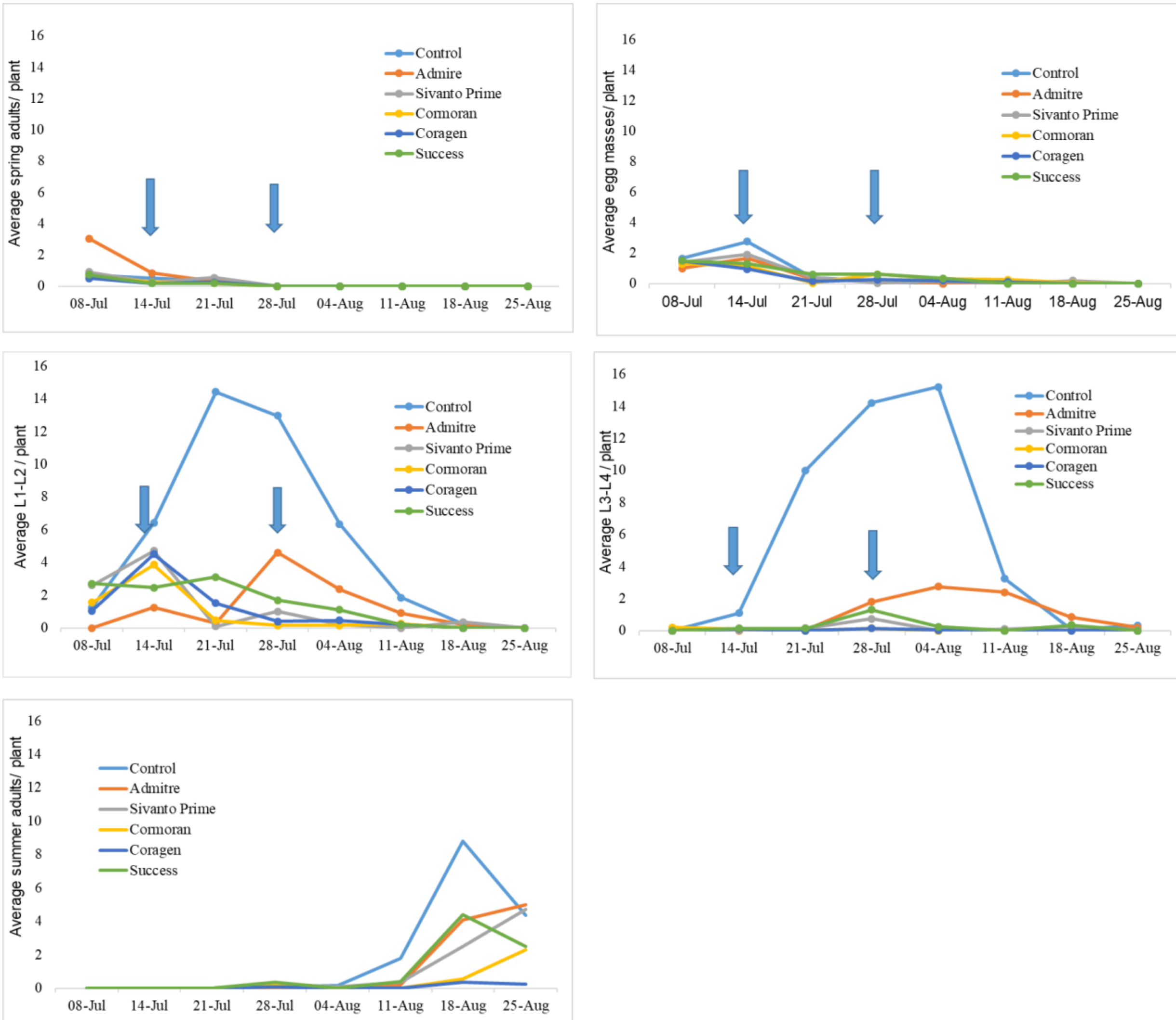

Figure 1: Average number of Colorado potato beetle adults and larvae found per plant over the growing season on potato plants treated with one of five different insecticides. Arrow indicates spray date.

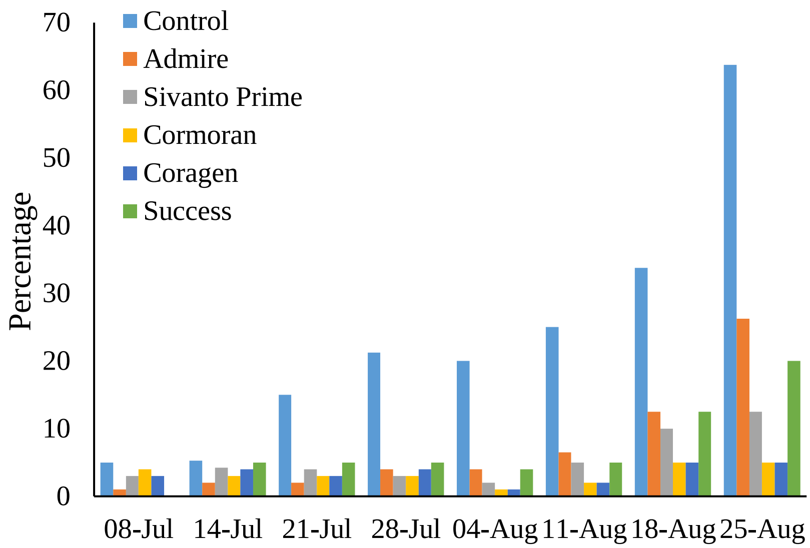

Figure 2: Percentage defoliation by CPB adults and larvae of potato plants treated with five different insecticides

Table1: Total and marketable yield of potatoes treated with five insecticides to control Colorado potato beetles in the field.

Treatment	Number of applications	Total Yield	Market yield
Control		30.81304 a[1]	29.92995 a
Admire @ 9.8 ml of product/100 m of row (IF)[2]	1	38.98733 b	37.76652 b
Coragen @500ml/ha (F)[2]	2	37.59296 b	36.75561 b
Cormoran @700ml/ha (F)	2	38.69132 b	37.68445 b
Sivanto prime 1000ml/ha (F)	2	36.66547 b	35.26481 b
Success 125ml/ha (F)	2	36.25016 b	35.03967 b

[1]Numbers in a column followed by the same letter are not significantly different at $P = 0.05$ (TukeyHSD)
[2] IF = In furrow application, (F) = foliar application

2021 PMR REPORT # 04 **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

CROP: Apple, *Malus domestica* Borkhausen (Rosaceae)

PEST: Apple leafcurling midge, *Dasineura mali* Kieffer (Diptera: Cecidomyiidae)

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TITLE: HOST RANGE OF *PLATYGASTER DEMADES* AND *SYNOPEAS MYLES* PARASITOID BIOLOGICAL CONTROL AGENTS OF *DASINEURA MALI* (DIPTERA: CECIDOMYIIDAE)

MATERIALS: Parasitoids: *Platygaster demades* Walker (Hymenoptera: Platygastridae) used in this study emerged from pupating *Dasineura mali* Kieffer (Diptera: Cecidomyiidae) collected as larvae in apple galls in Nova Scotia and *Synopeas myles* (Walker) (Hymenoptera: Platygastridae) emerged from pupating *D. mali* collected in the Okanagan and Similkameen valleys of British Columbia.
Cecidomyiidae: The midge species used in this study are listed in Table 1. *Aphidoletes aphidimyza* (Rondani) (Diptera: Cecidomyiidae) were purchased from WestGrow Biologicals, Langley, British Columbia and Koppert Canada Ltd. Scarborough, Ontario. Adult midges in British Columbia were provided aphid infested apple shoots on which eggs were oviposited and larvae developed. All other midge species used in the trials were obtained from host plants located close to apple orchards in the province listed.

METHODS: The parasitoids *P. demades* and *S. myles* are important in the suppression of apple leafcurling midge, *D. mali* populations in Canada. Both parasitoids have been recorded to parasitize more than one Cecidomyiidae species and, while parasitism of multiple species may have positive pest management impacts and provide alternative hosts to ensure parasitoid survival when key host populations are low or missing, some Cecidomyiidae are beneficial and suppression of these species would not be advantageous. Of particular concern is the susceptibility of the beneficial species *Aphidoletes aphidimyza* that is an important predator of small soft bodied arthropod pests in Canadian orchards. Female *A. aphidimyza* eggs are oviposited on aphid-infested apple leaves and the resulting aphidophagous larvae may be vulnerable to these less than specific Platygastridae parasitoids. Also included in this study is a second beneficial Cecidomyiidae, *Spurgia esulae* Gagné that feeds on the weed leafy spurge, *Euphoria esula* L. (Euphorbiaceae). Our goal in this study was to better understand the susceptibility of *A. aphidimyza* and other non-target Cecidomyiidae associated with, or adjacent to Canadian apple orchards to parasitism by *P. demades* and *S. myles* through choice and no-choice Petri dish laboratory host range trials.

<u>Parasitism by *P. demades* and *S. myles* of target *D. mali* eggs and larvae:</u> Ten *D. mali* eggs or early instar larvae were placed on a circular freshly cut 15 mm diameter apple leaf disc in test arenas (50 × 9 mm, locking Petri dish). A single mated female parasitoid was placed in the arena and observed for 30 consecutive minutes under a microscope. The mean percentage of the total time that the parasitoid spent in contact with the eggs or larvae was recorded as well as the incidence of observed parasitism (inserted ovipositor). Both observations were reported as per minute for each trial to allow comparison across tests. In order to avoid false-negatives, parasitoids were exposed to target host material (10 *D. mali* eggs or early instar larvae) immediately after each trial and only the trials in which the females attempted to parasitize the target host material were included in the evaluations.

<u>Parasitism by *P. demades* and *S. myles* of non-target Cecidomyiidae larvae from non-apple plant hosts:</u> Five early instar non-target Cecidomyiidae larvae were placed on a 20 mm dia leaf disc freshly cut from the gall-formers’ host plant in a 54 x 14 mm, tight fitting clear plastic dish, Semadeni AG, Ostermundigen, Switzerland test arena. A three to seven day old mated *P. demades* female was introduced and observed for a minimum of 5 and up to 30 minutes per trial. Parasitism was recorded when the female inserted her ovipositor into the larvae. The test duration was complete either at the 30 minute mark or sometime after a minimum of 5 minutes once the female inserted her ovipositor into larva(e) more than once. As above, five *D. mali* larvae on a similar freshly cut apple leaf disc was provided to each female that oviposited and observed for up to 30 minutes. Parasitism of controls was recorded and test duration determined as above.

Synopeas myles was only tested on a single non-target plant-feeding host, the black locust gall midge, *Obolodiplosis robiniae* (Haldeman). The same protocol previously described for testing non-target larvae was used, except that the trials were conducted for 20 minutes. Parasitism of control *D. mali* larvae by each parasitoid individual was recorded immediately after each *O. robiniae* trial. The percentage of the total time that the parasitoid spent on each disc as well as parasitism per minute of each trial were recorded.

<u>Parasitism of *A. aphidimyza*:</u> No-choice *A. aphidimyza* parasitism trials with both *P. demades* and *S. myles* were conducted using the same protocol described previously. In choice tests, ten test *D. mali* and *A. aphidimyza* eggs and larvae were arranged individually on apple leaf disks in a 50 × 9 mm, locking Petri dish; however, two discs were placed in each dish, each holding a different species of eggs or larvae. The percentage of the total time that the parasitoid spent on each disc as well as any parasitism per minute of each trial were recorded.

RESULTS: As outlined in Tables 1-4.

CONCLUSIONS: <u>Parasitism by *P. demades* and *S. myles* of target *D. mali* eggs and larvae:</u> *Platygaster demades* females in the no-choice trials contacted a mean of 0.3 *D. mali* egg and larva per minute (9 per 30 min) in the tests (Table 2). This contact resulted in a mean incidence of probable *P. demades* parasitism on *D. mali* eggs and larvae of 0.29 and 0.24 per minute, respectively (Table 2) confirming that *P. demades* parasitizes both *D. mali* eggs and larvae. In contrast, the *S. myles* females contacted a mean of only 0.01 *D. mali* egg per minute (0.3 per 30 min) and this resulted in only one *D. mali* egg being observed as parasitized by the *S. myles* in 10 replications that equates to a mean of 0.01 *D. mali* egg being parasitized per minute. The *S. myles* consistently parasitized the *D. mali* larvae, contacting a mean of 0.18 larvae per minute (5.4 per 30 min) and parasitizing 0.13 *D. mali* larvae per minute (3.9 per 30 min) (Table 2).

<u>Parasitism by *P. demades* and *S. myles* of non-target Cecidomyiidae larvae from non-apple host plants:</u> The synchronous availability of test non-target larvae and parasitoids enabled only six to eleven trials using *P. demades* on each of the six non-target species. All non-target Cecidomyiidae species were observed to be probably parasitized by the *P. demades* (Table 3). When compared with the control (*D. mali*) *P. demades* females appeared to parasitize *Janetiella ulmii* (Beutenmüller) larvae the most at 88% (Table 3).

Synopeas myles females were observed to contact a mean of 0.09 black locust midge larva, *O. robiniae* per minute (2.7 per 30 min) in the no-choice tests on black locust leaf discs that resulted in the *S. myles* appearing to possibly parasitize a mean of only 0.02 of the *O. robiniae* larvae per minute (0.6 larvae per 30 min) (Table 2). A single *O. robiniae* was contacted and possibly parasitized in only 3 of the 10 trials and two larvae were parasitized in only one of the trials.

<u>Parasitism of *A. aphidimyza*:</u> The *P. demades* had only 0.07 and 0.13 contacts per minute with *A. aphidimyza* eggs and larvae, respectively in no-choice trials and the parasitoid was observed to possibly parasitize only 0.01 and 0.03 of each of the *A. aphidimyza* eggs and larvae per minute. Similarly, the *S. myles* contacted the *A. aphidimyza* eggs and larvae a mean of only 0.11 and 0.14 times per minute, respectively in the no-choice trials and was not recorded parasitizing any of the predacious midge eggs or larvae in the trials (Table 2).

<u>Parasitism choice tests:</u> When presented with a choice of *D. mali* and *A. aphidimyza* eggs in the same arena, *P. demades* females chose to spend more time on the *D. mali* leaf disc and parasitize significantly more *D. mali* versus *A. aphidimyza* eggs (Table 4, contacts per minute: $t = 4.6$; $P < 0.0001$; parasitism per minute: $t = 6.8$; $P < 0.0001$). Similarly, the *P. demades* females preferred to parasitize *D. mali* larvae in choice tests with *A. aphidimyza* larvae (Table 4, contacts per minute: $t = 4.3$, $P = 0.003$; parasitism per minute: $t = 4.1$, $P = 0.004$).

When *S. myles* were presented with a choice of *D. mali* and *A. aphidimyza* eggs in the same arena, none of either of the two host eggs were parasitized and there was no significant difference ($P > 0.05$) in the contact time that the parasitoids spent on each disc (Table 4). When *S. myles* females were presented with both *D. mali* and *A. aphidimyza* larvae, they all chose to spend significantly more time on the apple leaf disk with the *D. mali* larvae ($t = 2.6$; $P = 0.023$) and parasitize more *D. mali* larvae versus *A. aphidimyza* larvae ($t = 4.5$; $P = 0.0005$; Table 4).

Platygaster demades were observed to parasitize larvae of six gall-forming Cecidomyiidae (Diptera) in addition to their natural apple leaf curl galls, including *Contarinia* sp. from Manitoba maple, *Dasineura apicata* from ash leaf fold, *Dasineura* sp. from ash leaf curl, *Janetiella ulmii* from American elm, *Spurgia esulae,* the weed biological control agent from Leafy spurge, and an unknown midge species from ironwood. *Platygaster demades* was rarely observed to parasitize the eggs or larvae of the beneficial predaceous midge, *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae). *Synopeas myles* occasionally parasitized larvae of the black locust midge, *Obolodiplosis robiniae* outside of their galls, did not parasitize *A. aphidimyza* eggs and was observed to rarely parasitize *A. aphidimyza* larvae. Both parasitoid species parasitized and spent more time in contact with *D. mali* larvae than *A. aphidimyza* in choice tests. None of the assumed incidences of parasitism were confirmed with molecular tests or rearing. Our data suggest that both *P. demades* and *S. myles* are oligophagous and will attack cecidomyiid species that are found in plant leaf galls. The results also indicate that predacious cecidomyiid species may be vulnerable and there is a need for follow up studies to verify that *P. demades* and *S. myles* will parasitize these and other species.

Platygaster robinae was found to parasitize the black locust midge in British Columbia. This is the first record of the parasitoid in North America.

Table 1. Cecidomyiidae species tested in laboratory trials, host plants, gall type and source used in parasitism trials

Midge species	Host plant	Gall type	Source*
Dasineura mali Kieffer, apple leaf curling midge	apple, *Malus domestica* Borkhausen (Rosaceae)	Globular	BC, ON
Aphidoletes aphidimyza (Rodani)	apple, *M. domestica*	No gall; predator	Commercial source
Obolodiplosis robiniae (Haldeman), black locust gall midge	black locust *Robinia pseudoacacia* L. (Fabaceae)	Leaf fold	BC
Contarinia sp. Manitoba maple globular pouch gall midge	Manitoba maple *Acer negundo* L. (Sapindaceae)	Leaf curl	ON
Dasineura apicata Felt	ash *Fraxinus sp.* L. (Oleaceae)	Leaf fold	ON
Dasineura sp.	ash *Fraxinus sp.* L. (Oleaceae)	Leaf curl	ON
Janetiella ulmii Beutenmüller, elm midge	American elm *Ulmus americana* L. (Ulmaceae)	Leaf pouch	ON
midge species	ironwood, *Ostrya virginiana* (Mill.) K. Koch (Betulaceae)	Leaf fold	ON
Spurgia esulae Gagné	leafy spurge, *Euphorbia esula* L. (Euphorbiaceae)	Leaf curl	ON

*British Columbia = BC, Ontario = ON

Table 2. No-choice tests exposing individual *Platygaster demandes* or *Synopeas myles* females to 10 eggs or larvae of *Dasineura mali* and *Aphidoletes aphidimyza* (*Aa*) on apple leaf discs or *Obolodiplosis robiniae* on black locust leaf discs. Replicated 5 to 15 times. Parasitism was assumed when ovipositor was inserted.

Parasitoid	Mean parasitism per minute (s.e.)		Mean contact per minute (s.e.)	
	D. mali eggs	*D. mali* larvae	*D. mali* eggs	*D. mali* larvae
Platygaster demades	0.29 (0.04)	0.24 (0.04)	0.30 (0.42)	0.31 (0.04)
Synopeas myles	0.01 (0.01)	0.13 (0.04)	0.01 (0.01)	0.18 (0.05)
	A. aphidimyza eggs	*Aa* larvae	*A. aphidimyza* eggs	*Aa* larvae
Platygaster demades	0.01 (0.01)	0.03 (0.02)	0.07 (0.01)	0.13 (0.03)
Synopeas myles	0 (0)	0 (0)	0.11 (0.04)	0.14 (0.03)
		O. robiniae larvae		*O. robiniae larvae*
Synopeas myles		0.02 (0.01)		0.09 (0.04)

Table 3. Proportion of trials resulting in parasitism by *Platygaster demades* of gall-forming Cecidomyiidae larvae exposed on host plant leaf discs and parasitism of *Dasineura mali* larvae on apple leaf discs (control).

Plant species	Cecidomyiid species	Trials	proportion parasitized	proportion control parasitized
Apple	*Dasineura mali*	4	1	0.75
Elm	*Janetiella ulmii*	8	0.88	0.88
Leafy spurge	*Spurgia esulae*	7	0.57	1
Ironwood	a midge species	9	0.55	0.88
Ash (leaf fold)	*Dasineura apicata*	6	0.5	0.83
Manitoba maple	*Contarinia* sp.	11	0.45	0.91
Ash (leaf curl)	*Dasineura* sp.	6	0.33	0.83

Table 4. Choice tests exposing individual Platygastridae females to 10 eggs or 10 larvae of *Dasineura mali* and *Aphidoletes aphidimyza* on apple leaf discs for at least 20 minute periods. Replicated 5 to 15 times. Parasitism was assumed when ovipositor was inserted.

Parasitoid	Mean parasitism per minute (s.e.)		Mean percent of time on disk (s.e.)	
	D. mali eggs	*A. aphidimyza* eggs	*D. mali* eggs	*A. aphidimyza* eggs
Platygaster demades	0.19 (0.03) a*	0.01 (0.01) b	0.58 (0.08) a	0.15 (0.05) b
Synopeas myles	0 (0) a	0 (0) a	0.20 (0.10) a	0.06 (0.03) a
	D. mali larvae	*A. aphidimyza* larvae	*D. mali* larvae	*A. aphidimyza* larvae
Platygaster demades	0.18 (0.04) a	0.01 (0.01) b	0.59 (0.05) a	0.30 (0.05) b
Synopeas myles	0.15 (0.03) a	0.01 (0.01) b	0.41 (0.07) a	0.15 (0.03) b

* means within data category of choice test followed by the same letter are not significantly different as determined by student’s t-test using SAS, version 9.4 SAS Institute Inc., Cary, NY, USA.

2021 PMR REPORT # 05 SECTION H: PEST MANAGEMENT METHODS – BIOLOGICAL CONTROL

CROP: Onion (*Allium cepa* L.)
PEST: Onion Maggot (*Delia antiqua* (L.))

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TITLE: FOURTH YEAR FIELD DEMONSTRATION OF THE STERILE FLY RELEASE TECHNOLOGY FOR ONION MAGGOT MANAGEMENT IN ONION SET AND COOKING ONION PRODUCTION IN ONTARIO

MATERIALS: Sterilized/irradiated *Delia antiqua* pupae.

METHODS: Several fields near Exeter, Thedford and Scotland, Ontario were sown with onions in the spring of 2021. At the Exeter and Thedford field sites, two fields comprised of Brady sandy-loam and Blackwell clay were seeded at a high density of ~20 million seeds / ha (~8 million seeds / ac) to produce onion sets with no soil application of chlorpyrifos. Onion seeds were sown in 11-13 May at these two fields. The field where sterile flies were released (Figure 1, A), measured approximately 9.7 ha (24.0 ac) and was seeded approximately 150 m from fields where sterile flies were release during the 2018, 2019 and 2020 field seasons (Figure 1, B–C). There were no major onion fields within 20km of this sterile fly release field. The control field, where no sterile flies were released, was situated 28.4 km Southwest of the release field, near Thedford Ontario. This second field was approximately 9.8 ha (24.3 ac) in size (**Figure 2, A**) and the closest onion field was situated approximately 4 km Northwest in 2021.

The remaining fields were transplanted with cooking onions near Scotland, Ontario, at an average density of ~345,000 plants / ha (140,000 plants / ac) with no soil application of chlorpyrifos. At both of these fields, approximately 1.4 km apart, sterile flies were released. The first field comprised of Caledon sandy-loam was approximately 6.7 ha (16.5 ac) in size and planted from 13 May to 20 May directly adjacent to fields where sterile flies were released in 2019 and 2020 (Figure 3, A). The other field where sterile flies were released was comprised of Granby and Brady loamy-sand, was approximately 7.0 ha (17.1 ac) in size and planted from 27 April to 11 May (Figure 3, B). There were no other major onion fields within a 20 km radius from either of these fields near Scotland. Onion flies were reared by Phytodata, and then sterilized and released according to the protocol developed by Phytodata, using the Sterile Insect Technology (SIT). The *Delia antiqua* pupae were irradiated by Nordion, dyed pink, and then shipped to Thedford and Scotland, ON, emerged as adult flies and kept alive until release following protocols developed by Phytodata Inc (Figure 4, C). Four onion maggot sticky traps consisting of three stakes with blue sticky cards clipped above the crop canopy were placed on the middle of each side of every field (Figure 4, B). Cards were monitored weekly for natural onion maggot populations as well as for the displacement of sterile / pink flies throughout the growing season. Fly releases at the Exeter and Scotland sites began the week of 12 May and continued weekly until the week of 16 September. Flies were released after harvest to target the onion maggot population that would be overwintering. Flies were released at least 30 m from the closest sticky card trap at all fields. In the fields producing onion sets, damage plots measuring 15 cm x 15 cm capturing ~40 plants were set up a short distance away from the sticky traps at the flag leaf stage (Figure 4, A). At the Scotland fields, damage plots were created by counting out 25 plants on four rows for a total of 100 plants / plot. Damage plots were counted weekly until harvest at all field sites. The onions were harvested the week of 14 August at the Exeter field, 25 August at the Thedford field, and the Scotland fields were harvested starting from mid August to late September (Tables 1, 3).

RESULTS: As outlined in Tables 1–4 and in Figures 1–6.

CONCLUSION: Onion maggot (*Delia antiqua*) management has relied heavily on group 1B organophosphates, specifically chlorpyrifos insecticides which are currently in the process of phasing-out in Canada. Sterile Insect Technology (SIT) in Québec has shown that the release rates of sterile flies could be decreased by up to 90% within 5 years of repeated use due to the reduction of wild populations while also decreasing the cost of the sterile fly program itself. At the Exeter field site, sticky card counts of wild flies indicated that there is no increase in the average number of wild flies during the population peaks compared to 2020 or 2019 despite the field being adjacent to previous year's fields (Figure 5). An average of 12.9 flies/trap/week were counted during the main peak which occurred 22 June (Table 1; Figure 5). At the Exeter field site, fewer than five plants were found during the duration of the season that showed onion maggot damage, compared to no damage observed in 2019 or 2020. Despite growing onions in fields adjacent to each other or only implementing a single year without onion, populations of wild flies did not increase to levels high enough to cause observable damage at the Exeter field site (Figure 5; Table 1). These results seem to indicate that even with continuing cropping of onion sets in the same area continuously for four years, wild onion maggot levels remained low even with no clothianidin/ imidacloprid seed treatment or chlorpyrifos drench at planting. At the Thedford control field 28.4 km away, no sterile flies have been released to date and sticky card counts revealed a relatively larger peak of 34.6 flies/trap/week. While this field has not been cropped with onions for at least 5 years, it was situated less than 4.0 km from other commercial onion fields where onions have been grown yearly for over 50 years (**Figure 2**). Weekly scouting revealed several damaged plants with onion maggot larvae throughout the growing season. No pink flies were found on any of the sticky cards at the control field at the Thedford location.

At the Scotland field sites, a peak of 38.0 wild flies/trap/week was observed 16 June at the north release field and a peak of 25.0 wild flies/trap/week at the south release field (Table 3; Figure 6). The north release field was adjacent to a field where a peak of 159.9 flies/trap/week was observed in 2020. Fly counts remained low relative to these peaks after 23 June (Table 3; Figure 6). Onion maggot larvae were found and identified throughout the season at the Scotland, however these plants were not in the damage plots (Table 3). Both field sites in Scotland were closely planted to onion fields in 2020 or 2019 (<3 km apart) that had no sterilized flies released (Figure 3). These control fields may have acted as a refuge for wild flies. Throughout the demonstration, sticky cards were typically replaced on Tuesday/Wednesday, while the sterile flies were released on Sunday/Monday. If the sticky cards would have had to have been changed more frequently, a more accurate number of wild and sterile flies may have been recorded. A continuation of this release and survey should reveal the long-term effects of a sterile fly release on the onion maggot population and determine the overall effectiveness, and, in turn, reduce the need of chemical control options.

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Table 1. Sterile fly release dates, plant stage, weekly average trap counts and damage plot fly population levels at the Exeter release and Thedford control field sites.

		Release Field – Exeter ~9.7 ha				Control Field - Thedford			
Date	Release Quantity (‘000)	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots
21/05/12	27	--	--	--	--	--	--	--	--
21/05/19	27	--	--	--	--	--	--	--	--
21/05/25	67	loop	2.5	0.4	--	loop	2.8	0.0	--
21/06/01	84	flag	9.9	0.3	--	flag	18.4	0.0	--
21/06/08	107	1LS	6.3	0.0	38.5	1LS	34.6	0.0	34.5
21/06/15	154	2LS	3.8	0.1	36.8	2LS	14.1	0.0	34.0
21/06/22	181	3LS	12.9	0.2	39.3	3LS	20.1	0.0	32.3
21/06/29	181	3LS	5.2	0.0	36.0	3LS	8.6	0.0	32.8
21/07/06	154	4LS	5.7	0.0	34.0	4LS	16.6	0.0	33.0
21/07/13	169	5LS	5.6	0.0	37.3	5LS	9.3	0.0	31.8
21/07/20	101	6LS	4.3	0.0	36.5	6LS	6.2	0.0	31.8
21/07/27	56	6LS	9.3	0.0	34.8	6LS	4.0	0.0	30.3
21/08/03	46	6LS	7.6	0.0	33.3	6LS	2.9	0.0	30.5
21/08/10	62	7LS	3.8	0.2	28.5	7LS	7.8	0.0	27.8
21/08/17	80	wind	10.1	0.0	--	7LS	7.1	0.0	--
21/08/24	40	wind	11.8	0.0	--	7LS	4.3	0.0	--
21/09/02	0	post	4.4	0.0	--	post	1.4	0.0	--
21/09/09	55	post	--	--	--	post	--	--	--
21/09/16	57	post	--	--	--	post	--	--	--

[1] Plant stage where pre = pre-emergence, loop = loop stage, flag = flag leaf stage, LS = leaf stage and post = after pulling/harvest and -- = data points not taken

Table 2. Insecticide applications from seeding to harvest at the Thedford onion set field. No insecticides were applied at the release field during the 2021 season.

Date	Field	Trade Name	Common Name	Rate / Hectare
21/06/01	Thedford	Mako	Cypermethrin	175 mL
21/06/24	Thedford	Matador	Lambda-cyhalothrin	188 mL
21/07/14	Thedford	Dibrom	Naled	530 mL
21/08/19	Thedford	Mako	Cypermethrin	175 mL

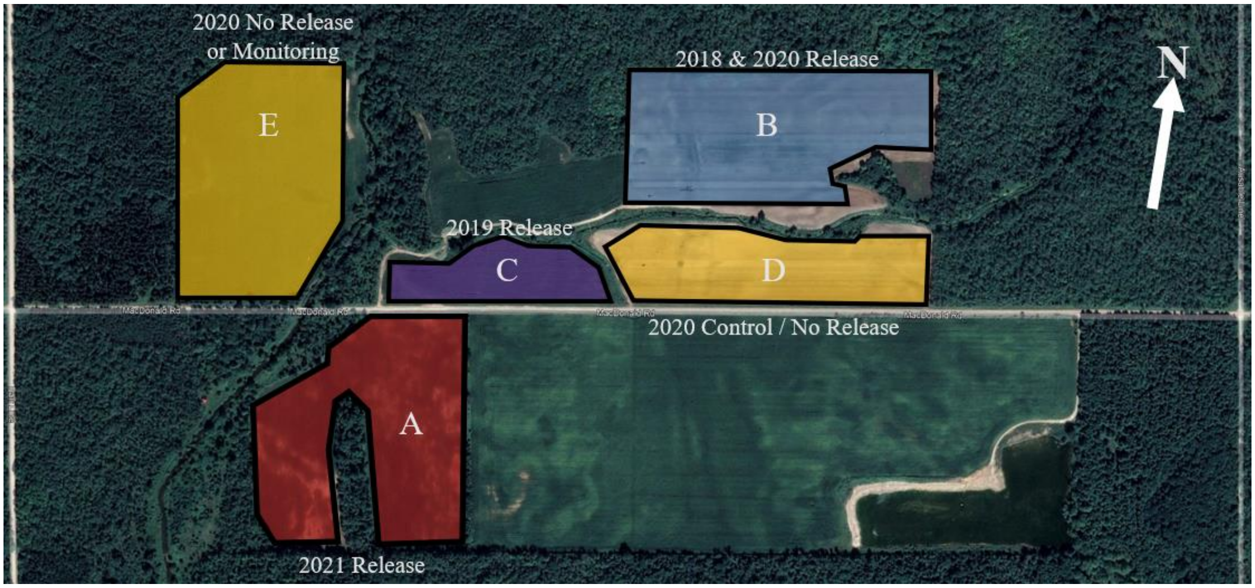

Figure 1. The release field site approximately 9.7 ha (24.0 ac) near Exeter (**A**) was seeded approximately 150 m from the field where sterile flies were release during the 2020 field season measuring approximately 10.8 ha (26.6 ac) (**B**). The field between these two sites (**C**), measuring 3.2 ha (8.0 ac) was the location for the 2019 sterile fly releases. A monitored control field where no sterile flies were released in 2020 (**D**), was situated between 2018, 2019 and 2020 release sites and was approximately 6.0 ha (14.9 ac) in size. An additional onion field approximately 9.7 ha (23.3 ac) in size was seeded in 2020 (**E**) and no monitoring took place and no sterile flies were released at this field.

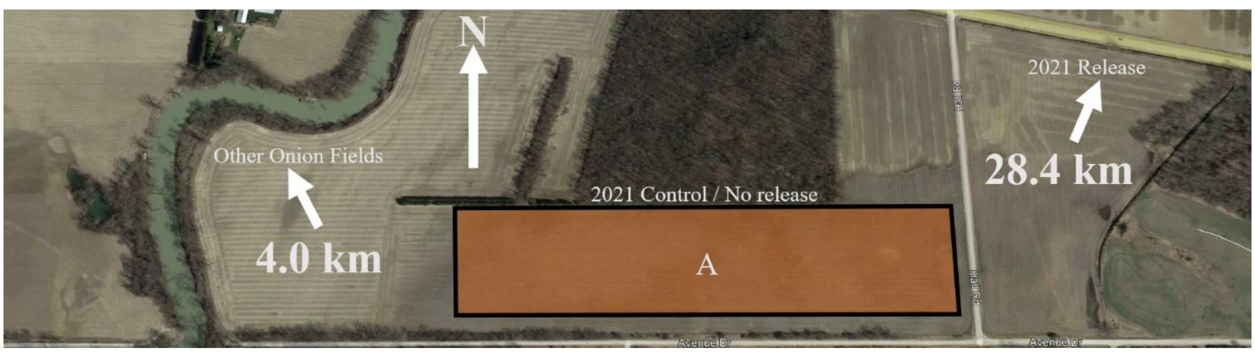

Figure 2. The monitored control field where no sterile flies were released in 2021 was approximately 9.8 ha (24.3 ac) in size (**A**).

Table 3. Sterile fly release dates, plant stage, trap counts and damage plot fly population levels at the two release and one control field site near Scotland, ON.

	Release Field 1 – North ~6.7 ha					Release Field 2 – South ~7.0 ha				
Date	Release Quantity (‘000)	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots	Release Quantity (‘000)	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots
21/05/13	9	--	--	--	--	9	--	--	--	--
21/05/20	9	--	--	--	--	9	--	--	--	--
21/05/27	22	3LS	5.1	2.0	99.3	24	3LS	4.5	6.8	98.8
21/06/02	28	4LS	16.5	1.3	99.0	31	4LS	22.2	3.8	97.5
21/06/09	36	4LS	14.9	0.3	94.8	38	4LS	18.0	1.4	96.5
21/06/16	51	5LS	38.0	1.7	94.5	56	5LS	25.0	1.7	96.5
21/06/23	60	6LS	23.3	2.7	94.0	65	6LS	16.3	1.9	96.0
21/06/30	60	7LS	5.4	0.7	92.0	65	7LS	10.3	1.5	95.0
21/07/07	51	9LS	6.4	0.3	91.0	56	9LS	10.1	0.2	93.5
21/07/14	56	10LS	8.1	1.0	91.0	62	10LS	9.4	3.0	93.3
21/07/22	33	10LS	5.8	0.4	89.8	36	10LS	4.9	0.3	91.5
	19	11LS	5.9	0.2	87.5	20				
21/07/28							11LS	3.2	0.0	91.0
21/08/04	15	11LS	8.8	0.1	85.5	16	11LS	3.4	0.1	90.0
21/08/11	21	12LS	9.0	0.4	83.0	22	12LS	3.1	1.5	90.0
21/08/18	20	12LS	9.8	1.3	78.8	22	12LS	4.9	0.8	88.0
21/08/25	13	wind	12.8	0.0	--	15	12LS	6.3	2.3	87.8
21/09/01	0	wind	3.8	0.0	--	0	wind	2.4	0.1	--
21/09/08	19	post	--	--	--	25	post	--	--	--
21/09/16	18	post	--	--	--	15	post	--	--	--

[1] Plant stage where LS = leaf stage, wind = pulled/windrowed, and post = harvest and -- = data points not taken

Table 4. Insecticide applications from seeding to harvest at the Scotland field sites.

Date	Field	Trade Name	Common Name	Rate / Hectare
21/06/08	All	Agri-Mek SC	Abamectin	200 mL
21/06/15	All	Agri-Mek SC	Abamectin	200 mL
21/06/25	All	Movento 240 SC	Spirotetramat	356 mL
21/07/02	All	Movento 240 SC	Spirotetramat	356 mL
21/07/20	All	Dibrom	Naled	530 mL
21/07/26	All	Delegate WG	Spinetoram	336 g
21/08/02	All	Delegate WG	Spinetoram	336 g

Figure 3. Sterile flies were released and monitored at two onion field sites near Scotland. The northern release field was approximately 6.7 ha (16.5 ac) in size (**A**) and was located adjacent to three 2020 release fields (**C-E**) and the field where sterile flies were released in 2019 (**F**). The southern release field was 7.0 ha (17.1 ac) in size (**B**) and was located 1.4 km south of the north release field (**A**). Other fields planted with onions in 2019 and 2020 were located 2.8 km west of the 2021 field sites (**G-H**).

Figure 4. Damage plots (**A**), sticky cards (**B**) and sterilized, pink onion maggot flies prior to release (**C**).

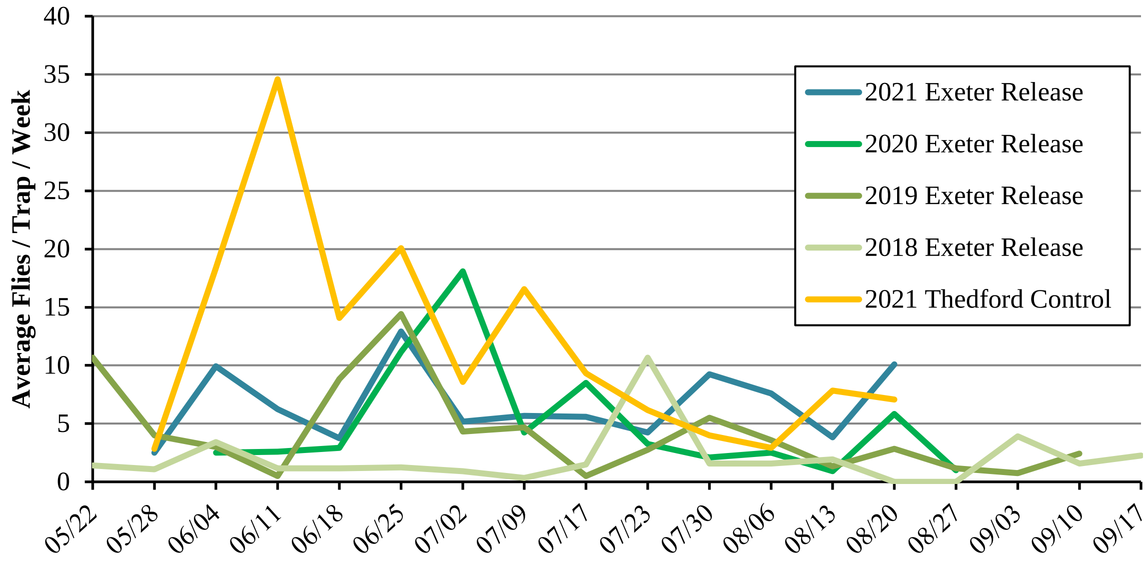

Figure 5. Average wild flies per sticky trap per week at the field site near Exeter, ON from 2018 to 2021 and Thedford, ON in 2021. Wild/fertile fly counts showed peaks in late June/early July in 2019, 2020 and 2021 while the first peak was identified in late July in 2018 (**blue/greens**). The Control field where no sterile flies were released and was within 4 km of other commercial onion fields peaked in mid June (**yellow**).

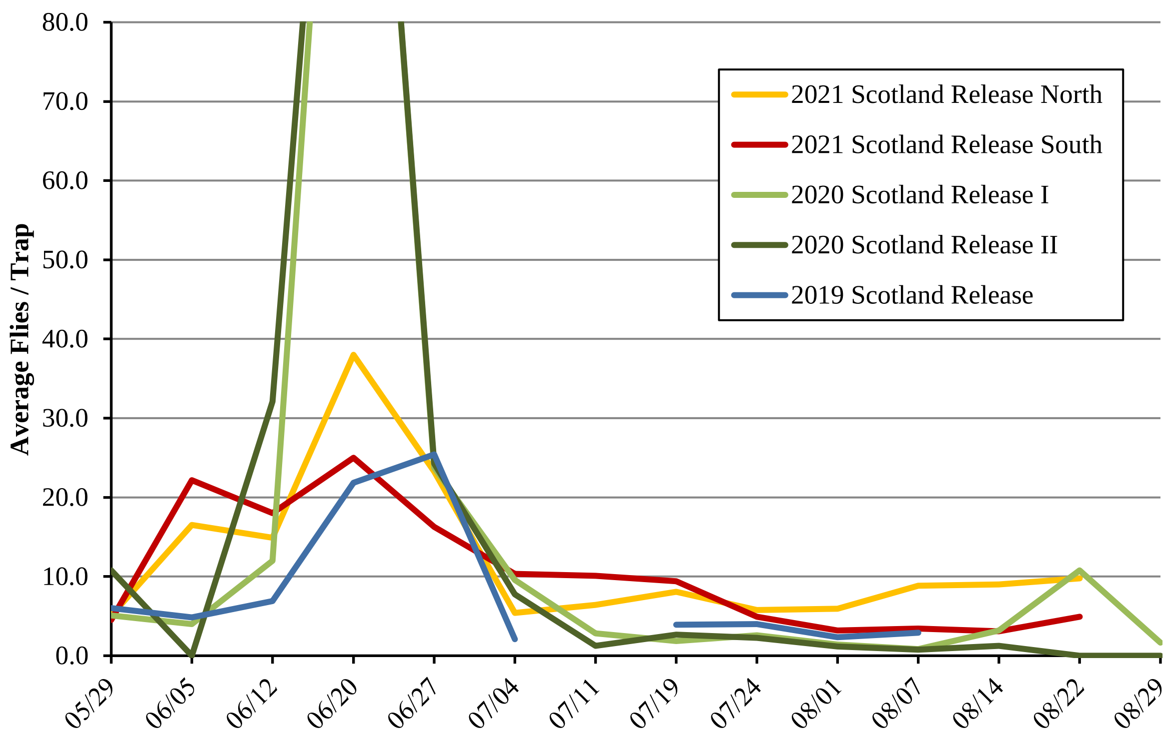

Figure 6. Average wild flies per sticky trap per week at the field sites near Scotland, ON. Wild/fertile fly counts at the release fields in 2021 (**yellow and red**) peaked at 38 and 25 flies/trap/week. In 2020, the wild fly counts at two release fields (**dark and light green**) peaked the week of 20 June and filled the sticky cards at an average of 160 flies/card (peaks not shown). The release field in 2019 peaked at 25.4 flies/trap/week (**blue**). Both 2021 fields were within 3 km of a field planted with onions in 2019 and 2020.

PMRR 2021

2021 PMR REPORT # 06 **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

CROP: Nursery outdoor ornamentals (Euonymus, Picea, Pieris, Sambucus, Thuja)
PEST: Two-spotted spider mite ((*Tetranychus urticae*), European red mite (*Panonychus ulmi*), spruce spider mite (*Oligonychus ununguis*)

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TITLE: MANAGEMENT OF SPIDER MITES IN ORNAMENTAL NURSERIES WITH THE PREDATORY MITE, *NEOSEIULUS FALLACIS*

MATERIALS: *Neoseiulus (Amblyseius) fallacis* (1000/pkg), VENDEX 50WP (fenbutatin oxide 50%)

METHODS: The trial was conducted on five outdoor nursery crops located at three different commercial nurseries in the British Columbia Fraser Valley over the course of the 2008 field season. Crops and treatments are summarized in Table 1. Crops and sites were selected based on a history of spider mite infestation in the previous or current growing season, and a sufficient number of pots to arrange in three separate treatment sections with a 1-m space between each section. No physical barriers separated the three treatment sections. As this was primarily a demonstration study, for each nursery/crop combination there was only one replicate of each treatment. All crops were in 1-gallon (4 L) pots except Thuja 'Holmstrup' which were in 3-gallon (12 L) pots.

The trial consisted of three treatments: 1) Control – no chemical or biological treatment, 2) Chemical – 50WP at 0.5 g/L in 1000 L water/ha applied with a CO_2 backpack sprayer at 276 kPa using a triple-nozzle boom with 8002 VS Teejet nozzles and 3) Biological – release of the predatory mite *Neoseiulus fallacis* (Applied Bio-nomics Ltd., Victoria, BC); one package of 1000 mites in vermiculite per treatment application. Each treatment was applied to one section of a crop on the same date. The number of times that the biological and chemical treatments were applied varied for each crop/site, as the start date varied from June 6 (four applications at monthly intervals) to September 19 (one application) depending on when pest mites were observed (Table 1**)**. All sprays and predatory mite releases were done during the first half of the day with air temperatures ranging from 14.5 to 21ºC on the various treatment dates and minimal or no wind. Overhead irrigation was withheld for at least 24-h following each treatment application.

Pest mite populations (adults and nymphs) were assessed prior to the treatment applications and at weekly or bi-weekly intervals thereafter up to October 10. For Pieris and Sambucus, single leaves were examined; for Euonymus, Picea and Thuja, samples consisted of the top 5-cm of a branch with all leaves/needles along the branch tip examined. For each treatment in each crop, 30 leaves or branch tips were collected randomly from each of the Control, Chemical and Biological sections then visually examined under a dissecting microscope and the numbers of pest and predatory mites recorded. Samples were held in the refrigerator for one to five days prior to examination. For spruce mites on Thuja and Picea, an additional assessment was done using tapping counts: a white sheet of paper attached to a clipboard was placed under a branch which was tapped 10 times and the number of mites dislodged onto the paper was then counted (Cullen 2006). Because more mites were observed in tapping counts than visual counts on Thuja and Picea, only tapping data are presented. Follow-up counts of predatory and spruce mites were done on Thuja in spring 2009.

One-way analysis of variance (ANOVA) was performed using CoStat Version 6.400, 2008, CoHort Software, Monterey, California, USA, ©1998-2008. Treatment means were compared in Duncan's Multiple Range Test (MRT) and Tukey's HSD at $P<0.05$.

Table 1. Crops, target pest mites and treatment dates for chemical and biological control applications in outdoor nursery crops.

Location	Crop details	Target pest mite	Treatment dates
Langley	*Euonymus radicans* 1-gallon (4 L) pots 675 pots/treatment	2-spotted	June 6, July 18, Aug. 15, Sept. 19
Langley	*Pieris japonica* 'Forest Flame' 1-gallon (4 L) pots 400 pots/treatment	European red mite	June 6, July 18, Aug. 15, Sept. 19
Langley	*Pieris japonica* 'Mountain Fire' 1-gallon (4 L) pots 400 pots/treatment	European red mite	June 6, July 18, Aug. 15, Sept. 19
	Picea glauca var. *albertiana* 'Conica' 1-gallon (4 L) pots 960 pots – Biological 640 pots – Control 320 pots – Chemical	Spruce mite	Aug. 15, Sept. 19
Abbotsford	*Thuja occidentalis* 'Holmstrup' 3-gallon (12 L) pots 312 pots/treatment	Spruce mite	Sept. 19
	Sambucus nigra 'Thundercloud' 1-gallon (4 L) pots 435 pots – Chemical and Biological 380 pots – Control	2-spotted	Sept. 19

RESULTS: As presented in Tables 2 and 3 and Figures 1-6.
CONCLUSIONS: In four of the five crops, Euonymus, Sambucus, Thuja and Picea, releases of the predatory mite *N. fallacis* kept spruce and two-spotted mite populations at lower levels for a longer period

of time than the chemical (VENDEX) applications. This was accomplished by maintaining a low pest population at already low levels (e.g., two-spotted mite on Euonymus), suppressing the overall growth of the pest population (e.g., spruce mite on Picea), or reducing a high pest population and maintaining that reduction (e.g., spruce mite on Thuja, two-spotted mite on Sambucus). Two releases of *N. fallacis* controlled spruce spider mite on Picea significantly better, overall, than either the Chemical or Control treatments in Tukey's HSD at $p<0.05$.

On Sambucus and Thuja, a single treatment was made on September 19. There was an immediate decline in spider mites in the first week following the Chemical treatment. The Biological treatment took two weeks to show a reduction in spider mite populations, however, spruce and two-spotted mite numbers also declined at the same time in the Control areas, possibly due to the onset of colder temperatures and shorter days. Thus, the decline in pest mites in the Biological plots after Sept 19 cannot be attributed exclusively to the predator release. However, by the final count on Oct 10, pest mite numbers were trending upward in both the Chemical and Control plots but not in the Biological.

Monthly releases of predatory mites did not appear to affect the number of European red mites (ERM) on Pieris. On both varieties of Pieris, the population of ERM in the Biological treatment was consistently either higher than, or similar to, that in the Control and Chemical treatments. Unfortunately, the Control plants in both varieties were sprayed with the insecticide Tristar 70 WSP (acetamiprid 70%) on July 20 for control of lacebugs, which also appeared to have knocked back the European red mite population. However, another study also suggests the effect of *N. fallacis* on European red mite in apple and pear may be limited (Lester et al. 2000).

In April 2009, both spruce mite and *N. fallacis* were present in all three treatment plots of Thuja 'Holmstrup'. *N. fallacis* is native to the area. However, the Biological treatment had highest ratio of predator to pest mites (approximately 2:1 versus 1:1 in the other treatments) and the lowest pest mite population, suggesting that the predatory mites released in 2008 had overwintered.

In this demonstration trial, *N. fallacis* release rates were at least 4-6 times higher than those recommended for other field-grown horticultural crops. Determining appropriate release rates for nursery crops should help to lower the cost of biological control.

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Cullen, E. 2006. Spidermites: A to Z. Proc. of the 2006 Wisconsin Fertilizer, Aglime, & Pest Management Conference. 45:130-133.

Lester, P.J., H.M.A. Thistlewood, and R. Harmsen. 2000. Some effects of pre-release host plant on the biological control of *Panonychus ulmi* by the predatory mite *Amblyseius fallacis*. Exp. and Appl. Acarology 24(1):19-33.

ACKNOWLEDGEMENTS: Thank you to all of the nursery growers who participated in this study. Funding for this project was provided by the BC Landscape and Nursery Association (BCLNA) and by Agriculture and Agri-Food Canada and the Government of British Columbia through programs delivered by the Investment Agriculture Foundation of BC (IAFBC). Opinions expressed in this report are those of the authors and not necessarily those of IAFBC, the Government of British Columbia or Agriculture and Agri-Food Canada.

Table 2. Euonymus: Mean number of two-spotted mites per leaf per date.[1, 2]

Treatment	18/07	25/07	01/08	22/08	29/08	12/09	19/09	26/09	03/10	10/10	Mean Sum
Control	0.3a	0.0a	0.03a	0.4a	0.4a	0.87a	0.2a	0.27a	0.17a	0.07a	2.4±5.4a
Biological	0.0a	0.0a	0.0a	0.1a	0.03b	0.0a	0.2a	0.17a	0.17a	0.07a	0.7±1.2a
Chemical	0.0a	0.4a	0.03a	0.03a	0.17ab	0.87a	0.0a	0.07a	0.10a	0.0a	1.7±6.9a

[1]Mean of 30 leaves examined per treatment per date; only dates with non-zero numbers are shown.
[2]Numbers followed by the same letter are not significantly different in Duncan's MRT at p<0.05.

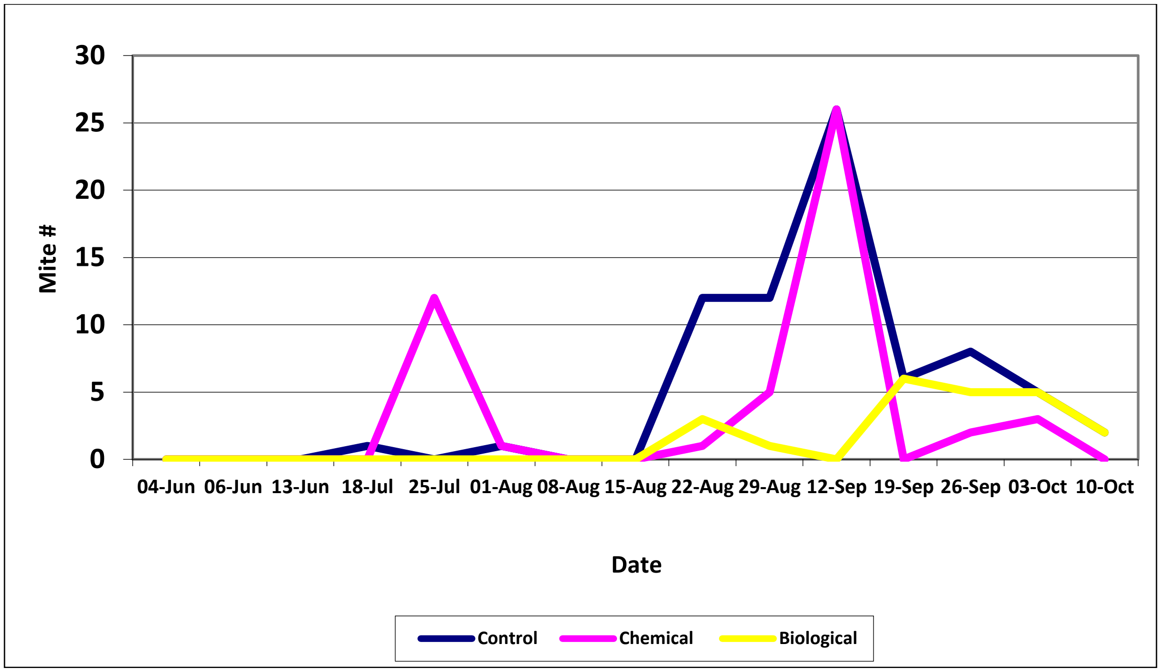

Fig. 1. Two-spotted spider mite weekly total leaf count numbers per treatment on Euonymus. Treatments were applied monthly on June 6, July 18, August 15 and September 19.

Table 3. Picea: Mean number of spruce spider mites per plant per date.[1, 2]

Treatment	15/08	22/08	29/08	12/09	19/09	26/09	03/10	10/10	Mean Sum
Control	1.5a	1.7a	3.7a	7.1a	6.4a	3.3ab	0.5a	0.2a	24.4 ± 10.9 a
Biological	0.2b	0.1a	1.9b	2.2b	3.6a	0.6b	0.3a	0.2a	9.1 ± 4.9 b
Chemical	0.7ab	3.1a	3.1ab	2.9ab	12.9a	4.4a	0.8a	0.2a	28.1 ± 13.4 a

[1]Mean of 10 plants tapped over a white sheet per treatment per date.
[2]Numbers followed by the same letter are not significantly different in Tukey's HSD at p<0.05.

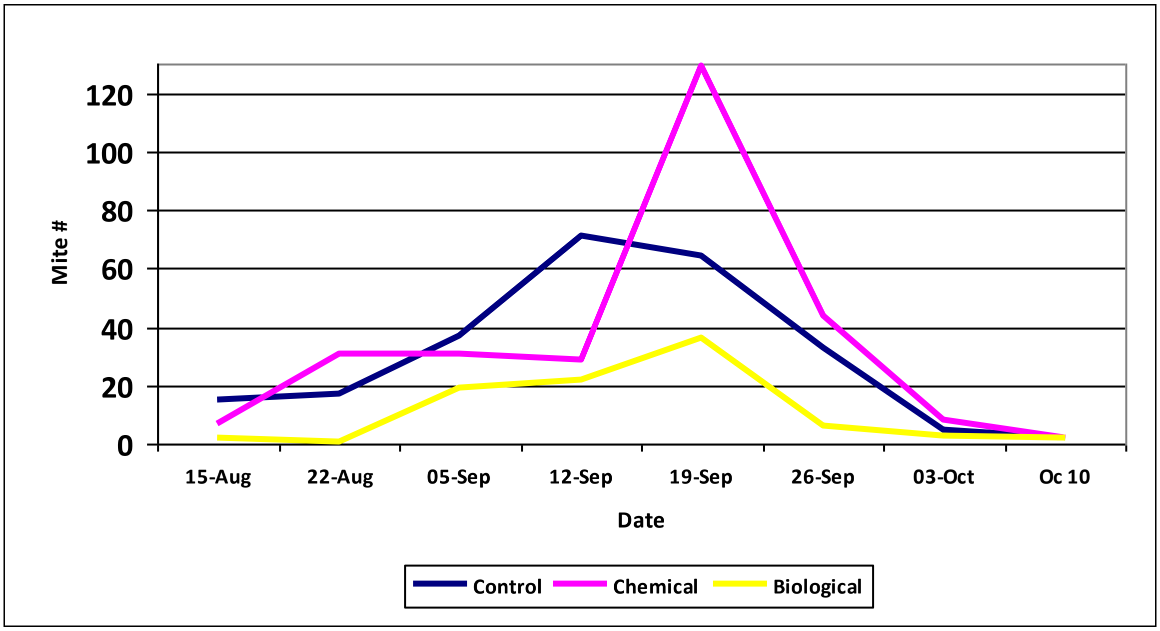

Fig. 2. Spruce spider mite weekly total tapping count numbers per treatment on *Picea*. Treatments were applied on August 15 and September 19.

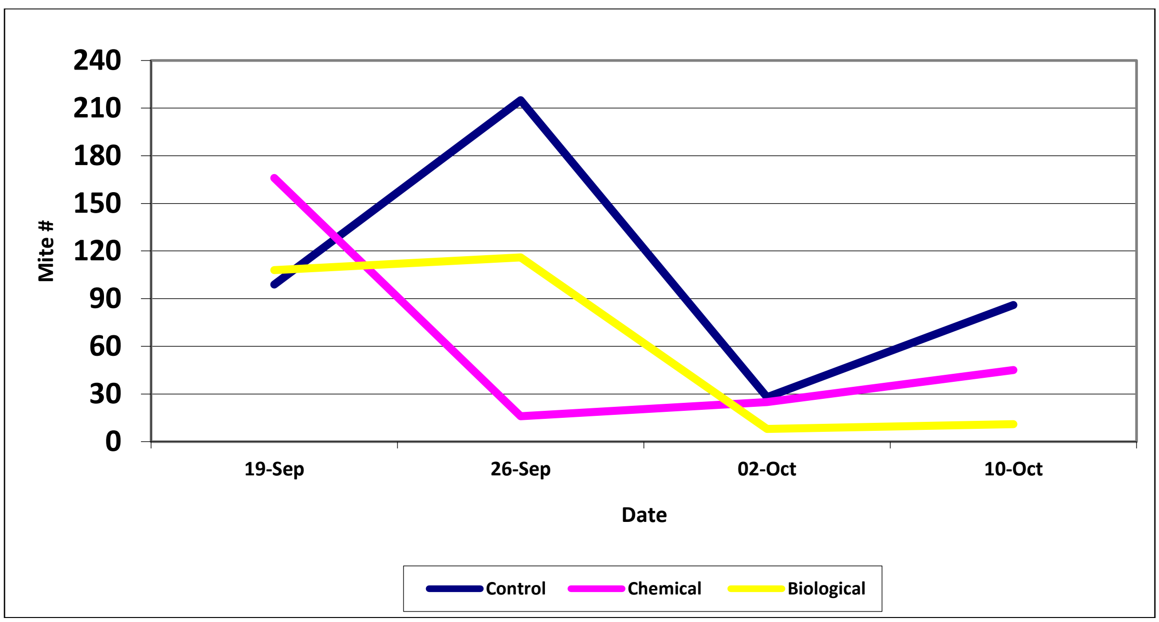

Fig. 3. Spruce spider mite weekly total tapping count numbers per treatment on Thuja 'Holmstrup'. Treatments were applied on September 19.

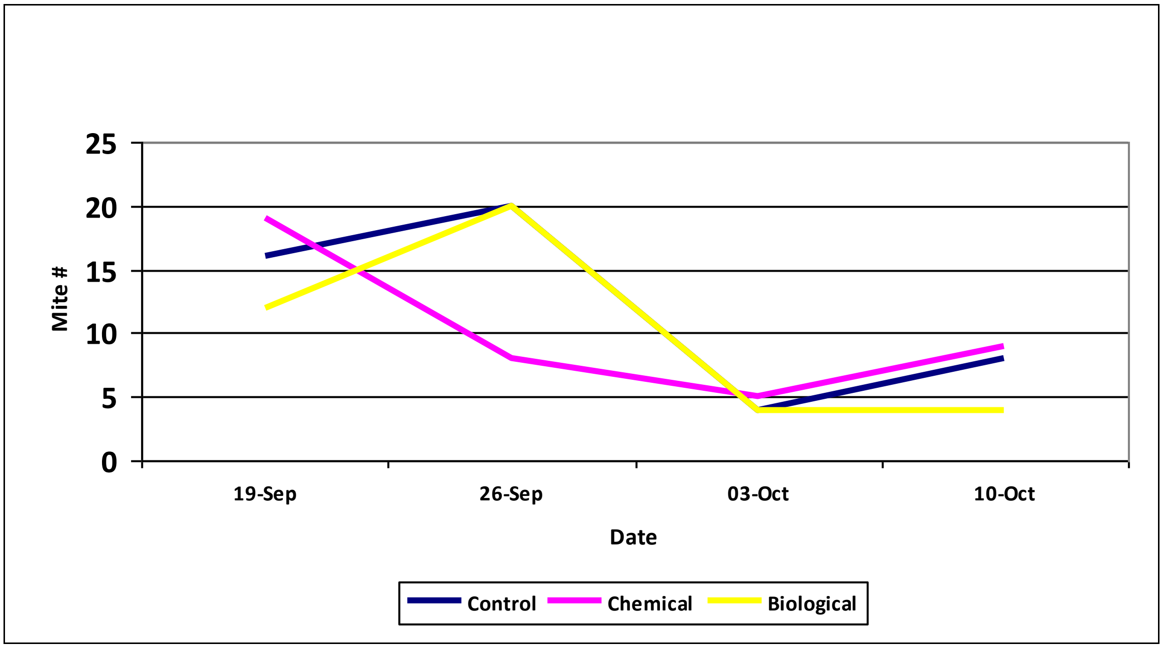

Fig. 4. Two-spotted spider mite weekly total leaf count numbers on Sambucus 'Thundercloud'. Treatments were applied on September 19.

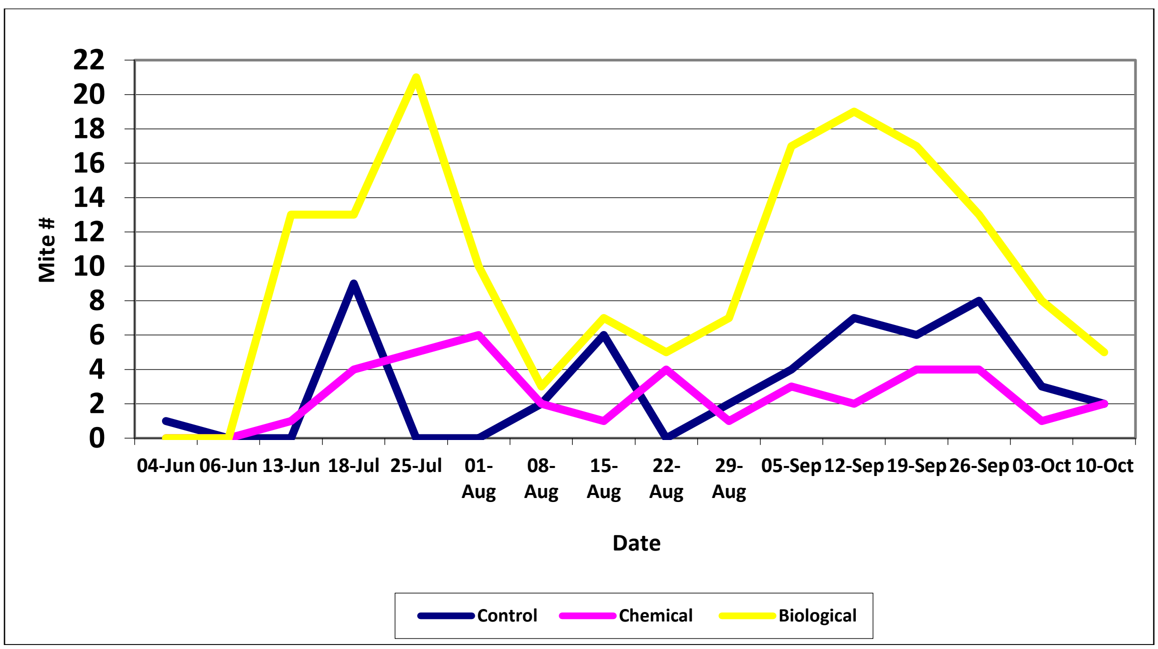

Fig. 5a. European red mite weekly total leaf count numbers on Pieris 'Mountain Fire'. Treatments were applied monthly on June 6, July18, August 15 and September 19.

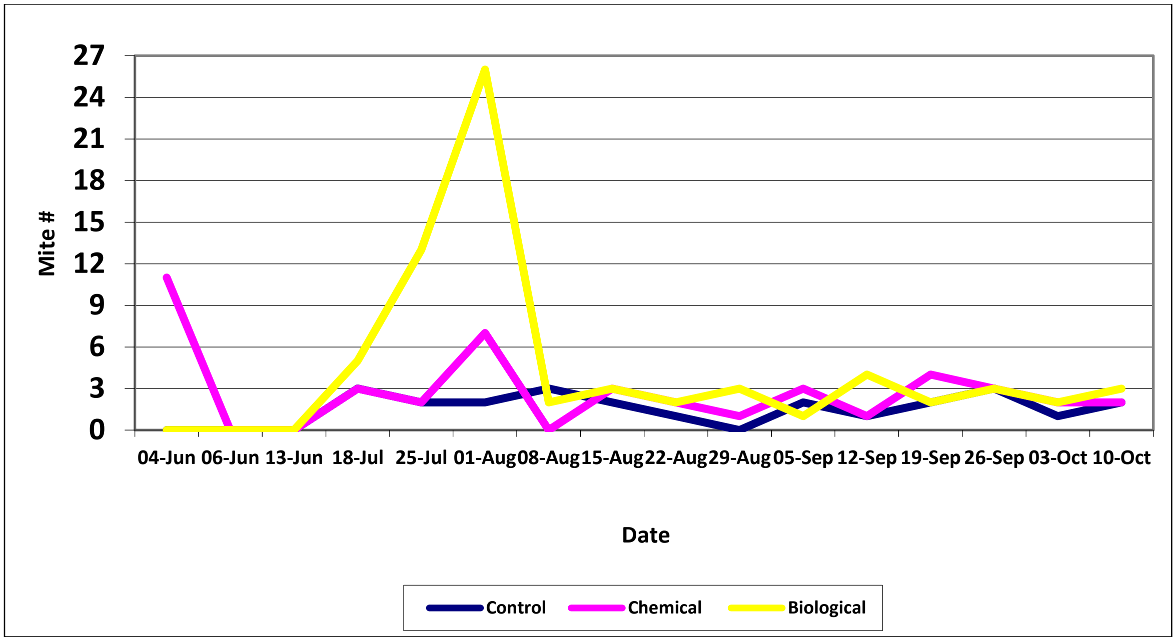

Fig. 5b. European red mite weekly total leaf count numbers on Pieris 'Forest Flame'. Treatments were applied monthly on June 6, July18, August 15 and September 19.

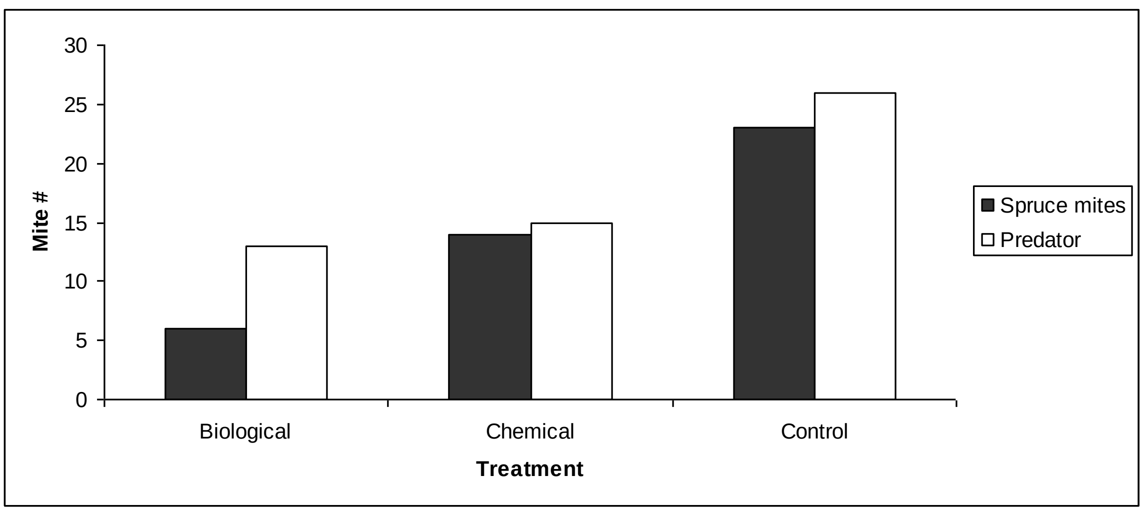

Fig. 6. Total spruce and predatory (*Neoseiulus fallacis*) mites on Thuja 'Holmstrup' in April 2009. Sum of 20 plants tapped per treatment.

2021 PMR Report # 07 **SECTION J: NEMATODES**

CROP: Garlic (*Allium sativum* L.), cv. Music
PEST: Stem and bulb nematode (*Ditylenchus dipsaci*) (Kühn, 1857) Filip'ev, 1936

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TITLE: **EVALUATION OF NEMATICIDES FOR CONTROL OF THE STEM AND BULB NEMATODE IN GARLIC, 2020-21**

MATERIALS: AGRI-MEK SC (abamectin 84 g/L), PREV-AM (sodium tetraborohydrate decahydrate 0.99%), PROMAX (thyme oil 3.5%), VELUM PRIME (fluopyram 500g/L)

METHODS: The field trial was conducted in a mineral soil field (organic matter 3.1%, pH 7.4) free of stem and bulb nematode (SBN) near Cookstown, Ontario. A randomized complete block design with five (5) replicates per treatment was used. Garlic cloves (seed) used were infested with 6 SBN/g clove. Nematode counts were determined at the University of Guelph Ontario Crops Research Centre - Bradford using the Baermann pan method. The treatments were: AGRI-MEK SC, PREV-AM, PROMAX and VELUM PRIME applied as a soak (S) or drench (D). Seed soak treatments, and the associated soaking times, were: AGRI-MEK S at 0.9 mL/L for 4-hours, PREV-AM S at 8 mL/L for 4-hours, PROMAX S at 37.4 mL/L for 4-hours and VELUM PRIME S at 1.7 mL/L for 2- and 4-hours. Soak treatments were applied by placing cloves in a mesh bag in 10 L of each treatment solution for each respective amount of time. After treatment, cloves were air dried before planting. The drench treatments were VELUM PRIME D at 500 mL/ha using a standard water volume rate of 1000 L/ha and a 1.5 times water volume rate of 1500 L/ha. Drench treatments were applied directly over the cloves at planting at an application rate of 90 mL/m using a beaker. An untreated infested seed check was also included. Each experimental unit consisted of 25 garlic cloves planted ~5 cm deep and 10 cm apart in 2.5 m long single rows spaced 40 cm apart. The trial was planted on 27 October 2020. Emergence and plant heights were recorded on 14 June 2021. Garlic was harvested on 4 August. Bulbs were counted, weighed, assessed for basal plate rot and sorted into classes using a 0-4 rating scale, where: 0 = no damage, 1 = 1-24% basal plate missing; 2 = 25-50% basal plate missing; 3 = > 50% basal plate missing and 4 = completely desiccated bulb. These data were used to calculate a disease severity index (DSI) using the formula below.

$$DSI = \frac{\sum [(\text{class no.})\ (\text{no. of garlic bulbs in each class})]}{(\text{total no. garlic bulbs assessed})\ (\text{no. classes -1})} \times 100$$

Stem and bulb nematodes were extracted and quantified from a 10 g sample of cloves after harvest using the Baermann pan method.
Data were analyzed using the PROC GLIMMIX function in SAS version 9.4. Means separation was obtained using Tukey's HSD test with $P = 0.05$ level of significance.

RESULTS: Data are presented in Tables 1 and 2.

CONCLUSIONS: The VELUM PRIME and AGRI-MEK treatments reduced nematode damage and increased marketable yield compared to the untreated check. The organic product PREV-AM resulted in higher damage and lower marketable yield than the untreated check. The 2-hour soak with VELUM PRIME was as effective as the 4-hour soak for disease severity (2.7 and 3.8%) and percent marketable yield (98.8 and 96.4%), respectively. VELUM PRIME was very effective for management of SBN in garlic as a soak or drench. The organic products PREV-AM and PROMAX did not protect garlic from SBN damage. No significant differences in emergence and plant height were found among treatments.

Table 1. Garlic emergence and plant heights on 14 June after nematicide application for stem and bulb nematode infested seed cloves near Cookstown, Ontario, 2021.

Treatment	App Method[1]	Soak Time (hr)	% Emergence (of 25 plants)	Plant Height (cm)
Check	-	-	93.6 ns[2]	85.0 ns
VELUM PRIME	S	4	92.8	92.7
PROMAX	S	4	92.0	84.9
VELUM PRIME	1.5x D[3]	-	90.4	90.2
VELUM PRIME	Std D[3]	-	89.6	92.3
AGRI-MEK	S	4	88.0	87.4
VELUM PRIME	S	2	85.6	87.4
PREV-AM	S	4	85.6	81.0

[1] Application Method: S = Soak; D = Drench
[2] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's HSD test
[3] The Std drench rate was 1000 L/ha and the 1.5x drench rate was 1500 L/ha.

Table 2. Percent marketable bulbs, nematode disease severity index (DSI), marketable yield and nematode counts from harvested garlic treated with various nematicides to control stem and bulb nematode (SBN) near Cookstown, Ontario, 2020-2021.

Treatment	App. Method[1]	Soak Time (hours)	% Marketable Bulbs	DSI[2]	Marketable Yield (g/plot)	Harvest SBN Count (SBN/g clove)
VELUM PRIME	S	4	96.6 a[3]	3.8 a	1653.9 a	0.0 ns[4]
VELUM PRIME	S	2	98.1 a	2.7 a	1505.5 a	0.2
VELUM PRIME	Std D[5]	-	95.4 a	6.5 a	1463.5 a	13.0
AGRI-MEK	S	4	92.9 a	6.9 a	1316.2 ab	1.4
VELUM PRIME	1.5x D[5]	-	85.8 ab	13.5 ab	1283.8 ab	12.8
PROMAX	S	4	65.1 bc	34.1 bc	833.7 bc	0.1
Check	-	-	52.8 c	44.1 c	689.5 c	0.6
PREV-AM	S	4	10.9 d	86.6 d	66.7 d	6.2

[1] Application Method: S = Soak; D = Drench
[2] DSI was calculated using the following equation:

$$DSI = \frac{\sum [(\text{class no.})\ (\text{no. of garlic bulbs in each class})]}{(\text{total no. garlic bulbs assessed})\ (\text{no. classes} - 1)} \times 100$$

[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Tukey's HSD test
[4] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's HSD test
[5] The Std drench rate was 1000 L/ha and the 1.5x drench rate was 1500 L/ha.

Funding for this project was provided by the California Garlic and Onion Research Advisory Board and the Fresh Vegetable Growers of Ontario representing the Ontario Garlic Growers Association.

2021 PMR REPORT # 08 **SECTION K: FRUIT - DISEASES**

CROP: Strawberry cv. 'Albion'
PEST: Anthracnose, *Colletotrichum nymphaeae*

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TITLE: EVALUATION OF FUNGICIDES AND BIOFUNGICIDES FOR CONTROL OF ANTHRACNOSE IN DAY-NEUTRAL STRAWBERRIES

MATERIALS: SERIFEL (*Bacillus amyloliquefaciens* strain MBI 600), PROBLAD BIOFUNGICIDE (BLAD polypeptide 20%), DIPLOMAT 5 SC (polyoxin D zinc salt 5%), SWITCH 62.5 WG (fludioxonil 25% + cyprodinil 37.5%), CEVYA (mefentrifluconazole 400 g/L), METTLE 125 ME (tetraconazole 125 g/L), INSPIRE (difenoconazole 250 g/L), FULLBACK 125 SC (flutriafol 125 g/L), SERCADIS (fluxapyroxad 300 g/L)

METHODS: Bare root strawberry plants were transplanted on 13 May 2021. Plants were planted in white plastic raised beds, each plot was 2 rows with 40 cm between plants within a row, rows were staggered, with a total of 24 plants per plot. Plots were arranged in a randomized complete block design with 4 replications. Fungicide treatments were applied on 9, 19, 27 July, 3, 10, 17, 24, 31 August and 7 September using a CO_2 backpack sprayer equipped with two TeeJet Air Induction XR11005 nozzles spaced 50 cm apart and calibrated to deliver 400 L/ha at 35 PSI. To make sure disease was present in the trial, plants were inoculated with a spore suspension of *Colletotrichum nymphaeae* on 21 July using a conidial suspension of 1.13×10^6 conidia/ml, derived from a 4-week-old PDA-grown cultures of the fungus. Tween 20 was added (1 drop Tween 20 per 500mL conidial suspension) and the suspension was sprayed to the foliage until runoff (~4ml/plant).

Plots were harvested by hand twice a week on 27, 30 July, 3, 6, 10, 13, 17, 20, 24, 27, 31 August, 3 and 7 September. Berries were sorted into marketable and unmarketable, weighed and counted. Marketability was determined based on the shape, size, and quality of the fruit. Diseased and misshapen fruit were separated, and all considered unmarketable. Anthracnose incidence (% berries with lesions) was determined by counting the total number of berries with anthracnose. Area under the disease progress curve (AUDPC) was based on the anthracnose incidence ratings and was determined using the following equation:

$$\text{AUDPC} = \sum_{j=1}^{N_{j-1}} \left(\frac{y_j + y_{j+1}}{2}\right)(t_{j+1} - t_j)$$

Data was analyzed using analysis of variance function in R Studio. Means separation was obtained using Tukey's HSD test with P = 0.05 level of significance.

RESULTS: Refer to Table 1, 2 and Figure 1.

CONCLUSIONS: Anthracnose was present at a low level during the first harvest on 27 July. There were no significant differences amongst the fungicide treatments compared to the untreated control until 10 August. SWTICH was more effective than the untreated control and FULLBACK. SWITCH was consistently more effective than the untreated control and other fungicide treatments. DIPLOMAT was more effective than FULLBACK on 27 August. When disease pressure was very high, 31 August, 3 & 7 September, SWITCH was the only effective product at reducing disease.

Table 1. Yield of strawberries cv. Albion totaled from the 13 harvests.

Treatment	Rate	Total marketable[1] yield (g/plot)	Total unmarketable yield (g/plot)
Untreated control		1932 a[2]	4656 ns[3]
SERIFEL	500 g/ha	2614 a	5334
PROBLAD BIOFUNGICIDE	3300 ml/ha	2302 a	4692
DIPLOMAT 5 SC	926 ml/ha	2448 a	4763
SWITCH 62.5 WG	975 g/ha	4727 b	3583
CEVYA	375 ml/ha	2779 a	4790
METTLE 125 ME	365 ml/ha	2036 a	4165
INSPIRE	500 ml/ha	2456 a	4999
FULLBACK 125 SC	1024 ml/ha	1535 a	4536
SERCADIS	666 ml/ha	2086 a	4537

[1]Marketability was determined based on the shape, size, and quality of the fruit. Diseased and misshapen fruit were separated, and all considered unmarketable.
[2] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Tukey's HSD test.
[3]ns= no significant differences at a confidence level of 5%, Tukey's HSD.

Table 2. Incidence (% infected) of fruit with anthracnose (*Colletotrichum nymphaeae*) on strawberry cv. Albion at each harvest date

Treatment	7/27	7/30	8/03	8/06	8/10	8/13	8/17	8/20	8/24	8/27	8/31	9/03	9/07
Untreated control	0 ns[1]	0 ns	21.6 ns	7.9 ns	39.7 a[2]	32.7 ab	94.1 ns	81.6 a	59.3 a	54.4 ab	97.1 a	98.9 a	100 a
SERIFEL	4.7	3.8	27.4	9.9	33.7 ab	34.1 ab	95.8	84.6 a	60.6 a	59 ab	95.6 a	94.9 a	100 a
PROBLAD BIOFUNGICIDE	1.4	1.7	20.8	7.1	21.9 ab	34.1 ab	94.2	79.8 a	55.9 a	53.2 ab	96.9 a	93.7 a	100 a
DIPLOMAT 5 SC	0	3.9	14.6	5.3	21.3 ab	22.7 ab	92.8	73.7 a	45.9 ab	32.3 b	88.3 a	83.7 a	99.4 a
SWITCH 62.5 WG	0	1.3	0	0	4.4 b	17.7 b	74	29.6 b	18.6 b	8.9 c	32.8 b	38.7 b	56.8 b
CEVYA	0.9	1.9	22.3	2.3	32.1 ab	30.8 ab	93.6	85.3 a	61.3 a	50.8 a	96 a	96.1 a	100 a
METTLE 125 ME	7.9	4.9	11.8	9.9	23 ab	29.3 ab	89.4	77.3 a	45.1 ab	42 ab	93.5 a	97.8 a	100 a
INSPIRE	5.8	9.4	17.5	9.2	30.3 ab	27.2 ab	90.7	76.9 a	62.6 a	45.7 ab	94.9 a	94.3 a	100 a
FULLBACK 125	19	21	29	10.8	49.3 a	44.5 a	93.8	86.6 a	66.2 a	64.6 a	98.7 a	98.6 a	100 a
SERCADIS	0	2.7	17	9.1	20.8 ab	26.4 ab	94.2	78 a	46.7 ab	43.5 ab	99.2 a	100 a	100 a

[1] ns= no significant differences at a confidence level of 5%, Tukey's HSD.
[2]Numbers in a column followed by the same letter are not significantly different at P = 0.05, Tukey's HSD test.

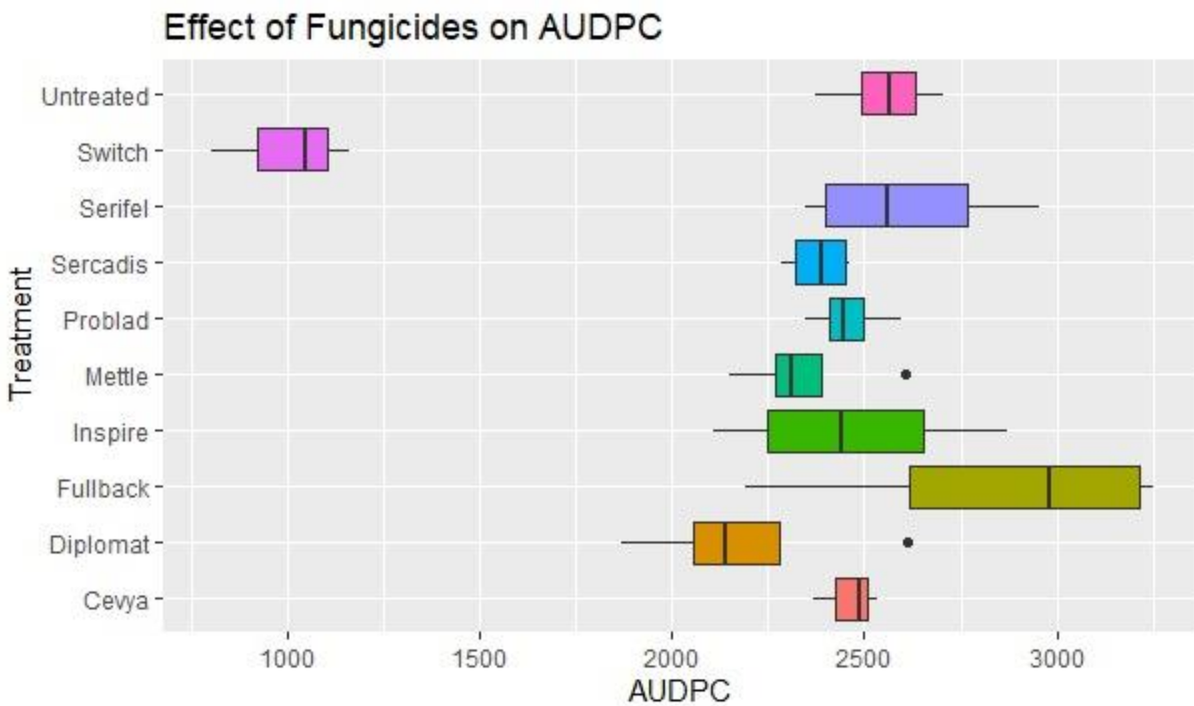

Figure 1. Area under the disease progress curve (AUDPC) for anthracnose incidence for each fungicide treatment. AUDPC was based on the anthracnose incidence ratings at harvest on 27, 30 July, 3, 6, 10, 13, 17, 20, 24, 27, 31 August, 3 and 7 September.

ACKNOWLEDGEMENTS: We would like to thank the Canadian Agricultural Partnership and the Berry Growers of Ontario for funding this project.

2021 PMR REPORT # 09 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Onion (*Allium cepa* L.), cv. Milestone
PEST: Onion downy mildew (*Peronospora destructor* (Berk.) Casp. in Berk.)

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TITLE: **EVALUATION OF FUNGICIDES FOR CONTROL OF DOWNY MILDEW ON DRY BULB ONIONS, 2021**

MATERIALS: ORONDIS ULTRA (oxathiapiprolin 30 g/L, mandipropamid 250 g/L), ZAMPRO SC (ametoctradin 300 g/L, dimethomorph 225 g/L), RIDOMIL GOLD MZ 68 WG (metalaxyl-M and S-isomer 4%, mancozeb 64%), DITHANE 750 F (mancozeb 75%), SYLGARD 309 (siloxylated polyether 76%), DIPLOMAT (polyoxin D zinc salt 5%), PICARBUTRAZOX 10SC (picarbutrazox), SERIFEL (Bacillus amyloliquefaciens strain mbi 600), PREV-AM (sodium tetraborohydrate decahydrate 0.99%)

METHODS: Onions, cv. Milestone, were direct seeded on 6 May into organic soil, (organic matter ≈ 68.3%, pH ≈ 6.4) using a Stanhay Precision seeder at the Ontario Crops Research Centre - Bradford, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of four rows spaced 43 cm apart, and 6 m in length. Treatments were applied as foliar sprays using a CO_2 backpack sprayer equipped with four TeeJet 8002 fan nozzles calibrated to deliver 500 L/ha at 275 kPa. Treatments were: ORONDIS ULTRA at 400 mL/ha, ZAMPRO at 1.0 L/ha + Sylgard at 0.25% v/v, T-77 at 500 g/ha, ORONDIS ULTRA at 400 mL/ha alternated with ZAMPRO at 1.0 L/ha + Sylgard at 0.25% v/v, ORONDIS ULTRA at 400 mL/ha alternated with RIDOMIL MZ at 2.5 kg/ha, RIDOMIL MZ at 2.5 kg/ha and DITHANE at 3.25 kg/ha, + SYLGARD at 0.25% v/v. An untreated check was also included. Treatments were applied on 12, 20 July, and 3, and 13 August based on disease forecasting. On 24 July, 9 and 16 August, all onions in each replicate were visually examined for the presence of downy mildew (DM) lesions. On 9 September, onions in two, 2.32 m sections of row (2 x 1 m^2) per replicate were pulled. On 9 October, onions were removed from storage, sorted into size categories, weighed and counted to determine yield.
Yield data were analyzed using the General Analysis of Variance function of Statistix V.10. Means separation was obtained by using Fisher's Protected LSD test at P = 0.05 level of significance.

RESULTS: as presented in Tables 1 and 2

CONCLUSIONS: The weather in 2021 was conducive to the development of downy mildew in onions but no lesions were detected until early August. No significant differences in the number of downy mildew lesions between treatments were observed in the trial (Table 1). The DIPLOMAT and PREV AM treatments had the highest numbers of lesions. No significant differences in yield or size distribution were observed among the treatments (Table 2).

Table 1. Downy mildew (DM) incidence for onions, cv. Milestone, treated with fungicides and grown at the Ontario Crops Research Centre - Bradford, Holland Marsh, Ontario, 2021.

Treatment[1]	Rate (per ha)	DM Lesions/plot[2]			Total lesions
		24 Jul	9 Aug	16 Aug	
RIDOMIL MZ alt/w ORONDIS ULTRA[3]	2.5 kg	0 ns[4]	0.0 ns	0.0 ns	0.0 ns
PICARBUTRAZOX	880 mL	0	0.3	0.5	0.8
ZAMPRO + SYLGARD	1.0 L + 0.25% v/v	0	0.5	0.8	1.3
ORONDIS ULTRA	400 mL	0	0.8	1.8	2.5
SEREFIL	1.0 kg	0	3.0	2.3	5.3.
PREV-AM	2.0 L	0	8.0	2.5	10.5
DIPLOMAT	926 mL	0	15.5	5.5	21.0
Check	-	0	8.8	7.3	16.0

[1] Treatments were applied on 12, 20 July, 3, 13 August.
[2] The entire plot was visually examined for DM lesions and numbers recorded.
[3] RIDOMIL MZ was applied on 12 July, 3 August. ORONDIS ULTRA was applied on 20 July, 13 August.
[4] ns = no significant differences were found among treatments at P = 0.05, Fisher's Protected LSD test.

Table 2. Yield and size distribution for onions, cv. Milestone, treated with fungicides and grown at the Ontario Crops Research Centre – Bradford, Holland Marsh, Ontario, 2021.

Treatment	Yield (t/ha)	% Mkb	Size distribution (%)[1]		
			Jumbo (>76 mm)	Large (76-64 mm)	Medium (63-45 mm)
ORONDIS ULTRA	80.7 ns[2]	98.8 ns	4.6 ns	40.1 ns	54.1 ns
SEREFIL	76.8	98.2	2.6	42.1	53.5
ZAMPRO + SYLGARD	76.5	97.6	3.8	38.6	55.3
DIPLOMAT	75.2	98.0	1.0	39.4	57.6
RIDOMIL MZ alt/w ORONDIS ULTRA[3]	74.8	97.3	0.3	43.5	53.5
PICARBUTRAZOX	74.6	97.9	1.6	43.2	53.2
Check	70.4	95.8	1.3	35.4	59.1
PREV-AM	69.5	97.2	0.7	30.4	66.1

[1] Percentage was determined by weight.
[2] ns = no significant differences at P = 0.05, Fisher's Protected LSD test

Funding for this project was provided by the Plant Production Systems of the Ontario Agri-Food Innovation Alliance and by the California Garlic and Onion Research Advisory Board.

2021 PMR REPORT # 10 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Yellow cooking onions (*Allium cepa* L.), cv. Catskill
PEST: Stemphylium leaf blight (*Stemphylium vesicarium* (Wallr.))

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TITLE: EVALUATION OF VARIOUS FUNGICIDES FOR CONTROL OF STEMPHYLIUM LEAF BLIGHT ON ONIONS, 2021

MATERIALS: SERCADIS (fluxapyroxad 300 g/L), MIRAVIS DUO (pydiflumetofen 75 g/L, difenoconazole 125 g/L), MERIVON (pyraclostrobin 250 g/L, fluxapyroxad 250 g//L), T-77 (*Trichoderma atroviride* strain 77B < 2.5 x 10^9 spores/g), PREV-AM (sodium tetraborohydrate decahydrate 0.99%)

METHODS: Onions, cv. Catskill, were direct seeded (≈ 35 seeds/m) on 6 May into organic soil (organic matter ≈ 68.1%, pH ≈ 6.2) at the Ontario Crops Research Centre - Bradford, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of eight rows spaced 40 cm apart, and 6 m in length. Fungicide sprays were applied on 30 June, 12, 21 and 28 July using a tractor-mounted sprayer fitted with hollow cone D-3 spray nozzles at 620 kPa to deliver 500 L solution/ha. Fungicide treatments were: SERCADIS at 666 mL/ha, MIRAVIS DUO at 1.0 L/ha, MERIVON at 600 mL/ha, T-77 at 250 g/ha, PREV-AM at (2.0 L/ha), SERCADIS at 666 mL/ha (12 and 28 July) alternated with T-77 at 250 g/ha (30 June and 21 July), MIRAVIS DUO at 1.0 L/ha (12 and 28 July) alternated with T-77 at 250 g/ha (30 June and 21 July). An untreated check was also included. On 14, 22, 30 July the three oldest leaves on 20 randomly chosen onions per replicate were visually examined for stemphylium leaf blight (SLB) symptoms and rated on a 0-6 scale where 0 = no SLB symptoms, 1 = 1-4%, 2 = 5-10%, 3 = 11-25%, 4 = 26-50%, 5 = 51-75% and 6 = >75% of leaf area infected with symptoms of *Stemphylium* infection. These classes were used to determine the disease severity index (DSI) using the following formula:

$$\text{DSI} = \frac{\sum [(\text{class no.})\ (\text{no. of leaves in each class})]}{(\text{total no. leaves assessed})\ (\text{no. classes -1})} \times 100$$

On 10 September, the onions in two 2.32 m sections of row were pulled from the inner rows for a yield sample. Onions were weighed and graded for size on 25 October to determine yield**.** Data were analyzed using the General Analysis of Variance function of Statistix V.10. Means separation was obtained by using Fisher's Protected LSD test at P = 0.05 level of significance.

RESULTS: as presented in Tables 1 and 2

CONCLUSIONS: Stemphylium incidence was moderate in 2021 and increased through July. Significant differences in disease severity were observed among fungicide treatments when plants were destructively sampled and assessed on Aug 10 (Table 1). Onions sprayed with MIRAVIS DUO, SERCADIS and MERIVON had significantly lower disease severity than onions treated with PREV-AM or the untreated check. Only onions treated with MIRAVIS DUO alone had lower incidence than the untreated check. Onions sprayed with MIRAVIS DUO, SERCADIS or MERIVON alone had the most leaves in the 0 and 1 categories (no symptoms of less than 4% of the leaf affected). Significant differences in yield and size distribution were observed among the treatments (Table 2). Onions treated with MIRAVIS DUO or SERCADIS had significantly higher yield (t/ha) and a higher percentage of large onions (except SERCADIS alone) compared to the PREV-AM, T-77 treatments and the check.

Table 1. Stemphylium leaf blight (SLB) incidence and severity for onions, cv. Catskill, sprayed with various fungicides, at the Ontario Crops Research Centre - Bradford, Holland Marsh, Ontario, 2021.

Treatment	% Leaves rated 0 or 1[1]	SLB incidence	DSI
MIRAVIS DUO	46.4 a[3]	75.0 a	32.5 a
SERCADIS	40.2 ab	80.5 ab	37.2 ab
MERIVON	40.0 ab	82.0 ab	38.3 abc
T-77 alt/w MIRAVIS DUO	35.4 bc	83.0 b	39.2 a-d
T-77	31.5 bc	81.3 ab	43.6 b-e
T-77 alt/w SERCADIS	29.8 bc	86.9 b	46.2 cde
PREV-AM	28.1 c	85.7 b	46.8 de
check	27.3 c	88.2 b	49.5 e

[1] On 10 August the leaves of 20 plants were sorted into classes: 0= no disease, 1 = 1-4%, 2 = 5-10%, 3 = 11-25%, 4 = 26-50%, 5 = 51-75%, 6 > 75% based on the percentage of leaf area infected with Stemphylium.

[3] Disease severity (DSI) was calculated using the following formula:

$$\text{DSI} = \frac{\sum [(\text{class no.})\ (\text{no. of leaves in each class})]}{(\text{total no. leaves assessed})\ (\text{no. classes -1})} \times 100$$

[3] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.

Table 2. Yield data for onions, cv. Catskill, sprayed with various fungicides at the Ontario Crops Research Centre - Bradford, Holland Marsh, Ontario, 2021.

Treatment	Yield (t/ha)	% Mkb	Size distribution (%)		
			Jumbo (>76mm)	Large (76-64 mm)	Medium (45-64 mm)
MIRAVIS DUO	66.2 a[1]	98.1 ns[2]	8.6 ns	43.2 a	46.3 cd
T-77 alt/w MIRAVIS DUO	65.8 a	98.2	3.9	34.3 ab	60.1 b
SERCADIS	64.1 ab	97.3	7.6	31.7 abc	57.9 bc
T-77 alt/w SERCADIS	64.0 ab	98.3	9.8	42.9 a	45.6 d
MERIVON	60.8 abc	97.5	3.6	30.1 bc	63.8 ab
Check	58.8 bc	97.3	3.4	33.9 abc	60.1 b
PREV-AM	55.7 c	97.1	3.1	33.7 abc	60.3 b
T-77	54.5 c	97.1	1.8	21.9 c	73.3 a

[1] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test

[2] ns = no significant differences at P = 0.05, Fisher's Protected LSD test.

Funding for this project was provided by Plant Production Systems of the Ontario Ministry of

Agriculture, Food and Rural Affairs and the University of Guelph partnership, the California Onion and Garlic Research Advisory Board and the Bradford Co-operative and Storage.

2021 PMR REPORT # 11 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Sugarbeet (*Beta vulgaris* L. subsp. *vulgaris*), cv. HIL-9908
PEST: Cercospora leaf spot, *Cercospora beticola* (Saccardo)

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TITLE: FUNGICIDE EFFICACY TESTING FOR THE MANAGEMENT OF CERCOSPORA LEAF SPOT ON SUGARBEET, 2021

MATERIALS: MANZATE PRO-STICK (mancozeb 75%), MILSTOP (potassium bicarbonate 85%), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), CUEVA (copper octanoate 1.8%), PARASOL WP (copper hydroxide 50%), VEGOL CROP OIL (canola oil 96%), DOUBLE NICKEL 55 (*Bacillus amyloliquefaciens* strain D747 5×10^{10} spores/g).

METHODS: The trial was conducted at Ridgetown Campus, University of Guelph. Sugarbeet cultivar 'H9908' was planted in a sandy clay loam soil on May 11 at a rate of 9 seeds per meter. Each treatment plot consisted of two 7.0 m long rows, spaced 75 cm apart and separated by two guard rows. The trial was set up as a randomized complete block with four replications per treatment. Plots were inoculated on June 28 where one dried infected sugarbeet leaf, collected in 2020, was placed in the middle of each guard row. Treatments were applied using a hand-held CO_2 sprayer (40 psi) with Hardi® iso injet™ 03 nozzles and a water volume of 300 L/ha. Treatments were applied on a 7 to 11-day calendar schedule. Disease severity was assessed on July 23, August 4, August 19, September 1, September 16, September 28, and October 14 using a 0-9 scale as described by Battilani et al. (1990). This data was used to determine the percent leaf area affected by Cercospora leaf spot (CLS) by converting ratings to a midpoint percent value, where 0 = 0% leaf area affected, 1 = 1% leaf area affected, 2 = 5% leaf area affected, 3 = 10% leaf area affected, 4 = 15% leaf area affected, 5 = 30% leaf area affected, 6 = 49% leaf area affected, 7 = 70% leaf area affected, 8 = 90.5% leaf area affected, and 9 = 99% leaf area affected. The air temperatures were above the long term (10 year) average for April (7.9 °C, 2021 average), May (13 °C), June (20.7 °C), July (20.6 °C), August (22 °C), September (17.4 °C), and October (14.2 °C). Total rainfall was above the long term (10 year) average for June (4.2 mm, 2021 average), August (2.8 mm), September (3.8 mm), and October (4.3 mm) and below average for April (1.6 mm), May (1.5 mm), and July (4 mm). Sugarbeets were harvested from a 4 m section of each plot on October 18 and 19. Fifteen randomly selected roots were assessed for polarization (POL), refractometric dry solids (RDS), sugar percentage, and recoverable white sugar per ton (RWST) on October 22 by the Michigan Sugar Company. RWST was converted to recoverable white sugar per hectare (RWSH). Statistical analysis was conducted using SAS 2021 (SAS Institute Inc.). Analysis of variance was conducted and, when $P \leq 0.05$, means comparisons were performed using Tukey's honest significant difference test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: PARASOL and PARASOL + VEGOL applications resulted in lower AUDPC and disease severity on October 14 than the Nontreated control. AUDPC for MANZATE PRO-STICK was also lower than the Nontreated control. RWSH was statistically higher in CUEVA treated plots than plots treated with MILSTOP, but equivalent to all other treatments. No significant differences were found among treatments for purity and sugar percentage (*data not shown*), or beet yield.

ACKNOWLEDGEMENTS: Technical assistance of Kevin Dufton. This project was funded by the Ontario Agri-Food Innovation Alliance Research Program, the Ontario Sugarbeet Growers' Association (OSGA), and the Michigan Sugar Company (MSC).

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Table 1. Field evaluation of fungicide efficacy for the control of Cercospora leaf spot on sugar beet, Ridgetown, ON, 2021.

Treatment (product rate/ha) [a]	Disease Severity (%) [b, c]	AUDPC	Beet Yield (kg/ 4m row)	RWSH (kg/ha) [d]
Nontreated control	14 a [e, f]	476 a	16 ns	6761 ab
MANZATE PRO-STICK @ 2.25 kg	11 a	144 bc	17	7276 ab
MILSTOP @ 5.6 kg	14 a	436 a	15	6032 b
PHOSTROL @ 5.6 L	12 a	339 ab	17	7197 ab
CUEVA @ 1% v/v	12 a	259 abc	18	7845 a
PARASOL @ 4.25 kg	1 b	24 c	18	7778 ab
VEGOL @ # L	12 a	388 ab	15	6401 ab
PARASOL @ 4.25 kg + VEGOL @ 3 L	1 b	55 c	17	7318 ab
DOUBLE NICKEL @ 2.34 L	15 a	443 a	16	6802 ab

[a] Treatments were applied on June 21, July 2, July 9, July 19, July 28, August 5, August 12, August 19, August 26, September 3, September 14, and September 24.
[b] Disease severity ratings from October 14, 2021, which was the last assessment date prior to harvest.
[c] Means separation in this column is based on arcsine square root transformation to satisfy assumptions of normality. Original means are presented.
[d] RWSH is the recoverable white sugar per hectare.
[e] Values followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.
[f] Disease severity values collected biweekly were used to calculate the area under the disease progress curve (AUDPC) using the formula $AUDPC = \Sigma_{i=1}[(Y_{i+1}+Y_i)/2][X_{i+1}-X_i]$ where Y_i is the mean rating at day X_i and Y_{i-1} is the mean rating at day X_{i-1}.

2021 PMR REPORT # 12 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Sugarbeet (*Beta vulgaris* L. subsp. *vulgaris*), cv. G932NT
PEST: Cercospora leaf spot, *Cercospora beticola* (Saccardo)

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TITLE: **ALTERNATIVE SPRAY PROGRAMS FOR THE MANAGEMENT OF CERCOSPORA LEAF SPOT ON SUGARBEET CV. G932NT, 2021**

MATERIALS: PROLINE 480 SC (prothioconazole 480 g/L), MANZATE PRO-STICK (mancozeb 75%), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), PARASOL WP (copper hydroxide 50%), VEGOL CROP OIL (canola oil 96%).

METHODS: This trial was conducted at Ridgetown Campus, University of Guelph. Sugarbeet cultivar 'G932NT' was planted in a sandy clay loam soil on April 27 at a rate of 9 seeds per meter. Each treatment plot consisted of two 7.0 m long rows, spaced 75 cm apart and separated by two guard rows. The trial was set up as a randomized complete block with four replications per treatment. Plots were inoculated on June 28. One dried infected sugarbeet leaf, collected in 2020, was placed in the middle of each guard row. Treatments were applied using a hand-held CO_2 sprayer (40 psi) with Hardi® iso injet™ 03 nozzles and a water volume of 300 L/ha, based on three different spray programs: BEETcast moderate, BEETcast susceptible, and a calendar application. Disease severity was assessed on July 23, August 4, August 19, September 1, September 17, and September 29 using a 0-9 scale as described by Battilani et al. (1990). This data was used to determine the percent leaf area affected by Cercospora leaf spot (CLS) by converting ratings to a midpoint value where, 0 = 0% leaf area affected, 1 = 1% leaf area affected, 2 = 5% leaf area affected, 3 = 10% leaf area affected, 4 = 15% leaf area affected, 5 = 30% leaf area affected, 6 = 49% leaf area affected, 7 = 70% leaf area affected, 8 = 90.5% leaf area affected, and 9 = 99% leaf area affected. The air temperatures were above the long term (10 year) average for April (7.9 °C, 2021 average), May (13 °C), June (20.7 °C), July (20.6 °C), August (22 °C), September (17.4 °C), and October (14.2 °C).Total rainfall was above the long term (10 year) average for June (4.2 mm, 2021 average), August (2.8 mm), September (3.8 mm), and October (4.3 mm) and below average for April (1.6 mm), May (1.5 mm), and July (4 mm). Sugarbeets were harvested from a 4 m section of each plot on October 4 & 5. Twelve randomly selected roots were assessed for polarization (POL), refractometric dry solids (RDS), sugar percentage, and recoverable white sugar per ton (RWST) on October 2 by the Michigan Sugar Company. RWST was converted to recoverable white sugar per hectare (RWSH). Statistical analysis was conducted using SAS 2021 (SAS Institute Inc.). Analysis of variance was conducted and, when $P \leq 0.05$, means comparisons were performed using Tukey's honest significant difference test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: All programs with three or more applications of PHOSTROL alone resulted in disease accumulation over the season (AUDPC) equal to the Nontreated control (treatment 1) except for the calendar application of MANZATE PRO-STICK with PHOSTROL, PARASOL and VEGOL (treatment 18). All BEETcast moderate programs reduced percent leaf area with CLS compared to the Nontreated control except MANZATE PRO-STICK with PROLINE and PHOSTROL (treatment 4) and PROLINE with PHOSTROL (treatment 6), while all BEETcast susceptible programs reduced percent disease severity to a similar level as one another except MANZATE PRO-STICK with PROLINE and PHOSTROL (treatment 10) and PROLINE with PHOSTROL (treatment 12). In both the BEETcast susceptible and moderate application timings, treatments with MANZATE PRO-STICK with PROLINE and PHOSTROL (treatment 4 and 10) and PROLINE with PHOSTROL (treatment 6 and 12) resulted in CLS severity equivalent to the Nontreated control (treatment 1). All calendar programs reduced percent disease severity compared to the Nontreated control (treatment 1) except MANZATE PRO-STICK with PHOSTROL (treatment 17) and PHOSTROL (treatment 20).

MANZATE PRO-STICK with PROLINE PARASOL and VEGOL applied using the BEETcast susceptible timing (treatment 9) and calendar application of MANZATE PRO-STICK with PHOSTROL, PARASOL and VEGOL (treatment 18) yielded greater RWSH than the Nontreated control (treatment 1). All other treatments had similar RWSH as the Nontreated control (treatment 1). No differences among treatments were found for beet yield (Table 1) or purity (*data not shown*). The calendar application of MANZATE PRO-STICK with PHOSTROL, PARASOL and VEGOL (treatment 18) was the only treatment to have a greater percentage of sugar yielded (*data not shown*) than the Nontreated control (treatment 1).

ACKNOWLEDGEMENTS: Technical assistance of Kevin Dufton. This project was funded by the Ontario Agri-Food Innovation Alliance Research Program, the Ontario Sugarbeet Growers' Association (OSGA), and the Michigan Sugar Company (MSC).

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Table 1. Field evaluation of fungicide programs for the control of Cercospora leaf spot of sugar beet, Ridgetown, ON, 2021.

Treatment [a] (product rate/ha)	Disease Severity (%) [b]	AUDPC [c]	Beet Yield (kg/ 4 m row)	RWSH (kg/Ha) [d]
1. Nontreated control	50 abc [e]	1285 a	27 ns [f]	970 bc
BEETcast™ moderate application interval [g]				
2. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EIKNPS)	28 cd	417 b-g	29	1160 abc
3. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EI) PARASOL @ 4.25 kg + VEGOL @ 3 L (KNPS)	16 d	236 e-h	31	1223 ab
4. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EI) PHOSTROL @ 5.6 L (KNPS)	62 a	774 a-d	28	1060 abc
5. PROLINE @ 365 ml (BG) PARASOL @ 4.25 kg + VEGOL @ 3 L (EIKNPS)	14 d	240 e-h	30	1155 abc
6. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BG) PHOSTROL @ 5.6 L (EIKNPS)	60 a	890 abc	28	1017 abc
7. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BG) PHOSTROL @ 5.6 L (EI)	16 d	295 d-g	28	1095 abc

PARASOL @ 4.25 kg + VEGOL @ 3 L (KNPS)				
BEETcast™ susceptible application interval				
8. MANZATE 2.25 kg + PROLINE @ 365 ml (AF)				
MANZATE 2.25 kg (CGHJLNOR)	22 d	205 e-h	31	1188 abc
9. MANZATE 2.25 kg + PROLINE @ 365 ml (AF)				
MANZATE 2.25 kg (CG)				
PARASOL @ 4.25 kg + VEGOL @ 3 L (HJLNOR)	11 d	95 h	32	1250 a
10. MANZATE 2.25 kg + PHOSTROL @ 5.6 L +				
PROLINE @ 365 ml (AF)				
MANZATE 2.25 kg + PHOSTROL @ 5.6 L (CG)				
PHOSTROL (HJLNOR)	60 a	465 a-f	29	1117 abc
11. PROLINE @ 365 ml (AF)				
PARASOL @ 4.25 kg + VEGOL @ 3 L (CGHJLNOR)	13 d	147 gh	30	1130 abc
12. PROLINE @ 365 ml (AF)				
PHOSTROL @ 5.6 L (CGHJLNOR)	61 a	880 abc	26	931 c
13. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (AF)				
PHOSTROL @ 5.6 L (CG)				
PARASOL @ 4.25 kg + VEGOL @ 3 L (HJLNOR)	14 d	167 fgh	29	1149 abc
Calendar application interval				
14. PROLINE @ 365 ml (BG)				
MANZATE 2.25 kg (DIMQT)	30 cd	481 a-e	29	1071 abc
15. MANZATE 2.25 kg (BDGIMQT)	32 bcd	436 a-f	29	1103 abc
16. MANZATE 2.25 kg (BDGI)				
PARASOL @ 4.25 kg + VEGOL @ 3 L (MQT)	22 d	400 b-g	30	1197 abc
17. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGI)				
PHOSTROL @ 5.6 L (MQT)	65 a	1037 ab	28	1014 abc
18. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGI)				
PARASOL @ 4.25 kg + VEGOL @ 3 L + PHOSTROL				
@ 5.6 L (MQT)	19 d	316 c-g	31	1251 a
19. PARASOL @ 4.25 kg + VEGOL @ 3 L				
(BDGIMQT)	16 d	300 d-g	31	1154 abc
20. PHOSTROL @ 5.6 L (BDGIMQT)	55 ab	984 ab	29	1042 abc
21. PARASOL @ 4.25 kg + VEGOL @ 3 L +				
PHOSTROL @ 5.6 L (BGMQT)				
PHOSTROL @ 5.6 L (DI)	25 d	451 b-f	27	1058 abc

[a] BEETcast™ moderate application programs were made on B = June 21 (42 DSV), E = July 9 (33 DSV), G = July 19 (26 DSV), I = Aug 2 (24 DSV), K = Aug 11 (19 DSV), N = Aug 19 (19 DSV), P = Aug 27 (18 DSV), and S = Sept 3 (16 DSV). BEETcast™ susceptible application programs were made on A = June 18 (33 DSV), C = July 2 (27 DSV), F = July 12 (21 DSV), G = July 19 (20 DSV), H = July 27 (16 DSV), J = Aug 6 (13 DSV), L = Aug 12 (17 DSV), N = Aug 19 (16 DSV), O = Aug 26 (15 DSV), R = Aug 31 (15 DSV). Calendar applications were made on a 12 to 14-day interval on B = June 21, D = July 5, G = July 19, I = Aug 2, L = Aug 12, Q = Aug 30, and T = Sept 14.
[b] Disease severity ratings from September 29, 2021, which was the last assessment date.
[c] Disease severity values collected biweekly were used to calculate the area under the disease progress curve (AUDPC) using the formula AUDPC = $\Sigma_{i=1}[(Y_{i+1}+Y_i)/2][X_{i+1}-X_i]$ where Y_i is the mean rating at day X_i and Y_{i-1} is the mean rating at day X_{i-1}.
[d] RWSH is the recoverable white sugar per hectare.
[e] Values followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.
[f] ns indicates no significant differences.

2021 PMR REPORT # 13 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Sugarbeet (*Beta vulgaris* L. subsp. *vulgaris*), cv. HIL-9908
PEST: Cercospora leaf spot, *Cercospora beticola* (Saccardo)

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TITLE: **ALTERNATIVE SPRAY PROGRAMS FOR THE MANAGEMENT OF CERCOSPORA LEAF SPOT ON SUGARBEET CV. HL-9908, 2021**

MATERIALS: PROLINE 480 SC (prothioconazole 480 g/L), MANZATE PRO-STICK (mancozeb 75%), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), PARASOL WP (copper hydroxide 50%), VEGOL CROP OIL (canola oil 96%).

METHODS: This trial was conducted at Ridgetown Campus, University of Guelph. Sugarbeet cultivar 'HIL-9908' was planted in a sandy clay loam soil on May 11 at a rate of 9 seeds per meter. Each treatment plot consisted of two 7.0 m long rows, spaced 75 cm apart and separated by two guard rows. The trial was set up as a randomized complete block with four replications per treatment. Plots were inoculated on June 28. One dried infected sugarbeet leaf, collected in 2020, was placed in the middle of each guard row. Treatments were applied using a hand-held CO_2 sprayer (40 psi) with Hardi® iso injet™ 03 nozzles and a water volume of 300 L/ha, based on three different spray programs: BEETcast moderate, BEETcast susceptible, and a 12–14-day calendar application Disease severity was assessed on July 23, August 5, August 20, September 3, September 18, and September 28 using a 0-9 scale as described by Battilani et al. (1990). This data was then used to determine the percent leaf area affected by Cercospora leaf spot (CLS) by converting ratings to a midpoint percent value where, 0 = 0% leaf area affected, 1 = 1% leaf area affected, 2 = 5% leaf area affected, 3 = 10% leaf area affected, 4 = 15% leaf area affected, 5 = 30% leaf area affected, 6 = 49% leaf area affected, 7 = 70% leaf area affected, 8 = 90.5% leaf area affected, and 9 = 99% leaf area affected. The air temperatures were above the long term (10 year) average for April (7.9 °C, 2021 average), May (13 °C), June (20.7 °C), July (20.6 °C), August (22 °C), September (17.4 °C), and October (14.2 °C).Total rainfall was above the long term (10 year) average for June (4.2 mm, 2021 average), August (2.8 mm), September (3.8 mm), and October (4.3 mm) and below average for April (1.6 mm), May (1.5 mm), and July (4 mm). Sugarbeets were harvested from a 4 m section of each plot on October 12 & 13. Fifteen randomly selected roots were assessed for polarization (POL), refractometric dry solids (RDS), sugar percentage, and recoverable white sugar per ton (RWST) on October 18 by the Michigan Sugar Company. RWST was converted to recoverable white sugar per hectare (RWSH). Statistical analysis was conducted using SAS 2021 (SAS Institute Inc.). Analysis of variance was conducted and, when $P \leq 0.05$, means comparisons were performed using Tukey's honest significant difference test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: All application programs except for BEETcast moderate application of PROLINE with PHOSTROL (treatment 6), BEETcast susceptible application of MANZATE PRO-STICK with

PHOSTROL (treatment 10) and the calendar application of PHOSTROL (treatment 20) had lower disease accumulation over the season (AUDPC) than the Nontreated control (treatment 1). Percent disease severity was equivalent among all BEETcast moderate treatments except for PROLINE with PARASOL and VEGOL (treatment 5) and PHOSTROL, PROLINE, and PARASOL with VEGOL (treatment 7), which had lower disease severity. Percent disease severity for all BEETcast susceptible applications were similar to one another with the exception of MANZATE PRO-STICK with PHOSTROL and PROLINE (treatment 10) and PROLINE with PHOSTROL (treatment 12), which had more leaf area affected by CLS. No differences were found for percent disease severity among calendar application treatments except for PHOSTROL (treatment 20) which was significantly higher than MANZATE PRO-STICK with PARASOL AND VEGOL (treatment 16), MANZATE PRO-STICK, PHOSTROL with PARASOL and VEGOL (treatment 18), PARASOL and VEGOL (treatment 19), and PARASOL with VEGOL and PHOSTROL (treatment 21).

No treatments resulted in higher beet yield than the Nontreated control (treatment 1). BEETcast moderate treatments MANZATE PRO-STICK with PROLINE and PHOSTROL (treatment 4), PROLINE with PARASOL and VEGOL (treatment 5) and PHOSTROL with PROLINE, PARASOL and VEGOL (treatment 7), BEETcast susceptible treatment MANZATE PRO-stick with PROLINE, PARASOL and VEGOL (treatment 9) and PROLINE with PARASOL and VEGOL (treatment 11) had greater RWST than the Nontreated control (treatment 1). The BEETcast moderate treatment of PHOSTROL, PROLINE, and PARASOL with VEGOL (treatment 7) and the BEETcast susceptible application of PROLINE with PARASOL and VEGOL (treatment 11) had a percentage of sugar yielded of 17%, which was greater than the Nontreated control (treatment 1) (15%) (*data not shown*). No differences were found among treatments for sugar purity or RWSH *(data not shown*).

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Table 1. Field evaluation of fungicide programs for the control of CLS, Ridgetown, ON, 2021.

Treatment (product rate/ha) [a]	Disease Severity (%) [b]	AUDPC [c]	Beet Yield (kg/ 4 m row)	RWST (kg/ha) [d]
1. Nontreated control	9 a-f [e]	210 a	13 ab	235 b
BEETcast™ moderate application interval				
2. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EIKNPS)	2 b-h	63 c	15 ab	253 ab
3. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EI) PARASOL @ 4.25 kg + VEGOL @ 3 L (KNPS)	2 fgh	36 c	16 ab	252 ab
4. MANZATE 2.25 kg + PROLINE @ 365 ml (BG) MANZATE 2.25 kg (EI) PHOSTROL @ 5.6 L (KNPS)	10 a-e	92 bc	22 a	262 a
5. PROLINE @ 365 ml (BG) PARASOL @ 4.25 kg + VEGOL @ 3 L (EIKNPS)	1 h	10 c	16 ab	262 a
6. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BG) PHOSTROL @ 5.6 L (EIKNPS)	13 a	189 ab	15 ab	252 ab

7. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BG) PHOSTROL @ 5.6 L (EI) PARASOL @ 4.25 kg + VEGOL @ 3 L (KNPS)	1 gh	20 c	16 ab	262 a
BEETcast™ susceptible application interval				
8. MANZATE 2.25 kg + PROLINE @ 365 ml (AF) MANZATE 2.25 kg (CGHJLNOR)	1 gh	13 c	16 ab	257 ab
9. MANZATE 2.25 kg + PROLINE @ 365 ml (AF) MANZATE 2.25 kg (CG) PARASOL @ 4.25 kg + VEGOL @ 3 L (HJLNOR)	1 gh	18 c	16 ab	262 a
10. MANZATE 2.25 kg + PHOSTROL @ 5.6 L + PROLINE @ 365 ml (AF) MANZATE 2.25 kg + PHOSTROL @ 5.6 L (CG) PHOSTROL (HJLNOR)	11 abc	115 abc	15 ab	258 ab
11. PROLINE @ 365 ml (AF) PARASOL @ 4.25 kg + VEGOL @ 3 L (CGHJLNOR)	2 fgh	23 c	14 ab	266 a
12. PROLINE @ 365 ml (AF) PHOSTROL @ 5.6 L (CGHJLNOR)	10 a-d	103 bc	14 ab	248 ab
13. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (AF) PHOSTROL @ 5.6 L (CG) PARASOL @ 4.25 kg + VEGOL @ 3 L (HJLNOR)	2 gh	16 c	15 ab	254 ab
Calendar application interval				
14. PROLINE @ 365 ml (BG) MANZATE 2.25 kg (DIMQT)	7 a-g	89 bc	16 ab	253 ab
15. MANZATE 2.25 kg (BDGIMQT)	8 a-f	103 bc	11 b	252 ab
16. MANZATE 2.25 kg (BDGI) PARASOL @ 4.25 kg + VEGOL @ 3 L (MQT)	5 c-h	42 c	15 ab	260 ab
17. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGI) PHOSTROL @ 5.6 L (MQT)	9 a-e	97 bc	17 ab	242 ab
18. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGI) PARASOL @ 4.25 kg + VEGOL @ 3 L + PHOSTROL @ 5.6 L (MQT)	5 d-h	47 c	14 ab	255 ab
19. PARASOL @ 4.25 kg + VEGOL @ 3 L (BDGIMQT)	4 d-h	55 c	14 ab	254 ab
20. PHOSTROL @ 5.6 L (BDGIMQT)	11 ab	183 ab	12 ab	252 ab
21. PARASOL @ 4.25 kg + VEGOL @ 3 L + PHOSTROL @ 5.6 L (BGMQT) PHOSTROL @ 5.6 L (DI)	4 fgh	44 c	14 ab	253 ab

[a] BEETcast™ moderate application programs were made on B = June 21 (42 DSV), E = July 9 (33 DSV), G = July 19 (26 DSV), I = Aug 2 (24 DSV), K = Aug 11 (19 DSV), N = Aug 19 (19 DSV), P = Aug 27 (18 DSV), and S = Sept 3 (16 DSV). BEETcast™ susceptible application programs were made on A = June 18 (33 DSV), C = July 2 (27 DSV), F = July 12 (21 DSV), G = July 19 (20 DSV), H = July 27 (16 DSV), J = Aug 6 (13 DSV), L = Aug 12 (17 DSV), N = Aug 19 (16 DSV), O = Aug 26 (15 DSV), R = Aug 31 (15 DSV). Calendar applications were made on a 12 to 14-day interval on B = June 21, D = July 5, G = July 19, I = Aug 2, L = Aug 12, Q = Aug 30, and T = Sept 14.

[b] Disease severity ratings from September 29, 2021, which was the last assessment date.

[c] Disease severity values collected biweekly were used to calculate the area under the disease progress curve (AUDPC) using the formula AUDPC = $\Sigma_{i=1}[(Y_{i+1}+Y_i)/2][X_{i+1}-X_i]$ where Y_i is the mean rating at day X_i and Y_{i-1} is the mean rating at day X_{i-1}.

[d] RWSH is the recoverable white sugar per hectare.

[e] Values followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2021 PMR Report # 14 **SECTION L: VEGETABLES and SPECIAL CROPS - DISEASES**

CROP: Tomato (*Solanum lycopersicum* L.), cv. H9706
PEST: Early blight (*Alternaria solani* Sorauer), Septoria leaf spot (*Septoria lycopersici* Speg.), anthracnose fruit rot (*Colletotrichum* spp.)

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TITLE: FUNGICIDES FOR DISEASE MANAGEMENT IN TOMATO, 2021

MATERIALS: BRAVO ZN (chlorothalonil 500g L^{-1}), QUADRIS (azoxystrobin 250 g L^{-1}), FONTELIS (penthiopyrad 200 g L^{-1}), APROVIA TOP (benzovindiflupyr 78 g L^{-1}, difenoconazole 117 g L^{-1}), SERCADIS (fluxapyroxad 300 g L^{-1}), MIRAVIS DUO (pydiflumetofen 75 g L^{-1}, difenoconazole 125 g L^{-1}), CUEVA (copper octanoate 1.8%), TANOS (famoxadone 25%, cymoxanil 25%), PHOSTROL (mono- and di-potassium salts of phosphorous acid 53.6%), LUNA PRIVILEGE (fluopyram 500 g L^{-1}), CEVYA (mefentrifluconazole 400 g L^{-1}), MAESTRO (captan 80%), DIPLOMAT (polyoxin D zinc salt 5%)

METHODS: The trial was conducted at Ridgetown Campus, University of Guelph on a sandy loam soil. Tomatoes were transplanted on May 25 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 2 m apart. Each treatment plot was 7 m long and consisted of one twin-row. The trial was set up as a randomized complete block design with four replications per treatment. Treatments (Table 1) were applied using a hand-held CO_2 sprayer (35 psi) with ULD 120-03 nozzles and water volume of 300 L/ha. The trial was inoculated with plants exhibiting symptoms of early blight and Septoria leaf spot after the first fungicide application on June 28. This was done by removing and replacing one healthy seedling at the front and back of each plot with a tomato seedling previously inoculated with *A. solani* or *S. lycopersici*, respectively. The seedlings were inoculated 2-3 weeks before transplanting. Overhead irrigation was applied every night for approximately 15 minutes, on days when no natural precipitation occurred. This continued until Jul 22, when disease symptoms consistent with early blight and Septoria leaf spot were observed in control plots. No inoculation was performed for anthracnose fruit rot. Defoliation was estimated July 30, August 19, 26, and September 2 using an incremental 5% scale and used to calculate the area under the disease progress curve (AUDPC). Tomatoes were harvested from a 2 m section of each plot on September 10. Fifty randomly selected red fruit were assessed for anthracnose after three days in storage. Statistical analysis was conducted using ARM 2019 (Gylling Data Management, Brookings, SD). Analysis of variance was conducted and, when $P \leq 0.05$, means comparisons were performed using Tukey's honest significant difference test.

The average daily minimum and maximum temperatures in May, June, July, August, and September were 6.2 and 19.9, 15.5 and 26.4, 15.2 and 26.5, 16.5 and 28.0, and 11.8 and 23.6°C, respectively. Total precipitation in May, June, July and August was 21.4 123.8, 123.6 and 88.6 mm. Precipitation data for September was unavailable.

RESULTS: As outlined in Table 1.

CONCLUSIONS: Foliar disease pressure from early blight and Septoria leaf blight was high, with obvious visual differences between plots appearing by mid-August and 80% defoliation in control plots by early September. On the final assessment date on Sep 2, defoliation was lower in all fungicide treated plots than the nontreated control, except CUEVA, PHOSTROL, and PHOSTROL + CUEVA + DIPLOMAT. The lowest level of defoliation on Sept 2 was observed with both rates of BRAVO ZN, QUADRIS, SERCADIS, APROVIA TOP, MIRAVIS DUO, PHOSTROL + BRAVO ZN, and CEVYA; these treatments had less defoliation than CUEVA, TANOS, PHOSTROL, PHOSTROL + CUEVA, and PHOSTROL + CUEVA + DIPLOMAT, but were equivalent to MAESTRO, FONTELIS, and LUNA PRIVILEGE. Total disease over the season (AUDPC) was lower in all fungicide treated plots than the nontreated control except CUEVA and PHOSTROL. The lowest AUDPC was achieved using APROVIA TOP, but this was equivalent to both rates of BRAVO ZN, MAESTRO, QUADRIS, SERCADIS, MIRAVIS DUO, LUNA PRIVILEGE, PHOSTROL + BRAVO ZN, and CEVYA. Anthracnose incidence in the nontreated control was moderate (17%) but variable and none of the fungicide treatments had lower incidence of anthracnose than the nontreated control. Yield for all fungicide treatments was equivalent to the nontreated control (data not shown).

ACKNOWLEDGEMENTS: This research was funded by the Ontario Tomato Research Institute, Ontario Agri-Food Innovation Alliance, and Belchim Crop Protection Canada. We thank Heinz Seed for seed donation and crop protection companies for in-kind product donations.

Table 1. Percent defoliation, area under the disease progress curve (AUDPC), and anthracnose fruit rot incidence in tomatoes treated with different fungicides for management of early blight, Septoria leaf spot, and anthracnose fruit rot, Ridgetown, Ontario, 2021.

Treatment (per ha) [1]	Defoliation (%)		Anthracnose (%)
	Sept 2	AUDPC [2]	
Control	80 a [3]	1297 a	17 abc
BRAVO ZN @ 3.2 L	3 e	112 fg	5 bc
BRAVO ZN @ 2.4 L	3 e	120 fg	6 bc
MAESTRO @ 4.25 kg	21 de	401 defg	10 abc
CUEVA @ 1% v/v	66 abc	988 ab	23 a
QUADRIS @ 400 mL	2 e	79 fg	3 c
TANOS @ 560 g	43 cd	595 cde	8 bc
SERCADIS @ 250 mL	5 e	116 fg	6 bc
FONTELIS @ 1.5 L	21 de	426 def	13 abc
APROVIA TOP @ 805 mL	3 e	58 g	8 bc
MIRAVIS DUO @ 1.0 L	7 e	122 fg	14 abc
LUNA PRIVILEGE @ 225 mL	24 de	288 efg	10 abc
PHOSTROL @ 5.6 L	73 ab	1036 ab	18 ab
PHOSTROL @ 5.6 L + BRAVO ZN @ 2.4 L	3 e	97 fg	6 bc
CEVYA @ 190 mL	4 e	74 fg	5 bc
PHOSTROL @ 5.6 L + CUEVA @ 1 % v/v	48 bcd	699 bcd	10 abc
PHOSTROL @ 5.6 L + CUEVA @ 1 % v/v + DIPLOMAT @ 500 mL	61 abc	833 bc	23 abc

[1] Treatments were applied on A = Jun 24, B = Jul 5, C = Jul 15, D = Jul 26, E = Aug 5, F = Aug 17, G = Aug 27.

[2] AUDPC = $\sum [((Y_i + Y_{i-1}) (X_i - X_{i-1}))/2]$, where Y_i is number of infected leaves at day X_i and Y_{i-1} is number of infected leaves at day X_{i-1}.

[3] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.