2020 Pest Management Research Report (PMRR) 2020 Growing Season

2020 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2020

Canada

English

2020 PEST MANAGEMENT RESEARCH REPORT

Prepared by: Pest Management Centre, Agriculture and Agri-Food Canada
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[1] This is the 21st 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 22 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 2021 Annual PMR Report will be sent in fall, 2021. They will also be available from Stefan Bussmann.

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 2020 has been assigned a Volume number for the 21st 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 59.

An individual report will be cited as follows:
Author(s). 2020. Title. 2020 Pest Management Research Report - 2020 Growing Season. Agriculture and AgriFood Canada. March 2021. Report No. x. Vol. 59: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2020

Préparé par: Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada
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Titre officiel du document
2020 Rapport de recherches sur la lutte dirigée - pour la saison 2020. Compilé par Agriculture et Agroalimentaire Canada, 960 avenue Carling, Ed. 57, Ottawa ON K1A 0C6, Canada
Mars 2021 volume 59[1]. 73 pp. 22 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 22 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 2021 seront distribuées à l'automne 2021. Elles seront aussi disponibles via Stefan Bussmann.

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. 2020. Titre. 2020 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. Mars, 2021. Rapport n^{o} x. vol. 59: pp-pp.

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2020 PMR REPORT # 01 **SECTION B: VEGETABLES and SPECIAL CROPS**

CROP: Garlic (*Allium sativum* L.), cv. Music
PEST: Leek Moth (*Acrolepiopsis assectella* (Zeller))

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TITLE: SURVEY OF LEEK MOTH POPULATIONS IN ONTARIO, 2020

MATERIALS: DELTA 1 Pheromone trap, lure #40AS009.

METHODS: DELTA 1 pheromone traps with a leek moth (*Acrolepiopsis assectella*) lure #40AS009 (Distributions Solida, Montreal, Quebec) were set up in 11 locations in nine counties in Southwestern Ontario from May 5 to May 20, 2020. Counties surveyed include Brant, Chatham-Kent, Essex, Grey, Huron, Niagara, Oxford, Perth, and Renfrew. Traps were hung on wooden stakes approximately 40 cm above the ground. Ten of the fields surveyed were planted with garlic and one field (Perth County, first site) was planted with leek. If onions were grown nearby, traps were moved from garlic to onions once the garlic was harvested (Perth County, second site). Sticky cards were changed weekly while pheromone lures were changed every two weeks during the duration of the study. Specimens were counted using a dissecting scope and identified visually without extracting genitalia. Average moths/trap/week were recorded if the field site had more than one trap per field. Traps were left in several fields after garlic harvest to capture the third flight of the season. In the leek field, the traps were left until September 1, 2020.

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

CONCLUSIONS: Leek moth were detected at all locations surveyed during the 2020 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. Leek moth counts were below an average of 10 moths/trap/week or 1 moth/trap/day in the majority of the locations. Several of the fields monitored in 2020 were also monitored in 2019 and 2018. A spike of 16 leek moths was observed at a single location in Grey county on July 9 which was the same week a spike of 40 moths was observed in the same field on July 12 in 2019, and 38 moths on July 14, 2018 **(Figure 2)**. With no conventional insecticides applied, the number of captured leek moths doubled in 2019 compared to 2018 at a site in Renfrew county but did not increase in 2020 (**Figure 3**). At a field site in Huron county, two conventional insecticide applications were applied three to 10 days after the second peak in June 2018, 2019 and 2020. Trap counts after these applications fell in 2019 and remained that way throughout 2020 at this site (**Figure 4**).

ACKNOWLEDGEMENTS: Thank you to Joshua Mosiondz, Hannah Fraser, Cora Loucks, Dennis Van Dyk, Ashleigh Ahrens and Maria Polsinelli for their help throughout the growing season.

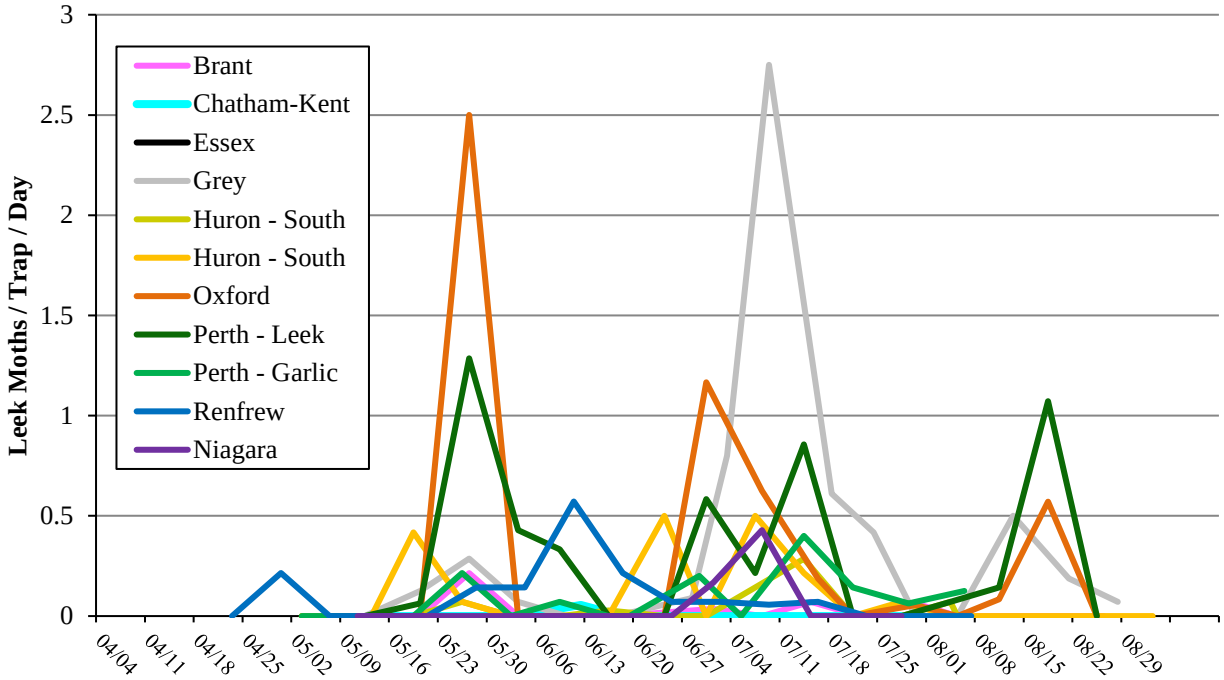

Figure 1. Average number of leek moths per sticky trap per day at 10 garlic fields and one leek field within the surveyed counties of Brant, Chatham-Kent, Grey, Huron, Oxford, Perth, and Renfrew, 2020. No leek moths were observed in Essex County.

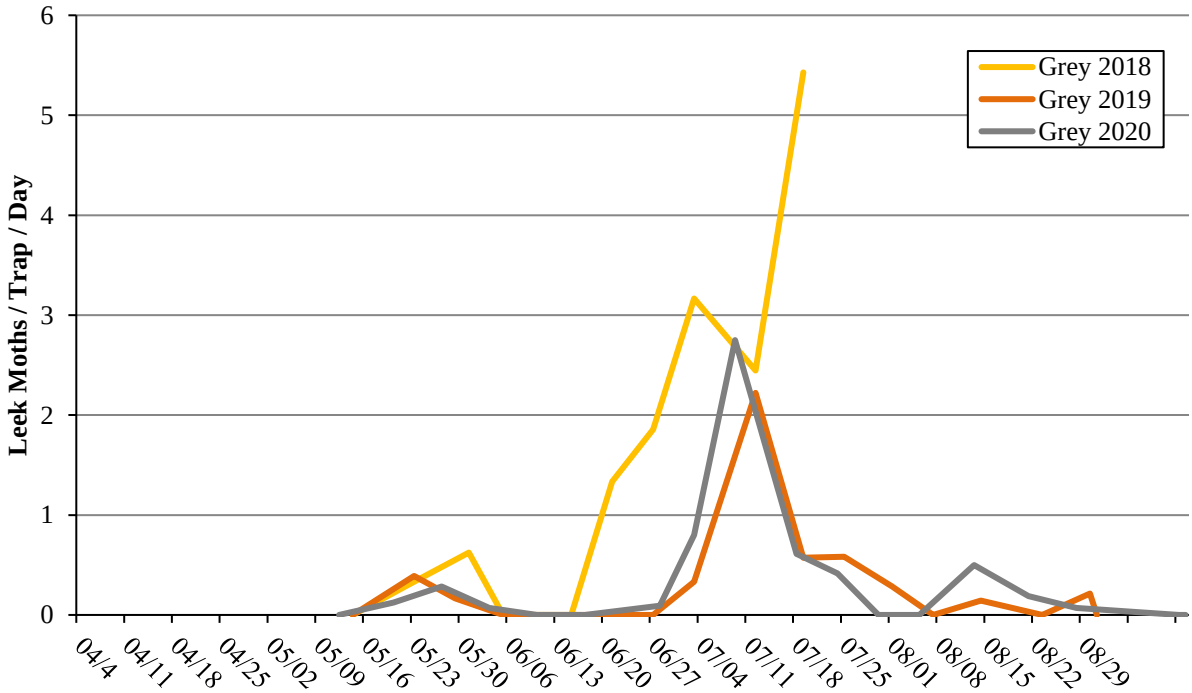

Figure 2. Leek moth counts in Grey County in 2020 (grey), 2019 (orange), and 2018 (yellow). Monitoring stopped in 2018 following garlic harvest, however it was continued until September in 2019 and 2020.

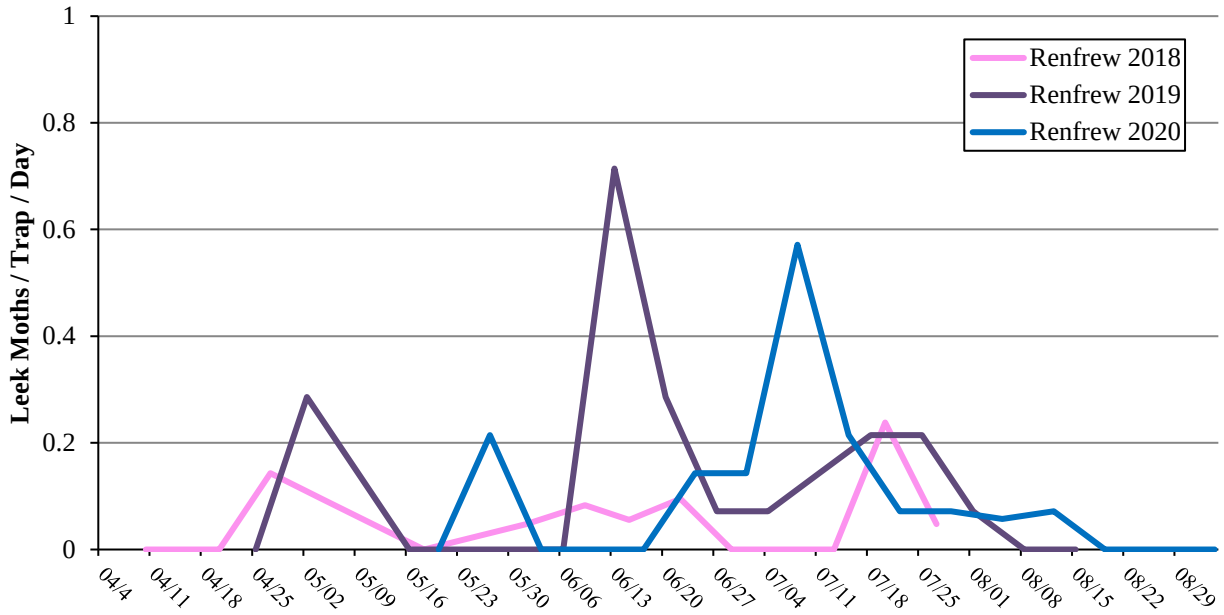

Figure 3. Leek moth counts in Renfrew County in 2020 (blue), 2019 (purple), and 2018 (pink).

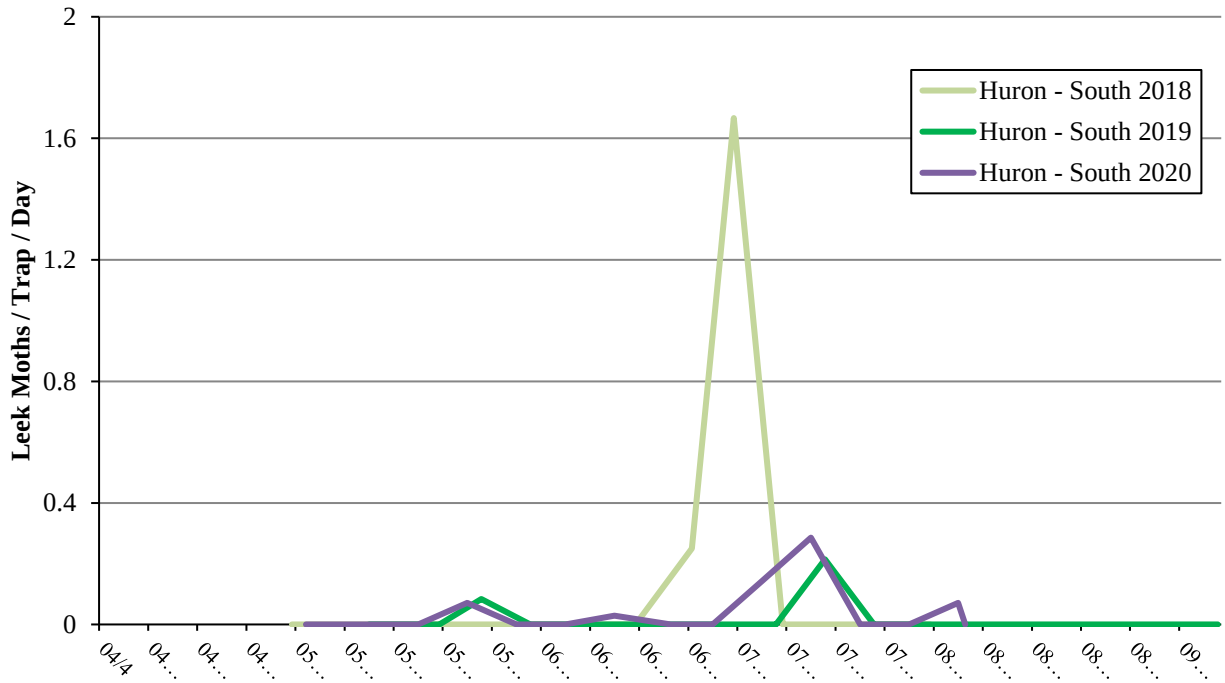

Figure 4. Leek moth counts at a field site in South Huron County in 2020 (purple), 2019 (dark green), and 2019 (light green) with two insecticide applications following the second peak each year.

2020 PMR REPORT #02 **SECTION B: VEGETABLES and SPECIAL CROPS**

CROP: Yellow cooking onions (*Allium cepa* L.), cv. Fortress
PESTS: Onion maggot, (*Delia antiqua* (Meigen))
Seed corn maggot, (*Delia platura* (Meigen))

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TITLE: **EVALUATION OF VARIOUS INSECTICIDES FOR CONTROL OF MAGGOTS IN YELLOW COOKING ONIONS, 2020**

MATERIALS: SEPRESTO 75 WS (clothianidin 56.25%, imidacloprid 18.75%), REGARD SC (spinosad 22.5%), CRUISER 70 WS (thiamethoxam 70%), GOVERNOR 75 SP (cyromazine 75%), EVERGOL PRIME (penflufen 22.7%), 42-S THIRAM (thiram (tetramethylthiuram disulfide) 42%)

METHODS: The trial was conducted on organic soil (pH ≈ 6.2, organic matter ≈ 68.1%) naturally infested with *Delia antiqua* and *D. platura* pupae at the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four rows, spaced 40 cm apart, 6 m in length. Onions, cv. Fortress, were seeded (≈ 35 seeds/m) on 16 May using a Stanhay precision seeder. Insecticide seed treatments applied at the manufacturers recommended rates were: SEPRESTO, REGARD + CRUISER, REGARD and GOVERNOR. A no-insecticide check was also included. All treatments also included EVERGOL PRIME for smut control and thiram. Refer to Table 1 for treatment rates. Treatments and pelleting were done by Incotec using standard methods. Three randomly chosen 2 m sections of row for damage plots plus a 2.32 m section for a yield sample were staked out in each replicate. Emergence counts were conducted within the 2 m staked sections on 29 May to determine initial stands. Beginning on 3 June and continuing weekly, onion plants within the 2 m sections were examined for loss due to maggot damage or damage caused by other pests. Damaged onions were removed, and numbers and the cause of damage recorded. The remaining onions within the assigned 2 m sections were removed and visually examined for maggot damage on 29 June (three weeks after the first generation peak), 29 July (three weeks after the second generation peak) and after lodging on 21 September. On 16 September, onions from the 2.32 m yield section of row were pulled, sorted by size and weighed to determine yield. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.10. Means separation was obtained using Fisher's Protected LSD Test at P = 0.05 level of significance.

RESULTS: as presented in Tables 2 & 3

CONCLUSIONS: Significant differences in the number of onions lost to maggot damage were found

among the treatments at all assessments (Table 2). After the 1st generation of maggot damage, onions grown from seeds treated with SEPRESTO or REGARD + CRUISER had fewer losses due to maggot damage than the GOVERNOR treatment or the check seed. After the 2nd generation of maggot damage and at the harvest assessment, all insecticide seed treatments had statistically fewer losses than the untreated check. Significant differences in yield and onions per meter at harvest were found among the treatments (Table 3). All insecticide seed treatments resulted in higher yields than the untreated check and SEPRESTO, REGARD+ CRUISER and REGARD alone had more onions per meter than the untreated check and SEPRESTO, REGARD + CRUISER and REGARD alone had more onions per meter than the untreated check. No significant differences in size distribution were found among the treatments.

ACKNOWLEDGEMENT: Funding was provided by Incotec for seed pelleting, Bayer Crop Science for the Sepresto insecticide, the Plant Production Systems of the Ontario Agri-Food Innovation Alliance and the California Garlic and Onion Research Advisory Board. Dr. Taylor's effort was supported under the United States Multi-State project, W-3168.

Table 1. Seed treatments label rates for onion seed, cv. Fortress, pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

#	Treatment[1]	Insecticide Active Ingredients and Label Rates
1	Check seed	–
2	REGARD	spinosad 0.2 g ai/1,000 seeds
3	REGARD + CRUISER	spinosad 0.2 g ai + thiamethoxam 0.2 g ai/1,000 seeds
4	SEPRESTO	clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds
5	GOVERNOR	cyromazine 49.5 g ai/kg

[1] Pellet also includes EVERGOL PRIME (penflufen 0.0087 g ai/1,000 seeds) and thiram (at 12.5 g ai/kg seed) for smut control.

Table 2. Emergence and percentage of onions (cv. Fortress) lost due to maggot damage, treated with various insecticide seed treatments, pelleted by Incotec and grown at the Muck Crop Research Station, Holland Marsh, Ontario, 2020.

Treatment[1]	Emergence (plants/m)	% Onions lost due to maggot damage		
		1st Gen	1st & 2nd Gen	Total Season
SEPRESTO	25.9 ns[2]	3.4 a[3]	16.1 a	5.0 a
REGARD + CRUISER	26.2	5.0 a	19.2 a	13.6 a
REGARD	24.5	12.3 ab	16.3 a	8.2 a
GOVERNOR	20.1	15.5 b	8.5 a	12.5 a
Check seed	21.3	36.7 c	51.9 b	53.8 b

[1] Treatment details are listed in Table 1.
[2] ns = no significant differences were found among treatments at P = 0.05, Fisher's Protected LSD test.
[3] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.

Table 3. Yield, number and size distribution for onions, cv. Fortress, treated with various insecticide seed treatments, pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment[1]	Yield (t/ha)	Onions/ m	Size Distribution[2] (%)			
			Jumbo (>76mm)	Large (76-64 mm)	Medium (>64-45 mm)	Cull[3] (<45mm)
SEPRESTO	76.8 a[4]	21.2 a	24.2 ns[5]	48.3 ns	26.7 ns	0.8 ns
GOVERNOR	67.5 a	15.3 ab	38.0	51.9	10.0	0.1
REGARD + CRUISER	62.7 a	16.9 a	31.1	43.0	25.4	0.4
REGARD	62.3 a	17.2 a	28.9	43.0	27.4	0.7
Check seed	34.1 b	7.3 b	53.0	33.9	12.8	0.3

[1] See treatment details listed in Table 1.
[2] Size distribution was based on weights.
[3] The cull category also includes unmarketable onions due to maggot damage.
[4] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.
[5] ns = no significant differences at P = 0.05, Fisher's Protected LSD test.

2020 PMR REPORT # 03 **SECTION C: POTATOES – Insect Pests**

CROP: Potato (*Solanum tuberosum* L.), cv. Superior and Kennebec
PEST: Wireworm (Coleoptera: Elateridae) - Eastern field wireworm (*Limonius agonus* Say), *Melanotus* spp. and *Agriotes mancus* Say and/or *A. pubescens* Melsheimer

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TITLE: FIELD EVALUATION OF CYANTRANILIPROLE FOR THE CONTROL OF WIREWORM DAMAGE ON EARLY AND LATE SEASON POTATOES, 2019

MATERIALS: VERIMARK (cyantraniliprole 18.7%), THIMET 20-G (phorate 20%), MAXIM (fludioxonil 0.5%), CURZATE (cymoxanil 60%), MANZATE PROSTICK (mancozeb 75%), BRAVO ZN (clorothalonil 50%), REASON 500 SC (fenamidone 50%), KOCIDE 2000 (copper hydroxide 53.8%), REGLONE (diquat 24%)

METHODS: Field trials were set up at two sites in fields near Rodney (Site 1) and Jeannettes Creek (Site 2), Ontario that were infested with wireworms. Between late April and the end of May, 2019, wireworm *Limonius agonus*, *Melanotus* spp. were collected at Site 1 and *Agriotes mancus* and/or *A. pubescens* were collected at Site 2 using corn and wheat seed baits. To prepare the sites for planting, loose surface weeds were removed by hand, fertilizer (37.5 kg 5-15-40 and 25 kg 8-32-16 kg per plot) was spread by hand, and tilled with a tractor and tiller. Potatoes of an early (Superior) and late (Kennebec) variety were planted in the second week of June, as wireworms were still active at this time. Treatment plots consisted of 3 replicates of 5 m rows with 17 potatoes per row and 30 cm between plants with guard rows on each side. Adjacent treatments shared a common guard row with all rows 1 m apart. Two outer guard rows separated the potato rows from a corn field (Site 1) and tomato field (Site 2). At the London Agriculture and Agri-Food Canada (AAFC) laboratory, the fungicide Maxim was applied to potato seed pieces of both the treatment rows and guard rows the day before planting. The seed potato pieces were weighed in separate bags for the seed treatment with Verimark (45 mL/100 kg seed piece). The measured amount of Verimark (9 mL/100 m row) and Thimet (161 g/100 m row) for field treatments were applied by hand to the potato pieces in the furrow and covered by hand. Treatment rows were weeded by hand as necessary over the course of the trial. To prevent late blight, three fungicide applications were made between the end of July and the end of August in the following order: Curzate / Manzate Prostick (225 g/ha and 1.6 kg/ha, respectively); Bravo ZN / Reason (2.4 L/ha and 200 mL/ha, respectively); Manzate Prostick / Kocide 2000 (2.25 kg/ha and 2.52 kg/ha, respectively). A few days prior to harvest, Reglone (3.5 L/ha) was applied as a foliar top-kill at both sites. In late August (Superior) and late September (Kennebec) (between 96-139 DAP), plots were harvested and potatoes were returned to AAFC London for assessment. Potatoes larger than 5 cm in length from each treatment and site were assessed for wireworm damage (holes and scars, combined are blemishes). Holes were characterized as 0.15 mm or deeper and visible if the skin was scraped away. Scars were less than 0.15 mm in depth, generally wider and healed over. Holes and scars were circled with a Sharpie marker, potatoes were numbered, and potato length and weight was recorded. The percent of unmarketable potatoes from each trial site (insecticide x variety) was determined by the proportion of potatoes with $\geq$ 2 blemishes. Statistical analyses was

completed on each measurement using a Two-Way ANOVA with either a type I or type II error statement and post-hoc Tukey's HSD comparison of means test (R Studio, version 4.0.3).

RESULTS: See Tables 1-3

CONCLUSIONS: The average number of blemishes per early variety (cv. Superior) potato caused by wireworm feeding was not significantly different between insecticide treatments, Verimark (in furrow or seed application), Thimet or the check at Site 1 (Tukey's HSD; P>0.3268) (Table 1) or Site 2 (Tukey's HSD; P>0.1320) (Table 2) . In comparison, the late season variety (cv. Kennebec) treated with Verimark in furrow had significantly fewer blemishes than the other treatments at Site 1 (Tukey's HSD; P<0.0014) (Table 1), but not at Site 2 (Tukey's HSD; P>0.3619) (Table 2). The percent unmarketability of potatoes within each variety was not significantly different at Site 1 (Two-way ANOVA (var. x insect.); d.f.=3,16; F= 0.524; P=0.672) or 2 (Two-way ANOVA (var. x insect.); d.f.=3,15; F= 0.330; P=0.8040), but the cv. Superior potatoes had a lower percent unmarketability than the cv. Kennebec potatoes (Two-Way ANOVA (var.); P<0.0007) at both field sites (Table 3). A comparison of average potato weight, length and numbers (potatoes greater than 5 cm in length) at both field sites determined no effect from insecticide treatment (Tables 1 and 2). In general, the measurements were not significantly different within each variety at Site 1, with the exception that Thimet-treated cv. Superior potatoes weighed significantly more than the check potatoes (Tukey's HSD; P=0.0005) (Table 1). At Site 2, the cv. Kennebec had a higher weight and length than cv. Superior potatoes across all treatments except the check (length) and Verimark seed treatment (weight) (Tukey's HSD; P>0.0785) (Table 2).

To summarize, the results of the 2019 field trials indicate that the Verimark in furrow and seed treatments did not reduce wireworm feeding damage relative to the Thimet-treated or untreated potatoes. It was noted that there was less wireworm damage to the early variety compared to the late variety potatoes, likely due to the earlier harvest, a factor which may be important to consider since the insecticides did not provide any greater protection relative to the untreated potatoes.

Table 1. Average blemishes (scars + holes) per tuber, average size and number of potatoes harvested from an insecticide trial at Site 1 in 2019.

Treatment	Average # of Holes (S.E.)		Average # of Scars (S.E.)		Average # of Blemishes (S.E.)		Average Weight (g) (S.E.)		Average Length (cm) (S.E.)		# of Potatoes (S.E.)	
	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec
Check	0.22 (0.4)b	0.52 (0.08)a	1.5 (0.11)c	3.3 (0.16)a	1.7 (0.12)c	3.8 (0.19)a	119.7 (3.06)d	161.3 (4.84)ab	7.8 (0.09)bc	8.6 (0.12)a	95.3 (2.40)a	73.7 (5.36)a
Verimark seed treatment	0.25 (0.06)b	0.31 (0.08)ab	1.0 (0.07)c	3.1 (0.14)a	1.3 (0.10)c	3.4 (0.17)a	127.5 (3.85)cd	151.0 (4.48)ab	8.1 (0.24)ab	8.4 (0.12)ab	79.3 (2.97))a	75.7 (5.21)a
Verimark in furrow	0.25 (0.06)b	0.14 (0.04)b	1.4 (0.10)c	2.5 (0.14)b	1.7 (0.12)c	2.6 (0.14)b	111.2 (3.11)d	146.2 (9.3)b	7.4 (0.09)c	8.1 (0.11)ab	79.0 (4.16)a	82.3 (8.41)a
Thimet in furrow	0.12 (0.05)b	0.09 (0.03)b	1.4 (0.09)c	3.5 (0.17)a	1.6 (0.11)c	3.6 (0.17)a	143.6 (3.82)bc	168.1 (5.25)a	8.2 (0.10)ab	8.5 (0.15)a	84.0 (4.73)a	84.7 (12.25)a

Values with the same letters within each measurement are not significantly different (Two-Way ANOVA, type II error statement; Tukey's comparison of means test; P>0.05). Each measurement column includes two potato varieties.

Table 2. Average blemishes (scars + holes) per tuber, average size and number of potatoes harvested from an insecticide trial at Site 2 in 2019.

Treatment	Average # of Holes (S.E.)		Average # of Scars (S.E.)		Average # of Blemishes (S.E.)		Average Weight (g) (S.E.)		Average Length (cm) (S.E.)		Average # of Potatoes (S.E.)	
	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec	Superior	Kennebec
Check	0.16 (0.05)a	0.36 (0.14)a	1.0 (0.15)d	3.4 (0.25)a	1.1 (0.17)b	3.8 (0.28)a	87.1 (4.61)c	119.0 (7.09)ab	6.7 (0.17)cd	7.5 (0.21)bc	32.7 (6.98)a	30.7 (12.91) a
Verimark seed treatment	0.20 (0.06)a	0.28 (0.07)a	1.3 (0.18)cd	3.1 (0.21)a	1.5 (0.19)b	3.4 (0.23)a	79.8 (5.19)cd	103.6 (4.76)bc	6.1 (0.18)de	7.2 (0.17)bc	23.0 (11.79)a	40.0 (6.08)a
Verimark in furrow	0.21 (0.12)a	0.40 (0.11)a	1.2 (0.22)cd	2.7 (0.21)ab	1.4 (0.28)b	3.1 (0.24)a	52.8 (5.10)d	129.9 (7.12)a	5.6 (0.21)e	7.8 (0.23)ab	13.0 (2.52)a	32.7 (10.41)a
Thimet in furrow	0.10 (0.04)a	0.10 (0.04)a	1.9 (0.16)bc	3.3 (0.22)a	2.0 (0.17)b	3.4 (0.23)a	94.5 (5.90)bc	142.2 (8.22)a	6.8 (0.18)cd	8.1 (0.81)a	26.3 (12.67)a	36.3 (18.84)a

Values with the same letters within each measurement are not significantly different (Two-Way ANOVA, type II error statement; Tukey's comparison of means test; $P>0.05$). Each measurement column includes two potato varieties.

Table 3. Percent unmarketability of potatoes harvested from insecticide trials at two field sites in 2019.

	Percent unmarketable (S.E.)			
Treatment	**Site 1**		**Site 2**	
	Superior	Kennebec	Superior	Kennebec
Check	45.3 (15.30)abc	90.5 (11.06)a	33.3 (16.97)a	87.4 (17.30)a
Verimark seed treatment	34.9 (3.77)c	85.9 (9.87)ab	39.9 (18.91)a	80.0 (12.35)a
Verimark in furrow	44.5 (4.29)bc	73.3 (10.67)abc	39.8 (16.25)a	83.9 (7.22)a
Thimet in furrow	45.5 (8.87)abc	83.0 (5.06)ab	63.4 (2.74)a	91.2 (9.38)a

Values with the same letters within each site are not significantly different (Two-Way ANOVA; Tukey's comparison of means test; $P>0.05$). Each site column includes two potato varieties.

2020 PMR REPORT # 04 **SECTION G: BASIC STUDIES (ENTOMOLOGY)**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.)
Cabbage (*Brassica oleraceae* var. *capitata*), cv. Lennox and Expect
PEST: Carrot rust fly (*Psila rosae* F.)
Western flower thrips (*Frankliniella occidentalis* (Pergande))

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TITLE: TRAPPING METHODS FOR VEGETABLE INSECT PESTS

MATERIALS:FRANKLINIELLA PRO CAPS (western flower thrips lure)

METHODS: Carrot rust fly trapping experiments were conducted at the Muck Research Station, Kettleby, Ontario as part of an Agriculture and Agri-Food Canada Pest Management Centre project on carrot rust fly. In 2015, to compare trap colour, 5 yellow-orange carton (Evergreen Packaging Canada Ltd number pantone 1235 yellow) and 5 dark orange carton traps (pantone orange 021C) were placed, alternating colors, with 25 m between traps at two sites. Each trap was 13 x 13 cm. The traps were one half of a waxed milk carton that were printed with the specific colour by the company. To compare trap orientation, 10 yellow-orange carton traps, 5 for each orientation, were spaced 25 m apart alternating perpendicular and angled (45°) orientations at two sites. Traps were set up on 24 June and taken down 3 September. First capture in the color experiment occurred on 26 June and last capture on 3 September with first capture in the orientation experiment occurring on 26 June and last capture on 27 August. Traps were checked twice per week and total season capture from each trap was used for analysis. In 2016, the orientation experiment as described for 2015 was repeated (traps set up on 8 June and taken down 26 September) and an additional experiment where trap color and material were evaluated was conducted. Five traps of each type: orange carton, yellow carton and yellow acrylic (23 x 15 cm cut from acrylic sheets sourced from Piedmont Plastics, Dartmouth, Nova Scotia) were alternated within 2 fields. Traps were set up on 8 June and taken down on 29 August for the color and material experiment. First capture was noted on 10 June and last capture on 18 August. Traps were checked twice per week and total season capture from each trap used for analysis. Number of flies per trap was transformed using a log(x+1) transformation prior to analysis using ANOVA with R software (R-project.org). Tukey's HSD *post-hoc* means separation test was used when results were significant.

A preliminary thrips trapping experiment was conducted on a Brookfield Farms field located in Milton, Prince Edward Island during 2019. Blue and yellow sticky traps were used to evaluate the FRANKLINIELLA PRO CAPS lure (M2i Biocontrol) under field conditions. Two traps of each type: blue (no lure), blue (lure) and yellow (lure) were alternated within a field planted in two short season cabbage varieties (Lennox and Expect) on 12 June. Traps were checked each week with final collection on 2 August when the cabbage was harvested. Thrips captures began on 19 July. Total season capture per trap was used in analysis following transformation with log(x+1).

RESULTS: Data are presented in Tables 1 for carrot rust fly experiments conducted in 2015 and 2016 and Table 2 for thrips trapping experiments conducted in 2019.

CONCLUSIONS: Results from the carrot rust fly experiment are consistent with the trial conducted in 2014 (Muck Research Station Research Report 2014) where yellow-orange (standard colour) traps are more effective than dark orange to capture carrot rust fly, and there was no difference in capture when traps were oriented perpendicular to the ground or on a 45° angle. The dark orange carton trap may not be as effective to detect carrot rust fly when populations are low. There were no differences among the traps in the thrips trial, probably due to high variability with the yellow traps. The FRANKLINIELLA PROP CAPS lure tended to be more attractive to thrips than an unbaited trap and a difference between the yellow and blue traps is also suggested. Further work with this lure and trap color in late season cabbage varieties is recommended.

Table 1: Carrot rust fly (*Psila rosae*) total season captures (mean ± SE) from an experiment in 2015 evaluating trap color and orientation and an experiment in 2016 evaluating 3 trap substrate and color combinations. Experiments conducted at the Muck Research Station, Kettleby, Ontario.

Year	Orientation	Color/material	Mean ± SE	Statistics
2015	Flat	Yellow-orange carton	7.1 ± 1.8 a[1]	$F_{1,16} = 45.3$, $P < 0.0001$
		Dark orange carton	1.7 ± 0.5 b	
	Angled	Yellow-orange carton	2.8 ± 1.3 a	$F_{1,16} = 0.9$, $P = 0.4$
	Flat	Yellow-orange carton	3.4 ± 1.2 a	
2016	Flat	Dark orange carton	2.3 ± 0.8 b	$F_{2,24} = 4.0$, $P = 0.03$
		Yellow-orange carton	5.4 ± 1.2 ab	
		Yellow acrylic	6.6 ± 1.7 a	
	Angled/flat	Yellow-orange carton	----	Not enough flies to analyse

[1]Numbers in column within an experiment followed by the same letter are not significantly different, Tukey's HSD

Table 2: Western flower thrips (*Frankliniella occidentalis*) captures on blue and yellow sticky traps with and without a lure in cabbage. Experiment conducted at Brookfield Farms, Milton, Prince Edward Island.

Trap color	Lure	Mean ± SE	Statistics
Blue	No	10.0 ± 6.4 ns[1]	$F_{2,6} = 0.2$, $P = 0.8$
Blue	Yes	16.7 ± 9.7	
Yellow	Yes	22.7 ± 20.7	

[1]ns = No significant differences were found among the treatments.

2020 PMR REPORT # 05 **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

CROP: Canola (*Brassica napus* L. and *Brassica rapa* L.), cabbage, collards, kale, broccoli, brussels sprouts, cauliflower, etc. (varieties of *Brassica oleracea* L.)

PEST: Diamondback moth *Plutella xylostella* L.

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TITLE: HOST RANGE TESTING PARAMETERS FOR DIADROMUS COLLARIS

MATERIALS: The solitary pupal parasitoid *Diadromus collaris* (Gravenhorst) (Hymenoptera: Ichneumonidae) was obtained from Delémont, Switzerland in 2016 and a culture has been maintained in containment at 21°C ± 1°C and a 16:8 L:D photoperiod cycle with 40 ± 25 % relative humidity. Host diamondback moth were reared on cabbage (*Brassica oleracea* L. var. *capitata*). Clear plastic dishes (Semadeni AG, Ostermundigen, Switzerland) were used as experimental arenas.

METHODS: In host-range testing of candidate biological control agents, it is important to maximize the motivation of the agent to oviposit, to avoid false negatives. We tested the following parameters for their effect on parasitism of diamondback moth pupae by *Diadromus collaris*: diet, parasitoid age, substrate, presence or absence of cocoon and length of exposure to host.

Effect of diet: Unmated, newly emerged *D. collaris* females were placed in individual clear plastic dishes (90 mm in diameter x 25 mm in height) and provided with one of the following 11 treatments (10 replicates per treatment): distilled water; 10% sucrose solution; distilled water + honey smear; 10% sucrose solution + honey smear; distilled water + bee pollen paste; 10% sucrose solution + bee pollen paste; distilled water + honey smear + bee pollen paste; 10% sucrose solution + bee pollen paste + honey smear; 5 diamondback moth pupae + distilled water; 5 diamondback moth pupae + 10% sucrose solution; 5 diamondback moth pupae + distilled water + honey smear. The 10% sucrose solution and the distilled water were provided on 1 cm-long cotton dental wicks soaked in solution, and pollen was provided by dipping either the sucrose wick or the distilled water wick halfway into the paste. After 24 hours, two male *D. collaris* were added to each plastic dish and allowed to mate for the next 48 hours. Food resources were refreshed every second day, for seven days. The seven-day-old wasps were then provided with 10 fresh diamondback moth pupae for a period of 24 hours. These exposed pupae were removed and monitored for *D. collaris* emergence.

Effect of *D. collaris* age: For each replicate (11 replicates), within 4 hours of emergence, seven female wasps were separated into clear plastic dishes (90 x 25 mm), provided with a dental wick soaked in 10% sucrose solution, and randomly assigned to an age treatment ranging from three to nine days old. Two males were added to each dish for a 48-hour mating period. When they had reached their target age, females were provided with 10 fresh diamondback pupae for a period of 24 hours. The exposed pupae were then removed and monitored for *D. collaris* emergence.

Effect of substrate: For each replicate (20 replicates), within 24 hours of emergence, female wasps were placed in clear plastic dishes (101 x 54 mm) with three females in each. Three males were added to each dish and removed after 48 hours. After seven days, female wasps were placed individually in clear plastic dishes (90 x 25 mm). For 24 hours, each wasp was provided with either a diamondback moth pupa on a 2 cm x 2 cm cabbage leaf, or one of two inert substrates that differed in how securely the pupa was fastened to the substrate: a pupa that was unsecured on a filter paper, and thus free to roll, or a pupa secured to a sponge by pinning two insect minuten pins through the cocoon. The exposed pupae were then removed and monitored for *D. collaris* emergence.

Effect of host cocoon: Within 24 hours of emergence, 40 female wasps were separated into clear plastic dishes (101 x 54 mm) with ten females in each. Ten males were added to each dish and removed after 48 hours. After seven days, individual females were separated into clear plastic dishes (90 x 25 mm) and provided with a diamondback moth pupa with or without a cocoon (the mesh cocoons were removed with forceps just prior to exposure) for a period of 24 hours. Host pupae were secured on sponges with insect minuten pins. Simultaneously, control pupae with and without cocoons were set up as described above but not exposed to *D. collaris*, to determine whether cocoon removal kills host pupae (thus rendering them invalid hosts).

Effect of exposure length: For each replicate (20 replicates), within 24 hours of emergence, female wasps in groups of three were placed into clear plastic dishes (101 x 54 mm). Three males were added to each dish and removed after 48 hours. After seven days, the individuals in each group of three were assigned to one of three exposure treatments (6-, 12- or 24-hour exposure) and transferred to individual clear plastic dishes (90 x 25 mm). Each was provided with a single pupa secured on a sponge with minuten pins. After the prescribed exposure time, the process was repeated with a new pupa. The exposed pupae were then monitored for *D. collaris* emergence.

RESULTS: As outlined in Tables 1-5.

CONCLUSIONS: The results from this study were used to design a host range testing protocol for *D. collaris* that maximizes both the motivation to oviposit and testing efficiency, with the following parameters: a diet of sucrose and pollen (a carbohydrate is essential), three- to nine-day-old wasps, pupae presented without the need to add host plant material and either secured or unsecured to a substrate, pupae with cocoons intact, and a 24-hour exposure length. Although the number of offspring produced was not significantly different between two 24-hour exposure periods and two 6-hour exposure periods, the 24-hour exposure period appeared to allow time for a greater renewal of egg load. Moreover, a 24-hour exposure period is easier to schedule into the workday.

Table 1. Offspring produced by female *Diadromus collaris* wasps fed for seven days on different diet treatments (Mean of 10 females for each treatment).

Treatment	*D. collaris* offspring emerging (mean of 10 replicates)[1]
Water	0.0 a
Honey	3.2 a
Honey + pollen	2.9 a
Sucrose	3.9 a
Sucrose + pollen	4.0 a
Sucrose + honey + pollen	3.2 a
Pollen	2.9 a
Sucrose + honey	3.5 a
Diamondback moth pupae + water	0.0 a
Diamondback moth pupae + honey	4.6 a
Diamondback moth pupae + sucrose	4.4 a

[1] Offspring emergence varied significantly among diet treatment types (likelihood ratio test, $\chi^2 = 141.95$, df = 10, $p < 0.0001$); however, post-hoc Tukey's comparison tests showed no significant differences among the different diet treatments, likely due to the large number of pairwise comparisons. For wasps deprived of a carbohydrate (i.e., the water treatment and the pupae + water treatment), offspring emergence was zero; none of the females in these treatments survived to day seven, the time when females were presented with hosts for oviposition.

Table 2. Offspring produced by female *Diadromus collaris* wasps of different ages during a 24-hour oviposition period.

Age in days	*D. collaris* offspring emerging (mean of 11 replicates)[1]
3	4.45
4	3.09
5	4.27
6	3.73
7	3.82
8	3.60
9	3.60

[1] Offspring emergence did not vary significantly among age treatments (likelihood ratio test, $\chi^2 = 3.5824$, df = 6, $p = 0.733$)

Table 3. Number of *Diadromus collaris* that emerged from diamondback moth pupae presented on a piece of cabbage leaf, unsecured on a filter paper, or secured to a sponge with minuten pins. There was a total of 20 replicates (one wasp + one pupa), each of which could have produced one parasitoid offspring or not

Treatment	*D. collaris* offspring emerging (from a possible total of 20)[1]
Pupa on cabbage leaf	15
Pupa unsecured on filter paper	16
Pupa secured to sponge with minuten pins	18

[1] Offspring emergence did not vary significantly among the substrate on which hosts were presented (χ^2 = 1.558, df = 2, p = 0.459).

Table 4. Number of emerged *Diadromus collaris* and pupal mortality for diamondback moth pupae provided to *D. collaris* with their cocoons either intact or absent.

Treatment	*D. collaris* offspring emerging (out of a possible total of 20)[1]	Diamondback moth mortality (out of a possible total of 20)[2]
Cocoon removed	10	15
Cocoon intact	13	20

[1] *D. collaris* emergence did not differ significantly depending on the presence or absence of a cocoon on the diamondback moth pupae (χ^2 = 0.921, df = 1, p = 0.337).

[2] Pupal mortality was significantly higher for pupae that were provided with their cocoons intact than for pupae provided without cocoons (χ^2 = 5.714, df = 1, p = 0.017). The cocoon might provide chemical cues from frass or salivary compounds on the silk that excite the wasps, leading to host-feeding (feeding on the pupa without ovipositing) or possibly superparasitism of the pupae, either of which might have caused additional mortality.

Removing the cocoon does not induce mortality in diamondback moth pupae; all control pupae that were not exposed to *D. collaris* survived (not shown).

Table 5. Number of *Diadromus collaris* offspring that emerged after two successive exposures to diamondback moth pupae for a period of 6 hours, 12 hours or 24 hours.

Treatment	*D. collaris* offspring emerging (cumulative total from 20 replicate females x 2 exposures)[1]
6-hour exposure	22 ab
12-hour exposure	17 a
24-hour exposure	31 b

[1] *D. collaris* emergence was significantly different among exposure times ($\chi^2 = 5.952$ df = 2, p = 0.031). Two 24-hour exposures resulted in significantly higher wasp emergence than two 12-hour exposure (Post-hoc Tukey's comparison, z = 2.60, p = 0.025).

2020 PMR REPORT #06 **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

CROP: Celery (*Apium graveloens* L.), cv. TZ 6200
PEST: Fungus Gnat (*Bradysia sp.* (Winnertz))

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TITLE: **EVALUATING THE BIOCONTROL POT POPPER PEARLS FOR FUNGUS GNAT CONTROL, 2019**

MATERIALS: ENVIRONMENTAL FACTOR, INC. POT POPPER PEARLS (*Steninernema feltiae*), CITATION 75WP (cyromazine 75%)

METHODS: The trial was conducted in 2019 at the Muck Crops Research Station greenhouse in the Holland Marsh, Ontario. The experiment was designed to evaluate the efficacy of Environmental Factor, Inc. Pot Popper Pearls (*Steninernema feltiae*) to control fungus gnats (*Bradysia sp.*) in vegetable transplant production. The experimental unit was a 60 cm x 60 cm domed Headless – Soil Emergence Trap (BugDorm) containing one 288-cell plug tray of celery transplants. Treatments were: Pot Popper Pearls at 10-15 (low), 16-30 (mid) and 60-70 (high) nematodes/pearl, untreated control (with fungus gnats), untreated control (no fungus gnats), and CITATION 75WP (insecticide control). There were four replications per treatment. On 27 September, celery, cv. TZ 6200, was seeded 1 seed/cell using a vacuum seeder into 288-cell plug trays filled with ASB soilless mix. Pot Popper Pearls of the corresponding treatments (low, mid, and high) were added at 1 pearl/cell following seeding. All plug trays were watered to ensure high soil moisture to promote fungus gnat development and placed on an Ebb and Flow table covered with a thrips-mesh in the appropriate BugDorm enclosure. Each enclosure (excluding the untreated control with no fungus gnats) was infested with 20 adult fungus gnats on 3, 10, and 18 October, and with 25 larval fungus gnats on 31 October, allowing high population pressures to establish. Fungus gnats used for the infestations were collected from infested plants in a nearby commercial ornamental greenhouse on each the day of infestation. CITATION was applied at 0.13 g/L on 19, 26 November and 3 December at a rate of ~200 ml/tray using a watering can (OMAFRA Crop Protection Guide for Greenhouse Vegetables recommendations). Celery plants were grown for ~10 weeks (27 September - 10 December) on Ebb and Flow benches, water that included 20-20-20 fertilizer at 50 ppm occurred twice per week. Adult fungus gnat emergence was monitored weekly from 12 November to 10 December for a 48-hour period using 4.5 cm x 5.5 cm one-sided yellow sticky cards that were placed in each enclosure ~3 cm above the canopy. Adult fungus gnats flying in each BugDorm and caught on sticky cards were counted at the end of each 48-hour period. Total population counts of adult fungus gnats were combined over the five weeks of collection. On 10 December trays were removed from

the enclosures and 20 plants/tray were randomly selected assessed for the following criteria: plant height, fresh weight of tops and roots. Ten plugs/tray were randomly assessed for the number of fungus gnat larvae per plug. Six random plugs/tray were taken from each of the Pot Popper Pearl treatments and nematodes were extracted from the soil using the Baermann pan method and nematodes numbers counted and recorded. Data were analyzed using an ANOVA general linear model using RStudio (RStudio Team, Boston, MA, version 3.5.2) to determine the effect of treatment on mean plant height, mean fresh weight of tops, mean fresh weight of roots, mean number of fungus gnat larvae per plug, and mean number of nematodes per plug. The total population counts of adult fungus gnats were analyzed using an ANOVA general linear model log transformed with a negative binomial distribution using RStudio (RStudio Team, Boston, MA, version 3.5.2) to determine the effect of treatment on total cumulative adult fungus gnat population. Mean separation was obtained using a Tukey's HSD test with $\alpha = 0.05$ level of significance.

RESULTS: as presented in Tables 1 & 2

CONCLUSIONS: Celery grown in plug trays with Pot Popper Pearls at the high rate had fewer adult fungus gnats than the untreated control but did not differ from Pot Popper Pearl at the lower rates or trays treated with CITATION (Table 1). There were no significant differences in fungus gnat larvae per plug among treatments when assessed on 10 December (Table 1). Higher numbers of nematodes were extracted from the celery plugs from all three Pot Popper Pearl treatments than those contained initially in the Pearls. The increase in nematodes suggests that nematode populations were able to establish in the celery plugs. The number of nematodes was significantly higher in the mid and high rates compared to the low rate (Table 1). Celery plants that received the low rate of Pot Poppers were taller and had higher root and shoot weights than both controls (fungus gnats and no fungus gnats) and plants were taller than the plants treated with the CITATION (Table 2). Plants that received the high rate of Pot Poppers were also taller than the those that were treated with CITATION. Fresh weight of the shoots was also higher in plants receiving the middle rate of nematodes. Root fresh weight was significantly higher in all treatments when compared to the control with fungus gnats (Table 2). These results demonstrate that fungus gnat larvae can significantly reduce the mass of plant roots from feeding. There were significant differences in both average plant height and fresh top weight (Table 2). These variations could be attributed to fungus gnat populations or greenhouse table placement. A repetition of this study would be beneficial to support the conclusions provided.

This study indicates that the addition of nematodes in the Pot Popper Pearls at the high rate reduced the number of adult fungus gnats, and the low rate consistently increased plant growth. These beneficial nematodes could be an effective addition to a greenhouse IPM program for vegetable transplants.

Table 1. Mean cumulative adult fungus gnats per treatment in celery transplants treated with Pot Popper Pearls, 2019

Treatments	Cumulative adult fungus gnats per 48 hr		Fungus gnat larva per plug 10 Dec		Nematodes per plug 10 Dec	
	Mean	SE	Mean	SE	Mean	SE
Control (no fungus gnats)	0 a[1]		0 ns[2]		NA	
Control (fungus gnats)	143 c	± 44.9	6	±5.5	NA	
Pot Popper Pearls – 10-15 nematodes/pearl	79 bc	± 9.9	7	±3.0	65 a	±22.0
Pot Popper Pearls – 16-30 nematodes/pearl	103 bc	± 33.7	13	±5.8	285 b	±65.8
Pot Popper Pearls – 60-70 nematodes/pearl	46 b	± 19.6	9	±4.4	296 b	±82.9
CITATION	67 bc	± 15.6	0	±0.0	NA	

Cumulative number of adults in a 48-hour period per week, averaged from 12 November until 10 December, 2019, and fungus gnat larvae per plug and nematodes per plug assessed on December 10, 2019.

[1-] Different letters within columns denote significantly different groups according to Tukey's HSD ($\alpha = 0.05$).

[2-] ns indicates all numbers in the column are not significantly different at $\alpha = 0.05$ according to Tukey's HSD test.

Table 2. Mean (±SE) plant height, fresh weight of tops and roots of celery transplants treated with Pot Popper Pearls for the control of fungus gnats grown University of Guelph, 2019.

Treatments	Plant height/plug(cm)		Top fresh weight/plug (g)		Root fresh weight/plug (g)	
	Mean	SE	Mean	SE	Mean	SE
Control (no fungus gnats)	13 d[1]	±0.9	0.7 c[1]	±0.06	0.29 b[1]	±0.03
Control (fungus gnats)	16 bcd	±0.4	0.9 c	±0.05	0.14 c	±0.02
Pot Popper Pearls – 10-15 nematodes/pearl	21 a	±1.0	1.7 a	±0.14	0.44 a	±0.05
Pot Popper Pearls – 16-30 nematodes/pearl	18 abc	±1.6	1.5 ab	±0.22	0.30 b	±0.02
Pot Popper Pearls – 60-70 nematodes/pearl	19 ab	±0.7	1.1 bcd	±0.10	0.41 ab	±0.04
CITATION	15 cd	±0.5	1.0 bc	±0.08	0.35 ab	±0.04

[1-] Different letters within columns denote significantly different groups according to Tukey's HSD ($\alpha = 0.05$).

ACKNOWLEDGEMENTS: Funding for this project was provided by ENVIRONMENTAL FACTOR, INC.

2020 PMR REPORT # 07 **SECTION H: PEST MANAGEMENT METHODS – BIOLOGICAL CONTROL**

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

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TITLE: THIRD 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 and Scotland, Ontario were sown with onions in the spring of 2020. At the Exeter field site, three fields comprised of Granby sandy-loam and Granby/Brady sandy-loam 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 13 May at these three fields. The field where sterile flies were released (**Figure 1, A**), measured approximately 10.8 ha (26.6 ac) and was seeded approximately 100 m from the field where sterile flies were release during the 2019 field season measuring approximately 3.2 ha (8.0 ac) (**Figure 1, B**). The control field where no sterile flies were released was situated between 2018, 2019 and 2020 release sites and was approximately 6.0 ha (14.9 ac) in size (**Figure 1, C**). An additional onion field approximately 9.7 ha (23.3 ac) in size was seeded in 2020 and no monitoring took place nor sterile flies were released at this field (**Figure 1, D**). At the second site near Scotland, Ontario, three fields were transplanted with onions at an average density of ~345,000 plants / ha (140,000 plants / ac) with no soil application of chlorpyrifos. At two of these three fields, approximately 3 km apart, sterile flies were released. The first field, comprised of Caledon sandy-loam was approximately 5.3 ha (13.0 ac) in size (**Figure 2, A)** and planted from 27 April to 18 May directly adjacent to the field where sterile flies were released in 2019 (**Figure 2, B**). Two other fields were planted with onions near this first field in 2020 but were not monitored (**Figure 2, C & D**). Sterile flies were released at these fields at the same concentrations of sterile flies / acre but were not monitored using sticky cards. The second field where sterile flies were released and monitored (**Figure 2, E**), was adjacent to the 2019 control field which had no sterile flies released in 2019 (**Figure 2, F**). This second field was comprised of Brady loamy-sand, was approximately 5.1 ha (12.6 ac) in size and was planted 25–30 May. In addition, a field near Princeton, Ontario was planted 6–8 May, approximately 17 km from the first two fields, and was comprised of Brady and Granby sandy-loam, measuring approximately 4.2 ha (10.3 ac) in size (**Figure 3**, **A**). No sterile flies were released at this third, control field and onions had been planted near this field every year for the previous five years. There were no other major onion fields within a 20 km radius from either the Exeter or Scotland field sites. 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 Exeter 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 on 13 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. 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 at each of the four sites around the onion set fields near Exeter (**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 24 August at the Exeter fields, and the Scotland fields were harvested starting from mid August to early October (**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, there was no control field monitored in 2019 and the control field in 2020 was adjacent to the release field. Sticky card counts of wild flies indicated that there is a year to year increase in the average number of wild flies during the population peaks (**Figure 5**). An average of 18.1 flies/trap/week were counted during the first peak 30 June and 5.8 flies/trap/week during the second distinct peak 18 August (**Table 1; Figure 5**). Sterile, pink flies were found on a single sticky card on the west side of the control field 30 June. At the Exeter field site, the level of onion maggot damage in these fields in 2018 and 2019 was low relative to other years and no onion maggot damage was observed in 2020 (Grower correspondence). Despite growing onions in fields adjacent to each other or only implementing a single year without onion, levels of wild flies did not increase to levels high enough to cause observable damage at the Exeter field site (**Figure 1, 5; Table 1**). At the Scotland field sites, an average of 159.9 wild flies/trap/week were observed 17 June at both release fields while a peak of 70.8 wild flies/trap/week were observed 17 June at the Princeton field. The peaks of an average of 159.9 flies/trap/week observed at both release fields 17 June was likely an under-estimation due to the cards being completely covered by flies and being unable to catch any additional flies. 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. Fly counts remained low relative to these peaks after 4 July (**Tables 3,4; Figure 6**). At both Scotland release fields, pink flies were found at every trap but most were quantified throughout the season at the closest trap relative to where the sterile flies were released. No pink flies were found on any of the sticky cards at the control field at the Princeton location. Destructive sampling did not find any onion maggot larvae throughout the season however onion maggot damaged was observed in other plants (**Tables 1 & 3**). At the Scotland release fields, wild fly pressure was high to begin with due to the high levels observed in 2019 and previous years. The previous onion maggot population was most likely unequal between the two release sites and control. Both field sites in Scotland were closely planted to onion fields in 2020 or 2019 that had no sterilized flies released which may have acted as a refuge for wild flies. A continuation of this program is required to observe the long-term effects of a sterile fly release on the onion maggot population to determine the overall effectiveness, and, in turn, reduce the need of chemical control options.

ACKNOWLEDGEMENTS: Funding for this project was provided by Pesticide Risk Reduction Program through the Pest Management Centre. Thank you to Hannah Fraser, Cora Loucks, Dennis Van Dyk, Ashleigh Ahrens and Maria Polsinelli for their help throughout the growing season.

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

		Release Field				Control Field			
Date	Release Quantity ('000)	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots
20/05/12	27	--	--	--	--	--	--	--	--
20/05/19	27	--	--	--	--	--	--	--	--
20/05/26	67	--	--	--	--	--	--	--	--
20/06/02	85	loop	2.5	0.0	0.0	loop	1.8	0.0	0.0
20/06/09	107	flag	2.6	0.3	32.3	flag	1.6	0.0	37.0
20/06/16	154	1LS	2.9	0.0	33.0	1LS	2.0	0.0	41.3
20/06/24	181	3LS	11.2	0.0	27.3	3LS	15.0	0.0	34.3
20/06/30	181	4LS	18.1	0.0	28.3	4LS	12.8	0.1	40.0
20/07/07	154	5LS	4.3	0.0	26.8	5LS	3.7	0.0	39.8
20/07/14	168	6LS	8.5	5.5	32.0	6LS	4.7	0.0	35.3
20/07/21	101	7LS	3.3	1.1	27.3	6LS	4.4	0.0	40.0
20/07/28	56	7LS	2.1	0.3	24.0	7LS	1.5	0.0	38.0
20/08/04	46	8LS	2.5	0.0	23.0	8LS	2.5	0.0	35.8
20/08/11	62	8LS	0.9	0.8	18.0	8LS	1.8	0.0	24.5
20/08/18	80	8LS	5.8	6.3	26.0	8LS	1.1	0.0	40.5
20/08/26	40	--	--	--	--	--	--	--	--
20/09/02	0	--	--	--	--	--	--	--	--
20/09/09	55	post	1.0	2.8	--	post	0.5	0.6	--
20/09/16	57	--	--	--	--	--	--	--	--

[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 Exeter field site.

Date	Field	Trade Name	Common Name	Rate / Hectare
20/06/19	All	Mako	Cypermethrin	175 mL

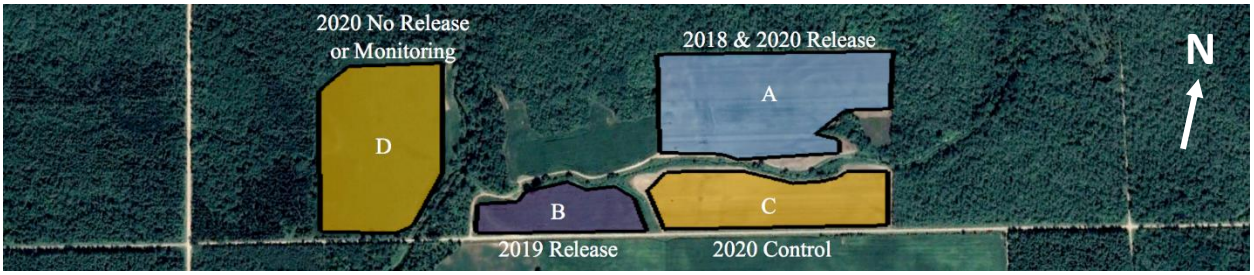

Figure 1. The release field site approximately 10.8 ha (26.6 ac) near Exeter (**A**) was seeded approximately 100 m from the field where sterile flies were release during the 2019 field season measuring approximately 3.2 ha (8.0 ac) (**B**). The monitored control field where no sterile flies were released (**C**), 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 (**D**) and no monitoring took place and no sterile flies were released at this field.

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

	First Release Field					Second Release Field					Control Field			
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	Plant Stage[1]	Wild Flies	Pink Flies	Damage Plots
20/05/12	9	--	--	--	--	7	--	--	--	--	--	--	--	--
20/05/19	9	--	--	--	--	7	--	--	--	--	--	--	--	--
20/05/28	22	2LS	5.1	0.0	99.3	17	2LS	10.8	9.1	--	2LS	4.8	0.0	99.5
20/06/04	28	3LS	4.0	0.0	97.5	22	3LS	--	--	--	3LS	3.1	0.0	99.0
20/06/11	36	4LS	12.0	1.0	97.3	27	4LS	32.1	0.1	99.8	4LS	9.4	0.0	99.0
20/06/17	51	5LS	159.9	0.0	97.3	40	5LS	159.9	0.1	99.8	5LS	70.8	0.0	98.0
20/06/25	60	7LS	23.8	2.0	99.0	46	5LS	24.3	3.5	99.8	7LS	19.5	0.0	98.0
20/07/01	60	8LS	9.6	0.7	98.0	46	6LS	7.8	1.6	99.5	8LS	8.4	0.0	98.0
20/07/08	51	9LS	2.8	0.0	98.0	40	6LS	1.3	0.0	99.5	9LS	1.3	0.0	98.0
20/07/15	56	10LS	1.8	0.3	98.0	43	7LS	2.7	0.3	99.3	10LS	2.4	0.0	96.3
20/07/23	33	11LS	2.6	0.0	98.0	26	8LS	2.3	0.3	98.5	11LS	3.7	0.0	96.3
20/07/30	19	12LS	1.4	0.0	98.0	14	9LS	1.2	0.4	98.5	12LS	6.8	0.0	94.5
20/08/05	15	12LS	0.8	0.1	97.8	12	9LS	0.8	0.0	98.5	12LS	6.3	0.0	92.5
20/08/12	21	13LS	3.2	0.5	87.7	16	9LS	1.3	0.6	98.5	13LS	5.8	0.0	88.8
20/08/19	20	13LS	10.8	9.1	27.7	15	9LS	--	--	--	13LS	10.3	0.0	88.5
20/08/26	13	--	--	--	--	10	--	--	--	--	--	--	--	--
20/09/02	0	--	--	--	--	0	--	--	--	--	--	--	--	--
20/09/09	19	--	--	--	--	12	--	--	--	--	--	--	--	--
20/09/16	18	--	--	--	--	6	--	--	--	--	--	--	--	--

[1] Plant stage where LS = leaf stage 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
20/06/08	All	Movento 240 SC	Spirotetramat	356 mL
20/06/15	All	Movento 240 SC	Spirotetramat	356 mL
20/06/29	All	Agri-Mek SC	Abamectin	200 mL
20/07/13	All	Agri-Mek SC	Abamectin	200 mL
20/07/25	All	Delegate WG	Spinetoram	336 g
20/08/07	All	Delegate WG	Spinetoram	336 g
20/08/14	All	Dibrom	Naled	530 mL

Figure 2. The field sites near Scotland had four release fields in 2020 and two were monitored. Release I was approximately 5.3 ha (13.0 ac) in size (**A**) and was located adjacent to the 2019 release field (**B**). Two other onion fields saw sterile flies released but were not monitored in 2020 (**C & D**). Release field II (**E**), was located adjacent to the 2019 control field where no sterile flies were released in 2019 (**F**) and was approximately 5.1 ha (12.6 ac) in size.

Figure 3. The control field site (**A**) near Princeton, was situated ~17 km from the release sites and was approximately 4.2 ha (10.3 ac) in size. No sterile flies were released at this field site.

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

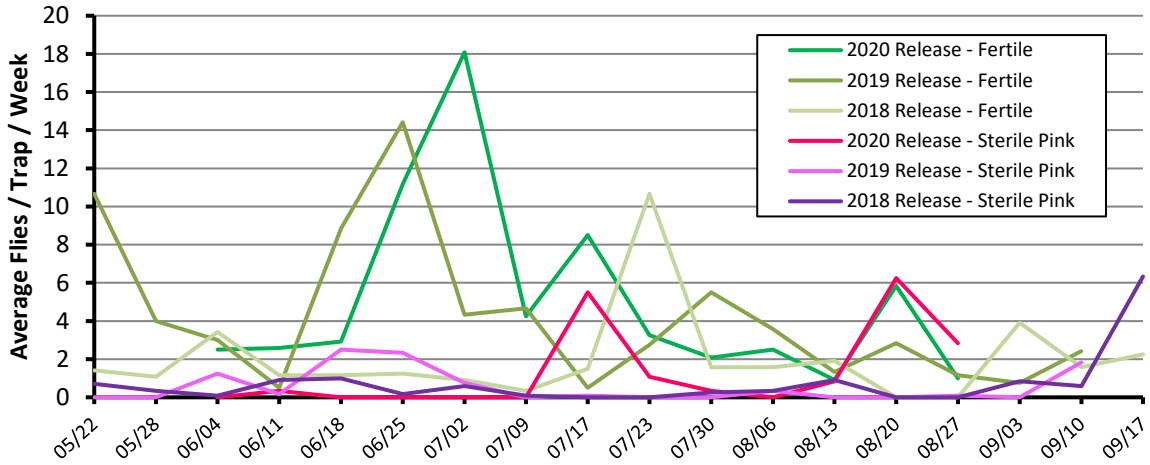

Figure 5. Average wild flies per sticky trap per week at the field site near Exeter from 2018 to 2020. Wild/fertile fly counts showed peaks in late June/early July in 2019 and 2020 while the first peak was identified in late July in 2018 (**greens**). Counts of sterile pink flies remained relatively low all three years (**pink/purple**).

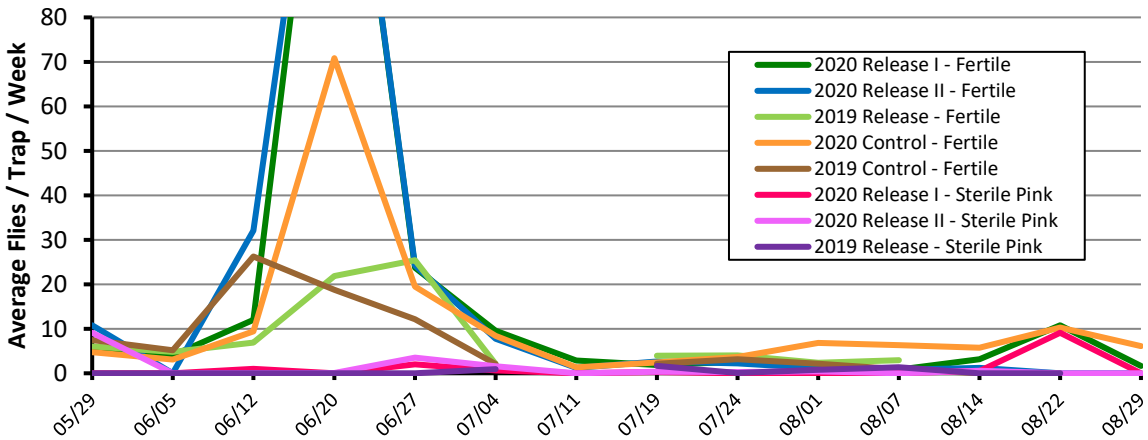

Figure 6. Average wild flies per sticky trap per week at the field sites near Scotland. Wild/fertile fly counts at the release fields in 2020 (**dark green and blue**) peaked the week of 20 June and filled the sticky cards at an average of 160 flies/card. Wild/fertile flies also reached a peak at the control field approximately 17 km away (**orange**) the same week. Both release fields were adjacent to fields planted with onions in 2019. Sterile pink flies were found in relatively low numbers at the release fields throughout the season (**red, pink**) and in 2019 (**purple**).

2020 PMR REPORT #08 **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

CROP: Turf (green roof fescue mix)
PEST: Crane fly (*Tipula oleracea* L.)

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TITLE: **EFFECT OF TWO ENTOMOPATHOGENIC NEMATODES ON CRANE FLY (*TIPULA OLERACEA* L. (DIPTERA: TILPULIDAE)) LARVAL MORTALITY**

MATERIALS: ENTONEM (*Steinernema feltiae*), TERRANEM (*Heterorhabditis bacteriophora*)

METHODS: On May 24, 2012, larvae of the marsh crane fly (*Tipula oleracea* L.) were observed causing damage to fescue in a green roof installation in Vancouver, British Columbia. The six acre (2.43 ha) green roof had been seeded in 2009 with three types of fescue, Idaho fescue (*Festuca idahoensis*) at 9.6 kg/ha, Quatro sheep's fescue (*Festuca ovina vulgaris*) at 6.7 kg/ha and creeping red fescue (*Festuca rubra*) at 5.7 kg/ha, in addition to seashore bent grass (*Agrostis pallens*) and a variety of other grasses, sedges, bulbs and drought-resistant flowering plants (installation contractor, personal communication, July 2012). The fescue was observed to be brown, dying or dead, in patches ranging from a few cm to several square meters scattered over all sections of the roof. The total affected area comprised approximately one-third (two acres (0.81 ha)) of the planting. Affected areas had either no grass (bald), or only a few small green "tufts" remaining. There was minimal root growth on the remaining "tufts". The asters and other broadleaf plants on the roof were unaffected and showed no signs of damage. No chemical fertilizers or pesticides had been applied. The population of crane fly larvae in 15 randomly-selected squares was one to three larvae per sq. ft. (10-30/m^2), all of which were identified as mid-to-late instar stages of *T. oleracea* based on morphological characteristics of adults later reared from collected larvae. The larvae were observed in the root zone of the fescue and feeding in soil crowns of the grass "tufts", including at the advancing margins of the damaged patches. On June 1, 2012, a 50:50 tank mix of *Steinernema feltiae* (ENTONEM) and *Heterorhabditis bacteriophora* (TERRANEM) (Koppert Biological Systems, Canada) was applied by a commercial applicator using pump-action backpack sprayers. Nine packs of each nematode species (18 packs total; 250 million nematodes per pack) were mixed in 620 L water (7.25 million nematodes/L) and applied in a solution volume of approximately 50 L/100 m^2 (3.6 million nematodes/m^2) to control the crane fly larvae on the roof.

On June 1, prior to the commercial application, crane fly larvae, fescue plants (leaves and roots) and soil visibly free of larvae were collected from the green roof and divided equally among four assay boxes, for a total of 20 larvae per box. Each assay box was a rectangular plastic storage container with the top cut out and replaced with a mesh screen. Each box had a surface area of 125 cm^2 and was filled to approximately three quarters with one kg of slightly moist soil from the green roof site. The larvae were all mid-to-late (second to fourth) instars of *T. oleracea*. After distributing the larvae equally among the containers and covering them with soil, each container received a different nematode treatment for a total of four treatments: a water control, *S. feltiae*, *H. bacteriophora*, or a sample of the 50:50 mixture of *S. feltiae* and *H. bacteriophora* used in the commercial application. The nematodes were obtained from the commercial packages of ENTONEM (*S. feltiae*) and TERRANEM (*H. bacteriophora*) nematodes (Koppert Biological Systems) used by the commercial applicator to treat the green roof and mixed in water. Nematodes were counted on a haemocytometer and the concentration adjusted to approximately 7

x 10^6 nematodes per litre. To ensure an even distribution of the nematodes, each container was treated with 150 mL of the nematode solution, equivalent to 1.2 L/m², approximately twice the commercial roof treatment volume of 0.5 L/m^2. Treatments were applied with a hand-spray bottle to the surface of the soil, the fescue plants collected from the roof were placed on top of the soil and the boxes were left outdoors at ambient temperature, under cover from direct sun and rain. At three days, one week, two weeks and four weeks after application of the treatments, the boxes were assessed for crane fly larval mortality by gently removing and sifting the soil, counting live (moving) and dead larvae, then returning soil and live larvae to the box. Dead larvae were removed from the boxes at each assessment.

RESULTS: As presented in Table 1.

CONCLUSIONS: In a controlled, non-replicated, container assay of two commercial entomopathogens, ENTONEM (*S. feltiae*) and TERRANEM (*H. bacteriophora*), *S. feltiae* caused 100% mortality of mid- to late-instar larvae of *Tipula oleracea* three days after application compared to 5% with *H. bacteriophora* or water alone. The results suggest that *S. feltiae* can provide effective control of *T. oleracea* crane fly larvae at low (10-15ºC) temperatures. *H. bacteriophora* was much slower to kill the larvae but did have some effect. Larval mortality in the box treated with *H. bacteriophora* was 15-20% greater than in the water check after two and four weeks. Larval mortality in the check was most likely due to environmental conditions and starvation as the fescue added to the boxes senesced and desiccated.

The treatments were not replicated due to lack of sufficient larvae, but the wide difference in larval mortality and the consistency in results between the full and half-rate mixture of *S. feltiae* (100% vs. 50% mortality after three days), provide confidence that *S. feltiae* was more effective than *H. bacteriophora* under the conditions of the experiment. The low temperature under which the assay was conducted (10-15ºC) may have favoured *S. feltiae*, which is known as a low-temperature parasite, and inhibited the activity of *H. bacteriophora* which is more active at temperatures of 16-22ºC. Also, as a more stationary parasite, *S. feltiae* may have performed better in the confined space of the assay box than in the field.

Most studies of entomopathogenic nematodes for crane fly control have been conducted on the European crane fly, *T. paludosa* Meigen. Ansari and Butt (2012) reported that *H. bacteriophora* caused 28 and 65% larval mortality at four and eight weeks, respectively. Oestergaard et al. (2006) reported that *S. feltiae* caused <50% mortality of young *T. paludosa* larvae while *S. carpocapsae* was >80% effective at temperatures >12ºC. However, Peters and Ehlers (1994) found that, in laboratory assays, *T. oleracea* was more susceptible than *T. paludosa* to *S. feltiae.* Although both species occur in south coastal British Columbia, only *T. oleracea* has been observed on the green roof, possibly because it is a stronger flier than *T. paludosa*.

Post-application surveys of the green roof treated with the 50:50 mix showed that four weeks after the commercial application, 15 previously-marked “hot-spots” on the green roof had no crane fly larvae or pupae and the grass had begun to grow back. Severely damaged areas were re-seeded. Four second-generation adults were caught on yellow sticky traps from Aug 31 to Sept 14, but only one dying larva was found in 35 x 1ft^2 sample sites. However, re-infestation has continued in subsequent years requiring annual treatment of hot-spots with *S. feltiae* in May-June.

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Peters, A. and Ehlers, R-U. 1994. Susceptibility of leatherjackets (*Tipula paludosa* and *Tipula oleracea*; Tipulidae; Nematocera) to the entomopathogenic nematode *Steinernema feltiae*. Journal of Invertebrate Pathology 63:163-171.

Table 1. Crane fly (*T. oleracea*) larval mortality in test boxes after application of entomopathogenic nematodes.

Treatment	Rate (No. nems/L)*	% larval mortality after nematode application			
		3 days	1 week	2 weeks	4 weeks
1. Water control	-	5	10	45	75
2. *S. feltiae*	7×10^6	100	-	-	-
3. *H. bacteriophora*	7×10^6	5	10	60	95
4. *S. feltiae* + *H. bacteriophora*	$7 \times 10^{6**}$	50	75	95	100

*Each box = 150 mL of nematode solution per 125 cm^2; one box per treatment.
**50:50 tank-mix applied to the turf containing approximately 3.5×10^6 of each species.

2020 PMR REPORT #09 **SECTION J: NEMATODES**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.), cvs. Cellobunch and Bergen
PESTS: Carrot cyst nematode (*Heterodera carotae*) Jones, 1950; Root-lesion nematode (*Pratylenchus penetrans*) (Cobb, 1917) Filip'ev & Schuurmans Stekhoven, 1941

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TITLE: FIELD EVALUATIONS OF NEMATICIDES FOR CARROT CYST AND ROOT-LESION NEMATODE CONTROL IN CARROTS, 2020

MATERIALS: NIMITZ (fluensulfone 480 g/L), SALIBRO (fluazaindolizine 500 g/L), VYDATE (oxamyl 240 g/L)

METHODS: Two trials were conducted in commercial fields in the Holland/Bradford Marsh, Ontario, one known to be infested with root-lesion nematode (*Pratylenchus penetrans*) (Trial 1) and the other infested with carrot cyst nematode (*Heterodera carotae*) (Trial 2). A randomized complete block design with five replicates per treatment was used. The treatments were: NIMITZ at 4.0 L/ha, SALIBRO at 0.56, 1.12, 2.24 and 4.48 L/ha, VYDATE at 4.67 and 9.3 L/ha, a low rate combination of SALIBRO at 0.56 L/ha + VYDATE 4.67 L/ha, and a high rate combination of SALIBRO at 1.12 L/ha + VYDATE 9.3 L/ha. All treatments were applied to the soil surface using a CO_2 backpack sprayer fitted with TeeJet 8003 flat fan nozzles at the rate of 200 L/ha and were incorporated into carrot hills at seeding. For Trial 1, carrots, cv. Bergen, were direct seeded in all treatments at 40 seeds/m on raised beds on 3 June. For Trial 2, carrots, cv. Cellobunch, were direct seeded at 65 seeds/m on raised beds on 1 June. Each experimental unit consisted of three rows, 66 cm apart and 7 m in length for Trial 1, and 66 cm apart and 10 m in length for Trial 2. An untreated check was also included in both trials. Twelve 15 cm soil cores were taken from each plot to create one soil sample at seeding and at 8 weeks after application (8 WAA) for nematode analysis. Nematodes were extracted at the University of Guelph Muck Crops Research Station using the Baermann pan method for motile nematodes and Fenwick method for female carrot cyst nematodes. Carrot emergence was recorded on 9 July and phytotoxicity and vigor were recorded on 29 June, 10 July, 24, July and 5 August for both trials.
In Trial 1, carrots were hand harvested from two 1.28 m sections of row on 27 October and placed in cold storage until assessment on 4 November. In Trial 2, carrots were hand harvested from two 1.5 m sections of row on 28 October, placed in cold storage, and assessment on 6 November. Carrot samples were assessed for nematode damage (stunting and forking) and sorted into the following classes: 0 = no nematode damage; 1 = few small cysts, difficult to find; 2 = small cysts only but clearly visible, main roots clean; 3 = some larger cysts visible, minimal forking on main root; 4 = larger cysts predominate, minor forking; 5 = many cysts, minor forking and stunting; 6 = cysts easily present, carrots forked or stunted; 7 = carrots forked and/or stunted, some "hairy" roots; 8 = major forking and/or stunting, "hairy" roots, few clean roots visible; 9 = significant forking and/or stunting, very "hairy" roots, plant usually dying; 10 = all roots severely damaged, no root. Marketable yield was also determined from the harvest samples. Carrots in classes 0 to 3 were considered marketable and carrots in classes 4 to 10 were considered unmarketable. The damage severity index (DSI) was determined using the following equation:

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

Data were analyzed using the General Analysis of Variance function of the Linear Analysis section of Statistix V.10. Means separation was obtained using Fisher's Protected LSD test with $P = 0.05$ level of significance.

RESULTS: Data are presented in Tables 1, 2, 3 and 4.

CONCLUSIONS: In Trial 1, where the soil was infested with root-lesion nematode, VYDATE at 9.3 L/ha and SALIBRO at 0.56, 1.12 and 4.48 L/ha treatments had significantly higher percent marketable carrots and lower nematode damage incidence and severity than the untreated check (Table 3). The combination treatment of SALIBRO at 0.56 L/ha and VYDATE at 4.67 L/ha also had significantly lower root-lesion nematode damage incidence than the untreated check. Nematode counts after application varied among treatments and there were no significant differences in the reproduction ratio among the treatments in both trials (Tables 1 and 2).

Due to localized flooding around the beginning of August, one replication from Trial 2 was discarded at harvest. In addition, high temperatures after seeding resulted in heat canker which lowered the stand in Trial 2. No significant differences were observed at harvest among the treatments in Trial 2 (Table 4). No phytotoxicity or differences in vigor were observed in either trial.

ACKNOWLEDGEMENTS: Funding for this project was provided by Corteva Agriscience.

Table 1. Root-lesion nematode soil counts (nematodes/kg of soil) and reproduction ratio from carrot soil at planting and eight weeks after application of nematicides in the Holland Marsh, Ontario, 2020, Trial 1.

Treatment	Rate (L/ha)	Root-Lesion Nematode Counts (nematodes/kg soil)		Reproduction Ratio[1]
		At Planting	8 Weeks After Application	
VYDATE	9.3	288 ns[2]	600 ns	311.9 ns
NIMITZ	4.0	232	584	3.0
SALIBRO + VYDATE	0.56 + 4.67	208	512	1.8
Untreated	-	184	768	58.9
SALIBRO	2.24	160	1520	276.0
SALIBRO + VYDATE	1.12 + 9.3	128	624	5.0
SALIBRO	0.56	112	304	2.3
SALIBRO	4.48	104	656	520.4
SALIBRO	1.12	88	472	6.7
VYDATE	4.67	56	448	224.7

[1] Reproduction ratio = (final population – initial population)/initial population

[2] ns indicates no significant differences were found among the treatments at $P = 0.05$, Fisher's Protected LSD test

Table 2. Carrot cyst nematode soil counts (juveniles/kg of soil) and reproduction ratio from carrot soil at planting and eight weeks after treatment with nematicides in the Holland Marsh, Ontario, 2020, Trial 2.

Treatment	Rate (L/ha)	Carrot Cyst Nematode Counts (juveniles/kg soil)		Reproduction Ratio[1]
		At Planting	8 Weeks After Application	
SALIBRO	1.12	2376 ns	448 ns	3.7 ns
VYDATE	9.3	2370	512	-0.8
SALIBRO + VYDATE	0.56 + 4.67	1912	672	0.4
NIMITZ	4.0	1768	360	-0.7
Untreated	-	1336	568	-0.2
SALIBRO	2.24	1240	464	0.1
VYDATE	4.67	1016	488	55.3
SALIBRO + VYDATE	1.12 + 9.3	944	712	-0.3
SALIBRO	0.56	488	376	0.1
SALIBRO	4.48	352	472	71.8

[1] Reproduction ratio = (final population – initial population)/initial population
[2] ns indicates no significant differences were found among the treatments at $P = 0.05$, Fisher's Protected LSD test

Table 3. Percent marketable, marketable yield, percent nematode damage and damage severity index (DSI) for carrots, cv. Bergen, grown in root-lesion nematode infested soil treated with nematicides in the Holland Marsh, Ontario, 2020, Trial 1.

Treatment	Rate (L/ha)	% Marketable Carrots	Marketable Yield (t/ha)	% Nematode Damage	DSI[1]
VYDATE	9.3	81.5 a[2]	40.9 a	35.3 a	14.3 a
SALIBRO	0.56	81.0 a	40.3 a	37.9 a	14.6 a
SALIBRO	1.12	80.1 a	37.2 ab	39.1 a	15.5 a
SALIBRO	4.48	79.9 ab	33.0 abc	33.6 a	14.9 a
SALIBRO + VYDATE	0.56 + 4.67	70.0 abc	29.7 bc	45.5 ab	21.8 ab
SALIBRO + VYDATE	1.12 + 9.3	68.9 abc	32.7 abc	51.4 abc	23.3 ab
VYDATE	4.67	61.5 abc	28.1 bc	55.3 abc	26.3 ab
NIMITZ	4.0	58.0 bc	30.8 abc	65.3 bc	30.5 b
Untreated	-	52.3 c	34.2 abc	71.4 c	33.5 b
SALIBRO	2.24	50.5 c	24.3 c	68.4 bc	32.8 b

[1] DSI was calculated using the following equation:

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

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

Table 4. Percent marketable, marketable yield, percent nematode damage and damage severity index (DSI) for carrots, cv. Cellobunch, grown in carrot cyst nematode infested soil treated with nematicides in the Holland Marsh, Ontario, 2020, Trial 2.

Treatment	Rate (L/ha)	% Marketable Carrots	Marketable Yield (t/ha)	% Nematode Damage	DSI[1]
SALIBRO	4.48	57.1 ns[2]	14.3 ns	56.9 ns	26.0 ns
VYDATE	4.67	55.6	22.9	59.0	31.0
SALIBRO	1.12	53.6	15.8	63.8	32.2
VYDATE	9.3	52.8	15.1	65.9	32.7
SALIBRO + VYDATE	0.56 + 4.67	49.3	10.6	66.7	34.5
Untreated	-	49.1	11.3	65.0	33.7
NIMITZ	4.0	47.9	11.4	71.1	37.2
SALIBRO	2.24	45.7	13.2	72.8	36.8
SALIBRO	0.56	44.6	10.6	65.0	34.9
SALIBRO + VYDATE	1.12 + 9.3	42.5	11.2	67.1	37.6

[1] DSI was calculated using the following equation:

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

[2] ns indicates no significant differences were found among the treatments at $P = 0.05$, Fisher's Protected LSD test

2020 PMR REPORT #10 **SECTION J: NEMATODES**
CROP: Garlic (*Allium sativum* L.), cv. Music
PESTS: 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 IN A MINERAL SOIL FIELD, 2019-20

MATERIALS: AGRI-MEK SC (abamectin 84 g/L), 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. Two types of garlic cloves (seed) were included in the trial: SBN infested seed (7 SBN/g) and clean seed free of SBN. Nematode counts were determined at the University of Guelph Muck Crops Research Station using the Baermann pan method. The treatments were: AGRI-MEK SC, PROMAX and VELUM PRIME applied as a soak (S) or drench (D). Treatments receiving a product soak, and the associated soaking times, were: AGRI-MEK S at 0.9 mL/L for 4-hours, PROMAX S at 37.4 mL/L for 4-, 6- and 8-hours and VELUM PRIME S at 1.7 mL/L for 1-, 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 treatment was VELUM PRIME D at 500 mL/ha applied directly over the cloves at planting at an application rate of 40 mL/m using a 100 mL beaker. An untreated infested and clean seed checks were 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 29 October 2019. Emergence was recorded on 4 June 2020 and plant heights on 25 June. Garlic was harvested on 30 July. 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.

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

Stem and bulb nematodes were extracted 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. A Beta distribution was assumed in the harvest assessment analysis.

RESULTS: Data are presented in Tables 1 and 2.

CONCLUSIONS: The VELUM PRIME S treatment soaked for 2-hours had significantly lower SBN incidence and severity at harvest compared to all other treatments. For all VELUM PRIME S treatments, 100% of garlic bulbs were marketable at harvest while the other treatments were numerically lower. The PROMAX S treatment that soaked for 8 hours had the highest damage incidence, severity and SBN cloves counts and the lowest percent of bulbs that were marketable, numerically. No significant differences were found among treatments in terms of emergence and plant height. Stem and bulb nematode damage was low, overall, throughout the trial.

AKNOWLEDGEMENTS: Funding for this project was provided by the California Garlic and Onion Research Advisory Board, the Plant Production Systems of the Ontario Agri-Food Innovation Alliance, and the Fresh Vegetable Growers of Ontario representing the Ontario Garlic Growers Association.

Table 1. Garlic emergence and plant heights on 4 June and 25 June, respectively, after nematicide application near Cookstown, Ontario, 2020.

Treatment	Soaking Time (hr)	Emergence	Plant Height (cm)
Clean seed	-	24.4 ns[1]	86.6 ns
VELUM PRIME S	2	23.4	86.3
PROMAX S	4	22.6	81.0
Untreated	-	21.6	81.9
VELUM PRIME S	1	21.6	83.3
AGRI-MEK S	4	21.6	82.8
VELUM PRIME D	-	21.6	86.1
PROMAX S	6	21.6	82.1
VELUM PRIME S	4	21.6	83.6
PROMAX S	8	21.2	82.0

[1] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's HSD test

Table 2. Nematode damage incidence, disease severity index (DSI), percent marketable bulbs, marketable yield and stem and bulb nematodes (SBN) in cloves from harvested garlic treated with nematicides to control SBN in a mineral soil field trial near Cookstown, Ontario, 2019-2020.

Treatment	Soaking Time (hr)	% Nematode Damage	DSI[1]	% Marketable Bulbs	Marketable Yield (g/plot)	SBN /g of Garlic Cloves
VELUM PRIME S	2	0.0 a[2]	0.0 a	100.0 ns[3]	815.3 ns	1.6 ns
VELUM PRIME S	1	2.2 b	0.6 b	100.0	870.5	0.2
VELUM PRIME S	4	4.0 b	1.0 b	100.0	888.2	58.4
PROMAX S	4	5.4 b	2.6 b	97.4	830.5	8.8
AGRI-MEK S	4	5.8 b	3.8 b	95.1	829.8	86.6
PROMAX S	6	9.2 b	4.6 b	95.4	800.1	253.2
Clean seed	-	10.7 b	5.0 b	93.3	682.1	268.4
Untreated	-	11.1 b	7.9 b	91.8	761.3	42.6
VELUM PRIME D	-	12.0 b	4.6 b	95.6	804.7	199.6
PROMAX S	8	16.9 b	11.1 b	88.1	763.4	862.4

[1] DSI was calculated using the following equation:

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

[2] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Tukey's HSD test
[3] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's HSD test

2020 PMR REPORT #11 **SECTION J: NEMATODES**

CROP: Romaine Lettuce (*Lactuca sativa* L.), cv. Arroyo
PESTS: Northern root-knot nematode (*Meloidogyne hapla*) Chitwood, 1949

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TITLE: A MICROPLOT EVALUATION OF AN EXPERIMENTAL NEMATICIDE FOR CONTROL OF ROOT-KNOT NEMATODE IN ROMAINE LETTUCE, 2020

MATERIALS: EXPERIMENTAL (300 g/L)

METHODS: The trial was conducted in enclosed microplots with muck soil (organic matter 76.8%, pH 6.2) infested with root-knot nematode (RKN) at the Muck Crops Research Station (MCRS). The microplot trial was arranged in a randomized complete block design with four (4) replicates. Two rates of an EXPERIMENTAL nematicide, 0.167 L/ha and 0.333 L/ha, were evaluated on the efficacy to control RKN. The treatments were applied at an application rate of 22.8 mL/m directly over the row at seeding using a 100 mL beaker. An untreated check was also included. Fifty lettuce seeds were planted per treatment (microplot) 6 cm apart in two 1.5 m long rows spaced 30 cm apart on 14 July and were thinned on 14 August. Microplots were soil sampled at seeding for nematode by taking twelve 15 cm soil cores for nematode analysis. Nematodes were extracted from the soil using the Baermann pan method and quantified at the MCRS. Lettuce emergence, phytotoxicity and vigor were recorded on 28 July and 5 August. A mid-season assessment evaluated root galling and plant weights from six plants per treatment on 1 September. The number of RKN eggs in roots were also quantified using a NaOCl egg extraction protocol. Lettuce was harvested on 18 September. Lettuce top and root weights were recorded, and roots were assessed for RKN galling. The extent of RKN galling in lettuce roots from the mid-season and harvest assessment were determined using the Bridge and Page 0-10 rating scale (1980), where: 0 = no galls on roots; 1 = very few small galls difficult to find; 2 = small galls only but clearly visible; 3 = some larger galls visible but main roots clean; 4 = larger galls predominate, but main roots clean; 5 = 50% of roots galled, galling on parts of main root system; 6 = galling on some main roots, some coalesced; 7 = majority of main roots galled; coalescing common; 8 = galling on all main roots, few clean roots visible; 9 = all roots severely galled, mostly coalesced, plant usually dying; 10 = all roots severely galled, no root. The damage severity index (DSI) was determined using the following equation:

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

Data were analyzed using the General Analysis of Variance function of the Linear Analysis section of Statistix V.10. 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 EXPERIMENTAL nematicide at 0.333 L/ha had significantly lower root-knot nematode damage incidence and severity than the same product at a lower rate and the untreated check during the mid-season assessment (Table 1). There were no significant differences among treatments at harvest although the EXPERIMENTAL at 0.333 L/ha treatment maintained lower root-knot nematode damage incidence and severity, numerically. There were no significant lettuce emergence or vigor differences among the treatments and no phytotoxicity was observed throughout the duration of the trial.

AKNOWLEDGEMENTS: Funding for this project was provided Syngenta Canada Inc.

Table 1. Nematode damage incidence, damage severity index (DSI) and lettuce top and root weight from root-knot nematode (RKN) infested microplots during the mid-season assessment at the Muck Crops Research Station, 2020.

Treatment	Rate (L/ha)	% Nematode Damage	DSI[1]	Top Weight (kg)	Root Weight (g)	RKN Eggs/g Root
EXPERIMENTAL	0.333	33.3 a[2]	3.8 a	1.5 ns[3]	88.3 ns	256.2 ns
EXPERIMENTAL	0.167	58.3 b	7.9 b	2.1	129.3	218.4
Untreated	-	62.5 b	8.3 b	1.8	117.7	581.6

[1] DSI was calculated using the following equation:

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

[2] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Tukey's test
[3] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's test

Table 2. Nematode damage incidence, damage severity index (DSI) and lettuce top and root weight at harvest from root-knot nematode (RKN) infested microplots at the Muck Crops Research Station, 2020.

Treatment	Rate (L/ha)	% Nematode Damage	DSI[1]	Top Weight (kg)	Root Weight (g)
EXPERIMENTAL	0.333	27.0 ns[2]	3.1 ns	4.1	252.5 ns
EXPERIMENTAL	0.167	37.1	4.8	4.7	247.5
Untreated	-	37.8	6.1	4.2	292.5

[1] DSI was calculated using the following equation:

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

[2] ns indicates that no significant differences were found among the treatments at $P = 0.05$, Tukey's test

2020 PMR REPORT #12 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.), cv. Cellobunch
PESTS: Alternaria leaf blight (*Alternaria dauci* (Kühn) Groves & Skolko)
Cercospora leaf blight (*Cercospora carotae* (Pass.) Solheim))

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TITLE: EVALUATION OF FUNGICIDES FOR LEAF BLIGHT CONTROL IN CARROTS, 2020

MATERIALS: Product A (experimental), FLINT (trifloxystrobin 50%)

METHODS: The trial was conducted on mineral soil (pH ≈ 7.8, organic matter ≈ 2.7 %) near the Muck Crops Research Station, Holland Marsh, Ontario. Carrots, cv. Cellobunch, were direct seeded (82 seeds/m) into raised beds using a Stanhay precision seeder on 19 May. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of two rows, 86 cm apart, and 6 m in length. Treatments were Product A at 1000, and 1500 mL/ha, Product A at 1,000, 1,500 and 3,000 mL/ha + AGRAL 90 at 0.02% v/v and FLINT at 210 g/ha. An untreated check was also included. Treatments were applied on 30 July, 11, 20, 28 August and 9 September using a CO_2 backpack sprayer equipped with four TeeJet 8002VS fan nozzles spaced 40 cm apart and calibrated to deliver 400 L/ha at 275 kPa. On 10, 18, 25 August, 1 and 14 September, carrot foliage in every replicate was rated for leaf blight symptoms, not differentiating between Alternaria and Cercospora, using a 0-10 scale where 0= no disease, 2= some lesions mainly on leaves, 4= many lesions, few on petioles, 6= numerous lesions on leaves and petioles, 8= 50% leaves dead and 10= 100% leaves dead.
Area under the disease progress curve (AUDPC) was based on the leaf blight severity plot ratings for 10, 18, 25 August and 1, 14 September and was determined using the following equation:

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

On 17 September, the leaves of ten carrots per replicate were removed for a blight assessment. Leaves were visually assessed for the percentage of leaf area blighted, not differentiating between Alternaria and Cercospora, and sorted into the following classes: 0= 0%, 1= 1-5%, 2= 6-10%, 3= 11-25%, 4= 26-50%, 5= 51-75%, 6= >75%, 7= 100% dead. The disease severity index (DSI) was determined using the following formula:

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

On 28 September, carrots in three 1.16 m sections of row were pulled, topped and graded by size to determine yield.
Compared to the previous 10-year average, air temperatures in 2020 were above average for July (23.3°C), average for June (19.2°C), August (20.6°C), and below average for May (11.6°C) and September (15.0°C).

The 10-year average temperatures were: May 14.2°C, June 18.5°C, July 21.5°C, August 20.3°C and September 16.5°C. Monthly rainfall was above the 10-year average for August (140 mm), average for September (65 mm), and below average for May (38 mm), June (77 mm) and July (58 mm). The 10-year rainfall averages were: May 73 mm, June 103 mm, July 84 mm, August 76 mm and September 62 mm. Data were analyzed using the General Analysis of Variance with Statistix V.10. Means separation was obtained using Tukey's HSD Test at P = 0.05 level of significance.

RESULTS: as presented in Tables 1, 2 and 3

CONCLUSIONS: Leaf blight incidence was high in the trial with 87% incidence in untreated carrots (Table 1). Significant differences in LB plot ratings, the area under the disease progress curve (AUDPC), leaf blight incidence and severity, the percentage of dead leaves and the number of healthy leaves per plant were found among the treatments (Tables 1 & 2). All treated carrots had a lower AUDPC than untreated carrots. Carrots treated with Product A at 3,000 mL/ha + AGRAL 90 had a lower AUDPC than carrots treated with Product A at 1,000 mL/ha with or without AGRAL 90.

Carrots treated with Product A at 3,000 mL/ha + AGRAL 90 or FLINT had lower leaf blight incidence and severity than carrots treated with Product A at 1,000 mL/ha with or without AGRAL 90 and untreated carrots (Table 1). No significant differences in AUDPC, leaf blight incidence or severity were observed with the addition of AGRAL 90 to Product A at 1,000 or 1,500 mL/ha (Tables 1 & 2).

Significant differences in the percentage of marketable carrots (carrots > 2.0 cm) were observed among the treatments (Table 3). Carrots treated with Product A at 3,000 mL/ha + AGRAL 90 or FLINT had more marketable carrots than carrots treated with lower rates of Product A or untreated carrots.

Product A at 3,000 mL/ha + AGRAL 90 was more efficient at reducing leaf blight and increasing yield than Product A at 1,000 mL/ha and was comparable to FLINT. The addition of AGRAL 90 to the lower rates of Product A did not improve efficacy.

ACKNOWLEDGEMENT: Funding for this project was provided by Agriculture and Agri-Food Canada.

Table 1. Leaf blight incidence and severity assessed on 17 September for carrots, cv. Cellobunch, treated with fungicides and grown near Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment	Product rate (mL/ha)	Leaf blight Incidence (%)	DSI[1,2] (0-100)	Dead leaves (%)	Healthy leaves/plant
Product A + NIS[3]	3,000	57.3 a[4]	37.7 a	22.0 a	3.2 a
FLINT	210 g	60.1 a	37.8 a	24.9 ab	2.8 ab
Product A + NIS	1,500	66.5 ab	44.4 ab	27.0 ab	2.5 abc
Product A	1,500	69.6 ab	49.5 ab	38.7 b	2.3 abc
Product A +NIS	1,000	76.9 bc	52.2 b	35.7 ab	1.8 bcd
Product A	1,000	77.9 bc	52.5 b	33.6 ab	1.5 cd
Check	-	86.6 c	75.2 c	65.9 c	1.1 d

[1] Leaves of 10 plants sorted into the following classes: 0= no disease, 1= 1-5%, 2= 6-10%, 3= 11-25%, 4= 26-50%, 5=51-75% and 6=>75% leaf blight per leaf on 17 September

[2] Disease severity index (DSI) was determined using the following equation:

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

[3] NIS = non-ionic AGRAL 90 at 0.02% v/v

[4] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Tukey's HSD test.

Table 2. Leaf blight (LB) severity plot ratings and area under the disease progress curve (AUDPC) for carrots, cv. Cellobunch, treated with fungicides and grown near Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment	Product rate (mL/ha)	AUDPC[1]	LB Severity Plot Ratings[2]				
			10 Aug	18 Aug	25 Aug	1 Sept	14 Sept
Product A + NIS[3]	3,000	95.9 a[4]	1.8 ns[5]	2.8 a	2.3 a	2.6 a	3.5 a
Product A + NIS	1,500	109.7 ab	2.3	2.8 a	3.3 ab	3.4 ab	3.6 a
FLINT	210 g	110.9 ab	2.3	2.8 a	3.3 ab	3.3 ab	4.0 a
Product A	1,500	116.6 ab	1.8	3.4 a	3.4 ab	3.9 b	3.4 a
Product A +NIS	1,000	135.4 b	2.3	3.9 ab	4.1 b	4.0 b	4.4 a
Product A	1,000	137.9 b	2.5	3.6 a	4.3 b	4.3 b	4.4 a
Check	-	196.1 c	3.3	5.1 b	5.9 c	6.4 c	6.1 b

[1] Area under the disease progress curve (AUDPC) was based on the LB severity plot ratings for 10, 18, 25 August and 1, 14 September and was determined using the following equation:

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

[2] Plots were rated for leaf blight (LB) on a 0-10 scale where 0 = no disease, 2 = some lesions mainly on leaves, 4 = many lesions, few on petioles, 6 = numerous lesions on leaves and petioles, 8 = 50% leaves dead and 10 = 100% leaves dead.

[3] NIS = non-ionic surfactant (AGRAL 90 at 0.02% v/v)

[4] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Tukey's HSD test.

[5] ns = no significant differences were found among the treatments using Tukey's HSD test.

Table 3. Yield and size distribution of carrots, cv. Cellobunch, treated with fungicides and grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment	Product rate (mL/ha)	% Marketable[1]	% Medium (2.0-4.5 cm)	% Jumbo (> 4.5 cm)	Mkb Yield (t/ha)	Wgt/mkb carrot (g)
FLINT	210 g	95.7 a[2]	91.7 ns[3]	4.0 ns	19.4 ns	63.8 ns
Product A + NIS[4]	3000	95.5 a	87.7	7.8	22.0	66.6
Product A + NIS	1000	94.8 ab	88.8	6.0	18.1	58.5
Product A	1500	93.9 ab	92.0	1.9	17.0	56.9
Product A + NIS	1500	93.1 ab	84.9	8.2	18.8	63.5
Product A	1000	90.3 ab	90.3	0.0	15.1	53.6
Check	-	83.7 b	83.7	0.0	10.0	38.0

[1] Marketability was based on size. Carrots less than 2.0 cm in diameter were classed as 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 were found among the treatments
[4] NIS = non-ionic surfactant (AGRAL 90 at 0.02% v/v)

2020 PMR REPORT # 13 SECTION L: VEGETABLES and SPECIAL CROPS - Diseases

CROP: Hop (*Humulus lupulus* L.), cv. Chinook
PEST: Cone diseases (*Alternaria alternata* (Fr)Keissl and *Pseudoperonospora humuli* Miyabe&Takah)
Hop downy mildew (*Pseudoperonospora humuli* Miyabe&Takah)

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TITLE: FIELD EVALUATION OF BIOLOGICAL/ORGANIC FUNGICIDES FOR THE CONTROL OF DOWNY MILDEW AND CONE DISEASES OF HOPS, 2018-2019.

MATERIALS: ACTINOVATE (*Streptomyces lydicus* strain WYEC 108 1.0 x 10^7 CFU/g (min.) (0.0371%)), ORGANOCIDE (5% sesame oil, 95% other ingredients (water, lecithin, fish oil and potassium sorbate)), TIMOREX GOLD (tea tree oil, 23.8%), Buran (garlic powder, 15%), TIVANO (citric acid 10.73 g/L, lactic acid 21.37 g/L), PHOSTROL (Mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), CUEVA (copper octanoate 1.8%), OXIDATE 2.0 (hydrogen peroxide 27%, peroxyacetic acid 2.5%), SERENADE OPTI (QST 713 strain of dried *Bacillus subtilis* min. 1.31 x 10^{10} CFU/g), TORRENT 400SC (cyazofamid 34.5%), AGRAL 90 (nonylphenoxy polyethoxy ethanol 92%).

METHODS: Hops cv. Chinook were planted in the field at Simcoe Research Station on 17-18 May 2018 using a spacing of 3.96 m between rows and 1.07 m between plants in-row. Three bines per plant were trained onto 5 m long coir strings on 4 June 2018 (one string per plant) and 14 May 2019 (two strings per plant). Standard cultural practices for fertility and insect pest management were followed. Each experimental unit (plot) consisted of 7 plants and data were collected from the middle 5 plants of each plot. Treatments were: ACTINOVATE (840 g/ha), ORGANOCIDE (7.9 ml/L in 2018, 24 ml/L in 2019), TIMOREX GOLD (8 L/ha in 2018, 15 L/ha 2019), BURAN (18 L/ha), TIVANO (16 L/ha 2018, 12 L/ha 2019), PHOSTROL (5.8 L/ha), CUEVA (2% v/v), OXIDATE 2.0 (1% v/v), SERENADE OPTI (3.3 kg/ha), and the commercial standard TORRENT 400SC (0.2 L/ha). In 2019 a rotation of TIVANO and CUEVA was used instead of PHOSTROL. The non-ionic surfactant AGRAL 90 at 0.1% v/v was included in all applications of TIVANO and TORRENT. Treatments were applied using a Solo 451 motorized mistblower. Spray volume was 500 L/ha for all treatments in 2018 and was 500-1000 L/ha in 2019 with spray volume increasing as plant height increased. Application dates in 2018 were 2, 9, 20 August for all treatments and in 2019 were 24, 31 May, 7, 19, 28 June, 10, 24 July, 2, 12, 23 August for all treatments except for ORGANOCIDE (24 May, 19 June, 3, 12, 23 Aug) and TORRENT 400SC (24 May, 7, 28 June, 24 July, 12, 23 Aug.). The incidence and severity of foliar downy mildew lesions and cone diseases were assessed weekly during the season. Severity of foliar downy mildew lesions was rated from 0-6, with: 0=no symptoms, 1=1-5% leaf area affected, 2=6-10%, 3=11-20%, 4=21-30%, 5=31-50%, 6=51-100%. Severity of cone diseases was rated from 0-5 with: 0=no discoloration, 1=<10% of bracts with brown lesions, 2=11-25%, 3=26-49%, 4=50-79%, 5=> 80%. The inside 5 plants in each plot were harvested on 31 Aug. 2018 and the inside 3 plants were harvested on 28 Aug. 2019. Total cone weight was recorded, and a 100-cone sample was assessed for incidence and severity of cone disease. Data were analyzed using the General Linear Model procedure in 2018 and the GLIMMIX procedure in 2019 of SAS ver. 9.4.

Means were separated using Tukey's HSD test at $P = 0.05$. In 2019, disease severity index (DSI) and percent of leaves with foliar downy mildew were analyzed using the number of downy mildew basal spikes (indicative of systemic infection) recorded on 12 June as a covariate.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: Cone Diseases: In 2018, the fungicide treatments had no effect on cone yield (data not shown), 100-cone weight, and incidence and severity of cone diseases at harvest. In 2019, application of TORRENT 400SC was the only treatment that significantly reduced the incidence and severity of cone diseases compared to the untreated check.
Downy mildew: In 2018, the foliar downy mildew was not observed in the field. In 2019, no fungicide treatment had any impact of the disease incidence or severity, except for TORRENT 400SC that significantly reduced the percentage of infected leaves compared to the untreated check at the last rating. Of the organic fungicides tested, applications of CUEVA, TIVANO and the CUEVA/TIVANO rotation tended to result in numerically lower levels of disease.

Table 1: Effect of fungicides on weight of 100 cones, disease incidence and Disease Severity Index (DSI) against cone diseases caused by *Alternaria alternata* and *Pseudoperonospora humuli* at harvest on hops cv. Chinook, at Simcoe, Ontario, 2018-2019.

Treatment	2018			2019		
	Weight of 100 cones (g)	Incidence of cone diseases (%)	DSI	Weight of 100 cones (g)	Incidence of cone diseases (%)	DSI[3]
Untreated Check	64 ns[1]	99 ns	39 ns	63ns	99 a[2]	55 a
SERENADE OPTI 3.3 kg/ha	71	98	42	61	100 a	63 a
BURAN 18L/ha	67	95	38	55	99 a	61 a
TIMOREX GOLD 8L/ha (2018) or 24L/ha (2019)	67	100	45	60	100 a	60 a
ORGANOCIDE 7.9 ml/L (2018) or 24ml/L (2019)	66	97	39	60	99 a	60 a
OXIDATE 2.0 1%v/v	69	99	47	56	100 a	59 a
ACTINOVATE 840 g/ha	65	100	43	59	98 ab	58 a
TIVANO 16L/ha + CUEVA 2% v/v, rotation	.	.	.	60	96 ab	55 a
TIVANO 16L/ha (2018 or 12L/ha 2019) + AGRAL 90	75	100	47	61	99 a	54 a
CUEVA 2%v/v		98	42	58	97 ab	52 a
TORRENT 400SC + AGRAL 90	65	97	41	63	87 b	35 b
PHOSTROL 5.8 l/ha	66	97	40		.	.
***P* value**	0.9053	0.4404	0.1561	0.8911	0.0267	0.0001

[1] No significant differences among the treatments.

[2] Numbers in a column followed by the same letter are not significantly different ($P = 0.05$, Tukey's HSD).

[3] Disease severity index (DSI) was calculated as: $= \frac{[(\text{class no.})(\text{no.of plants in each class})]}{(\text{total no. plants per sample})(\text{no.classes}-1)} \text{ x}100$

Table 2: Effect of fungicides on percent leaves infected, Disease Severity Index (DSI) and Area Under Disease Progress Curve (AUDPC) in the field against downy mildew of hops grown at Simcoe, Ontario, 2019.

Treatment	Percent Leaves Infected (%)			DSI[1]			AUDPC[2]
	26-Jun	29-Jul	26-Aug	26-Jun	29-Jul	26-Aug	
Untreated Check	19.9 ns[3]	12.6 ab[4]	38.5 abc	17.8 ab	14.3 a	21.9 ab	78.2 ab
SERENADE OPTI 3.3 kg/ha	15.3	10.3 ab	46.1 abc	16.1 abc	13.4 a	31.8 ab	87.5 ab
BURAN 18L/ha	23.4	16.2 a	68.1 a	21.6 a	15.8 a	46.6 a	104.4 a
TIMOREX GOLD 24L/ha	12.0	10.5 ab	33.6 abc	14.2 abc	12.6 a	20 ab	72.1 ab
ORGANOCIDE 24ml/L	20.5	9.1 ab	63.7 ab	22.5 a	13.3 a	40.8 ab	101.8 a
OXIDATE 2.0 1%v/v	4.5	6.1 ab	32.0 abc	15.9 abc	12.3 a	14.5 b	66.6 ab
ACTINOVATE 840 g/ha	14.5	7.2 ab	45.7 abc	12.4 abc	10.1 a	29.8 ab	66.8 b
TIVANO 16L/ha, CUEVA 2% v/v rotation	6.3	1.4 b	21.2 abc	10.7 abc	3.6 a	18.7 ab	37.8 b
TIVANO 12L/ha + AGRAL 90	5.6	3.4 b	43.4 abc	8.8 bc	6.8 a	24.5 ab	48.5 ab
CUEVA 2%v/v	12.0	4.4 b	13.7 bc	12.2 abc	10.3 a	13.6 b	58 ab
TORRENT 400SC + AGRAL 90	3.9	2.4 b	6.9 c	4.6 c	3.4 a	12.8 b	30.4 b
***P* value**	0.0595	0.0065	0.0041	0.0011	0.0387	0.0078	0.0044

[1] Disease severity index (DSI) was calculated as: $= \frac{[(\text{class no.})(\text{ no.of plants in each class})]}{(\text{total no. plants per sample})(\text{no.classes}-1)}$ x100

[2] AUDPC (Area Under Disease Progress Curve) = $\sum_{j=1}^{nj-1} (\frac{yj+yj+1}{2}) (t\,j+1-tj)$, where: *y*= leaf lesion severity at *j*th observation, *t*= time (days) since the previous rating at *j*th observation and *n*= total number of observations.

[3]No significant differences among the treatments.

[4] Numbers in a column followed by the same letter are not significantly different ($P = 0.05$, Tukey's HSD).

2020 PMR REPORT #14 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Lettuce (*Lactuca sativa* L.), cv. Mighty Joe
PEST: Sclerotinia head rot and leaf drop (*Sclerotinia sclerotiorum* (Lib.) de Bary)

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TITLE: **FIELD EVALUATION OF INTUITY FUNGICIDE FOR THE CONTROL OF SCLEROTINIA HEAD ROT AND LEAF DROP IN HEAD LETTUCE, 2019**

MATERIALS: INTUITY (mandestrobin 43.4%), ALLEGRO 500F (fluazinam, 40.0%), SYLGARD 309 (siloxylated polyether 76%, surfactant mixture 24%)

METHODS:
Head lettuce cv. Mighty Joe was seeded on 1 May 2019 into 128 cell plastic plug trays filled with commercial soil-less mix. Seedlings were raised in a greenhouse for 4 weeks and then transplanted into the field (soil organic matter ≈ 1.1%, pH ≈ 6.0) at Simcoe research station using a mechanical transplanter. A randomized complete block design with four replicates per treatment was used. Each experimental unit (plot) consisted of four rows, 0.75 m apart, 7 m long and plants were spaced 0.3 m apart within the row. Treatments were non-inoculated check, inoculated check, INTUITY at three different rates (439, 585, and 877 ml/ha), INTUITY at 877 ml/ha plus SYLGARD 309 at 0.125 % v/v, and a commercial standard, ALLEGRO, at the rate of 1.2 L/ha. Treatments were applied using a CO_2 backpack sprayer equipped with three TeeJet XR8005 nozzles spaced 50 cm apart and calibrated to deliver 500 l/ha at 220 kPa. Treatments were applied on 3 and 17 June. A culture of *Sclerotinia sclerotiorum* was grown on potato dextrose agar for a week at 22ºC. The mycelial plugs containing sclerotia of the fungus were mixed with moist sterilized barley grains and grown for 4-6 weeks at 22ºC. The mixture of sclerotia and infested grains was used as inoculum and was distributed evenly over each lettuce row (200 ml/row, 800 ml/plot) in a 10 cm wide band on 5 June. Due to high plant mortality, disease incidence and severity was assessed using sixteen plant on 3, 13 June and ten plants on 25 June, 3, 15 July from the inside 5 m of the middle two rows of each plot. The brown water-soaked stem and leaf lesions and wilting of plant heads were rated on a scale of 0-5, where: 0= no symptoms; 1= 5-10% plant area around the stem and at the soil line show lesions covered with mycelium; 2= 11-30% enlarged lesions completely girdling the stem and soil line leaves or 11-30% plant head wilted-mycelium and sclerotia are visible; 3= 31-50% plant head wilted; 4= 51-70 % plant head wilted; 5= 71-100 % plant head wilted, foliage destroyed. A 5 m section of the middle two rows of each plot was harvested by hand on 24-25 July. The lower loose lettuce leaves were removed, and the percentage of marketable heads was determined. Compared to previous 10-year averages, the air temperatures in 2019 were below average for May (12.8°C), average for June (18.4°C), and above average for July (22.6°C). The 10-yr average temperatures were: May 14.9°C, June 19°C, and July 21.8°C. Monthly rainfall was above the 10-year average for May (124 mm), June (124 mm), and July (112 mm). The 10-year rainfall averages were: May 89 mm, June 105 mm, and July 76 mm. Data was analysed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. Tukey's HSD test was used to detect differences among the treatment means at P=0.05.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: Inoculation was successful and disease pressure was high. Plant mortality was high in the inoculated treatments; therefore, no statistically significant differences in disease incidence or severity were observed among those treatments. There were no statistically significant differences in total yield, percent marketable and infected among the inoculated treatments.

Table 1. Effect of fungicides on disease incidence, Disease Severity Index (DSI), Area Under Disease Progress Curve (AUDPC), and percent survival of plants against Sclerotinia head rot and leaf drop as reported on various dates for head lettuce cv. Mighty Joe grown in Simcoe, Ontario, 2019.

Treatment and Application rate **INTUITY, ml/ha** **SYLGARD 309, 0.125%v/v**	**Disease Incidence (%)[1]**			**Disease Severity Index[3]**			**AUDPC[4]**
	25 June	3 July	15 July	25 June	3 July	15 July	
Non-inoculated Check	10 b[2]	20 b	28 b	2 c	4 c	6 b	5.3 c
Inoculated Check	63 a	66.7 a	73 a	22 ab	35.7 a	32 a	39.9 a
INTUITY @ 439	48 a	52.5 a	68 a	15 ab	26 ab	29.5 a	31 ab
@ 585	65 a	60 a	80 a	24 a	29 ab	43 a	40.8 a
@ 877	35 ab	47 ab	78 a	11 abc	17 bc	39.5 a	27 ab
INTUITY @ 877 + SYLGARD	40 ab	52.5 a	88 a	14 abc	21 b	39.5 a	30.8 ab
ALLEGRO @ 1.2 L/ha	40 ab	52.5 a	68 a	10 bc	18 bc	31 a	25.5 ab

[1] number of plants with leaf lesions (head wilted)/total plant assessed *100

[2] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$ using Tukey's HSD test.

[3] Disease severity index (DSI) was calculated as: $= \frac{[(\text{class no.})(\text{ no.of plants in each class})]}{(\text{total no. plants per sample})(\text{no.classes}-1)}$ x100

[4] Area under the disease progress curve (AUDPC) was calculated using the following formula:

$$\text{AUDPC} = \sum_{j=1}^{nj-1} \left(\frac{yj+yj+1}{2}\right)(t\,j+1-tj)$$

Table 2: Effect of fungicides on percent survival of plants (%), total yield, percent marketable and infected at harvest against Sclerotinia head rot and leaf drop as reported on various dates for head lettuce cv. Mighty Joe grown in Simcoe, Ontario, in 2019.

Treatment **INTUITY (ml/ha)** **ALLEGRO (L/ha)** **SYLGARD 309, 0.125%v/v**	**Survival of plants (%)**			**Total yield (t/ha)**	**Market-able (%)**	**Percent infected (%)**
	13 June	3 July	15 July			
Non-inoculated Check	98 a[1]	97 a	97 a	34.7 a	45 a	0 b
Inoculated Check	89 a	37 c	24 c	10.6 b	53.4 a	19.7 a
INTUITY @ 439	98 a	47 bc	31 c	12 b	53.3 a	13.4 ab
@ 585	97 a	37 c	28 c	10.2 b	30.6 a	18.4 a
@ 877	96 a	47 bc	34 c	9.3 b	52.4 a	11 ab
INTUITY @877 + SYLGARD	97 a	54 bc	38 bc	10.7 b	51 a	24.4 a
ALLEGRO@ 1.2 L/ha	99 a	72 ab	57 b	17.9 b	60.3 a	16.7 ab

[1] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$ using Tukey's HSD test.

2020 PMR REPORT #15 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Mint (Scotch spearmint, *Mentha* × *gracilis* Sole) Trial 1
Mint (Mojito mint, *Mentha* x *villosa* Huds.) Trial 2
PEST: Powdery mildew (*Erysiphe* spp.)

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TITLE: **FIELD EVALUATION OF QUADRIS TOP FUNGICIDE FOR CONTROL OF POWDERY MILDEW IN MINT, 2019**

MATERIALS: QUADRIS TOP (azoxystrobin 200 g/L, difenoconazole 125 g/L), QUILT (azoxystrobin 75 g/L, propiconazole 125 g/L)

METHODS: Two field trials were conducted to assess different rates of the fungicide QUADRIS TOP for control of powdery mildew on mint at the Simcoe Research Station (Simcoe, Ontario), in 2019. Rooted cuttings of Scotch spearmint from Richters Herbs (Goodwood, Ontario) were transplanted into the soil (organic matter ≈ 1.1, pH ≈ 6.8) on 5 July using a RJ mechanical transplanter. A randomized complete block design with four replicates per treatment was used. Each experimental unit (plot) consisted of four rows, 0.75 m apart, 5 m long, and plants were spaced 0.35 m apart within the row. Treatments were: QUADRIS TOP (at three different rates: 0.566, 1, and 2 L/ha), QUILT (1 L/ha), and one untreated check. Products were applied using a CO_2 backpack sprayer equipped with three TeeJet XR11003 nozzles spaced 50 cm apart and calibrated to deliver 300 L/ha water at 220 kPa on 14 and 29 August for both trials. Powdery mildew occurred naturally so inoculation was not needed. Disease incidence and severity were rated on 13, 21 August, 6, 18, 30 September for Trial 1 and 13, 21 August, 6, 24, 30 September for Trial 2 on twelve randomly selected plants within the middle rows of each plot using a scale of 0 to 6 (0 = no disease, 1 = <1% leaf area diseased, 2 = 1-5%, 3 = 6-20%, 4 = 21-40%, 5 = 41-60%, 6 = >60%). A 3 m section of two middle rows of each plot was harvested on 10 and 11 October and total and marketable yields were recorded, as well as the disease severity and incidence on a sub-sample of 30 plants from each plot. Disease incidence was calculated as the number of plants with powdery mildew symptoms/total number of plants assessed*100. Disease severity index (DSI) was calculated using the equation:

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

Area Under Disease Progress Curve (AUDPC) was calculated using the equation:

$$\text{AUDPC} = \sum_{j=1}^{nj-1} \left(\frac{yj+yj+1}{2}\right)(t\,j+1-tj)$$

where: *y*= leaf lesion severity at *j*th observation, *t* = time (days) since the previous rating at *j*th observation, and *n* = total number of observations.
Compared to the previous 10-year averages, the air temperatures in 2019 were above average for July (22.6°C) and September (17.8°C), and average for August (20.5°C), and October (11°C). The 10-yr average temperatures were: July 21.9°C, August 20.8 °C, September 17.2°C, and October 10.8°C. Monthly rainfall was above the 10-year average for July (112 mm), August (138.4 mm), October (148 mm), and below average for September (61.6 mm). The 10-year rainfall averages were: July 76 mm, August 89 mm, September 79 mm, and October 106.8 mm. Data were analyzed using the General

Analysis of Variance function of the Linear Models section of Statistix V.9. Means separation was obtained using Tukey's HSD at $P = 0.05$ level of significance.

RESULTS: As outlined in Tables 1, 2, and 3.

CONCLUSIONS: QUADRIS TOP demonstrated efficacy against powdery mildew and resulted in similar or lower levels of disease compared to the commercial standard QUILT. QUADRIS TOP @ 2 L/ha did result in the lowest DSI at harvest and significantly higher yields than the untreated check.

Table 1: Effect of fungicides on powdery mildew incidence, Disease Severity Index (DSI), and Area Under Disease Progress Curve (AUDPC) on selected dates for mint trial 1, Simcoe Research Station, Ontario, 2019.

Treatment	**Disease Incidence (%)**			**DSI**			**AUDPC**
	6 Sep	18 Sep	30 Sep	6 Sep	18 Sep	30 Sep	
Untreated Check	91.6 a	100 a	100 a	28.9 a	63.3 a	100 a	112.7 a
QUADRIS TOP:							
@ 0.566 L/ha	6.2 b	5.2 b	100 a	0.5 b	1.1 b	65.6 b	26.5 b
@1 L/ha	12.5 b	5.2 b	100 a	1.5 b	1.1 b	58.0 bc	25.0 b
@ 2 L/ha	10.4 b	8.5 ab	95.8 a	1.7 b	1.9 b	48.9 c	22.0 b
QUILT @1 L/ha	2.0 b	0.7 b	100 a	0.09 b	0.24 b	69.1 b	26.1 b

[1] Numbers in a column followed by the same letter are not significantly different ($P = 0.05$, Tukey's HSD).

Table 2: Effect of fungicides against powdery mildew on disease incidence (%), Area Under Disease Progress Curve (AUDPC), and Disease Severity Index (DSI) as reported on various dates for mint trial 2, Simcoe Research Station, Ontario, 2019.

Treatment	**Disease Incidence (%)**			**DSI**			**AUDPC**
	6 Sep	24 Sep	30 Sep	6 Sep	24 Sep	30 Sep	
Untreated Check	17.9 a	100 a	100 a	3.3 a	74.9 a	93.7 a	78.8 a
QUADRIS TOP:							
@ 0.566 L/ha	2.0 a	5.8 ab	100 a	0.5 a	1.4 b	59.4 b	13.4 bc
@1 L/ha	0.7 a	2.0 b	99.4 a	0.2 a	0.5 b	52.7 b	11.0 bc
@ 2 L/ha	2.5 a	4.3 ab	84.2 b	0.7 a	0.9 b	37.5 c	8.8 c
QUILT @1 L/ha	4.3 a	3.4 ab	100 a	0.9 a	1.9 b	64.2 b	15.2 b

[1]Numbers in a column followed by the same letter are not significantly different (as above).

Table 3: Effect of fungicides against powdery mildew on total yields, percent marketable and disease severity index (DSI) for mint trials 1 and 2, Simcoe Research Station, Ontario, 2019.

Treatment	**Trial 1**			**Trial 2**		
	Total Yield (t/ha)	Marketable (%)	DSI	Total Yield (t/ha)	Marketable (%)	DSI
Untreated Check	12.5 b[1]	0.0 a	99.6 a	8.6 b	0.0 c	89.4 a
QUADRIS TOP:						
@ 0.566 L/ha	15.5 ab	0.0 a	73.2 b	11.4 ab	4.8 bc	45.5 c
@ 1 L/ha	17.4 a	0.0 a	67.5 b	12.2 a	15.9 b	31.5 cd
@ 2 L/ha	17.0 a	7.0 a	44.6 c	12.2 a	44.8 a	18.7 d
QUILT @ 1 L/ha	15.6 ab	0.0 a	84.8 b	11.1 a	1.96 c	62.5 b

[1] Numbers in a column followed by the same letter are not significantly different (as above).

2020 PMR REPORT #16 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Yellow cooking onions (*Allium cepa* L.), cv. Fortress
PEST: Onion smut (*Urocystis colchici* var. *cepulae* Cooke)

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TITLE: **EVALUATION OF VARIOUS FUNGICIDES FOR CONTROL OF ONION SMUT IN YELLOW COOKING ONIONS, 2020**

MATERIALS: EVERGOL PRIME (penflufen 22.7%), RANCONA (ipconazole 9.38 g/L), PRO-GRO (carboxin 30% + thiram 30%), 42-S THIRAM (tetramethylthiuram disulfide 42%), SEPRESTO 75 WS (clothianidin 56.25%, imidacloprid 18.75%), FARMORE F300 ((APRON XL(metalaxyl-M and S-isomer 33.3%) + MAXIM 4 FS (fludioxonil 40.3%) + DYNASTY (azoxystrobin 9.6%))

METHODS: The trial was conducted on organic soil (pH ≈ 6.3, organic matter ≈ 69.0%) naturally infested with *Urocystis colchici* at the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four rows, spaced 43 cm apart, 6 m in length. Onions, cv. Fortress, were seeded (≈ 35 seeds/m) on 16 May using a Stanhay Precision Seeder. Treatments applied at the manufacturer's recommended rates were: EVERGOL PRIME, RANCONA and PRO-GRO and PRO-GRO + FARMORE F300 (See Table 1 for rates). A no-fungicide check was also included. Both treatments and pelleting were done by Incotec using standard methods. Three randomly chosen 2 m sections of row to be used as damage plots and a 2.32 m yield section were staked out in each replicate. Emerged onions were counted within the 2 m sections on 29 May to determine initial stands. Beginning on 3 June and continuing weekly, plants within the 2 m sections were examined for loss due to onion smut or damage caused by other pests. Damaged onions were removed and numbers and the cause of the damage recorded. The remaining onions within the assigned 2 m sections were removed and visually examined for smut damage at the first true-leaf stage (8 June), at the 3-leaf stage (24 June) and after lodging (2 September). On 16 September, onions from the 2.32 m yield section of row were pulled, sorted by size and weighed to determine yield. Compared to the previous 10-year average, air temperatures in 2020 were above average for July (23.3°C), average for June (19.2°C), August (20.6°C), and below average for May (11.6°C) and September (15.0°C). The 10-year average temperatures were: May 14.2°C, June 18.5°C, July 21.5°C, August 20.3°C and September 16.5°C.
Monthly rainfall was above the 10-year average for August (140 mm), average for September (65 mm), and below average for May (38 mm), June (77 mm) and July (58 mm). The 10-year rainfall averages were: May 73 mm, June 103 mm, July 84 mm, August 76 mm and September 62 mm.

Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.10. Means separation was obtained using Fisher's Protected LSD Test at P = 0.05 level of significance.

RESULTS: as presented in Tables 2 & 3

CONCLUSIONS: Significant differences in the incidence of smut at the 1st and 3rd-leaf stages and at harvest were found among the treatments (Table 2). At the 1st-leaf stage, onions treated with any fungicide treatment had less smut than the check. Onions treated with EVERGOL PRIME had significantly less smut than the RANCONA and PRO-GRO treatments.
At the 3rd-leaf stage, onions treated with EVERGOL PRIME, PRO-GRO + F300, and PRO-GRO had less smut (0 - 6%) than onions treated with RANCONA (17%) or the check (15%).
At the harvest, onions treated with EVERGOL PRIME or PRO-GRO + F300 had a significantly lower incidence of smut (1.6 & 3% respectively) than the check (11%).
More smut was found in untreated onions at the 1st true leaf stage (19%), compared to smut incidence at harvest (11%). Smut at the 1st leaf stage includes smut found only in the flag leaf which falls off and may not infect the bulb. By harvest, smut incidence was lower but is located in the bulb and will result in an unmarketable onion.
Significant differences in yield and onions per meter were found among the treatments (Table 3). Onions treated with EVERGOL PRIME, PRO-GRO, or PRO-GRO + F300 had significantly higher yields (68 - 74 t/ha) than the check (51 t/ha). Onions treated with any fungicide had more onions per meter than the check. No differences in size distribution were found among the treatments.

ACKNOWLEDGEMENTS: Funding was provided by Incotec for seed pelleting, by Bayer Crop Science for the Sepresto insecticide, the Plant Production Systems of the Ontario Agri-Food Innovation Alliance and the California Garlic and Onion Research Advisory Board. Dr. Taylor's effort was supported under the United States Multi-State project, W-3168.

Table 1. Seed treatment label rates for onion seed, cv. Fortress, pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

#	Treatment	Fungicide Active Ingredients and Label Rates
1	Check seed (Thiram)	–
2	EVERGOL PRIME	penflufen 0.0087 g ai/1,000 seeds
3	RANCONA	ipconazole at 100 g ai/100 g seed
4	PRO-GRO	carboxin 7.50 g ai + thiram 12.5 g ai per kg seed
5	PRO-GRO + FARMORE F300	carboxin 7.50 g ai, thiram 12.5 g ai/kg seed + APRON XL (metalaxyl-M and S-isomer 33%) + MAXIM 4FS (fludioxonil 40.3%) + DYNASTY (azoxystrobin 9.6%)

[1] All pellets also included the insecticide SEPRESTO 75 WS (clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds) for maggot control and fungicide 42-S THIRAM (1.875 g ai/kg seed) for damping off control.

Table 2. Smut incidence for onions, cv. Fortress, treated with various fungicide seed treatments and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment[1]	29 May Emergence (plants/m)	Smut Incidence (%)		
		1st True Leaf	3rd-leaf Stage	Harvest
EVERGOL PRIME	23.1 ns[2]	1.0 a[3]	0.0 a	1.6 a[4]
PRO-GRO + F300	23.6	5.7 ab	6.3 a	2.9 ab
PRO-GRO	23.8	6.9 b	3.8 a	5.4 abc
RANCONA	25.0	6.1 b	16.8 b	8.8 bc
Check (thiram)	23.0	19.1 c	14.9 b	11.1 c

[1] All treatments included SEPRESTO 75 WS (clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds) and 42-S Thiram (1.875 g ai/kg seed)
[2] ns = no significant differences were found among treatments
[3] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.
[4] P = 0.06, but letters showing significant differences were added.

Table 3. Yield, number and size distribution for onions, cv. Fortress, treated with various fungicide seed treatments pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment[1]	Yield (t/ha)	Onions/m	Size Distribution[2] (%)			
			Jumbo (>76 mm)	Large (76-64 mm)	Medium (<64-45 mm)	Cull (<45 mm)
EVERGOL PRIME	68.2 ab[3]	19.2 b	15.0 ns[4]	59.5 ns	24.8 ns	0.6 ns
PRO-GRO + F300	71.3 ab	20.0 ab	19.0	56.9	23.7	0.3
PRO-GRO	74.3 a	22.9 a	8.1	55.8	35.0	1.1
RANCONA	65.2 b	17.9 b	22.2	53.6	23.6	0.5
Check (thiram)	51.1 c	14.0 c	25.2	54.0	19.7	1.1

[1] All treatments included SEPRESTO 75 WS (clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds) and 42-S Thiram (1.875 g ai/kg seed)
[2] Percentages were determined by weight
[3] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.
[4] ns = no significant differences were found among the treatments

2020 PMR REPORT #17 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

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

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TITLE: **EVALUATION OF VARIOUS FUNGICIDES FOR CONTROL OF STEMPHYLIUM LEAF BLIGHT ON ONIONS, 2020**

MATERIALS: LUNA TRANQUILITY (fluopyram 125 g/L, pyrimethanil 375 g/L), APROVIA TOP (benzovindiflupyr 78 g/L, difenoconazole 117 g/L), QUADRIS TOP (azoxystrobin 200 g/L, difenoconazole 125 g/L), SERCADIS (fluxapyroxad 300 g/L), T-77 (*Trichoderma atroviride* strain 77B ≥ 2.5 x 10^9 spores/g), PREV-AM (sodium tetraborohydrate decahydrate 0.99%), BRAVO ZN (chlorothalonil 500 g/L), DITHANE RAINSHIELD WG (mancozeb 75.0%), EVERGOL PRIME (22.7% penflufen), PRO-GRO (carboxin 30% + thiram 30%)

METHODS: Onions, cv. Traverse, were direct seeded (≈ 35 seeds/m) on 6 May into organic soil (organic matter ≈ 68.1%, pH ≈ 6.2) using a Stanhay precision seeder at the Muck Crops Research Station, Holland Marsh, Ontario. Treatments were arranged in a split-plot design with four replicates, fungicide treatments as the main plot factor and a penflufen seed treatment or the commercial standard (PRO-GRO pelleted + DITHANE WG at 8.8 kg/ha in-furrow) as the subplot factor. Each subplot consisted of four rows (40 cm apart), 6 m in length. Fungicide sprays were applied to side by side subplots (eight rows) on 26 June, 6, 15, 24 July and 6 August 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: LUNA TRANQUILITY at 1.2 L/ha alternated with QUADRIS TOP at 1.0 L/ha, APROVIA TOP at 767 mL/ha, T-77 at 250 g/ha, SERCADIS at 666 mL/ha, PREV-AM at 0.4% v/v, SERCADIS at 666 mL/ha and APROVIA TOP at 767 mL/ha alternated with T-77 at 250 g/ha, SERCADIS at 666 mL/ha + BRAVO ZN at 2.4 L/ha alternated with DITHANE at 2.5 kg/ha, APROVIA TOP at 767 mL/ha + BRAVO ZN at 2.4 L/ha alternated with QUADRIS TOP at 1.0 L/ha + DITHANE at 2.5 kg/ha (See Table 1). An untreated check was also included. On 26 June, 6, 13, 21, 27 July, in-field assessments were conducted using the three oldest leaves on 20 randomly chosen onions per replicate. The area of the leaf infected with Stemphylium was rated using a 0-4 scale where 0 = no symptoms, 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4= >50%. The rating for the plant is the sum of the score of the three leaves. The number of plants in each class was used to determine the disease severity index (DSI) using the following formula:

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

and the area under the disease progress curve (AUDPC) using the following formula:

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

Where j is the order index for the times and n_j is the total number of assessments, y_j is the average OT

count at day t_j, y_{j+1} is the average OT count at day t_{j+1} and (t_{j+1} - t_j) is the number of days between two assessments.

On 11 August, the green leaves of 20 onion plants randomly chosen from the inner rows of every replicate were removed and sorted into classes based on the percentage of the leaf area infected with stemphylium. The classes were: 0 = no disease, 1 = 1-4%, 2 = 5-10%, 3 = 11-25%, 4 = 26-50%, 5 = 51-75%, 6 > 75% infected with stemphylium. Dead leaves were counted separately. The number of leaves in each class were used to determine the disease severity index (DSI) using the above formula. 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 15 October to determine yield**.**

Compared to the previous 10-year average, air temperatures in 2020 were above average for July (23.3°C), average for June (19.2°C), August (20.6°C), and below average for May (11.6°C) and September (15.0°C). The 10-year average temperatures were: May 14.2°C, June 18.5°C, July 21.5°C, August 20.3°C and September 16.5°C. Monthly rainfall was above the 10-year average for August (140 mm), average for September (65 mm), and below average for May (38 mm), June (77 mm) and July (58 mm). The 10-year rainfall averages were: May 73 mm, June 103 mm, July 84 mm, August 76 mm and September 62 mm

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 2, 3 & 4

CONCLUSIONS: Stemphylium incidence was moderate in 2020 and increased through July. Significant differences in disease severity were observed on 6 and 21 July among fungicide treatments (Table 2). Onions (with and without a penflufen seed treatment) sprayed with T-77, SERCADIS, LUNA TRANQUILITY alternated with QUADRIS TOP, SERCADIS alternated with T-77 or PREV-AM had a significantly lower area under the disease progress curve (AUDPC) than onions treated with APROVIA TOP alternated with T-77, SERCADIS + BRAVO ZN alternated with DITHANE, APROVIA TOP + BRAVO ZN alternated with QUADRIS TOP + DITHANE and onions not sprayed with a fungicide.

Onions grown from seeds treated with PENFLUFEN had a lower AUDPC than onions treated with PRO-GRO + DITHANE (Table 3). No significant differences in stemphylium severity were found among the fungicide treatments for the in-field rating on 27 July or at the 11 August destructive final assessment (Table 3). No significant differences in yield or size distribution were observed among the treatments (Table 4).

ACKNOWLEDGEMENTS: 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.

Table 1. Fungicide treatments applied to onions, cv. Traverse, with and without EVERGOL PRIME seed treatments, grown at Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Treatment[1] abbreviations	26 Jun	6 Jul	15 Jul	24 Jul	6 Aug
LT or QT	LUNA TRANQUILITY	QUADRIS TOP	LUNA TRANQUILITY	QUADRIS TOP	LUNA TRANQUILITY
AT	APROVIA TOP	APROVIA TOP	APROVIA TOP	APROVIA TOP	APROVIA TOP
SERC	SERCADIS	SERCADIS	SERCADIS	SERCADIS	SERCADIS
T-77	T-77	T-77	T-77	T-77	T-77
PREV-AM	PREV-AM	PREV-AM	PREV-AM	PREV-AM	PREV-AM
SERC or T-77	SERCADIS	T-77	SERCADIS	T-77	SERCADIS
AT or T-77	APROVIA TOP	T-77	APROVIA TOP	T-77	APROVIA TOP
SERC+BR or DITH	SERCADIS + BRAVO ZN	DITHANE	SERCADIS + BRAVO ZN	DITHANE	SERCADIS + BRAVO ZN
AT+BR or QT+DITH	APROVIA TOP + BRAVO ZN	QUADRIS TOP + DITHANE	APROVIA TOP + BRAVO ZN	QUADRIS TOP + DITHANE	APROVIA TOP + BRAVO ZN
Check	-	-	-	-	-

[1] LT (Luna Tranquility) at 1.2 L/ha, QT (Quadris Top) at 1.0 L/ha, AT (Aprovia Top) at 767 mL/ha, SERC (Sercadis) at 666 mL/ha, T-77 at 250 g/ha, PREV-AM at 0.4% v/v, BR (Bravo Zinc) at 2.4 L/ha, DITH (Dithane Rainshield WG) at 2.5 kg/ha

Table 2. Area under the disease progress curve (AUDPC) for onions, cv. Traverse, treated with and without a penflufen seed treatment and sprayed with various fungicides at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Trt #	Fungicide[1]	AUDPC[2]	DSI[3]			
			6 July	21 July	27 July	11 Aug[4]
4	T-77	182.2 a[5]	1.6 a-d	4.9 ab	26.6 ns[6]	23.6 ns
3	SER	184.4 a	1.7 a-d	4.7 ab	28.0	23.1
1	LT or QT	190.1 a	0.9 a	5.2 ab	24.7	22.4
6	SER or T-77	190.2 a	1.0 ab	7.2 cd	26.4	21.6
5	PREV-AM	196.5 a	2.0 cd	6.1 a-d	26.7	26.8
2	AT	201.9 ab	1.1 abc	4.5 a	27.9	26.4
7	AT or T-77	231.0 bc	1.9 b-d	6.4 bcd	28.0	23.8
8	SER+BR or DITH	235.4 c	2.3 d	7.9 d	27.6	26.2
9	AT+BR or QT+DITH	245.4 c	1.4 abc	6.3 a-d	27.6	24.4
10	check	248.4 c	1.9 b-d	5.8 abc	27.6	26.0

* Data were combined as there was no significant interaction for seed treatment by fungicide.

[1] See Table 1 for fungicide product names and rates.

[2] Area under the disease progress curve (AUDPC), see formula below, was based on the DSI calculated from 26 June, 6, 13, 21 & 27 July 20 plant ratings using a 0-4 scale where 0 = no stemphylium symptoms, 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4= >50% of leaf area infected with stemphylium symptoms. The rating for the plant is the sum of the score of the three leaves.

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

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

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

[4] The 11 August DSI was not used in the AUDPC calculation and was based on the destructive assessment, sorting leaves of 20 plants 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.

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

[6] ns = no significant differences were found among treatments at P = 0.05, Fisher's Protected LSD test.

Table 3. Area under the disease progress curve (AUDPC) for onions, cv. Traverse, treated with and without a penflufen seed treatment and sprayed with various fungicides at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Seed treatment	AUDPC[1]	DSI					
		26 June	6 July	13 July	21 July	27 July	11 Aug[2]
PENFLUFEN	178.6 a[3]	0.50 ns[4]	1.3 a	6.3 a[5]	5.7 ns	25.9 a	24.7 ns
PRO-GRO + DITHANE	242.5 b	0.57	1.9 b	12.7 b	6.2	28.4 b	24.1

* Data for fungicide sprays were combined as there was generally no significant interaction for seed treatment by fungicide.

[1] Area under the disease progress curve (AUDPC) was based on the DSI for 26 June, 6, 13, 21 & 27 July and was determined using the following equation:

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

[2] The destructive assessment, sorting leaves of 20 plants 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, was used to calculate the 11 August DSI and was not used in the AUDPC calculation.

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

[4] ns = no significant differences

[5] There was a significant seed treatment by fungicide interaction.

Table 4. Yield data for onions, cv. Traverse, treated with and without a penflufen seed treatment and sprayed with various fungicides at the Muck Crops Research Station, Holland Marsh, Ontario, 2020.

Trt #	Fungicide[1]	Yield (t/ha)	% Mkb	Size distribution (%)			
				Jumbo (>76mm)	Large (76-64 mm)	Medium (>64-45 mm)	Cull (<45mm)
1	LT or QT	80.0 ns[2]	99.1 ns	18.3 ns	61.2 ns	19.6 ns	0.9 ns
7	AT or T-77	79.9	99.0	19.5	59.4	20.0	1.0
5	PREV AM	79.3	99.4	20.0	59.3	20.0	0.6
6	SER or T-77	78.5	99.4	26.2	55.2	18.0	0.6
8	SER+BR or DITH	78.4	98.9	11.5	61.5	25.9	1.1
2	AT	78.2	96.7	20.9	57.3	18.5	3.3
3	SER	77.8	99.2	23.6	55.6	20.0	0.8
4	T-77	77.4	97.5	16.4	60.4	20.6	2.5
9	AT+BR or QT+DITH	74.3	98.9	16.0	58.3	24.6	1.1
10	check	72.4	98.5	21.3	56.0	21.3	1.4

*Data were combined as there was no statistical interaction for seed treatment by fungicide.

[1] See Table 1 for fungicide product names and rates.

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

2020 PMR REPORT #18 **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 BETICOLA ON SUGARBEET, 2020

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 'H9908' was planted in a sandy clay loam soil on April 22 at a rate of 9 seeds per meter. Rows were spaced 75 cm apart. Each treatment plot consisted of two 7.0 m long rows, spaced 75 cm apart and plots were 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 29 where one dried infected sugarbeet leaf, collected in 2019, was placed in the middle of each guard row separating plots. Treatments were applied using a hand-held CO2 sprayer (40 psi) with Hardi® iso injet™ 03 nozzles and a water volume of 300 L/ha. Disease severity was assessed on July 22, August 6, August 20, September 4, and September 18 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 predetermined equivalent 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 June (20.5 °C), July (23.7 °C), and August (20.8 °C) while April (5.5 °C), May (12.6 °C), September (16.3 °C), and October (9.9 °C) were below average. Total rainfall was above the long term (10 year) average for August (4.9 mm) and below average for April (1.7 mm), May (2.4 mm), June (1.4 mm), July (2.7 mm), September (2.2 mm), and October (1.9 mm). Sugarbeets were harvested from a 4 m section of each plot on September 29. Twelve randomly selected sugarbeet 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 ARM 2020 (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.

RESULTS: As outlined in Table 1.

CONCLUSIONS: All programs, including those that had reduced or omitted PROLINE and/or MANZATE PRO-STICK by replacement with PHOSTROL or PARASOL + VEGOL, except Calendar applications of PHOSTROL (treatment 20), had lower percent leaf area with CLS than the nontreated

control (treatment 1) just prior to harvest. Leaf area with CLS using the BEETcast susceptible standard consisting of PROLINE and MANZATE PRO-STICK (treatment 8), was lower than the Calendar applications of PHOSTROL (treatment 20), the BEETcast susceptible program of PROLINE, PARASOL + VEGOL (treatment 11), the BEETcast susceptible program of reduced MANZATE PRO-STICK with PHOSTROL and PROLINE (treatment 10), and the BEETcast moderate program with no MANZATE PRO-STICK with PHOSTROL and PROLINE (treatment 6). With regards to the AUDPC values, the Calendar applications of PHOSTROL (treatment 20) spray program reduced disease in comparison to the nontreated control but had significantly higher disease than any of the other programs. Disease accumulation over the season (AUDPC) of CLS was higher in the BEETcast susceptible program of PHOSTROL and PROLINE (treatment 12) than the BEETcast Susceptible standard (treatment 8, MANZATE and PROLINE). All other application programs had similar AUDPC to one another. All alternative programs yielded recoverable white sugar amounts per hectare (RWSH) similar to both the BEETcast susceptible standard (treatment 8) and the nontreated control. No significant differences among treatments were found for beet yield.

ACKNOWLEDGEMENTS: Technical assistance of Phyllis May. 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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Battilani, P., Beltrami, G., Meriggi, P., Ponti, I., Rossi, A., Rossi, V., Rosso, F., Tugnoli, V., & Zocca, A. (1990). Nuovi indrizzi di difesa anticercosporica. L'Informatore Agrario, 46, 53-70.

Table 1. Field evaluation of fungicide programs for the control of CLS, Ridgetown, ON, 2020.

Treatment [a] (product rate/Ha)	Disease Severity (%) [b]	AUDPC [c]	Beet Yield (kg/ 4 m row)	RWSH (kg/Ha) [d]
1. Nontreated control	63 a [e]	1569 a	19.60 ns [f]	7613 b
BEETcast™ moderate application interval [g]				
2. MANZATE 2.25 kg + PROLINE @ 365 ml (BH) MANZATE 2.25 kg (EJMPSU)	9 de	130 cd	21.49	8965 ab
3. MANZATE 2.25 kg + PROLINE @ 365 ml (BH) MANZATE 2.25 kg (EJ) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (MPSU)	18 b-e	186 cd	22.93	9307 ab
4. MANZATE 2.25 kg + PROLINE @ 365 ml (BH) MANZATE 2.25 kg (EJ) PHOSTROL @ 5.6 L (MPSU)	20 b-e	232 cd	22.64	9209 ab
5. PROLINE @ 365 ml (BH) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (EJMPSU)	7 de	149 cd	22.29	8910 ab
6. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BH) PHOSTROL @ 5.6 L (EJMPSU)	33 bc	416 cd	21.22	8377 ab
7. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (BH) PHOSTROL @ 5.6 L (EJMPSU) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (MPSU)	12 cde	216 cd	20.67	8486 ab
BEETcast™ susceptible application interval				
8. MANZATE 2.25 kg + PROLINE @ 365 ml (AF) MANZATE 2.25 kg (CHILOQTU)	4 e	71 d	23.77	10122 a
9. MANZATE 2.25 kg + PROLINE @ 365 ml (AF) MANZATE 2.25 kg (CH) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (ILOQTU)	9 de	112 cd	21.27	8632 ab

10. MANZATE 2.25 kg + PHOSTROL @ 5.6 L + PROLINE @ 365 ml (AF) MANZATE 2.25 kg + PHOSTROL @ 5.6 L (CH) PHOSTROL (ILOQTU)	28 bcd	309 cd	20.15	9015 ab
11. PROLINE @ 365 ml (AF) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (CHILOQTU)	7 de	132 cd	19.86	8072 ab
12. PROLINE @ 365 ml (AF) PHOSTROL @ 5.6 L (CHILOQTU)	34 bc	466 c	20.64	8265 ab
13. PHOSTROL @ 5.6 L + PROLINE @ 365 ml (AF) PHOSTROL @ 5.6 L (CHILOQTU) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (ILOQTU)	5 de	89 cd	19.80	8025 ab
Calendar application interval				
14. PROLINE @ 365 ml (BG) MANZATE 2.25 kg (DHNRV)	8 de	143 cd	19.98	8414 ab
15. MANZATE 2.25 kg (BDGHNRV)	11 cde	217 cd	20.07	8237 ab
16. MANZATE 2.25 kg (BDGH) PARASOL @ 4.25 kg + VEGOL @ 1% v/v (NRV)	17 cde	194 cd	19.11	7900 ab
17. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGH) PHOSTROL @ 5.6 L (NRV)	23 b-e	337 cd	21.24	8786 ab
18. MANZATE 2.25 kg + PHOSTROL @ 5.6 L (BDGH) PARASOL @ 4.25 kg + VEGOL @ 1% v/v + PHOSTROL @ 5.6 L (NRV)	14 cde	174 cd	22.25	9397 ab
19. PARASOL @ 4.25 kg + VEGOL @ 1% v/v (BDGHNRV)	11 cde	162 cd	21.33	8866 ab
20. PHOSTROL @ 5.6 L (BDGHNRV)	40 ab	856 b	19.75	7872 ab
21. PARASOL @ 4.25 kg + VEGOL @ 1% v/v + PHOSTROL @ 5.6 L (BGNRV) PHOSTROL @ 5.6 L (DH)	14 cde	241 cd	21.68	8988 ab

[a] Treatments were applied on A = June 12, B = June 19, C = June 26, D = July 2, E = July 6 , F = July 9, G = July 15, H = July 18, I = July 27, J = July 28, K = July 30, L = Aug 3, M = Aug 6, N = Aug 10, O = Aug 12, P = Aug 17, Q = Aug 21, R = Aug 24, S = Aug 27, T = Aug 28, U = Sept 4, and V = Sept 8.

[b] Disease severity ratings from September 18, 2020, which was the final assessment before harvest.

[c] Disease severity values 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.

[g] BEETcast™ moderate application programs were made on June 19 (41 DSV), July 6 (36 DSV), July 18 (26 DSV), July 30 (27 DSV), Aug 6 (17 DSV), Aug 17 (24 DSV), Aug 27 (20 DSV), Sept 4 (16 DSV). BEETcast™ susceptible application programs were made on June 12 (35 DSV), June 26 (21 DSV), July 9 (29 DSV), July 18 (18 DSV), July 27 (20 DSV), Aug 3 (19 DSV), Aug 12 (16 DSV), Aug 21 (18 DSV), Aug 28 (18 DSV), and Sept 4 (13 DSV). Calendar applications were made on a 12 to 14-day interval.

2020 PMR REPORT #19 **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 BETICOLA ON SUGARBEET, 2020

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 'H9908' was planted in a sandy clay loam soil on April 22 at a rate of 9 seeds per meter but replanted on May 25 due to poor emergence. Rows were spaced 75 cm apart. Each treatment plot consisted of two 7.0 m long rows, spaced 75 cm apart and plots were 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 29 where one dried infected sugarbeet leaf, collected in 2019, was placed in the middle of each guard row separating plots. Treatments were applied using a hand-held CO2 sprayer (40 psi) with Hardi® iso injet™ 03 nozzles and a water volume of 300 L/ha. Treatments were applied on a 7-10-day calendar schedule. Disease severity was assessed on July 27, August 11, August 24, September 4, and September 18 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 predetermined equivalent 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 June (20.5 °C), July (23.7 °C), and August (20.8 °C) while April (5.5 °C), May (12.6 °C), September (16.3 °C), and October (9.9 °C) were below average. Total rainfall was above the long term (10 year) average for August (4.9 mm) and below average for April (1.7 mm), May (2.4 mm), June (1.4 mm), July (2.7 mm), September (2.2 mm), and October (1.9 mm). Sugarbeets were harvested from a 4 m section of each plot on September 28. Fifteen randomly selected sugarbeet 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 ARM 2020 (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.

RESULTS: As outlined in Table 1.

CONCLUSIONS: PARASOL + VEGOL resulted in the lowest leaf area affected with CLS September

18 and this was statistically different from the Nontreated control. However, it was also equivalent to MANZATE PRO-STICK, PHOSTROL, CUEVA, and PARASOL treatments, which were not significantly different from the Nontreated control. Identical trends were seen in the AUDPC values whereas the lowest AUDPC value was achieved using PARASOL +VEGOL but this was equivalent to MANZATE PRO-STICK, MILSTOP, PHOSTROL, CUEVA, and PARASOL treatments. No significant differences were found amongst RWSH yields or beet yields. MANZATE PRO-STICK treated plots, as well as MILSTOP, PHOSTROL, CUEVA, and VEGOL treatments had a numerically higher average beet yield than the 'Nontreated Control'.

ACKNOWLEDGEMENTS: Technical assistance of Phyllis May. 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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Battilani, P., Beltrami, G., Meriggi, P., Ponti, I., Rossi, A., Rossi, V., Rosso, F., Tugnoli, V., & Zocca, A. (1990). Nuovi indrizzi di difesa anticercosporica. L'Informatore Agrario, 46, 53-70.

Table 1. Field evaluation of fungicide efficacy for the control of CLS, Ridgetown, ON, 2020.

Treatment [a] (product rate/Ha)	Disease Severity (%) [b]	AUDPC [c]	Beet Yield (kg/ 4m row)	RWSH (kg/Ha) [d]
Nontreated control	27 ab [e]	528 ab	14 ns	6090 ns
MANZATE PRO-STICK @ 2.25 kg	5 bc	73 c	16	7192
MILSTOP @ 5.6 kg	33 a	498 abc	14	5898
PHOSTROL @ 5.6 L	21 abc	318 abc	13	5802
CUEVA @ 1% v/v	25 abc	461 abc	13	5818
PARASOL @ 4.25 kg	4 bc	93 bc	16	6807
VEGOL @ 1% v/v	35 a	620 a	13	5516
PARASOL @ 4.25 kg + VEGOL @ 1% v/v	2 c	54 c	16	7087
DOUBLE NICKEL @ 2.34 L	31 a	647 a	14	6184

[a] Treatments were applied on June 26, July 6, July 14, July 23, July 31, August 10, August 18, August 26, and September 3.
[b] Disease severity ratings from September 18, 2020, which was the final assessment before harvest.
[c] Disease severity values 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.

2020 PMR REPORT #20 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Sugarbeet (*Beta vulgaris* L.) var. HIL-9908
PEST: Cercospora Leaf Spot, *Cercospora beticola* (Sacc.)

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TITLE: **EVALUATION OF A DEPOSITION AID AND CARRIER VOLUME FOR MANAGEMENT OF CERCOSPORA LEAF SPOT IN EARLY PLANTED SUGARBEET, 2020.**

MATERIALS: MANZATE PRO-STICK (mancozeb), INTERLOCK (modified vegetable oil, vegetable oil, emulsifier: polyoxyethylene sorbitan fatty acid ester)

METHODS: The trial was completed at the University of Guelph Ridgetown Campus. Sugarbeets were seeded on April 22 in a sandy clay loam soil. The trial was arranged in a randomized complete block design with four replications. Rows were spaced 75 cm apart and seeds were planted at a rate of 10 seeds m^{-1}. Plots consisted of two rows with two unsprayed guard rows separating each plot and a 1 m walkway between replicated blocks. Fungicide treatments were applied using a hand-held 1.5 m CO_2 boom sprayer using Hardi ISO injet air inclusion nozzles for 115, 235, 350, and 470 L ha^{-1} using 275.8 kPa. MANZATE PRO-STICK was applied using 2.25 kg ha^{-1}. INTERLOCK was applied at 0.136% v/v. Applications began on June 24, when a BEETcast™ disease severity value (DSV) of 50 was reached, then continued on a 14-day interval (total of 7 treatments applied on (June 24, July 9, 23, August 7, 21, September 4 and 18)). Weekly scouting for Cercospora leaf spot (CLS) symptoms began in early June. The trial was inoculated on June 29 using dry sugarbeet leaves with CLS lesions collected in 2019. Two leaves were placed in each guard row. Ten plants in each plot were evaluated for severity of CLS symptoms on June 17, 23, July 1, 15, 29, August 12, 27, September 9, 23, and October 7 using a modified Agronomica scale, where 0 = healthy foliage, 0% leaf area affected (LAA), 1 = >0 to 2% LAA, 2 = >2 to 8% LAA, 3 = >8 to 12 % LAA, 4 = >12 to 18% LAA, 5 = >18 to 42% LAA, 6 = >42 to 58% LAA, 7 = >58 to 82% LAA, 8 = >82 to 99% LAA, and 9 = >99% LAA. Midpoint values were used to calculate mean severity for each plot. These values were used to calculate the area under the disease progress stairs (AUDPS). A 4 m section of each plot was harvested by hand on October 20 and the number and weight of harvested beets was recorded. A subsample of approximately 12 roots was used for sugar analysis. Air temperatures were below the long term (10 year) average for April (5.5°C), below average for May (12.6°C), above average for June (20.5°C), above average for July (23.7°C), above average for August (20.8°C), below average for September (16.3°C), and below average for October (9.9°C). Total precipitation was below the long term (10 year) average for April (1.7mm), below average for May (2.4mm), below average for June (1.4mm), below average for July (2.7mm), above average for August (4.9mm), below average for September (2.2mm), and below average for October (1.9mm). Statistical analysis was conducted using the glimmix procedure in SAS v9.4. Means were separated using Tukey's HSD and considered significant at $P \leq 0.05$.

RESULTS: As outlined in Table 1.

CONCLUSIONS: CLS was first observed on July 15 and severity was moderate, reaching 43% just prior to harvest. Programs that included MANZATE PRO-STICK had lower final disease severity and AUDPS than those treated with INTERLOCK or water alone. Adding INTERLOCK to MANZATE PRO-STICK did not reduce disease more than applications of MANZATE PRO-STICK alone. There was no effect of program on any yield or quality variable. Carrier volume had no effect on fungicide efficacy for disease management, and did not improve sugar recovery or quality.

ACKNOWLEDGEMENT: This project was funded in part through the Canadian Agricultural Partnership (the Partnership), a federal-provincial-territorial initiative. Project funding was also provided by the Ontario Agri-Food Innovation Alliance Research Program, the Ontario Sugarbeet Growers' Association (OSGA) and the Michigan Sugar Company (MSC).

Table 1. Effect of program and application carrier volume on disease, beet and sugar yield, and sugar quality, Ridgetown, ON, 2020.

Factor	Severity (%) Oct 7	AUDPS[1]	Beet Yield (T ha^{-1})	Sugar Content (%)	RWSH[2] (kg ha^{-1})	RWS[3] (kg T^{-1})
Program						
Water	43.1 a[4]	1830.4 a	66.7 ns	17.8 ns	8887.8 ns	133.7 ns
INTERLOCK @ 0.136%v/v	44.0 a	1794.4 a	67.8	17.6	8906.9	132.1
MANZATE PRO-STICK @ 2.25 kg/ha	27.0 b	1110.1 b	70.3	17.6	9266.6	132.3
MANZATE PRO-STICK @ 2.25 kg/ha + INTERLOCK @ 0.136%v/v	25.8 b	1018.1 b	73.7	18.0	9961.8	135.4
se[5]	3.354	104.0	3.999	0.3020	501.5	2.641
p-value	<0.0001	<0.0001	0.2008	0.2968	0.0613	0.4044
Carrier Volume (L ha^{-1})						
115	38.4 ns	1456.7 ns	71.7 ns	17.6 ns	9464.2 ns	132.8 ns
235	37.1	1538.6	65.9	17.9	8878.6	134.8
350	30.4	1313.5	71.5	17.8	9563.9	134.4
470	34.0	1444.3	69.5	17.5	9116.5	131.5
se	3.352	104.0	3.999	0.3020	501.5	2.641
p-value	0.2107	0.3890	0.3118	0.2285	0.3815	0.3963

[1]AUDPS = AUDPC + $[(Y_1 + Y_n)/2 \times (D/n-1)]$, where Y_1 is the disease level at first assessment, Y_n is the disease level at last assessment, D is the difference in the number of days from the first to the last assessment, n is the number of assessments, and AUDPC = $\sum [((Y_i + Y_{i-1})(X_i - X_{i-1}))/2]$. For AUDPC, 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}.

[2] RWSH = recoverable white sugar per hectare.

[3] RWS = recoverable white sugar per tonne of sugarbeet.

[4] Numbers in a column followed by the same letter are not significantly different at P≤0.05 Tukey's HSD, ns= not significant. Treatment means include data from program treatments and carrier volume treatments because of no significant program*volume interaction.

[5] Standard error of INTERLOCK and 115 L ha^{-1} was 107.6 for AUDPS.

2020 PMR REPORT #21 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Sugarbeet (*Beta vulgaris* L.) var. HIL-9908
PEST: Cercospora Leaf Spot, *Cercospora beticola* (Sacc.)

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TITLE: **EVALUATION OF A DEPOSITION AID AND CARRIER VOLUME FOR MANAGEMENT OF CERCOSPORA LEAF SPOT IN LATE PLANTED SUGARBEET, 2020.**

MATERIALS: MANZATE PRO-STICK (mancozeb), INTERLOCK (modified vegetable oil, vegetable oil, emulsifier: polyoxyethylene sorbitan fatty acid ester)

METHODS: The trial was completed at the University of Guelph Ridgetown Campus. Sugarbeets were seeded on May 25 in a sandy clay loam soil. The trial was arranged in a randomized complete block design with four replications. Rows were spaced 75 cm apart and seeds were planted at a rate of 10 seeds m^{-1}. Plots consisted of two rows with two unsprayed guard rows separating each plot and a 1 m walkway between replicated blocks. Fungicide treatments were applied using a hand-held 1.5 m CO_2 boom sprayer using Hardi ISO injet air inclusion nozzles for 115, 235, 350, and 470 L ha^{-1} using 275.8 kPa. MANZATE PRO-STICK was applied using 2.25 kg ha^{-1}. INTERLOCK was applied at 0.136% v/v. Applications began on June 29, when a BEETcast™ disease severity value (DSV) of 50 was reached, then continued on a 14-day interval (total of 8 treatments on (June 29, July 13, 27, August 10, 24, September 18, 21, and October 5)). Weekly scouting for Cercospora leaf spot (CLS) symptoms began in early June. The trial was inoculated on June 30 and July 22 using dry sugarbeet leaves with CLS lesions collected in 2019. Two leaves were placed in each guard row. Ten plants in each plot were evaluated for severity of CLS symptoms on July 1, 8, 22, August 5, 18, September 2, 16, 29, and October 14 using a modified Agronomica scale, where 0 = healthy foliage, 0% leaf area affected (LAA), 1 = >0 to 2% LAA, 2 = >2 to 8% LAA, 3 = >8 to 12 % LAA, 4 = >12 to 18% LAA, 5 = >18 to 42% LAA, 6 = >42 to 58% LAA, 7 = >58 to 82% LAA, 8 = >82 to 99% LAA, and 9 = >99% LAA. Midpoint values were used to calculate mean severity for each plot. These values were used to calculate the area under the disease progress stairs (AUDPS) using the formula: AUDPS = AUDPC + $[(Y_1 + Y_n)/2 \times (D/n-1)]$, where Y_1 is the disease level at first assessment, Y_n is the disease level at last assessment, D is the difference in the number of days from the first to the last assessment, n is the number of assessments, and AUDPC = $\sum [((Y_i + Y_{i-1}) (X_i - X_{i-1}))/2]$. For AUDPC, 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}. A 4 m section of each plot was harvested by hand on October 26 and the number and weight of harvested beets was recorded. A subsample of approximately 12 roots was used for sugar analysis. Air temperatures were below the long term (10 year) average for April (5.5°C), below average for May (12.6°C), above average for June (20.5°C), above average for July (23.7°C), above average for August (20.8°C), below average for September (16.3°C), and below average for October

(9.9°C). Total precipitation was below the long term (10 year) average for April (1.7mm), below average for May (2.4mm), below average for June (1.4mm), below average for July (2.7mm), above average for August (4.9mm), below average for September (2.2mm), and below average for October (1.9mm). Statistical analysis was conducted using the glimmix procedure in SAS v9.4. Means were separated using Tukey's HSD and considered significant at $P \leq 0.05$.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: CLS was first observed on August 5 and severity was low to moderate at 32% just prior to harvest. Programs that included MANZATE PRO-STICK had lower disease severity on the final assessment date than those treated with INTERLOCK or water alone. Adding INTERLOCK to MANZATE PRO-STICK reduced disease severity by 18% compared to applications of MANZATE PRO-STICK alone. Beet yield was greater for MANZATE PRO-STICK than INTERLOCK, but neither treatment was different compared to water and MANZATE PRO-STICK + INTERLOCK. Sugar content and RWS was greater for MANZATE PRO-STICK + INTERLOCK compared to INTERLOCK alone, but neither treatment was different than water or MANZATE PRO-STICK alone. RWSH was greater for programs that included MANZATE PRO-STICK compared to INTERLOCK alone, but no treatment was different than water alone (Table 1). Carrier volume had no effect on disease severity, and did not improve sugar recovery or quality. For all carrier volumes, programs that included MANZATE PRO-STICK reduced total disease accumulation (AUDPS) more than treatments of water or INTERLOCK alone. Adding INTERLOCK to MANZATE PRO-STICK did not reduce AUDPS more than applications of MANZATE PRO-STICK alone for any carrier volume. There was no effect of carrier volume for water and MANZATE PRO-STICK + INTERLOCK treatments. For INTERLOCK, using 350 L ha^{-1} reduced AUDPS by 29% compared to using 115 L ha^{-1}. For MANZATE PRO-STICK, using 470 L ha^{-1} reduced AUDPS by 29% compared to using 115 L ha^{-1} (Table 2).

ACKNOWLEDGEMENT: This project was funded in part through the Canadian Agricultural Partnership (the Partnership), a federal-provincial-territorial initiative. Project funding was also provided by the Ontario Agri-Food Innovation Alliance Research Program, the Ontario Sugarbeet Growers' Association (OSGA) and the Michigan Sugar Company (MSC).

Table 1. Effect of program and application carrier volume on disease severity, beet and sugar yield, and sugar quality, Ridgetown, ON, 2020.

Factor	Severity (%) Oct 14[1]	Beet Yield (T ha^{-1})	Sugar Content (%)	RWSH[2] (kg ha^{-1})	RWS[3] (kg T^{-1})
Program					
Water	32.1 a[4]	76.8 ab	20.2 ab	11650 ab	153.8 ab
INTERLOCK @ 0.136%v/v	33.4 a	74.2 a	19.7 a	11113 a	149.8 a
MANZATE PRO-STICK @ 2.25 kg/ha	21.7 b	80.3 b	20.1 ab	12298 b	153.1 ab
MANZATE PRO-STICK @ 2.25 kg/ha + INTERLOCK @ 0.136%v/v	17.8 c	78.2 ab	20.6 b	12312 b	157.6 b
se[5]	2.872	1.983	0.1519	355.5	1.300
p-value	<0.0001	0.0058	0.0011	0.0002	0.0019
Carrier Volume (L ha^{-1})					
115	27.1 ns	75.7 ns	20.1 ns	11440 ns	153.3 ns
235	25.1	78.5	20.1	11982	152.6
350	24.3	76.8	20.3	11906	155.1
470	25.0	78.5	20.2	12044	153.5
se	3.325	1.983	0.1519	355.5	1.300
p-value	0.4327	0.2590	0.7949	0.1497	0.6165

[1] Disease severity was analyzed in lognormal. Back-transformed means and se are presented.
[2] RWSH= recoverable white sugar per hectare.
[3] RWS = recoverable white sugar per tonne of sugarbeet.
[4] Numbers in a column followed by the same letter are not significantly different at p≤0.05 Tukey's HSD, ns= not significant. Treatment means include data from program treatments and carrier volume treatments because of no significant program*volume interaction.
[5] Standard error of water and 115 L ha^{-1} was 1.360 for RWS and 0.1581 for sugar. Standard error of INTERLOCK, MANZATE PRO-STICK + INTERLOCK, and water are 4.425, 2.354, and 4.272, and 115, 235, and 350 L ha^{-1} is 3.590, 3.322, and 3.222 for severity.

Table 2. Effect of program and application carrier volume on area under the disease progress stairs.

	Application Carrier Volume L ha^{-1}							
Program	115		235		350		470	
Water	1022.7 NS	a[1]	1033.2	a	1150.6	a	1162.9	a
INTERLOCK @ 0.136%v/v	1386.3 A	b	1158.8 AB	a	988.8 B	a	1106.1 AB	a
MANZATE PRO-STICK @ 2.25 kg/ha	762.5 A	c	671.4 AB	b	613.1 AB	b	545.0 B	b
MANZATE PRO-STICK @ 2.25 kg/ha + INTERLOCK @ 0.136%v/v	619.6 NS	c	579.6	b	603.6	b	511.4	b
se[2]	118.70		119.92		133.55		142.93	

Data was analyzed in lognormal. Backtransformed means and se are presented.

[1] Numbers in a row followed by the same upper-case letter and numbers in a column followed by the same lower-case letter are not significantly different at p≤0.05 Tukey's HSD, ns= not significant. Program*volume means are presented due to a significant interaction.

[2] Standard error of 115 L ha was 160.91, 88.50, and 71. 92, 235 L ha was 134.50, 77.93, and 67.27, 350 L ha was 114.77, 71.16, and 70.10, and 470 L ha was 128.38, 66.98, and 59.36 for InterLock, Manzate, and Manzate + InterLock, respectively.

2020 PMRR # 22 **SECTION O: CEREALS, FORAGE CROPS and OILSEEDS**
Diseases

CROP: Winter wheat (*Triticum aestivum* L.), cv. Several
PEST: Fusarium head blight, *Fusarium graminearum* Schwabe

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TITLE: EVALUATION OF CANADIAN EASTERN SOFT RED WINTER (CESRW) WHEAT POPULATION (CA14-19) FOR RESISTANCE TO FUSARIUM HEAD BLIGHT (FHB) IN INOCULATED AND MISTED PLOTS

METHODS: The winter wheat lines (CESRW), from the University of Guelph, Ridgetown Campus population CA14-19, were planted in a randomized complete block design, replicated trial on October 20, 2018 at Ridgetown, Ontario. The parents ('UGRC Ring' and 'Marker') were also included. 'Marker' is rated as a Fusarium head blight (FHB) moderately resistant (MR) and 'UGRC Ring' as moderately susceptible (MS) wheat by the Ontario Cereal Crop Committee (OCCC). The plots were planted in three replications at 270 seeds/plot, in single rows, 2 m long and spaced 17.8 cm apart. Each plot was fertilized and maintained using provincial recommendations and spray inoculated with 100 mL of combined suspension of macroconidia (50,000 spores/mL) of four *Fusarium graminearum* isolates per plot. Plots were misted daily beginning after the first plots were inoculated. The overhead mister was set to run from 11:00-16:00 and misted for approximately 60-90 seconds every 8-10 minutes. The mist system was engaged until three days after the last variety was inoculated with *F. graminearum*. FHB symptoms were recorded as incidence (percent of heads infected) and severity (percent of spikelets infected). FHB severity was estimated according to Stack and McMullen (1995). FHB index for each plot was the product of severity and incidence divided by 100. All data were analyzed using ANOVA (ARM 8 software). The Student-Newman-Keuls test was used to detect differences among the treatments at $p<0.05$.

RESULTS: The results are given in Table 1.

CONCLUSIONS: The FHB severity, incidence and index ranged from 19.0% to 83%; 27.0% to 80.0% and 9.6% to 63.5%, respectively. Averaged FHB severity, incidence and index were 45.4%, 58.7% and 26.9%, respectively. The parents 'UGRC Ring' and 'Marker' had FHB indices of 10.9% and 28.2%, respectively. The lowest FHB index was for wheat line Ca 14-019-161 (9.6%), and the highest FHB index was for wheat line Ca 14-019-116 (63.5%). The most FHB resistant lines, with good agronomic performance, will be used in future crosses and potentially registered with CFIA for Canadian growers.

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Table 1. Fusarium head blight severity, incidence and index across winter wheat breeding lines (CA14-9) and checks in inoculated and misted plots at Ridgetown, Ontario. 2018-2019.

	Name	FHB severity (%)	FHB incidence (%)	FHB index (%)
1	ca 14-019-106	29.0	50.0	14.9
2	ca 14-019-107	38.7	46.7	17.7
3	Marker	49.7	60.0	28.2
4	ca 14-019-109	40.3	60.0	24.2
5	ca 14-019-110	44.3	56.7	24.4
6	ca 14-019-111	54.0	40.0	19.5
7	ca 14-019-112	49.7	56.7	28.1
8	ca 14-019-113	34.7	46.7	17.2
9	ca 14-019-114	55.3	76.7	42.1
10	ca 14-019-115	33.0	56.7	18.7
11	ca 14-019-116	82.7	76.7	63.5
12	ca 14-019-117	29.0	36.7	11.3
13	ca 14-019-118	38.7	63.3	24.9
14	ca 14-019-119	33.0	66.7	22.0
15	ca 14-019-120	66.0	50.0	33.0
16	ca 14-019-121	38.7	36.7	13.2
17	ca 14-019-122	44.3	70.0	31.6
18	ca 14-019-123	44.3	43.3	19.4
19	ca 14-019-124	55.3	70.0	39.3
20	ca 14-019-125	34.7	30.0	10.4
21	ca 14-019-126	49.7	53.3	27.0
22	ca 14-019-127	33.0	56.7	18.7
23	ca 14-019-128	50.0	73.3	36.7
24	ca 14-019-129	38.7	46.7	17.1
25	ca 14-019-130	69.3	26.7	18.2
26	ca 14-019-131	49.7	70.0	34.8
27	ca 14-019-132	25.0	76.7	18.9
28	ca 14-019-133	33.0	76.7	25.3
29	ca 14-019-134	44.3	53.3	22.1
30	ca 14-019-135	34.7	46.7	16.2
31	ca 14-019-136	44.0	66.7	29.7
32	ca 14-019-137	55.3	63.3	35.4
33	ca 14-019-138	38.7	73.3	27.6
34	ca 14-019-139	38.7	63.3	23.7
35	ca 14-019-140	29.0	63.3	18.1
36	ca 14-019-141	50.0	53.3	26.7
37	ca 14-019-142	38.7	60.0	23.8
38	ca 14-019-143	50.0	56.7	28.3

39	ca 14-019-144	44.3	63.3	28.8
40	ca 14-019-145	21.0	50.0	10.5
41	ca 14-019-146	33.0	70.0	23.1
42	ca 14-019-147	38.7	76.7	29.8
43	ca 14-019-148	29.0	36.7	10.1
44	ca 14-019-149	65.0	80.0	52.0
45	ca 14-019-150	55.3	50.0	27.7
46	ca 14-019-151	59.7	76.7	45.1
47	ca 14-019-152	60.7	56.7	34.2
48	ca 14-019-153	38.7	70.0	27.6
49	ca 14-019-154	65.0	60.0	39.0
50	ca 14-019-155	55.3	33.3	18.3
51	ca 14-019-156	34.7	43.3	13.6
52	ca 14-019-157	44.3	46.7	21.1
53	ca 14-019-158	33.0	56.7	18.7
54	ca 14-019-159	44.3	66.7	28.8
55	ca 14-019-160	60.7	60.0	36.9
56	ca 14-019-161	25.0	40.0	9.6
57	ca 14-019-162	50.0	70.0	35.0
58	ca 14-019-163	32.3	53.3	17.9
59	ca 14-019-164	65.0	70.0	45.5
60	ca 14-019-165	44.3	50.0	23.9
61	ca 14-019-166	55.3	53.3	29.3
62	ca 14-019-167	54.0	63.3	32.5
63	ca 14-019-168	55.3	46.7	26.0
64	ca 14-019-169	49.7	43.3	21.0
65	ca 14-019-170	33.0	63.3	20.9
66	UGRC Ring	34.7	33.3	10.9
67	ca 14-019-172	44.3	53.3	23.8
68	ca 14-019-173	55.3	70.0	37.7
69	ca 14-019-174	38.7	40.0	14.9
70	ca 14-019-175	29.0	50.0	14.1
71	ca 14-019-176	60.7	76.7	46.9
72	ca 14-019-177	50.0	50.0	26.9
73	ca 14-019-178	49.7	53.3	26.5
74	ca 14-019-179	44.3	40.0	17.7
75	ca 14-019-180	29.0	76.7	22.5
76	ca 14-019-181	44.3	63.3	28.8
77	ca 14-019-182	69.3	53.3	39.2
78	ca 14-019-183	50.0	53.3	26.7
79	ca 14-019-184	59.7	46.7	28.2
80	ca 14-019-185	49.7	66.7	32.6
81	ca 14-019-186	29.0	80.0	23.2
82	ca 14-019-187	44.3	66.7	29.9
83	ca 14-019-188	55.3	76.7	42.6

84	ca 14-019-189	49.7	60.0	28.1
85	ca 14-019-190	38.7	70.0	26.5
86	ca 14-019-191	55.3	66.7	36.0
87	ca 14-019-192	29.0	53.3	15.2
88	ca 14-019-193	60.7	70.0	43.0
89	ca 14-019-194	50.0	70.0	35.0
90	ca 14-019-195	33.0	73.3	24.2
91	ca 14-019-196	34.7	40.0	14.3
92	ca 14-019-197	44.3	46.7	21.6
93	ca 14-019-198	58.7	60.0	35.5
94	ca 14-019-199	59.7	56.7	34.1
95	ca 14-019-200	34.7	46.7	14.3
96	ca 14-019-201	49.7	66.7	34.8
97	ca 14-019-203	29.0	36.7	10.9
98	ca 14-019-204	29.0	73.3	21.4
99	ca 14-019-205	78.3	66.7	52.6
100	ca 14-019-206	38.7	56.7	22.1
101	ca 14-019-207	44.3	66.7	29.4
102	ca 14-019-208	49.7	70.0	35.3
103	ca 14-019-209	44.3	70.0	32.7
104	ca 14-019-210	49.7	56.7	30.4
105	ca 14-019-211	18.7	80.0	14.7
106	ca 14-019-212	60.7	63.3	38.6
107	ca 14-019-213	33.0	46.7	15.4
108	ca 14-019-214	50.0	70.0	35.0
109	ca 14-019-215	49.7	70.0	34.2
110	ca 14-019-216	78.3	76.7	58.9
Mean		45.4	58.7	26.9
LSD (p=.05)		18.3	18.7	13.1
Standard Deviation		11.5	11.7	8.2
CV		25.3	19.9	30.4