2018 Pest Management Research Report (PMRR) 2018 Growing Season

2018 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2018

Canada

English

2018 PEST MANAGEMENT RESEARCH REPORT

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

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[1] This is the 19th 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 28 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 2019 Annual PMR Report will be sent in fall, 2019. 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 2018 has been assigned a Volume number for the 19th 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 57.

An individual report will be cited as follows:
Author(s). 2018. Title. 2018 Pest Management Research Report - 2018 Growing Season. Agriculture and AgriFood Canada. April 2019. Report No. x. Vol. 57: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2018

Préparé par: Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada
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Titre officiel du document
2018 Rapport de recherches sur la lutte dirigée - pour la saison 2018. Compilé par Agriculture et Agroalimentaire Canada, 960 avenue Carling, Ed. 57, Ottawa ON K1A 0C6, Canada
Avril 2019 volume 57[1]. 69 pp. 28 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 28 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 2019 seront distribuées à l'automne 2019. 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. 2018. Titre. 2018 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. Avril, 2019. Rapport n^{o} x. vol. 57: pp-pp.

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PESTS: Carrot Weevil, (*Listronotus oregonensis* (LeConte))
Carrot Rust Fly, (*Psila rosae* (Fab.))

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TITLE: FIELD EVALUATION OF FOLIAR INSECTICIDES FOR CONTROL OF CARROT WEEVIL AND CARROT RUST FLY DAMAGE IN CARROTS, 2018

MATERIALS: EXIREL Insecticide (cyantraniliprole 100 g/L), HARVANTA 50 SL (cyclaniliprole 4.55%), IMIDAN 70 WP (phosmet 70%), NEMASYS (*Steinernema feltiae* 87%), NO FLY WP (*Isaria fumosorosea* 18%), RIMON Insecticide (novaluron 10%)

METHODS: Carrots (cv. Cellobunch) were direct seeded (70 seeds/m) onto raised beds using a precision seeder on 17 May 2018, at the University of Guelph, Muck Crops Research Station, Holland Marsh, ON (soil: pH ~ 6.8, organic matter ~ 64.8%). A randomized complete block arrangement with five replications per treatment was used. Plots consisted of two rows, 86 cm apart and 5 m in length. Treatments were EXIREL (500 ml/ha and 1000 ml/ha), HARVANTA (1.2 L/ha), IMIDAN 70 WP (1.6 kg/ha), NEMASYS (500,000 IJs/m), NO FLY WP (4.5 kg/ha), RIMON (820 ml/ha). An untreated control was also included. All treatments were applied on 12 and 29 June, and 12 July using a CO_2 backpack sprayer equipped with 4 TeeJet 8004 fan nozzles calibrated to deliver 350 L/ha at 240 kPa. On 9 August and 4 October, carrots from two 1.2 m sections of row were taken from each plot to assess the carrots for CW and CRF damage. On 15 August and 12 October 2018, carrot samples were washed in a small drum washer and visually inspected for CW and CRF damage. The number and weight of damaged and marketable carrots was recorded. Marketable was defined as no insect damage. Data were analyzed using a repeated measures ANOVA generalized linear model using RStudio (RStudio Team, Boston, MA) to determine the effect of treatments on CW and CRF damage, and marketable yield. For CW, both harvest dates were assessed in the same analysis and Tukey's Test was performed to compare treatments to the control. Compared to the previous 10-year average, air temperatures in 2018 were above average for May (15.8°C), August (21.9°C), September (17.5°C), average for June (18.4°C), July (22.0°C) and below average for October (8.3°C). The 10-year average temperatures were: May 13.9°C, June 18.6°C, July 21.2°C, August 20.1°C, September 16.0°C and October 9.4°C. Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm), July (104 mm), October (69 mm) and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, September 67 mm and October 72 mm.

RESULTS: Results are presented in Table 1.

CONCLUSIONS: Overall, carrot weevil damage was very high. RIMON 10 EC, registered for CW control in 2015, was the only product that significantly reduced CW damage compared to the control, on individual and combined assessment dates. EXIREL at the low rate significantly reduced CW damage compared to the control in the harvest samples. The organic products NO FLY WP and NEMASYS did not reduce CW damage compared to the control. There were no significant differences in yield but the RIMON treatment had the numerically highest marketable yield. Carrot rust fly damage was very low in this trial and as a result no treatment significantly reduced CRF damage compared to the control

Table 1. Average carrot weevil (CW), and carrot rust fly (CRF) damage, and yield in a foliar insecticide carrot trial at the University of Guelph – Muck Crops Research Station, Holland Marsh, ON, 2018.

Treatment	CW Damage (%)[1]			CRF Damage (%)[1]	Yield (t/ha)[2]
	9 Aug	4 Oct	Dates Combined		
Control	16.8 ab[3]	34.2 a	24.5 a	0.6 ns[4]	39.5 ns
NO FLY WP	19.2 a	28.0 ab	23.6 a	1.0	38.3
NEMASYS	15.9 ab	30.2 ab	23.0 a	0.7	42.8
HARVANTA	14.0 ab	29.7 ab	21.9 a	1.3	43.4
IMIDAN 70 WP	12.4 abc	30.5 ab	21.4 a	1.3	44.7
EXIREL (1000)	7.0 abc	33.1 ab	20.0 a	1.7	42.6
EXIREL (500)	7.0 bc	22.9 b	15.0 ab	1.4	48.9
RIMON 10 EC	4.6 c	12.7 c	8.7 b	2.5	55.8

[1] Percent damaged is based on number of carrots assessed.

[2] Yield in t/ha was extrapolated from the average marketable yield of two 1.16 m carrot row section samples on 4 Oct.

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

[4] ns indicated all numbers in the column are not significantly different compared to the control at $\alpha = 0.05$ according to Tukey's test.

ACKNOWLEDGEMENT: The authors thank the University of Guelph – Muck Crop Research Station for technical advice and assistance. Funding for this project comes from the Ontario Agri-Food Innovation Alliance, OMAFRA- HQP Scholarship to A Stinson, Bradford Co-op Storage, Ltd., Engage Agro, Corteva Agriscience, and the Fresh Vegetable Growers of Ontario.

2018 PMR REPORT # 02 SECTION B: VEGETABLES and SPECIAL CROPS – Insect Pests

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang), cv. Cellobunch
PEST: Carrot Weevil, *Listronotus oregonensis* (LeConte)

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TITLE: EVALUATING APPLICATION TIMING OF RIMON AND EXIREL FOR CONTROL OF CARROT WEEVIL IN CARROT, 2017 and 2018

MATERIALS: IMIDAN 70 WP (phosmet 70%), EXIREL (cyantraniliprole 100 g/L), RIMON 10 EC (novaluron 10%)

METHODS: Carrots (cv. Cellobunch) were direct seeded (70 seeds/m) onto raised beds using a precision seeder on 24 May 2017 and 2018 at the Muck Crops Research Station, Holland Marsh, ON (soil: pH ≈ 6.8, organic matter ≈ 64.8%). A randomized complete block design containing four replications per treatment was used for plots consisting of four rows, 85 cm apart and 5 m in length. In 2017, treatments were EXIREL (750 ml/ha), and RIMON 10 EC (820 ml/ha). Products were applied in various combinations at the 2, 4, and 6 true leaf stage (TLS). An untreated control and an industry standard (IMIDAN 70 WP applied at 1.6 kg/ha at 4+6 TLS) were included. Treatments were applied on 5 July (4 TLS), 14 July (6 TLS), and 28 July (8 TLS) using a tractor mounted sprayer fitted with TeeJet Air Induction Even Flat spray tips (AI9503 EVS) at 415 kPa calibrated to deliver 500 L/ha. Optimally, treatments would have been applied at 2, 4, and 6 TLS however flooding from rain on June 23 delayed insecticide applications. In 2018, one trial examined EXIREL and another examined RIMON in various combinations at the 2, 4, and 6 TLS. Treatment rates were the same as 2017 and an untreated control was included. The RIMON trial had an additional two treatments to examine the efficacy of a four spray rotation with EXIREL as the 2nd or 2nd and 4th application. This four spray rotation extended foliar applications into the 8 TLS. Treatments were applied on 13 June (2 TLS), 28 June (4 TLS), 11 July (6 TLS), and 25 July (8 TLS) using the same methods as 2017. On 31 July-15 August (mid-season) and 12-31 October (harvest) 2017 and 2018, carrots from two 1.16 m sections of row were taken from the centre rows of each plot to assess the carrots for carrot weevil (CW) damage. Carrots were washed in a small drum washer and visually inspected for CW damage; number and weight of damaged and marketable (no insect damage) carrots was recorded. Each trial was analysed using repeated measures ANOVA in Proc Mixed (SAS 9.4) to determine treatment effect on CW damage and yield.

RESULTS: Results can be found in Table 1 and Table 2. CW damage from 2017 is presented as an average from both sampling dates as there were no significant differences in CW damage between dates.

CONCLUSIONS: Applications of RIMON were effective at reducing CW damage. EXIREL had no consistent effect on CW, with no control exhibited in 2018. While RIMON - EXIREL rotations effectively controlled CW, the rotations provided no additional efficacy then RIMON alone; it is likely the RIMON is providing all of the CW control in the rotation.

Table 1. Mean carrot weevil (CW) damage in carrots in a trial evaluating application timings of EXIREL and RIMON 10 EC at the University of Guelph – Muck Crops Research Station, Holland Marsh, 2017.

Treatment	Applications (TLS)	CW Damage (%)[1]	Mean Yield (t/ha)
CONTROL	N/A	13.6 ab	31.6 ns[2]
IMIDAN 70 WP	4+6	11.4 abc	30.8
EXIREL	4	7.8 bcd	34.2
	6	15.1 a	31.1
	4+6	6.2 cd	38.9
	4+6+8	4.6 d	36.8
RIMON 10 EC	4	5.0 cd	38.9
	6	6.1 cd	39.2
	4+6	2.5 d	38.9
	4+6+8	3.1 d	38.9
Standard error		±3.7	±3.2

[1]Values with different letters within columns are significantly different according to Tukey's test (α=0.05)
[2] ns- no significant differences

Table 2. Mean carrot weevil (CW) damage in carrots in a trial evaluating application timings of EXIREL and RIMON 10 EC at the University of Guelph – Muck Crops Research Station, Holland Marsh, 2018.

Treatment	Application Timing (TLS)	CW Damage (%)[1,2]			Marketable Yield (t/ha)[2]
		Mid-Season	Harvest	Combined Average	
CONTROL[3]	N/A	3.7 b	23.7 a	13.7 ns	28.9 ns
EXIREL	2	5.0 b	20.7 a	12.8	34.5
	4	5.6 b	20.2 a	12.9	34.4
	2+4	3.4 b	20.3 a	11.8	36.5
	4+6	7.9 b	29.9 a	18.9	28.4
	2+4+6	2.1 b	19.4 a	10.7	31.6
Standard Error		±3.7	±3.7	±5.0	±5.0
CONTROL[3]	n/a	6.2 ab	16.4 a	11.3 a	42.0 ns
RIMON	2	1.3 b	6.7 ab	4.0 b	52.6
	4	3.3 b	7.2 ab	5.2 ab	45.2
	2 + 4	0.0 b	1.6 b	0.8 b	51.2
	2 + 4 + 6	0.0 b	1.9 b	1.0 b	54.6
	4 + 6	1.8 b	1.8 b	1.8 b	44.3
RIMON + EXIREL	2 (R) + 4 (E) + 6 (R) + 8 (E)	0.0 b	1.1 b	0.5 b	51.3
	2 (R) + 4 (E) + 6 (R) + 8 (R)	0.8 b	2.2 b	1.5 b	59.6
Standard Error		±3.0	±3.0	±2.1	±3.8

[1] Values with different letters within columns, or between the Mid-Season and Harvest column, are significantly different according to Tukey's test (α=0.05)
[2] ns = no significant differences
[3] Two separate trials are presented in the table.

ACKNOWLEDGEMENT: Funding for this project comes from the OMAFRA-University of Guelph Research Program, Bradford Co-op Storage, Ltd., Engage Agro, E.I. DuPont Canada Co., and Fresh Vegetable Growers of Ontario.

2018 PMR REPORT # 03 SECTION B: VEGETABLES and SPECIAL CROPS – Insect Pests

CROP: Carrots (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang), cv. Belgrado, Cellobunch, Enterprise
PESTS: Carrot Weevil, *Listronotus oregonensis* (LeConte)

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TITLE: FIELD EVALUATION OF THE IPM PROGRAM RECOMMENDATIONS FOR OF CARROT WEEVIL, 2017 AND 2018

MATERIALS: IMIDAN 70 WP (phosmet 70%), RIMON 10 EC (novaluron 10%)

METHODS: Carrots (cv. Belgrado and Enterprise at Site 1 in 2017 and 2018 respectively, Belgrado and Cellobunch at Site 2 in 2017 and 2018 respectively) were direct seeded (70 seeds/m) onto raised beds (86 cm rows) with a Stanhay precision seeder on 17 May 2017 and 18 May 2018 at the University of Guelph -Muck Crops Research Station (Site 1) and 18 May 2017 and 24 May 2018 at a nearby commercial field (Site 2). Plots were 15 X 7 m with three replications per treatment established in a randomized complete block design. Treatments consisted of control (no insecticide applications) or insecticide applications following CW action thresholds of either IMIDAN and RIMON, depending on treatment. CW was monitored using the Boivin trap, and in all years at all sites the 2nd action threshold was reached, justifying insecticide applications at the 2 and 4 true leaf stage. Applications of IMIDAN (1.6 kg/ha) or RIMON (820 ml/ha) were applied to the appropriate plots on 16 June and 14 July, 2017 and 15 and 29 June, 2018. All insecticides were applied using a tractor mounted sprayer fitted with TeeJet Air Induction Even Flat spray tips (AI9503 EVS) at 415 kPa calibrated to deliver 500 L/ha. In both years, between 2-8 August and 2-9 October, carrots from four random 1.16 m sections of row were taken from each plot to assess for carrot weevil (CW) damage. Carrot samples were washed in a small drum washer and visually inspected for CW damage, recording the number and weight of damaged and marketable carrots. Marketable was defined as no insect damage. Data were analysed using repeated measures ANOVA in Proc Mixed using SAS 9.4 (SAS Institute, Cary, NC) to determine the impact of treatments on CW damage and yield.

RESULTS: Results are presented in Table 1.

CONCLUSIONS: Overall, RIMON was effective at reducing CW damage when IPM recommendations of foliar applications at the 2nd and 4th true-leaf stage are followed. This was true both under high CW pressure at Site 1 and lower CW pressure at Site 2 over two years. These results also suggest IMIDAN fails to reduce CW damage, and in one instance higher damage was seen in the IMIDAN treated plots compared to the untreated control. This is potentially due to the IMIDAN treatment affecting CW natural enemy communities or in areas with long-term reliance on IMIDAN, resistance to IMIDAN may have developed in local CW populations. Based on these results, we are confident that RIMON is effective for CW control.

ACKNOWLEDGEMENT: Funding for this project comes from the Ontario Agri-Food Innovation Alliance, Bradford Co-Op Storage, Ltd., and the Fresh Vegetable Growers of Ontario.

Table 1. Evaluation of current carrot weevil (CW) integrated pest management recommendations[1] at two locations: Site 1 – Muck Crops Research Station and Site 2 – Commercial Field, Holland Marsh, Ontario, 2017 and 2018.

Site 1, 2017				
		CW Damage (%)		
Treatment	Yield (t/ha)[2,3]	Mid-Season Sample[5]	Late-Season Sample[5]	Combined Average[2]
CHECK	26.5 b	20.0 ab	38.0 a	29.0 a
IMIDAN	32.9 b	8.3 b	28.1 a	18.2 a
RIMON	46.5 a	1.2 b	5.2 b	3.2 b
Site 1, 2018				
		CW Damage (%)		
Treatment	Yield (t/ha)[3,4]	Mid-Season Sample[4]	Late-Season Sample[5]	Combined Average[2]
CHECK	50.1 ns	32.4 a	23.7 ab	28.0 a
IMIDAN	39.6	27.8 a	33.0 a	30.4 a
RIMON	50.2	8.6 b	11.0 b	9.8 b
Site 2, 2017				
		CW Damage (%)		
Treatment	Yield (t/ha)[3,4]	Mid-Season Sample[5]	Late-Season Sample[5]	Combined Average[2]
CHECK	71.8 ns	3.2 ns	4.7 ns	4.0 b
IMIDAN	75.6	8.4	9.5	9.0 a
RIMON	72.0	2.3	2.3	2.3 b
Site 2, 2018				
		CW Damage (%)		
Treatment	Yield (t/ha)[2,3]	Mid-Season Sample[5]	Late-Season Sample[5]	Combined Average[2]
CHECK	32.9 ns	3.5 ab	7.2 a	5.3 a
IMIDAN	38.0	0.7 ab	5.7 ab	3.2 ab
RIMON	41.0	0.2 b	0.8 ab	0.5 b

[1] These recommendations recommend up to two insecticide applications at the 2nd and 4th true-leaf stage if the first (1.5 cumulative carrot weevil/trap) and 2nd (5 cumulative carrot weevil/trap) threshold are reached using the Boivin trap. In all trials, both thresholds were reached and treated plots received two insecticide applications

[2] Values with different letters are significantly different according to LSD at $\alpha = 0.05$

[3] Yield in t/ha was extrapolated from the average marketable yield of two 1.5 m carrot row section samples on 3 Oct

[4] ns indicates all numbers in the column are not significantly different compared to the control at $\alpha = 0.05$

[5] Mid-season and late season values were assessed using repeated measures, therefore values with different letters are significantly different according to LSD at $\alpha = 0.05$ across both columns

2018 PMR REPORT # 04 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 VARIOUS COUNTIES IN SOUTHWESTERN ONTARIO, 2018

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

METHODS: DELTA 1 pheromone traps with a leek moth (*Acrolepiopsis assectella*) lure #40AS009 were set up in nine garlic fields in six counties in Southwestern Ontario from May 1 to May 14, 2018. Counties surveyed include Grey, Huron, Wellington, Brant, Renfrew and Kent. Traps were hung on wooden stakes approximately 40 cm above the ground. Pheromone lures were changed every two weeks and sticky cards were changed weekly. Traps with 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 1 trap per field. Depending on the location, traps were left in several fields after harvest to capture the third flight of the season.

RESULTS: As outlined in Figure 1.

CONCLUSIONS: Leek moth were detected at all locations surveyed during the 2018 field season. A spike of 38 leek moths was observed at a single location on July 19; the trap was removed permanently the same day the field was harvested (Figure 1). While leek moth counts were below 15 moths/card/week in the majority of the locations, only at the location with the spike of 38 leek moths was physical damage observed on several garlic plants. The three population spikes observed are consistent with previous studies that have indicated that there are three flights per season in Southwestern Ontario.

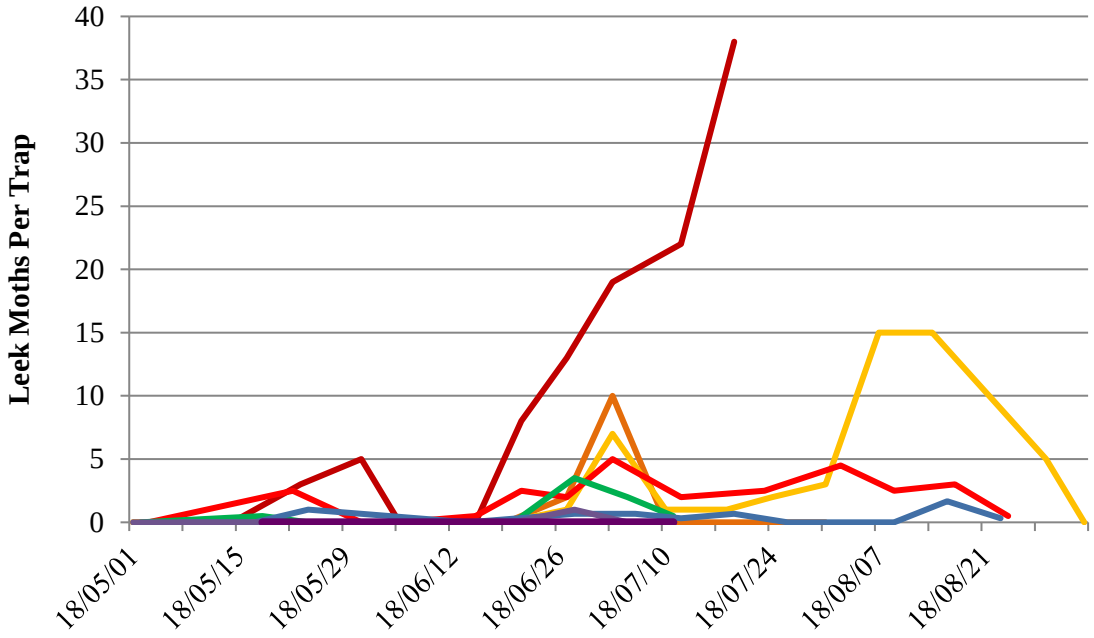

Figure 1. Average flies per sticky trap per week at garlic fields within the surveyed counties of Grey, Huron, Wellington, Brant, Renfrew and Kent.

ACKNOWLEDGEMENT: Thank you to Hannah Fraser, Cora Loucks, Dennis Van Dyk, Ashleigh Ahrens, Jordan Elshof, Josh Mosiondz, and Laura Stoltz for their help throughout the growing season.

2018 PMR REPORT #05 SECTION B: VEGETABLES and SPECIAL CROPS - Insect Pests

CROP: Yellow cooking onions (*Allium cepa* L.), cv. La Salle
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, 2018

MATERIALS: FARMORE F300 (APRON XL (metalaxyl-M and S-iromer 33.3%), MAXIM 4 FS (fludioxonil 40.3%), DYNASTY (azoxystrobin 9.6%)), PRO-GRO (carboxin 30% + thiram 30%), SEPRESTO (clothianidin 56.25%, imidacloprid 18.75%), REGARD (spinosad 22.5%), CRUISER 70 WS (thiamethoxam 70%), TRIGARD (cyromazine 75%), EVERGOL PRIME (penflufen 22.7%), LORSBAN 15 G (chlorpyrifos 15%)

METHODS: The trial was conducted on organic soil (pH ≈ 6.0, organic matter ≈ 70.4%) 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. La Salle, were seeded (≈ 35 seeds/m) on 7 May using a Stanhay precision seeder. Insecticide seed treatments applied at the manufacturers recommended rates were: SEPRESTO, REGARD + CRUISER, REGARD, TRIGARD and SEPRESTO + EVERGOL PRIME and SEPRESTO + EVERGOL PRIME + LORSBAN 15 G. A no-insecticide check and the no-insecticide check + LORSBAN 15G were also included. Refer to Table 1 for fungicides included in the treatments. All treatments and pelleting were done by Incotec using standard methods. Three randomly chosen 2 m sections of row were staked out in each replicate. Emergence counts were conducted within these 2 m sections on 5 June to determine initial stands. Beginning on 8 June and continuing weekly, plants within the 2 m sections were examined for onions lost due to maggot damage or damage caused by other pests. Damaged onions were removed and numbers and the cause recorded. The remaining onions within the assigned 2 m sections were removed and visually examined for maggot damage on 3 July (three weeks after the first generation peak), 13 August (three weeks after the second generation peak) and after lodging on 13 September. On 18 September, onions from a 2.32 m 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 & DISCUSSION: as presented in Tables 2 & 3

CONCLUSIONS: Significant differences in emergence were found among the treatments on 5 June. Onions grown from pellets containing EVERGOL PRIME (treatments 6 & 7) had significantly fewer plants emerged on 5 June (≈16 plants/m) than onions grown from all other treatments (Table 2). Total season onion maggot losses were low in the trial and ranged from 7 – 26%. No significant differences in the number of onions lost due to maggot damage were found among the treatments (Table 2). However, onions grown from pellets containing SEPRESTO + EVERGOL PRIME, TRIGARD or SEPRESTO + EVERGOL PRIME + LORSBAN 15 G had numerically fewer onions lost to maggot damage (7, 9, & 10% losses respectively) compared to onions grown from pellets without insecticide (check seed) (26% losses) (Table 2). Significant differences in the percentage of Jumbo and Canada No. 1 onions and onions per meter were found among the treatments (Table 3). EVERGOL PRIME treatments had fewer onions per meter at harvest than all other treatments and had more Jumbo onions than Canada No. 1 onions compared to all other treatments except for the REGARD treatment. This may be a result of low plant stands.

ACKNOWLEDGEMENT: Funding was provided by Incotec for seed pelleting, and by Bayer Crop Science for the Sepresto insecticide. 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. La Salle, pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

#	Treatment	Insecticide Active Ingredients and Label Rates
1	Check seed[1]	–
2	SEPRESTO[1]	clothianidin 0.18 g ai + imidacloprid 0.06 g ai/1,000 seeds
3	REGARD + CRUISER[1]	spinosad 0.2 g ai + thiamethoxam 0.2 g ai/1,000 seeds
4	REGARD[1]	spinosad 0.2 g ai/1,000 seeds
5	TRIGARD[1]	cyromazine 49.5 g ai/kg
6	SEPRESTO + EVERGOL PRIME[2]	clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds
7	SEPRESTO+ EVERGOL PRIME[2] + *LORSBAN 15 G*	clothianidin 0.18 g ai + imidacloprid 0.6 g ai/1,000 seeds + *chlorpyrifos 15% at 16 kg product/ha in-furrow*
8	Check seed[1] + *LORSBAN 15 G*	*15% chlorpyrifos at 16 kg product/ha in-furrow*

[1] Pellet also includes FarMore F300 (APRON XL (mefenoxam 0.075 g ai/kg), MAXIM 4FS (fludioxonil 0.025 gai/kg), DYNASTY (azoxystrobin 0.025 g ai/kg)) & PRO-GRO (carboxin 7.5 g ai/kg, thiram 12.5 g ai/kg seed)
[2] EVERGOL PRIME (penflufen 0.0087 g ai/1,000 seeds) fungicide seed treatment.

Table 2. Percentage of maggot damage in onions, cv. La Salle, treated with various insecticides and pelleted by Incotec and grown at the Muck Crop Research Station, Holland Marsh, Ontario, 2018.

#	Treatment[1]	Emergence 5 June (plants/m)	% Onions Lost Due to Maggot Damage		
			1st Gen	1st & 2nd Gen	Total Season
6	SEPRESTO + EVERGOL PRIME	16.5 d[2]	4.9 ns[3]	5.5 ns	6.7 ns
5	TRIGARD	25.8 b	1.6	4.5	9.0
7	SEPRESTO+ EVERGOL PRIME + LORSBAN 15G	16.3 d	6.4	11.4	9.9
2	SEPRESTO	27.9 a	1.7	9.8	12.1
4	REGARD	22.8 c	6.9	12.4	13.3
3	REGARD + CRUISER	27.6 a	3.5	9.0	17.4
7	Check seed + LORSBAN 15G	26.0 b	7.2	8.4	19.2
1	Check seed	24.5 b	8.1	12.1	25.9

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

Table 3. Yield and size distribution for onions, cv. La Salle, treated with various insecticides, pelleted by Incotec and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment[1]	Yield (t/ha)	% Mkb	Size Distribution (%)			Onions/ m
			Jumbo (>76mm)	Can. No. 1 (45-76mm)	Cull[2] (<45mm)	
SEPRESTO	81.9 ns[3]	98.0 ns	10.0 c[4]	88.0 ab	2.0 ns	30.9 a
Check seed	75.1	98.1	6.4 c	91.7 a	1.9	28.4 ab
REGARD + CRUISER	73.1	94.8	17.2 c	77.6 ab	5.2	28.4 ab
TRIGARD	71.6	95.5	14.7 c	80.7 ab	4.5	27.5 ab
Check seed + LORSBAN 15G	67.2	95.4	15.4 c	80.0 ab	4.6	26.1 b
REGARD	66.1	96.3	28.7 bc	67.6 bc	3.7	21.9 c
SEPRESTO+ EVERGOL PRIME + LORSBAN 15G	66.0	95.8	52.2 a	43.6 d	4.2	17.6 d
SEPRESTO + EVERGOL PRIME	52.5	93.8	41.4 ab	52.5 cd	6.2	16.3 d

[1] Treatment details are listed in Table 1.
[2] Cull category also includes unmarketable onions due to maggot damage.
[3] ns = no significant differences at P = 0.05, Fisher's Protected LSD test.
[4] Numbers in a column followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD test.

2018 PMR REPORT # 06 **SECTION H: PEST MANAGEMENT METHODS-BIOLOGICAL CONTROL**

CROP: Broccoli, *Brassica oleracea* L. var. *italic*
PEST: Cabbage looper, *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae)

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TITLE: **EVALUATION OF *BEAUVERIA BASSIANA* ISOLATES FOR THE CONTROL OF CABBAGE LOOPER, *TRICHOPLUSIA NI*, ON BROCCOLI VIA DIRECT AND RESIDUAL CONTACT APPLICATION**

MATERIALS: *Beauveria bassiana* isolates (ISH-189, ISH-190, ISH-252, ISH-285, OK-372, and OK-373), BOTANIGARD ® 22WP (*B. bassiana* strain GHA)

METHODS: The study was carried out at the Institute for Sustainable Horticulture (ISH) research laboratory at Kwantlen Polytechnic University (KPU), Langley campus, BC. Eggs of cabbage looper were purchased from Benzon Research Inc. (Carlisle, PA) and reared on disinfected organic broccoli leaves (*Brassica oleracea* L. var. *italica*) grown in the ISH research greenhouse. Four isolates of coastal *Beauveria bassiana*, ISH-189, ISH-190, ISH-252, and ISH-285, and two Okanagan isolates, OK-372 and OK-373, were selected as treatments. *BotaniGard*® and 0.1% Tween-20 were considered as positive and negative controls, respectively. The isolates were cultured on Potato Dextrose Agar in Petri dishes and kept in the dark at 25 ± 1°C, relative humidity (RH) 70 ± 5 % for two weeks. Conidial stock suspensions of *B. bassiana* isolates were prepared using conidia harvested from the cultures. However, conidia formulated as a commercially available wettable powder (BotaniGard ® 22WP) was used as the commercial standard. To obtain a concentration of 4×10^8 conidia/ml, either conidia harvested from culture, or a small amount of BotaniGard 22WP was suspended in Tween water (0.1% Tween-20 in sterile water) and counted using a Neubauer hemocytometer. Additionally, the number of viable conidia was determined by viability plate counts for each isolate. In the direct contact toxicity test, two microliters of 4×10^8 conidia/ml suspension of each treatment, as well as Tween water were directly applied to the dorsal body surface of each third instar larva (8×10^5 conidia/larva). The larvae were placed on broccoli leaf discs (2 cm diameter) in 2 oz. plastic cups, one larva per cup. For residual contact toxicity, 20 µl of a 4×10^8 conidia/ml suspension were painted on broccoli leaf discs (2 cm diameter). Leaves were allowed to dry for 30 minutes and each leaf disc was placed into one 2 oz. plastic cup containing a third instar larva. Four replicates of ten larvae per replicate were treated for each treatment, as well as controls, and incubated at 25 ± 1°C, 70 ± 5 % RH, and a 16:8 light/dark cycle. All larvae were assessed daily for mortality and sporulation. While alive, the larvae were fed with fresh, untreated leaves as needed and their frass was removed. Percent mortality on larvae, and LT_{50} and LT_{90} values on direct and residual contact toxicity were estimated for each *B. bassiana* isolate. To confirm that larval mortality was caused by *B. bassiana*, post-mortem examinations were employed. Statistical analysis was performed using

Probit to estimate lethal times with a confidence limit (CL) of 95% (LdP Line, Finney, 1971). Mortality was analyzed using one-way ANOVA and means were compared with Tukey's Honestly Significant Difference (HSD) test (SPSS Inc. 2002).

RESULTS: The results are summarized in Table 1 and 2.

CONCLUSION: The results showed that all isolates tested were capable of infecting and killing third instar larvae of cabbage looper (Table 1). Significant differences were observed among treatments via direct and residual contact toxicity ($p < 0.0001$). While residual conidia on host plant foliage was shown to cause mortality, direct application of *Beauveria* will provide faster control of larvae. In the direct contact toxicity trial, ISH-189, ISH-190 and ISH-252 demonstrated mortality greater than 90% five days after exposure and the same mortality was observed for the Okanagan isolates seven days post exposure. ISH-285 and BotaniGard showed greater than 60% mortality. By day nine, all isolates causing the highest mortality of *T. ni* larvae were only significantly different from the negative control. For residual contact toxicity, ISH-190 and ISH-252 were the most effective isolates five days after exposure. By the seventh day, ISH-190, ISH-252 and OK-373 caused 100% mortality of treated larvae but there was no statistical difference between these and ISH-189 and OK-372. On the ninth day, ISH-189, ISH-190, ISH-252, and OK-373 had all caused 100% mortality. OK-372 was insignificantly different from this group even though it displayed somewhat lower mortality. BotaniGard and ISH-285 had significantly lower efficacy than the four most efficacious isolates. All isolates killed the larvae between 1.06 to 2.09 times faster by direct contact as opposed to residual (Table 2). All isolates, either in direct contact or in residual (indirect), were effective to control cabbage looper larvae; however, the most toxic isolates to *T. ni* (i.e. lowest LT_{50} and LT_{90} values) were ISH-190 and ISH-252, killing 50% and 90% respectively, of larvae faster than the other isolates via both direct and residual contact. The next group, ISH-189, OK-372, and OK-373 all demonstrated faster mortality than BotaniGard. In conclusion, experiments on cabbage looper display 100% larval mortality caused by ISH189, ISH-190, ISH-252, OK-372, and OK-373 via direct and residual contact, excluding OK-372 by residual contact which showed 92.04% of larval mortality nine days after application. In conclusion, the coastal isolates (ISH-189, ISH-190, and ISH-252) and the Okanagan isolates (OK-372 and OK-373) have potential to control and manage cabbage looper, a serious lepidopteran pest in horticulture, via direct and residual contact. Further research trials should be conducted in the lab and field to evaluate the virulence of the isolates against other lepidopteran pests and optimize large scale production of the isolates.

ACKNOWLDGEMENT: We thank *BC Wine Grape Council* and *Natural Sciences and Engineering Research Council of Canada* for providing financial support.

Table 1. Percentage Mortality (mean ± SE) of third instar larvae of *T. ni* exposed to *B. bassiana* isolates via direct (D) and residual (R) contact toxicity

Treatments	Exposure Method	Days post exposure		
		5	7	9
ISH-189	D	93.33 ± 3.33 ^{ab}	100 ^{a}	100 ^{a}
	R	45.93 ± 7.73 ^{BC}	74.81 ± 9.97 ^{AB}	100 ^{A}
ISH-190	D	100 ^{a}	100 ^{a}	100 ^{a}
	R	96.67 ± 3.33 ^{A}	100 ^{A}	100 ^{A}
ISH-252	D	96.67 ± 3.33 ^{ab}	100 ^{a}	100 ^{a}
	R	95.83 ± 4.17 ^{AB}	100 ^{A}	100 ^{A}
ISH-285	D	10.0 ± 5.77 ^{d}	65.83 ± 15.3 ^{c}	96.67 ± 3.33 ^{a}
	R	0 ^{C}	15.74 ± 7.91 ^{C}	66.39 ± 2.17 ^{C}
OK-372	D	76.67 ± 6.67 ^{abc}	96.67 ± 3.33 ^{ab}	100 ^{a}
	R	43.21 ± 16.68 ^{C}	80.24 ± 3.095 ^{AB}	92.04 ± 4.14 ^{AB}
OK-373	D	61.48 ± 14.35 ^{bc}	93.33 ± 6.67 ^{abc}	100 ^{a}
	R	23.7 ± 18.43 ^{C}	100 ^{A}	100 ^{A}
BotaniGard®	D	55.09 ± 11.90 ^{c}	67.88 ± 5.01 ^{bc}	96.67 ± 3.33 ^{a}
	R	30.0 ± 11.55 ^{C}	55.0 ± 10.41 ^{B}	89.17 ± 0.83 ^{B}
Control (0.1% Tween-20)	D	0 ^{d}	0 ^{d}	0 ^{b}
	R	0 ^{C}	0 ^{C}	0 ^{D}

Values followed by different letters in columns, direct contact (lower case letters) and residual contact (upper case letters), are significantly different according to Tukey's test (0.05)

Table 2. LT_{50} and LT_{90} values for various *B. bassiana* isolates on third instar larvae of cabbage looper via direct and residual toxicity

Isolates	LT_{50} (days)		LT_{90} (days)	
	Direct Contact	Residual Contact	Direct Contact	Residual Contact
ISH-189	2.55	5.32	6.59	7.89
ISH-190	2.05	3.17	3.65	5.19
ISH-252	3.0	3.17	5.35	5.38
ISH-285	6.65	8.13	8.56	10.78
OKA-372	3.35	5.49	6.49	9.42
OKA-373	3.45	4.87	7.77	7.58
BotaniGard®	4.52	6.18	9.46	11.02

2018 PMR REPORT # 07 **SECTION H: PEST MANAGEMENT METHODS-BIOLOGICAL CONTROL**

CROP: Broccoli, *Brassica oleracea* L. var. *italica*
PEST: Diamondback moth, *Plutella xylostella* Linnaeus (Lepidoptera: Plutellidae)

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TITLE: **EVALUATION OF *BEAUVERIA BASSIANA* ISOLATES FOR THE CONTROL OF DIAMONDBACK MOTH, *PLUTELLA XYLOSTELLA*, ON BROCCOLI VIA DIRECT AND RESIDUAL CONTACT APPLICATION**

MATERIALS: *Beauveria bassiana* isolates (ISH-189, ISH-190, ISH-252, ISH-285, OK-372, and OK-373), BOTANIGARD ® 22WP (*B. bassiana* strain GHA)

METHODS: The assay was conducted at the Institute for Sustainable Horticulture (ISH) research laboratory at Kwantlen Polytechnic University (KPU), Langley campus, BC. The egg sheets of diamondback moth were purchased from Benzon Research Inc. (Carlisle, PA) and reared on disinfected organic broccoli leaves (*Brassica oleracea* L. var. *italica*) grown in the ISH research greenhouse. Four isolates of *Beauveria bassiana* retrieved from the coastal area of BC, ISH-189, ISH-190, ISH-252, and ISH-285 and two from the Okanagan region of BC, OK-372 and OK-373, were applied via direct and indirect (residual) contact. *BotaniGard* and 0.1% Tween-20 were applied as positive and negative controls, respectively. The isolates were cultured on Potato Dextrose Agar in Petri dishes and kept in the dark at 25 ± 1°C, RH 70 ± 5 % for 2 weeks. Conidial stock suspensions of each BC isolate of *B. bassiana* were prepared using conidia harvested from the Petri dish cultures suspended in 0.1% Tween-20. However, conidia formulated as a commercially available wettable powder (BotaniGard ® 22WP) was used as the commercial standard. Conidial concentrations were adjusted to 4×10^8 conidia/ml per isolate using a Neubauer hemocytometer, and viability plate counts. In the direct contact toxicity test, one microliter of the 4×10^8 conidia/ml suspension of each isolate was directly applied to the dorsal body surface of each third instar larva of diamondback moth (4×10^5 conidia per larva). One microliter of a 0.1% Tween-20 solution without fungal spores per larva was used as the negative control treatment. The larvae were placed on 2 cm diameter broccoli leaf discs in one ounce Solo® cups, one larva per cup. For residual toxicity, a 20 µl aliquot of a 4×10^8 conidia/ml suspension (or the Tween solution for the negative control) was painted on each 2cm diameter broccoli leaf disc (8×10^6 conidia per leaf disc) for each treatment. Leaves were allowed to dry for 30 minutes before being placed with one 3rd instar larva into Solo® cups. Four replicates per treatment consisting of ten larvae per replicate were treated and incubated at 25 ± 1°C with RH 70 ± 5 % and a 16:8 hour light: dark cycle in a completely randomized design. Larvae were checked daily for ten days (or until death and sporulation). Live larvae were fed with fresh, untreated leaves as needed and their frass removed. Percent mortality of the larvae and LT_{50} and LT_{90}

values of isolates on direct and residual contact toxicity were estimated. To confirm that mortality of larvae had been caused by *B. bassiana*, post mortem autopsy examinations were employed. Probit analysis was used to estimate lethal times of the isolates with 95% confidence limit (CL) (LdP Line, Finney, 1971). Mortality was analyzed using one-way ANOVA and means compared with Tukey's honestly significant difference (HSD) test (SPSS Inc. 2002).

RESULTS: The results are summarized in Table 1 and 2.

CONCLUSIONS: Isolates of ISH-189, ISH-190, ISH-252, OK-372, OK-373, and BotaniGard showed the highest efficacy (100% mortality) against *P. xylostella* third instar larvae at 4×10^8 conidia/ml concentration in both direct and residual contact toxicity by 9 days after exposure (Table 1). ISH-189, ISH-190, ISH-252, and OK-372 caused the highest mortality by the 3rd day post exposure via direct contact toxicity but there were no significant differences between these isolates and OK-373. BotaniGard had significantly lower mortality than the first four isolates; however, there was no significant difference between BotaniGard and OK-373. On the 5th to 9th days after exposure via both methods, ISH-189, ISH-190, ISH-252, OK-372, and OK-373 caused high mortality (90% -100%) to the larvae. BotaniGard also caused high mortality with direct exposure and very good efficacy with residual exposure to the larvae. In contrast, ISH-285 did not appear to be efficacious and showed the lowest mortality. Larval mortality was 10% in the negative control after 9 days following direct exposure to 0.1% Tween 20; whereas, residual exposure to 0.1% Tween 20 lead to only 2.5% mortality after 9 days. *B.bassiana* isolates were able to kill 50% of the treated population 1.3 to 2.49 times earlier by direct contact compared with residual toxicity (Table 2). Based on LT_{50} values from direct contact treatments, ISH-190 was able to kill 50% of treated larvae faster than the other isolates, which in declining order are ISH-189, OK-372, ISH-252, OK-373 and BotaniGard. By contrast, LT_{50} values from residual treatments showed OK-372 placed first in efficacy, followed by ISH-190, ISH-189, OK-373, ISH-252 and BotaniGard, respectively. In summary, more than 90% of third instar larvae of diamondback moth were killed using *B. bassiana* isolates ISH-189, ISH-190, ISH-252, OK-372, and OK-373 via direct or residual contact approximately 3-5 days after application.

ACKNOWLDGEMENT: We thank *BC Wine Grape Council* and *Natural Sciences and Engineering Research Council of Canada* for providing financial support.

Table 1. Mortality (%) ± SE of *P. xylostella* third instar larvae exposed to *B. bassiana* isolates at 4×10^8 conidia/ml of concentration via direct (D) and residual (R) contact toxicity

Treatments	Exposure Method	Days post exposure			
		3	5	7	9
ISH-189	D	100 ^{a}	100 ^{a}	100 ^{a}	100 ^{a}
	R		95.0 ± 2.89 ^{AB}	97.5 ± 2.5 ^{A}	100 ^{A}
ISH-190	D	100 ^{a}	100 ^{a}	100 ^{a}	100 ^{a}
	R		97.5 ± 2.5 ^{AB}	100 ^{A}	100 ^{A}
ISH-252	D	92.5 ± 4.79 ^{a}	100 ^{a}	100 ^{a}	100 ^{a}
	R		100 ^{A}	100 ^{A}	100 ^{A}
ISH-285	D	15.0 ± 6.45 ^{c}	22.5 ± 6.29 ^{b}	27.5 ± 8.5 ^{b}	40.0 ± 10.8 ^{b}
	R		0.0 ^{C}	7.5 ± 4.79 ^{B}	10.0 ± 7.07 ^{B}
OK-372	D	97.5 ± 2.5 ^{a}	97.5 ± 2.5 ^{a}	100 ^{a}	100 ^{a}
	R		100 ^{A}	100 ^{A}	100 ^{A}
OK-373	D	81.87 ± 4.49 ^{ab}	91.87 ± 4.9 ^{a}	100 ^{a}	100 ^{a}
	R		92.22 ± 4.84 ^{AB}	100 ^{A}	100 ^{A}
BotaniGard®	D	67.59 ± 5.47 ^{b}	100 ^{a}	100 ^{a}	100 ^{a}
	R		88.24 ± 3.4 ^{B}	100 ^{A}	100 ^{A}
Control (0.1% Tween20)	D	3.33 ± 1.92 ^{c}	4.17 ± 2.5 ^{c}	9.17 ± 3.7 ^{c}	10.0 ± 3.6 ^{b}
	R		0 ^{C}	0 ^{B}	2.5 ± 1.6 ^{B}

Values followed by different letters in columns, direct contact (lower case letters) and residual contact (upper case letters), are significantly different according to Tukey's test (0.05)

Table 2. Lethal time values (LT_{50} and LT_{90}) for *B. bassiana* isolates at 4×10^8 conidia/ml of concentration on third instar of *P. xylostella* via direct and residual contact toxicity

Isolates	LT_{50} (days)		LT_{90} (days)	
	Direct Contact	Residual Contact	Direct Contact	Residual Contact
ISH-189	1.41	3.46	1.85	5.48
ISH-190	0.97	2.03	1.58	3.67
ISH-252	1.58	3.93	2.8	7.02
OK-372	1.46	1.85	4.28	2.87
OK-373	2.12	3.56	2.06	5.25
BotaniGard®	2.37	4.28	4.65	5.22

2018 PMR REPORT #08 **SECTION H: PEST MANAGEMENT METHODS-BIOLOGICAL CONTROL**

CROP: Carrot, *Daucus carota* L., cv. Neptune
PEST: Carrot weevil, *Listronotus oregonensis* (LeConte)

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TITLE: ENTOMOPATHOGENIC NEMATODES FOR CARROT WEEVIL CONTROL

MATERIALS: STEINER SYSTEM (BIOBEST), *Steinernema feltiae*
B-GREEN SYSTEM (BIOBEST), *Heterorhabditis bacteriophora*

METHODS: Field trials in Ontario were conducted using commercially available nematode products from BioBest, available from PlantProtect. Two products, Steiner System (*S. feltiae*) and B-Green System (*H. bacteriophora*) were tested using the label rates: 1 M nematodes / m^2 (B-Green) and 0.5 M nematodes / m^2 (Steiner), delivered in water and applied at a rate of 1000 L/ha. Following application the plots were irrigated for 1 hour in the evening and for 1 hour for the next 3 evenings. Plots of carrot were 5 m in length and 2 beds wide, each bed being double-seeded with carrot in June of 2018. One site was established at the Harrow Research and Development Centre. Each product was applied twice early in the season and twice later in the season generating 9 treatments: control (water only), early 1 Steiner, early 1 B-Green, early 2 Steiner, early 2 B-Green, late 1 Steiner, late 1 B-Green, late 2 Steiner and late 2 B-Green. Products were applied using a backpack CO_2 sprayer. Early 1 application occurred on 6 July (3-5 true leaf stage), Early 2 occurred on 27 July (8-9 true leaf stage), Late 1 occurred on August 10 (11-12 true leaf stage) and Late 2 occurred on 6 September (full canopy). Five replicates of each treatment were organized in a randomized design. At the time of application of the product soil moisture readings were taken using a SpecWare TDS soil moisture gauge. Nematode survival was determined by sampling each plot 4 days, 3 and 6 weeks after application of the product. Soil cores were randomly taken to remove approximately 125 mL of soil each time from each plot and brought to the lab in Petri dishes (10 cm diam.) Waxworms (*Galleria* spp.) were placed on each soil sample and evaluated for infectivity after 1 week. At harvest (October) carrots were sampled by digging up a 0.75 m length in each bed and assessing the carrots for carrot weevil damage in the lab. Percentage of carrots with damage were analysed for differences between treatments using ANOVA following by.a post hoc Tukey test with Bonferroni correction in R.

RESULTS: Entomopathogenic nematode products gave variable results with respect to carrot weevil control. Best results were attained with the Steiner and B-Green Systems applied early showing significantly less damage than the Control (Figure 1). Nematode infectivity was excellent for the B-Green System with rates ranging from 78-98% in three out of four applications (Early 1, Early 2 and Late 2) (Table 1). Nematodes were infective 11 weeks post application with both Early 1 and Early 2 application, but not for the Late applications. Steiner System had high infectivity when applied Early 2 and Late 2 (100 and 98%, respectively), but the Early 1 application had low infectivity (39%).

Nematodes were infective 11 weeks post application of the Steiner System with both Early 1 and 2 applications, but not the Late 2. A similar experiment was conducted in Nova Scotia, but carrot weevil damage within the field was too low to obtain significant results.

CONCLUSIONS: Entomopathogenic nematodes represent a potential biocontrol measure against carrot weevil if applied early in the season. From this work, a single application of either *Heterorhabditis bacteriophora* (B-Green) or *Steinernema feltiae* (Steiner System) was sufficient to reduce damage from carrot weevil by 20%. Later applications did not significantly reduce carrot weevil damage compared with the control. From an economic perspective, use of the Steiner System would be more cost-effective as similar control is achieved with half the rate and the nematodes have greater infectivity and longevity in the soil than B-Green. Further work to determine the best timing of application and if the nematodes will survive the winter thus providing residual control the following year is recommended.

Table 1: Mean percentage of waxworms infected with nematodes at time of application and at 2, 5, 8 and 11 weeks following application. Early 1 = 3-5 true leaf stage, Early 2 = 8-9 true leaf stage, Late 1 = 11-12 true leaf stage and Late 2 = full canopy.

		Percentage of waxworms infected				
Treatment	Timing	Application	2 weeks	5 weeks	8 weeks	11 weeks
Control	Early 1	0.0	0.0	0.0	6.0	0.0
	Early 2	0.0	0.0	6.0	0.0	0.0
	Late 1	10.0	12.0	0.0	0.0	0.0
	Late 2	2.0	4.0	0.0	0.0	0.0
B-Green	Early 1	78.0	22.0	44.0	10.0	6.0
	Early 2	84.5	38.0	8.0	4.0	6.0
	Late 1	44.2	14.0	22.0	0.0	0.0
	Late 2	94.0	60.0	24.0	10.0	0.0
Steiner*	Early 1	39.6	8.0	28.0	4.0	4.0
	Early 2	100.0	82.0	70.0	62.0	24.0
	Late 2	98.0	92.0	84.0	80.0	0.0

*Late 1 application missing as product arrived and nematodes were dead.

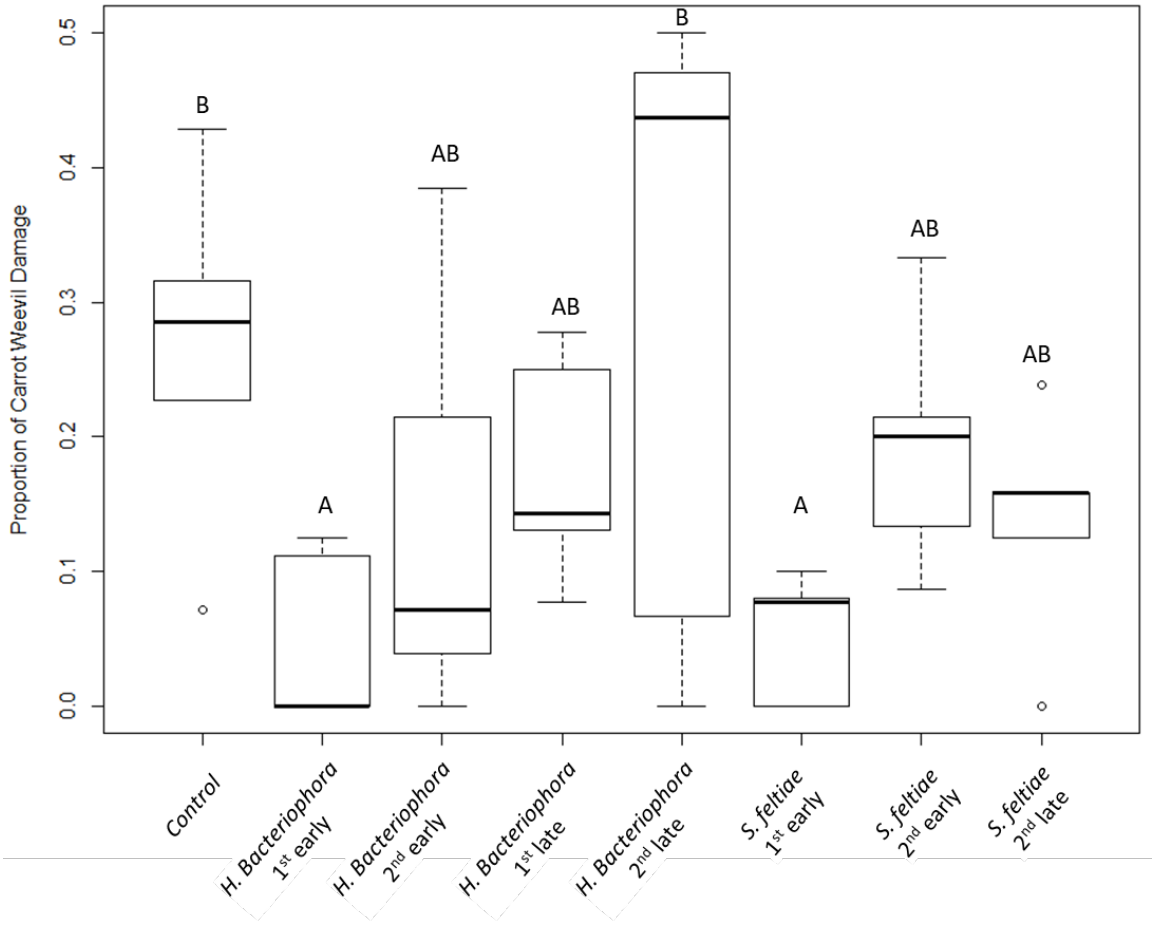

Figure 1: Boxplot of carrot weevil damage from plots treated with entomopathogenic nematode products Steiner and B-Green Systems applied at four different times during the growing season. Bars with different letters significant ($P < 0.10$). Early 1 = 3-5 true leaf stage, Early 2 = 8-9 true leaf stage, Late 1 = 11-12 true leaf stage and Late 2 = full canopy.

2018 PMR REPORT # 09 **SECTION H: PEST MANAGEMENT METHODS – BIOLOGICAL CONTROL**

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

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TITLE: **FIELD DEMONSTRATION OF THE STERILE FLY RELEASE TECHNOLOGY FOR ONION MAGGOT MANAGEMENT IN ONION SET PRODUCTION IN ONTARIO**

MATERIALS: Sterilized/irradiated *Delia antiqua* pupae.

METHODS: Two fields of onion sets approximately 4.3 km apart were sown in Granby sandy loam near Exeter, Ontario in the spring of 2018. Both fields were seeded at a high density of ~20 million seeds / ha (~8 million seeds / ac) with no soil application of chlorpyrifos. The release field was approximately 7.4 ha (18.3 ac) in size and was sown on 10 May. The control field was approximately 3.7 ha (9.3 ac) in size and was seeded one week after the release field approximately 4.3 km away (**Figure 1**). There were no other major onion fields within a 20 km radius from either the control or release field. The field used for onion sets the previous year (2017), was approximately 2.8 km and 2.9 km away from the control and release fields respectively. Onion flies were produced by Phytodata Inc., and then sterilized and released according to the protocol developed by Phytodata Inc., using the Sterile Insect Technology (SIT). The *Delia antiqua* pupae were irradiated by Nordion and then shipped to Guelph, ON, and kept alive until release following protocols developed by Phytodata Inc. Four onion maggot sticky traps consisting of three stakes with blue sticky cards clipped above the crop canopy were placed on each side of both fields (**Figure 2B**). 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 began on May 16 and continued weekly until September 11. Flies were released on the north-west corner of the release field at least 30 m from the closest sticky card trap at the west side of the field. Damage plots measuring 30 x 30 cm capturing approximately 100 plants were set up a short distance away from the sticky traps at the flag leaf stage on May 29 at each of the four sites per field (**Figure 2A**). The number of plants were counted weekly until August 7. In addition, 50 onion plants were harvested every week starting on July 10 to September 3 to monitor for maggot damage (**Figure 2C**). The control field was harvested September 7 and the release field was harvested September 14. The final fly release took place September 11 and the final sticky card assessment was on September 19. Weather parameters were measured hourly using a HOBO datalogger U30 RX3000 (Onset Computer Corporation) from April 11 onwards. Weather data from April 1 to April 10 was collected for degree day modeling from a nearby weather station (43.437, -81.654) approximately 12.3 km from the field site. An onion maggot degree day model was used to track the development and predict the generation time of adult flies. Degree day values using a base of 4°C started to accumulate April 1 using the following formula: ((Max Temp + Min Temp)/2) – 4°C.

RESULTS: Sticky card counts throughout the season indicate that the control field had a higher fertile fly pressure than the release field from June 13 until harvest (**Figure 3**). An average of 2.2 flies/trap/week were counted per trap in the release field compared to 5.4 flies/trap/week in the control (**Table 1**). Pink flies were found at every trap at the release field but most were quantified throughout the season at the west trap which was 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. Degree day modeling predicted generational peaks for onion maggot fly emergence to occur May 16 (1st Generation, 210DD), July 5 (2nd generation, 1025DD) and August 17 (3rd generation, 1772DD) using the DD model ((Max Temp + Min Temp)/2) – 4°C with values accumulating after April 1st (**Figure 4**). The emergence peak observed in the field on July 24 was ~19 days after the predicted second generation emergence and ~24 days before the third generation emergence. It is likely that the second emergence peak occurred July 24 and the third emergence occurred between August 15 and August 28 when the sticky cards were compromised due to a weather event. Sticky card trap counts indicated that the main spike in fertile flies at both field sites occurred the week leading up to July 24, (release: 27 flies/trap/week, control: 10 flies/trap/week). The emergence peak observed in the field on July 24 was ~19 days after the predicted second generation emergence and ~24 days before the third generation emergence. Damage plots showed a stand loss of 43% ((74/131)-1) in the release field and 28% ((75/104)-1) in the control (**Table 1**). Destructive sampling did not find any onion maggot larvae throughout the season. The level of onion maggot damage in these fields this year was low relative to other years (Grower correspondence).

CONCLUSION: Onion maggot (*Delia antiqua*) management relies heavily on group 1B organophosphates, specifically chlorpyrifos insecticides which have been identified as a major surface water contaminant in some vegetable growing areas. The prospect of insecticide resistance and potential restrictions of use illustrate the importance of alternative management strategies for this insect. Throughout this trial, sticky cards were the only monitoring strategy that could compare insect levels between the two fields since destructive sampling did not find any onion maggot larvae throughout the season. Differences in stand-loss observed by damage plots between the two fields showed a 43% loss in the release field and 28% in the control. Given the higher seeding density of the field, it is likely that competition for space and moisture resulted in the greater stand loss percentage in the release field compared to the control. Overall, both fields were harvested with roughly the same density of onions at harvest between the two fields. Sterile Insect Technology (SIT) in Quebec has proven to eliminate the application of soil and foliar chlorpyrifos insecticides in most fields while maintaining onion yields comparable to pesticide-based programs. Onion acreage in Quebec using SIT has grown from 140 ha in 2011 to 680 ha in 2017. Work in Quebec 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.

ACKNOWLEDGEMENT: 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, Jordan Elshof, Josh Mosiondz, and Laura Stoltz for their help throughout the growing season.

Table 1. Sterile fly release dates, plant stage, trap counts and damage plot levels.

		Release Field				Control Field			
Date	Release Quantity ('000)	Plant Stage [1]	Fertile Flies	Pink Flies	Damage Plots	Plant Stage[1]	Fertile Flies	Pink Flies	Damage Plots
18/05/16	56	pre	--	--	--	pre	--	--	--
18/05/23	69	loop	1.4	0.7	--	loop	1.9	0.0	
18/05/29	85	flag	1.1	0.3	131	loop	1.6	0.0	86
18/06/05	108	flag	3.4	0.1	--	flag	1.2	0.0	--
18/06/13	155	1LS	1.2	0.9	119	1LS	2.7	0.0	104
18/06/19	182	2LS	1.2	1.0	104	2LS	2.8	0.0	93
18/06/27	182	3LS	1.3	0.2	101	3LS	4.6	0.0	89
18/07/03	155	3LS	0.9	0.6	106	3LS	2.4	0.0	80
18/07/10	142	4LS	0.3	0.1	105	3LS	3.6	0.0	88
18/07/17	101	4LS	1.5	0	104	4LS	2.7	0.0	90
18/07/24	56	5LS	10.7	0	96	4LS	27.4	0.0	85
18/07/31	46	5LS	1.6	0.3	93	5LS	3.3	0.0	89
18/08/07	77	5LS	1.6	0.3	74	5LS	3.8	0.0	75
18/08/14	60	5LS	1.9	0.9	--	5LS	9.5	0.0	--
18/08/22	41	5LS	--	--	--	5LS	--	--	--
18/08/29	34	5LS	--	--	--	5LS	--	--	--
18/09/03	42	5LS	3.9	0.8	--	5LS	9.6	0.0	--
18/09/11	36	5LS	1.6	0.6	--	post	4.1	0.0	--
18/09/19	--	post	2.3	6.3	--	post	5.0	0.0	--

[1] Plant stage where pre = pre-emergence, loop = loop stage, flag = flag leaf stage, LS = leaf stage and post = after harvest

-- = Data points not taken or no flies were released

Table 2. Insecticide applications from seeding to harvest.

Date	Field	Trade Name	Common Name	Rate / Acre
18/06/08	Control	Matador	Lambda-cyhalothrin	75 mL
18/06/29	Release	Mako	Cypermethrin	70 mL
18/07/06	Control + Release	Matador	Lambda-cyhalothrin	75 mL
18/07/18	Control + Release	Agri-mek	Abamectin	100 mL
18/07/25	Control	Mako	Cypermethrin	70 mL
18/07/27	Control	Dibrom	Naled	200 mL
18/08/01	Release	Mako	Cypermethrin	70 mL
18/08/04	Control	Dibrom	Naled	200 mL

Figure 1. The control field (**A**) was approximately 3.7 ha (9.3 ac) in size while the release field (**B**) was situated 4.3 km away and was approximately 7.4 ha (18.3 ac) in size.

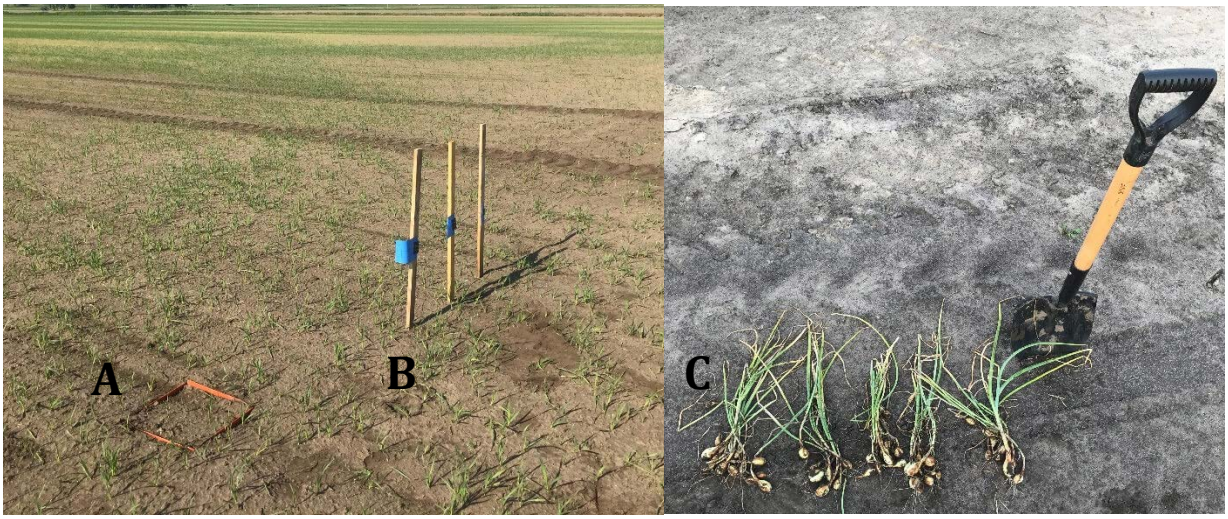

Figure 2. Damage plots (**A**), sticky cards (**B**) and destructive sampling (**C**) conducted on various dates outlined in **Table 1**.

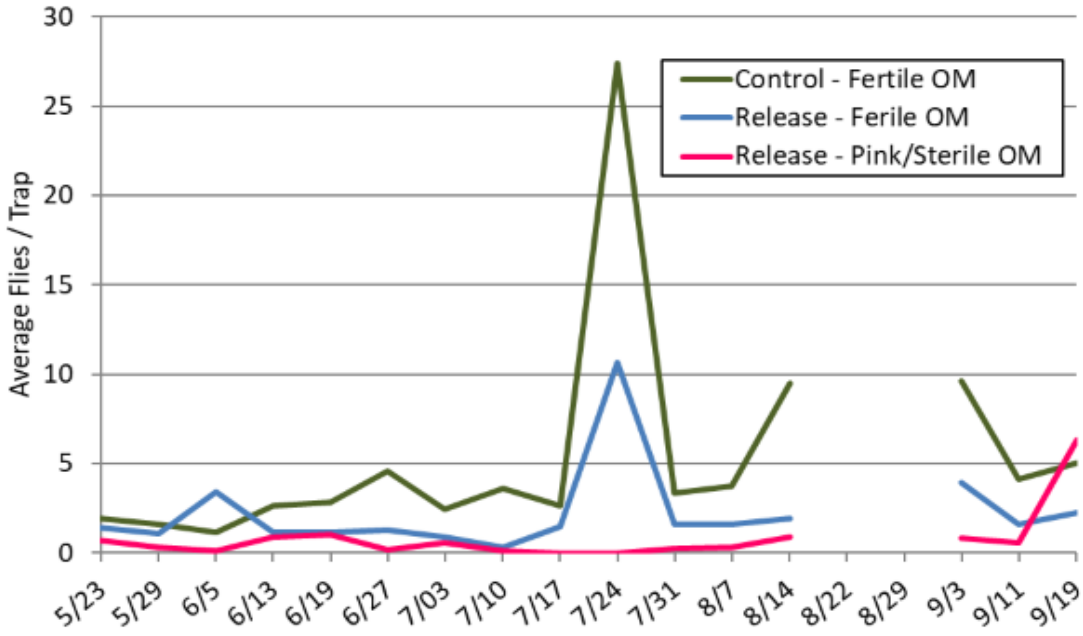

Figure 3. Average flies per sticky trap per week at both field sites. Fertile fly counts at the control field (green) were generally higher than counts at the release field (blue). Sterile flies were found in relatively low numbers at the release field (pink) while no sterile flies were found at the control field 4.3 km away.

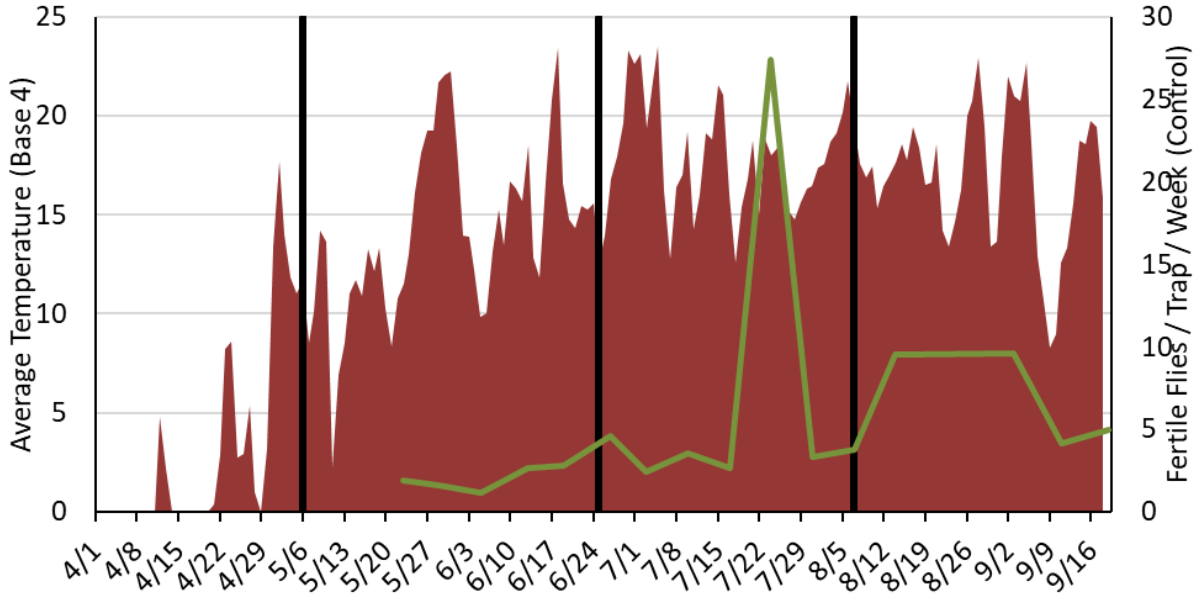

Figure 4. Growing Degree Days values (red) using a base of 4°C from April 1st using the formula: ((Max Temp + Min Temp)/2) – 4°C. Generational peaks for onion maggot fly emergence (black columns) were predicted to occur May 16 (1st Generation, 210DD), July 5 (2nd generation, 1025DD) and August 17 (3rd generation, 1772DD). Average fertile flies per sticky trap per week from the control field (green) on secondary axis.

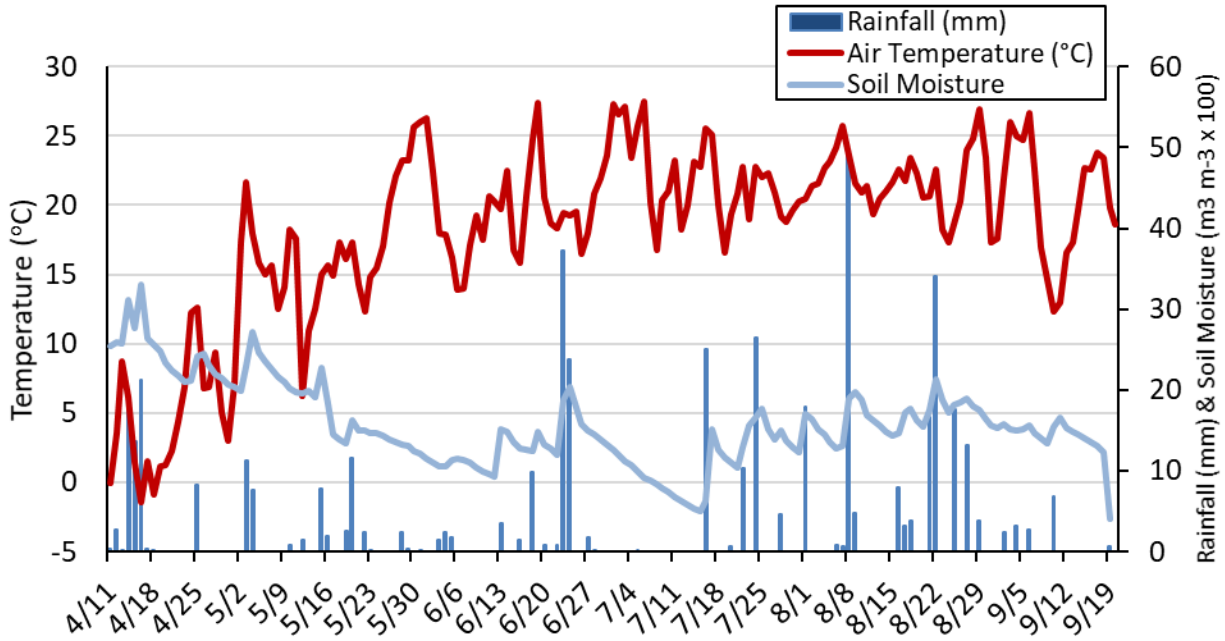

Figure 5. Ambient temperature (°C), rainfall (mm) and relative humidity (%) taken from the onsite weather station.

2018 PMR REPORT #10 **SECTION J: NEMATODES**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.), cv. Enterprise
PESTS: Carrot cyst nematode, (*Heterodera carotae* Jones)

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TITLE: FIELD EVALUATIONS OF NEMATICIDES AND FUMIGANTS FOR CARROT CYST NEMATODE CONTROL IN CARROTS, 2018

MATERIALS: BUSAN (metam sodium 42.5%), GRANDEVO (*Chromobacterium subtsugae* strain PRAA4-1), MAJESTENE (*Burkholderia* spp. strain A396), PIC PLUS (chloropicrin 86%), SALIBRO (fluazaindolizine), VELUM PRIME (fluopyram 50%)

METHODS: The trial was conducted in a commercial field known to be infested with carrot cyst nematode (*Heterodera carotae*) in the Holland/Bradford Marsh, Ontario. A randomized complete block design with five replicates per treatment was used. The pre-seedling treatments included BUSAN at 467 L/ha rate and a high rate of PIC PLUS at 108 L/ha and were applied on May 24, and 28 respectively. BUSAN was applied using a 2 meter wide custom fumigator with 14 John Blue fumigant shanks spaced 17 cm apart, product was applied 25 cm below the soil surface. The BUSAN was immediately sealed into the soil with a roller attached to the fumigator. PIC PLUS was applied 25 cm below the carrot hills using shanks attached directly to the bed shaper of the carrot seeder
Treatments at seeding were: GRANDEVO at 4.0 kg/ha, MAJESTENE at 20 L/ha, and VELUM PRIME at 500 mL/ha applied over the seed using StreamJet nozzles SJ3-03-VP to apply the solution at 16.8 mL/m. A low rate of PIC PLUS at 54 L/ha applied using the same method described above. SALIBRO at 4.48 L/ha was applied as a drench directly over beds after seeding on 27 June using watering containers, applying the solution at 400 mL/m.
Carrots, cv. Enterprise, were direct seeded in all treatments at 65 seeds/m on raised beds on 1 June. Each experimental unit consisted of three rows, 66 cm apart and 11 m in length. An untreated check was also included. Ten soil cores were taken from each replicate to create one soil sample on 23 May (pre-plant) and 10 July (post-treatment) using a 25 cm long soil probe. Pre-plant samples were sent for analysis to the University of Guelph Agriculture and Food Laboratory which uses the Baermann pan method for nematode extraction. Post-treatment samples were extracted at the University of Guelph Muck Crops Research Station using the Baermann pan method.
A harvest sample of carrots from two 1.5 m sections of row were harvested by hand on 18 October and placed in cold storage until assessment on 31 October. Carrot samples were assessed for nematode damage (stunting and forking) and sorted into the following classes: 0 = no galling or forking (healthy); 1 = very minor stunting or forking with no noticeable cysts; 2 = minor stunting and forking with no noticeable cysts; 3 = moderate stunting and forking with possible visible cysts; 4 = moderate to severe stunting and forking with probable visible cysts; 5 = very severe stunting with visible cysts. Marketable yield was also determined from the harvest samples. The damage severity index (DSI) was determined using the following equation:

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

Compared to the previous 10-year average, air temperatures in 2018 were above average for May (15.8°C), August (21.9°C), September (17.5°C), average for June (18.4°C), July (22.0°C) and below average for October (8.3°C). The 10-year average temperatures were: May 13.9°C, June 18.6°C, July 21.2°C, August 20.1°C, September 16.0°C and October 9.4°C.

Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm), July (104 mm), October (69 mm) and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, September 67 mm and October 72 mm.

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 LSD test with $P = 0.05$ level of significance.

RESULTS: Data are presented in Tables 1 and 2.

CONCLUSION: There was a high amount of variability in the distribution of the nematodes in this trial and nematode damage was moderate overall. There were no significant differences found among the products and the untreated check. The untreated check had numerically the lowest percent marketable carrots and highest nematode damage.

Table 1. Percent marketable, percent nematode damage, damage severity index (DSI), and marketable yield for carrots, cv. Enterprise, grown in soil treated with fumigants and non-fumigant nematicides in the Holland Marsh, Ontario, 2018.

Treatment	% Marketable Carrots	% Nematode Damage	DSI[2]	Marketable Yield (t/ha)
HIGH PIC PLUS	88.1 ns[1]	11.9 ns	5.2 ns	42.7 ns
LOW PIC PLUS	86.7	13.3	7.5	50.6
VELUM PRIME	84.1	15.9	8.6	36.8
GRANDEVO	83.0	17.0	9.0	36.8
SALIBRO	81.6	18.4	9.7	38.4
BUSAN	79.6	20.4	10.4	36.7
MAJESTENE	77.8	22.2	10.1	42.6
Check	73.2	26.8	13.7	36.2

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

[2] DSI was calculated using the following equation:

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

Table 2. Carrot cyst nematode soil counts (juveniles/kg of dry soil) and reproduction ratio from carrot soil before (pre-plant) and after (post-treatment) treatment with fumigants and non-fumigant nematicides in the Holland Marsh, Ontario, 2018.

Treatment	Carrot Cyst Nematode Counts (juveniles/kg dry soil)		Reproduction Ratio[2]
	Pre-plant (23 May)	Post-treatment (10 July)	
HIGH PIC PLUS	1028 ns[1]	566 ns	-0.5 ns
LOW PIC PLUS	1096	1099	0.0
VELUM PRIME	1420	1697	0.2
GRANDEVO	452	2004	3.4
SALIBRO	1144	1988	0.7
BUSAN	2840	420	-0.9
MAJESTENE	1484	2117	0.4
Check	412	1034	1.5

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

2018 PMRR REPORT # 11 **SECTION K: Fruit Diseases**

CROP: Strawberry (*Fragaria* x *ananassa* Duchesne), cv. Donna and Governor Simcoe
PEST: Anthracnose (*Colletotrichum* spp.)

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TITLE: EVALUATION OF FUNGICIDES FOR CONTROL OF *COLLETOTRICHUM* SPP. IN STRABERRIES

MATERIALS: INSPIRE SUPER (difenoconazole 86 g/L, cyprodinil 249 g/L), CABRIO (pyraclostrobin 20%)

METHODS: Two field trials were conducted at the Simcoe Research Station, Simcoe in 2016. Strawberries were planted in May 2014 and grown using a matted-row planting system. Rows were spaced 1.2 m apart and plants were spaced 0.3 m apart in the row. Plots consisted of one 4 m long row. Treatments were: INSPIRE SUPER (2950 ml/ha), INSPIRE SUPER (1161 ml/ha), INSPIRE SUPER (1475 ml/ha), CABRIO (750ml/ha) plus an untreated control and were arranged in a randomized order with four replications. Products were applied using a CO_2 backpack sprayer equipped with two TeeJet XR8010 nozzles spaced 50 cm apart and calibrated to deliver 1000 L/ha on 18 May and 300 L/ha on 31 May, 2016 at 220 kPa. Plots were inoculated on 20 May, 2 June 2016, using a conidial suspension of 1.5 x 10^6 conidia/ml, derived from a 4 week-old V8-grown culture of the fungus. Tween 20 was added (1 drop Tween 20 per 500mL conidial suspension) and the suspension was sprayed to the foliage until runoff. Weekly disease incidence and severity assessment were done on 50 leaflets per plot within the middle rows, by assigning a rating of 0-6 (0 = no disease, 1 = <1% leaf/fruit area diseased, 2 = 1-10%, 3 = 11-25%, 4 = 26-50%, 5 = 51-75%, 6 = >75%). The inside 2 m of the plot was harvested on 13, 16, 21 June 2016 for cv. Donna and 14, 17, 20, 24, 28 June 2016 for cv. Governor Simcoe and yields, percent marketable and infected fruit were recorded. Compared to the previous 10-year averages, the air temperatures in 2016 were below average for April, 5.2°C, May, 14.7°C, and above average for June, 20.1°C. The 10-year average temperatures were for April 7.4°C, May 14.8°C and June 19.2°C. Monthly rainfall was below the 10-year average for April, 70 mm, May, 39 mm, and June, 33 mm. The 10-year rainfall averages were for April 79 mm, May 73 mm, and June 92 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 test at $P = 0.05$ level of significance.

RESULTS: As outlined in Table 1 and 2.

CONCLUSIONS: No symptoms of anthracnose were observed on the leaves or stems of any of the treatments; however, there was severe anthracnose infection on the fruit. Significant differences were observed among treatments for cv. Donna. For this cultivar, all INSPIRE SUPER treatments significantly reduced the incidence of anthracnose compared to the inoculated check and commercial standard CABRIO. The highest rate (2950 ml/ha) of INSPIRE SUPER had the lowest number of fruit infected

compared to the other rates tested. For cv. Governor Simcoe, the various rates of INSPIRE SUPER did reduce incidence of anthracnose on fruit and increased the marketable yield but the effect was not statistically significant.

Table 1: Effect of fungicides on anthracnose on yield, percent marketable and infected fruit within each treatment group for strawberry cv. Donna in 2016.

Treatment	Rate (ml/ha)	Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Fruit Infected (%)[3]
Uninoculated Check	-	18.7 ns[1]	12.2 a[2]	69.7 a	25.2 c
Inoculated Check	-	14.6	5.1 b	39.3 c	57.7 a
INSPIRE SUPER	2950	16.2	9.4 ab	60.1 ab	36.0 bc
INSPIRE SUPER	1161	17.1	9.2 ab	56.5 b	40.7 b
INSPIRE SUPER	1475	15.6	7.8 ab	52.4 b	43.4 b
CABRIO	750	16.7	6.1 b	37.5 c	60.2 a

[1] no significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.
[2] Numbers in a column followed by the same letter are not significantly different at P=0.05 using Tukey's HSD test
[3] number of fruit with anthracnose symptoms/total number of fruit assessed*100

Table 2: Effect of fungicides on yield, percent marketable and infected fruit within each treatment group for strawberry cv. Governor Simcoe in 2016.

Treatment	Rate (ml/ha)	Total Yield	Marketable Yield	Marketable (%)	Fruit Infected (%)[3]
Uninoculated Check	-	21.5 ns[1]	17.1 ns	75.5 a[2]	16.6 b
Inoculated Check	-	24.8	14.6	54.6 b	40.4 a
INSPIRE SUPER	2950	22.8	16.6	69.9 ab	26.3 ab
INSPIRE SUPER	1161	21.0	14.5	66.1 ab	29.7 ab
INSPIRE SUPER	1475	21.1	12.6	55.7 ab	39.1 a
CABRIO	750	18.8	10.9	50.2 b	45.8 a

[1] no significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.
[2] Numbers in a column followed by the same letter are not significantly different at P=0.05 using Tukey's HSD test
[3] number of fruit with anthracnose symptoms/total number of fruit assessed*100

2018 PMR REPORT # 12 **SECTION L: VEGETABLES and SPECIAL CROPS – Diseases**

CROP: Celery (*Apium graveloens* L.) cv. TZ 6200
PEST: Anthracnose leaf curl, (*Colletotrichum fioriniae* (Marcelino & Gouli) Pennycook)

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TITLE: **EVALUATION OF WEATHER-BASED FORECASTING MODELS TO MANAGE LEAF CURL ON CELERY CROPS IN THE HOLLAND MARSH, ONTARIO, 2018**

MATERIALS: QUADRIS FLOWABLE (250 g/L azoxystrobin), SWITCH 62.5WG (cyprodinil 37.5% and fludioxonil 25.0%)

METHODS: The trial was conducted in 2018 at the Muck Crops Research Station in the Holland Marsh, Ontario. Celery cultivar TZ 6200 was seeded into 288-cell plug trays on 10 May. On 9 July, celery was transplanted using a mechanical transplanter into the field in organic soil (soil: pH ≈ 7.0, organic matter ≈ 65%). A randomized complete block design with five replicates per treatment was used. Each replicate plot consisted of six rows that were 55 cm apart, 5 m in length with in-row spacing of 15 cm. Fungicide QUADRIS FLOWABLE was alternated with SWITCH 62.5WG. QUADRIS FLOWABLE was applied at a rate of 1.12 L/ha and SWITCH 62.5 WG was applied at 1 kg/ha. Fungicide application timing was determined using weather-based forecasting models: TOMCAST at Disease Severity Value (DSV) threshold of 15, TOMCAST with a DSV threshold of 25, the strawberry anthracnose model (SAM) with a threshold of ≥0.15 and SAM with a threshold of ≥0.50. All weather-based forecasting models were compared to a 7 to 10-day CALENDAR spray program and a non-treated CONTROL. Leaf wetness and temperature data were collected from a weather station on site within a nearby field. The border rows of each treatment were inoculated with *Colletotrichum fioriniae* (1×10^5 spores/mL) on 10 August. Three litres of the spore suspension were applied using a CO_2 backpack sprayer fitted with a single nozzle fan-type TeeJet 8002, at a rate of 10 mL per row meter. The inner four rows were visually assessed weekly for the presence of leaf curl symptoms. Prior to harvest, six plants adjacent to the inoculated border rows were randomly sampled (two leaves per plant), and plated on semi-selective agar to track the spread of the pathogen to the inner rows. Celery was harvested on 16 October, and a total of 20 plants/plot (five plants/inner row/plot) were assessed. Marketable weight was first determined by removing stalks with lesions or discarding plants with crown rot and weighing only disease-free plants after trimming to marketable length (40 cm). The percent marketable by weight was determined by dividing the marketable weight by the total weight, which was the weight of the marketable and unmarketable tissue. The marketable weight per plant was determined by dividing the marketable weight by the number of marketable plants in each replicate plot.
Compared to the previous 10-year average, air temperatures in 2018 were above average for May (15.8°C), August (21.9°C), September (17.5°C), average for June (18.4°C), July (22.0°C) and below average for October (8.3°C). The 10-year average temperatures were: May 13.9°C, June 18.6°C, July

21.2°C, August 20.1°C, September 16.0°C and October 9.4°C. Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm), July (104 mm), October (69 mm) and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, September 67 mm and October 72 mm. All statistical analyses were performed using the General Analysis of Variance function of Statistix 10. Means separation was obtained using Fisher's Protected LSD test with $P = 0.05$ level of significance.

RESULTS: As outlined in Table 1.

CONCLUSION: For the inner four rows, there were no significant differences in disease incidence and percent marketable weight among any of the disease forecasting treatments and when compared to the no-spray CONTROL. Both ≥0.15 SAM and the CALENDAR spray program had six fungicide applications, however, the number of fungicide applications was reduced to five for TOMCAST 15, and four for both ≥0.50 SAM and TOMCAST 25. For the inoculated border rows, disease incidence was significantly higher for the no-spray CONTROL, when compared to the other models. When leaves sampled from the rows adjacent to the inoculated borders were plated on semi-selective agar, no *C. fioriniae* growth was observed from any treatments. This indicates the lack of spread of the pathogen to the inner four rows, and is consistent with the low disease incidence observed in these rows. Although the high temperatures in August were conducive for leaf curl, *C. fioriniae* is dependent on irrigation and rainfall for dispersal. In conclusion, ≥0.50 SAM and TOMCAST 25 resulted in the lowest number (four) of fungicide applications and associated costs, with a comparable reduction in disease incidence compared to treatments based on different models that resulted in a higher number of fungicide applications (up to six).

Table 1. Number of sprays, estimated spray cost, disease incidence, and percent marketable yield by weight for forecasting fungicide applications to manage leaf curl on celery cv. TZ 6200 at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	Application date (DAFA)[1]	No. of sprays	Spray cost ($/ha)[2]	Incidence within inner four rows (%)[3]	Incidence within border rows (%)[5]	Market. by Wt. (%)
CALENDAR	0, 10, 20, 28, 42, 51	6	1092.75	0.0 ns[4]	26.6 a[6]	100.0 ns
≥0.15 SAM	0, 10, 20, 28, 42, 51	6	1092.75	0.2	25.1 a	100.0
≥0.50 SAM	0, 16, 27, 43	4	728.50	0.5	26.1 a	100.0
TOMCAST 15	0, 10, 20, 28, 42	5	859.46	0.0	26.9 a	100.0
TOMCAST 25	0, 16, 27, 43	4	728.50	0.5	28.5 a	100.0
CONTROL	--	--	--	1.1	50.9 b	98.8

[1] DAFA = Days after first spray; first fungicide application was on 7 August for ≥0.15 SAM, ≥0.50 SAM TOMCAST 15, TOMCAST 25 and the CALENDAR spray program treatments (first application = 0 days)
[2] Cost per spray: QUADRIS FLOWABLE = $130.96/ha, and SWITCH 62.5WG = $233.29/ha
[3] Disease incidence of inner 4 rows measured prior to harvest
[4] ns = no significant differences were found at $P = 0.05$, based on analysis of variance
[5] Disease incidence of inoculated border rows prior to harvest
[6] Values with different letters within columns were significantly different at $P = 0.05$, based on Fisher's Protected LSD test

2018 PMR REPORT #13 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Leaf lettuce (*Lactuca sativa* L.), cv. Bergams Green
PEST: Downy mildew (*Bremia lactucae* Regel)

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TITLE: **EVALUATION OF PICARBUTRAZOX 10 SC FOR CONTROL OF DOWNY MILDEW IN LEAF LETTUCE, 2018**

MATERIALS: PICARBUTRAZOX 10 SC (picarbutrazox 10 g/L), ALIETTE WDG (fosetyl AL 80%)

METHODS: Lettuce, cv. Bergams Green, was seeded into 128-cell plug trays on 20 June and transplanted by hand into organic soil (pH ≈ 6.5, organic matter ≈ 65.8%) on 16 July. A randomized complete block design was used. Each experimental unit consisted of four, 5.0 m long rows, spaced 40 cm apart with plants set at 25 cm in-row spacing. Treatments were: PICARBUTRAZOX 10 SC at 750, 880, 1,000 and 2,000 mL/ha and ALIETTE WDG at 2.8 kg/ha. An untreated inoculated check was also included. Treatments were applied on 30 July, 7 and 16 August as foliar sprays using a CO_2 back pack sprayer equipped with four TeeJet 8002 fan nozzles calibrated to deliver 500 L/ha at 275 kPa. Inoculum was prepared on 20 August using leaf lettuce leaves infected with downy mildew (DM) collected from a nearby lettuce field. The actively sporulating lesions were scraped with a probe to lift off oospores which were then put into a beaker of distilled water. This suspension was made up to 4 L using distilled water with a final concentration of 1.0×10^4 spores/mL, as determined using a hemocytometer. The suspension was immediately applied at the rate of 160 mL/replicate using a CO_2 backpack sprayer fitted with a single TeeJet 11002 fan-type nozzle. On 13 and 24 August the underside of two lower, mature green leaves on ten plants per replicate were visually examined for downy mildew lesions. Lesions were counted, and numbers recorded. On 28 August, 10 plants per replicate were cut from the inside two rows and weighed to determine total yield. All diseased leaves were removed, and plants reweighed to determine marketable yield. Compared to the previous 10-year average, air temperatures in 2018 were above average for August (21.9°C), and average for July (22.0°C) The 10-year average temperatures were: June 18.6°C, and July 21.2°C. Monthly rainfall was above the 10-year average for August (109 mm) and average for July (104 mm). The 10-year rainfall averages were: July 97 mm and August. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.10. Means separation was obtained using Tukey's HSD Test at $P = 0.05$ level of significance.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: All rates of PICARBUTRAZOX 10 SC were effective in reducing DM incidence in leaf lettuce resulting in higher marketable yields compared to the check. Significant differences in the number of DM lesions per plant and DM incidence were found among the treatments on 24 August (Table 1). Lettuce treated with any tested rate of PICARBUTRAZOX or ALIETTE had fewer DM lesions than untreated lettuce. Lettuce treated with PICARBUTRAZOX at 2,000 or 1,000 mL/ha had lower disease incidence than ALIETTE treated or untreated lettuce.

The higher rates also reduced incidence and increased the weight of marketable lettuce compared to ALIETTE (standard treatment). Significant differences in the percentage of marketable lettuce and the weight per marketable plant were found among the treatments (Table 2). Lettuce treated with PICARBUTRAZOX at 2000 or 880 mL/ha had a higher percentage of marketable lettuce than in the untreated check. Lettuce treated with PICARBUTRAZOX at 2000, 1000 or 880 mL/ha had significantly higher weights per marketable plant compared to lettuce treated with ALIETTE or untreated lettuce.

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

Table 1. Disease severity and incidence for lettuce, cv. Bergams Green, treated with various rates of picarbutrazox for control of downy mildew (DM) and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	Rate (mL/ha)	# DM Lesions/plant		DM Incidence[1] (%)
		13 Aug	24 Aug	
PICARBUTRAZOX 10 SC	2,000	0 ns[2]	0.15 a[3]	15.0 a
PICARBUTRAZOX 10 SC	1,000	0	0.25 a	20.0 a
PICARBUTRAZOX 10 SC	750	0	0.40 a	30.0 ab
PICARBUTRAZOX 10 SC	880	0	0.43 a	35.0 ab
ALIETTE WDG	2.8 kg/ha	0	1.2 a	67.5 bc
Untreated check	--	0	4.6 b	100.0 c

[1] Incidence was determined using 24 August DM lesion counts and the following equation: # diseased plants/10 × 100.
[2] ns = no significant differences were found among the treatments at $P = 0.05$, Tukey's HSD test.
[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Tukey's HSD test.

Table 2. Yield for lettuce, cv. Bergams Green, treated with various rates of picarbutrazox for control of downy mildew (DM) and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	Rate (mL/ha)	Harvest Wgt/plant[1] (g)	Wgt/Mkb plant (g)	% Marketable
PICARBUTRAZOX 10 SC	2,000	807.3 ns[2]	577.3 a[3]	71.8 a
PICARBUTRAZOX 10 SC	880	791.0	556.3 a	70.5 a
PICARBUTRAZOX 10 SC	1,000	830.0	564.0 a	68.2 ab
PICARBUTRAZOX 10 SC	750	808.8	547.0 ab	67.6 ab
ALIETTE WDG	2.8 kg/ha	728.3	439.0 bc	60.1 ab
Untreated check	--	717.3	401.0 c	56.3 b

[1] Average weight of lettuce plants before diseased leaves were removed
[2] No significant differences were found among treatments at $P = 0.05$, Tukey's HSD test.
[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Tukey's HSD test.

2018 PMR REPORT # 14 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Lettuce (*Lactuca sativa* L.), cv. Mighty Joe & cv. Bergams Green
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 AND LEAF LETTUCE, 2017**

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

METHODS:
Two trials, one of leaf lettuce cv. Bergams Green and the other of head lettuce cv. Mighty Joe, were seeded on 1 and 2 May 2017, respectively, into 128 cell black 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 ≈ 2%, pH ≈ 6.5) using a mechanical transplanter. For each trial, 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 0.05 % 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 XR11005 nozzles spaced 50 cm apart and calibrated to deliver 500 l/ha at 220 kPa. Treatments were applied on 2 and 13 June. A culture of *Sclerotinia sclerotium* 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 beside each lettuce row (250 g/row, 1000 g/plot) in a 10 cm wide band on 1 June. Disease incidence and severity of the disease was assessed on 31 May, 7, 15, 20, 27 June, 4 July for both leaf and head lettuce, 10 July for leaf lettuce and 11, 19 July for head lettuce using sixteen plants 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 was 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 completely destroyed. On 10 July, cv. Bergams Green was harvested from the 2.5 m section of the middle two rows of each plot and on 19 July, cv. Mighty Joe was harvested in the same fashion. 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 2017 were below average for May (12.7°C), and average for June (19.4°C) and July (21.3°C). The 10-yr average temperatures were: May 14.7°C, June 19.3°C and July 21.6°C. Monthly rainfall was above the 10-year average for May (153 mm), below average for June (80 mm) and July (25 mm). The 10-year rainfall averages were: May 81 mm, June 92 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 very high but variable among the replicates. Plant mortality was high in the inoculated treatments; therefore, no statistically significant differences in disease incidence or severity were observed among those treatments. In addition, total yield was not statistically different in plots treated with INTUITY or ALLEGRO from the non-inoculated check (data not shown).

Table 2: Effect of fungicides on incidence of sclerotinia head rot and leaf drop, as reported on various dates for cv. Bergams Green and cv. Mighty Joe grown in Simcoe, Ontario, in 2017.

Treatment and Application rate	Disease Incidence (%)[1]				Disease Incidence (%)			
INTUITY, ml/ha	Leaf Lettuce cv. Bergams Green				Head Lettuce cv. Mighty Joe			
SYLGARD 309, 0.05%v/v	20	27	4	10	27	4	11	19
AALEGRO, L/ha	June	June	July	July	June	July	July	July
Non-inoculated Check	0 ns[2]	0 b[3]	37 b	12 b	21 b	48 ns	51 b	96 ns
Inoculated Check	37	60 a	98 a	71 a	79 a	73	84 ab	96
INTUITY @ 439	23	57 a	93 a	81 a	73 a	75	90 a	96
@ 585	25	54 a	96 a	78 a	81 a	71	89 a	100
@ 877	17	53 a	96 a	62 a	67 ab	70	82 ab	98
INTUITY @ 877 + SYLGARD	26	57 a	89 a	65 a	62 ab	67	84 ab	98
ALLEGRO @ 1.2	15	43 ab	97 a	54 a	73 a	53	82 ab	93

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

[2] ns = no significant differences (P=0.05, Tukey's HSD test) were found among treatments

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

Table 3: Effect of fungicides on Disease Severity Index (DSI) and the area under disease progress curve (AUDPC) for cv. Bergams Green and cv. Mighty Joe grown at Simcoe in 2017.

Treatment INTUITY (ml/ha) ALLEGRO (L/ha)	Disease Severity Index[1] cv. Bergams Green				AUDPC[2] cv. Bergams green	Disease Severity Index cv. Mighty Joe				AUDPC cv. Mighty Joe
	20 June	27 June	4 July	10 July		27 June	4 July	11 July	19 July	
Non-inoculated Check	0 ns[3]	0 b[4]	7 b	2 b	2 b	4 ns	10 ns	11 b	23 b	15 b
Inoculated Check	18	41 a	66 a	54 a	57 a	45	55	62 a	67 a	92 ab
INTUITY @ 439	7	23 ab	51 a	53 a	36 a	52	63	70 a	71 a	109 a
@ 585	10	23 ab	48 a	59 a	42 a	41	55	64 a	70 a	85 ab
@ 877	6	16 ab	39 a	41 a	31 ab	37	54	63 a	76 a	90 ab
INTUITY @877 + SYLGARD 309	11	26 ab	46 a	50 a	45 a	46	52	59 ab	66 a	100 ab
ALLEGRO@ 1.2	6	19 ab	55 a	39 a	37 a	36	43	57 ab	63 ab	74 ab

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

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

[3] ns = no significant differences (P=0.05, Tukey's HSD test) were found among treatments

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

2018 PMR REPORT # 15 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Mint (Scotch spearmint, *Mentha* × *gracilis* Sole)
PEST: Powdery mildew (*Erysiphe* spp.)

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TITLE: **FIELD EVALUATION OF QUADRIS TOP FUNGICIDE FOR CONTROL OF POWDERY MILDEW IN MINT, 2016**

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

METHODS: A field trial was 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 2016. Rooted cuttings of Scotch spearmint from Richters Herbs (Goodwood, Ontario) were transplanted into the soil (organic matter ≈ 1.6%, pH ≈ 6.9) on 3 June 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, 75 cm apart, 5 m long, and plants were spaced 0.5 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 an untreated check. Products were applied using a CO_2 backpack sprayer equipped with three TeeJet XR8004 nozzles spaced 50 cm apart and calibrated to deliver 300 L/ha water at 220 kPa on 23 August and 5 September. Powdery mildew occurred naturally so inoculation was not needed. Disease incidence and severity were rated on 19, 26 August, 1, 8, 15, 22, 29 September on ten 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 one of the middle rows of each plot was harvested on 3 October and total and marketable yields were recorded, as well as the disease severity and incidence on a sub-sample of 50 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:

$$\text{DSI}= \frac{[(\text{class no.})(\text{ no.of leaves in each class})]}{(\text{total n0.leaves per sample})(\text{n0.classes}-1)} \text{ x100}$$

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 2016 were above average for June (20.1°C), July (23.6°C), August (23.9°C), September (19.0°C) and October (11.3°C). The 10-yr average temperatures were: May 14.8°C, June 19.2°C, July 21.6°C, August 20.6 °C, September 17.0°C, and October 10.6°C. Monthly rainfall was below the 10-year average for June (33 mm), July (46 mm), August (26 mm), average for October (78 mm), and above average for September (99 mm). The 10-year rainfall averages were: June 92 mm, July 81 mm, August 85 mm, September 87 mm, and October 82 mm.

Data was 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 reduced disease incidence and severity and increased marketable yield compared to the untreated check and provided similar level of disease control as the commercial standard QUILT. There were no significant differences among the rates of QUADRIS TOP, although the 1 L/ha rate consistently resulted in numerically lower levels of disease and highest marketable yield.

Table 1: Effect of fungicides on powdery mildew incidence as reported on various dates for mint grown at the Simcoe Research Station, Ontario, in 2016.

Treatment	Disease Incidence (%)						
	19 Aug	26 Aug	1 Sep	8 Sep	15 Sep	22 Sep	29 Sep
Untreated Check	0.0	90.0	100.0	100.0 a	100.0 a	100.0 a	100.0 a
QUADRIS TOP:							
@ 0.566 L/ha	0.0	60.0	75.0	47.5 bc	40.0 bc	40.0 b	30.0 b
@ 1 L/ha	0.0	45.0	65.0	42.5 c	22.5 c	35.0 b	32.5 b
@ 2 L/ha	0.0	62.5	80.0	77.5 abc	67.5 b	65.0 ab	50.0 b
QUILT @ 1 L/ha	0.0	47.5	60.0	50.0 bc	52.5 b	50.0 b	37.5 b

[1] No significant differences ($P = 0.05$, Tukey's HSD) were found among the treatments.
[2] Numbers in a column followed by the same letter are not significantly different (as above).

Table 2: Effect of fungicides against powdery mildew on the Area Under Disease Progress Curve (AUDPC) and Disease Severity Index (DSI) as reported on various dates for mint grown at the Simcoe Research Station, Ontario, in 2016.

Treatment	**AUDPC**	**DSI**						
		19 Aug	26 Aug	1 Sep	8 Sep	15 Sep	22 Sep	29 Sep
Untreated Check	136.3 a	0.0	31.2 a	45.0 a	58.3 a	68.7 a	80.8 a	80.8 a
QUADRIS TOP:								
@ 0.566 L/ha	29.6 b	0.0	15.4 ab	15.4 b	15.4 c	10.0 b	10.4 b	7.9 b
@1 L/ha	20.7 b	0.0	7.9 b	11.6 b	12.1 c	5.0 b	8.7 b	7.9 b
@ 2 L/ha	44.7 b	0.0	12.1 b	17.0 b	22.0 bc	21.6 b	25.8 b	15.4 b
QUILT @1 L/ha	29.3 b	0.0	10.0 b	12.5 b	14.5 c	14.1 b	13.3 b	10.4b

[1]Numbers in a column followed by the same letter are not significantly different ($P = 0.05$, Tukey's HSD).
[2] No significant differences (as above) were found among the treatments.

Table 3: Effect of fungicides to control powdery mildew on yields, percent marketable and percent infected fruit within each treatment group for mint grown at the Simcoe Research Station, Ontario, in 2016, as assessed on 3 October.

Treatment	Total Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Infected (%)
Untreated Check	5.3 ns[1]	0.0 b[2]	0.0 b	100.0 a
QUADRIS TOP:				
QUADRIS TOP:@ 0.566 L/ha	8.8 a	7.5 a	85.3 a	14.6 b
@ 1 L/ha	8.7 a	7.8 a	91.3 a	8.7 b
@ 2 L/ha	9.3 a	6.9 a	75.7 a	24.2 b
QUILT @ 1 L/ha	9.8 a	8.2 a	91.7 a	8.2 b

[1] No significant differences ($P = 0.05$, Tukey's HSD) were found among the treatments.
[2] Numbers in a column followed by the same letter are not significantly different (as above).

2018 PMR REPORT # 16 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

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

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TITLE: FUNGICIDE APPLICATION TIMING FOR MANAGEMENT OF STEMPHYLIUM LEAF BLIGHT OF ONION, 2018

MATERIALS: LUNA TRANQUILITY (fluopyram 125 g/L, pyrimethanil 375 g/L), QUADRIS TOP (azoxystrobin 200 g/L, difenoconazole 125 g/L), EVERGOL PRIME (penflufen 2.5 g ai/kg seed), FARMORE F300 (mefenoxam 0.075 g ai/kg seed, fludioxonil 0.0275 g ai/kg seed, azoxystrobin 0.025 g ai/kg seed), CIVITAS (mineral oil 98.0%)

METHODS: Onion cv. LaSalle was direct seeded (35 seeds/m) on 9 May 2018 using a Stanhay Precision Seeder into organic soil (organic matter ≈ 69.3, pH ≈ 6.1) at the Muck Crops Research Station, King, Ontario in a randomized complete block design with four replicates. Each plot consisted of two adjacent beds, each 6 m x 1.5 m and seeded with four paired rows, with 7.5 cm between paired rows and 35 cm between pairs of rows. Blocks were separated by a 1.5 m-wide pathway.

The treatments consisted of an untreated control, two fungicide seed treatments (EVERGOL PRIME or FARMORE F300) followed by sprays every 7–10 days, weekly sprays with two starting dates (2-leaf or 4-leaf growth stage), CIVITAS drench at emergence followed by weekly sprays, and two forecasting models; TOMCAST at disease severity value (DSV) threshold of 15 and a slightly modified version of BSPCAST. CIVITAS was applied as a plant-based drench at emergence, and foliar sprays of QUADRIS TOP (1 L/ha in 500 L/ha of water) alternated with LUNA TRANQUILITY (1.2 L/ha in 500 L/ha of water) were applied at several different timings. A scale of 0 to 4 was used to assess disease severity of the three oldest leaves for 20 onions per plot: 0 = no yellowing, 1 = 1–10% yellowed, 2 = 11–25% yellowed, 3 = 26–50% yellowed, 4 > 51% yellowed area. A disease severity index (DSI) was calculated as:

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

On 14 September, onion plants in two 2.3 m sections of row were harvested from the middle rows of each plot, weighed, and graded to determine yield**.** Data were analyzed using the GLIMMIX function of SAS version 9.4 (SAS Institute 2017). Means separation was assessed using Tukey's honest significant difference (HSD) test at $P = 0.05$.

Compared to the previous 10-year average, air temperature in 2018 was above average for May (15.8°C), August (21.9°C), and September (17.5°C), and near-normal for June (18.4°C) and July (22.0°C). The 10-year monthly mean temperatures were May 13.9°C, June 18.6°C, July 21.2°C, August 20.1°C, and

September 16.0°C. Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm) and July (104 mm), and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, and September 67 mm.

RESULTS: As presented in Tables 1 and 2.

CONCLUSIONS: The weekly schedules resulted in five (4-leaf stage) to seven (2-leaf stage) foliar applications of fungicide. Weekly foliar applications and application of CIVITAS did not reduce blight incidence or severity compared to the untreated control. Disease pressure was high, and the forecasting models did not reduce fungicide application, with five applications recommended by TOMCAST and six applications by BSPCAST. However, fungicide seed treatment in combination with weekly foliar sprays reduced incidence by 22–31% and severity by 42–53% relative to the control (Table 1). There were no differences in yield among treatments. The EVERGOL PRIME seed coating resulted in fewer, slightly larger bulbs/m (Table 2), but this was likely associated with low emergence in this treatment (data not shown).

ACKNOWLEDGEMENT: Funding for this project was provided by the OMAFRA / U of G partnership, the Bradford Cooperative Storage Inc., and the Fresh Vegetable Growers of Ontario.

Table 1. Effect of fungicide applications on Stemphylium leaf blight levels at the Muck Crops Research Station on 14 August 2018.

Treatment	# Applications	Incidence (%)	Severity (DSI)
Control	0	98 a	57 a[2]
Weekly spray (2-leaf)	7	93 ab	51 ab
BSPCAST	6	90 ab	50 ab
Weekly spray (4-leaf)	5	86 ab	46 abc
CIVITAS + weekly spray	7	89 ab	42 abc
TOMCAST	5	88 abc	40 abc
FARMORE F300 seed coating + weekly spray	7	76 bc	33 bc
EVERGOL PRIME seed coating + weekly spray	7	68 b	27 c

[1] Means in column followed by the same letter do not differ at $P = 0.05$ based on Tukey's HSD test.

Table 2. Effect of fungicide application on yield and size distribution (# bulbs) of onion in 2018.

Treatment	Yield (t/ha)	Bulbs (m^{-1})	Bulb wt. (g)	Size distribution (# onions)		
				Cull (<32 mm)	Can. No. 1 (32–76 mm)	Jumbo (>76 mm)
Control	45.3 ns[1]	21.0 a[2]	93.3 ab	2 b	94 a	2 ns
CIVITAS + weekly spray	48.1	20.5 a	100.3 ab	2 b	92 a	2
TOMCAST	50.5	19.8 a	109.4 ab	3 ab	85 a	3
Weekly spray (4-leaf)	37.6	19.5 a	84.4 b	8 a	81 a	2
BSPCAST	41.6	17.9 ab	100.8 ab	1 b	78 ab	4
FARMORE F300 seed coating + weekly spray	40.8	17.6 ab	100.3 ab	4 ab	77 ab	2
Weekly spray (2-leaf)	38.1	16.5 ab	100.8 ab	2 b	71 ab	4
EVERGOL PRIME seed coat + weekly spray	35.9	11.9 b	125.9 ab	2 b	48 b	5

[1] ns = No significant differences ($P = 0.05$) were found among the treatments.
[2] Means in column followed by the same letter do not differ at $P = 0.05$ based on Tukey's HSD test.

2018 PMR REPORT # 17 **SECTION L: VEGETABLES and SPECIAL CROPS – Diseases**

CROP: Rutabaga (*Brassica napus* var. *napobrassica* L.), cv. Laurentian
PEST: Black leg (*Phoma lingam* (Tode) Desm.)

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TITLE: FIELD EVALUATION OF QUADRIS TOP FUNGICIDE FOR CONTROL OF BLACK LEG IN RUTABAGA, 2016

MATERIALS: QUADRIS TOP (azoxystrobin 18.2%, difenoconazole 11.4%), TILT 250E (propiconazole 250 g/l)

METHODS: Two trials with rutabaga, cv 'Laurentian', were planted directly in the field (soil organic matter ≈ 1.6%, pH ≈ 6.7) at the Simcoe Research Station on 26 May and 28 June 2016, using a Clean Seeder planter at a depth of 1.5 cm. Seeds were planted at a density of 10 seeds per m. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four rows, 75 cm apart, 7 m long. Treatments were non-inoculated check, inoculated check, QUADRIS TOP at the rate of 600, 1000, and 2000 ml/ha and a commercial standard, TILT 250E, at the rate of 400 ml/ha. Treatments were applied using a CO_2 backpack sprayer equipped with three TeeJet XR8004 nozzles spaced 50 cm apart and calibrated to deliver 300 l/ha at 220 kPa. For Trial 1, treatments were applied on 22 June, 6 and 19 July and for trial 2, on 19 July, 2 and 15 Aug. A conidial suspension of 1.5×10^6 conidia/ml of *Phoma lingam* was prepared from 4-6 weeks old potato dextrose agar plates. The suspension was sprayed onto the foliage until run off. All plots (except the non-inoculated check) were inoculated on 23 June for Trial 1, and 21 July for trial 2, when the crop was at the 2-3 leaf stage. Inoculation was repeated on 8 July for Trial 1 and 17 August for Trial 2. Disease incidence and severity of black leg was assessed on 12, 21, 29 July, 5, 12, 19 Aug for trial 1 and 19, 27 July, 5, 12, 19, 25 August, 1 September for trial 2. Sixty leaves from the middle two rows of each plot were examined and rated from 0-6 with: 0 = no disease, 1 = 1-5% leaf area diseased, 2 = 6-10%, 3 = 11-20%, 4 = 21-30%, 5 = 31-40%, 6 = >40%. A 2.5-meter section of the middle 2 rows of each plot was hand harvested on 26 Aug for trial 1 and on 3 October 2016 for trial 2. Roots were graded as unmarketable based on the presence of disease or if roots were less than 50 mm in diameter. Harvested roots were assessed for disease severity by assigning a rating of 0-6 with: 0 = no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%. Compared to the previous 10-year averages, the air temperatures in 2016 were average for May (14.7°C), above average for June (20.1°C), July (23.6°C), August (23.9°C), September (19.0°C) and October (11.3°C). The 10-yr average temperatures were: May 14.8°C, June 19.2°C, July 21.6°C, August 20.6 °C, September 17.0°C, and October 10.6°C. Monthly rainfall was below the 10-year average for May (39 mm), June (33 mm), July (46 mm), August (26 mm), average for October (78 mm) and above average for September (99 mm). The 10-year rainfall averages were: May 73 mm, June 92 mm, July 81 mm August 85 mm, September 87 mm and October 82 mm. Data was analyzed 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 Table 1 for trial 1 and Table 2 for trial 2.

CONCLUSIONS: No symptoms of black leg were observed on the leaves and stems during the in-field assessments (data not shown), however lesions were observed on the roots at harvest. Total yield did not differ among the treatments for both trials. In trial 1, marketable yield and percent marketable were lowest in the inoculated check and TILT treatments. Plots treated with QUADRIS TOP produced a similar marketable yield and percent marketable as the non-inoculated check regardless of the rate applied. No significant differences in marketable yields were observed for trial 2. In both trials, applications of QUADRIS TOP significantly reduced black leg incidence and disease severity index (DSI) compared to the non-inoculated check and TILT treatments. Although the highest rate of QUADRIS TOP resulted in the numerically lowest disease incidence and DSI, there were no statistically significant differences among the different rates. No phytotoxicity was observed due to QUADRIS TOP (data not shown).

Table 1. Effect of fungicides to control black leg on yield, percent marketable, incidence and severity within each treatment group for rutabaga cv. Laurentian for trial 1 in Simcoe, Ontario, in 2016, as assessed on 26 September.

Treatment	Total Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Disease Incidence (%)	DSI [1] 0-100
Non-inoculated Check	46.5 ns[2]	41.0 a[3]	89.35 a	4.60 b	1.90 b
Inoculated Check	52.9	6.4 b	18.45 b	76.40 a	53.50a
QUADRIS TOP @ 600 ml/ha	63.6	42.3 a	67.60 a	24.13 b	13.43b
QUADRIS TOP @ 1000 ml/ha	46.9	41.5 a	87.70 a	9.80 b	4.98 b
QUADRIS TOP @ 2000 ml/ha	49.4	44.7 a	89.48 a	5.43 b	2.70 b
TILT 250E @ 400 ml/ha	51.6	6.7 b	12.25 b	84.65 a	57.85a

[1] Disease severity ratings, 0=no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%, Disease Severity Index formula:

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

[2] No significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.

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

Table 2. Effect of fungicides to control black leg on yield, percent marketable, incidence and disease severity index (DSI) within each treatment group for rutabaga cv. Laurentian for trial 2 in Simcoe, Ontario, in 2016, as assessed on 3 October.

Treatment	Total Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Disease Incidence (%)	DSI[1] 0-100
Non-inoculated Check	63.3 ns[2]	57.6 ns	92.15 ns	0.00 b[3]	0.00 b
Inoculated Check	55.9	36.7	65.13	33.23 a	15.00 a
QUADRIS TOP @ 600 ml/ha	63.5	52.1	84.65	3.23 b	0.55 b
QUADRIS TOP @ 1000 ml/ha	66.5	53.6	82.40	1.85 b	0.60 b
QUADRIS TOP @ 2000 ml/ha	69.6	58.0	82.28	0.00 b	0.00 b
TILT 250E @ 400 ml/ha	65.1	35.9	55.35	25.60 a	9.25 a

[1] Disease severity ratings, 0=no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%, Disease Severity Index formula:

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

[2] no significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.

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

2018 PMR REPORT #18 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Swiss chard (*Beta vulgaris* subsp. *vulgaris*), cv. Burpee's Rhubarb Chard
PEST: Cercospora leaf spot (*Cercospora beticola* Sacc.)

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TITLE: **EVALUATION OF CUEVA FUNGICIDE FOR CONTROL OF CERCOSPORA LEAF SPOT ON SWISS CHARD, 2018**

MATERIALS: CUEVA FUNGICIDE (copper octanoate 1.8%), PROLINE 480 SC (prothioconazole 480 g/L)

METHODS: Swiss chard, cv. Burpee's Rhubarb Chard, was direct seeded into organic soil (pH ≈ 6.9, organic matter ≈ 63.5%) on 17 July using an Earthway push seeder fitted with plate no. 1002-22. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four, 5.0 m long rows, spaced 40 cm apart. Treatments were: CUEVA FUNGICIDE at 0.5, 1, 2 and 4% v/v and PROLINE 480 SC at 415 mL/ha. An untreated inoculated check was also included. Treatments were applied on 9, 15, 23 and 30 August as foliar sprays using a CO_2 back pack sprayer equipped with four TeeJet 8002 fan nozzles calibrated to deliver 500 L/ha at 275 kPa. On 24 August, inoculum was prepared using approximately 200 g of dried sugar beet leaves infected with *Cercospora beticola*. Leaves were submerged and soaked for 10 minutes in a large glass beaker filled with water and lined with cheese cloth. The wetted leaves were squeezed by hand to release conidia. Leaves were removed from the beaker using the cheese cloth. The resulting spore suspension was diluted to a concentration of 1.0×10^4 spores/mL, as determined using a hemocytometer. This suspension was immediately applied to all replicates at the rate of 160 mL/replicate using a CO_2 backpack sprayer fitted with a single TeeJet 11002 fan-type nozzle. After inoculation, check plots were visually examined for leaf spot on a weekly basis. On 7 September, leaf spot was found and confirmed in the lab as *C. beticola*. On 11 September, a fully expanded lower leaf was removed from 20 randomly chosen plants per replicate. Leaves were visually examined for leaf spots, and numbers were counted and recorded. On 24 September, 10 consecutive plants per replicate were cut from the inside two rows (five from each row) and weighed to determine total yield. All diseased leaves were removed, and plants reweighed to determine marketable yield. Compared to the previous 10-year average, air temperatures in 2018 were above average for August (21.9°C) and September (17.5°C), and average for July (22.0°C). The 10-year average temperatures were: July 21.2°C, August 20.1°C and September 16.0°C. Monthly rainfall was above the 10-year average for August (109 mm), average for July (104 mm) and below average for September (20 mm). The 10-year rainfall averages were: July 97 mm, August 75 mm and September 67 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 Tukey's HSD Test at $P = 0.05$ level of significance.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: CUEVA FUNGICIDE applied at 1-4% v/v reduced Cercospora leaf spot in Swiss chard. Significant differences in lesions per leaf and the percentage of diseased leaves were found among

the treatments (Table 1). Swiss chard treated with PROLINE or CUEVA FUNGICIDE at 1% or 2% v/v had significantly fewer leaf spots than untreated Swiss chard. However, the number of Cercospora leaf spots found on Swiss chard treated with PROLINE or any tested rate of CUEVA FUNGICIDE ranged from 0.3 to 1.4 spots per leaf and did not differ statistically from each other. Swiss chard treated with PROLINE had a lower percentage of diseased leaves (20%) compared to Swiss chard treated with CUEVA FUNGICIDE at 0.5% or untreated Swiss chard (56.3 and 80% respectively).

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

Table 1. Cercospora leaf spot severity (number of leaf spots per leaf) and incidence (percentage of diseased leaves) for Swiss chard, cv. Burpee's Rhubarb Chard, treated with fungicides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	Leaf spots/leaf[1]	Diseased leaves (%)
PROLINE	0.3 a[2]	20.0 a
CUEVA 1%	0.7 a	36.3 ab
CUEVA 2%	0.9 a	52.5 abc
CUEVA 4%	1.1 ab	48.8 abc
CUEVA 0.5%	1.4 ab	56 3 bc
Untreated check	3.6 b	80.0 c

[1] Assessed on 20 leaves per replicate

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

Table 2. Yield for Swiss chard, cv. Burpee's Rhubarb Chard, treated with fungicides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	% Marketable	Mkb wgt/plant (g)	Total wgt/plant (g)
PROLINE	89.3 a[1]	51.0 ns[2]	57.0 ns
CUEVA 2.0%	86.2 a	46.8	54.3
CUEVA 4.0%	84.5 a	43.8	52.0
CUEVA 1.0%	82.9 a	44.0	52.8
CUEVA 0.5%	78.6 a	45.5	58.5
Untreated check	61.6 b	37.8	62.3

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

[2] ns indicates no significant differences were found among the treatments.

2018 PMR REPORT # 19 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Swiss chard (*Beta vulgaris* subsp. *vulgaris*), var. Silverado
PEST: Cercospora leaf spot (*Cercospora beticola* Sacc.)

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TITLE: **FIELD EVALUATION OF CUEVA FUNGICIDE FOR CONTROL OF CERCOSPORA LEAF SPOT IN SWISS CHARD, 2017**

MATERIALS: CUEVA (copper octanoate 1.8%, liquid), PROLINE 480 SC (prothioconazole 41%)

METHODS: Swiss chard variety Silverado was planted directly in the field (organic matter ≈ 2.8%, pH ≈ 6.65) at Simcoe Research Station on 14 June 2017, using a Clean Seeder planter at a depth of 1.25 cm. Seeds were planted at a density of 10 seeds per m. 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 10 cm apart within the row. Treatments were non-inoculated check, inoculated check, CUEVA at 0.5 % solution, CUEVA at 1, 2 and 4% solution and commercial standard PROLINE at the rate of 415 ml/ha. Treatments were applied using a CO_2 backpack sprayer equipped with three TeeJet XR11005 nozzles spaced 50 cm apart and calibrated to deliver 500 l/ha at 220 kPa. Treatments were applied on 18, 26 July, 1, 16 and 22 August. Mycelial plugs (0.5 cm diameter) from 20-30-day old cultures of *Cercospora beticola* in potato dextrose agar were used to inoculate the wet leaf surface of plants in each plot (except for the non-inoculated check) on 19 July. A total of two fully expanded leaves per plant were inoculated with one plug per leaf. Disease incidence and severity were assessed on 14, 24 July, 1, 10, 17, 25 August on twelve plants from the middle two rows of each plot. The number of plants assessed was increased to 16 for the last three assessments. Incidence was calculated as the number of plants with cercospora leaf spot/total plant assessed *100. Plants were assigned a rating from 0-10 where: 0 = healthy plant; 1 = a single isolated spot on one or more than one leaves of a plant; 2 = 20 spots on a leaf or on more than one leaf of a plant; 3 = 21-50 spots on one leaf or on more than one leaf of a plant; 4 = 51-100 spots on a leaf or more than one leaf; 5 = 50% of the leaf area is infected on one or more leaves of a plant; 6 = 60% of the leaf area is infected; 7 = 70% of the leaf area is infected; 8 = 80% leaf area infected; 9 = the entire foliage is strongly affected; 10 = the foliage is completely destroyed. Disease severity rating was used to calculate severity index (DSI) and area under disease progress curve (AUDPC). On 29 August, Swiss chard was harvested from a 2.5-meter section of the middle 2 rows of each plot. The total yield of harvested leaves was recorded, and a sub-sample of 50 leaves was randomly selected to assess disease incidence and percent marketable. Compared to previous 10-year averages, the air temperatures in 2017 were average for June (19.4°C), July (21.3°C) and below average for August (19.7°C). The 10-yr average temperatures were: June 19.3°C, July 21.6°C and August 20.6 °C. Monthly rainfall was below the 10-year average for June (80 mm), July (25 mm) and August (62 mm). The 10-year rainfall averages were: June 92 mm, July 76 mm and August 83 mm. Data was analyzed 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 presented in Tables 1 and 2.

CONCLUSIONS: The inoculation was successful, but disease development was slow. Although the percentage of infected plant was high at harvest, disease severity was low. Both incidence and severity varied considerably among replications and therefore, resulted in no significant differences among treatments. Although not statistically significant, there was a numerical trend of lower AUDPC with increasing rates of CUEVA. Applications of PROLINE or 4% CUEVA resulted in statistically similar levels of disease as the non-inoculated check on two of the assessment dates, suggesting some product efficacy. No significant differences in total or marketable yield were observed (data not shown).

Table 4: Effect of fungicides on disease incidence as reported on various dates for Swiss chard var. Silverado grown at the Simcoe Research Station, Ontario, in 2017.

Treatment	Disease Incidence (%)[1]					
	14 July	24 July	1 Aug.	10 Aug.	17 Aug.	25 Aug.
Non-inoculated Check	0.0 ns[2]	0.0 ns	0.0 ns	9.3 b[3]	28.1 b	39.0 b
Inoculated Check	0.0	0.0	0.75	67.2 a	71.8 a	81.2 a
CUEVA @ 0.5 % v/v	0.0	0.0	1.5	65.6 a	71.8 a	81.2 a
CUEVA @ 1 % v/v	0.0	0.0	0.0	59.4 a	67.1 a	70.3 ab
CUEVA @ 2 % v/v	0.0	0.0	0.0	59.4 a	62.5 a	68.7 ab
CUEVA @ 4 % v/v	0.0	0.0	0.0	45.3 ab	56.2 a	79.6 ab
PROLINE @ 415 ml/ha	0.0	0.0	0.0	39.0 ab	45.3 ab	46.8 ab

[1] number of plants with cercospora leaf spot/total plant assessed *100
[2] ns = no significant differences (P=0.05, Tukey's HSD test) were found among treatments
[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$ using Tukey's HSD test.

Table 2: Cercospora leaf spot severity for Swiss chard var. Silverado treated with fungicides and grown at the Simcoe Research Station, Ontario, in 2017.

Treatment	Disease Severity Index (DSI)						AUDPC[2]
	14 July	24 July	1 Aug.	10 Aug.	17 Aug.	25 Aug.	
Non-inoculated Check	0.0 ns[3]	0.0	0.00 ns	0.8 b[4]	2.9 c	5.3 ns	5.0 b
Inoculated Check	0.0	0.0	0.1	8.8 a	11.1 a	12.8	20.9 a
CUEVA @ 0.5% v/v	0.0	0.0	0.3	9.3 a	9.5 ab	13.3	21.1 a
CUEVA @ 1% v/v	0.0	0.0	0.0	7.3 a	9.5 ab	12.6	17.1 a
CUEVA @ 2% v/v	0.0	0.0	0.0	7.2 a	6.75 ab	9.4	14.5 a
CUEVA @ 4%v/v	0.0	0.0	0.0	4.8 a	6.2 abc	11.9	13.4 a
PROLINE @ 415 ml/ha	0.0	0.0	0.0	4.3 ab	4.6 bc	6.90	9.47 ab

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

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

[2] Area under the disease progress curve was calculated using the following formula,

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

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

2018 PMR REPORT # 20 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

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

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TITLE: FUNGICIDE APPLICATION TIMING FOR MANAGEMENT OF STEMPHYLIUM LEAF BLIGHT OF ONION, 2018

MATERIALS: LUNA TRANQUILITY (fluopyram 125 g/L, pyrimethanil 375 g/L), QUADRIS TOP (azoxystrobin 200 g/L, difenoconazole 125 g/L), EVERGOL PRIME (penflufen 2.5 g ai/kg seed), FARMORE F300 (mefenoxam 0.075 g ai/kg seed, fludioxonil 0.0275 g ai/kg seed, azoxystrobin 0.025 g ai/kg seed), CIVITAS (mineral oil 98.0%)

METHODS: Onion cv. LaSalle was direct seeded (35 seeds/m) on 9 May 2018 using a Stanhay Precision Seeder into organic soil (organic matter ≈ 69.3, pH ≈ 6.1) at the Muck Crops Research Station, King, Ontario in a randomized complete block design with four replicates. Each plot consisted of two adjacent beds, each 6 m x 1.5 m and seeded with four paired rows, with 7.5 cm between paired rows and 35 cm between pairs of rows. Blocks were separated by a 1.5 m-wide pathway.

The treatments consisted of an untreated control, two fungicide seed treatments (EVERGOL PRIME or FARMORE F300) followed by sprays every 7–10 days, weekly sprays with two starting dates (2-leaf or 4-leaf growth stage), CIVITAS drench at emergence followed by weekly sprays, and two forecasting models; TOMCAST at disease severity value (DSV) threshold of 15 and a slightly modified version of BSPCAST. CIVITAS was applied as a plant-based drench at emergence, and foliar sprays of QUADRIS TOP (1 L/ha in 500 L/ha of water) alternated with LUNA TRANQUILITY (1.2 L/ha in 500 L/ha of water) were applied at several different timings. A scale of 0 to 4 was used to assess disease severity of the three oldest leaves for 20 onions per plot: 0 = no yellowing, 1 = 1–10% yellowed, 2 = 11–25% yellowed, 3 = 26–50% yellowed, 4 > 51% yellowed area. A disease severity index (DSI) was calculated as:

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

On 14 September, onion plants in two 2.3 m sections of row were harvested from the middle rows of each plot, weighed, and graded to determine yield**.** Data were analyzed using the GLIMMIX function of SAS version 9.4 (SAS Institute 2017). Means separation was assessed using Tukey's honest significant difference (HSD) test at $P = 0.05$.

Compared to the previous 10-year average, air temperature in 2018 was above average for May (15.8°C), August (21.9°C), and September (17.5°C), and near-normal for June (18.4°C) and July (22.0°C). The 10-

year monthly mean temperatures were May 13.9°C, June 18.6°C, July 21.2°C, August 20.1°C, and September 16.0°C. Monthly rainfall was above the 10-year average for August (109 mm), average for May (82 mm) and July (104 mm), and below average for June (59 mm) and September (20 mm). The 10-year rainfall averages were: May 74 mm, June 101 mm, July 97 mm, August 75 mm, and September 67 mm.

RESULTS: As presented in Tables 1 and 2.

CONCLUSIONS: The weekly schedules resulted in five (4-leaf stage) to seven (2-leaf stage) foliar applications of fungicide. Weekly foliar applications and application of CIVITAS did not reduce blight incidence or severity compared to the untreated control. Disease pressure was high, and the forecasting models did not reduce fungicide application, with five applications recommended by TOMCAST and six applications by BSPCAST. However, fungicide seed treatment in combination with weekly foliar sprays reduced incidence by 22–31% and severity by 42–53% relative to the control (Table 1). There were no differences in yield among treatments. The EVERGOL PRIME seed coating resulted in fewer, slightly larger bulbs/m (Table 2), but this was likely associated with low emergence in this treatment (data not shown).

ACKNOWLEDGEMENT: Funding for this project was provided by the OMAFRA / U of G partnership, the Bradford Cooperative Storage Inc., and the Fresh Vegetable Growers of Ontario.

Table 1. Effect of fungicide applications on Stemphylium leaf blight levels at the Muck Crops Research Station on 14 August 2018.

Treatment	# Applications	Incidence (%)	Severity (DSI)
Control	0	98 a	57 a[2]
Weekly spray (2-leaf)	7	93 ab	51 ab
BSPCAST	6	90 ab	50 ab
Weekly spray (4-leaf)	5	86 ab	46 abc
CIVITAS + weekly spray	7	89 ab	42 abc
TOMCAST	5	88 abc	40 abc
FARMORE F300 seed coating + weekly spray	7	76 bc	33 bc
EVERGOL PRIME seed coating + weekly spray	7	68 b	27 c

[1] Means in column followed by the same letter do not differ at $P = 0.05$ based on Tukey's HSD test.

Table 2. Effect of fungicide application on yield and size distribution (# bulbs) of onion in 2018.

Treatment	Yield (t/ha)	Bulbs (m^{-1})	Bulb wt. (g)	Size distribution (# onions)		
				Cull (<32 mm)	Can. No. 1 (32–76 mm)	Jumbo (>76 mm)
Control	45.3 ns[1]	21.0 a[2]	93.3 ab	2 b	94 a	2 ns
CIVITAS + weekly spray	48.1	20.5 a	100.3 ab	2 b	92 a	2
TOMCAST	50.5	19.8 a	109.4 ab	3 ab	85 a	3
Weekly spray (4-leaf)	37.6	19.5 a	84.4 b	8 a	81 a	2
BSPCAST	41.6	17.9 ab	100.8 ab	1 b	78 ab	4
FARMORE F300 seed coating + weekly spray	40.8	17.6 ab	100.3 ab	4 ab	77 ab	2
Weekly spray (2-leaf)	38.1	16.5 ab	100.8 ab	2 b	71 ab	4
EVERGOL PRIME seed coat + weekly spray	35.9	11.9 b	125.9 ab	2 b	48 b	5

[1] ns = No significant differences ($P = 0.05$) were found among the treatments.
[2] Means in column followed by the same letter do not differ at $P = 0.05$ based on Tukey's HSD test.

2018 PMR REPORT # 21 **SECTION L: VEGETABLES and SPECIAL CROPS – Diseases**

CROP: Rutabaga (*Brassica napus* var. *napobrassica* L.), cv. Laurentian
PEST: Black leg (*Phoma lingam* (Tode) Desm.)

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TITLE: FIELD EVALUATION OF QUADRIS TOP FUNGICIDE FOR CONTROL OF BLACK LEG IN RUTABAGA, 2016

MATERIALS: QUADRIS TOP (azoxystrobin 18.2%, difenoconazole 11.4%), TILT 250E (propiconazole 250 g/l)

METHODS: Two trials with rutabaga, cv 'Laurentian', were planted directly in the field (soil organic matter ≈ 1.6%, pH ≈ 6.7) at the Simcoe Research Station on 26 May and 28 June 2016, using a Clean Seeder planter at a depth of 1.5 cm. Seeds were planted at a density of 10 seeds per m. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four rows, 75 cm apart, 7 m long. Treatments were non-inoculated check, inoculated check, QUADRIS TOP at the rate of 600, 1000, and 2000 ml/ha and a commercial standard, TILT 250E, at the rate of 400 ml/ha. Treatments were applied using a CO_2 backpack sprayer equipped with three TeeJet XR8004 nozzles spaced 50 cm apart and calibrated to deliver 300 l/ha at 220 kPa. For Trial 1, treatments were applied on 22 June, 6 and 19 July and for trial 2, on 19 July, 2 and 15 Aug. A conidial suspension of 1.5×10^6 conidia/ml of *Phoma lingam* was prepared from 4-6 weeks old potato dextrose agar plates. The suspension was sprayed onto the foliage until run off. All plots (except the non-inoculated check) were inoculated on 23 June for Trial 1, and 21 July for trial 2, when the crop was at the 2-3 leaf stage. Inoculation was repeated on 8 July for Trial 1 and 17 August for Trial 2. Disease incidence and severity of black leg was assessed on 12, 21, 29 July, 5, 12, 19 Aug for trial 1 and 19, 27 July, 5, 12, 19, 25 August, 1 September for trial 2. Sixty leaves from the middle two rows of each plot were examined and rated from 0-6 with: 0 = no disease, 1 = 1-5% leaf area diseased, 2 = 6-10%, 3 = 11-20%, 4 = 21-30%, 5 = 31-40%, 6 = >40%. A 2.5-meter section of the middle 2 rows of each plot was hand harvested on 26 Aug for trial 1 and on 3 October 2016 for trial 2. Roots were graded as unmarketable based on the presence of disease or if roots were less than 50 mm in diameter. Harvested roots were assessed for disease severity by assigning a rating of 0-6 with: 0 = no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%. Compared to the previous 10-year averages, the air temperatures in 2016 were average for May (14.7°C), above average for June (20.1°C), July (23.6°C), August (23.9°C), September (19.0°C) and October (11.3°C). The 10-yr average temperatures were: May 14.8°C, June 19.2°C, July 21.6°C, August 20.6 °C, September 17.0°C, and October 10.6°C. Monthly rainfall was below the 10-year average for May (39 mm), June (33 mm), July (46 mm), August (26 mm), average for October (78 mm) and above average for September (99 mm). The 10-year rainfall averages were: May 73 mm, June 92 mm, July 81 mm August 85 mm, September 87 mm and October 82 mm. Data was analyzed 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 Table 1 for trial 1 and Table 2 for trial 2.

CONCLUSIONS: No symptoms of black leg were observed on the leaves and stems during the in-field assessments (data not shown), however lesions were observed on the roots at harvest. Total yield did not differ among the treatments for both trials. In trial 1, marketable yield and percent marketable were lowest in the inoculated check and TILT treatments. Plots treated with QUADRIS TOP produced a similar marketable yield and percent marketable as the non-inoculated check regardless of the rate applied. No significant differences in marketable yields were observed for trial 2. In both trials, applications of QUADRIS TOP significantly reduced black leg incidence and disease severity index (DSI) compared to the non-inoculated check and TILT treatments. Although the highest rate of QUADRIS TOP resulted in the numerically lowest disease incidence and DSI, there were no statistically significant differences among the different rates. No phytotoxicity was observed due to QUADRIS TOP (data not shown).

Table 1. Effect of fungicides to control black leg on yield, percent marketable, incidence and severity within each treatment group for rutabaga cv. Laurentian for trial 1 in Simcoe, Ontario, in 2016, as assessed on 26 September.

Treatment	Total Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Disease Incidence (%)	DSI [1] 0-100
Non-inoculated Check	46.5 ns[2]	41.0 a[3]	89.35 a	4.60 b	1.90 b
Inoculated Check	52.9	6.4 b	18.45 b	76.40 a	53.50a
QUADRIS TOP @ 600 ml/ha	63.6	42.3 a	67.60 a	24.13 b	13.43b
QUADRIS TOP @ 1000 ml/ha	46.9	41.5 a	87.70 a	9.80 b	4.98 b
QUADRIS TOP @ 2000 ml/ha	49.4	44.7 a	89.48 a	5.43 b	2.70 b
TILT 250E @ 400 ml/ha	51.6	6.7 b	12.25 b	84.65 a	57.85a

[1] Disease severity ratings, 0=no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%, Disease Severity Index formula:

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

[2] No significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.

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

Table 2. Effect of fungicides to control black leg on yield, percent marketable, incidence and disease severity index (DSI) within each treatment group for rutabaga cv. Laurentian for trial 2 in Simcoe, Ontario, in 2016, as assessed on 3 October.

Treatment	Total Yield (t/ha)	Marketable Yield (t/ha)	Marketable (%)	Disease Incidence (%)	DSI[1] 0-100
Non-inoculated Check	63.3 ns[2]	57.6 ns	92.15 ns	0.00 b[3]	0.00 b
Inoculated Check	55.9	36.7	65.13	33.23 a	15.00 a
QUADRIS TOP @ 600 ml/ha	63.5	52.1	84.65	3.23 b	0.55 b
QUADRIS TOP @ 1000 ml/ha	66.5	53.6	82.40	1.85 b	0.60 b
QUADRIS TOP @ 2000 ml/ha	69.6	58.0	82.28	0.00 b	0.00 b
TILT 250E @ 400 ml/ha	65.1	35.9	55.35	25.60 a	9.25 a

[1] Disease severity ratings, 0=no disease, 1 = 1-10% root area diseased, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = >50%, Disease Severity Index formula:

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

[2] no significant differences (P = 0.05, Tukey's HSD test) were found among the treatments.

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

2018 PMR REPORT #22 **SECTION L: VEGETABLES and SPECIAL CROPS**
Diseases

CROP: Swiss chard (*Beta vulgaris* subsp. *vulgaris*), cv. Burpee's Rhubarb Chard
PEST: Cercospora leaf spot (*Cercospora beticola* Sacc.)

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TITLE: **EVALUATION OF CUEVA FUNGICIDE FOR CONTROL OF CERCOSPORA LEAF SPOT ON SWISS CHARD, 2018**

MATERIALS: CUEVA FUNGICIDE (copper octanoate 1.8%), PROLINE 480 SC (prothioconazole 480 g/L)

METHODS: Swiss chard, cv. Burpee's Rhubarb Chard, was direct seeded into organic soil (pH ≈ 6.9, organic matter ≈ 63.5%) on 17 July using an Earthway push seeder fitted with plate no. 1002-22. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four, 5.0 m long rows, spaced 40 cm apart. Treatments were: CUEVA FUNGICIDE at 0.5, 1, 2 and 4% v/v and PROLINE 480 SC at 415 mL/ha. An untreated inoculated check was also included. Treatments were applied on 9, 15, 23 and 30 August as foliar sprays using a CO_2 back pack sprayer equipped with four TeeJet 8002 fan nozzles calibrated to deliver 500 L/ha at 275 kPa. On 24 August, inoculum was prepared using approximately 200 g of dried sugar beet leaves infected with *Cercospora beticola*. Leaves were submerged and soaked for 10 minutes in a large glass beaker filled with water and lined with cheese cloth. The wetted leaves were squeezed by hand to release conidia. Leaves were removed from the beaker using the cheese cloth. The resulting spore suspension was diluted to a concentration of 1.0×10^4 spores/mL, as determined using a hemocytometer. This suspension was immediately applied to all replicates at the rate of 160 mL/replicate using a CO_2 backpack sprayer fitted with a single TeeJet 11002 fan-type nozzle. After inoculation, check plots were visually examined for leaf spot on a weekly basis. On 7 September, leaf spot was found and confirmed in the lab as *C. beticola*. On 11 September, a fully expanded lower leaf was removed from 20 randomly chosen plants per replicate. Leaves were visually examined for leaf spots, and numbers were counted and recorded. On 24 September, 10 consecutive plants per replicate were cut from the inside two rows (five from each row) and weighed to determine total yield. All diseased leaves were removed, and plants reweighed to determine marketable yield. Compared to the previous 10-year average, air temperatures in 2018 were above average for August (21.9°C) and September (17.5°C), and average for July (22.0°C). The 10-year average temperatures were: July 21.2°C, August 20.1°C and September 16.0°C. Monthly rainfall was above the 10-year average for August (109 mm), average for July (104 mm) and below average for September (20 mm). The 10-year rainfall averages were: July 97 mm, August 75 mm and September 67 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 Tukey's HSD Test at $P = 0.05$ level of significance.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: CUEVA FUNGICIDE applied at 1-4% v/v reduced Cercospora leaf spot in Swiss chard. Significant differences in lesions per leaf and the percentage of diseased leaves were found among

the treatments (Table 1). Swiss chard treated with PROLINE or CUEVA FUNGICIDE at 1% or 2% v/v had significantly fewer leaf spots than untreated Swiss chard. However, the number of Cercospora leaf spots found on Swiss chard treated with PROLINE or any tested rate of CUEVA FUNGICIDE ranged from 0.3 to 1.4 spots per leaf and did not differ statistically from each other. Swiss chard treated with PROLINE had a lower percentage of diseased leaves (20%) compared to Swiss chard treated with CUEVA FUNGICIDE at 0.5% or untreated Swiss chard (56.3 and 80% respectively).

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

Table 1. Cercospora leaf spot severity (number of leaf spots per leaf) and incidence (percentage of diseased leaves) for Swiss chard, cv. Burpee's Rhubarb Chard, treated with fungicides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	Leaf spots/leaf[1]	Diseased leaves (%)
PROLINE	0.3 a[2]	20.0 a
CUEVA 1%	0.7 a	36.3 ab
CUEVA 2%	0.9 a	52.5 abc
CUEVA 4%	1.1 ab	48.8 abc
CUEVA 0.5%	1.4 ab	56 3 bc
Untreated check	3.6 b	80.0 c

[1] Assessed on 20 leaves per replicate
[2] Numbers in a column followed by the same letter are not significantly different at *P*=0.05, Tukey's HSD test.

Table 2. Yield for Swiss chard, cv. Burpee's Rhubarb Chard, treated with fungicides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2018.

Treatment	% Marketable	Mkb wgt/plant (g)	Total wgt/plant (g)
PROLINE	89.3 a[1]	51.0 ns[2]	57.0 ns
CUEVA 2.0%	86.2 a	46.8	54.3
CUEVA 4.0%	84.5 a	43.8	52.0
CUEVA 1.0%	82.9 a	44.0	52.8
CUEVA 0.5%	78.6 a	45.5	58.5
Untreated check	61.6 b	37.8	62.3

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

2018 PMR REPORT # 23 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Swiss chard (*Beta vulgaris* subsp. *vulgaris*), var. Silverado
PEST: Cercospora leaf spot (*Cercospora beticola* Sacc.)

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TITLE: **FIELD EVALUATION OF CUEVA FUNGICIDE FOR CONTROL OF CERCOSPORA LEAF SPOT IN SWISS CHARD, 2017**

MATERIALS: CUEVA (copper octanoate 1.8%, liquid), PROLINE 480 SC (prothioconazole 41%)

METHODS: Swiss chard variety Silverado was planted directly in the field (organic matter ≈ 2.8%, pH ≈ 6.65) at Simcoe Research Station on 14 June 2017, using a Clean Seeder planter at a depth of 1.25 cm. Seeds were planted at a density of 10 seeds per m. 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 10 cm apart within the row. Treatments were non-inoculated check, inoculated check, CUEVA at 0.5 % solution, CUEVA at 1, 2 and 4% solution and commercial standard PROLINE at the rate of 415 ml/ha. Treatments were applied using a CO_2 backpack sprayer equipped with three TeeJet XR11005 nozzles spaced 50 cm apart and calibrated to deliver 500 l/ha at 220 kPa. Treatments were applied on 18, 26 July, 1, 16 and 22 August. Mycelial plugs (0.5 cm diameter) from 20-30-day old cultures of *Cercospora beticola* in potato dextrose agar were used to inoculate the wet leaf surface of plants in each plot (except for the non-inoculated check) on 19 July. A total of two fully expanded leaves per plant were inoculated with one plug per leaf. Disease incidence and severity were assessed on 14, 24 July, 1, 10, 17, 25 August on twelve plants from the middle two rows of each plot. The number of plants assessed was increased to 16 for the last three assessments. Incidence was calculated as the number of plants with cercospora leaf spot/total plant assessed *100. Plants were assigned a rating from 0-10 where: 0 = healthy plant; 1 = a single isolated spot on one or more than one leaves of a plant; 2 = 20 spots on a leaf or on more than one leaf of a plant; 3 = 21-50 spots on one leaf or on more than one leaf of a plant; 4 = 51-100 spots on a leaf or more than one leaf; 5 = 50% of the leaf area is infected on one or more leaves of a plant; 6 = 60% of the leaf area is infected; 7 = 70% of the leaf area is infected; 8 = 80% leaf area infected; 9 = the entire foliage is strongly affected; 10 = the foliage is completely destroyed. Disease severity rating was used to calculate severity index (DSI) and area under disease progress curve (AUDPC). On 29 August, Swiss chard was harvested from a 2.5-meter section of the middle 2 rows of each plot. The total yield of harvested leaves was recorded, and a sub-sample of 50 leaves was randomly selected to assess disease incidence and percent marketable. Compared to previous 10-year averages, the air temperatures in 2017 were average for June (19.4°C), July (21.3°C) and below average for August (19.7°C). The 10-yr average temperatures were: June 19.3°C, July 21.6°C and August 20.6 °C. Monthly rainfall was below the 10-year average for June (80 mm), July (25 mm) and August (62 mm). The 10-year rainfall averages were: June 92 mm, July 76 mm and August 83 mm. Data was analyzed 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 presented in Tables 1 and 2.

CONCLUSIONS: The inoculation was successful, but disease development was slow. Although the percentage of infected plant was high at harvest, disease severity was low. Both incidence and severity varied considerably among replications and therefore, resulted in no significant differences among treatments. Although not statistically significant, there was a numerical trend of lower AUDPC with increasing rates of CUEVA. Applications of PROLINE or 4% CUEVA resulted in statistically similar levels of disease as the non-inoculated check on two of the assessment dates, suggesting some product efficacy. No significant differences in total or marketable yield were observed (data not shown).

Table 5: Effect of fungicides on disease incidence as reported on various dates for Swiss chard var. Silverado grown at the Simcoe Research Station, Ontario, in 2017.

Treatment	Disease Incidence (%)[1]					
	14 July	24 July	1 Aug.	10 Aug.	17 Aug.	25 Aug.
Non-inoculated Check	0.0 ns[2]	0.0 ns	0.0 ns	9.3 b[3]	28.1 b	39.0 b
Inoculated Check	0.0	0.0	0.75	67.2 a	71.8 a	81.2 a
CUEVA @ 0.5 % v/v	0.0	0.0	1.5	65.6 a	71.8 a	81.2 a
CUEVA @ 1 % v/v	0.0	0.0	0.0	59.4 a	67.1 a	70.3 ab
CUEVA @ 2 % v/v	0.0	0.0	0.0	59.4 a	62.5 a	68.7 ab
CUEVA @ 4 % v/v	0.0	0.0	0.0	45.3 ab	56.2 a	79.6 ab
PROLINE @ 415 ml/ha	0.0	0.0	0.0	39.0 ab	45.3 ab	46.8 ab

[1] number of plants with cercospora leaf spot/total plant assessed *100
[2] ns = no significant differences (P=0.05, Tukey's HSD test) were found among treatments
[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$ using Tukey's HSD test.

Table 2: Cercospora leaf spot severity for Swiss chard var. Silverado treated with fungicides and grown at the Simcoe Research Station, Ontario, in 2017.

Treatment	Disease Severity Index (DSI)						AUDPC[2]
	14 July	24 July	1 Aug.	10 Aug.	17 Aug.	25 Aug.	
Non-inoculated Check	0.0 ns[3]	0.0	0.00 ns	0.8 b[4]	2.9 c	5.3 ns	5.0 b
Inoculated Check	0.0	0.0	0.1	8.8 a	11.1 a	12.8	20.9 a
CUEVA @ 0.5% v/v	0.0	0.0	0.3	9.3 a	9.5 ab	13.3	21.1 a
CUEVA @ 1% v/v	0.0	0.0	0.0	7.3 a	9.5 ab	12.6	17.1 a
CUEVA @ 2% v/v	0.0	0.0	0.0	7.2 a	6.75 ab	9.4	14.5 a
CUEVA @ 4%v/v	0.0	0.0	0.0	4.8 a	6.2 abc	11.9	13.4 a
PROLINE @ 415 ml/ha	0.0	0.0	0.0	4.3 ab	4.6 bc	6.90	9.47 ab

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

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

[2] Area under the disease progress curve was calculated using the following formula,

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

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

2018 PMR Report # 24 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

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

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TITLE: FUNGICIDES FOR DISEASE MANAGEMENT IN TOMATO, 2018

MATERIALS: BRAVO ZN (chlorothalonil 500 g L^{-1}), QUADRIS FLOWABLE (azoxystrobin 250 g L^{-1}), MANZATE PRO-STICK (mancozeb 75%), FONTELIS (penthiopyrad 200 g L^{-1}), APROVIA TOP (benzovindiflupyr 78 g L^{-1}, difenoconazole 117 g L^{-1}), SERCADIS (fluxapyroxad 300 g/L), A20259 (pydiflumetofen 75 g L^{-1}, difenoconazole 125 g L^{-1}), CUEVA (copper octanoate 1.8%), TANOS 50 DF (famoxadone 25%, cymoxanil 25%), PRODUCT A (unknown), PRODUCT B (unknown), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%)

METHODS: The trial was conducted at Ridgetown Campus, University of Guelph. Tomatoes were transplanted on May 29 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 2 m apart. Each treatment plot was 7 m long and consisted of one twin-row. The trial was set up as a randomized complete block design with four replications per treatment. Treatments were applied using a hand-held CO_2 sprayer (35 psi) with ULD 120-03 nozzles and water volume of 300 L/ha. On June 27, one healthy seedling at the front of each plot was removed and replaced with a tomato seedling showing symptoms of early blight and previously inoculated with *A. solani* strains As56C, AS63c, As99b, As97f, As35e, As36d, and As37. Inoculation with *S. lycopersici* occurred on August 15 by placing two symptomatic leaves in the centre of each plot. No inoculation was performed for anthracnose fruit rot. Defoliation was estimated August 7, 20, 31, and September 14 using an incremental 5% scale and used to calculate the area under the disease progress stairs (AUDPS). Tomatoes were harvested from a 2 m section of each plot on September 17. Fifty randomly selected red fruit were assessed for anthracnose after three days in storage. Statistical analysis was conducted using ARM 2018 (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. Symptoms of a disease or disorder were identified in all plots in early August. The cause could not be identified using standard techniques and there was no association with treatments. This made foliar disease assessment more difficult.

CONCLUSIONS: Treatments QUADRIS, TANOS, FONTELIS, APROVIA TOP, A20259, and PHOSTROL + BRAVO ZN had lower AUDPS than the nontreated control. Defoliation on the final assessment date was lower in treatments BRAVO ZN, QUADRIS, TANOS, SERCADIS, FONTELIS, APROVIA TOP, A20259, and PHOSTROL + BRAVO ZN. Anthracnose fruit rot incidence was very low and there were no differences among treatments (Table 1). Yield for all fungicide treatments was equivalent to the nontreated control (data not shown).

ACKNOWLEDGEMENT: This research was supported by the Ontario Tomato Research Institute and the Ontario Agri-Food Innovation Alliance.

Table 1. Percent defoliation, area under the disease progress stairs (AUDPS), and anthracnose fruit rot incidence in tomatoes treated with different fungicides for management of early blight, Septoria leaf spot, and anthracnose fruit rot, Ridgetown, Ontario, 2018.

Treatment (per ha) [1]	Defoliation (%)		Anthracnose (%)
	Sept 14 [2]	AUDPS [3]	
Control	97 a	2318 ab [4]	6.6 a
BRAVO ZN @ 3.2 L	71 cde	1562 b-f	2.5 a
MANZATE PRO-STICK @ 2.5 kg	86 abc	1797 a-e	4.0 a
CUEVA @ 0.5% v/v	96 ab	2289 abc	9.5 a
QUADRIS @ 400 mL	32 f	677 g	1.0 a
TANOS @ 560 g	72 cde	1494 c-g	2.4 a
SERCADIS @ 250 mL	76 bcd	1629 b-f	6.3 a
FONTELIS @ 1.5 L	74 b-e	1448 d-g	0.5 a
APROVIA TOP @ 805 mL	42 ef	898 fg	4.5 a
A20259 @ 1 L	53 def	1094 efg	4.0 a
PRODUCT A @ 200 ppm	97 a	2496 a	8.5 a
PRODUCT B @ 300 ppm	96 ab	2463 a	8.0 a
PHOSTROL @ 2.9 L	90 abc	2005 a-d	4.0 a
PHOSTROL @ 2.9 L + CUEVA @ 0.5 % v/v	95 ab	2303 abc	8.0 a
PHOSTROL @ 2.9 L + BRAVO ZN @ 3.2 L	53 def	1078 efg	1.0 a

[1] Treatments were applied on June 26, July 7, July 17, July 26, August 7, August 17, August 30.
[2] Data was transformed using an arcsine square root transformation and the back-transformed means are presented.
[3] 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 last assessment to the first 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}.
[4] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2018 PMR Report # 25 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Tomato (*Solanum lycopersicum* L.), cv. H5108
PEST: Bacterial spot (*Xanthomonas gardneri* (ex Sutic) Jones, nom rev., comb. nov. DC00T7A)

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TITLE: BACTERICIDES FOR BACTERIAL SPOT IN TOMATO, 2018

MATERIALS: KOCIDE 2000 (copper hydroxide 53.8%), LIFEGARD WG (*Bacillus mycoides* isolate J 40%), DOUBLE NICKEL LC (*Bacillus amyloliquefaciens* strain D747 1×10^{10} spores/mL (minimum)), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%)

METHODS: The trial was conducted at Ridgetown Campus, University of Guelph. Tomatoes were transplanted on May 25 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 2 m apart. Each treatment plot was 7 m long and consisted of one twin-row. The trial was set up as a randomized complete block design with four replications per treatment. Pre-transplant foliar applications were made to tomato foliage using a hand-held mist sprayer in 1000 L of water/ha one day before transplanting. Post-transplant foliar treatments were applied using a hand-held CO_2 sprayer (40 psi) with ULD 120-02 nozzles. Application water volume was 200 L/ha for the first four applications and 300 L/ha for the final four applications. The trial was inoculated with a copper sensitive strain of *X. gardneri*, DC00T7A, on June 4 using a concentration of approximately 1 x 10^7 CFU/mL. Bravo ZN (3.2 L/ha) was applied to manage fungal diseases on June 28, July 11, 20, and August 1. Defoliation was assessed August 2, 10, 14, and 20 using a 5% incremental scale. These values were used to calculate the area under the disease progress stairs (AUDPS). Tomatoes were harvested from a 2 m section of each plot on August 27. One hundred red fruit were randomly selected and assessed for incidence of bacterial spot. Statistical analysis was conducted using ARM 2018 (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 and Table 2.

CONCLUSIONS: The only treatment to reduce defoliation compared to the nontreated control was KOCIDE 2000. This did not result in a reduction in bacterial spot incidence on fruit or an increase in tomato yield. PHOSTROL, DOUBLE NICKEL and LIFEGARD did not demonstrate strong potential for management of bacterial spot under the conditions tested. The trial was inoculated with a copper sensitive strain of *X. gardneri*, but recent surveys confirm the *X. gardneri* population in Ontario is largely copper insensitive. Therefore, KOCIDE 2000 may not show the same performance under commercial field conditions.

ACKNOWLEDGEMENT: This research was supported by the Ontario Tomato Research Institute and the Ontario Agri-Food Innovation Alliance.

Table 1. Defoliation and area under the disease progress stairs (AUDPS) for tomatoes treated with products for bacterial spot caused by a copper sensitive strain of *X. gardneri*, Ridgetown, Ontario, 2018.

Treatment (application timing) [1]	Defoliation (%)		Incidence
	Aug 20	AUDPS [2]	(% fruit)
Water	58 a [3]	658 a	10.9 a
KOCIDE 2000 @ 2.25 kg/ha (B-I)	35 b	270 b	6.4 a
LIFEGARD @ 100 g/ha (B-I)	55 ab	629 a	15.6 a
DOUBLE NICKEL LC @ 2.3 L/ha (B-I)	60 a	633 a	13.3 a
PHOSTROL @ 2.47 L/ha (A)	50 ab	568 a	11.4 a
PHOSTROL @ 2.27 L/ha (B-I)			
PHOSTROL @ 2.47 L/ha (A)	60 a	678 a	12.2 a
DOUBLE NICKEL LC @ 2.3 L/ha + PHOSTROL @ 2.27 L/ha (B-I)			

[1] Application dates were: A = May 24 (before transplanting), B = June 8, C = June 15, D = June 23, E = June 29, F = July 7, G = July 13, H = July 20, I = July 27.
[2] 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 last assessment to the first 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}.
[3] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

Table 2. Tomato yield in plots treated with products for bacterial spot caused by a copper sensitive strain of *X. gardneri*, Ridgetown, Ontario, 2018.

Treatment (application timing) [1]	Yield (tonnes/hectare)			
	Reds	Greens	Rots	Total
Water	61.4 a	2.5 a	1.1 a	65.0 a
KOCIDE 2000 @ 2.25 kg/ha (B-I)	70.6 a	5.4 a	0.7 a	76.6 a
LIFEGARD @ 100 g/ha (B-I)	89.6 a	2.5 a	1.1 a	73.0 a
DOUBLE NICKEL LC @ 2.3 L/ha (B-I)	62.3 a	2.7 a	0.4 a	65.4 a
PHOSTROL @ 2.47 L/ha (A)				
PHOSTROL @ 2.27 L/ha (B-I)	60.3 a	3.8 a	0.7 a	65.0 a
PHOSTROL @ 2.47 L/ha (A)				
DOUBLE NICKEL LC @ 2.3 L/ha + PHOSTROL @ 2.27 L/ha (B-I)	61.4 a	2.7 a	1.1 a	65.2 a

[1] Application dates were: A = May 24 (foliar drench before planting), B = June 8, C = June 15, D = June 23, E = June 29, F = July 7, G = July 13, H = July 20, I = July 27.
[2] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2018 PMR Report # 26 **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

CROP: Tomato (*Solanum lycopersicum* L.), cv. H3406 and cv. H3101
PEST: Phytophthora fruit rot (*Phytophthora capsici* Leonian)

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TITLE: **MANAGEMENT OF PHYTOPHTHORA FRUIT ROT IN TOMATO, 2018**

MATERIALS: PRESIDIO (fluopicolide 39.5%), REVUS (mandipropamid 23.3%), ORONDIS ULTRA (oxathiapiprolin 30 g/L, mandipropamid 250 g/L), PHOSTROL (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), ZAMPRO (ametoctradin 300 g/L, dimethomorph 225 g/L), TORRENT 400SC (cyazofamid 34.5%)

METHODS: The strip trial was established at a commercial processing tomato field in Essex County, Ontario. Previous tomato crops a the site had economic losses from Phytopthora fruit rot. The trial was arranged in a randomized complete block design with three replications. The treated area for each plot was a minimum of 9 m wide and 305 m long. Tomatoes were transplanted on June 1 using cv. H3406 (replication one) and cv. H1301 (replications 2 and 3). The crop was grown according to standard grower practices. Maintenance applications against fungal diseases were applied to all plots on June 28 (mancozeb), July 13 (chlorothalonil), Aug 28 (chlorothalonil), and Sept 8 (azoxystrobin). The cooperating grower used standard transplanting equipment to apply in-furrow treatments and a commercial field sprayer to apply foliar fungicide treatments beginning at early fruit set, using hollow cone nozzles with an application water volume of 346 L/ha and 120 psi. In mid-August, three 2 m harvest areas per plot were marked with flags. Harvest areas were determined by walking a transect perpendicular to the length of the treated plots. Harvest areas were marked with flags, and care was taken to avoid areas that introduced additional variability, particularly low spots or areas with low plant stand. Tomatoes were harvested on September 11 and 12. All tomatoes within each 2 m harvest area were sorted into reds, greens, and rots (fruit with no structural integrity) and weighed. Statistical analysis was conducted using ARM 2018 (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: The fungicide programs reduced yield of tomato rots by an average of 61%. There was no advantage to the in-furrow + foliar program compared to foliar only program. The foliar program was beneficial for management of Phytophthora root rot under the conditions tested.

ACKNOWLEDGEMENT: This research was funded by the Ontario Tomato Research Institute and the Ontario Agri-Food Innovation Alliance. In-kind support was provided by Syngenta Canada, Engage Agro, BASF, Valent Canada, and the grower cooperator.

Table 1. Yield of tomatoes treated with different fungicide programs for management of Phytophthora fruit rot, Essex County, Ontario, 2018.

Treatment (application timing) [1]	Yield (tonnes/hectare)			
	Reds	Greens	Rots	Total
Control	85.8 a	3.4 a	8.3 a	97.7 a
PRESIDIO @ 2.2 mL/100 m + REVUS @ 5.4 mL/100 m (A) ORONDIS ULTRA @ 600 mL/ha + PHOSTROL 2.9 L/ha (B) ZAMPRO @ 1 L + PHOSTROL @ 2.9 L/ha (C) TORRENT @ 200 mL + PHOSTROL @ 2.9 L/ha (D) ORONDIS ULTRA @ 600 mL/ha (E) ZAMPRO @ 1 L/ha (F)	94.8 a	4.5 a	3.6 b	103.0 a
ORONDIS ULTRA @ 600 mL/ha + PHOSTROL 2.9 L/ha (B) ZAMPRO @ 1 L + PHOSTROL @ 2.9 L/ha (C) TORRENT @ 200 mL + PHOSTROL @ 2.9 L/ha (D) ORONDIS ULTRA @ 600 mL/ha (E) ZAMPRO @ 1 L/ha (F)	105.1 a	6.0 a	2.9 b	114.0 a

[1] Application timings: A = June 21 (in-furrow), B = July 5, C = July 16 D = July 25, E = August 4, F = August 15 (foliar).
[2] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2018 PMR REPORT #27 **SECTION N: POTATO - Diseases**

CROP: Potato (*Solanum tuberosum cepa* L.),
PEST: Black Dot disease (Colletotrichum coccodes) Wallhr. Hughes

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TITLE: IN-VITRO SCREENING FOR EFFICACY OF SELECTED FUNGICIDES AGAINST COLLETROTRICHUM COCCODES (BLACKDOT PATHOGEN) OF POTATO.

MATERIALS: CANTUS WDG (boscalid 70%), BRAVO 500 (chlorothalonil 500 g/L), DITHANE RAINSHIELD (mancozeb 75%), EVITO 480 TM SC (fluoxastrobin 480 g/L), HEADLINE EC (pyraclostrobin 250 g/L), PHOSTROL (Na and K salts of Phosphorus acid 53.6%), QUADRIS (azoxystrobin 250 g/L), and REASON 500 SC (fenamidone 500 g/L), SWITCH 62.5 WG (cyprodinil 37.5% + Fludioxonil 25%)

METHODS: Nine fungicides were selected for testing efficacy against *Colletotrichum coccodes* in-vitro, using poison plate technique. *C. coccodes* fungal cultures were isolated from blackdot infected stems collected from different locations in Manitoba potato fields. Four isolates (designated as A, B, C and D) from a collection of about 10 isolates, were used in this study. For the in-vitro trial, the cultures were grown on acidified Potato Dextrose Agar amended with Chloramphenicol and Streptomycin sulfate (PDA+). Seven-day old cultures were used for obtaining 5 mm plugs at the center of fungicide amended PDA+ plates. Fungicides amendment of the PDA+ were at six concentrations: 0, 0.1, 1, 10, 100 and 1000 ppm. There were 4 replication for each treatment (concentration and fungal isolate). The plates were incubated under light bench (12 hours light) at room temperature of around 22^{O}C. Growth of the mycelium was measured 3-days and 7-days after plating. Data analysis was done using Statistix V10; and presented here are main factor analysis for fungicide, concentration and isolate. Data for 3-day and 7-day growth were analyzed separately.

RESULTS & DISCUSSION: As outlined in Tables 1 to 3.
Some of the fungicides significantly reduced mycelial growth of *C. coccodes*, but some fungicides were ineffective in reducing the mycelial growth to below 50% of the control. The mycelial growth reduced significantly by increasing the concentrations of the fungicides. The four isolates of *C. coccodes* showed variability in sensitivity to fungicides (Table 1 C, Table 3); however, isolate B appeared to be more tolerant to fungicides compared to other isolates.

Table 1. A, B C. Comparison of main effects of fungicides, the concentrations and isolates on mycelial growth (% of untreated control) of *C. coccodes*, after 7-days incubation.

A.

Fungicide	**Mean** [1/]
Phostrol	92.7 a
Cantus	92.2 a
Dithane	87.9 b
Bravo	77.0 c
Reason	51.2 d
Evito	50.6 d
Quadris	50.2 d
Headline	34.9 e
Switch	33.0 e

B.

Conc (ppm)	**Mean**
0.1	80.7 a
1	70.0 b
10	62.9 c
100	56.0 d
1000	46.9 e

C.

Isolate	**Mean**
B	66.3 a
A	65.0 a
C	61.3 b
D	60.6 b

[1/] Numbers in columns followed by same letter are not significantly different at P = 0.05, Fisher's LSD test.

Table 2. Mycelial growth (% of untreated control) of Colletotrichum coccodes affected by fungicides at various concentrations (summation over four isolates), after 7-days incubation.

Conc (ppm)	Bravo	Cantus	Dithane	Evito	Headline	Phostrol	Quadris	Reason	Switch
0.1	90.7 a	94.1 ab	95.4 a	76.9 a	69.4 a	93.1 a	65.2 a	69.0 a	75.9 a
1	90.2 ab	95.8 a	93.9 a	53.0 b	52.2 b	93.3 a	57.6 b	64.7 b	**26.4 b**
10	86.5 b	93.1 bc	93.7 a	**48.1 c**	**29.3 c**	93.5 a	**49.5 c**	**48.4 c**	**24.4 bc**
100	68.3 c	90.7 cd	88.8 b	**41.5 d**	**12.2 d**	92.3 a	**41.9 d**	**46.3 c**	**22.0 c**
1000	**49.2 d**	88.3 d	67.9 c	**33.3 e**	**11.5 d**	91.2 a	**36.5 e**	**27.5 d**	**16.5 d**
P=0.05	***	***	***	***	***	NS	***	***	***

Table 3. Mycelial growth (% of untreated control) of *Colletotrichum coccodes* isolates affected by fungicides (summation over concentrations of fungicides), after 7-days incubation.

Isolate	Bravo	Cantus	Dithane	Evito	Headline	Phostrol	Quadris	Reason	Switch
A	80.7 a	96.5 a	86.2 b	58.2 a	38.4 a	93.0 ab	51.0 b	51.6 ab	32.0 b
B	76.8 b	90.8 b	90.5 a	51.8 b	41.8 a	93.0 ab	61.3 a	53.3 a	36.3 a
C	76.2 b	90.6 b	88.2 ab	46.9 c	28.9 b	93.6 a	45.1 c	51.0 ab	32.0 b
D	74.3 b	91.7 b	86.9 b	45.4 c	30.6 b	91.1 b	43.2 c	48.7 b	31.9 b
P=0.05	***	***	***	***	***	NS	***	NS	***

CONCLUSIONS:

Fungicides, registered for use on potatoes, Cantus, Dithane Rainshield and Phostrol appeared ineffective in reducing *C. coccodes* growth to below 50% of control even at 1000ppm. Bravo had some affect, but only at the highest concentration. Evito, Headline, Quadris, Reason and Switch appeared to be effective, even at 10ppm; Headline and Switch were the most effective.

There is variability in sensitivity of the fungal isolates; this suggests that more isolates need to be tested against selected fungicide to determine is fungicide resistant/tolerant isolates have a defined distribution in Manitoba.

More fungicides need to be tested to identify effective products, to provide alternative chemistries for blackdot control and for resistance risk management.

2018 PMR REPORT #28 **SECTION R: BIOLOGICAL CONTROL**

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

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TITLE: **EVALUATION OF BIOLOGICAL PRODUCTS FOR YIELD IMPROVEMENTS IN GARLIC INFECTED WITH BULB AND STEM NEMATODE DURING THE 2017-2018 FIELD SEASON**

MATERIALS: SYNERGRO (Potash 0.2% and microbial consortium 5.2%), ONGARD 5-0-0 (Soy protein hydrolysates), LCFX (Microbial extract), RHIZOVITAL 42 (*Bacillus amyloliquefaciens* strain FZB4) PHYTER (*Clonostachys rosea*)

METHODS: Garlic cloves contaminated with stem and bulb nematode (*Ditylenchus dipsaci*) were seeded by hand in Mount Forest, Ontario, in Harriston loam, on 19 October, 2017 and in Dashwood, Ontario, in Huron clay loam, on 20 October, 2017. The trial was arranged in a randomized complete block design with four replicates at two sites. Each replicate consisted of three rows (2m long) with ten plants per row for a total of 30 plants per plot. Biostimulant products were applied as a drench or weighed and applied as a granular formulation in furrow directly after planting before the furrow was closed. The cloves were covered with 2-5 cm of soil and grown under standard cultivation conditions. Emergence was assessed 3 April, 2018 in Mount Forest and 4 April, 2018 in Dashwood. Mid-season plant height was measured 24 May in Mount Forest and 25 May in Dashwood. Scaping was conducted in Mount Forest 21 June and Dashwood 19 June. The plots at each site were hand weeded as necessary and plants were harvested and assessed on 23 July in Dashwood and 24 July in Mount Forest when an average of 50% of the leaves had senesced. At harvest, bulb basal plates were rated for damage by assessing the percentage of basal plate missing 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. Basal plate damage was assumed to be caused by bulb and stem nematode. Budget limitations did not allow for quantification of nematodes before planting or after harvesting however nematodes were extracted from several bulbs from both sites. Bulbs were hung to dry in a mesh bag in a forced air drying shed shortly after harvesting for 12 days and dry weights were collected on 13 August. Data were analyzed using SAS version 9.3 (SAS Institute, Cary NC). Means were separated using Tukey-Kramer multiple mean comparison test (P = 0.05).

RESULTS: As outlined in Table 1.

CONCLUSIONS: Both locations showed no significant differences in plant emergence in the early spring or differences in a mid-season height and leaf stage assessment roughly six weeks later. While not statistically significant from the non-inoculated control, RHIZOVITAL 42 performed well across most measured variables at harvest and had less basal plate rot at both locations. (**Table 1**).

Table 1. Plant measurements collected July 23rd and 24th and dry weights collected August 13th for various biological treatments on garlic grown near Dashwood and Mount Forest, Ontario, 2017-2018.

Dashwood	Plant Fresh Weight (g)	Diameter (cm)	Bulb Circumference (cm)	Basal Plate Rot[1]	Bulb Fresh Weight (g)	Marketable Weight (kg)[2]	# Cloves
SYNERGRO	91.6ns	4.8b	15.8ns	0.2ns	63.1ns	1.35ns	6.4ns
ONGARD 5-0-0	90.3	4.8b	15.9	0.2	63.4	1.17	6.5
LCFX	89.4	4.9ab	16.2	0.2	65.0	1.24	6.6
RHIZOVITAL 42	95.2	5.3a	16.5	0.1	67.6	1.38	6.4
PHYTER	93.0	5.1ab	16.5	0.2	68.1	1.30	6.5
Non-inoculated control	90.2	5.0ab	16.3	0.2	64.6	1.22	6.5
Mount Forest	**Plant Fresh Weight (g)**	**Diameter (cm)**	**Bulb Circumference (cm)**	**Basal Plate Rot[1]**	**Bulb Fresh Weight (g)**	**Marketable Weight (kg)[2]**	**# Cloves**
SYNERGRO	73.1ab	4.5ns	15.2ns	0.5ab	52.3ns	0.92ns	6.5ns
ONGARD 5-0-0	84.6ab	4.8	16.0	0.3ab	57.1	1.10	6.7
LCFX	85.6a	5.2	16.0	0.3ab	56.5	1.01	6.8
RHIZOVITAL 42	84.1a	4.8	15.8	0.2b	56.8	1.12	6.9
PHYTER	72.6b	4.5	15.1	0.5a	50.0	0.89	6.5
Non-inoculated control	74.9ab	4.6	15.4	0.5ab	54.2	0.73	6.9

[1] Basal plate rot rating is calculated by assessing the percentage of basal plate missing 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

[2] Marketable weight was determined by combining all marketable cloves within a single replicate

[3] ns = no significant differences were found among the treatments

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