2014 Pest Management Research Report (PMRR) 2014 Growing Season

2014 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2014

Canada

English

2014 PEST MANAGEMENT RESEARCH REPORT

Prepared by: Pest Management Centre, Agriculture and Agri-Food Canada
960 Carling Avenue, Building 57, Ottawa ON K1A 0C6, Canada

The Official Title of the Report

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[1] This is the fifteenth 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 ii.

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 12 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.

Contact:

Tristan Jobin
Tel. (450) 515-2056
Fax. (450) 346-7740
Email. Tristan.Jobin@agr.gc.ca

Procedures for the 2015 Annual PMR Report will be sent in fall, 2015. They will also be available from Tristan Jobin.

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 2014 has been assigned a Volume number for the thirteenth 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 53.

An individual report will be cited as follows:
Author(s). 2014. Title. 2014 Pest Management Research Report - 2014 Growing Season. Agriculture and AgriFood Canada. March 2015. Report No. x. Vol. 53: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2014

Préparé par: Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada
960 avenue Carling, Ed. 57, Ottawa ON K1A 0C6, Canada

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[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 12 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.

Contacter:

Tristan Jobin
Tél. (450) 515-2056
Télécopie. (450) 346-7740
Email. Tristan.Jobin@agr.gc.ca

Des procédures pour le rapport annuel de 2015 seront distribuées à l'automne 2015. Elles seront aussi disponibles via Tristan Jobin.

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. 2014. Titre. 2014 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. Mars, 2015. Rapport n^{o} x. vol. 53: pp-pp.

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2014 PMR REPORT # 01 **SECTION B: VEGETABLES and SPECIAL CROPS - Insect Pests**

CROP: Yellow cooking onions (*Allium cepa* L.), cv. Hendrix
PEST: Onion maggot, *Delia antiqua* (Meigen)

NAME AND AGENCY:
MCDONALD M R[1], VANDER KOOI K[1] and TAYLOR A G[2]
[1] University of Guelph, Dept. of Plant Agriculture, Muck Crops Research Station
1125 Woodchoppers Lane, King, ON L7B 0E9

Tel: (905) 775-3783 **Fax:** (905) 775-4546 **Email:** mrmcdona@uoguelph.ca

[2] Dept. of Horticultural Science, New York State Agricultural Experiment Station
630 West North St., Geneva, New York 14456, USA

Tel: (315) 787-2243 **Fax:** (315) 787-2216 **Email:** agt1@cornell.edu

TITLE: **EVALUATION OF INSECTICIDES FOR CONTROL OF ONION MAGGOT IN YELLOW COOKING ONIONS, 2014**

MATERIALS: SEPRESTO 75 WS (clothianidin 56.25% + imidacloprid 18.75%), ENTRUST 80 W (spinosad 80%), CRUISER 70 WS (thiamethoxam 70.0%), TRIGARD (cyromazine 75%), APRON XL LS (metalaxyl-M 33.3%), PENFLUFEN FS 50 (penflufen 4.81%), CAPTURE 2 EC (bifenthrin 25.1%), VERIMARK (cyantraniliprole 200 g/L), ACTARA (thiamethoxam 240 g/L), FORCE 3.0 G (tefluthrin 3.0%), LORSBAN 15 G (chlorpyrifos 15%)

METHODS: Various insecticide seed treatments, granular insecticides and drench applications were evaluated on yellow cooking onions in a field trial conducted on organic soil (pH ≈ 6.7, organic matter ≈ 71%) naturally infested with *Delia antiqua* 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 4 rows, spaced 40 cm apart, 6 m in length. Onions were seeded on 9 May using a V-belt seeder for granular and liquid treatments and a cone seeder for seed treatments. Seed treatments were: SEPRESTO, ENTRUST, ENTRUST + CRUISER and TRIGARD. Granular in-furrow treatments were FORCE, and LORSBAN applied on the belt with the seed. (See tables for product rates). Liquid in-furrow treatments were CAPTURE at 3.0 mL/100 m, VERIMARK at 1 L/ha, ACTARA at 4.4 mL/100 m applied using a drench volume of 125 mL/6 m row over the seed before row closure with attached shoe. An untreated check was also included. All seeds were also treated with the fungicides APRON XL at 15 mg ai/100 g, and PENFLUFEN FS 50 at 250 mg ai/100 g for damping-off and onion smut control respectively. Seed treatments were applied using film coating technology at Cornell University by Dr. Alan Taylor. Three randomly chosen 2 m sections and a 2.32 m yield section of row were staked out in each experimental unit. Emergence counts were conducted within the 2 m sections on 30 May, 2, 3 and 11 June to determine initial stands. Beginning on 16 June, plants within the 2 m sections were examined for onion maggot losses or damage caused by other pests twice weekly. Damaged plants were removed and the number of onions lost from maggot damage was included in the total number of onions lost in each 2 m section. Final destructive assessments of remaining plants within the 2 m sections were conducted three weeks after the end of the first generation peak (4 July), three weeks after the second generation peak (28 July) and after lodging (9 September). On 10 September, onions from the 2.32 m yield section of row were harvested and on 6 November, bulbs were graded and yield determined. Compared to the previous 10 year averages, air temperature in 2014 were average for May (13.8°C), June

19.4°C), August (19.2°C) and September (15.7°C) and below average for July (19.2°C). Monthly rainfall was below the 10 year average for May (58 mm), July (92 mm) and August (63 mm) and above average for June (88 mm) and September (113 mm). The 10 year rainfall averages were: May 71 mm, June 71 mm, July 95 mm, August 73 mm and September 76 mm. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.10. Means separation was obtained using Fisher's Protected LSD Test at $P = 0.05$ level of significance.

RESULTS AND DISCUSSION: Significant differences in the percentage of onions lost due to maggot damage were observed at all assessment times (Table 1). After the first generation maggot emergence, onions treated with ENTRUST + CRUISER had a significantly lower percentage of onions lost due to onion maggot than onions treated with ACTARA, CAPTURE, VERIMARK, FORCE, or untreated onions. After the total season, significant differences in onion losses were observed among the treatments (Table 1). Onions grown from seeds treated with SEPRESTO, ENTRUST + CRUISER and TRIGARD had significantly less maggot damage then onions grown from seeds treated with ACTARA, CAPTURE, FORCE and VERIMARK or untreated onions.
Significant differences in the number of plants emerged on 11 June were observed among the treatments (Table 2). Onions treated in-furrow with FORCE, CAPTURE and ACTARA had significantly more plants per meter than onions treated with the film-coated seed treatments; however, at the end of the season, onions treated with FORCE, CAPTURE and ACTARA had a significantly lower percentage of marketable onions (75 to 79%) due to losses and damage from onion maggots. Significant differences in yield were observed among the treatments (Table 2). Onions grown from seeds treated with TRIGARD, SEPRESTO or ENTRUST had significantly higher yields than onions treated with in-furrow treatments CAPTURE, ACTARA or FORCE. Onions grown from seeds treated with ENTRUST + CRUISER had a yield not significantly different from the check.

CONCLUSIONS: ENTRUST, SEPRESTO, TRIGARD and ENTRUST + CRUISER effectively protect onions from onion maggots over the total season. Seeds treated with ENTRUST + CRUISER reduced plant stands compared to the check. Onions grown from seeds treated with SEPRESTO, ENTRUST and ENTRUST + CRUISER had yields similar to untreated onions. In-furrow treatments VERIMARK, LORSBAN, CAPTURE, FORCE and ACTARA did not reduce onions losses due to maggots over the total season or improve yields compared to the check.

ACKNOWLEDGEMENT: Funding was provided by the California Onion and Garlic Research Advisory Board. The New York State Agricultural Experiment Station, Cornell University provided support for seed treatment application. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of Cornell University or those of Rutgers State University of New Jersey.

2014 PMR Report # 02 SECTION B: VEGETABLES and SPECIAL CROPS – Insect Pests

CROP: Sweet corn (*Zea mays* L. subsp. *mays*), cv. Temptation
PESTS: European corn borer (*Ostrinia nubilalis* Hübner), western bean cutworm (*Striacosta albicosta* Smith), corn earworm (*Helicoverpa zea* Boddie)

NAME AND AGENCY:
TRUEMAN C L
Ridgetown Campus
University of Guelph
120 Main Street E
Ridgetown, ON N0P 2C0

Tel: (519) 674-1500 x63646 **Fax:** 519-674-1699 **Email:** ctrueman@uoguelph.ca

TITLE: FIELD EVALUATION OF PRODUCTS FOR MANAGEMENT OF EUROPEAN CORN BORER, CORN EARWORM, AND WESTERN BEAN CUTWORM IN SWEET CORN, EARLY SEEDED TRIAL, 2014

MATERIALS: CORAGEN (chlorantraniliprole 200 g/L), INTREPID (methoxyfenozide 240 g L^{-1}), MATADOR 120 EC (cyhalothrin-lambda 120 g L^{-1}), DELEGATE WG (spinetoram 25%), ENTRUST 80 (spinosad 80%), VOLIAM XPRESS (cyhalothrin-lambda 50 g/L + chlorantraniliprole 100 g/L), SEVIN XLR (carbaryl 42.8%), DIPEL 2X (*Bacillus thuringiensis* var. *kurstaki* 57%)

METHODS: A trial was completed at Ridgetown Campus, University of Guelph. Sweet corn hybrid 'Temptation' was seeded with a Kearny planter on May 24 at a rate of 5 seeds/m. The trial was setup as a randomized complete block design with 4 replicates per treatment. Each treatment plot consisted of 6 rows spaced 75 cm apart and 7 m in length. The four outside rows (rows 1, 2, 5, 6) were guard rows while the two inner rows (rows 3 and 4) were used for the damage assessment and insect counts. A 1.5 m pathway was maintained between each plot within the same replication and a 2 m pathway was maintained between each replicated block. The first insecticide application was made on July 8 (tassel emergence); however it rained within one hour of application, so treatments were reapplied on Jul 10. Additional insecticide applications were made on July 17 (early tassel), July 24 (tassel), and July 31 (late silk) using a hand-held 1.5 m boom CO_2 sprayer (40 psi) with ULD 120-03 nozzles, and water volume of 300 L/ha. All corn cobs from row 3 in each plot were harvested and assessed for feeding damage on husks and cobs on August 6. The number and species of larvae found feeding on corn ears were also recorded, including European corn borer (ECB), corn earworm (CEW), and western bean cutworm (WBC). Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Analysis of variance was completed and means were separated using Tukey's HSD, $P \leq 0.05$.

RESULTS: As outlined in Table 1.

CONCLUSIONS: Corn treated with any of the tested insecticides had fewer WBC than the nontreated control, but equivalent numbers of ECB to the untreated control. Applications of SEVIN, CORAGEN, and both rates of DELEGATE resulted in a significant reduction in the number of CEW compared to the untreated control. There were no differences among treatments in feeding damage to either husk or kernels.

Table 1. Incidence of western bean cutworm (WBC), European corn borer (ECB), and corn earworm (CEW) larvae and feeding damage detected in mature sweet corn cobs treated with insecticides, Ridgetown, ON, 2014.

Treatment (rate)	Lepidopteran Larvae (# per 100 cobs)			Feeding Damage (%) [1]	
	WBC	ECB	CEW	Husks	Cobs
Untreated control	1 a [4]	2 a[2]	4.7 a	0.8 a[3]	5.8 a[3]
MATADOR @ 83 mL/ha	0 b	0 a	0.2 ab	0.2 a	0.0 a
SEVIN XLR @ 4 L/ha	0 b	0 a	0.0 b	1.5 a	0.0 a
INTREPID @ 600 mL/ha	0 b	0 a	1.5 ab	0.8 a	3.9 a
CORAGEN @ 375 mL/ha	0 b	0 a	0.0 b	0.0 a	0.3 a
ENTRUST @ 50 g/ha	0 b	0 a	0.3 ab	0.4 a	0.7 a
DELEGATE @ 120 g/ha	0 b	0 a	0.0 b	0.2 a	1.7 a
DELEGATE @ 210 g/ha	0 b	0 a	0.0 b	0.0 a	1.7 a
VOLIAM XPRESS @ 500 mL/ha	0 b	0 a	0.8 ab	0.0 a	1.4 a
DIPEL 2X @ 840 g/ha	0 b	0 a	2.8 ab	0.0 a	3.3 a

[1] Husks refers to the percentage of sweet corn with feeding damage on the husk, and cobs refers to percentage of sweet corn with feeding damage on corn kernels.
[2] Data in column were transformed using a square root transformation; the back transformed means are shown here.
[3] Data in column were transformed using a log transformation; the back transformed means are shown here.
[4] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2014 PMR Report # 03 SECTION B: VEGETABLES and SPECIAL CROPS – Insect Pests

CROP: Sweet corn (*Zea mays* L. subsp. *mays*), cv. Temptation
PESTS: European corn borer (*Ostrinia nubilalis* Hübner), western bean cutworm (*Striacosta albicosta* Smith), corn earworm (*Helicoverpa zea* Boddie)

NAME AND AGENCY:
TRUEMAN C L
Ridgetown Campus
University of Guelph
120 Main Street E
Ridgetown, ON N0P 2C0

Tel: (519) 674-1500 x63646 **Fax:** 519-674-1699 **Email:** ctrueman@uoguelph.ca

TITLE: FIELD EVALUATION OF PRODUCTS FOR MANAGEMENT OF EUROPEAN CORN BORER, CORN EARWORM, AND WESTERN BEAN CUTWORM IN SWEET CORN, LATE SEEDED TRIAL, 2014

MATERIALS: CORAGEN (chlorantraniliprole 200 g/L), INTREPID (methoxyfenozide 240 g L^{-1}), MATADOR 120 EC (cyhalothrin-lambda 120 g L^{-1}), DELEGATE WG (spinetoram 25%), ENTRUST 80 (spinosad 80%), VOLIAM XPRESS (cyhalothrin-lambda 50 g/L + chlorantraniliprole 100 g/L), SEVIN XLR (carbaryl 42.8%), DIPEL 2X (*Bacillus thuringiensis* var. *kurstaki* 57%)

METHODS: A trial was completed at Ridgetown Campus, University of Guelph. Sweet corn hybrid 'Temptation' was seeded with a Kearny planter on June 13 at a rate of 5 seeds/m. The trial was setup as a randomized complete block design with 4 replicates per treatment. Each treatment plot consisted of 6 rows spaced 75 cm apart and 7 m in length. The four outside rows (rows 1, 2, 5, 6) were guard rows while the two inner rows (rows 3 and 4) were used for the damage assessment and insect counts. A 1.5 m pathway was maintained between each plot within the same replication and a 2 m pathway was maintained between each replicated block. Insecticide applications were made on July 31 (tassel emergence), August 7 (early tassel), August 14 (silk), and August 21 (dry silk) using a hand-held 1.5 m boom CO_2 sprayer (40 psi) with ULD 120-03 nozzles, and water volume of 300 L/ha. All corn cobs from row 3 and 4 in each plot were harvested and assessed for feeding damage on husks and cobs on August 26. The number and species of larvae found feeding on corn ears were also recorded, including European corn borer (ECB), corn earworm (CEW), and western bean cutworm (WBC). Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Analysis of variance was completed and means were separated using Tukey's HSD, $P \leq 0.05$.

RESULTS: As outlined in Table 1.

CONCLUSIONS: All treatments, except DIPEL, reduced the number of WBC larvae found on corn cobs compared to the untreated control. All insecticides except DIPEL and SEVIN, and INTREPID and DIPEL reduced feeding damage on cobs and husks, respectively.

Table 1. Incidence of western bean cutworm (WBC), European corn borer (ECB), and corn earworm (CEW) larvae and feeding damage detected in mature sweet corn cobs treated with insecticides , Ridgetown, ON, 2014.

Treatment (rate)	Lepidopteran Larvae (# per 100 cobs)			Feeding Damage (%) [1]	
	WBC	ECB	CEW	Husks	Cobs
Untreated control	9.3 a [3]	8.0 a	0.0 a	24.7 a	15.8 a [2]
MATADOR @ 83 mL/ha	0.5 b	0.0 a	0.0 a	0.8 b	0.5 c
SEVIN XLR @ 4 L/ha	0.0 b	0.0 a	0.0 a	1.5 b	1.8 abc
INTREPID @ 600 mL/ha	0.4 b	0.0 a	0.4 a	2.7 ab	1.6 bc
CORAGEN @ 375 mL/ha	0.0 b	0.0 a	0.0 a	0.0 b	0.3 c
ENTRUST @ 50 g/ha	0.4 b	0.0 a	0.0 a	0.8 b	0.4 c
DELEGATE @ 120 g/ha	0.4 b	0.0 a	0.0 a	0.3 b	0.3 c
DELEGATE @ 210 g/ha	0.3 b	0.0 a	0.0 a	0.3 b	0.3 c
VOLIAM XPRESS @ 500 mL/ha	0.0 b	0.0 a	0.0 a	0.7 b	0.0 c
DIPEL 2X @ 840 g/ha	12.8 a	2.9 a	0.0 a	7.2 ab	11.7 ab

[1] Husks refers to the percentage of sweet corn with feeding damage on the husk, and cobs refer to percentage of sweet corn with feeding damage on corn kernels.
[2] Data in column were transformed using a log transformation; the back transformed means are shown here.
[3] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2014 PMR REPORT # 04 **SECTION H: PEST MANAGEMENT METHODS – BIOLOGICAL CONTROL**

CROP: Cereal crops: wheat and barley
PEST: Cereal aphids: specifically the English grain aphid, *Sitobion avenae*

NAME AND AGENCY: WIST T J[1], OLIVIER C[1], GAVLOSKI J[2], LUKASH A[1,], JEULAND M[3], OLFERT O[1]

[1] Saskatoon Research Centre 107 Science Place, Saskatoon, Saskatchewan, S7N 0X2
Tel: 306-956-7670 **Fax:** 306-956-7248 **E-mail:** Tyler.Wist@AGR.GC.CA

Tel: 306-956-7686 **Fax:** 306-956-7686 **E-mail:** Chrystel.Olivier@AGR.GC.CA

Tel: 306-956-7288 **Fax:** 306-956-7288 **E-mail:** Owen.Olfert@AGR.GC.CA

Tel: 306-956-7278 **Fax:** 306-956-7278 **Email:** Alicia.Lukash@AGR.GC.CA

[2] Manitoba Agriculture, Food and Rural Development, Crops Knowledge Centre, Box 1149, 65-3rd Ave NE, Carman, MB, R0G 0J0,

Tel: 204-745-5668 **Fax**: 204-745-5690 **Email:** John.Gavloski@gov.mb.ca

[3]Agronomy College of Pouillé, Route de Pouillé, BP-90049, 49136 Les Ponts de Cé, France
Tel: 306-956-7278 **Fax:** 306-956-7278 **Email:** martin.jeuland@gmail.com

TITLE: SURVEY OF PREDATORS, PARASITOIDS AND POPULATIONS OF CEREAL APHIDS AND AN ESTIMATION OF THE ECONOMIC THRESHOLD BASED ON SWEEP NETTING IN SASKATCHEWAN, 2013

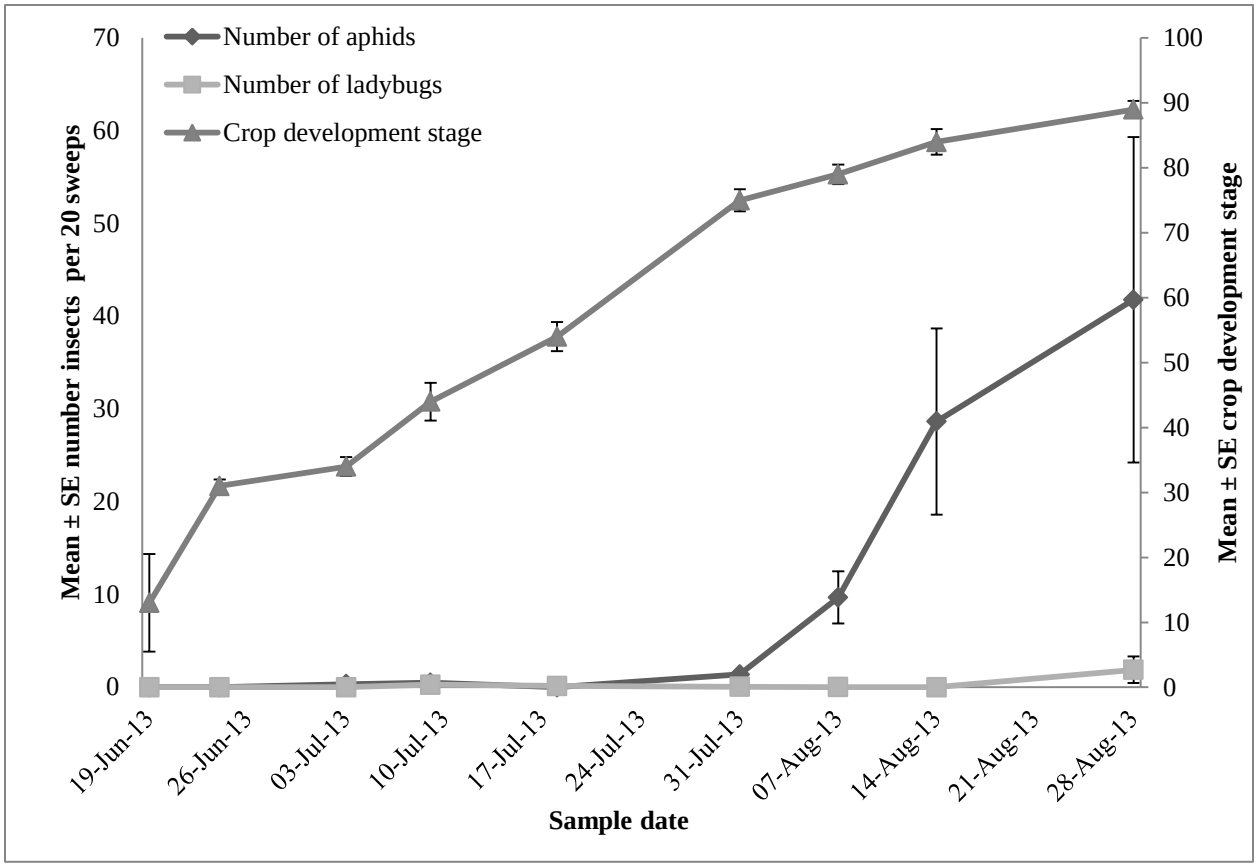
METHODS: A survey to identify and track populations of cereal aphid species and their natural enemies in cereal crops on the prairies was undertaken in 2012 (Wist et al. 2013) and continued in 2013. Predator and aphid numbers from several fields in Saskatchewan are presented as well as parasitoids that emerged from mummies collected from both provinces. In 2013, six sites with three to seven conventionally managed cereal fields (wheat, barley and oats) per site were selected from the Western, Central and Eastern areas across Saskatchewan, Canada. In Manitoba (parasitism) three fields from each area of the province were selected. During the growing season and until crop harvest, insects were sampled weekly using sweep nets (Wist et al. 2013). Samples were maintained in a cooler during transport and stored at -18C until aphids and their potential predators and parasitoids were identified in the laboratory in AAFC-Saskatoon. A mummy subsample was not frozen. The crop growth stages were also recorded at each sampling period using the Zadoks scale (Zadoks et al. 1977) to determine if the aphid population reached damaging proportions during susceptible growth stages. Aphid mummies began to appear in field samples late in the 2013 growing season (first appearance was on August 21st). Subsamples of mummies were taken in several fields and maintained in plastic vials with foam stoppers at room temperature, allowing the parasitoid larvae to complete their development and emerge as adults. Mummies were separated according to their sample sites.

RESULTS: English grain aphids (EGA) dominated the survey. The Oat-birdcherry aphid, *Rhopalosiphum padi* (L.) (Hemiptera: Aphididae) was also present, although in numbers much lower than EGA. Aphids did not appear in the sampled fields until the Zadoks stage 75 (mid-milk stage) and were only found in low numbers (Fig. 1). The aphid population rose to a mean of ~30 aphids per 20 sweeps in Saskatchewan cereal fields before the soft dough stage (Zadoks 84) on August 14th and peaked at ~ 40 aphids per 20 sweeps on August 28th, prior to harvest. Ladybugs, mostly *Coccinella septempunctata* (Coleoptera: Coccinellidae) adults and larvae (Fig. 1) were the dominant predators in Saskatchewan in 2013. Green lacewing larvae, *Chrysoperla carnea* and *Chrysopa oculata* (Neuroptera: Chrysopidae) (not shown) were present in other surveyed fields in Saskatchewan. Parasitism (see below) was low as well and most likely reflects the low aphid population density. Manitoba population data is not presented here.

The number of aphids per 20 sweeps was converted into a number of aphids per tiller, a number typically used to estimate the ET for cereal aphids. This conversion was accomplished by counting the number of heads touched by a 180° sweep in several wheat and barley fields (n=20 sweeps) in order to estimate the mean number of heads sampled in one 180° sweep. In 2013, this number was estimated at 121 ± 3.45 SE heads/sweep. Based on an ET of 12 aphids per tiller, the corresponding ET per sweep transect (i.e., 20 sweeps) would be 29,040 aphids (12 x 121 x 20). However, there is no guarantee that every aphid was caught in the transect sweep. A conservative estimation is that half of the aphids are not caught in the sweep net. Therefore, this ET estimation should be divided in half, yielding an ET number per sweep transect of 14,520. After conversion, even at the peak aphid population on 28 August, 2013, the mean number of aphids per tiller did not exceed the ET of 12-15 aphids per tiller (Harper 1973, Gavloski and Olfert 2011) or the lower threshold of 10/tiller (Vereijken 1979). The aphid population peak also occurred after the crop had matured beyond its susceptible stage suggesting that yield loss due to aphids in the sampled cereal fields did not occur in 2013.

Out of the aphids that appeared to be developing into mummies, 69 were confirmed to be parasitized. Out of the 69 mummies, three were of the black type that characterizes parasitism by *Aphelinus* spp and the remainder were the brown type that characterizes *Aphidius* spp. (Hymenoptera: Aphelinidae) parasitism (Powell 1982). Twenty-six hymenopterans emerged from the confirmed mummies (38% emergence). Eleven of these were primary parasitoids (42%), a mix of *Aphidius avenaphis* and *A. colemani* (Aphidiidae), and the rest (58%) were hyperparasitized (including all of the black *Aphelinus* type), with six *Asaphes suspensus* (Pteromalidae), three *Alloxysta* sp. (Figitidae) and three *Dendrocerus bicolor* (Megaspilidae) emerging from mummies instead of the primary parasitoids.

Figure 1. Mean ± SE number of aphids and ladybugs (nymphs and adults) and Zadoks (Zadoks et al. 1977) crop development stage (on secondary y axis) of cereal crops from three sites in Saskatchewan (2013).



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2014 PMR REPORT #05 **SECTION J: NEMATODES**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.) cvs. Cellobunch
PESTS: Carrot cyst nematode (*Heterodera carotae*), Pin nematode (*Paratylenchus* spp.), and Root lesion nematode (*Pratylenchus penetrans*), Root-knot nematode (*Meloidogyne hapla*)

NAME AND AGENCY:
VAN DYK D, JORDAN K, and MCDONALD M R
University of Guelph, Dept. of Plant Agriculture, Muck Crops Research Station
1125 Woodchoppers Lane, King, Ontario L7B 0E9

Tel: (905) 775-3783 Fax: (905) 775-4546 Email: vandykd@uoguelph.ca

TITLE: FIELD EVALUATION OF FUMIGANTS AND NEMATICIDES FOR NEMATODE CONTROL ON MUCK SOIL IN ONTARIO, 2014

MATERIALS: PIC-PLUS (chloropicrin 86%), BUSAN 1236 (metam sodium 42.5%), NIMITZ (fluensulfone 480 g/L) MUSTGROW (oriental mustard seed meal 100%), DAZITOL (capsaicin 0.42%, oleoresin of capsicum 3.7%), AGRI-MEK (abamectin 2%)

METHODS: The trial was conducted on muck soil with a history of nematode damage to carrots near Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with six replicates per treatment was used. The treatments were: PIC PLUS at 78 kg/ha, VAPAM at 275 L/ha, NIMITZ EC at 8.3 L/ha, MUSTGROW at 1680 kg.ha, DAZITOL at 60 L/ha, AGRI-MEK at 20 L/ha, and an untreated check. On 22 May, VAPAM and on 2 June, DAZITOL (60 L/ha in 400 L/ha water) was applied using a 2m wide custom fumigator. Both were applied 25cm below the soil surface with fourteen John Blue fumigant shanks spaced 17cm apart. The soil was immediately sealed following application with a roller attached to the unit. NIMITZ (8.2 L/ha in 400 L/ha water) was applied on 29 May, using a 2m wide custom fumigator. The product was applied 15cm below the soil surface with fourteen John blue fumigant shanks spaced 17cm apart, and four Teejet 8008 flat fan nozzles mounted on the front of the fumigator to apply NIMITZ to the soil surface. The soil was immediately sealed following application with a roller attached to the unit. On 2 June, MUSTGROW was broadcast applied and incorporated. Carrots, cv. Cellobunch (~65 seeds/m) were direct seeded on 5 June on raised beds. Other treatments at seeding were: PICPLUS at 78 kg/ha using a custom-built carrot seeder equipped with shanks to inject the product 25cm below the seeds. AGRI-MEK at 10L/ha was applied directly in the seed furrow at seeding at the equivalent rate of 500 L/ha water. Each experimental unit consisted of three rows, 66 cm apart and 13 m long. Carrots were managed as part of a commercial carrot field for the entire growing season. On 30 October two 1.5m sections of carrots were harvested and put into cold storage. Soil samples were taken on 21 May (pre-plant), 22 August (Mid-season), and 13 November (Harvest) to determine soil nematode counts. Ten soil cores were taken from each plot with a 10" soil sampler. Samples were sent for analysis to University of Guelph Agriculture and Food Laboratory which uses the Pan Method (a modified Baermann method) of extraction. On 21 November, carrots were assessed for forking and stunting and cyst nematode damage. Damaged and healthy carrots were counted and weighed. Nematode damage was rated on a 0 to 5 gall index where 0= no galling or forking, 1= 1-10 galls on secondary roots, 2= 10-50 galls with light forking, 3= 50-100 galls with forking, 4= >100 galls with severe forking, 5= >100 galls with severe forking and severe stunting. Disease severity index (DSI) was calculated using the following formula:

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

Reproduction factor (RF) was used to estimate the reproductive ability of nematodes. Reproduction factor was calculated using the formula: RF= final nematode population/initial nematode population. Compared to the previous 10 year averages, air temperatures in 2014 were average for May (13.8°C), June (19.4°C), August (19.2°C) and September (15.7°C), below average for July (19.2°C), and above average for October (10.5°C). The 10 year average temperatures were: May 13.2°C, June 18.5°C, July 20.9°C, August 19.5°C, September 15.6°C and October 9.4°C. Monthly rainfall was below the 10 year average for May (58 mm), July (92 mm) and August (63 mm), above average for June (88 mm) and September (113 mm), and average for October (67 mm). The 10 year rainfall averages were: May 71 mm, June 71 mm, July 95 mm, August 73 mm, September 76 mm and October 68 mm. Data were analyzed using Statistix V.10.using Tukey's HSD test at P = 0.05 level of significance.

RESULTS: Carrots grown in soil treated with VAPAM + PICPLUS, NIMITZ + PICPLUS, VAPAM, PICPLUS, and NIMITZ had greater yields than carrots grown in soil treated with DAZITOL, MUSTGROW, or the untreated check (Table 1). Carrots grown in soil treated with NIMITZ + PICPLUS, VAPAM + PICPLUS, and PICPLUS, had higher percent marketable than soil treated with DAZITOL, MUSTGROW, or the untreated check (Table 1). All treatments had a lower DSI (disease severity index) than the untreated check (Table 1). No significant difference in average gall rating was found among the treatments (Table 1). No differences in cyst nematode replication factor, and cyst nematode soil counts at pre-plant, mid-season, or harvest were found among the treatments (Table 2). No differences in total plant parasitic nematode soil counts at pre-plant, mid-season, or harvest were found among the treatments (Figure 3).

CONCLUSIONS: PICPLUS, VAPAM, NIMITZ, and a combination of these products increased carrot yield and percent marketable carrots while reducing disease severity. Although VAPAM + PICPLUS numerically had the highest yield and lowest DSI, combining applications of PICPLUS at seeding and pre-plant applications of VAPAM or NIMITZ did not significantly increase efficacy over the separate application of these products. The non-fumigant nematicide, NIMITZ, reduced damage and increased yields comparable to the grower standard fumigants. DAZITOL and MUSTGROW decreased disease severity compared the untreated check but had not effect on marketability or yield of the carrots. There was negative correlation between DSI and yield ($r= -0.33$, $p= 0.014$) so an increase is disease severity led to a decrease in yield. DSI and average gall rating was positively correlated ($r= 0.30$, $p= 0.025$). There was a negative correlation between RF and DSI ($r= -0.30$, $p= 0.027$) indicating that as disease severity decreased, the nematodes reproduction increased. It is unclear what would cause this but it may be due to reduced nematode competition as a result of soil treatment. No correlation between nematode soil counts and damage or yield was found. Carrots are very sensitive to damage during taproot formation which causes disruption and unmarketability, so soil nematode counts during the growing season or at harvest may not give an accurate quantification of potential for damage in this case.

Table 1. Yield, percent healthy carrots, disease severity index, and average gall rating for carrots (cv. Cellobunch) treated with fumigants and non-fumigant nematicides near the Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	Yield (Bushels/acre)	Percent Marketable	DSI[2]	Average Gall Rating
VAPAM + PICPLUS	1192.2 a[1]	80.2 ab	6.7 a	2.6 ns[3]
NIMITZ + PICPLUS	1162.9 a	84.5 a	6.8 a	2.2
VAPAM	1105.4 a	76.9 bcd	11.0 a	2.5
PICPLUS	1084.5 a	80.0 ab	9.8 a	2.6
NIMITZ	1015.1 ab	78.3 abc	9.3 a	2.5
AGRI-MEK	829.4 bc	78.9 abc	9.8 a	2.7
DAZITOL	783.0 c	72.7 cd	15.0 a	3.1
MUSTGROW	766.6 c	71.3 d	14.5 a	2.7
Check	767.7 c	72.7 cd	24.5 b	3.1

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

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

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

Table 2. Carrot cyst nematode reproduction factor, and soil counts assessed at pre-plant, mid-season, and harvest using the Baermann pan method of extraction near the Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	RF[1]	Average cyst nematode soil counts (juveniles/kg soil)		
		Pre-plant 21 May	Mid-season 22 August	Harvest 13 November
VAPAM + PICPLUS	2.7 ns[2]	3587 ns	1213 ns	3913 ns
NIMITZ + PICPLUS	17.2	4277	3053	10067
VAPAM	6.9	3243	1333	7333
PICPLUS	8.9	2057	6033	11100
NIMITZ	13.9	660	3543	6420
AGRI-MEK	5.4	2083	2000	5153
DAZITOL	9.0	1413	2167	6267
MUSTGROW	5.9	1827	3757	5313
Check	5.5	3810	2070	7488

[1] Nematode reproduction factor = final count/initial count

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

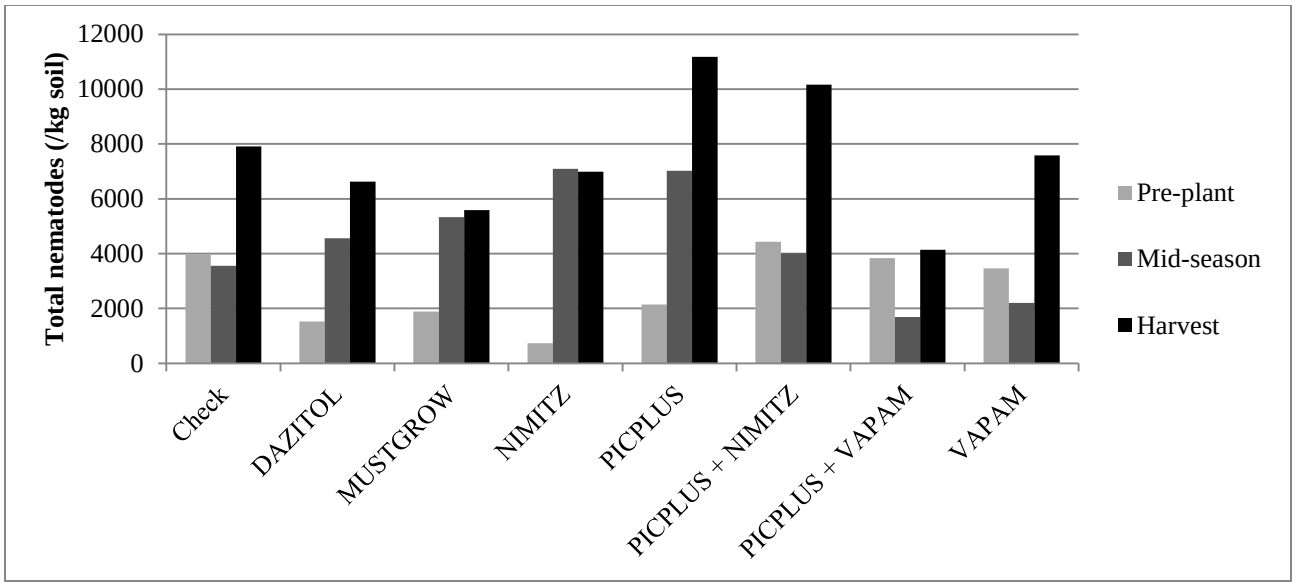

Figure 1. Total plant parasitic nematode (carrot cyst nematode, pin nematode, lesion nematode, root-knot nematode) soil counts taken throughout the season on 21 May (Pre-plant), 22 August (Mid-season), and 13 November (Harvest).

Funding for this project was provided by the Canadian Agricultural Adaptation Program, the Bradford Cooperative and Storage Ltd., The Fresh Vegetable Growers of Ontario and the University of Guelph/OMAFRA partnership.

2014 PMR REPORT # 06 **SECTION J: NEMATODES**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.) cv. Cellobunch
Tomato (*Solanum lycopersicum* L.) cv. Rutgers
PESTS: Root-knot nematode (*Meloidogyne hapla*)

NAME AND AGENCY:
VAN DYK D, JORDAN K, and MCDONALD M R
University of Guelph, Dept. of Plant Agriculture, Muck Crops Research Station
1125 Woodchoppers Lane, King, Ontario L7B 0E9

Tel: (905) 775-3783 Fax: (905) 775-4546 Email: vandykd@uoguelph.ca

TITLE: GROWTH ROOM EVALUATION OF NEMATICIDES FOR CONTROL OF ROOT-KNOT NEMATODE ONCARROT AND TOMATO IN ONTARIO, 2014

MATERIALS: BUSAN 1236 (metam sodium 42.5%), NIMITZ (fluensulfone 15%), MUSTGROW (oriental mustard seed meal 100%), DAZITOL (capsaicin 0.42%, oleoresin of capsicum 3.7%), MOVENTO (spirotetramat 240 g/L), AGRI-MEK (abamectin 2%), BASAMID (dazomet, 99.0%)

METHODS: Two growth room trials were conducted using organic soil (pH~6.8, organic matter 69.4%) and mineral soil (pH~7.1, organic matter 1.8%) with no previous history of root-knot nematode. Both soils were inoculated with eggs of *Meloidogyne hapla* at a rate of 1097 eggs/100 cm3. After inoculation, treatments were applied according to their corresponding pre-plant intervals. The treatments were BUSAN 1236 at 275 L/ha, DAZITOL at 60 L/ha, MUSTGROW at 1680 kg/ha, MOVENTO at 350 ml/ha, AGRI-MEK at 20 L/ha, NIMITZ at 8.3 L/ha, BASAMID at 275 kg/ha, and slow release fertilizer (5-5-5). Inoculated and non-inoculated checks were included. Carrots cv. Cellobunch, were seeded into the muck soil and tomatoes cv. Rutgers were transplanted into the mineral soil in cone-tainers. The trials were conducted in a growth room at the University of Guelph temperature controlled at 24^{o}C with a photoperiod of 10 hours. At 95 days after transplanting for tomatoes, and 125 days after seeding for carrots the plants were assessed for nematode damage, green rating, wet/dry top weight, and wet/dry root weight. On carrots, nematode damage was rated using a 0 to 5 gall index where 0= no galling or forking, 1= 1-10 galls on secondary roots, 2= 10-50 galls with light forking, 3= 50-100 galls with forking, 4= >100 galls with severe forking, 5= >100 galls with severe forking and severe stunting. On tomatoes, nematode damage was rated as a percent of root mass exhibiting signs of root galling. On tomatoes a greenness rating was taken using a SPAD reader which measures the chlorophyll content of the leaves. Ten random leaves were measured per experimental unit and an average was taken. Data were analyzed using Statistix V.10.using Tukey's HSD test at P = 0.05 level of significance.

RESULTS: Carrots grown in soil treated with BASAMID and the non-inoculated check had more percent healthy than the inoculated check (Table 1). Carrots grown in the non-inoculated soil had a lower average gall rating than all the other treatments except for BASAMID. No differences in dry root weight per plant were found among the treatments. Carrots grown in soil treated with BASAMID and BUSAN had a higher dry top weight per plant than soil treated with other products. Tomatoes grown in soil treated with BUSAN, BASAMID, NIMITZ, and the non-inoculated check had lower nematode infection compared to all other treatments (Table 2). AGRI-MEK also reduced percent root infested compared to the inoculated check. Tomatoes grown in soil treated with BASAMID, BUSAN, MUSTGROW, NIMITZ, and the non-inoculated check had higher chlorophyll content than the inoculated check. The fumigant treatments had a higher chlorophyll content than the non-inoculated check. Tomatoes grown in soil treated with BUSAN had higher average dry root weight than DAZITOL, MOVENTO, fertilizer, or the

inoculated check. Tomatoes grown in soil treated with BUSAN and BASAMID had a higher average dry top weight compared to all other treatments. NIMITZ and AGRI-MEK had a higher dry top weight than the inoculated check.

CONCLUSIONS: The fumigants BUSAN and BASAMID provided the best control of root-knot nematode on tomatoes and BASAMID provided the best control on carrots. NIMITZ reduced root-knot nematode damage comparable to fumigants on tomato and shows potential as an effective non-fumigant nematicide. AGRI-MEK also reduced root-knot nematode damage on tomato.

Table 1. Average gall rating, percent healthy carrots, and average dry top and root weight for carrots (cv. Cellobunch) grown in organic soil treated with fumigants and non-fumigant nematicides at the University of Guelph, Ontario, 2014.

Treatment	Average Gall Rating	Healthy Carrots (Percent)	Dry Root Weight (g/plant)	Dry Top Weight (g/plant)
Non - Inoculated Check	0.0 a[1]	100.0 a	2.6 ns[2]	0.77 abc
BASAMID	1.3 ab	85.3 ab	2.5	0.91 a
BUSAN	1.6 b	51.7 abc	2.6	0.85 ab
NIMITZ	2.2 b	34.6 bc	2.3	0.66 c
DAZITOL	1.9 b	32.6 bc	2.2	0.74 bc
MOVENTO	1.8 b	23.7 c	2.3	0.72 bc
AGRI-MEK	2.1 b	17.6 c	2.4	0.73 bc
Fertilizer	2.2 b	15.7 c	2.3	0.82 abc
Inoculated Check	2.1 b	3.3 c	2.5	0.80 abc
MUSTGROW	2.1 b	3.1 c	2.6	0.80 abc

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

Table 2. Nematode infection, green rating, dry root and top weight of tomatoes grown in mineral soil treated with fumigant and non-fumigant nematicides at the University of Guelph, Ontario, 2014.

Treatment	Nematode Infection (% root mass infected)	SPAD Reading (Chlorophyll content)	Dry Root Weight (g/plant)	Dry Top Weight (g/plant)
Non - Inoculated Check	0.0 a[1]	20.4 cd	20.4 ab	11.9 bc
BASAMID	0.0 a	25.6 a	23.8 ab	18.7 a
BUSAN	0.0 a	25.4 ab	25.5 a	18.4 a
NIMITZ	0.8 a	21.8 bcd	25.4 ab	12.8 b
AGRI-MEK	52.5 b	18.9 de	18.9 ab	12.4 b
DAZITOL	66.1 bc	14.7 f	16.1 b	6.2 d
MOVENTO	67.6 bc	12.9 f	14.8 b	7.6 cd
Fertilizer	69.7 bc	16.2 ef	16.2 b	7.9 cd
MUSTGROW	72.6 bc	23.8 abc	21.8 ab	11.4 bc
Inoculated Check	83.2 c	16.1 ef	12.9 b	7.7 cd

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

Investment in this project has been provided by Agriculture and Agri-Food Canada through the Canadian Agricultural Adaptation Program (CAAP). In Ontario, this program is delivered by the Agricultural Adaptation Council. Acknowledgements also include the Fresh Vegetable Growers of Ontario (FVGO) and the OMAFRA/University of Guelph Partnership.

2014 PMR REPORT # 07 SECTION L: VEGETABLES and SPECIAL CROPS - Diseases

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.) cv. Cellobunch
PESTS: Pythium root die back, *Pythium intermedium* de Bary, *Pythium irregulare* Buisman, *Pythium sulcatum* Pratt & Mitchell, *Pythium sylvaticum* W.A. Campbell & J.W. Hendrix, *Pythium dissotocum* Drechsler, *Pythium aphanidermatum* (Edson) Fitzp.)
Root lesion nematode, *Pratylenchus penetrans* (Cobb, 1917) Filipjev & Schuurmans Stekhoven, 1941

NAME AND AGENCY:
MCDONALD M R & VANDER KOOI K
University of Guelph, Dept. of Plant Agriculture, Muck Crops Research Station
1125 Woodchoppers Lane, King, ON L7B 0E9

Tel: (905) 775-3783 **Fax:** (906) 775-4546 **Email:** mrmcdona@uoguelph.ca

TITLE: EVALUATION OF VARIOUS PRODUCTS FOR CONTROL OF LESION NEMATODE AND PYTHIUM ROOT DIE-BACK ON CARROTS, 2014

MATERIALS: DAZITOL (capsaicin and related capsaicinoids 0.42%, allyl isothiocyanate 3.7%), PIC PLUS (chloropicrin 86%), Bacteria A, REASON 500 SC (fenamidone 44%), NIMITZ (fluensulfone 40%), LUNA TRANQUILTY (fluopyram12.5% + pyrimethanil 37.5%), QUADRIS (azoxystrobin 25%),

METHODS: The trial was conducted on organic soil (pH ≈ 6.8, organic matter ≈ 64.8%) naturally infested with *Pythium* spp. and root lesion nematode (*Pratylenchus penetrans*) in a commercial field near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with five replicates per treatment (Table 1) was used. The pre-seeding treatments NIMITZ and DAZITOL were applied according to the following descriptions. NIMITZ (8.3 L/ha in 400 L/ha of water) was applied on 26 May, using a 2 meter wide custom fumigator. The product was applied 15 cm below the soil surface with 14 John Blue fumigant shanks spaced 17 cm apart and with four TeeJet 8008 flat fan nozzles mounted on the front of the fumigator to apply NIMITZ to the soil surface. The soil was immediately sealed following application with a roller attached to the unit. DAZITOL (60 L/ha in 400 L/ha water) was applied on 2 June, using a 2 meter wide custom fumigator. The product was applied 25 cm below the soil surface with 14 John Blue fumigant shanks spaced 17 cm apart. The soil was immediately sealed following application with a roller attached to the unit. Treatments at seeding (Table 1) were: PIC PLUS at 78 kg/ha applied using a custom-built carrot seeder equipped with shanks to inject the product 25 cm below the carrot seed. The fungicides QUADRIS at 6 mL/100 meters of row + REASON at 600 mL/ha, and LUNA TRANQUILITY at 500 mL/ha were applied in-furrow, directly over the seed in the equivalent of 250 L/ha of water. BACTERIA A (obtained from A & L Laboratories) was applied in-furrow at seeding at the equivalent rate of 600 L/ha. NIMITZ (applied preplant on 26 May) + BACTERIA (applied at seeding) and an untreated check were also included in the trial. Carrots, cv. Cellobunch, were direct seeded on 4 June, (≈ 65 seeds/m) on raised beds. Each experimental unit consisted of three rows, 15 m in length, spaced 66 cm apart. Carrots were managed as part of a commercial carrot field for the growing season. On 3 November, carrots from one 1.5 m section of row were harvested from each treatment and placed into cold storage. On 9 December, carrots were assessed for forking and stunting and lesion nematode damage. Damaged and healthy carrots were counted and weighed. Compared to the previous 10 year averages, air temperatures in 2014 were average for May (13.8°C), June (19.4°C), August (19.2°C) and September (15.7°C), below average for July (19.2°C), and above average for October (10.5°C). Monthly rainfall was below the 10 year average for May (58 mm), July (92 mm) and August (63 mm), above average for June (88 mm), and September (113 mm), and average for October (67 mm). Data were analyzed using the General Analysis of Variance function of the

Linear Models section of Statistics V.10. Means separation was obtained using Fisher's Protected LSD test with P =0.05 level of significance.

RESULTS: as presented in Tables 1 & 2

CONCLUSIONS: The location chosen for the trial was a commercial carrot field with a history of pythium and nematode damage to carrots. Significant differences in marketable yield, percent marketable carrots and damage caused by lesion nematode was observed in the trial (Table 2). Carrots treated with PIC PLUS had significantly higher marketable yields and more marketable carrots than all other treatments. All other treatments in the trial had very forked and stunted carrots, likely caused by early pythium infection. The PIC PLUS treatments had significantly fewer forked and stunted carrots but also significantly higher lesion nematode damage than all other treatments. Carrots treated with PIC PLUS were protected from damage by pythium in the early stage of growth but were damaged by root lesion nematode later in the season after taproots had developed.

ACKNOWLEDGMENT: Funding for this project was provided by the Plant Production Systems of the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs and the University of Guelph partnership.

Table 1. Days before seeding (DBS), equipment used and the location of products used in treatments for carrots, cv. Cellobunch, grown near Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	Timing of Applications (DBS)	Equipment	Product Location
PIC PLUS	at seeding	custom seeder	banded -25cm below seed
DAZITOL	2 DBS	custom fumigator	broadcast 25 cm below soil
LUNA TRANQUILITY	at seeding	HYPRO roller pump	in-furrow above seed
NIMITZ	7 DBS	custom fumigator	broadcast 15 cm below soil and soil surface
BACTERIA A	at seeding	HYPRO roller pump	in furrow above seed
NIMITZ + BACTERIA	7 DBS + at seeding	HYPRO roller pump	broadcast 15 cm below soil and soil surface + in-furrow
QUADRIS + REASON	at seeding	HYPRO roller pump	in-furrow above seed
Check	--	--	--

Table 2. Yield, percent marketable and nematode damage for carrots, cv. Cellobunch, treated with various fumigants and fungicides grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	Rate/ha	Yield (t/ha)	Marketable (%)	Stunted Roots (%)	Lesion Nematode Damage (%)
PIC PLUS	78 kg	71.2 a[1]	56.7 a	9.9 a	21.5 b
DAZITOL	60 L	27.0 b	23.3 b	25.1 b	13.2 ab
LUNA TRANQUILITY	500 mL	27.6 b	24.4 b	25.0 b	11.1 a
NIMITZ	8.3 L	25.8 b	21.8 b	27.7 b	10.2 a
BACTERIA A	600 L	24.1 b	20.7 b	30.3 b	9.2 a
NIMITZ + BACTERIA	8.3 L + 0.6 L	22.3 b	19.5 b	27.8 b	6.3 a
QUADRIS +REASON	6 mL + 600 mL	13.9 b	12.1 b	30.7 b	12.1 a
Check	--	12.1 b	11.2 b	36.4 b	12.0 a

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

2014 PMR REPORT # 08 SECTION L: VEGETABLES and SPECIAL CROPS - Diseases

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

NAME AND AGENCY:
MCDONALD M R & VANDER KOOI K
University of Guelph, Dept. of Plant Agriculture, Muck Crops Research Station
1125 Woodchoppers Lane, King, ON L7B 0E9

Tel: (905) 775-3783 **Fax:** (906) 775-4546 **Email:** mrmcdona@uoguelph.ca

TITLE: EVALUATION OF FUNGICIDES FOR CONTROL OF DOWNY MILDEW ON DRY BULB ONIONS, 2014

MATERIALS: SYLGARD 309 (siloxylated polyether 76%), ALIETTE WDG (fosetyl-al 80%), ALLEGRO 500 F (fluazinam 40%), QUADRIS TOP (azoxystrobin 18.2%, difenoconazole 11.4%), DITHANE 750 F (mancozeb 75%), ZAMPRO (ametoctradin 300 g/L, dimethomorph 225 g/L), A20941 (oxathiapiprolin 100 g/L), RIDOMIL MZ (mefenoxam 480 g/L), CABRIO (pyraclostrobin 20%)

METHODS: Onions, cv. La Salle, were seeded 3 seeds per cell into 128 cell plug trays on 17 March, grown in the greenhouse and transplanted on 22 May using a mechanical transplanter into organic soil (organic matter ≈ 50.4%, pH ≈ 7.4) near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of eight rows (1.5 m apart), 6 m in length. Treatments were applied using a tractor mounted plot sprayer fitted with AI TeeJet Air Induction Even Flat nozzles (AI9503 EVS) at 415 kPa calibrated to deliver 500 L/ha of water. Treatments were: CABRIO at 840 g/ha, ZAMPRO at 1.0 L/ha + SYLGARD at 0.25% v/v, ALLEGRO at 1.16 L/ha, QUADRIS TOP at 1.0 L/ha, A20941 at 350 mL/ha, RIDOMIL at 2.5 kg/ha alternated with ALIETTE at 2.8 kg/ha, and DITHANE at 32.5 kg/ha. An untreated check was also included. Treatments were applied on 18 and 25 July, 1 and 8 August. On 18 and 21 August, all onions in two, randomly selected 0.5 m sections of row from one of the inside six rows were visually examined for downy mildew (DM) lesions. The number of plants and number of lesions were counted to determine DM lesions/plant. On 5 September, all onions in two, 2.32 m sections of row per replicate were harvested and placed into storage. On 13 November, onions were removed from storage, weighed and counted to determine yield. Compared to the previous 10 year averages, air temperature in 2014 were average for May (13.8°C), June 19.4°C), August (19.2°C) and September (15.7°C) and below average for July (19.2°C). The 10 year average temperatures were: May 13.2°C, June 18.5°C, July 20.9°C, August 19.5°C and September 15.6°C. Monthly rainfall was below the 10 year average for May (58 mm), July (92 mm) and August (63 mm) and above average for June (88 mm) and September (113 mm). The 10 year rainfall averages were: May 71 mm, June 71 mm, July 95 mm, August 73 mm, and September 76 mm. Data were analyzed using the General Analysis of Variance function of Statistix V.10. Means separation was obtained by using Fisher's Protected LSD test at $P = 0.05$ level of significance.

RESULTS: as presented in Tables 1 & 2

CONCLUSIONS: Downy mildew was first observed in the trial shortly before lodging (18 August) and was not evenly distributed in the plot. No significant differences in downy mildew lesions per plant were found among the treatments (Table 1). However, numerically, onions treated with ZAMPRO had the lowest number of lesions per plant and the incidence of downy mildew for onions treated with CABRIO was similar to the check. No significant differences in yield or size distribution were observed among the treatments (Table 2).

ACKNOWLEDGMENT: Funding for this project was provided by the Plant Production Systems of the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs and the University of Guelph partnership.

Table 1. Downy mildew incidence for onions, cv. La Salle, treated with fungicides grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	Rate (per ha)	Lesions/Plant		Cumulative Lesions
		18 Aug	21 Aug	
ZAMPRO + SYLGARD	1.0 L + 0.25% v/v	0.0 ns[1]	0.0 ns	0.0 ns
A20941	350 mL	0.0	0.1	0.1
DITHANE	32.5 kg	0.0	0.1	0.2
QUADRIS TOP	1.0 L	0.0	0.2	0.2
RIDOMIL/ALIETTE[2]	2.5/2.8 kg	0.1	0.1	0.2
ALLEGRO	1.16 L	0.1	0.3	0.3
Check	--	0.2	1.6	1.8
CABRIO	840 g	0.6	2.2	2.8

[1] ns = not significantly different at $P = 0.05$, Fisher's Protected LSD test
[2] RIDOMIL MZ was applied on 18 July & 1 August. ALIETTE was applied on 25 July & 8 August

Table 2. Yield and size distribution for onions cv. La Salle, treated with fungicides for the control of downy mildew grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2014.

Treatment	Rate (per ha)	% Mkb	Yield (t/ha)	Size Distribution (%)[1]		
				Jumbo (>76 mm)	Can. No. 1 (45-76 mm)	Cull (<45 mm)
CABRIO	840 g	98.9 ns[2]	57.0 ns	44.5 ns	54.4 ns	1.1 ns
ZAMPRO + SYLGARD	1.0 L + 0.25% v/v	99.4	54.7	46.0	53.4	0.6
ALLEGRO	1.16 L	99.0	52.9	47.1	51.9	1.0
QUADRIS TOP	1.0 L	99.1	47.2	47.3	51.8	0.9
A20941	350 mL	98.7	48.4	49.2	49.5	1.3
RIDOMIL/ALIETTE[3]	2.5/2.8 kg	99.4	61.1	54.4	45.0	0.6
DITHANE	32.5 kg	98.8	52.9	44.4	54.4	1.2
Check	--	98.9	56.0	43.1	55.8	1.1

[1] Percentage values were determined using weight.
[2] ns indicates no significant differences between treatments.
[3] RIDOMIL MZ was applied on 18 July & 1 August. ALIETTE was applied on 25 July & 8 August

2014 PMR Report # 09 **SECTION O: CEREALS, FORAGE CROPS and OILSEEDS-Diseases**

CROP: Winter wheat (*Triticum aestivum* L.), cv. Several

PEST: Fusarium head blight, *Fusarium graminearum* Schwabe

NAME AND AGENCY:
TAMBURIC-ILINCIC L
Ridgetown Campus, University of Guelph
Ridgetown, ON, NOP 2CO

Tel: (519) 674-1500 x 63557; **Fax:** (519) 674-1600; **E-mail:** ltamburi@uoguelph.ca

TITLE: EVALUATION OF WINTER WHEAT BREEDING LINES FOR RESISTANCE TO FUSARIUM HEAD BLIGHT (FHB) IN INOCULATED AND MISTED PLOTS

METHODS: The soft winter wheat breeding lines from KWS Company and two designated checks from Ontario (Emmit and Ava) were planted on October 22, 2013 at Ridgetown, Ontario. The plots were planted in a randomized block design with three replications at 270 seeds/plot, in single rows, 2 m long and spaced 17.8 cm apart. The plots were fertilized and maintained using provincial recommendations. Each plot was inoculated with100 mL of combined suspension of macroconidia (50,000 spores/mL) of four *Fusarium graminearum* isolates per plot. Plots were misted daily beginning after the first plots were inoculated. The overhead mister was set to run from 11:00-16:00 and misted for approximately 60-90 seconds every 8-10 minutes. The mist system was engaged until three days after the last variety was inoculated with *F. graminearum*. Fusarium head blight (FHB) symptoms were recorded as incidence (percent of heads infected) and severity (percent of spikelets infected). FHB severity was estimated according to Stack and McMullen (1995). FHB index for each plot was the product of severity and incidence divided by 100.

RESULTS: The results are given in the Table 1.

CONCLUSION: Inoculations with *F. graminearum* provided a wide range of FHB symptoms. All lines, except line14C-04, had lower numeric FHB index than Emmit (moderately susceptible check in Ontario). In addition, number of lines had lower FHB index than Ava (moderately resistant check in Ontario). Line 14C-09 had the lowest FHB index (4.2 %). Correlation between FHB severity and FHB incidence, FHB severity and FHB index and FHB incidence and FHB index were significant (0.69. 0.89 and 0.92, respectively). The results indicated that breeding lines from KWS Company are potentially excellent parents for new crosses with a goal to increase resistance to FHB in winter wheat in Ontario.

ACKNOWLEDGEMENT: Funding for this project was provided by the Grain Farmers of Ontario.

Table 1: Fusarium head blight severity, incidence and index across winter wheat breeding lines in inoculated and misted plots at Ridgetown, Ontario. 2013-2014.

	Line	FHB Severity (%)	FHB Incidence (%)	FHB Index (%)
1	14C-01	21.7	25.0	5.4
2	14C-02	56.7	53.3	27.2
3	14C-03	55.0	66.7	36.2
4	14C-04	73.3	76.7	55.3
5	14C-05	33.3	38.3	13.5
6	14C-06	46.7	25.0	12.5
7	14C-07	30.0	25.0	7.5
8	14C-08	40.0	26.7	10.3
9	14C-09	21.7	15.0	4.2
10	14C-10	65.0	66.7	42.3
11	14C-11	53.3	50.0	28.0
12	14C-12	33.3	61.7	22.1
13	14C-13	21.7	31.7	6.7
14	14C-14	33.3	21.7	7.2
15	14C-15	41.7	28.3	12.5
16	14C-16	45.0	30.0	14.7
17	14C-17	61.7	33.3	21.0
18	14C-18	55.0	43.3	25.0
19	14C-19	45.0	35.0	15.8
20	14C-20	46.7	33.3	15.7
21	14C-21	30.0	30.0	9.0
22	14C-22	41.7	21.7	8.8
23	Emmit	80.0	63.3	50.7
24	Ava	66.7	38.3	28.2
Mean		45.4	38.6	19.6
LSD (P=.05)		26.8	22.5	16.0
Standard Deviation		16.3	13.6	9.7
CV		35.8	35.3	49.7

2014 PMR Report # 10 **SECTION O: CEREALS, FORAGE CROPS and OILSEEDS-Diseases**

CROP: Winter wheat (*Triticum aestivum* L.), cv. Several

PEST: Fusarium head blight, *Fusarium graminearum* Schwabe

NAME AND AGENCY:

TAMBURIC-ILINCIC L

Ridgetown Campus, University of Guelph

Ridgetown, ON, NOP 2CO

Tel: (519) 674-1500 x 63557; **Fax:** (519) 674-1600; **E-mail:** ltamburi@uoguelph.ca

TITLE: **NUWWSN-EVALUATION OF WINTER WHEAT BREEDING LINES FOR RESISTANCE TO FUSARIUM HEAD BLIGHT (FHB) IN INOCULATED AND MISTED PLOTS**

METHODS: The winter wheat breeding lines from NUWWSN tests were planted on October 22, 2013 at Ridgetown, Ontario. The plots were planted in a randomized block design with three replications at 270 seeds/plot, in single rows, 2 m long and spaced 17.8 cm apart. The plots were fertilized and maintained using provincial recommendations. Each plot was inoculated with100 mL of combined suspension of macroconidia (50,000 spores/mL) of four *Fusarium graminearum* isolates per plot. Plots were misted daily beginning after the first plots were inoculated. The overhead mister was set to run from 11:00-16:00 and misted for approximately 60-90 seconds every 8-10 minutes. The mist system was engaged until three days after the last variety was inoculated with *F. graminearum*. Fusarium head blight (FHB) symptoms were recorded as incidence (percent of heads infected) and severity (percent of spikelets infected). FHB severity was estimated according to Stack and McMullen (1995). FHB index for each plot was the product of severity and incidence divided by 100. The test also included three FHB moderately resistant checks (Truman, Ernie and Freedom) and one FHB susceptible check (Pioneer 2545).

RESULTS: The results are given in the Table 1.

CONCLUSION: FHB index ranged from 0.5 % (Truman) to 44.7 % (GL 133). Heading dates ranged from 155 to 161 days. There was no significant correlation between heading date and FHB index. The best performing lines will be used in the future crosses at University of Guelph, Ridgetown Campus breeding program.

ACKNOWLEDGEMENT: Funding for this project was provided by the Grain Farmers of Ontario.

Table 1: Heading date, fusarium head blight severity, incidence and index across winter wheat breeding lines in inoculated and misted plots at Ridgetown, Ontario. 2013-2014.

Line	Heading Days Julian	FHB Severity (%)	FHB Incidence (%)	FHB Index (%)
TRUMAN	160	6.7	6.7	0.5
ERNIE	156	30.0	30.0	9.7
FREEDOM	161	23.3	31.7	8.0
PIONEER2545	156	40.0	55.0	23.0
NY01016-AN	158	15.0	23.3	3.8
NY01066-278	158	31.7	48.3	15.8
NY99059-249	159	25.0	28.3	7.3
NY99069-249	159	36.7	30.0	11.4
NY99069-352	159	18.3	25.0	6.1
KWS023	160	18.3	23.3	4.3
KWS024	158	58.3	46.7	30.3
KWS025	156	21.7	20.0	4.4
KWS028	158	18.3	20.0	3.8
L29230	156	38.3	46.7	18.3
LCS321	155	21.7	21.7	5.0
E6012	157	25.0	36.7	10.2
F0036R	156	40.0	33.3	13.3
F0039	158	61.7	66.7	40.5
F1014	160	31.7	30.0	9.8
OH07-263-3	155	33.3	35.0	12.1
OH08-206-69	155	28.3	33.3	9.5
OH08-269-58	158	30.0	60.0	18.3
0570A1-2-32-5-1-4	156	10.0	10.0	1.0
0762A1-2-8	156	16.7	23.3	3.7
08334A1-31	156	20.0	33.3	7.5
10641B1-9-11-7	155	36.7	25.0	9.3
B08-91993	156	36.7	38.3	14.2
B09*900256	158	56.7	48.3	28.3
M09L-9547	156	21.7	20.0	4.3
M10-1100#	159	20.0	20.0	4.5
M11-1027#	156	16.7	10.0	1.7
M11-2298	159	40.0	38.3	15.3
GL133	155	60.0	73.3	44.7
GL164	156	33.3	43.3	16.7
UGRC C2-78	156	15.0	20.0	3.0
UGRC C5-116	159	15.0	17.5	3.0
IL09-24328	155	16.7	18.3	3.0

IL09-3264	155	25.0	20.0	5.0
IL10-19464	157	18.3	18.3	3.4
IL10-6855	156	26.7	36.7	10.3
KY05C-1020-4-6-5	158	23.3	25.0	5.9
KY05C-1105-43-6-1	158	36.7	28.3	10.5
KY06C-3003-43-13-3	158	16.7	25.0	3.9
KY204604	161	60.0	35.0	19.3
MD08-22-22-13-4	160	17.5	20.0	4.3
MD08-22-22-13-10	159	21.7	13.3	3.0
MD09W272-8-4-13-3	157	18.3	16.7	3.5
MDC07026-12-28	156	28.3	20.0	6.4
MO120194	158	16.7	16.7	3.0
MO120452	160	13.3	28.3	2.2
MO120794	158	30.0	33.3	9.3
MO121183	155	33.3	30.0	10.0
NE06545	157	16.7	15.0	2.2
NE08499	158	26.7	26.7	6.7
NE10478	155	28.3	30.0	9.5
NI12702W	158	18.3	23.3	3.4
VA10W-140	160	16.7	23.3	4.0
VA11W-106[†]	158	13.3	18.3	2.5
VA11W-301	156	50.0	48.3	27.0
VA12FHB-53	156	28.3	31.7	9.1
MEAN	157	27.5	29.6	9.8
CV	1.2	38.2	48.8	67.9
LSD	3.1	17.0	23.3	8.8

2014 PMR REPORT # 11 **SECTION P: ORNAMENTALS, GREENHOUSE CROPS and TURF – Diseases**

CROP: **Medicinal marijuana** (*Cannabis indica* L.*)* cv. 'Bubba Kush'
PEST: **Powdery mildew** *(Podosphaera macularis* (Wallr.) U. Braun & S. Takam. or *Erysiphe cichoracearum* (DC.))*

NAME AND AGENCY:
HAYES, J. R.[1], SVEINSON-DYER, S. and ELMHIRST, J. F.[2]
[1]Bio-Smart Solutions
#8-5960 Cowichan Street,
Chilliwack, BC V2R 0L6
Tel: (604)-799-8636 **Fax:** n/a **Email**: jenniferhayes@hotmail.ca

[2]Elmhirst Diagnostics & Research
5727 Riverside Street,
Abbotsford, BC V4X 1T6
Tel: (604) 820-4075 **Fax:** 604-820-4075 **Email:** janice.elmhirst@shaw.ca

TITLE: **PURESPRAY GREEN SPRAY OIL 13E FOR CONTROL OF POWDERY MILDEW OF MEDICINAL MARIJUANA**

MATERIALS: MILSTOP FOLIAR FUNGICIDE (potassium bicarbonate 85.0%), PURESPRAY GREEN SPRAY OIL 13E (mineral oil 99%)

METHODS: The trial was conducted at a licensed commercial medical marijuana production facility in British Columbia, Canada. Plants were cloned by cuttings on April 13, 2014 and grown for two weeks in rock wool blocks, then transplanted into a Sunshine Mix/perlite potting mix in 1gallon (6 inch, 15cm diameter) pots and grown vegetatively for four weeks in a 'baby room' and then moved to 'Grow Room A' on June 1. On June 15, the plants were transplanted into larger #15 pots (15 gallon, 55L) in the same potting mix, to be grown 'tree style'. Plants were fertigated using General Hydroponics Brand: the plants were watered or fertigated every second day during vegetative growth and daily after the transition to flowering. **Note:** Fertilizer rates remain confidential, as per the grower's request. Plants were grown vegetatively in Grow Room A from June 1 – July 21 on an 18h light and 6h dark schedule, under metal halide 1000watt bulbs. On July 21, the plants were separated into two rooms: Room A contained Replicates I and II while Room B housed Replicates III and IV. On this date, the plants were also 'flipped' to stimulate flower development by growing them under 12h dark and 12h light, under high-pressure sodium 1000watt bulbs. After plants were separated into rooms they were put on an alternating "flip-flop" lighting schedule, meaning when one room was lit, the other was dark. Each plot was $2m^2$ with two plants per plot arranged in an RCB trial design with four replicates per treatment and 30-50cm plant spacing. Plants were de-leafed from Aug. 22-26, near the end of bud development, as per commercial practice.

At each application, the two plants in each plot were isolated from the others by a plastic poly shield and sprayed with the test product solutions. Treatments were applied as foliar sprays with a CO_2 backpack sprayer at 276kPa (40psi) using a double-nozzle boom for applications one through four and a single-nozzle boom for applications five through eight, with Teejet 8001VS fine-mist nozzles. Applications one through four were all made at least 3h prior to lights coming on. After the plants were

transitioned, Replicates I and II in Room A were sprayed just after the lights were turned off, while Replicates III and IV in Room B were sprayed at least 3h before the lights were turned on.
The first application was made on June 13, preventively, before mildew was seen on the plants and the last application on August 11, at budding. The solution volume was increased from 1000 to 2000 to 3000L/ha as the crop grew, to ensure adequate coverage of the foliage. Before the transition to bloom on July 21, PURESPRAY was applied on two different schedules: four applications at 1.0, 1.5 or 2.0% v/v, 7-12 days apart on June 13, 20, 28 and July 10, versus two applications at 1.0 or 2% v/v, 15 days apart, on June 13 and 28. MILSTOP was applied at 560 g/1000m^2 on the latter schedule. All treatments were applied on July 21, just before the transition to bloom and then weekly on July 28, August 4 and August 11. Check plots were sprayed with water alone on each application date. Plants were monitored regularly from June 13, prior to the first application, to July 6, prior to the 4th application, for disease development. No disease was observed until July 7. After this date, assessments were made every 7-14 days and at 3, 10 and 16 days after the last application. Disease incidence was determined by counting the number of leaves with powdery mildew lesions per plant. Since the plants were very uniform in growth, the total number of leaves per plant was estimated by counting the total number of leaves on 4 plants on each assessment date and averaging; this number was used to calculate the percentage of diseased leaves per plant. Disease severity, defined as the percentage of total leaf area covered with mildew, was rated per plant, per date, on a visual scale of 0-100% and the area under the disease progress curve (AUDPC) was calculated following the standard formula: $\sum((x_i+x_{ii})/2 \text{ X } (t_{ii}-t_i))$ where x= % diseased, *i* = date and t = time. Crop tolerance (phytotoxicity), *i.e*., symptoms of chlorosis, necrosis, leaf or bud burn or distortion caused by the test products, was assessed on a visual scale of 0-100 on each assessment date, throughout the trial. Statistical analysis (ANOVA) was performed using Co-Stat 6.400, CoHort Software, Monterey, CA, USA, © 1998-2008 and means were compared in LSD and Tukey's HSD test at P=0.05.

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

CONCLUSIONS: PURESPRAY GREEN SPRAY OIL 13E was evaluated for control of powdery mildew of medicinal marijuana 'Kush' (*C. indica*) variety in comparison to the commercial standard MILSTOP (potassium bicarbonate) and a water-sprayed check. Under high disease pressure, in a commercial medical production facility in British Columbia, Canada, preventative applications of PURESPRAY GREEN at 2% v/v, starting just after cuttings were transplanted and before powdery mildew was observed, reduced the percentage of diseased leaves by more than 90%, throughout the trial, and the percentage of leaf area with mildew by 85% overall, significantly different from the check and better than MILSTOP in Tukey's HSD at P=0.05. Applications of PURESPRAY at 1 or 1.5% v/v were not significantly different from 2% for the percentage of diseased leaves but resulted in larger mildew colonies and a significantly higher AUDPC for the percentage of leaf area diseased than the 2% v/v treatment. Two applications of PURESPRAY in the vegetative stage were as effective as four applications, when followed by weekly applications during the bloom period. No phytotoxicity was observed in any treatment. Good coverage was essential for good disease control and a little mildew was present on new growth and inside the plant canopy in areas not reached by the spray.

*In May 2015, the powdery mildew in this trial was confirmed as *Erysiphe cichoracearum*, by DNA sequencing.

Table 1. PURESPRAY GREEN OIL 13E: Cannabis 2014: Mean number of leaves with powdery mildew per plant.[1, 2]

Treatment	Product Rate	No. of App.	Jul-07	Jul-20	Aug-04	Aug-14	Aug-21	Aug-27
CHECK	-	8[3]	41.0 a	942.5 a	1692.0 a	1857.5 a	2052.0 a	562.5 a
PURESPRAY	1.5% v/v	8[3]	3.2 b	42.8 c	115.4 c	55.2 c	107.1 c	32.0 c
PURESPRAY	1.0% v/v	8[3]	2.2 b	35.0 c	107.9 c	84.0 c	113.4 c	47.2 c
PURESPRAY	2.0% v/v	8[3]	3.9 b	30.6 c	39.0 c	39.9 c	59.4 c	31.6 c
PURESPRAY	1.0% v/v	6[4]	16.6 b	61.1 c	121.8 c	70.2 c	116.1 c	44.9 c
PURESPRAY	2.0% v/v	6[4]	0.9 b	32.5 c	19.1 c	18.2 c	45.0 c	17.2 c
MILSTOP	560g/ 1000m^2	6[4]	9.8 b	273.9 b	1008.6 b	1377.5 b	1533.9 b	327.0 b

[1]Mean and standard deviation of two plants per plot; 2m^2 /plot; four replicates per treatment; RCB design.
[2] Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.
[3]Applied 8 times, 7-12 days apart on June 13, June 20, June 28, July 10, July 21, July 28, Aug 4 and Aug 11.
[4]Applied 6 times, 7-23 days apart on June 13, June 28, July 21, July 28, Aug 4 and Aug 11.

Table 2. PURESPRAY GREEN OIL 13E: Cannabis 2014: Mean percentage of leaves with powdery mildew per plant.[1, 2]

Treatment	Product Rate	No. of App.	Jul-07	Jul-20	Aug-04	Aug-14	Aug-21	Aug-27
CHECK	-	8[3]	5.5 a	89.8 a	94.0 a	92.9 a	97.7 a	93.8 a
PURESPRAY	1.5% v/v	8[3]	0.4 b	4.1 c	6.4 c	2.8 c	5.1 c	5.3 c
PURESPRAY	1.0% v/v	8[3]	0.3 b	3.3 c	6.0 c	4.2 c	5.4 c	7.9 c
PURESPRAY	2.0% v/v	8[3]	0.5 b	2.9 c	2.1 c	2.0 c	2.8 c	5.3 c
PURESPRAY	1.0% v/v	6[4]	2.2 b	5.8 c	6.8 c	3.5 c	5.5 c	7.5 c
PURESPRAY	2.0% v/v	6[4]	0.1 b	3.1 c	1.1 c	0.9 c	2.2 c	2.9 c
MILSTOP	560g/ 1000m^2	6[4]	1.3 b	26.1b	56.0 b	68.9 b	73.0 b	54.5 b

[1]Mean and standard deviation of two plants per plot; 2m^2 /plot; four replicates per treatment; RCB design.
[2] Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.
[3]Applied 8 times, 7-12 days apart on June 13, June 20, June 28, July 10, July 21, July 28, Aug 4 and Aug 11.
[4]Applied 6 times, 7-23 days apart on June 13, June 28, July 21, July 28, Aug 4 and Aug 11.

Table 3. PURESPRAY GREEN OIL 13E: Cannabis 2014: Mean percentage of leaf area covered with mildew on a visual scale of 0-100 and mean area under the disease progress curve (AUDPC).[1, 2]

Treatment	Product Rate	No. of App.	Jul-07	Jul-20	Aug-04	Aug-14	Aug-21	Aug-27	AUDPC
CHECK	-	8[3]	7.4 a	85.6 a	88.1 a	83.8 a	100.0 a	100.0 a	4010.1 a
PURESPRAY	1.5% v/v	8[3]	1.6 b	1.8 d	45.0 b	14.8 c	35.6 bcd	41.2 bcd	1078.2 b
PURESPRAY	1.0% v/v	8[3]	0.8 b	8.6 c	43.8 b	20.1 bc	36.2 bc	46.2 bc	1217.9 b
PURESPRAY	2.0% v/v	8[3]	0.9 b	2.0 d	22.4 c	6.0 c	21.9 cd	33.1 bcd	605.9 c
PURESPRAY	1.0% v/v	6[4]	2.5 b	9.4 c	41.2 bc	33.0 b	44.4 b	48.8 b	1378.3 b
PURESPRAY	2.0% v/v	6[4]	0.4 b	2.0 d	21.1 c	11.1 c	21.9 cd	30.6 cd	623.1 c
MILSTOP	560g/ 1000m^2	6[4]	1.5 b	25.9 b	35.0 bc	17.1 c	20.6 d	25.0 d	1164.1 b

[1]Mean and standard deviation of two plants per plot; 2m^2 /plot; four replicates per treatment; RCB design.
[2] Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.
[3]Applied 8 times, 7-12 days apart on June 13, June 20, June 28, July 10, July 21, July 28, Aug 4 and Aug 11.
[4]Applied 6 times, 7-23 days apart on June 13, June 28, July 21, July 28, Aug 4 and Aug 11.

2014 PMR REPORT # 12 **SECTION P: ORNAMENTALS, GREENHOUSE CROPS and TURF – Diseases**

CROP: **Mini-cucumber** (*Cucumis sativus* L.) cv. 'Picowell'
PEST: **Powdery mildew** (*Podosphaera xanthii* (Castagne) U. Braun & N. Shishkoff)

NAME AND AGENCY:
ELMHIRST J F and BESSARD P
Elmhirst Diagnostics & Research
5727 Riverside Street,
Abbotsford, BC V4X 1T6

Tel: (604) 820-4075 **Fax:** 604-820-4075 **Email:** janice.elmhirst@shaw.ca

TITLE: **PURESPRAY GREEN SPRAY OIL 13E FOR CONTROL OF POWDERY MILDEW OF GREENHOUSE CUCUMBER, 2013**

MATERIALS: NOVA 40W (myclobutanil 40%), PURESPRAY GREEN SPRAY OIL 13E (mineral oil 99%)

METHODS: The trial was conducted in 2013 in a designated research greenhouse at Kwantlen Polytechnic University (KPU) in Langley, British Columbia, Canada, using natural inoculum. Mini-cucumber cv. 'Picowell' plants in rockwool blocks were purchased from a commercial propagator in the BC Fraser Valley and transplanted into coir bags in the research greenhouse on Aug. 2, 2013, with a single emitter to each plant. Plants were fertilized for 2 minutes every 4 hours with a Plant Products 7-11-27 at 229.3 g/20 L plus $CaNO_3$ at 169.3 g/20L, pH 5.5 using a Mix-Rite Fertilizer injector. There were 4 replicates per treatment in a randomized complete block (RCB) design with 4 plants ($2m^2$) per plot. Treatments were applied as foliar sprays with a CO_2 backpack sprayer at 276kPa (40psi) using a single nozzle boom equipped with 8001VS fine mist nozzles. At each application, the 4 plants in each plot were isolated from the neighboring plots using a plastic poly shield. PURESPRAY GREEN OIL was applied 4 times on a 7-day interval: August 14, August 21, August 28 and September 4, at 1% and 2% v/v. NOVA 40W was applied on August 14 in a tank-mix with SUCCESS (50 mL/1000L) for aphids and thrips and FLORAMITE (125 mL/400L) for spider mite control, and, on August 28, in a tank-mix with SUCCESS for thrips. The check plots were sprayed with water alone at each application. The number and percentage of leaves with mildew per plant and the number of mildew colonies per leaf was counted weekly. The percentage of leaf area covered with mildew on each plant was assessed weekly on the Horsfall-Barratt scale of 0-11 where 0= no disease; 1= 0-3%; 2= 3-6%; 3= 6-12%; 4= 12-25%; 5= 25-50%; 6= 50-75%; 7=75-88%; 8= 88-94%; 9= 94-97%; 10= 97-100%; 11= 100%, transformed to percentages using the grade formula of Redman, King and Brown, where grade 0=1.17%, grade 1=2.34%, grade 2=4.68%, grade 3=9.37%, grade 4=18.75%, grade 5=37.5%, grade 6=62.5%, grade 7=81.25%, grade 8=90.63%, grade 9=95.31%, grade 10=97.66%, grade 11=98.82%, and the area under the disease progress (AUDPC) was calculated using the standard formula: $\sum((x_i+x_{ii})/2 \text{ X } (t_{ii}-t_i))$ where x= % diseased, *i* = date and t = time. Marketable-sized fruit were harvested and weighed every 2-4 days. Statistical analysis (ANOVA) was performed using Co-Stat 6.400, CoHort Software, Monterey, CA, USA, © 1998-2008 and means were compared in LSD, Student-Newman-Keuls and Tukey-Kramer's test at P=0.05.

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

CONCLUSIONS: Under high disease pressure, PURESPRAY GREEN OIL 13E reduced the number of powdery mildew lesions on greenhouse cucumber leaves, the percentage of diseased leaves per plant, and the percent leaf area diseased, significantly compared to the water check in Tukey-Kramer's at P=0.05.

PURESPRAY at 2%v/v was more effective than the 1% and continued to control mildew on treated leaves for up to 14 days after the last application (81.5% fewer lesions and 77.2% less leaf area diseased than the check). In the last two weeks of the trial, powdery mildew began to develop on new, young, upper leaves that had not been sprayed or had been sprayed only once with PURESPRAY. No phytotoxicity was observed with weekly applications of PURESPRAY at 1 or 2% v/v. There was no difference in marketable fruit or total yield over the five weeks of the trial (data not shown).

Table 1. Mini-cucumber (*Cucumis sativus* L.) cv. 'Picowell': Mean number of powdery mildew colonies per leaf. [1]

Treatment	Rate of Product Applied	Appl. Interval (days)	Mean Number of Powdery Mildew Colonies[1] Wk 1 Aug. 14 ●♦ [2]	Wk 2 Aug. 21 ● [3]	Wk 3 Aug. 28 ●♦ [3]	Wk 4 Sept. 4 ● [3]	Wk 5 Sept. 11 [3]	Wk 6 Sept. 18 [3]
CHECK (water)	0	7	2.2 a	43.2 a	106.1 a	625.3 a	1000.0 a	1562.5 a
PURESPRAY GREEN OIL	1% v/v	7	3.1 a	19.7 b	47.8 b	173.3 b	401.4 b	460.4 b
PURESPRAY GREEN OIL	2% v/v	7	1.5 a	19.5 b	36.8 b	112.7 b	264.6 c	293.7 c
NOVA 40W	340g/ 1000L	14	3.5 a	9.0 c	11.2 c	21.4 c	27.9 d	24.3 d

[1]Mean and standard deviation of 5 lower leaves per plant, 4 plants per plot, 4 replicates per treatment, RCB design.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD, P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Tukey-Kramer's, P=0.05.
●PURESPRAY applied every 7 days on Aug. 14, 21, and 28 and Sept. 4.
♦NOVA applied every 14 days on Aug. 14 and 28.

Table 2. Mini-cucumber (*Cucumis sativus* L.) cv. 'Picowell': Mean percentage of leaves with powdery mildew.

Treatment	Rate of Product Applied	Appl. Interval (days)	Mean Percentage of Leaves with Powdery Mildew[1] Wk 1 Aug. 14 ●♦ [2, 4]	Wk 2 Aug. 21 ● [3,4]	Wk 3 Aug. 28 ●♦ [3,4]	Wk 4 Sept. 4 ● [3,5]	Wk 5 Sept. 11 [3, 5]	Wk 6 Sept. 18 [3, 5]
CHECK (water)	0	7	28.7 a	93.7 a	98.7 a	85.5 a	89.1 a	90.7 a
PURESPRAY GREEN OIL	1% v/v	7	27.5 a	67.5 b	88.7 b	75.1 b	85.3 a	84.8 ab
PURESPRAY GREEN OIL	2% v/v	7	20.0 a	65.0 b	68.7 b	67.3 b	75.9 b	78.2 b
NOVA 40W	340g/ 1000L	14	27.5 a	50.0 c	55.0 b	47.4 c	48.2 c	50.1 c

[1]Mean and standard deviation of 4 plants per plot, 4 replicates per treatment, RCB design.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD, P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Tukey-Kramer's, P=0.05.
[4]Out of five lover leaves per plant.
[5]Out of total leaves per plant.
●PURESPRAY applied every 7 days on Aug. 14, 21, and 28 and Sept. 4.
♦NOVA applied every 14 days on Aug. 14 and 28.

Table 3. Mini-cucumber (*Cucumis sativus* L.) cv. 'Picowell': Mean percentage of leaf area covered with powdery mildew and area under the disease progress curve (AUDPC).

Treatment	Rate of Product Applied	Appl. Interval (days)	Mean Percentage of Leaf Area Diseased[1]						
			Wk 1 Aug. 14[2] ●♦	Wk 2 Aug. 21[3] ●	Wk 3 Aug. 28[3] ●♦	Wk 4 Sept. 4[3] ●	Wk 5 Sept. 11[3]	Wk 6 Sept. 18[3]	AUDPC[3]
CHECK (water)	0	7	1.3 ab (a)	4.4 a	10.1 a	85. 0 a	83.2 a	92.8 a	320.3 a
PURESPRAY GREEN OIL	1% v/v	7	1.6 a (a)	2.8 b	2.9 b	19.9 b	32.8 b	42.2 b	142.1 b
PURESPRAY GREEN OIL	2% v/v	7	1.2 b (a)	2.3 bc	2.7 b	11.1 c	18.2 c	21.2 c	69.8 c
NOVA 40W	340g/ 1000L	14	1.5 ab (a)	1.7 c	1.7 c	3.7 d	2.6 d	4.1 d	9.0 d

[1]Mean and standard deviation of 4 plants per plot, 4 replicates per treatment, RCB design.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD (Student-Newman-Keuls) in brackets), P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Tukey-Kramer's, P=0.05.
●PURESPRAY applied every 7 days on Aug. 14, 21, and 28 and Sept. 4.
♦NOVA applied every 14 days on Aug. 14 and 28.

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