Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

2011 Pest Management Research Report (PMRR) 2011 Growing Season

2011 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2011

Canada

English

2011 PEST MANAGEMENT RESEARCH REPORT

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

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[1] This is the twelfth 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 21 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 is also extended to the section editors for reviewing the scientific content and merit of each report and to Allison Plunkett and Mary Munnoch for editorial and computer compilation services.

Suggestions for improving this publication are always welcome.

Contact Compiler:

Allison Plunkett
Tel. (613) 759-6175
Fax. (613) 694-2323
Email. allison.plunkett@agr.gc.ca

Procedures for the 2012 Annual PMR Report will be sent in fall, 2012. They will also be available from Allison Plunkett.

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 2011 has been assigned a Volume number for the twelth 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 50.

An individual report will be cited as follows:
Author(s). 2011. Title. 2011 Pest Management Research Report - 2011 Growing Season. Agriculture and AgriFood Canada. May 2012. Report No. x. Vol. 50: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2011

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 parti 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 21 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, et Allison Plunkett et Mary Munnoch qui ont fourni les services d'édition et de compilation sur ordinateur.

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

Contacter:

Allison Plunkett
Tél. (613) 759-6175
Télécopie. (613) 694-2323
Email. allison.plunkett@agr.gc.ca

Des procédures pour le rapport annuel de 2012 PMR seront introduites à l'automne 2012. Elles seront aussi disponibles par Allison Plunkett.

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. 2011. Titre. 2011 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. mai, 2012. Rapport n^{o} x. vol. 50: pp-pp.

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CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang.) cv. Cellobunch
PESTS: Carrot rust fly (*Psila rosae* (Fabricius))

NAME AND AGENCY:
MCDONALD M R and RICHES L
University of Guelph
Department of Plant Agriculture
Muck Crops Research Station
1125 Woodchoppers Lane
Kettleby ON L0G 1J0

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

TITLE: EVALUATION OF FOLIAR INSECTICIDES FOR CONTROL OF RUST FLY IN CARROTS, 2011

MATERIALS: CYAZYPR 10 SE (cyantraniliprole 100 g/L), RIPCORD 400 EC (cypermethrin 407 g/L).

METHODS: The trial was conducted on organic soil (pH ≈ 7.0, organic matter ≈ 69.4%) at the Muck Crops Research Station, Holland Marsh, Ontario. Carrots, cv. Cellobunch, were direct seeded (82 seeds/m) on raised beds using a Stanhay Precision Seeder on 31 May. Each experimental unit consisted of four rows, 5 m long, 86 cm apart with the outside two rows used as guard rows. A randomized complete block arrangement with four replicates per treatment was used. Treatments were: CYAZYPYR at 1.5 L/ha applied once, CYAZYPYR at 1.5, 1.125 and 0.75 L/ha and RIPCORD at 175 mL/ha applied four times. Carrot rust fly (CRF) counts in the plot were monitored using orange sticky traps to determine when CRF counts reached the threshold of 0.1 flies/trap/day. Treatments were applied on 4, 11, 18 and 31 August using a CO_2 backpack sprayer equipped with four TeeJet 8004 VK fan nozzles spaced 40 cm apart and calibrated to deliver 300 L/ha at 240 kPa (boom). On 25 August, at the start of the 2nd generation of CRF, 25 sequential carrots per replicate were pulled to determine the maximum damage from 1st generation CRF. On 4 November, all carrots in two 1.16 m long sections from the middle two rows per replicate were pulled for a harvest damage sample. On 29 August and 10 and 11 November carrot samples were washed in a small drum washer, visually examined for CRF damage and sorted into classes based on a scale of 0 to 3 where 0 = no damage, 1 = one superficial feeding track (light damage), 3 = ≥1 deep feeding track(s) (heavy damage). The weight of undamaged (marketable) carrots was used to determine yield. Compared to the averaged previous 10 years, the air temperatures in 2011 were average for May (14.1°C), June (18.4°C), August (20.2°C) and September (16.6°C), and above average for July (22.8°C) and October (10.1°C). The long term previous 10 year average temperatures were: May 13.3°C, June 18.5°C, July 20.4°C, August 19.6°C, September 15.7°C and October 8.9°C. Monthly rainfall was below the previous long term 10 year average for June (67 mm) and July (56 mm), average for September (67 mm) and above average for May (92 mm), August (113 mm) and October (83 mm). The long term previous 10 year rainfall averages were: May 76 mm, June 74 mm, July 82 mm, August 59 mm, September 72 mm and October 62 mm. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. For means comparison, one outlying observation was removed from the fourth replicate. Means separation was obtained by using Fisher's Protected LSD test at $P = 0.05$ level of significance.

RESULTS: As presented in Table 1.

CONCLUSIONS: No CRF damage was observed in carrots harvested on 25 August. Carrots receiving foliar application of either CYAZAPYR or RIPCORD had significantly less heavy damage from rust fly than untreated carrots (Table 1). All rates of application of CYAZYPYR or RIPCORD provided

equivalent control of heavy CRF damage. There were no differences in light rust fly damage to carrots among the treatments. Although the lowest marketable carrot yield was recorded in check plots, the differences among treatments were not statistically significant.

ACKNOWLEDGMENT: Funding was provided by the Pest Management Centre of Agriculture and Agri-Food Canada, Pesticide Risk Reduction Program.

Table 1. Carrot rust fly damage in carrots, cv. Cellobunch, treated with foliar insecticides grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatments	Rate per ha	% Heavy CRF damage[1, 2]	% Light CRF Damage[3]	Marketable Yield (t/ha)
CYAZYPYR	1.5 L x 1	12.5 a[4]	8.3 ns[5]	51.5 ns
CYAZYPYR	1.5 L x 4	12.2 a	8.2	52.3
CYAZYPYR	1.13 L x 4	10.1 a	7.8	51.7
CYAZYPYR	0.75 L x 4	12.4 a	8.2	53.0
RIPCORD	175 mL x 4	12.2 a	7.5	50.6
check	--	24.7 b[6]	10.9	42.9

[1] Heavy CRF damage = ≥1 deep feeding track(s)/carrot.
[2] Percent by number of carrots assessed.
[3] Light CRF damage = 1 superficial feeding track/carrot.
[4] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Fisher's Protected LSD test.
[5] ns indicates no significant differences.
[6] For means comparison, one outlying observation was removed from the fourth replicate.

2011 PMR REPORT #02 SECTION B: VEGETABLES and SPECIAL CROPS - Insect Pests

CROP: Yellow cooking onions (*Allium cepa* L.) cv. Tahoe
PEST: Onion thrips (*Thrips tabaci* L.)

NAME AND AGENCY:
MCDONALD M R and RICHES L
University of Guelph
Muck Crops Research Station
Department of Plant Agriculture
1125 Woodchoppers Lane
Kettleby ON L0G 1J0

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

TITLE: EVALUATION OF FOLIAR INSECTICIDES TO CONTROL ONION THRIPS IN YELLOW COOKING ONIONS, 2011

MATERIALS: CONCEPT (imidacloprid 75 g/L, deltamethrin 10 g/L), DELEGATE WG 400 (spinetoram 25%), MOVENTO (spirotetramat 240 g/L), AGRI-MEK (abamectin 1.9%), DIBROM (naled 87.4%), SYLGARD 309 (siloxylated polyether 76%), AGRAL 90 (nonylphenoxy polyethyoxyethanol 90%), MET 52 (M*etarhizium anisopliae* strain F52 11% (w/w)).

METHODS: Onions, cv. Tahoe, were direct seeded (34 seeds/m) in muck soil (pH ≈ 7.0, organic matter ≈ 57%) using a Stanhay Precision Seeder near the Muck Crops Research Station, Holland Marsh, Ontario on 11 May. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of two beds each with four twin rows (40 cm apart), 10 m in length. The first application of insecticide was applied on 19 July when thrips counts reached the threshold of one thrips per leaf. Subsequent sprays were applied 26 July, 2, 10 and 22 August using a tractor-mounted sprayer fitted with AI TeeJet® Air Induction Even Flat spray tips (AI9503 EVS) at 120 psi, delivering 500 L water/ha. Products, rates and sequence of treatments were as shown in Table 1. Adult and larval thrips were counted on 20 onions per replicate pulled from non-harvest rows on 15, 22, and 29 July, 5 and 15 August. All onions in two, 2.33 m sections of row were harvested on 28 September when onions were lodged and dry, and size distribution, total and marketable yield were determined. Compared to the averaged previous 10 years, the air temperatures in 2011 were average for May (14.1°C), June (18.4°C), August (20.2°C) and September (16.6°C), above average for July (22.8°C). The long term previous 10 year average temperatures were: May 13.3°C, June 18.5°C, July 20.4°C, August 19.6°C, and September 15.7°C. Monthly rainfall was below the previous long term 10 year average for June (67 mm) and July (56 mm), average for September (67 mm), and above average for May (92 mm), and August (113 mm). The long term previous 10 year rainfall averages were: May 76 mm, June 74 mm, July 82 mm, August 59 mm, and September 72 mm. Data were analyzed using the general analysis of variance function of the Linear Models section of Statistix V. 9. Comparison of means was done using Fisher's Protected LSD Test with $P < 0.05$.

RESULTS: as presented in Tables 2 and 3.

CONCLUSIONS: Thrips pressure was high in 2011. Application of DELEGATE alone or DELEGATE after two applications of MOVENTO significantly decreased thrips numbers to acceptable levels (7 and 5 thrips/plant respectively). Since fewer thrips were recorded on onions treated with MOVENTO plus AGRAL 90 (27) than on onions treated with MOVENTO alone (104), combination with an appropriate surfactant appeared essential for effective control of thrips by MOVENTO. At the 15 August thrips count, onions from the untreated check and onions treated with four applications of MET 52 had 156 and 169 thrips/plant. Low greenness ratings observed for onions sprayed with SYLGARD 309 and SYLGARD

309 + DIBROM may be due to phytotoxicity. Onion yields were highest in onions treated with: MOVENTO followed by DELEGATE (Tmt. 10); DELEGATE alone (Tmt. 2); AGRI-MEK alone (Tmt. 5); and, MOVENTO followed by CONCEPT (Tmt. 11).

ACKNOWLEDGEMENTS: Funding for this project was supplied by the Bradford Co-operative & Storage Ltd. through the Holland Marsh Growers' Association and Sustainable Systems Program of the Ontario Ministry of Agriculture, Food and Rural Affairs and the University of Guelph.

Table 1. Insecticide spray program for control of thrips on onions, cv. Tahoe, grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

No.	1st App 19 Jul	2nd App 26 Jul	3rd App 2 Aug	4th App 10 Aug	5th App 22 Aug
1	CONCEPT[1]	CONCEPT[1]	CONCEPT[1]	CONCEPT[1]	CONCEPT[1]
2	DELEGATE[2]	DELEGATE[2]	DELEGATE[2]	DELEGATE[2]	DELEGATE[2]
3	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]
4	MOVENTO[3]	MOVENTO[3]	MOVENTO[3]	MOVENTO[3]	MOVENTO[3]
5	AGRI-MEK[5]	AGRI-MEK[5]	AGRI-MEK[5]	AGRI-MEK[5]	AGRI-MEK[5]
6	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]
7	SYLGARD[7]	SYLGARD[7]	SYLGARD[7]	SYLGARD[7]	SYLGARD[7]
8	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]	DIBROM[6] + SYL[7]
9	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	AGRI-MEK[5]	AGRI-MEK[5]	AGRI-MEK[5]
10	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	DELEGATE[2]	DELEGATE[2]	DELEGATE[2]
11	MOVENTO[3] +AGRAL 90[4]	MOVENTO[3] +AGRAL 90[4]	CONCEPT[1]	CONCEPT[1]	CONCEPT[1]
12	DIBROM + SYL	MOVENTO[3] +AGRAL 90[4]	CONCEPT[1]	CONCEPT[1]	CONCEPT[1]
13	MET 52[8] + sugar[9]	MET 52[8] + sugar[9]	MET 52[8] + sugar[9]	MET 52[8] + sugar[9]	MET 52[8] + sugar[9]
14	---	---	---	---	---

Rates per ha:
[1] Concept OD @ 650 mL
[2] Delegate WG @ 400 mL
[3] Movento 240 SC @ 375 mL
[4] Agral 90 @ 0.2% v/v
[5] Agri-Mek SC @ 1.0 L
[6] Dibrom @ 550 mL
[7] Sylgard 309 @ 0.375% v/v
[8] Met52 @ 530 mL
[9] Sugar 1% w/v

Table 2. Onion thrips counts for onions, cv. Tahoe, treated with various insecticides grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatment		Mean # OT/Plant					Greenness Rating[3]
		15 July	22 July	29 July	5 August	15 Aug	
10	Mov/Delegate	14.2 ns	26.1 bcd	12.1 bcd	5.5 a	5.0 a	4.6 a
2	Delegate	19.6	8.1 a	2.6 a	7.3 a	6.7 a	4.8 a
9	Mov/AgMek	13.3	21.4 abc	11.6 bc	13.4 a	21.8 ab	4.3 ab
3	Mov + Agral	15.5	22.4 bcd	12.1 bcd	17.8 ab	27.2 abc	4.1 abc
8	Mov/Dibrom	12.8	35.5 d	11.3 b	19.2 ab	40.7 bc	3.9 bc
5	Agri-Mek	17.6	16.1 ab	11.5 bc	35.3 bc	41.2 bc	4.4 ab
11	Mov/Concept	15.3	23.3 abc	12.6 bcd	19.6 ab	48.2 c	3.9 bc
12	Dib/Mov/Con	17.8	28.5 bcd	23.5 ef	49.4 cd	90.4 d	3.1 d
6	Dibrom+Sylgard	20.6	33.0 cd	15.7 bcd	48.0 cd	98.1 d	2.4 ef
1	Concept	13.9	23.9 bcd	18.3 cde	58.7 d	101.0 de	3.5 cd
4	Movento	19.2	20.7 abc	18.5 de	62.1 d	103.9 de	3.0 de
7	Sylgard	12.0	25.2 bcd	30.2 fg	100.3 ef	125.4 e	2.3 f
14	check	20.9	28.7 bcd	35.8 g	109.9 f	156.5 f	1.8 f
13	Met 52	22.9	26.4 bcd	32.5 g	84.5 e	169.5 f	2.4 ef

[1] ns indicates no significant differences were found among the treatments.
[2] Means within a column followed by the same letter are not significantly different at $P=0.05$, Fisher's Protected LSD.
[3] Rated on a scale of 1 to 5 where 1=0–10% green, 2=11–25% green, 3=26–50% green, 4=51–75% green, 5=76–100% green.

Table 3. Yield and size distribution for onions, cv. Tahoe, treated with foliar insecticides for control of onion thrips grown near Muck Crops Research Station, Holland marsh, Ontario, 2011.

Treatment		Marketable Yield (t/ha)	Size distribution (%)			
			Jumbo (>76 mm)	Large (64-76 mm)	Medium (45-64 mm)	Small (<45 mm)
10	Mov/Delegate	38.0 a[1]	0.8 ns	16.9 ab	74.3 ns[2]	7.9 a
2	Delegate	34.6 ab	0.0	18.5 a	71.4	10.1 ab
5	Agri-Mek	32.5 abc	0.0	12.1 bc	76.6	11.3 ab
11	Mov/Concept	31.5 abc	0.0	11.9	75.9	12.2 ab
3	Mov + Agral	28.1 bcd	0.0	11.9 bc	74.0	14.1 ab
12	Dib/Mov/Con	27.0 cde	0.0	4.9 def	77.9	17.1 a-d
8	Mov/Dibrom	26.6 cde	0.0	7.1 c-f	77.3	15.6 abc
4	Movento (no adjuvant)	25.8 cde	0.0	9.3 cd	72.5	18.2 a-e
9	Mov/AgMek	25.1 c-f	0.0	8.7 cde	62.5	28.8 c-e
1	Concept	23.7d-g	0.0	5.3 def	74.4	20.4 a-e
6	Dibrom+Sylgard	21.0 d-g	0.0	3.0 def	73.3	23.7 b-e
13	MET 52	20.1 efg	0.0	3.4 def	73.4	23.3 b-e
14	check	17.9 fg	0.0	2.6 ef	66.9	30.4 de
7	SYLGARD	16.6 g	0.0	1.5 f	66.8	31.7 e

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

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

2011 PMR REPORT #03 **SECTION E: CEREALS, FORAGE CROPS and OILSEEDS - Insect Pests**

CROP: Corn, *Zea mays* (L.) See cultivars listed in Table 1
PEST: Western corn rootworm, *Diabrotica virgifera virgifera* (LeConte)

NAME AND AGENCY:
SMITH J L[1], PHIBBS T R[2] and SCHAAFSMA A W[3]
University of Guelph
Ridgetown Campus
120 Main Street East
Ridgetown ON N0P 2C0

[1] **Tel:** (519) 674-1500 x63551 **Fax:** (519) 674-1555 **Email:** jsmith@ridgetownc.uoguelph.ca
[2] **Tel:** (519) 674-1500 x63643 **Fax:** (519) 674-1555 **Email:** tphibbs@ridgetownc.uoguelph.ca
[3] **Tel:** (519) 674-1500 x63624 **Fax:** (519) 674-1555 **Email:** aschaafs@ridgetownc.uoguelph.ca

TITLE: EVALUATION OF CORN ROOTWORM CONTROL PRODUCT EFFICACY IN ONTARIO

MATERIALS: PONCHO® 600 FS (clothianidin, 600 g/L); CRUISER® 5 FS (thiamethoxam, 47.6 %); FORCE® 3.0 G (tefluthrin, 3.0%).

METHODS: All seed was commercially pre-treated with fungicide seed treatments. The trial was planted on 12 May as seventh year continuous corn on clay loam soil at the University of Guelph Ridgetown Campus and on 15 June as third year continuous corn on clay loam soil at Alvinston, ON. Trials were planted using a two-row cone-seeder at a rate of 8 seeds per metre. Plots were 4 rows, spaced 0.76 m apart and 10 m long in a randomized complete block design with four replications. The insecticide treatments Poncho 600 FS and Cruiser 5 FS were also applied commercially prior to planting; Force 3.0 G was applied in-furrow at planting using a Noble™ plot scale applicator. The trials were fertilized and maintained according to provincial recommendations.

Plant populations were recorded by counting all plants in the interior two rows of each plot. Plant vigour was assessed on the interior two rows of each plot using a scale of 0-100% (0 = plants dead in plot and 100 = furthest developed plants in the trial). To assess corn rootworm feeding injury, six plants per plot were carefully dug from the outside two rows to maintain the entire root mass and were thoroughly washed before being rated using the Iowa State Node-Injury scale where 0 = no damage and 3.00 = 3 or more nodes pruned to within 3.8 cm (Oleson, J.D. et al. 2005). Product consistency was calculated as the percentage of times the node-injury rating of a treatment was less than 0.25 in each plot (Oleson, J.D., et al. 2005). The root and shoot mass of the destructively sampled plants per plot were weighed at the time of root rating. Plant height was evaluated on five plants in each of the outer two rows per plot. The interior two rows of each plot were machine-harvested with a Gleaner combine to obtain yield and test weight measurements and all yields were corrected to 15% moisture.

Data were analysed using SAS v. 9.2 (SAS Institute, Cary, NC) employing PROC MIXED with blocks as a random variable. Tukey's HSD test was used for multiple treatment comparisons. To ensure that assumptions of ANOVA were met, PROC UNIVARIATE was used to test residuals. The Shapiro-Wilk statistic was used to test residuals for normal distribution and studentized residuals were calculated to test for outliers. The α level for statistical significance was set at 0.05 for all analyses.

RESULTS: Corn rootworm pressure in both locations was much lower than expected and perhaps excessive rainfall during the month of May resulted in significant egg mortality. No differences in plant stand were measured at the V1 stage at the Ridgetown location (Table 2). The plant stand of 35F40 + Cruiser 5 FS (0.25 mg ai/seed) was significantly lower than DKC 50-48 + Force 3G at the V2 and V7 stages at Ridgetown (Table 2). At Alvinston, no differences in plant stand were measured on either rating

date (Table 3). No differences were observed in plant vigour at either location during the V1 to V7 stages (Tables 2 and 3).

At the Ridgetown location, the most severe node-injury score (NIS) was measured on hybrids lacking transgenic rootworm protection and treated with the low rate of a neonicotinoid insecticide seed treatment, i.e. DKC 50-48 + Poncho 600 FS (0.25 mg ai/seed) (NIS=0.82), 35F40 + Cruiser 5 FS (0.25 mg ai/seed) (NIS=0.84) and N45A-GT/CB/LL + Cruiser 5 FS (0.25 mg ai/seed)(NIS 0.75)(Table 4). Rootworm feeding injury was significantly reduced on DKC 50-44 (Cry 3Bb1) + Poncho 600 FS (0.25 mg ai/seed) (NIS=0.19), 35F44 (Cry 34/35 Ab1) + Cruiser 5 FS (0.25 mg ai/seed) (NIS=0.28), N45A-GT/CB/LL + Force 3G (NIS=0.29), and N45A-3000GT (mCry 3A) + Cruiser 5 FS (0.25 mg ai/seed) (NIS=0.31) (Table 4). At the Alvinston location, the greatest rootworm feeding injury was sustained by 35F40 + Cruiser 5 FS (0.25 mg ai/seed) (NIS=0.49). Feeding damage was significantly lower in the DKC 50-44 (Cry 3Bb1) + Poncho 600 FS (0.25 mg ai/seed) (NIS=0.11) and DKC 50-45 (Cry 3Bb1 x Cry 34/35 Ab1) + Poncho 600 FS (0.25 mg ai/seed) (NIS=0.10); no significant differences were measured among other treatments (Table 4).

Product consistency analysis of node-injury ratings at the Ridgetown location found no differences among treatments (Table 4). At the Alvinston location, the greatest reliability in rootworm protection was found with DKC 50-44 (Cry 3Bb1) + Poncho 600 FS (0.25 mg ai/seed) and DKC 50-45 (Cry 3Bb1 x Cry 34/35 Ab1) + Poncho 600 FS (0.25 mg ai/seed) which was significantly greater than with 35F40 + Cruiser 5 FS (0.25 mg ai/seed); all other treatments performed similarly (Table 4). Fresh weight of shoots destructively sampled at Ridgetown was significantly greater in DKC 50-48 + Force 3G, DKC 50-48 + Poncho 600 FS (0.25 mg ai/seed), and 35F40 + Force 3G than all treatments except DKC 50-48 + Cruiser 5FS (0.25 mg ai/seed), DKC 50-44 (Cry 3Bb1) + Poncho 600 FS (0.25 mg ai/seed) and N45A-GT/CB/LL + Force 3G (Table 5). Root fresh weights of 35F40 + Force 3G were significantly greater than 35F40 or N45A-GT/CB/LL with either rate of Cruiser 5 FS seed treatment, DKC 50-48 with either rate of Poncho 600 FS seed treatment, DKC 50-45 (Cry 3Bb1 x Cry 34/35 Ab1) + Poncho 600 FS (0.25 mg ai/seed), and N45A-3000GT (mCry 3A) + Cruiser 5 FS (0.25 mg ai/seed) (Table 5). No differences in shoot or root fresh weights were measured at Alvinston (Table 5). Mean plant heights of DKC 50-48 + Force 3G and DKC 50-45 (Cry 3Bb1 x Cry 34/35 Ab1) + Poncho 600 FS (0.25 mg ai/seed) were significantly greater than those of 35F40 + Cruiser 5FS (0.25 mg ai/seed) and 35F40 + Cruiser 5 FS (1.25 mg ai/seed) at Ridgetown and Alvinston, respectively (Table 5).

At Ridgetown, goosenecking and lodging were most prevalent with N45A-GT/CB/LL + Cruiser 5 FS (0.25 mg ai/seed) and lowest with N45A-GT/CB/LL + Force 3G (Table 6). Lodging was significantly lower in plots of DKC 50-48, 35F40 and N45A-GT/CB/LL when Force 3G was added compared to the low rate seed treatments (Table 6). No significant differences in lodging were measured at the Alvinston location although the hybrids lacking Bt protection for rootworm with low rates of seed treatments generally had higher amounts of lodging than the other treatments (Table 6).

At both locations, the highest yields were achieved among treatments expressing transgenic insecticidal traits for rootworm control or non Bt rootworm traits + Force 3G (Table 6). The test weight of grain harvested from 35F40 + Cruiser 5FS (1.25 mg ai/seed) plots was greater than that of all DKC treatments except DKC 50-48 + Poncho 600 FS (1.25 mg ai/seed) and all N45A treatments at the Ridgetown location (Table 7). At the Alvinston location, test weights of DKC 50-44 (Cry 3Bb1) + Poncho 600 FS (0.25 mg ai/seed) and 35F40 + Cruiser 5 FS (0.25 mg ai/seed) were greater than those of N45A-GT/CB/LL + Cruiser 5 FS (1.25 mg ai/seed) or Force 3G (Table 7).

CONCLUSIONS: Corn hybrids expressing transgenic insecticidal traits for corn rootworm control or the addition of Force 3G soil insecticide to hybrids without Bt rootworm traits provided the most effective protection from rootworm feeding compared to insecticidal seed treatments in these trials that experienced low to moderate rootworm pressure. Although we observed a trend of decreasing node-injury and with increasing insecticide seed treatment rate and soil insecticide application, generally no statistical differences were measured among these treatments at either location. Product consistency did not differ greatly among treatments in these trials, likely due to low and variable populations of corn rootworm. The trend observed in rootworm injury reduction was also evident in goosenecking and lodging. Yields of hybrids expressing Bt traits for rootworm control and non-rootworm Bt hybrids +

Force 3G were higher than non-rootworm Bt hybrids with seed treatments. Yields of Bt rootworm hybrids were not significantly different with the exception of significantly lower yield with N45A-3000GT at the Ridgetown location. Differences in test weight were likely due to cultivar or seed source differences rather than rootworm injury.

REFERENCES:

Oleson, J.D., Y.L. Park, T.M. Nowatzki, and J.J. Tollefson. 2005. Node-injury scale to evaluate root injury by corn rootworms (*Coleoptera: Chrysomelidae*). Journal of Economic Entomology 98(1): 1-8.

Table 1. Cultivars containing Bt-traits for *Lepidoptera* and corn rootworm control used to evaluate the efficacy of corn rootworm control products at Ridgetown and Alvinston, Ontario in 2011.

Trait Brand Name	Corn Hybrid	CHU/RM[1]	*Lepidoptera*-targeting event (protein)	Rootworm-targeting event (protein)
YieldGard Corn Borer® (YGCB)	DKC50-47	3050/100	MON 810 (Cry 1Ab)	None
YieldGard VT® Triple (VT3)	DKC50-44	3050/100	MON 89034 (Cry 1A.105, Cry 2Ab2)	MON88017 (Cry 3Bb1)
Genuity™ SmartStax™ (SS)	DKC50-45	3050/100	MON89034 (Cry 1A.105, Cry 2Ab2) TC1507 (Cry 1F)	MON88017 (Cry 3Bb1) DAS-59122-7 (Cry 34/35 Ab1)
Herculex® I (HXI)	35F40	3150/105	TC1507 (Cry 1F)	None
Herculex® Xtra (HXX)	35F44	3150/105	TC 1507 (Cry 1F)	DAS-59122-7 (Cry 34/35 Ab1)
Agrisure® GT/CB/LL	N45A-GT/CB/LL	3100/101	BT11 (Cry 1Ab)	None
Agrisure® 3000GT	N45A-3000GT	3100/101	BT11 (Cry 1Ab)	MIR 604 (mCry3A)

[1] CHU/RM – corn heat units/relative maturity.

Table 2**. Mean plant population and vigour of transgenic corn hybrids and insecticide combinations following a long-term continuous corn rotation at the University of Guelph Ridgetown Campus in 2011.**

	Treatment	Rate (mg ai/seed)	Mean plant population (# plants/m)[1]			Mean plant vigour (0-100%)[1,2]	
			2 June (V1)	21 June (V2)	11 July (V7)	21 June (V2)	11 July (V7)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	9.8 a	10.1 ab	10.1 ab	72.5 a	83.8 a
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	10.1 a	10.2 ab	10.3 ab	77.5 a	87.5 a
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[3]	9.6 a	10.4 a	10.6 a	78.8 a	88.3 a
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	9.7 a	9.5 ab	9.9 ab	70.0 a	80.0 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	9.7 a	9.9 ab	9.9 ab	71.3 a	78.8 a
6	35F40 (HX1) + Cruiser 5 FS	0.25	9.3 a	9.2 b	9.3 b	70.0 a	72.5 a
7	35F40 (HX1) + Cruiser 5 FS	1.25	9.2 a	9.6 ab	10.1 ab	72.5 a	80.0 a
8	35F40 (HX1) + Force 3.0 G	37.5[3]	9.7 a	9.8 ab	10.1 ab	72.5 a	83.8 a
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	9.2 a	9.3 ab	9.5 b	70.0 a	77.5 a
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	9.7 a	9.8 ab	9.9 ab	73.8 a	80.0 a
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	8.9 a	9.4 ab	9.6 ab	67.5 a	77.5 a
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[3]	9.2 a	10.0 ab	10.2 ab	65.0 a	75.0 a
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	9.1 a	9.4 ab	9.6 ab	66.3 a	72.5 a
	se		0.282	0.227	0.209	3.922	4.246
	Pr >F		0.1994	0.0126	0.0078	0.4236	0.2317

[1] Means within columns followed by the same letter do not significantly differ ($P < 0.05$) as determined by PROC MIXED and Tukey's HSD test. Treatment means based on 2 rows x 10 m length x 4 reps.
[2] 0 = plants dead in plot and 100 = furthest developed plants in the trial.
[3] g per 100 m length of row applied in-furrow at planting.

Table 3. Mean plant population and vigour of transgenic corn hybrids and insecticide combinations in third-year corn at Alvinston, Ontario in 2011.

	Treatment	Rate (mg ai/seed)	Mean plant population (# plants/m)[1]		Mean plant vigour (0-100%)[1,2]	
			27 June (V2)	14 July (V6)	27 June (V2)	14 July (V6)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	10.3 a	10.4 a	83.8 a	90.0 a
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	9.8 a	9.9 a	68.8 a	80.0 a
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[3]	10.3 a	10.3 a	85.0 a	88.8 a
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	10.1 a	10.4 a	76.3 a	80.0 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	9.8 a	9.8 a	68.8 a	83.8 a
6	35F40 (HX1) + Cruiser 5 FS	0.25	10.1 a	10.3 a	82.5 a	86.3 a
7	35F40 (HX1) + Cruiser 5 FS	1.25	10.1 a	10.3 a	81.3 a	88.8 a
8	35F40 (HX1) + Force 3.0 G	37.5[3]	10.1 a	10.3 a	82.5 a	87.5 a
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	9.9 a	10.2 a	78.8 a	88.8 a
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	10.4 a	10.3 a	85.0 a	87.5 a
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	10.2 a	10.2 a	82.5 a	83.8 a
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[3]	10.3 a	10.3 a	68.8 a	80.0 a
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	10.2 a	10.2 a	68.8 a	86.3 a
	se		0.222	0.244	6.371	4.551
	Pr >F		0.5826	0.8339	0.6152	0.8239

[1] Means within columns followed by the same letter do not significantly differ ($P < 0.05$) as determined by PROC MIXED and Tukey's HSD test. Treatment means based on 2 rows x 10 m length x 4 reps.
[2] 0 = plants dead in plot and 100 = furthest developed plants in the trial.
[3] g per 100 m length of row applied in-furrow at planting.

Table 4. **Mean node-injury ratings and product consistency of transgenic corn hybrids and insecticide combinations following continuous corn rotations at Ridgetown and Alvinston, ON in 2011.**

	Treatment	Rate (mg ai/seed)	Mean node-injury rating (0-3.00)[1,2]		Mean product consistency (0-100%)[1,3]	
			Ridgetown 18 July (V9)	Alvinston 22 July (V6)	Ridgetown 18 July (V9)	Alvinston 22July (V6)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	0.82 a	0.33 ab	8.5 a	46.0 ab
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	0.65 ab	0.16 ab	16.8 a	95.7 ab
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[4]	0.46 ab	0.23 ab	16.8 a	71.0 ab
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	0.19 b	0.11 b	70.8 a	100.0 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	0.46 ab	0.10 b	41.8 a	100.0 a
6	35F40 (HX1) + Cruiser 5 FS	0.25	0.84 a	0.49 a	16.8 a	25.0 b
7	35F40 (HX1) + Cruiser 5 FS	1.25	0.60 ab	0.41 ab	33.3 a	29.3 ab
8	35F40 (HX1) + Force 3.0 G	37.5[4]	0.36 ab	0.25 ab	29.0 a	62.5 ab
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	0.28 b	0.18 ab	58.3 a	75.0 ab
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	0.75 a	0.35 ab	21.0 a	58.3 ab
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	0.43 ab	0.23 ab	16.8 a	75.0 ab
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[4]	0.29 b	0.28 ab	16.8 a	54.3 ab
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	0.31 b	0.20 ab	66.5 a	79.3 ab
	se		0.143	0.073	0.167	0.146
	Pr >F		0.0245	0.0099	0.1470	0.0065

[1] Means within columns followed by the same letter do not significantly differ (P < 0.05) as determined by PROC MIXED and Tukey's HSD test. Treatment means based on 6 plants x 4 reps = 24 observations.
[2] 0 = no damage and 3.00 = 3 or more nodes pruned to within 3.8 cm.
[3] Percentage of times node-injury rating was < 0.25.
[4] g per 100 m length of row applied in-furrow at planting.

Table 5. Mean fresh weight and height of transgenic corn hybrids and insecticide combinations following continuous corn rotations at Ridgetown and Alvinston, ON in 2011.

	Treatment	Rate (mg ai/seed	Mean fresh weight per plant[1,2] - Shoot (kg)		Mean fresh weight per plant[1,2] - Root (kg)		Mean plant height (cm)[1,3]	
			Ridgetown 18 July (V9)	Alvinston 22 July (V6)	Ridgetown 19 July (V9)	Alvinston 22 July (V6)	Ridgetown 11 July (V7)	Alvinston 22 July (V6)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	1.33 ab	0.35 a	0.79 bc	0.43 a	153.8 ab	94.6 ab
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	1.41 a	0.39 a	0.79 bc	0.46 a	158.9 ab	96.0 ab
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[4]	1.68 a	0.40 a	0.99 ab	0.45 a	167.4 a	97.2 ab
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	1.31 ab	0.49 a	0.81 abc	0.54 a	156.2 ab	106.5 ab
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	1.05 b	0.53 a	0.63 c	0.54 a	145.4 ab	113.8 a
6	35F40 (HX1) + Cruiser 5 FS	0.25	1.03 b	0.54 a	0.68 c	0.48 a	132.6 b	103.9 ab
7	35F40 (HX1) + Cruiser 5 FS	1.25	1.21 b	0.36 a	0.71 bc	0.45 a	146.8 ab	92.3 b
8	35F40 (HX1) + Force 3.0 G	37.5[4]	1.46 a	0.45 a	1.09 a	0.50 a	156.2 ab	104.1 ab
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	1.16 b	0.48 a	0.86 abc	0.54 a	145.5 ab	109.3 ab
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	1.10 b	0.41 a	0.75 bc	0.48 a	152.2 ab	103.2 ab
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	1.01 b	0.38 a	0.69 c	0.45 a	142.3 ab	102.8 ab
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[4]	1.39 ab	0.38 a	0.84 abc	0.49 a	161.1 ab	101.9 ab
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	1.13 b	0.48 a	0.78 bc	0.50 a	145.5 ab	108.4 ab
	se		0.138	0.960	0.066	0.074	7.839	4.915
	Pr >F		0.0346	0.1256	0.0002	0.8824	0.0423	0.0165

[1] Means within columns followed by the same letter do not significantly differ ($P < 0.05$) as determined by PROC MIXED and Tukey's HSD test.
[2] Treatment means based on 6 plants x 4 reps = 24 observations.
[3] Treatment means based on height measurement of 5 plants x 2 rows x 4 reps = 40 observations.
[4] g per 100 m length of row applied in-furrow at planting.

Table 6. **Mean percent goosenecked and lodged transgenic corn hybrids and insecticide combinations following continuous corn rotations at Ridgetown and Alvinston, ON in 2011.**

	Treatment	Rate (mg ai/seed)	Mean % goosenecking[1,2]	Mean % lodging[1,2]	
			Ridgetown 17 August (R3)	Ridgetown 17 August (R3)	Alvinston 8 August (R1)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	52.3 ef	35.7 de	65.5 a
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	26.8 abc	28.2 b-e	12.2 a
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[3]	33.8 a-e	14.5 ab	14.7 a
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	32.0 a-e	26.2 a-d	16.9 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	35.9 b-f	33.9 cde	11.8 a
6	35F40 (HX1) + Cruiser 5 FS	0.25	41.4 c-f	33.6 cde	41.2 a
7	35F40 (HX1) + Cruiser 5 FS	1.25	34.9 b-f	22.2 a-d	40.4 a
8	35F40 (HX1) + Force 3.0 G	37.5[3]	15.2 ab	11.5 a	10.0 a
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	27.2 a-d	19.8 abc	18.5 a
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	57.4 f	43.1 e	47.1 a
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	20.3 abc	19.7 abc	20.7 a
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[3]	11.3 a	12.2 a	11.8 a
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	50.0 def	21.2 a-d	13.2 a
	se		0.0835	0.054	0.126
	Pr >F		0.0044	0.0027	0.0534

[1] Means within columns followed by the same letter do not significantly differ ($P < 0.05$) as determined by PROC MIXED and Tukey's HSD test. Treatment means based on 2 rows x 10 m x 4 reps.

[2] Data analyzed following arcsine square root ($X + 0.01$) transformation. Means reported have been transformed back to the original scale.

[3] g per 100 m length of row applied in-furrow at planting.

Table 7. **Mean yield and test weight of transgenic corn hybrids and insecticide combinations following continuous corn rotations at Ridgetown and Alvinston, ON in 2011.**

	Treatment	Rate (mg ai/seed)	Mean yield (T/ha)[1]		Mean test weight (kg/hL)[1]	
			Ridgetown 17 November (R6)	Alvinston 18 November (R6)	Ridgetown 17 November (R6)	Alvinston 18 November (R6)
1	DKC 50-47 (YGCB) + Poncho 600 FS	0.25	8.7 abc	8.5 cd	75.6 b-e	63.9 abc
2	DKC 50-47 (YGCB) + Poncho 600 FS	1.25	9.6 abc	9.5 a	76.0 a-e	63.3 abc
3	DKC 50-47 (YGCB) + Force 3.0 G	37.5[2]	10.3 a	10.0 a	75.3 c-f	63.3 abc
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	10.4 a	10.8 ab	75.7 b-e	65.2 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	10.4 a	11.2 ab	74.7 def	63.6 abc
6	35F40 (HX1) + Cruiser 5 FS	0.25	8.0 c	9.3 bc	76.2 a-d	65.1 a
7	35F40 (HX1) + Cruiser 5 FS	1.25	8.0 c	7.9 d	77.4 a	64.7 ab
8	35F40 (HX1) + Force 3.0 G	37.5[2]	10.2 a	11.2 ab	77.2 ab	64.7 ab
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	9.9 ab	11.6 a	76.9 abc	64.8 ab
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	8.0 c	8.4 cd	74.5 ef	63.8 abc
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	8.7 abc	8.5 b	73.9 f	63.0 bc
12	N45A-GT/CB/LL (Agrisure CB) + Force 3.0 G	37.5[2]	8.2 bc	8.9 cd	74.6 ef	62.1 c
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	8.7 abc	10.2 b	74.8 def	64.7 ab
	se		0.427	0.924	0.363	0.383
	Pr >F		<0.0001	0.0136	<0.0001	<0.0001

[1] Means within columns followed by the same letter do not significantly differ (P < 0.05) as determined by PROC MIXED and Tukey's HSD test. Treatment means based on harvest of 2 rows x 10 m x 4 reps.
[2] g per 100 m length

2011 PMR REPORT #04 **SECTION H: PEST MANAGEMENT METHODS – Biological Control**

CROP: Potato *(Solanum tuberosum)*
PEST: Colorado potato beetle (CPB), *(Leptinotarsa decemlineata)*

NAME AND AGENCY:
CACERES L A[1], McGARVEY B D[2], SCOTT I M[2], CONN K[2] BERRUTI F[1], BRIENS C[1] and YEUNG K K C[1]

[1]University of Western Ontario
1151 Richmond Street North
London ON N6A 5B7

Tel: (519) 457-1470 x233 **Fax:** (519) 457-3997 **Email:** caceresl@AGR.GR.CA

[2]Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
1391 Sandford Street
London ON N5V 4T3

TITLE: PESTICIDAL PROPERTIES OF TOMATO PLANT RESIDUE BIO-OIL

MATERIALS: Bubbling bed reactor, tomato waste (TW) bio-oil, Agilent 5975C gas chromatography-mass spectrometer (GC-MS), Agilent 1200 series liquid chromatograph (LC), acetone HPLC grade, acetonitrile-190 HPLC grade, dichloromethane (DCM) HPLC grade (Caledon), Milli-Q water, NH2 Sep-Pak Cartridges (Waters).

METHODS: Approximately 3.0 kg of fresh tomato plant waste was pyrolized in a bubbling bed reactor at two temperatures (300°C and 500°C). Bio-oils were collected from both the electrostatic precipitator (ESP) and condenser parts of the reactor. Two solutions of bio-oils, 3 mg/mL and 30 mg/mL, using water and/or acetone as a solvent, were made and tested against CPB 2nd instars larvae (Agriculture and Agri-Food Canada, London, Ontario, insecticide-susceptible CPB colony) in a leaf disc bio-assay. Solvent extraction and partitioning was used to separate the 500^{o}C TW ESP bio-oil into fractions based on relative solubility in two immiscible solvents, in this case, water and DCM. The DCM fraction of the bio-oil was further separated using a NH_2 solid phase extraction cartridge. The following was the sequence of solvents used in order to get 10 fractions; Hexane, DCM, DCM/MeOH (3:1), DCM/MeOH (1:1), DCM/MeOH (1:3), MeOH, H_2O/MeOH (1:3), H_2O/MeOH (1:1), H_2O/MeOH (3:1) and H_2O.The hexane fraction was further fractionated into six sub-fractions using semi-preparative LC (reversed phase).

The identification of chemical compounds using GC-MS was determined using the NIST MS Search program with AMDIS, which first deconvolutes the GC-MS data to separate the various components.

One-way and two-way ANOVAs (SAS Ver. 2.03) were used to test for significant differences in CPB mortality between the separate partitions and fractions. The one-way ANOVA variable was fraction and the two-way ANOVA variables were bio-oil solution and temperature.

RESULTS: As outlined in Table 1, the 30 mg/mL solution made from the TW 500 ^{o}C ESP was the most active against CPB (64.2% mortality). There was a significantly greater mean mortality of CPB with the 30 mg/mL TW ESP 500^{o}C treatment compared to the other bio-oil solutions treatments and pyrolysis temperature except for the TW condenser acetone 500^{o}C treatment (Two-way ANOVA d.f.=15, 112; F=11.47; p= <0.0001). Evaluation of CPB mortality with the liquid-liquid extracted bio-oil showed that the non-polar fraction dissolved in acetone killed 62.2% of CPB larvae (Table 2). This was similar to the

results obtained in the CPB bio-assay with the 30 mg/mL ESP bio-oil (64.2%). In comparison, exposure to the water fraction resulted in only 13.3% mortality.

After solid phase extraction using an amino Sep-Pak, the hexane fraction was found to be the most active against CPB with 52.3% mortality after two days (Table 3). The mean mortality of the hexane fraction from the active bio-oil using the NH_2 Sep-Pack was significantly greater compared with the other treatments except for the (1:3) DCM/MeOH and MeOH treatments (One-way ANOVA d.f. =10, 51; F=8.61; p= <0.0001). Analysis of the hexane fraction by GC-MS after derivatization with MOX and MSTFA detected 407 molecules. Among the compounds identified using the NIST mass spectral library, neophytadiene was present at the highest concentration compared to other compounds.

The fifth and sixth fractions collected by semi-preparative HPLC were the most active against CPB (Table 4). The neophytadiene molecule was found to be present only in fraction 5 by GC-MS. According to CPB leaf disc bio-assays, pure neophytadiene (equivalent to 30 mg/mL) caused 40% mortality. Though the mortality of CPB was lower than that observed for the hexane fraction of bio-oil from the Sep-Pak, the 30 mg/mL neophytadiene also reduced in the amount of potato leaf consumed by 72% relative to the control (Table 5).

CONCLUSIONS: According to CPB bio-assay results, it can be stated that the most potent insecticidal activity is associated with the components of the bio-oil collected from the electrostatic precipitator at 500°C. Further separation by HPLC of the bio-oil could not isolate all of the observed activity within one fraction, indicating that two or more compounds act synergistically leading to the observed toxicity of the whole ESP bio-oil.

ACKNOWLEDGEMENTS: This research was supported by the Agricultural Bioproducts Innovation Program of Agriculture and Agri-food Canada, the Natural Science and Engineering Research Council of Canada and the University of Western Ontario.

Table 1. 48 hour percentage mortality ± standard error (S.E.) for CPB exposed to tomato plant bio-oil solutions.

Treatment	TW bio-oil obtained at 300°C		TW bio-oil obtained at 500°C	
	3 mg/mL (S.E.)	30 mg/mL (S.E.)	3 mg/mL (S.E.)	30 mg/mL (S.E.)
RO water control	5.0% (0.09) CD[1]	5.0% (0.09) CD	3.3% (0.08) C	3.3% (0.08) C
Acetone control	0.8% (0.04) D	0.8% (0.04) D	6.7% (0.13) CD	6.7% (0.13) CD
TW ESP acetone	3.3% (0.08) CD	15% (0.17) BC	12.5% (0.13) C	64.2% **(**0.30) A
TWcondenser/aqueous	2.5% (0.07) CD	9.2% (0.10) CD	6.7% (0.08) CD	16.7% (0.20) BC
TWcondenser/acetone	5.0% (0.11) CD	9.2% (0.12) CD	9.2% (0.10) CD	43% (0.34) AB

[1] Numbers followed by the same letter are not significantly different at p=0.05, Tukey's test.

CPB leaf disk bio-assay was done using a Petri dish containing potato leaf (4cm Ø) which was treated with 150 uL bio-oil solution. Five 2nd instars CPB larvae were added to each treated leaf. Mortality of CPB was calculated after 48 h.

Table 2. 48 hour percentage mortality ± standard error (S.E.) for CPB after liquid-liquid extraction using DCM and H2O of the ESP tomato waste bio-oil at 500°C.

Treatment	Percentage mortality (S.E.)
Water control	2.2 (0.11)
Acetone control	4.4 (0.15)
DCM fraction/acetone[2]	62.2 (0.35)
H_2O fraction/water[2]	13.3 (0.24)

[2] Solvent used to dissolve the bio-oil sub-fraction.

Table 3. 48 hour percent mortality ± standard error (S.E.) and percent leaf consumed for CPB exposed to tomato plant ESP 500°C bio-oil separated by DCM – solvent mixtures and NH_2 Sep-Pak fractionation.

SOLVENTS	**% mortality** (S.E.)	**% eaten after 2 days**
Acetone control	0.0 (0.0) CB[3]	73.8
Hexane	52.3 (0.29) A	3.4
DCM	20.0 (0.75) CB	37.5
3:1 DCM/MeOH	5.0 (0.25) CB	32.5
1:1 DCM/MeOH	5.0 (0.25) CB	27.5
1:3 DCM/MeOH	15.0 (0.25) AB	50.0
MeOH	20.0 (0.58) AB	30.0
1:3 H_2O/MeOH	5.0 (0.25) CB	18.8
1:1 H_2O/MeOH	10.0 (0.29) CB	17.5
3:1 H_2O/MeOH	5.0 (0.25) CB	26.3
H_2O	15.0 (0.48) CB	22.5

TW ESP 500°C DCM fraction was used as a positive control.
[3] Numbers in columns followed by same letter are not significantly different at p=0.05 Tukey's test.

Table 4. 48 hour percent mortality and percent leaf disc consumed for CPB exposed to 6 HPLC sub-fractions of the hexane fraction.

HPLC FRACTION[4]	**% mortality**	**% eaten after 2 days**
Acetone control	0.0	92.5
1	10.0	82.5
2	20.0	72.5
3	0.0	90.0
4	0.0	90.0
5	30.0	45.0
6	40.0	25.0

[4] HPLC fraction collection base on time (5 min).

Table 5. 48 hour percent mortality and percent leaf disc consumed for CPB exposed to neophytadiene (most abundant peak from the hexane fraction).

TREATMENT	% mortality	% eaten after 2 days
Acetone control	0.0	80.0
Neophytadiene	40.0	8.0

[5] The neophytadiene standard was isolated from tobacco bio-oil and it was applied directly on to the potato leaf to make it ~30 mg/mL.
There was no visual evidence of phytotoxic effects when using neophytadiene.

CROP: Apples (*Malus domestica* Borkh.) cv. Macintosh
PEST: Blue mold (*Penicillium expansum* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:**Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'MCINTOSH' APPLES FROM GRIMSBY, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at Agriculture & Agri-Food Canada using apples from a commercial farm (Moyer Farm) in Grimsby, ON. Apple cv. 'McIntosh' was maintained according to standard orchard practices. Apples were harvested on September 1, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 3, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Penicillium expansum*, PE-2R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *P. expansum* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, a lower blue mold disease incidence was observed in all the treatments (8.3%), including the positive control. The mixture of P. *fluorescens* strains 4-6 and 1-112 had no disease and the rest of the three biocontrol treatments had 2.1% blue mold and the control had 8.3%. By day 56, higher than 18.7% blue mold disease incidence was observed in all biocontrol treatments. The positive control showed 83.3% blue mold at day 56 and reached 100% disease incidence at 170 days. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 18.8% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease observed throughout the duration of the experiment.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest blue mold caused by *Penicillium expansum* on "McIntosh" apples from Grimsby, ON, 2010-11.

Treatment	% Blue mold incidence in cold storage at 0.5-2°C after[1] 28 days	56 days	86 days	114 days	142 days	170 days	Shelf-life 170 days + 7 days
Control 1- wound and no inoculum	2.1 b[2]	4.2 b	6.3 b	8.3 b	8.3 b	10.4 b	18.8 b
Control 2 – *P. expansum* $1x10^4$conidia/ml	8.3 c	83.3 g	93.8 f	93.8 e	97.9 f	100.0 e	100.0 d
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	2.1 b	52.1 f	91.7 f	91.7 e	91.7 e	100.0 e	100.0 d
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	2.1 b	35.4 d	66.7 c	72.9 c	79.2 c	83.3 c	87.5 c
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	18.8 c	79.2 d	83.3 d	83.3 d	89.6 d	97.9 d
BIOSAVE (*P. syringea*) @ 1.59g/L and *P. expansum* $1x10^4$conidia/ml	2.1 b	47.9 e	87.5 e	91.7 e	91.7 e	97.9 e	97.9 d
Chemical fungicide control							
SCHOLAR (Fludioxonil) @ 0.6 g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

[1] Apples were inoculated with *P. expansum* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

CROP: Apples (*Malus domestica* Borkh.) cv. Macintosh
PEST: Gray mold (*Penicillium expansum* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:**Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'MCINTOSH' APPLES FROM GRIMSBY, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at Agriculture & Agri-Food Canada using apples from a commercial farm (Moyer Farm) in Grimsby, ON. Apple cv. 'Macintosh' was maintained according to standard orchard practices. Apples were harvested on September 1, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 3, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Botrytis cinerea* BC-34R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *B. cinerea* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, significantly lower gray mold disease incidence was observed in all the biocontrol treatments than in the *B. cinerea* control. The apples that were treated with the chemical fungicide SCHOLAR had no disease. The treatments with biocontrol bacteria *P. fluorescens* strains 1-112 and 4-6, alone or in combination had lower disease than BIOSAVE. By the day 56, all the biocontrol treatments had more than 83% gray mold disease incidence. The positive control showed 87.5% disease incidence after 56 days. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 18.8%% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease observed throughout the duration of the experiment.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest gray mold caused by *Botrytis cinerea* on "McIntosh" apples from Grimsby, ON, 201011.

Treatment	% Blue mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	2.1 b[2]	4.2 b	6.3 b	8.3 b	8.3 b	10.4 b	18.8 b
Control 2 – and *B. cinerea* $1x10^4$conidia/ml	60.4 f	87.5 d	93.8 d	93.8 d	93.8 d	93.8 d	95.8 d
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	12.5 c	89.6 d	89.6 c	89.6 c	91.7 cd	91.7 cd	93.8 d
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	18.8 d	87.5 d	89.6 c	89.6 c	89.6 c	89.6 c	89.6 c
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	16.7 d	89.6 d	100.0 e	100.0 e	100.0 e	100.0 e	89.6 c
P. syringea (BIOSAVE) @ 1.59g/L and *B. cinerea* $1x10^4$conidia/ml	39.6 c	83.3 c	87.5 c	91.7 cd	91.7 cd	91.7 e	100.0 e
Chemical fungicide control							
Fludioxonil (Scholar) @ 0.6 g/L and *B. cinerea* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	91.7 a

[1] Apples were inoculated with *B. cinerea* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

CROP: Apples (*Malus domestica* Borkh.) cv. Empire
PEST: Gray mold (*Botrytis cinerea* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:**Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'EMPIRE' APPLES FROM GRIMSBY, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at Agriculture & Agri-Food Canada using apples from a commercial farm (Moyer Farm) in Grimsby, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. Apples were harvested on September 21, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 22, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Botrytis cinerea* BC-34R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *B. cinerea* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, with the exception of the treatment, SCHOLAR, gray mold disease was observed in all biocontrol treatments and the positive control. The individual bolocontrol treatments had 2.1 to 8,3% of gray mold. By the day 56, higher than 56.2% gray mold disease incidence was observed in all the biocontrol treatments. The positive control showed 87.5% at day 56. The negative control with no inoculum started to show some signs of disease incidence after the 56 days and continued to have a few apples infected until the final week with 10.4% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease for up to 86 days and a 2.1% disease was observed at 170 days and in the subsequent shelf-life study.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest gray mold caused by *Botrytis cinerea* on Empire apples from Grimsby, ON, 2010-11.

Treatment	% gray mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	0.0 a[2]	4.2 b	6.3 b	8.3 b	8.3 b	8.3 a	10.4 b
Control 2 – *B. cinerea* 1x10^{4}conidia/ml	60.4 e	87.5 e	100.0 g	100.0 g	100.0 g	100.0 e	100.0 g
Biocontrol agents							
P. fluorescens strain 4-6, 1x10^8 CFU/ml and *B. cinerea* 1x10^{4}conidia/ml	8.3 c	56.3 c	62.5 c	66.7 c	68.8 c	72.9 b	72.9 c
P. fluorescens strain 1-112 1x10^8 CFU/ml and *B. cinerea* 1x10^{4}conidia/ml	2.1 b	60.4 d	68.8 d	72.9 d	72.9 d	79.2 c	81.3 d
Mixture of *P. fluorescens* strains 4-6, 5x10^7 CFU/ml and 1-112, 5x10^7 CFU/ml and *B. cinerea* 1x10^{4}conidia/ml	18.8 d	91.7 f	93.8 f	93.8 f	93.8 f	93.8 d	95.8 f
P. syringea (BIOSAVE) @ 1.59g/L and *B. cinerea* 1x10^{4}conidia/ml	8.3 c	62.5 d	81.3 e	85.4 e	87.5 e	89.6 b	93.8 e
Chemical fungicide control							
SCHOLAR (Fludioxonil)@ 0.6 g/L and *B. cinerea* 1x10^{4}conidia/ml	0.0 a	0.0 a	0.0 a	2.1 a	2.1 a	2.1 a	2.1 a

[1] Apples were inoculated with *B. cinerea* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

CROP: Apples (*Malus domestica* Borkh.) cv. Empire
PEST: Blue mold (*Penicillium expansum* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:** Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POST HARVEST BLUE MOLD IN 'EMPIRE' APPLES FROM GRIMSBY, ON, 201011

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at Agriculture & Agri-Food Canada using apples from a commercial farm (Moyer Farm) in Grimsby, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. Apples were harvested on September 21, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 22, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Penicillium expansum*, PE-2R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *B. cinerea* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, with the exception of the treatment P. *fluorescens* strains 4-6 (4.2% blue mold), all other treatments had no disease. The positive control had 8.3% disease. By the day 56, higher than 37.5% blue mold disease incidence was observed in all biocontrol treatments. The positive control showed 93.8 at day 56. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 10.4% of the total apples being infected. All the biocontrol treatments and the positive control showed disease between 87.5 to 100.0%. The chemical postharvest fungicide SCHOLAR had no disease for up to 142 days and at 170 days, had a 4.2% and in the shelf life study had 10.4%of blue mold disease was observed.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest blue mold caused by *Penicillium expansum* on Empire apples from Grimsby, ON, 2010-11.

Treatment	% Blue mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	0.0[2] a	4.2 b	6.3 b	8.3 b	8.3 b	8.3 b	10.4 a
Control 2 – *P. expansum* $1x10^4$conidia/ml	8.3 c	93.8 e	95.8 f	97.9 e	97.9 e	97.9 e	97.9 d
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	4.2 b	35.4 c	87.5 e	89.6 c	93.8 d	93.8 d	93.8
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	37.5 c	77.1 d	85.4 b	87.5 c	87.5 c	87.5 b
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	58.3 d	93.8 f	100.0 c	100.0 e	100.0 e	100.0 d
P. syringea (BIOSAVE) @ 1.59g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	6.3 b	70.8 c	93.8 d	97.9 e	97.9 e	100.0 d
Chemical fungicide control							
Fludioxonil (Scholar) @ 0.3 g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	4.2 a	10.4 a

[1] Apples were inoculated with *P. expansum* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

2011 PMR REPORT #09 **SECTION K: FRUIT – Diseases**
STUDY DATA BASE: WBSE-T.1206.4U.QM

CROP: Apples (*Malus domestica* Borkh.) cv. Empire
PEST: Gray mold (*Botrytis cinerea* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:** Deena.Errampalli@agr.gc.ca

NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** 250 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'EMPIRE' APPLES FROM JORDAN STATION, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at the Agriculture & Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. Apples were harvested on September 21, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 22, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Botrytis cinerea* BC-34R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *B. cinerea* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, significantly lower gray mold disease incidence was observed in all the biocontrol treatments and chemical fungicide SCHOLAR than in the *B. cinerea* control. The treatments with biocontrol bacteria *P. fluorescens* strains 1-112 and BIOSAVE had same disease incidence, and BIOSAVE is a formulated product. By day 56, all the biocontrol treatments had more than 63% disease incidence. The positive control showed 100% disease incidence after 56 days. The negative control with no inoculum started to show some signs of disease incidence after the third evaluation and continued to have a few apples infected until the final week with 10.42% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease observed throughout the duration of the experiment.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on postharvest gray mold caused by *Botrytis cinerea* on "Empire" apples, Jordan Station, ON, 2010-11.

Treatment	% Gray mold incidence in cold storage at 0.5-2°C after[1]						170 days shelf life 7 days
	28 days	56 days	86 days	114 days	142 days	170 days	
Control 1- wound and no inoculum	0.0 a[2]	0.0 a	2.1 a	2.1 b	2.1 a	4.2 b	10.4 b
Control 2 - *B. cinerea* $1x10^4$conidia/ml	89.6 e	100.0 f	100.0 e	100.0 d	100.0 d	100.0 e	100.0 e
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	37.5 d	91.7 e	97.9 d	97.9 d	97.9 d	97.9 e	97.9 e
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	12.5 b	83.3 c	89.6 c	89.6 c	91.7 c	91.7 d	97.9 e
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *B. cinerea* $1x10^4$conidia/ml	29.2 c	89.6 d	91.7 c	91.7 c	93.8 c	93.8 d	93.8 d
BIOSAVE *P. syringea* @ 1.59g/L and *B. cinerea* $1x10^4$conidia/ml	12.5 b	62.5 b	72.9 b	72.9 b	72.9 b	72.9 c	75.0 c
Chemical fungicide control							
SCHOLAR (Fludioxonil) @ 0.6g/L and *B. cinerea* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

[1] Apples were inoculated with *B. cinerea* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

CROP: Apples (*Malus domestica* Borkh.) cv. McIntosh
PEST: Gray mold (*Botrytis cinerea* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:** Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-800 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'MCINTOSH' APPLES FROM JORDAN FARM, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at the Agriculture & Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Macintosh' was maintained according to standard orchard practices. Apples were harvested on September 1, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 3, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Botrytis cinerea* BC-34R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *B. cinerea* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, significantly lower gray mold disease incidence was observed in all the biocontrol treatments than in the *B. cinerea* control. The apples that were treated with the chemical fungicide SCHOLAR had no disease. The treatments with biocontrol bacteria *P. fluorescens* strains 1-112 and BIOSAVE had same disease incidence (54.2%). By day 56, all the biocontrol treatments had more than 89% disease incidence. The positive control showed 91.7% disease incidence after 56 days. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 56.2%% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease observed throughout the duration of the experiment, except during the final week showed 2.08% gray mold infection.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest gray mold caused by *Botrytis cinerea* on □McIntosh□ apples from Jordan Station, ON, 2010-11.

Treatment	% Gray mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	2.1 b[2]	14.6 b	20.8 b	20.8 b	20.8 b c	37.5 b	56.3 b
Control 2 - *B. cinerea* 1x10^{4}conidia/ml	77.1 f	91.7 c	93.8 d	93.8 de	93.8 d	93.8 de	95.8 d
Biocontrol agents							
P. fluorescens strain 4-6, 1x10^8 CFU/ml and *B. cinerea* 1x10^{4}conidia/ml	25.0 c	87.5 c	89.6 c	91.7 cd	91.7cd	91.7c	91.7 c
P. fluorescens strain 1-112 1x10^8 CFU/ and *B. cinerea* 1x10^{4}conidia/ml	54.2 e	95.8 d	95.8 d	95.8 e	95.8 d	95.8 e	95.8 d
Mixture of *P. fluorescens* strains 4-6, 5x10^7 CFU/ml and 1-112, 5x10^7 CFU/ml and *B. cinerea* 1x10^{4}conidia/ml	39.6 d	89.6 c	93.8 d	93.8 de	93.7 d	95.8be	100.0 e
BIOSAVE (*P. syringea*) @ 1.59g/L and *B. cinerea* 1x10^{4}conidia/ml	54.2 e	89.6 c	89.6 c	89.6 c	89.6 c	89.6 c	89.6 c
Chemical fungicide control							
SCHOLAR @ 0.3 g/L and *B. cinerea* 1x10^{4}conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.00a	2.1 a

[1] Apples were inoculated with *B. cinerea* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

CROP: Apples (*Malus domestica* Borkh.) cv. Empire
PEST: Blue mold (*Penicillium expansum* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:** Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'EMPIRE' APPLES FROM JORDAN STATION, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at the Agriculture & Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. Apples were harvested on September 21, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 22, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Penicillium expansum*, PE-2R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *P. expansum* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, a lower blue mold disease incidence was observed in all the treatments (6.3%), including positive control. The treatments with biocontrol bacteria *P. fluorescens* strain 1-112 alone and BIOSAVE had no disease, while P. *fluorescens* strain 4-6 and the mixture of P. *fluorescens* strains 4-6 and 1-112 had disease. By day 56, higher than 37.5% blue mold disease incidence was observed in all biocontrol treatments. The positive control showed 95.8 at day 56 and reached 100% disease incidence after 86 days. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 10.4% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease for up to 142 days and at 170 days, a 2.1% of blue mold disease was observed.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest blue mold caused by *Penicillium expansum* on "Empire" apples from Jordan Station, ON, 2010-2011.

Treatment	% Blue mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	0.0 a[2]	0.0 a	2.1 b	2.1 b	2.1 b	2.1 a	10.4a
Control 2 – *P. expansum* $1x10^4$conidia/ml	6.3 d	95.8 d	97.9 f	97.9 d	100.0 e	100.0 d	100.0 d
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	2.1 b	56.3 c	81.3 c	83.3 c	87.5 c	87.5 b	93.8 b
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	58.3 c	93.8 e	95.8 d	95.8 d	95.8 c	95.8 c
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	4.2 a	58.3 c	93.8 e	100.0 e	100.0 e	100.0 d	100.0 d
BIOSAVE (*P. syringea*) @ 1.59g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	37.5 b	89.6 d	97.9 d	100.0 e	100.0 d	100.0 d
Chemical fungicide control							
SCHOLAR (Fludioxonil) @ 0.6 g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	2.1 a	8.3 a

[1] Apples were inoculated with *P. expansum* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.

[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

2011 PMR REPORT #12 **SECTION K: FRUIT – Diseases**
STUDY DATA BASE: WBSE-T.1206.QM

CROP: Apples (*Malus domestica* Borkh.) cv. Macintosh
PEST: Blue mold (*Penicillium expansum* Link.)

NAME AND AGENCY:
ERRAMPALLI D, GOLUBOVIC N and WEREZAK R
Agriculture and Agri-Food Canada
Southern Crop Protection and Food Research Centre
P.O. Box 6000
4902 Victoria Avenue North
Vineland Station ON L0R 2E0

Tel: (905) 562-4113 x234 **Fax:** (905) 562-4335 **Email:** Deena.Errampalli@agr.gc.ca

NAME AND AGENCY:
NELSON L and MANTYKA D
University of British Columbia Okanagan
Irving K. Barber School of Arts and Sciences
3333 University Way
Kelowna BC V1V 1V7

Tel: (250) 807-8756 **Fax:** (250) 807-8001 **Email:** louise.nelson@ubc.ca

TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'MCINTOSH' APPLES FROM JORDAN STATION, ON, 2010-11

MATERIALS: *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, BIOSAVE (*Pseudomonas syringea*), SCHOLAR (50% Fludioxonil).

METHODS: During the 2010 growing season, a field trial was conducted at the Agriculture & Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Macintosh' was maintained according to standard orchard practices. Apples were harvested on September 1, 2010. The apples were surface sterilized in 40L of 0.61% bleach solution for 4 minutes followed by 4 minutes of rinsing in water. After the surface sterilization, the apples were allowed to air dry before being placed into mesh bags. The bags were then placed into plastic crates and then stored overnight in cold storage at 0.5 – 2.0 ºC. On Sept 3, 2011, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched with inoculum and/or treatments. Each treatment consisted of 1L of solution containing the $1x10^4$ spores/mL of the pathogen (*Penicillium expansum*, PE-2R) and/or the required concentration of the biocontrol bacteria or fungicide. This solution was reused to inoculate the remaining 3 replicates. The treatments are as follows: (1) Control 1- wound and no inoculum, (2) Control 2 - *P. expansum* $1x10^4$conidia/ml, (3) *P. fluorescens* strain 4-6, $1x10^8$ CFU/ml, (4) *P. fluorescens* strain 1-112 $1x10^8$ CFU/ml, (5) Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml (6) *P. syringea* (BIOSAVE) @ 1.59g/L, and (7) Fludioxonil (SCHOLAR) @ 0.3g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The apples were incubated for 170 days at 0.5-2.0 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. After the 170 day trial period the remaining apples were placed in a Conviron set at 20ºC for 7 days and then evaluated. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, Ill). Data recorded as percentage were subjected to arcsine square-root transformation before the ANOVA. All pair-wise multiple comparison procedures were determined with the Tukey test.

RESULTS: As outlined in Table 1.

CONCLUSIONS: At 28 days after treatment, with the exception of P. *fluorescens* strains 4-6 (4.3% blue mold), no disease was observed in other treatments and the positive control, had 27.1% disease. By the day 56, higher disease incidence was observed in all biocontrol treatments. The positive control showed 95.8 at day 56 and reached 100% disease incidence after 86 days. The negative control with no inoculum started to show some signs of disease incidence after the first evaluation and continued to have a few apples infected until the final week with 56.3% of the total apples being infected. The chemical postharvest fungicide SCHOLAR had no disease throughout the duration of the experiment.

Table 1. Effect of biocontrol agents *Pseudomonas fluorescens* strains 4-6 and 1-112 on post-harvest blue mold caused by *Penicillium expansum* on □McIntosh□ apples from Jordan Station, ON, 2010-11.

Treatment	% Blue mold incidence in cold storage at 0.5-2°C after[1]						Shelf-life
	28 days	56 days	86 days	114 days	142 days	170 days	170 days + 7 days
Control 1- wound and no inoculum	2.1 b[2]	14.6 b	20.8 b	20.8 b	20.8 b	37.5 b	56.3 b
Control 2 – *P. expansum* $1x10^4$conidia/ml	27.1 d	95.8 g	100.0 f	100.0 f	100.0 f	100.0 d	100.0 d
Biocontrol agents							
P. fluorescens strain 4-6, $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	4.2 c	52.1 d	85.4 d	85.4 c	85.4 c	97.9 d	100.0 d
P. fluorescens strain 1-112 $1x10^8$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	29.2 c	68.8 c	89.6 d	91.7 d	95.8 cd	97.9 cd
Mixture of *P. fluorescens* strains 4-6, $5x10^7$ CFU/ml and 1-112, $5x10^7$ CFU/ml and *P. expansum* $1x10^4$conidia/ml	0.0 a	68.8 e	89.6 e	89.6 d	89.6 d	93.8 c	95.8 c
P. syringea (BIOSAVE) @ 1.59g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	75.0 f	91.7 c	95.8 e	95.8 e	100.0 d	100.0 d
Chemical fungicide control							
Fludioxonil (Scholar) @ 0.3 g/L and *P. expansum* $1x10^4$conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a

[1] Apples were inoculated with *P. expansum* immediately after harvest, stored at 0.5-2.0°C and evaluated for disease incidence at 28, 56, 86, 114, 142 and 170 days.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at P= 0.05.

2011 PMR REPORT #13 **SECTION L: VEGETABLE and SPECIAL CROPS – Diseases**

CROP: Carrot (*Daucus carota* subsp. s*ativus* (Hoffm.) Arcang) cvs. Envy and Nevada
PEST: Sclerotinia rot of carrot (*Sclerotinia sclerotiorum* (Lib.) de Bary)

NAME AND AGENCY:
PARKER M[1], MCDONALD M R[1] and BOLAND G J[2]

University of Guelph
[1]Department of Plant Agriculture
Guelph ON N1G 2W1

Tel: (519) 824-4120 **Fax:** (519) 763-8933 **Email:** mrmcdona@uoguelph.ca

University of Guelph
[2]School of Environmental Sciences
Guelph ON N1G 2W1

Tel: (519) 824-4120 **Fax:** (519) 837–0442 **Email:** gboland@uoguelph.ca

TITLE: **EVALUATION OF CANOPY TRIMMING AND FUNGICIDES TO MANAGE SCLEROTINIA ROT OF CARROT, 2011**

MATERIALS: LANCE (boscalid 70%), ELEXA-4 (chitosan 4%).

METHODS: A field trial was conducted at the Muck Crops Research Station in the Bradford Marsh, Ontario in 2011 in organic soil (60% organic matter, pH 5.5-6.6) that was naturally infested with *S. sclerotiorum*. Carrots were seeded (80 seeds/m) using a Stan Hay Precision seeder on 31 May. A split-block arrangement with four replications per treatment was used. Each replication consisted of 2 raised beds, 5 m in length and 86 cm apart centre-to-centre having a 40 cm wide growing area on the top of the bed. The trial was a factorial design with three factors: (i) cultivar (Envy and Nevada); (ii) treatment (ELEXA-4, LANCE or control) and (iii) trimming (trimmed or untrimmed). LANCE (630 g/ha) was applied on 13 September and 5 October when the count of within-field ascospores of *S. sclerotiorum* surpassed the forecast model threshold of 5 detected ascospores using the Blue Plate Test on sclerotinia semi-selective medium. ELEXA-4 (20 L/ha) was applied at carrot canopy closure on 9 August and continued bi-weekly until 5 October. Both treatments were applied using a CO_2 backpack sprayer equipped with four TeeJet 11002 fan nozzles spaced 40 cm apart and calibrated to deliver 400 L/ha at 240 kPa. Each treatment was also combined with trimming 30 cm from the carrot canopy above the furrow between the rows using a hedge trimmer. Trimming occurred on 26 August. Disease was assessed bi-weekly from 9 August to 21 October in a 1 m section of a raised bed. The incidence of sclerotinia rot on carrot foliage was evaluated as the percentage of plants in the assessment area that had at least one diseased leaf or petiole. These values were used to calculate the area under the disease progress curve (AUDPC) using the following equation:

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

Where y = percent disease at the jth observation, t = time (days) since the previous percent disease at the jth observation and n = total number of observations.

The air temperatures in 2011 averaged the long term (10 year) average for May (14.1°C), June (18.4°C), August (20.2°C) and September (16.6°C) and were above average for July (22.8°C) and October (10.1°C). The long term (10 year) average temperatures were: May 13.3°C, June 18.5°C, July 20.4°C, August 19.6°C, September 15.7°C and October 8.9°C. Monthly rainfall was below the long term (10 year) average for June (67 mm) and July (56 mm), average for September (67 mm) and above average for May (92 mm), August (113 mm) and October (83 mm). The long term (10 year) rainfall averages were: May 76 mm, June 74 mm, July 82 mm, August 59 mm, September 72 mm and October 62 mm.
Data were analysed using the *proc glm* procedure of SAS version 9.1. Means separation was obtained using the Tukey's test with $P = 0.05$ level of significance.

RESULTS: There was no effect of cultivar on disease; therefore, the results outlined in Table 1 are combined for the two carrot cultivars.

CONCLUSIONS: All treatments significantly reduced the incidence of sclerotinia rot of carrot (SRC) compared to the untrimmed check. Trimming the carrot canopy alone was as effective in reducing incidence of SRC as combining trimming with ELEXA-4 or Lance application. Combining trimming the carrot canopy with ELEXA-4 or Lance application lowered disease incidence more than either treatment alone, however, the combined effect was significant only for ELEXA-4; LANCE was equally effective in reducing SRC when applied alone or in combination with trimming.

Table 1. Field evaluation of LANCE, ELEXA-4 and canopy trimming for management of sclerotinia rot of carrot in the Bradford Marsh, ON, 2011.

Treatment	Dose ha^{-1}	Total yield (t/ha)	AUDPC[1]
LANCE + trimming	630 g	73.9 ns[2]	145 a
ELEXA-4 + trimming	20 L	76.9	167 a
Trimmed check	--	71.3	307 ab
LANCE	630 g	75.8	418 ab
ELEXA-4	20 L	76.9	518 b
Untrimmed check	--	72.5	899 c
se			*72*
Contrasts			
Trimmed		73.3 a[3]	231 a
Untrimmed		74.4 a	683 b
Fungicide		75.8 a	312 a
No fungicide		71.2 b	603 b

[1] AUDPC = area under the disease progress curve.
[2] ns = No significant differences ($P = 0.05$, Tukey's Test) were found among the treatments.
[3] Numbers within a group in a column followed by the same letter are not significantly different at P 0.05, Tukey's Test.

2011 PMR REPORT #14 **SECTION L: VEGETABLE and SPECIAL CROPS - Diseases**

CROP: Cucumber (*Cucumis sativus* L.) cv. Fancipak
PEST: Downy Mildew (*Pseudoperonospora cubensis* (Berkeley and M. A. Curtis) Rostovzev)

NAME AND AGENCY:
TRUEMAN C L and MAY P
University of Guelph
Ridgetown Campus
120 Main Street East
Ridgetown ON N0P 2C0

Tel: (519) 674-1500 x63646 **Fax:** (519) 674-1600 **Email:** mtesaend@uoguelph.ca

TITLE: PRODUCTS FOR THE MANAGEMENT OF DOWNY MILDEW IN CUCUMBERS-2011

MATERIALS: PRESIDIO 4 SC (fluopicolide 39.5%), SYLGARD (siloxylated polyether 76%), MANZATE PRO-STICK (mancozeb 75%), RANMAN (cyazofamid 34.5%), TATTOO C (propamocarb HCl 375g L^{-1}, chlorothalonil 375 g L^{-1}), BRAVO 500 (chlorothalonil 500 g L^{-1}), PARASOL FL (copper hydroxide 24.4%), PRODUCT 1 (unknown), ZAMPRO (ametoctradin 27% + dimethomorph 20.3%), PREVICUR N (propamocarb hydrochloride 722 g L^{-1}), PRODUCT 2 (unknown).

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Cucumbers were seeded using a cone seeder on June 9 with in-row spacing of 10 seeds per meter and rows spaced 1.5m apart. The trial was setup as a randomized complete block design, with 4 repetitions per treatment. Each plot consisted of 1 row 7m in length. Treatments were applied using 200L of water Ha^{-1} on 5, 12, and 19 July using a hand-held sprayer with CO_2 pressure of 35 psi and ULD 120-02 nozzles. The first treatment application was made immediately following the first report of downy mildew in the area. Downy mildew was observed in the trial guard rows prior to the first treatment application but not in the trial itself. Drip irrigation was applied throughout the growing season as required. Monitor (methamidophos 480 g L^{-1}) was applied to the trial on 10 June to prevent mice from digging up the cucumber seed at a rate of 1L Ha^{1}. Downy mildew severity was assessed on 5, 11, 18, 25 July and 3 and 11 August. The number of leaves in a 2m section of each plot was counted and used to estimate the number of leaves in the whole plot. The number of visibly infected leaves, as determined by the presence of chlorotic lesions on the upper leaf surface, was counted for the whole plot, and then the percentage of infected leaves was calculated. The percentage of affected leaf area was assessed by estimating the area affected by downy mildew on infected leaves only. Cucumbers were harvested on 22 and 27 July. Mature fruit from the entire plot were harvested and graded into marketable classes and crooks and nubs. The number and weight of cucumbers in each class was recorded. Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed as indicated in the results tables. Analysis of variance was conducted and means were separated using Duncan's new multiple range test when ANOVA indicated significant variances due to treatment effects ($P \leq 0.05$).

RESULTS: Please refer to Table 1 through Table 3.

CONCLUSIONS: All fungicide treatments except PRODUCT 1 provided some reduction in downy mildew symptoms on cucumber, however the most consistent and greatest reductions were observed with treatments PRODUCT 2, PRESIDIO, PREVICUR N + BRAVO 500, TATTOO C and RANMAN + SYLGARD from 18 July to 3 August. PRODUCT 2 had fewer visibly infected leaves and less leaf area visibly affected by downy mildew on 11 August, which was 23 days after the last fungicide application. Harvest weight was significantly higher than the nontreated control for all fungicide treatments except PRODUCT 1 + PARASOL. All fungicide treatments also produced more cucumber fruit than the nontreated control, and all fungicide treatments except ZAMPRO produced more fruit than PRODUCT 1 + PARASOL.

ACKNOWLEDGEMENTS: This project was supported by the Ontario Cucumber Research Committee, OMAFRA, and University of Guelph, Ridgetown Campus.

Table 1. Percent of cucumber leaves visibly infected with downy mildew in treatments sprayed with different fungicides, Ridgetown, 2011.

Treatment	% Infected Leaves [a]					
	July 5 [b]	July 11	July 18	July 25	Aug 3	Aug 11 [b]
Nontreated control	0 ns [c]	8 ns	12 a	94 a	95 a	95 a
BRAVO 500 @ 4.8 L Ha^{-1}	0	8	9 ab	63 b	85 b	94 a
MANZATE PRO-STICK @ 3.25 kg Ha^{-1}	0	5	9 bc	63 b	90 ab	95 a
RANMAN @ 200 mL Ha^{-1} + SYLGARD 309 @ 150 mL Ha^{-1}	0	5	6 cd	28 cd	83 b	95 a
TATTOO C @ 2.7 L Ha^{-1}	0	8	7 bc	28 cd	65 c	83 b
PRODUCT 1 @ 1.5 L Ha^{-1} + PARASOL FL @ 3 L Ha^{-1}	1	10	12 a	90 a	95 a	95 a
PRESIDIO 4 SC @ 256 mL Ha^{-1}	0	5	6 cd	25 cd	70 c	88 ab
ZAMPRO @ 800 mL Ha^{-1}	0	6	10 ab	80 ab	90 ab	95 a
PREVICUR N @ 1403 mL Ha^{-1} + BRAVO 500 @ 2026 mL Ha^{-1}	0	6	8 bc	35 c	65 c	83 b
PRODUCT 2 @ 175 mL Ha^{-1}	1	8	4 d	11 d	9 d	28 c

[a] The percentage of visibly diseased leaves in the whole plot was evaluated, based on counting the number of leaves with visible symptoms, and estimating the number of leaves in a whole plot, based on the number of leaves in a 2m section of each plot.
[b] Data is not normal.
[c] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant at $P \leq 0.05$.

Table 2. Percent of cucumber leaf area infected with downy mildew in treatments sprayed with different fungicides, Ridgetown, 2011.

Treatment	% Leaf Area Affected [a]					
	July 5	July 11	July 18	July 25 [b]	Aug 3	Aug 11 [b]
Nontreated control	1 ns	17 ns	76 a	94 a	95 a	95 a
BRAVO 500 @ 4.8 L Ha^{-1}	3	15	33 bc	68 cd	80 bc	90 b
MANZATE PRO-STICK @ 3.25 kg Ha^{-1}	0	10	34 bc	55 d	90 ab	94 ab
RANMAN @ 200 mL Ha^{-1} + SYLGARD 309 @ 150 mL Ha^{-1}	3	13	23 c	24 e	75 c	90 b
TATTOO C @ 2.7 L Ha^{-1}	1	19	34 bc	32 e	55 d	78 c
PRODUCT 1 @ 1.5 L Ha^{-1} + PARASOL FL @ 3 L Ha^{-1}	3	22	70 a	91 ab	95 a	95 a
PRESIDIO 4 SC @ 256 mL Ha^{-1}	0	18	21 c	27 e	62 d	78 c
ZAMPRO @ 800 mL Ha^{-1}	0	10	49 b	81 bc	90 ab	91 ab
PREVICUR N @ 1403 mL Ha^{-1} + BRAVO 500 @ 2026 mL Ha^{-1}	0	24	29 bc	34 e	58 d	80 c
PRODUCT 2 @ 175 mL Ha^{-1}	1	16	15 c	9 f	25 e	27 d

[a] The percentage of leaf area affected by downy mildew on infected leaves.
[b] Data was transformed using an arcsine square root transformation; the back transformed means are shown here.
[e] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant at $P \leq 0.05$.

Table 3. Total number and weight of cucumbers sprayed with different fungicides for management of downy mildew, Ridgetown, 2011.

Treatment	Yield	
	Weight (kg)	Number
Nontreated control	12.35 c [a]	146.8 c
BRAVO 500 @ 4.8 L Ha^{-1}	25.32 ab	253.0 a
MANZATE PRO-STICK @ 3.25 kg Ha^{-1}	24.01 ab	238.0 a
RANMAN @ 200 mL Ha^{-1} + SYLGARD 309 @ 150 mL Ha^{-1}	27.45 a	245.3 a
TATTOO C @ 2.7 L Ha^{-1}	25.35 ab	250.5 a
PRODUCT 1 @ 1.5 L Ha^{-1} + PARASOL FL @ 3 L Ha^{-1}	16.46 c	190.8 b
PRESIDIO 4 SC @ 256 mL Ha^{-1}	24.95 ab	260.5 a
ZAMPRO @ 800 mL Ha^{-1}	21.79 b	225.8 ab
PREVICUR N @ 1403 mL Ha^{-1} + BRAVO 500 @ 2026 mL Ha^{-1}	23.69 ab	242.3 a
PRODUCT 2 @ 175 mL Ha^{-1}	26.31 ab	243.8 a

[a] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant at $P \leq 0.05$.

2011 PMR REPORT #15 **SECTION L: VEGETABLE and SPECIAL CROPS - Diseases**

CROP: Garlic (*Allium sativum* (L.)) cv. Music
PEST: Bulb and stem nematode (*Ditylenchus dipsaci* (Kuhn) Filipjev)

NAME AND AGENCY:
CELETTI M J[1] and PAIBOMESAI M[2]
Ontario Ministry of Agriculture
Food and Rural Affairs
University of Guelph
Guelph ON N1G 2W1

[1]**Tel:** (519) 824-4120 x58910 **Fax:** (519) 767-0755 **Email:** michael.celetti@ontario.ca

[2]**Tel:** (519) 519-826-4963 **Email**: marion.paibomesai@ontario.ca

TITLE: EFFICACY OF ABAMECTIN AS A SEED DIP FOR THE CONTOL OF SEED-BORNE BULB AND STEM NEMATODE IN GARLIC CV. MUSIC 2011

MATERIALS: AGRI-MEK (19 g.a.i. /L abamectin)**.**

METHODS: Seed cloves of garlic cv. Music with a high level of bulb and stem nematode infestation (617 nematodes/g dry cloves) and seed cloves of garlic cv. Music with a low level of nematode infestation (17 nematodes/g dry cloves) were soaked in a solution of 3.79 ml AGRI-MEK (19 g.a.i/L abamectin) per litre of water (0.072 g abamectin/L water) for 4 hours at room temperature. Samples of garlic bulbs with both levels of nematode infestation were soaked in water for 4 hours (WATER TREATED CHECK) at room temperature or left untreated (UNTREATED CHECK) for comparison. All treatments were compared with nematode-free garlic seed cloves obtained from tissue culture at University of Guelph New Liskeard Research Station. Twenty one cloves from each treatment were planted 5 cm deep, 12 cm apart in rows spaced 20 cm apart on October 10, 2010. Each plot contained 3 rows of garlic replicated 4 times and arranged in a randomized complete block design on land that had not been planted with garlic for 4 years. Emergence was evaluated on May 12, 2011. The scapes from plants were removed on June 29, 2011. Garlic was harvested, weighed and rated for bulb and stem nematode damage (1 = no damage, 4= severe damage) from all plots on July 14, 2011. Bulb and stem nematode were extracted from 10 bulbs harvested from each plot by placing the bulbs in Baermann funnels in a mist chamber for 24 hours. The stem and bulb nematodes extracted were identified to genus and enumerated. The garlic bulbs were then dried at 80^{o}C for 72 hours to obtain the dry weight of the garlic bulbs. Data was transformed using the Log (nematode/g dried bulb +1) to improve normality and additivity prior to statistical analysis. All data was analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. Fisher's protected least significant difference (LSD) test was used to detect differences among the means at P=0.05.

RESULTS: Soaking garlic seed in water or AGRI-MEK for 4 hours did not significantly affect the emergence of garlic plants (Table1). Similarly, soaking garlic seed in a solution of AGRI-MEK prior to planting did not significantly affect the number of garlic bulbs harvested. Garlic seed cloves with a high bulb and stem nematode infestation level that were soaked in an AGRI-MEK solution for 4 hours prior to planting produce significantly higher yields than untreated highly infested garlic seed or highly infested garlic seed that were soaked in water for 4 hours (Table 1). No differences in yield were detected when garlic seed with lower nematode infestation were soaked in an AGRI-MEK solution for 4 hours prior to planting compared to garlic seed with low nematode infestation that was untreated or soaked in water for 4 hours prior to planting. Bulbs that grew from the small nematode-free garlic seed produce the lowest yield due to the small size of the garlic seed at planting. Soaking garlic seed cloves with a high bulb and stem nematode infestation level in an AGRI-MEK solution for 4 hours prior to planting also produced

bulbs with significantly lower damage and lower *D. dipsaci* populations at harvest than bulbs produced from untreated highly infested garlic seed cloves or highly infested garlic seed cloves that were soaked in water for 4 hours prior to planting (Table 1). No differences in the damage or nematode populations in bulbs at harvest were detected among treatments applied to the garlic seed that had a low level of bulb and stem nematode at planting. Bulbs produced from nematode-free garlic seed cloves were slightly infested at harvest most likely due to nematodes moving in from neighbouring plots planted with highly infested garlic seed cloves or soil-borne nematodes.

CONCLUSIONS: Soaking garlic seed cloves infested with a high level of *D. dipsaci* in a solution of AGRI-MEK for 4 hours prior to planting significantly increased garlic yields, reduced disease severity and resulted in a lower population of *D. dipsaci* in garlic bulbs harvested compared to untreated highly infested garlic seed cloves or highly infested garlic seed cloves that were soaked in water for 4 hours.

Table 1. The effect of soaking garlic seed infested with levels of *D. dipsaci* in water and abamectin for 4 hours prior to planting on emergence, yield, nematode damage and number of *D. dipsaci* in garlic bulbs harvested compared to untreated and nematode free garlic seed.

Nematode infestation level of garlic seed at planting	Treatment	% Emergence May 11, 2011	Mean Number of garlic bulbs harvested	Yield (kg/m^2)	Nematode Damage (1-4)[1]	*D. dipsaci* per g dried bulb at harvest
NEMATODE FREE SEED		86.3 a[2]	16 a	0.462 d	1.01 d	4.57 b[3]
High (617 *D. dipsaci*/g dry clove)	UNTREATED	86.3 a	16 a	0.912 bc	2.96 a	234.75 a
	WATER	78.4 a	14 a	0.759 c	3.33 a	263.25 a
	AGRI-MEK	92.0 a	18 a	1.344 a	1.73 b	5.25 b
NEMATODE FREE SEED		88.6 a	18 a	0.453 d	1.23 cd	16.75 b
Low (17 *D. dipsaci*/g dry clove)	UNTREATED	92.0 a	19 a	1.144 a	1.69 bc	27.50 b
	WATER	89.8 a	17 a	1.130 ab	1.92 b	51.50 b
	AGRI-MEK	89.5 a	19 a	1.165 a	1.73 bc	1.13 b

1. Nematode damage 1 = no damage; 2= slight damage; 3= moderate damge; 4= severe damage.
2. Figures within columns followed by different letters are significantly different using a protected LSD ($P<0.05$).
3. Data was transformed using the Log (nematode/g dried bulb +1) to improve normality and additivity prior to statistical analysis however, actual means are presented.

2011 PMR REPORT #16 **SECTION L: VEGETABLE and SPECIAL CROPS – Diseases**

CROP: Yellow cooking onions (*Allium cepa* L.) cv. Taho
PEST: *Stemphylium vesicarium* (Wallr.)

NAME AND AGENCY:
TESFAENDRIAS M T and MCDONALD M R
University of Guelph
Department of Plant Agriculture
Muck Crops Research Station
1125 Woodchoppers Lane, RR# 1
Kettleby ON L0G 1J0

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

TITLE: EVALUATION OF FUNGICIDES FOR CONTROL OF STEMPHYLIUM LEAF BLIGHT IN ONIONS, 2011

MATERIALS: PRISTINE® (pyraclostrobin 25.2%, boscalid 12.8%), BRAVO® 500 (chlorothalonil 50%), MANZATE® 750F (mancozeb 75%), SWITCH® 62.5WG (cyprodinil 37.5%, fluodioxinil 25.0%), FONTELIS® 20SC (penthiopyrad 20%), INSPIRE® (difenoconzole 23.2%), LUNA TRANQUILITY® (fluopyram 11.3%, pyrimethanil 33.8%).

METHODS: Onion, cv. Taho, was direct seeded (34 seeds/m) using a Stanhay Precision Seeder on 7 May, into organic soil (organic matter ≈ 44%, pH ≈ 7.5) near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each experimental unit consisted of four rows, 42 cm apart, 5 m in length. Recommended control procedures for weeds and insects were followed. Treatments were: PRISTINE at 1.3 kg/ha, BRAVO 500 at 4.8 kg/ha, MANZATE 750F at 3.25 kg/ha, SWITCH 62.5WG at 975 g/ha, FONTELIS 20SC at 1.4 L/ha, INSPIRE at 512 mL/ha and LUNA TRANQUILITY at 1.4 L/ha. An untreated check was also included. Treatments were applied on 12, 19 and 27 July, and 5, 12 and 18 August using a CO_2 backpack sprayer equipped with four TeeJet 8002 VS fan nozzles spaced 40 cm apart and calibrated to deliver 400 L/ha at 240 kPa (boom). Experimental plots were assessed on 5, 12 and 18 August, and rated for stemphylium leaf blight using a 0-9 scale, where: 0 = 0%, 1 < 2%, 2 = 2-4%, 3 = 5-9%, 4 = 10-24%, 5 = 25-40 %, 6 = 41-55%, 7 = 56-70%, 8 = 71-85% and 9 > 85% foliar area diseased per plot. These values were used to calculate area under the disease progress curve (AUDPC) using the following equation:

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

Where j is the order index for the times and n_j is the total number of assessments, y_j is the rating for foliar area diseased per plot at day t_j, y_{j+1} is the rating for foliar area diseased per plot at day t_{j+1} and (t_{j+1} - t_j) is the number of days between two assessments.

On 26 August, ten plants from each replicate were pulled and assessed for percent of foliage infected. On 28 September, onions in two 2.32 m sections of row from each replicate were pulled for a yield sample. The onions were weighed and graded for size on 16 October.

Compared to the averaged previous 10 years, the air temperatures in 2011 were average for May (14.1ºC), June (18.4ºC), August (20.2 ºC) and September (16.6ºC), and above average for July (22.8ºC). The long term previous 10 year average temperatures were: May 13.3ºC, June 18.5ºC, July 20.4ºC, August 19.6ºC and September 15.7ºC. Monthly rainfall was below the previous long term 10 year average for June (67 mm) and July (56 mm), average for September (67 mm), and above average for May (92 mm) and August (113 mm). The long term previous 10 year rainfall averages were: May 76 mm, June 74

mm, July 82 mm, August 59 mm, September 72 mm and October 62 mm. Data were analysed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. Means separation was obtained using Fisher's Protected LSD test with $P = 0.05$ level of significance.

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: In 2011, disease pressure was high and increased over the assessment period. Stemphylium leaf blight started to develop around mid to late June in the Holland Marsh. Significant differences in stemphylium leaf blight severity were found among the treatments. All of the fungicides reduced disease compared to the untreated control. New products, FONTELIS, LUNA TRANQUILITY and INSPIRE were most effective in reducing stemphylium leaf blight with 19.8, 20.7 and 24.5% foliage with symptoms respectively, as compared to 67% in the untreated control (Table 1). In two of the plot ratings (August 5, August 12) and for the AUDPC values, there were no significant differences among the treatments (Table 1). At the third rating (August 19) all treatments except BRAVO and MANCOZEB were significantly different (i.e. lower disease ratings) from the untreated check but not significantly different from each other. No differences in yield or size distribution were found among the treatments (Table 2). However, reduced marketable yield was correlated ($r = -0.45$; $P = 0.01$) with percent total leaf length with stemphylium leaf blight symptoms. The percent of small onions (culls) also increased ($r = 0.43$; $P = 0.01$) with an increase in leaf length with disease symptoms. This indicates that fungicides which are registered for onion diseases can reduce stemphylium leaf blight and registration of the new materials can improve control. Three of the new fungicides were identified as relatively effective for control of stemphylium leaf blight.

ACKNOWLEDGEMENTS: Funding for this project was provided by the Holland Marsh Growers' Association through the support of the Bradford Co-operative Storage Ltd and by the OMAFRA/University of Guelph Partnership.

Table 1. Plot ratings, area under the disease progress curve and average percent of total leaf with stemphyllium leaf blight symptoms for onions, cv. Taho, treated with various fungicides, grown near Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatment	Rate per ha	% Total Leaf Length with Symptoms	Plot Ratings			AUDPC[1]
			Aug 5	Aug 12	Aug 19	
FONTELIS	1.4 L	19.8 a[2]	2.3 ns[3]	2.3 ns	2.5 ab	30.0 ns
LUNA TRANQUILITY	1.4 L	20.7 ab	1.8	2.3	2.3 a	27.5
INSPIRE	512 mL	24.5 abc	2.0	2.8	3.0 ab	33.9
PRISTINE	1.3 kg	33.6 bcd	2.3	2.5	3.0 ab	33.1
SWITCH	975 g	37.1 cd	2.5	2.8	3.3 ab	36.4
MANCOZEB	3.25 kg	37.4 cd	2.5	3.3	3.5 abc	40.4
BRAVO	4.8 kg	38.4 d	2.5	3.0	3.5 bc	39.5
Check	--	67.0 e	2.5	3.5	4.8 c	45.8

[1]AUDPC = area under the disease progress curve.
[2] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Fisher's Protected LSD test.
[3] Not significantly different at $P = 0.05$, Fisher's Protected LSD test.

Table 2. Comparison of marketable yield and size distribution of onions, cv. Taho, treated with various fungicides grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatment	Rate per ha	Marketable Yield (t/ha)	Size Distribution			
			% Jumbo (> 76 mm)	% Large (64 - 76 mm)	% Medium (45 - 64 mm)	% Small (< 45 mm)
LUNA TRANQUILITY	1.4 L	31.9 ns[z]	0.1 ns	6.1 ns	66.4 ns	27.3 ns
SWITCH	975 g	28.3	0.0	6.3	66.3	27.3
FONTELIS	1.4 L	27.3	0.2	8.1	65.9	25.1
Check	--	25.6	0.0	2.3	66.9	30.7
MANCOZEB	3.25 kg	25.2	0.0	3.9	60.1	35.9
PRISTINE	1.3 kg	24.6	0.1	3.3	61.5	34.9
INSPIRE	512 mL	23.7	0.1	4.7	66.1	28.9
BRAVO	4.8 kg	23.0	0.0	3.9	57.7	38.3

[1] Not significantly different at $P = 0.05$, Fisher's Protected LSD test.

2011 PMR REPORT #17 **SECTION L: VEGETABLE and SPECIAL CROPS - Diseases**

CROP: Zucchini (*Cucurbita pepo*) cv. Select (Stokes Seeds Ltd.)
PEST: Powdery mildew (*Sphaerotheca fuliginea* (Schlechtend.:Fr.) Pollacci)

NAME AND AGENCY:
MCDONALD M R and RICHES L
University of Guelph
Department of Plant Agriculture
Muck Crops Research Station
1125 Woodchoppers Lane, RR # 1
Kettleby ON L0G 1J0

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

TITLE: EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW ON ZUCCHINI, 2011

MATERIALS: IKF-309 300 SC (experimental), NOVA 40 WP (myclobutanil 40%).

METHODS: The field trial was conducted at a site near the Muck Crops Research Station, Holland Marsh, Ontario, in mineral soil (pH ≈ 7.8, organic matter ≈ 2.1%). On 14 June, zucchini, cv. Select (Stokes Seeds), was hand-seeded through holes cut into 1.5 m wide black plastic mulch. A randomized complete block arrangement with four replicates per treatment was used. Each experimental unit consisted of one 8 m long row, with rows spaced 2.8 m apart and 50 cm in-row spacing. Treatments were: IKF-309 300 SC at 300 mL/ha and NOVA 40 WP at 875 g/ha. An untreated check was also included. Treatments were applied on 27 July, 9 and 17 August using a CO_2 backpack sprayer equipped with four TeeJet 8002 VK fan nozzles spaced 40 cm apart and calibrated to deliver 300 L/ha at 240 kPa (boom). The trial was monitored weekly for powdery mildew (PM). On 9, 17 and 23 August, plots were assessed by counting the number of leaves per plant infected with PM. On 30 August plots were rated for percent PM present. The number of leaves with PM per plant values was used to calculate the area under the disease progress curve (AUDPC). On 2 August, zucchini were harvested, sorted into marketable, oversized and cull (due to rot) categories. Weights and numbers were recorded. Compared to the averaged previous 10 years, the air temperatures in 2011 were average for June (18.4°C), August (20.2°C) and September (16.6°C), above average for July (22.8°C). The long term previous 10 year average temperatures were: June 18.5°C, July 20.4°C, August 19.6°C, and September 15.7°C. Monthly rainfall was below the previous long term 10 year average for June (67 mm) and July (56 mm), average for September (67 mm), and above average for August (113 mm). The long term previous 10 year rainfall averages were: June 74 mm, July 82 mm, August 59 mm, and September 72 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 Fisher's Protected LSD test at $P = 0.05$ level of significance.

RESULTS: Powdery mildew was first observed in mid-August (60 DAS). Significant differences in PM incidence were observed among the treatments at the 17 and 23 August assessments and at the 30 August plot rating (Table 1). On 17 and 23 August, zucchini treated with either NOVA or IKF-309 had significantly less PM than the untreated check and there were no differences in disease incidence between the fungicide treatments. By 30 August, zucchini sprayed with NOVA had significantly less PM than zucchini sprayed with IKF-309. There were no differences in yield among the treatments and no phytotoxicity was observed in the trial.

CONCLUSIONS: Both IKF-309 and NOVA were effective in controlling powdery mildew in zucchini. NOVA may be more effective than IKF-309 in controlling PM infection late in the season.

ACKNOWLEDGEMENT: Funding for this project was provided by ISK Biosciences Corporation.

Table 1. Powdery mildew disease progress of zucchini, cv. Select, treated with foliar fungicides grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatment	# Leaves with PM/plant			AUDPC	Aug 30 Plot Rating (% PM)
	9 August	17 August	23 August		
IFK-309	0.0 ns[1]	0.6 a[2]	4.8 a	0.5 a	35.0 b
NOVA	0.0	1.2 a	4.9 a	0.6 a	18.8 a
Check	0.0	6.2 b	28.9 b	3.4 b	83.8 c

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

Table 2. Yield data for zucchini, cv. Select, treated with foliar fungicides grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2011.

Treatment	%[1] Oversized	% Marketable	% Culls[2]	Total # Harvested
IFK-309	84.7 ns[2]	9.8 ns	5.5 ns	57.0 ns
NOVA	84.6	8.9	6.5	51.5
Check	86.7	8.9	4.3	40.5

[1] % based on weight.
[2] Culls due to rot.
[3] ns indicated no significant differences were found among the treatments.

2011 PMR REPORT #18 **SECTION O: CEREALS, FORAGE CROPS and OILSEEDS - Diseases**

CROP: Winter durum wheat, *Triticum turgidum* subsp. *durum* L. cv. OAC Amber
PEST: Powdery mildew, *Blumeria graminis*
Septoria leaf blotch, *Septoria tritici*

NAME AND AGENCY:
TAMBURIC-ILINCIC L[1] and SPARRY E[2]

[1]University of Guelph
Ridgetown Campus
120 Main Street East
Ridgetown ON N0P 2C0

Tel: (519) 674-1500 x63557 **Fax:** (519) 674-1600 **Email:** ltamburi@ridgetownc.uoguelph.ca

[2]C&M Seeds
Palmerston ON K2E 7Z1

TITLE: THE EFFECT OF FUNGICIDE APPLICATION ON LEAF DISEASES AND YIELD IN WINTER DURUM 'OAC AMBER' IN ONTARIO IN 2011

MATERIALS: QUILT (Azoxystrobin 75 g/L, Propiconazole 125 g/L), PROSARO 250 EC, (Prothiconazole 125 g/L, Tebuconazole 125 g/L).

METHODS: The experiment was conducted in Palmerston, Ontario in 2011 and arranged in a factorial randomized complete block design with four replications. Three factors included nitrogen rate, seeding rate and fungicides. Each replicate consisted of 4 m long and 1 m wide plots of winter durum 'OAC Amber' seeded on October 9, 2010 with three different seeding rates (400 seeds/m^2, 440 seeds/m^2 and 480 seeds/m^2). Three rates of actual nitrogen (75 kg/ha, 100 kg/ha and 125 kg/ha) were applied on selected plots on May 4, 2011 in form of Urea. QUILT (0.75 L/ha) and PROSARO (0.8 L/ha) were applied on May 31, 2011 and June 17, 2011, respectively. Both fungicides were applied on the same plots with 200 L/ha of water. Plots without fungicides application served as control. Entire leaves were rated for powdery mildew and septoria leaf blotch on June 10, 2011 and July 5, 2011, respectively. The plots were harvested on August 12, 2012 and the yields were corrected to 14% moisture. Means separation for yield was obtained using Fisher's Protected LSD test at P= 0.05 level of significance.

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

CONCLUSIONS: 'OAC Amber' yield was significantly different across the treatments with fungicides application and control plots. Yield increase ranged from 3.7 % (tr # 9) to 28.3% (tr #1). Lowest yield, among the treatments with fungicide application, was observed after application of the lowest nitrogen rate (tr # 9). However, there was no significant difference in yield between highest and lowest seeding rate combined with the highest nitrogen rate and fungicide application (tr # 1 vs. tr 3 #). Mean incidence for powdery mildew, across the treatments, was 1.9 after fungicides application and 4.4 in control plots. The values for septoria leaf blotch incidence with fungicides application compared to control were 1.9 vs. 5.0. We concluded that fungicides controlled both leaf diseases in winter durum 'OAC Amber'. The highest yield was obtained after application of highest nitrogen rate plus fungicides application.

Table 1. 'OAC Amber' yield (t/ha) after fungicides application and in control plots. Palmerston, Ontario, 2011.

Treatment #	Treatment name	Yield (t/ha) Fungicides	Control	% increase
1	400 seeds/m2+125 kg N	6.66 a	5.19 j	28.3
2	440 seeds/m2+125 kg N	6.18 de	5.50 ghi	12.4
3	480 seeds/m2+125 kg N	6.57 ab	5.25 j	25.1
4	400 seeds/m2+100 kg N	6.11 e	5.25 j	16.4
5	440 seeds/m2+100 kg N	6.20 de	5.32 ij	16.5
6	480 seeds/m2+100 kg N	6.42 bc	5.53 gh	16.1
7	400 seeds/m2+ 75 kg N	6.32 cd	5.47 hi	15.5
8	440 seeds/m2+ 75 kg N	6.33 cd	5.18 j	22.2
9	480 seeds/m2+ 75 kg N	5.89 f	5.68 g	3.7
Mean		6.30	5.37	
SD		0.24	0.18	

Numbers in column 3 and 4 combined followed by the same letter are not significantly different at P = 0.05, Fisher's Protected LSD Test.

Table 2. Powdery mildew incidence (0-9) in 'OAC Amber' after fungicides application and in control plots. Palmerston, Ontario, 2011.

Treatment #	Treatment name	Powdery mildew (0-9) Fungicides	Control
1	400 seeds/m2+125 kg N	1.5 de	5.0 ab
2	440 seeds/m2+125 kg N	2.0 e	5.0 ab
3	480 seeds/m2+125 kg N	2.5 de	4.5 bc
4	400 seeds/m2+100 kg N	2.0 de	4.0 ab
5	440 seeds/m2+100 kg N	2.0 e	4.0 a
6	480 seeds/m2+100 kg N	2.0 e	5.0 ab
7	400 seeds/m2+ 75 kg N	2.0 de	4.0 a
8	440 seeds/m2+ 75 kg N	2.0 cd	5.0 ab
9	480 seeds/m2+ 75 kg N	1.5 cd	3.0 ab
Mean		1.9	4.4
SD		0.3	0.7

Numbers in column 3 and 4 combined followed by the same letter are not significantly different at P = 0.05, LSD Test.

Table 3. Septoria leaf blotch incidence (0-9) in 'OAC Amber' after fungicides application and in control plots. Palmerston, Ontario, 2011.

Treatment #	Treatment name	Septoria leaf blotch (0-9)	
		Fungicides	Control
1	400 seeds/m2+125 kg N	1.7 cd	5.7 ab
2	440 seeds/m2+125 kg N	3.0 cd	5.3 a
3	480 seeds/m2+125 kg N	3.0 d	5.0 bc
4	400 seeds/m2+100 kg N	1.7 cd	4.7 ab
5	440 seeds/m2+100 kg N	1.3 cd	5.7 ab
6	480 seeds/m2+100 kg N	1.0 cd	5.0 a
7	400 seeds/m2+ 75 kg N	2.0 d	4.7 a
8	440 seeds/m2+ 75 kg N	1.3 cd	5.0 a
9	480 seeds/m2+ 75 kg N	1.7 cd	4.0 a
Mean		1.9	5.0
SD		0.7	0.5

Numbers in column 3 and 4 combined followed by the same letter are not significantly different at P = 0.05, LSD Test.

2011 PMR REPORT #19 **SECTION P: GREENHOUSE CROPS, ORNAMENTALS and TURF - Diseases**

CROP: Honeylocust (*Gleditsia triacanthos* var. *inermis* (L.) Schneid.)
PEST: Coral Spot Nectria Canker, (*Nectria cinnabarina* (Tode) Fr. (anamorph *Tubercularia vulgari* Tode))

NAME AND AGENCY:
CELETTI M J[1] and LLEWELLYN J[2]
Ontario Ministry of Agriculture, Food and Rural Affairs
University of Guelph
Guelph ON N1G 2W1

[1]**Tel:** (519) 824-4120 x58910 **Fax:** (519) 767-0755 **Email:** michael.celetti@ontario.ca

[2] **Tel:** (519) 824-4120 x52671 **Fax:** (519) 767-0755 **Email**: jennifer.llewellyn@ontario.ca

TITLE: EFFICACY OF FUNGICIDE APPLICATION ON WOUNDED LIMBS OF HONEYLOCUST TREES TO PREVENT CORAL SPOT NECTRIA CANKER DEVELOPMENT 2010

MATERIALS: PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin), SENATOR 70WP (70% thiophanate-methyl), SCHOLAR 230SC (230 g.a.i./L fludioxonil), DACONIL 2787 (40.4% chlorothalonil).

METHODS: A 10 mm diameter wound was created with a cork borer on four limbs per honeylocust tree in a nursery near Hamilton Ontario on 2 June 2010. The fresh wounds were immediately sprayed with either sterile water, SENATOR 70WP (70% thiophanate-methyl) at a rate of 500 g in 1000 L of water, PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin) at a rate of 1000 g in 250 L of water, SCHOLAR 230SC (230 g.a.i./L fludioxonil) at a rate of 496 mL in 378 L of water or DACONIL 2787 (40.4% chlorothalonil) at a rate of 2.5 liters per 1000 L of water. The solutions were applied to the wounds with a 1 litre garden spray bottle, directing the spray nozzle at the wound and surrounding tissue. The treated wounds were allowed to dry for 1 hour. An 8 mm diameter plug of mycelia from the margin of a 7-day-old colony of *N. cinnabarina* growing on acidified potato dextrose agar (APDA) was placed in each fungicide-treated wound and in a set of wounds treated with water alone (INOCULATED CHECK). An 8 mm diameter plug of sterile APDA was placed in a second set of wounds treated with water alone (NON-INOCULATED CHECK) for comparison. All wounds were wrapped with polyethylene tape (flagging tape) to preserve moisture. Each tree received one treatment. The treated, wounded trees were replicated four times for a total of 16 wounds per treatment and arranged in a randomized complete block design.

The polyethylene tape was removed on 28 July 2010 (56 days after treatment). The length and width of the wound or cankers that developed around the inoculated wound was measured on 28 July (56 days after treatment), 1 September (91 days after treatment) and 4 October (124 days after treatments). The outside leading edge of cankers that developed around wounds was measured whereas, the inside edge of wounds that appeared to heal and shrink due to callus production was measured. Area of the cankers or healing wounds was calculated using the formula for an ellipse (π(½ L x ½ W)) and the data was statistically analyzed using Tukey's HSD test to detect differences among the means at P=0.05.

RESULTS: Small cankers developed around inoculated wounds that were treated with SENATOR 70WP and SCHOLAR 230SC but were significantly smaller and developed much more slowly when compared to the INOCULATED CHECK (Table 1). No canker development was observed around any of the wounds treated with PRISTINE WG or non-inoculated wounds. Inoculated wounds treated with

DACONIL 2787 were significantly smaller than the small cankers that formed around the inoculated wounds treated with SENATOR 70WP.

CONCLUSIONS: All fungicide treatments significantly reduced or eliminated the progression of canker expansion that developed around wounds on limbs inoculated with *N. cinnabarina*. PRISTINE WG and DACONIL 2787 prevented the development of coral spot cankers when applied to wounds prior to inoculation. SENATOR 70WP and SCHOLAR 230SC did not prevent the development of coral spot cankers, however, cankers were significantly smaller and development was significantly slower than the INOCULATED CHECK.

Table 1. The area of wounds and cankers that developed around wounds treated with a fungicide prior to inoculation with *N. cinnabarina* compared to wounds treated with water prior to inoculation with *N. cinnabarina* and non-inoculated wounds.

	Area of canker (mm) after treatment			
Treatment	56 days	91 days	124 days	AUDPC[1]
INOCULATED CHECK	481.92 a[2]	558.15 a	456.84 a	63550 a
SENATOR 70WP	198.08 b	186.13 b	209.70 b	23821 b
PRISTINE WG	157.45 b	123.77 b	124.22 c	16747 b
SCHOLAR 230SC	178.47 b	165.40 b	175.71 bc	21102 b
DACONIL 2787	158.75 b	159.43 b	147.74 bc	19386 b
NON-INOCULATED CHECK	189.96 b	171.84 b	142.61 c	21470 b

1. Area Under the Disease Progress Curve.
2. In each column, numbers followed by the same letter are not significantly different in Tukey's HSD (P=0.05).

2011 PMR REPORT #20 **SECTION P: GREENHOUSE CROPS, ORNAMENTALS and TURF - Diseases**

CROP: Honeylocust (*Gleditsia triacanthos* var. *inermis* (L.) Schneid.)
PEST: Coral Spot Nectria Canker, (*Nectria cinnabarina* (Tode) Fr. (anamorph *Tubercularia vulgaris*Tode))

NAME AND AGENCY:
CELETTI M J[1] and LLEWELLYN J[2]
Ontario Ministry of Agriculture, Food and Rural Affairs
University of Guelph
Guelph ON N1G 2W1

[1] **Tel:** (519) 824-4120 x58910 **Fax:** (519) 767-0755 **Email:** michael.celetti@ontario.ca

[2] **Tel:** (519) 824-4120 x52671 **Fax:** (519) 767-0755 **Email**: jennifer.llewellyn@ontario.ca

TITLE: EFFICACY OF FUNGICIDE APPLICATION ON WOUNDED TRUNKS OF HONEYLOCUST TREES TO PREVENT CORAL SPOT NECTRIA CANKER DEVELOPMENT 2011

MATERIALS: PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin), SENATOR 70WP (70% thiophanate-methyl), SCHOLAR 230SC (230 g.a.i./L fludioxonil), DACONIL 2787 (40.4% chlorothalonil).

METHODS: Four 10 mm diameter wounds were created with a cork borer on the main trunk of a honeylocust tree in a nursery near Grand Valley Ontario on 1 June 2011. The fresh wounds were immediately sprayed with either sterile water, SENATOR 70WP (70% thiophanate-methyl) at a rate of 500 g in 1000 L of water, PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin) at a rate of 1000 g in 250 L of water, SCHOLAR 230SC (230 g.a.i./L fludioxonil) at a rate of 496 mL in 378 L of water or DACONIL 2787 (40.4% chlorothalonil) at a rate of 2.5 liters per 1000 L of water. The solutions were applied to the wounds with a 1 litre garden spray bottle, directing the spray nozzle at the wound and surrounding tissue. The treated wounds were allowed to dry for 1 hour. An 8 mm diameter plug of mycelia from the margin of a 7-day-old colony of *Nectria cinnabarina* growing on acidified potato dextrose agar (APDA) was placed in each fungicide-treated wound and in a set of wounds treated with water alone (INOCULATED CHECK). An 8 mm diameter plug of sterile APDA was placed in a second set of wounds treated with water alone (NON-INOCULATED CHECK) for comparison. All wounds were wrapped with polyethylene tape (flagging tape) to preserve moisture. Each tree received one treatment. The treated, wounded trees were replicated four times for a total of 16 wounds per treatment and arranged in a randomized complete block design.

The polyethylene tape was removed on 13 July 2011 (42 days after treatment). The length and width of the wounds or cankers that developed around inoculated wounds was measured on 13 July (42 days after treatment), 10 August (70 days after treatment), 8 September (99 days after treatment) and 13 October (134 days after treatments). The outside leading edge of cankers that developed around wounds was measured whereas, the inside edge of wounds that appeared to heal and shrink due to callus production was measured. Area of the cankers or healing wounds was calculated using the formula for an ellipse (π(½ L x ½ W)) and the data was statistically analyzed using Tukey's HSD test to detect differences among the means at P=0.05.

RESULTS: Wounds treated with water and inoculated with *N. cinnabarina*) developed coral spot cankers 42 days after inoculation (Table 1). Callus growth and compartmentalization was observed developing around wounds that were treated with a fungicide prior to inoculation and not inoculated

wounds. Non-inoculated wounds and wounds treated with a fungicide began to shrink over the course of the experiment and were significantly smaller than the cankers that developed around inoculated wounds.

CONCLUSIONS: PRISTINE WG, SENATOR 70WP, SCHOLAR 230SC and DACONIL 2787 prevented or significantly reduced the development of coral spot cankers when applied to wounds on the main trunk of honeylocust trees prior to inoculating with *N. cinnabarina*.

Table 1. The area of wounds and cankers that developed around wounds treated with a fungicide prior to inoculation with *N. cinnabarina* compared to wounds treated with water prior to inoculation with *N. cinnabarina* and non-inoculated wounds.

	Area of canker (mm) after treatment				
Treatment	42 days	70 days	99 days	134 days	AUDPC[1]
INOCULATED CHECK	326.77 a[2]	503.50 a	674.45 a	875.64 a	70243 a
SENATOR 70WP	209.80 b	142.10 b	61.11 b	59.59 b	14579 b
PRISTINE WG	203.42 b	116.51 b	58.00 b	56.02 b	14114 b
SCHOLAR 230SC	218.75 b	125.21 b	65.56 b	84.89 b	15619 b
DACONIL 2787	231.28 b	124.71 b	63.73 b	86.03 b	15973 b
NON-INOCULATED CHECK	200.77 b	134.82 b	71.74 b	85.10 b	15356 b

1. Area Under the Disease Progress Curve.
2. In each column, numbers followed by the same letter are not significantly different in Tukey's HSD (P=0.05).

2011 PMR REPORT #21 **SECTION P: GREENHOUSE CROPS, ORNAMENTALS and TURF - Diseases**

CROP: Honeylocust (*Gleditsia triacanthos* var. *inermis* (L.) Schneid.)
PEST: Coral Spot Nectria Canker, (*Nectria cinnabarina* (Tode) Fr. (anamorph *Tubercularia vulgaris* Tode))

NAME AND AGENCY:
CELETTI M J[1] and LLEWELLYN J[2]
Ontario Ministry of Agriculture, Food and Rural Affairs
University of Guelph
Guelph ON N1G 2W

[1]**Tel:** (519) 824-4120 x58910 **Fax:** (519) 767-0755 **Email:** michael.celetti@ontario.ca

[2] **Tel:** (519) 824-4120 x52671 **Fax:** (519) 767-0755 **Email**: jennifer.llewellyn@ontario.ca

TITLE: TIMING OF FUNGICIDE APPLICATION ON WOUNDED TRUNKS OF HONEYLOCUST TREES TO PREVENT OR REDUCE CORAL SPOT NECTRIA CANKER DEVELOPMENT 2011

MATERIALS: PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin), DACONIL 2787 (40.4% chlorothalonil).

METHODS: Four 10-mm diameter wounds were created with a cork borer on the main trunks of a set of honeylocust trees in a nursery near Grand Valley, Ontario on 19 May 2011. The fresh wounds were immediately sprayed with either sterile water, PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin) at a rate of 1000 g in 250 L of water or DACONIL 2787 (40.4% chlorothalonil) at a rate of 2.5 liters per 1000 L of water. The solutions were applied to the wounds with a 1 litre garden spray bottle, directing the spray nozzle at the wound and surrounding tissue. The wounds were wrapped with polyethylene tape (flagging tape) to preserve moisture. Four 10- mm diameter wounds were created with a cork borer on the main trunks of 2 different sets of honeylocust trees in the same block on 1 June 2011. One set of the fresh wounds, to be treated 14 days later was sprayed with sterile water alone. The other set was immediately sprayed with water or fungicides as above and allowed to dry for 1 hour. All wounds including those made 14 days earlier on 19 May (14 day pre-inoculation treatment), were then inoculated on 1 June by placing an 8 mm diameter plug of mycelia from the margin of a 7-day-old colony of *Nectria cinnabarina* growing on acidified potato dextrose agar (APDA) in each wound, except for one set of water-treated wounds in which an 8 mm diameter plug of sterile APDA was placed as a NON-INOCULATED WATER CHECK for comparison. All wounds were then wrapped with polyethylene tape to preserve moisture. Fourteen days later, on 13 June 2011, the polyethylene tape was removed from the second set of water-treated, inoculated wounds made on June 1 which were then sprayed with the fungicide solutions or water alone as above (14 day post-inoculation treatment). Sixteen of the non-inoculated wounds made on 1 June were also unwrapped and sprayed with water to serve as a NON-INOCULATED WATER CHECK. All wounds were allowed to dry for 1 hour before re-wrapping with polyethylene tape to preserve moisture. Each tree received one treatment. The treated, wounded trees were replicated 4 times for a total of 16 wounds per treatment and arranged in a randomized complete block design.

The polyethylene tape was removed from all wounds on 13 July 2011. The length and width of the wounds or cankers that developed around inoculated wounds was measured on 13 July, 10 August, 8 September and 13 October. The outside leading edge of cankers that developed around wounds was measured, whereas the inside edge of wounds that appeared to heal and shrink due to callus production were measured. Area of the cankers or healing wounds was calculated using the formula for an ellipse (π(½ L x ½ W)) and the means compared in Tukey's HSD test at P=0.05.

RESULTS: Wounds treated with PRISTINE WG, DACONIL 2787 or water 14 days before inoculating with *N. cinnabarina* developed callus tissue and healed (Table 1). Wounds treated with PRISTINE WG or DACONIL 2787 one hour before inoculation developed callus tissue and began to heal by 10 August and cankers were significantly smaller than those that developed around the INOCULATED WATER CHECK. Applying PRISTINE WG 14 days after inoculation resulted in significantly smaller cankers than those that formed around the INOCULATED WATER CHECK.

CONCLUSIONS: Applying PRISTINE WG or DACONIL 2787 on the same day of wounding and inoculation eliminated coral spot canker establishment and development. Applying PRISTINE WG 14 days after wounds were inoculated with *N. cinnabarina* significantly reduced canker size and growth compared to the INOCULATED WATER CHECK but did not eliminate cankers. Cankers in wounds treated with DACONIL 2787 14 days after inoculation were consistently smaller than those in the INOCULATED WATER CHECK but not significantly different in Tukey's HSD at P=0.05. Cankers did not develop around wounds when treated with water 14 days before inoculation, indicating that the trees were capable of healing wounds during the 14 days before exposure to the pathogen.

Table 1. The area of wounds and cankers that developed around wounds treated with a fungicide 14 days post, one hour pre- and 14 days pre-inoculation with *N. cinnabarina*, compared to wounds treated with water 14 days post, one hour pre- and 14 days pre-inoculation with *N. cinnabarina* and non-inoculated wounds.

Application Timing	Treatment	Area of canker or healing wound (mm)				AUDPC[1]
		07/13/2011	08/10/2011	09/08/2011	10/13/2011	
14 Days Pre-Inoculation	INOCULATED WATER CHECK	234.49 a[2]	311.43 bc	42.90 c	42.80 c	13969 c
	PRISTINE WG	196.57 a	52.79 c	42.30 c	40.20 c	12664 c
	DACONIL 2787	215.82 a	60.13 c	48.50 c	46.00 c	13825 c
	NON-INOCULATED WATER CHECK	201.98 a	149.29 c	50.40 c	47.50 c	13433 c
One Hour Pre-Inoculation	INOCULATED WATER CHECK	358.03 a	643.93 a	913.30 ab	977.00 ab	87627 ab
	PRISTINE WG	210.35 a	155.10 c	66.00 c	65.50 c	14991 c
	DACONIL 2787	227.02 a	121.41 c	95.10 c	108.20 c	18123 c
	NON-INOCULATED WATER CHECK	201.30 a	265.33 c	159.40 c	147.90 c	21760 c
14 Days Post-Inoculation	INOCULATED WATER CHECK	445.73 a	800.42 a	1055.20 a	1250.40 a	104104 a
	PRISTINE WG	361.28 a	582.29 ab	591.50 b	623.80 b	61966 b
	DACONIL 2787	362.30 a	572.27 ab	680.80 ab	807.80 ab	70672 ab
	NON-INOCULATED WATER CHECK	214.49 a	281.04 c	119.50 c	123.40 c	19355 c

1. Area Under the Disease Progress Curve.
2. In each column, numbers followed by the same letter are not significantly different in Tukey's HSD (P=0.05).