Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

2010 Pest Management Research Report (PMRR) 2010 Growing Season

2010 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2010

Canada

English

2010 PEST MANAGEMENT RESEARCH REPORT

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This is the eleventh 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 26 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 Diane Holmes for editorial and computer compilation services.

Suggestions for improving this publication are always welcome.

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Procedures for the 2011 Annual PMR Report will be sent in fall, 2011. 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 2009 has been assigned a Volume number for the ninth 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 49.

An individual report will be cited as follows:
Author(s). 2010. Title. 2010 Pest Management Research Report - 2010 Growing Season. Agriculture and AgriFood Canada. March 2011. Report No. x. Vol. 49: pp-pp.

Français

Rapport de recherches sur la lutte dirigée - 2010

Préparé par: Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada
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mars 2010 volume 49[1]. 83 pp. 26 reports.
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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 26 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 Diane Holmes 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.

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Des procédures pour le rapport annuel de 2011 PMR seront introduites à l'automne 2011. 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. 2010. Titre. 2010 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. mars, 2011. Rapport n^{o} x. vol. 49: pp-pp.1

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2010 PMR REPORT # 01 **SECTION A: FRUIT-Insect Pests**

CROP: Apple, *Malus domestica* L.
PEST: Codling moth, *Cydia pomonella* L.

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TITLE: CODLING MOTH INSECTICIDE-RESISTANCE MONITORING IN ONTARIO APPLE ORCHARDS

MATERIALS: GUTHION 50 WSB (azinphos-methyl 50%), CALYPSO 480 SC (thiacloprid 48%)

METHODS: During the June 2010 codling moth (CM) flight, 1 conventionally managed apple orchard in Essex County and 4 in Norfolk County, Ontario, were selected for the collection of male CM adults. Orchards were selected based on adult CM trap catch data and damage reports from the previous 2 seasons within each region. One minimal spray orchard (<2 sprays/yr for 3+ yrs) was also surveyed from each region to provide assumed baseline insecticide susceptibility. In each orchard, 30 pheromone-baited sticky traps were installed when monitoring traps indicated peak flight. Sticky liners were removed daily over a 2-3 week period and taken to the Insecticide Toxicology laboratory, AAFC London for direct contact bioassays. Adult male CM caught on collected sticky liners were exposed to a diagnostic dose (DD) treatment with 1µl dose of acetone (control), the active ingredient of organophosphorus insecticide, GUTHION 50 WSB (azinphos-methyl) at 250 ppm in acetone or the active ingredient of neonicotinoid insecticide, CALYPSO 480 SC (thiacloprid) at 625 ppm in acetone. Using a micropipette, the dose was applied directly on the thorax of each CM selected at random. The DD was determined with dose-response data from 48 h direct contact bioassays with an insecticide-susceptible CM strain from AAFC London exposed to a range of up to 3 concentrations per compound. The concentration for each compound that caused >95% but <100% mortality was designated as the DD. Direct contact bioassays were conducted daily until each treatment tested 30-50 moths/orchard minimum. Treated moths were kept under controlled conditions (25ºC, 50% RH, 16:8 L:D) for 48 h. Mortality was assessed after 24 and 48 h. Moths were considered dead if they did not respond to probing with a fine paintbrush. During the August 2010 CM flight period, direct contact bioassays with male CM were repeated as previously described in 1 Essex County orchard and 3 Norfolk County orchards. All mortality was corrected using Abbotts formula and analyzed in SAS using ANOVA General Linear Model with Tukey's test at p= 0.05 level of significance.

During the August 2010 CM flight, adult male azinphosmethyl dose-response curves were generated for 1 conventionally managed apple orchards in Essex County and 2 in Norfolk County. Orchards were selected based on high adult trap catch numbers and evidence of strain tolerance in previous collection years. A dose-response curve was also generated for a minimal spray orchard (<2 sprays/yr, 3+ yrs) in Norfolk County as a source of assumed insecticide susceptibility. Adult male CM were collected using pheromone traps, as described earlier and exposed to a range of 3-5 concentrations of azinphosmethyl. Treated moths were kept under controlled conditions (25±1ºC, 40-50% RH, 16:8 L:D) for 48 h. Mortality was assessed after 24 and 48 h. Moths were considered dead if they did not respond to

probing with a fine paintbrush. Corrected mortality from azinphosmethyl dose-response tests were submitted to probit analysis to estimate the LC50 values. Resistance ratios (RR) were determined by dividing the LC50 of the field strain by the LC50 of the susceptible strain. Strains were classified as susceptible (RR<1), strain tolerant (1<RR<10) or resistant (RR > 10).

RESULTS: As outlined in Tables 1 and 2.

CONCLUSIONS: Minimal spray orchard CM strains were highly susceptible to azinphosmethyl and thiacloprid with mortality between 83 and 95% (Table 1). In both June and August 2010, adult male CM from Essex County treated with azinphosmethyl DD had significantly lower mortality within 48 h than insecticide susceptible strain (Table 1, $P<0.05$). Percent mortality of adult male CM from Norfolk County treated with azinphosmethyl tended to vary among field strains (Table 1). However, percent mortality of 3 of 4 managed orchard CM strains was significantly lower than the insecticide susceptible strain during both collection periods ($p<0.05$). Adult male CM from Essex County treated with thiacloprid had significantly lower mortality than insecticide susceptible strain during both collection periods (Table 1, $P<0.05$). Percent mortality of adult male CM from Norfolk County was only significantly lower than insecticide susceptible strain in Strain 1 (Table 1, $p<0.05$).

Dose-response curves generated from adult male CM from Essex and Norfolk County had approximately a 5-fold difference from the insecticide susceptible strain (Table 2). Based on the RR values, there is the potential for strain-tolerance development to azinphosmethyl to become established in Ontario. With continued and frequent use of organophosphorus insecticide products, chance of insecticide resistance development is increased in collected strain-tolerant CM populations.

Based on these surveys, there is potential for strain-tolerance development in currently registered organophorphorus and neonicotinoid insecticides. Further studies will continue to investigate, using larvae diet bioassays, the current state of insecticide susceptibility in ON CM populations to registered insecticides: Altacor (chlorantraniliprole), Delegate (spinetoram) and insect growth regulators, Intrepid (methoxyfenozide) and Rimon (novaluron). Studies have also been conducted with Quebec and Michigan CM strains with similar findings to the current study.

ACKNOWLEDGEMENTS: Funding was provided by NSERC IPS to K Grigg sponsored by the Ontario Apple Growers. Partial funding was also provided by Ontario Apple Growers to I Scott. We greatly appreciate the technical support from OMAFRA (P. Clendinning, P. LaBute and D. O'Sullivan) and AAFC (S. Broad, L. Chambers, E. Knight and K. Schieck) and gratefully acknowledge the apple growers in Essex and Norfolk Counties for allowing the use of their orchards.

Table 1. 48 h corrected percent mortality for June and August 2010 codling moth from Essex and Norfolk Counties.

Orchard	Azinphos-methyl				Thiacloprid			
	June		August		June		August	
	N	% mort.	N	% mort.	N	% mort.	N	% mort.
Essex MS[1]	77	83 a[2]	36	92 a	64	84 a	41	86 a
Essex 1	165	56 b	76	52 b	178	28 b	68	45 b
Norfolk MS[3]	66	95 A	50	93 A	27	90 A	45	90 A
Norfolk 1	84	37 B	39	45 B	68	20 B	31	43 B
Norfolk 2	88	53 B	17	41 B	88	41 AB	0	NA[4]
Norfolk 3	33	27 B	10	25 B	34	68 AB	0	NA
Norfolk 4	30	78 AB	0	NA	19	53 AB	0	NA

[1]Essex County minimal spray orchard (<2 insecticide sprays/yr, 3+ yrs), source of assumed insecticide-susceptible strain.
[2]Numbers in a column followed by the same letter are not significantly different at p= 0.05.
[3]Norfolk County minimal spray orchard (<2 insecticide sprays/yr, 3+ yrs), source of assumed insecticide-susceptible strain.
[4]No moths were collected at this orchard for this treatment.

Table 2. LC_{50} and resistance ratio (RR) of adult male codling moth strains from Essex and Norfolk County, ON for azinphosmethyl pheromone-trap topical bioassay, August 2010.

Orchard	LC_{50} (ppm)	RR[1]
Minimal Spray[2]	45.5	---
Essex 1	219	4.8
Norfolk 1	204	4.5
Norfolk 2	216	4.7

[1] Resistance ratio = ($LC_{50,field}/LC_{50,susceptible}$), minimal spray orchard used as assumed insecticide-susceptible strain
[2] Minimal spray orchard (<2 insecticide sprays/yr for 3+ yrs) source of assumed insecticide-susceptible strain

2010 PMR REPORT # 02 **SECTION A: FRUIT-Insect Pests**

CROP: Apple (*Malus domestica* L.) cv. Empire
PEST: Japanese beetle (*Popillia japonica* Newman)

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TITLE: ASSESSMENT OF CALYPSO (THIACLOPRID) FOR CONTROL OF JAPANESE BEETLE ON 'EMPIRE' APPLES, 2010.

MATERIALS: CALYPSO 480 SC (thiacloprid), IMIDAN 50 WP (phosmet).

METHODS: The trial was conducted in 2010 in an eleven-year-old 'Empire' apple orchard on the Agriculture and Agri-Food Canada research farm in Jordan Station, Ontario. Trees were spaced 4.6 m apart between rows and 2.4 m apart within rows. Two rates of CALYPSO 480 SC (70 g a.i./ha and 140 g a.i./ha) were compared to a single rate of IMIDAN 50 WP (1875 g a.i./ha) and an unsprayed control. Each treatment was replicated four times; each replicate had a single tree. The trial was arranged according to a randomized complete block design. The insecticide application occurred on 16 July (timed for an elevated population of adult Japanese beetles (JB)). The insecticides were applied in 3000 L of water per hectare with a SOLO backpack sprayer and applied to run-off. Assessments for JB populations occurred 19 July, 21 July, 26 July and 29 July (3, 5, 10 and 13 days after the application, respectively) by counting and recording the number of live JB found per treatment per replicate. Numbers of dead JB per treatment per replicate were counted and recorded on 19 July and 21 July (3 and 5 days after the application, respectively); the dead adult JB were removed from the treatments after each assessment. Data were analyzed using analysis of variance and means separated with a Tukey Test at P=0.05 significance level with ARM statistical software. The live and dead count variances of adult JB of 19 July and 21 July were not homogeneous and therefore were transformed using log(x+1). No phytotoxic effects were observed in any of the treatments at any time during the trial.

RESULTS: Data are presented in Table 1. The development of excessive ground cover under the tree canopy made location of dead Japanese beetle (JB) adults extremely difficult after 21 July, therefore counts for dead JB were no longer continued.

CONCLUSIONS: On 19 July, 21 July, 26 July and 29 July, all treatments significantly reduced the number of live Japanese beetle (JB) adults as compared to the control; there were no differences among or between the insecticide treatments. On 19 July, only the IMIDAN treatment had significantly more dead JB adults as compared to the control; although there were more dead JB adults found in both of the CALYPSO treatments than the control, there were no significant differences among or between the insecticide treatments. On 21 July, only the IMIDAN treatment had significantly more dead JB adults as compared to the control; there were no significant differences among or between the high rate of CALYPSO (140 g a.i./ha) and the IMIDAN treatment (Table1).

Table 1. Effect of thiacloprid (CALYPSO 480 SC) on adult Japanese beetle (JB) populations on 'Empire' apples.

		Number of JB found on 'Empire' apples					
		19 July (3 days)[2]		21 July (5 days)		26 July (10 days)	29 July (13 days)
Treatment[1]	Rate (g a.i. /ha)	live JB	dead JB	live JB	dead JB	live JB	live JB
CALYPSO 480 SC	70	2.8 b[3]	7.0 ab	4.5 b	3.8 b	5.5 b	5.3 b
CALYPSO 480 SC	140	3.0 b	12.3 ab	4.0 b	9.8 ab	7.8 b	3.3 b
IMIDAN 50 WP	1875	1.3 b	47.3 a	4.5 b	24.8 a	7.8 b	9.0 b
CONTROL	-	27.5 a	3.0 b	50.3 a	3.0 b	19.5 a	41.0 a

[1] Applied 16 July.
[2] Number of days after application (16 July).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey Test.

2010 PMR REPORT # 03 **SECTION A: FRUIT-Insect Pests**

CROP: Sweet Cherry (*Prunus avium* L.) cv. Vandalay
PEST: Japanese beetle (*Popillia japonica* Newman)

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TITLE: ASSESSMENT OF CALYPSO (THIACLOPRID) FOR CONTROL OF JAPANESE BEETLE ON 'VANDALAY' CHERRIES, 2010.

MATERIALS: CALYPSO 480 SC (thiacloprid), IMIDAN 50 WP (phosmet).

METHODS: The trial was conducted in 2010 in a four-year-old 'Vandalay' cherry orchard on the Agriculture and Agri-Food Canada research farm in Jordan Station, Ontario. Trees were spaced 5.5 m apart between rows and 5.5 m apart within rows. Two rates of CALYPSO 480 SC (70 g a.i./ha and 140 g a.i./ha) were compared to a single rate of IMIDAN 50 WP (1875 g a.i./ha), and an unsprayed control. Each treatment was replicated four times; each replicate had two trees. The trial was arranged according to a randomized complete block design. The insecticide application occurred on 8 July (timed for an elevated population of adult Japanese beetles (JB)). The insecticides were applied in 3000 L of water per hectare with a SOLO backpack sprayer and applied to run-off. Assessments for adult JB populations occurred 9 July, 12 July, 14 July, 19 July and 26 July (1, 4, 6, 11 and 18 days after the application, respectively) by counting and recording the number of live adult JB found per replicate per treatment. On 12 July, 14 July, 19 July, and 26 July (4, 6, 11 and 18 days after the application, respectively), the ground below the canopy of each tree was examined for dead adult JB; after the numbers of dead adult JB were counted and recorded per replicate per treatment, the dead adult JB were removed from each treatment. On 26 July, an assessment to determine the amount of feeding damage caused by adult JB was taken by visually estimating and recording the percentage of foliage per treatment per replicate that had been skeletonized by the adult JB. Data were analyzed using analysis of variance and means separated with a Tukey Test at P=0.05 significance level with ARM statistical software. The count variances of live adult Japanese beetles (JB) of 9 July, 12 July and 26 July and the count variances of dead adult JB of 12 July and 14 July were not homogeneous and were therefore transformed using log(x+1).

RESULTS: Data are presented in Table 1. No phytotoxic effects were observed in any of the treatments at any time during the trial.

CONCLUSIONS: On 9 July, all treatments significantly reduced the number of live Japanese beetle (JB) adults as compared to the control; the high rate of CALYPSO (140 g a.i./ha) and the IMIDAN treatments had significantly fewer live JB adults than the low rate of CALYPSO (70 g a.i./ha). On 12 July, only the IMIDAN and high rate of CALYPSO treatments significantly reduced the number of live JB adults as compared to the control; the IMIDAN treatment had significantly fewer live adult JB than the low rate of CALYPSO treatment. On 14 July, all treatments significantly reduced the number of live adult JB as compared to the control; there were no significant differences among or between the insecticide treatments. On 19 July, only the IMIDAN and high rate of CALYPSO treatments significantly reduced the number of live JB adults as compared to the control; there were no significant differences among or between the insecticide treatments. On 26 July, there were no significant differences in the number of live JB adults among or between the treatments and the control. On 12 July, all treatments had

significantly more dead JB adults than the control; there were no significant differences among or between the insecticide treatments. On 14 July, only the high rate of CALYPSO had significantly more dead JB adults than the control; there were no significant differences among or between the insecticide treatments. On 19 July and 26 July, there were no significant differences in the number of dead JB adults among or between the insecticide treatments and the control (Table1). On 26 July, all insecticide treatments had significantly less feeding damage caused by JB adults than the control; there were no significant differences among or between the insecticide treatments (Table2).

Table 1. Effect of thiacloprid (CALYPSO 480 SC) on adult Japanese beetle (JB) populations on 'Vandalay' cherries.

		Total number of JB found								
		9 July (1 day)[2]	12 July (4 days)		14 July (6 days)		19 July (11 days)		26 July (18 days)	
Treatment[1]	Rate (g a.i. /ha)	live JB	live JB	dead JB	live JB	dead JB	live JB	dead JB	live JB	dead JB
CALYPSO 480 SC	70	2.8 b[3]	63.5 ab	49.3 b	49.5 b	11.5 ab	199.3 ab	28.5 a	14.3 a	0.8 a
CALYPSO 480 SC	140	0.3 c	18.5 bc	57.5 b	18.5 b	27.8 b	111.0 b	41.8 a	30.0 a	0.3 a
IMIDAN 50 WP	1875	0.0 c	14.8 c	35.8 b	19.3 b	16.8 ab	60.3 b	36.3 a	17.8 a	0.3 a
CONTROL	-	46.0 a	169.0 a	6.5 a	115.8 a	2.8 a	300.3 a	7.0 a	13.8 a	0.0 a

[1] Applied 8 July.
[2] Number of days after application (8 July).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey Test.

Table 2. Effect of thiacloprid (CALYPSO 480 SC) on leaf damage caused by adult Japanese beetle feeding on 'Vandalay' cherries.

		total leaf damage (%)
Treatment[1]	Rate (g a.i./ha)	26 July (18 days)[2]
CALYPSO 480 SC	70	22.2 b
CALYPSO 480 SC	140	14.5 b
IMIDAN 50 WP	1875	14.5 b
CONTROL	-	43.4 a

[1] Applied 8 July.
[2] Number of days after application (8 July).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey Test.

2010 PMR REPORT # 04 **SECTION A: FRUIT-Insect Pests**

CROP: Grape (*Vitis vinifera* L.) cv. Baco Noir
PEST: Grape Berry Moth (*Endopiza viteana* Clemens)

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TITLE: ASSESSMENT OF SPINETORAM (DELEGATE WG) FOR CONTROL OF SECOND GENERATION GRAPE BERRY MOTH ON 'BACO NOIR' GRAPES, 2010.

MATERIALS: ALTACOR WG (RYNAXYPYR), DELEGATE WG (SPINETORAM), INTREPID 240 SC (METHOXYFENOZIDE).

METHODS: The trial was conducted in 2010 in a mature 'Baco Noir' vineyard in Niagara-on-the-Lake, Ontario. Grapevines were spaced 3.0 m apart between rows and vines were 1.5 m apart within rows. Two rates of DELEGATE WG (70 g a.i./ha and 105 g a.i./ha) were compared to two rates of INTREPID 240 SC (144 g a.i./ha and 240 g a.i./ha), a single rate of ALTACOR WG (75.25 g a.i./ha) and an untreated control. Each treatment was replicated four times and each replicate had four or five vines. The trial was arranged according to a randomized complete block design. Prior to the first application of insecticides, all grape bunches with first generation grape berry moth (GBM) damage were removed from all of the vines in the trial. The first application occurred on 23 June (timed for first egg hatch of second generation GBM) and the second application occurred on 5 July (12 days later). The insecticides were applied in 1000 L of water per hectare with a SOLO backpack sprayer. GBM damage was assessed by examining 50 random bunches of immature grape bunches per treatment per replicate on 28 June and 2 July (5 and 9 days after the first application of 23 June, respectively) and 9 July, 12 July, 16 July and 22 July (4, 7, 11 and 17 days, respectively, after the second application of 5 July); the percentage of bunches with GBM damage per treatment per replicate were recorded for each assessment date. Data were analyzed using analysis of variance and means were separated with a Tukey Test at P=0.05 significance level with ARM statistical software. The GBM count variances of 22 July were not homogeneous and were therefore transformed using an arcsine square root (%) transformation.

RESULTS: Data are presented in Table 1. No phytotoxic effects were observed in any of the treatments at any time during the trial. The vineyard in which this trial was conducted has had a previous history of high GBM pressure.

CONCLUSIONS: On 28 June, 2 July and 9 July, there were no significant differences in the percentage of grape bunches infested with grape berry moth (GBM) between and among the insecticide treatments and the untreated control. On 12 July, 16 July and 22 July, all insecticide treatments significantly reduced the percentage of grape bunches infested with GBM compared to the untreated control; there were no significant differences between and among the insecticide treatments (Table 1).

Table 1. Effect of spinetoram (DELEGATE WG) on second generation grape berry moth (GBM) infestation of 'Baco Noir' grapes .

Treatment[1]	Rate (g a.i. /ha)	Percent GBM infested grape bunches					
		28 June (5 days)[2]	2 July (9 days)[2]	9 July (4 days)[3]	12 July (7 days)[3]	16 July (11 days)[3]	22 July (17 days)[3]
DELEGATE WG	70	4.5 a[4]	3.5 a	3.0 a	3.5 b	4.0 b	3.5 b
DELEGATE WG	105	4.0 a	3.5 a	4.5 a	3.0 b	3.0 b	4.5 b
INTREPID 240 SC	144	4.0 a	5.0 a	4.0 a	5.0 b	4.0 b	7.0 b
INTREPID 240 SC	240	2.0 a	2.5 a	2.5 a	2.0 b	5.5 b	6.5 b
ALTACOR WG	75.25	4.0 a	6.5 a	1.5 a	4.0 b	3.0 b	8.0 b
CONTROL	-	6.0 a	6.0 a	6.0 a	12.5 a	12.0 a	22.0 a

[1] Applied 23 June and 5 July.
[2] Number of days after first application (23 June).
[3] Number of days after second application (5 July).
[4] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey Test.

2010 PMR REPORT # 05 **SECTION A: FRUIT-Insect Pests**

CROP: Grape (*Vitis vinifera* L.) cv. Baco Noir
PEST: Grape Berry Moth (*Endopiza viteana* Clemens)

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TITLE: ASSESSMENT OF SPINETORAM (DELEGATE WG) FOR CONTROL OF THIRD GENERATION GRAPE BERRY MOTH ON 'BACO NOIR' GRAPES, 2010.

MATERIALS: ALTACOR WG (RYNAXPYR), DELEGATE WG (SPINETORAM), INTREPID 240 SC (METHOXYFENOZIDE).

METHODS: The trial was conducted in 2010 in a mature 'Baco Noir' vineyard in Niagara-on-the-Lake, Ontario. Grapevines were spaced 3.0 m apart between rows and vines were 1.5 m apart within rows. Two rates of DELEGATE WG (70 g a.i./ha and 105 g a.i./ha) were compared to two rates of INTREPID 240 SC (144 g a.i./ha and 240 g a.i./ha), a single rate of ALTACOR WG (75.25 g a.i./ha) and an untreated control. Each treatment was replicated four times and each replicate had four or five vines. The trial was arranged according to a randomized complete block design. Prior to the first application of insecticides, attempts were made to remove all grape bunches infested with second generation grape berry moth (GBM) from all of the vines in the trial. The first application occurred on 5 August (timed for first egg hatch of third generation GBM) and the second application occurred on 16 August (11 days later). The insecticides were applied in 1000 L of water per hectare with a SOLO backpack sprayer. Infestation of grape bunches by GBM was assessed by examining 50 random bunches of grapes per treatment per replicate on 9 August and 13 August (4 and 8 days after the first application of 5 August), 20 August, 25 August and 31 August (4, 9 and 15 days, respectively, after the second application of 16 August); the number of bunches infested with GBM per treatment per replicate were recorded for each assessment date. Data were analyzed using analysis of variance and means were separated with a Tukey Test at P=0.05 significance level with ARM statistical software. The GBM count variances of 9 August and 13 August were not homogeneous and were therefore transformed using a log (x+1) transformation.

RESULTS: Data are presented in Table 1. The growing season was unusually advanced in 2010 causing very early maturation of the grapes, therefore the berries were large, and the bunches were very tight and already coloring at the time of the first application for third generation grape berry moth (GBM) control. This early season may have resulted in overlapping generations of GBM, as well as some second generation damage may not have been visible at the time of the removal of grapes prior to the first application. Also, the assessments for third generation GBM damage were confounded by lots of missing berries due to birds, early maturation (coloring) of the berries, and some mildew in the bunches. No phytotoxic effects were observed in any of the treatments at any time during the trial. The vineyard in which this trial was conducted has had a previous history of high GBM pressure.

CONCLUSIONS: On 9 August, only the DELEGATE treatments had significantly fewer GBM infested bunches than the control; there were no significant differences between and among the treatments. On 13 August, the DELEGATE treatments, the high rate of INTREPID (240 g ai/ha) and the ALTACOR treatment had significantly fewer GBM infested bunches than the untreated control. On 20 August, the high rate of DELEGATE (105 g ai/ha) and the high rate of INTREPID had significantly fewer GBM infested bunches than the untreated control; there were no significant differences between and among the treatments. On 25 August, both DELEGATE treatments, the high rate of INTREPID and the ALTACOR treatment had significantly fewer GBM infested bunches than the untreated control; there were no significant differences between and among the treatments. On 31 August, only the DELEGATE treatments had significantly fewer GBM infested bunches than the untreated control; there were no significant differences between and among the insecticide treatments. On all assessment dates, the high rate of DELEGATE had significantly fewer grape bunches infested with GBM as compared to the untreated control (Table 1).

Table 1. Effect of spinetoram (DELEGATE WG) on third generation grape berry moth (GBM) on 'Baco noir' grapes.

		Percent GBM infested grape bunches				
Treatment[1]	Rate (g a.i. /ha)	9 August (4 days)[2]	13 August (8 days)[2]	20 August (4 days)[3]	25 August (9 days)[3]	31 August (15 days)[3]
DELEGATE WG	70	6.5 b[4]	7.0 c	14.0 ab	13.5 b	29.5 b
DELEGATE WG	105	4.0 b	5.0 c	10.0 b	11.5 b	26.5 b
INTREPID 240 SC	144	20.5 ab	19.5 ab	17.0 ab	20.0 ab	44.5 ab
INTREPID 240 SC	240	9.0 ab	11.0 bc	10.5 b	17.5 b	39.0 ab
ALTACOR WG	75.25	9.0 ab	6.5 c	13.0 ab	17.5 b	32.5 ab
CONTROL	-	31.0 a	32.0 a	27.5 a	31.5 a	53.0 a

[1] Applied 5 August and 16 August.
[2] Number of days after first application (5 August).
[3] Number of days after second application (16 August).
[4] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey Test.

2010 PMR REPORT # 06 **SECTION B: VEGETABLE and SPECIAL CROPS**

CROP: Table Beet (*Beta vulgaris* L.*)* cv. Red Ace
PEST: Beet Leafminer (*Liriomyza spp.)*

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TITLE: FIELD EVALUATION OF INSECTICIDES FOR CONTROL OF BEET LEAFMINER

MATERIALS: DELEGATE WG (SPINETORAM 25%), MOVENTO 240 SC (SPIROTETRAMAT 240 g/L), ASSAIL 70 WP (ACETAMIPRID 70%), CITATION 75 WP (CYROMAZINE 75%).

METHODS: The trial was conducted in 2010 on an established crop of beets cv. 'Red Ace' in Abbotsford (Sumas Prairie), British Columbia with a pre-existing, natural infestation of leafminer. The trial was a randomized complete block (RCB) design with 4 replicates per treatment. Each plot consisted of 4 rows, 3.4 m long on a 1.9 m wide bed (centre to centre) for a total area of 6.5 m^2 per plot. Products were applied at 40 psi (276 kPa) as directed foliar sprays using a CO_2 backpack sprayer equipped with a Teejet 8002VS triple nozzle boom in 1000 L water per ha (650 mL of solution per plot). DELEGATE and MOVENTO were applied with AGRAL 90 surfactant at 2 mL/L; check plots were sprayed with water alone. Treatments were applied 5 times on a 5-8 day schedule: August 5, 12, 20, 26 (followed by heavy rain), and 30. The number of eggs, visible larvae, and individual mines were counted on all leaves in 1 m of the second row in each plot, prior to each application and at 3 and 8 days after the last application. The crop was seeded; fertilized and irrigated by the grower as per commercial practice and no other pest control products were applied. Statistical analysis (ANOVA) was performed using CoStat, Version 6.303 CoHort Software, Monterey, California, USA, © 1998-2004 and means were compared using LSD, Duncan's Multiple Range Test (MRT) or Tukey's HSD at P=0.05.

RESULTS: As outlined in Tables 1 to 4. No phytotoxicity was observed in any treatment. Leafminers were identified as a *Lyriomyza* species by rearing to pupal stage, but, because no adults emerged, the species could not be identified. It is possible that one or more *Lyriomyza* species may be involved, throughout the growing season.

CONCLUSIONS: The number of leafminer larvae was significantly less than the check in the ASSAIL 70WP and DELEGATE + AGRAL 90 treatments by one week after the second application (Aug.18), and the number of leaf mines was significantly less in Weeks 3, 4 and 5, up to 8 days after the last application (August 25, Sept. 2 and Sept.7; significantly different in Duncan's MRT and Tukey's HSD, P=0.05). There was no statistically significant difference between these two products. Application of CITATION 75WP or MOVENTO 240SC + AGRAL 90 reduced larvae and mines somewhat, but gave no significant control of damage in this trial. Although based on the number of eggs laid, ASSAIL 70WP seemed to significantly attract or stimulate oviposition (Table 1, Duncan's MRT at P=0.05), fewer leaf mines were recorded in plots treated with ASSAIL than in the other treatments (Tables 3 and 4).

Table 1. Impact of foliar insecticides on mean number of leafminer eggs per plot.[1]

TREATMENT	RATE (/ha)	Aug 4[2] (Pre-Trt)	Aug 11[3]	Aug 18[3]	Aug 25[2]	Sept 2[2]	Sept 7[2]
CHECK	-	14.2 a	18.8 b	47.2 b	55.2 ab	33.8 b	98.5 ab
DELEGATE WG + Agral 90	220g + 0.2% v/v	10.8 a	19.9 b	49.2 b	53.5 ab	28.0 b	95.5 ab
MOVENTO 240SC + Agral 90	365mL + 0.2% v/v	19.8 a	28.8 b	40.0 b	35.0 b	32.2 b	73.2 b
ASSAIL 70WP	86g	19.5 a	60.5 a	83.8 a	87.2 a	83.0 a	140.8 a
CITATION 75WP	188g	14.2 a	42.8 ab	60.8 ab	52.0 ab	51.2 ab	91.5 ab

[1]Mean of 4 replicates per treatment, RCB design; counted on 1 m of 1 central row per plot.
[2]Numbers in the same column followed by the same letter are not significantly different in Duncan's MRT at P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.

Table 2. Impact of foliar insecticides on mean number of leafminer larvae per plot.[1]

TREATMENT	RATE (/ha)	Aug 4[2] (Pre-Trt)	Aug 11[2]	Aug 18[2]	Aug 25[3]	Sept 2[4]	Sept 7[4]
CHECK	-	1.2 a	1.2 ab	1.2 a	6.8 a	4.8 a	6.8 a
DELEGATE WG + Agral 90	220g + 0.2% v/v	1.0 a	0.0 b	0.0 b	0.2 b	0.0 b	0.0 b
MOVENTO 240SC + Agral 90	365mL + 0.2% v/v	2.5 a	2.2 a	0.8 ab	1.0 b	3.0 ab	0.8 b
ASSAIL 70WP	86g	1.2 a	1.0 ab	0.0 b	0.0 b	0.0 b	0.0 b
CITATION 75WP	188g	1.8 a	1.0 ab	0.0 b	0.2 b	0.0 b	0.0 b

[1]Mean of 4 replicates per treatment; RCB design; counted on 1 m of 1 central row per plot.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD at P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Duncan's MRT at P=0.05.
[4]Numbers in the same column followed by the same letter are not significantly different in Tukey's HDS at P=0.05.

Table 3. Impact of foliar insecticides on mean number of leaf mines per plot.[1]

TREATMENT	RATE (/ha)	Aug 4[2] (Pre-Trt)	Aug 11[2]	Aug 18[2]	Aug 25[3]	Sept 2[4]	Sept 7[4]
CHECK	-	5.8 ab	3.0 a	6.0 a	13.0 a	12.8 a	16.8 a
DELEGATE WG + Agral 90	220g + 0.2% v/v	2.2 b	1.5 a	5.8 a	4.5 b	3.2 bc	2.0 bc
MOVENTO 240SC + Agral 90	365mL + 0.2% v/v	3.2 b	8.8 a	8.5 a	6.5 ab	12.0 a	4.8 bc
ASSAIL 70WP	86g	8.0 a	7.8 a	3.0 a	3.8 b	1.2 c	0.5 c
CITATION 75WP	188g	7.8 a	9.8 a	10.5 a	12.0 a	9.5 ab	8.8 b

[1]Mean of 4 replicates per treatment; RCB design; counted on 1 m of 1 central row per plot.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD at P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Duncan's MRT at P=0.05.
[4]Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.

Table 4. Impact of foliar insecticides on Damage Index (% of leaf mines as a proportion of eggs laid).[1]

TREATMENT	RATE (/ha)	Aug 4[2] (Pre-Trt)	Aug 11[2]	Aug 18[2]	Aug 25[2]	Sept 2[3]	Sept 7[3]
CHECK	-	39.8 a	17.6 a	12.1 ab	24.0 a	37.8 ab	16.6 a
DELEGATE WG + Agral 90	220g + 0.2% v/v	22.8 a	11.2 a	10.1 ab	13.5 ab	14.4 c	1.7 bc
MOVENTO 240SC + Agral 90	365mL + 0.2% v/v	13.6 a	29.1 a	23.6 a	20.2 a	40.1 a	6.8 bc
ASSAIL 70WP	86g	112.4 a	12.9 a	3.8 b	6.4 b	2.8 c	0.6 c
CITATION 75WP	188g	63.8 a	20.3 a	16.4 ab	21.7 a	20.0 bc	10.1 ab

[1]Damage Index (%) defined as # of mines / total # of eggs x 100, counted on 1 m of 1 central row of plants per plot; RCB design, 4 replicates.
[2]Numbers in the same column followed by the same letter are not significantly different in Duncan's MRT at P=0.05.
[3]Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.

2010 PMR REPORT # 07 **SECTION B: VEGETABLE and SPECIAL CROPS**

CROP: Cabbage (*Brassica oleracea capitata album*), cv. Constellation
PEST: Cabbage root maggot (CRM), *Delia radicum* (Linnaeus)
Imported cabbageworm (ICW), *Pieris rapae* (Linnaeus)

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TITLE: PLANTING AND EARLY SEASON TREATMENTS FOR CONTROL OF INSECT DAMAGE TO CABBAGE ON MINERAL SOIL, 2010

MATERIALS: BRIGADE 2 EC (bifenthrin 25.1% [w/w]), PYRINEX 480 EC (chlorpyrifos 44.7% [w/w]), LORSBAN 4 E (chlorpyrifos 44.9% [w/w]), DPX-HGW86 200 SC (cyantraniliprole 20.0% [w/w]), DIPEL 2X DF (*Bacillus thuringiensis* var. *kurstaki* 23.7% [w/w])

OBSERVATIONS: The tested rate of PPTD-application of chlorpyrifos (Tmt. 4) was extremely phytotoxic to transplanted cabbage seedlings resulting in reduced plant stand and stunting of surviving plants. After a lag period, cabbage plants that did survive the shock of Tmt. 4 did appear to grow normally although heading was delayed. By harvest, 132 days after transplanting, while mean wt/head of cabbage harvested from plots receiving PPTD-application of chlropyrifos (Tmt. 4) was not significantly different from the mean wt/head of cabbage from plots receiving BDR-application of chlorpyrifos (Tmt. 5), the greatly reduced stand would have greatly reduced overall yield.

RESULTS: Impact of planting and early season treatments on CRM-damage to roots of transplanted cabbage is shown in Table 2. Under the conditions of this experiment, there was only light damage to cabbage roots by maggots surviving from eggs deposited by lab-reared CRM adults. Hot dry weather following release likely shortened the oviposition period of released flies and reduced survival of maggots emerging from those eggs that were deposited. Only 2 examined roots suffered more than 10% damage from feeding CRM; no observed damage would have had a significant impact on subsequent cabbage growth. Nevertheless several treatments did significantly increase the % of undamaged roots. PPTD-application of either bifenthrin (Tmt. 3) or cyantraniliprole (Tmt. 6) or BD-application of the commercial standard, chlorpyrifos (Tmt. 5) significantly increased incidence of clean roots for the first assessment while significantly more clean roots were recorded during the 2nd root assessment for all treatments for

which roots were sampled (Table 2). No damage was observed on any sampled roots from plots treated BDR-application of the commercial standard, chlorpyrifos (Tmt. 5).

Impact of planting and early season treatments on ICW-feeding damage and yields of transplanted cabbage is shown in Table 3.

Repeated application of DIPEL 2X DF alone did not effectively control ICW-feeding damage in this trial (Table 3). On 27 July, after 3 applications of the biological insecticide an average of > 10 ICW-feeding holes were recorded in the 5^{th} - 8^{th} youngest leaves in CONTROL plots receiving no early season insecticides (Tmt. 7). On that date ICW-feeding damage was significantly reduced by 68% and 89% in plots treated with either 1 (Tmt. 1) or 2 (Tmt. 2) banded drenches of bifenthrin. No ICW-feeding damage was observed in plots planted with cabbage receiving PPTD-application of cyantraniliprole (Tmt. 6). PPTD application of bifenthrin (Tmt. 3) or either PPTD- (Tmt. 4) or BDR-application of chlorpyrifos (Tmt. 5) did not significantly reduce ICW-feeding damage on that date. Following 2 additional maintenance applications of DIPEL 2X DF, on 18 August, the mean number of ICW-feeding holes exceeded 49 (Table 3) in CONTROL plots receiving only the biological insecticide. On that date only PPTD-application of cyantraniliprole (Tmt. 6) maintained a significant reduction in ICW-feeding damage (Table 3). The number of ICW-feeding holes was reduced by over 90% on that date, 16 days after the last application of DIPEL 2X DF.

Although average cabbage weights/head were higher in plots receiving any planting or early season treatments except PPTD-application of bifenthrin (Tmt. 3), due to field variability, the increase was statistically significant only in plots planted with cabbage receiving PPTD-application of cyantraniliprole (Tmt. 6). Mean head-weights in these plots were >2x higher than weights recorded in CONTROL plots (Table 3). Although the difference was not statistically significant, average head weights tended to be lower in plots planted with cabbage receiving PPTD-application of bifenthrin (Tmt. 3) than in plots receiving either 1 (Tmt. 1) or 2 (Tmt. 2) banded drench applications of the insecticide (Table 3).

CONCLUSIONS: Although CRM-pressure was quite low, under the conditions of this experiment, all tested planting and early season treatments did increase the % of undamaged roots in examined transplant cabbage. Further experiments are thus warranted to determine efficacy under heavier pest pressure.

Systemic uptake of cyantraniliprole following PPTD-application provided excellent early season control of ICW-feeding damage. Additional experiments are warranted to optimize rate of application and verify efficacy against other lepidopterous pests of crucifers.

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Table 1. Planting and early season treatments applied to cabbage for control of cabbage root maggot (CRM) on mineral soil, Delhi, ON 2010.

Tmt. No.	Treatment Applied			Rate /1,000 Plants	
	Insecticide	Formulation	Method[1]	a.i.	Formulation
1	bifenthrin	BRIGADE 2 EC	BDR	112.0 g[2]	470.0 ml[2]
2	bifenthrin	BRIGADE 2 EC	BDR x2	112.0 g[2]	470.0 ml[2]
3	bifenthrin	BRIGADE 2 EC	PPTD	3.6 g	15.1 ml
4	chlorpyrifos	PYRINEX 480 EC	PPTD	32.5 g	67.6 ml
5	chlorpyrifos	LORSBAN 4 E	BDR	100.8 g[3]	210.0 ml[3]
6	cyantraniliprole	DPX-HGW86 200 SC	PPTD	7.5 g	37.5 ml
7	no insecticide	CONTROL	---	---	---

[1] - method of application: BDR - banded drench application post planting; PPTD - drench application to seedlings in plug tray prior to planting
[2] - Rate/ha
[3] - Rate/1,000 m row

Table 2. Impact of planting and early season treatments applied to cabbage for control of cabbage root maggot (CRM) on ratings of cabbage root damage on mineral soil, Delhi, ON, 2010.

	05 July				21 July			
Tmt. No.	% 0[1]	% Change[2]	% 0 + %1[1]	% Change[2]	% 0[1]	% Change[2]	% 0 + %1[1]	% Change[2]
1	81.3 abc[3]	+44.4	93.8 a	+15.4	75.0 b	+28.6	100.0 a	+4.4
2	68.8 bc	+22.2	93.8 a	+15.4	70.9 b	+21.6	95.8 a	0.0
3	93.8 ab	+66.6	93.8 a	+15.4	79.2 ab	+35.8	91.7 a	-4.3
4	***[4]	***	***	***	***	***	***	***
5	100.0 a	+77.6	100.0 a	+23.0	100.0 a	+71.5	100.0 a	+4.4
6	93.8 ab	+66.6	100.0 a	+23.0	75.0 b	+28.6	91.7 a	-4.3
7	56.3 c	---	81.3 a	---	58.3 c	---	95.8 a	---

[1] - Mean % Cabbage Roots with indicated Root Rating (RR) Scale: 0 = no root damage, 1 = less than 10% of the root surface with root maggot feeding channels, 2 = 11-25%, 3 = 26-50%, 4 = 51-75%, and 5 = 76-100% of the taproot surface area damaged (Dosdall *et al.*, 1994).

[2] - Mean % Change in % roots with indicated RR relative to % cabbage roots with indicated RR in CONTROL plots on that date.

[3] - Means within a column followed by the same letter are not significantly different ($P \leq 0.05$) as determined using ANOVA and Least Significant Difference range test.

[4] - No data collected due to severe phytotoxicity and reduced plant stand.

Table 3. Impact of planting and early season treatments applied to cabbage on damage due to imported cabbageworm and on final cabbage yields on mineral soil, Delhi, ON, 2010.

	ICW-Feeding Data for Indicated Date							
	27 July		18 August		Cabbage Harvest Data (Weight/head)			
Tmt. No.	Feeding Holes[1]	% Red'n[2]	Feeding Holes[1]	% Red'n[2]	Total Wt. (g)	% Change[3]	Mkt. Wt. (g)	% Change[3]
1	3.4 bc[4]	67.9	39.4 ab	19.9	927.4 ab	+35.6	843.3 ab	+40.1
2	1.2 cd	89.2	24.4 ab	50.3	1008.3 ab	+47.5	905.2 ab	+50.4
3	7.8 ab	26.7	44.8 a	8.8	550.3 b	-19.5	480.8 b	-20.1
4	7.5 ab	29.7	57.0 a	-16.1	881.7 ab	+28.9	801.1 ab	+33.1
5	12.8 a	-20.8	60.4 a	-23.0	797.3 b	+16.6	712.2 b	+18.3
6	0.0 d	100.0	4.0 b	91.9	1463.3 a	+114.0	1332.2 a	+121.4
7	10.6 a	---	49.1 a	---	683.8 b	---	601.8 b	---

[1] - Mean Total Number ICW-Feeding Holes in 5th - 8th youngest leaves, inclusive.
[2] - Mean % Reduction in total number ICW-Feeding Holes relative to total number ICW-Feeding Holes in 5th - 8th youngest leaves, inclusive, in CONTROL plots on the same date.
[3] - Mean Total or Marketable weight/head of harvested cabbage relative to indicated mean yield data for CONTROL plots.
[4] - Means within a column followed by the same letter are not significantly different ($P \leq 0.05$) as determined using ANOVA and Tukey's HSD range test.

2010 PMR REPORT # 08 **SECTION B: VEGETABLE and SPECIAL CROPS**

CROP: Sweet Corn (*Zea mays*), hybrid Legacy
PEST: European corn borer (ECB), (*Ostrinia nubilalis*)
Western bean cutworm (WBC), (*Striacosta albicosta*)
Corn earworm (CE), (*Helicoverpa zea*)
Fall armyworm (FA), (*Spodoptera frugiperda*)

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TITLE: PRODUCTS FOR MANAGEMENT OF LEPIDOPTERAN PESTS IN SWEET CORN, 2010

MATERIALS: CORAGEN (rynaxypyr 200 g L^{-1}), BELT (flubendiamide 480 g L^{-1}), INTREPID (methoxyfenozide 240 g L^{-1}), RIMON (novaluron 10%), MATADOR 120 EC (cyhalothrin-lambda 120 g L^{-1}), DELEGATE (spinetoram 25%), SEVIN XLR (carbaryl 466 g L^{-1}), HGW86 SE (cyantraniliprole 100 g L^{-1}), ENTRUST (spinosad 80%)

METHODS: Sweet corn was seeded with a Kinze planter on May 26 for Trial 1, and June 15 for Trial 2, at a rate of 5 seeds per meter, at Ridgetown Campus, University of Guelph. In-row spacing was 20 cm and between row spacing was 0.75 m. Each treatment plot consisted of 2 rows, 7 m in length, with one guard row on either side of each plot. The trial was arranged in a randomized complete block design with 4 replications per treatment. Treatments were applied on July 18, 27, and Aug 4 for Trial 1 and July 29 (except RIMON), Aug 2 (RIMON only), Aug 4, 13, and 24 for Trial 2 using a hand-held 1.5 m boom (3 nozzles) before Aug 4, and a 1 m boom (2 nozzles) on and after Aug 4, using a CO_2 sprayer (35 psi) with ULD 120-02 nozzles and water volume of 200 L Ha^{-1}. Treatments on and after Aug 4 were applied by turning the spray boom on its side and spraying the cobs in order to mimic drop nozzles. Trial 1 was at the flag/tassel stage and Trial 2 was at the tassel in the whorl stage when the first treatment was applied. Western bean cutworm (WBC) eggs were placed in both trials on July 26 by pinning one egg mass to the first or second leaf below the tassel on one plant per row. Trial 1 was in full tassel while Trial 2 was not yet in tassel. Twenty-five cobs per plot were harvested on Aug 13 for Trial 1, and on Sept 1 for Trial 2. Feeding damage and the number of larvae was assessed. Statistical analysis was conducted using SAS v.9.1.3 (The SAS Institute, Cary, NC). Analysis of variance was conducted using the MIXED procedure and means comparisons were performed when $P \leq 0.05$ using Tukey's adjustment.

RESULTS: See Table 1 and Table 2. There were less than 5 larvae detected in Trial 1 (*data not shown*).

CONCLUSIONS: Applications of CORAGEN, BELT, or HGW86 SE provided the most consistent reduction in the percentage of cobs with insect feeding damage and had the lowest number of larvae in Trial 2. While plots treated with MATADOR had significantly more damaged cobs than CONTROL plots in Trial 1, under the heavier pressure of Trial 2, the increase in undamaged cobs following application of MATADOR was not statistically significant.

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Table 1. Percentage of sweet corn cobs with no feeding damage, tip feeding damage, and deep feeding damage and sprayed with different insecticides, Trial 1 and Trial 2, Ridgetown, ON, 2010.

Treatment	Cobs (%) [1]					
	No Damage		Tip Damage		Deep Damage	
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Non-treated control	86.3 b [2]	59.0 c	7.1 ns	27.0 bc	2.0 ns	16.0 b
MATADOR @ 83 mL Ha^{-1}	99.9 a	72.0 bc	1.1	23.0 abc	0.0	3.0 a
SEVIN @ 4 L Ha^{-1}	96.9 ab	77.0 abc	3.1	17.0 abc	0.0	5.0 ab
DELEGATE @ 200 g Ha^{-1}	97.7 ab	81.0 abc	3.1	19.0 abc	0.0	0.0 a
DELEGATE @ 100 g Ha^{-1}	99.0 ab	81.0 abc	2.0	16.0 abc	0.0	1.0 a
INTREPID @ 550 mL Ha^{-1}	99.7 ab	83.0 abc	1.1	17.0 abc	0.0	0.0 a
BELT @ 200 mL Ha^{-1}	99.5 ab	94.0 ab	1.1	6.0 ab	0.0	0.0 a
RIMON @ 820 mL Ha^{-1}	92.3 ab	61.0 c	6.0	36.0 c	1.0	4.0 a
CORAGEN @ 375 mL Ha^{-1}	98.9 ab	98.0 a	1.1	2.0 a	0.0	0.0 a
HGW86 SE @ 1 L Ha^{-1}	99.5 ab	90.0 ab	0.5	10.0 ab	0.0	0.0 a
ENTRUST @ 50 g Ha^{-1}	97.2 ab	82.0 abc	3.9	18.0 abc	0.0	1.0 a

[1] Tip damage is in the third of the cob closest to the tip, deep damage in the two thirds of the cob away from tip.
[2] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's adjustment. ns = not significant.

Table 2. Number of European corn borer (ECB), corn earworm (CE), western bean cutworm (WBC), and fall army worm (FAW) larvae in sweet corn sprayed with different insecticides, Trial 2, Ridgetown, ON, 2010.

Treatment	Larvae (#) [1]				
	Total Leps	ECB	CE	WBC	FA
Non-treated control	4.8 cd [2]	2.3 b	1.0 ab	1.8 ns	0.7 ns
MATADOR @ 83 mL Ha^{-1}	4.4 bcd	0.5 ab	1.7 bc	1.3	1.6
SEVIN @ 4 L Ha^{-1}	2.5 abcd	0.0 a	1.1 abc	1.5	1.6
DELEGATE @ 200 g Ha^{-1}	1.4 abc	0.0 a	0.8 a	0.8	0.9
DELEGATE @ 100 g Ha^{-1}	2.9 abcd	0.5 ab	1.1 abc	1.3	1.2
INTREPID @ 550 mL Ha^{-1}	2.5 abcd	0.3 a	1.3 abc	0.5	0.7
BELT @ 200 mL Ha^{-1}	0.7 a	0.0 a	0.8 a	0.0	0.5
RIMON @ 820 mL Ha^{-1}	7.3 d	1.3 ab	1.8 c	3.0	2.3
CORAGEN @ 375 mL Ha^{-1}	0.9 ab	0.3 a	0.8 a	0.0	0.5
HGW86 SE @ 1 L Ha^{-1}	0.9 ab	0.0 a	0.7 a	0.5	0.9
ENTRUST @ 50 g Ha^{-1}	1.4 abc	0.3 a	0.8 a	0.8	1.0

[1] ECB = European corn borer, CE = corn earworm, WBC = western bean cutworm, FA = fall armyworm.
[2] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's adjustment. ns = not significant.

2010 PMR REPORT # 09 **SECTION C: POTATOES**

CROP: Potato (*Solanum tuberosum* L.), cv. Kennebec
PEST: Colorado potato beetle (CPB), *Leptinotarsa decemlineata* Say

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TITLE: SURVEY FOR IMIDACLOPRID-RESISTANCE AND SUSCEPTIBILITY TO NEW PRODUCTS IN COLORADO POTATO BEETLE POPULATIONS IN CANADIAN POTATO FIELDS, 2010

MATERIALS: ADMIRE 240 F (imidacloprid 21.4 %), ACTARA 240 SC (thiamethoxam 21.6 %), TITAN 600 FS (clothianidin 48 %), CORAGEN (chlorantraniliprole 18.4 %), DPX-HGW86 200SC (cyantraniliprole 20%).

METHODS: Colorado potato beetle (CPB) adults or mature larvae were collected from 34 field sites in 4 Canadian provinces. Either neonicotinoid insecticide or chlorantraniliprole control failure had been reported from some of those sites. CPB were shipped in chilled containers overnight to AAFC London and placed on fresh potato foliage (cv. Kennebec). The F1 generation 2nd instar larvae were used in subsequent leaf dip bioassays. A 5 cm diameter disc was cut from fresh potato leaves and dipped into aqueous solutions of formulated insecticides prepared at the discriminating concentration (DC) for each insecticide. Discs were allowed to dry and then 5, 2nd instar larvae were placed on each disc and held in a covered, disposable, plastic Petri plate. The LC_{95} for each compound was designated as the DC. The LC_{95} was determined with probit analyses of dose-response data from 48 h tests (imidacloprid, thiamethoxam and cyantraniliprole) or 72 h tests (clothianidin and chlorantraniliprole) with an insecticide-susceptible CPB strain (AAFC, London ON) using the leaf dip bioassay and a range of 5 to 6 concentrations causing from 0%-100% mortality in the susceptible population. Each field population was tested with a minimum of 60 larvae/DC. 48 h bioassays with a control mortality ≥ 10% and 72 h bioassays with a control mortality ≥ 15% were not used for the final results. Due to the loss of several populations before the completion of the bioassays, partial test result data (< 60 larvae/DC) have been included to indicate trends in those populations.

RESULTS: As outlined in Table 1 and 2. Less than 10 percent (2 out of 25 or 8%) of the Canadian CPB populations surveyed can be considered tolerant (< 30% mortality) at the imidacloprid DC (LC_{95}). Control (> 70% mortality) was still achieved in approximately half (52%) of the CPB populations. Of the remaining populations where partial test results with imidacloprid were obtained (Data not shown), 1 out of 4 (25%) showed trends toward tolerance (< 30% mortality), while 25% of the populations could be considered susceptible. No resistance was observed with thiamethoxam, clothianidin, chlorantraniliprole or cyantraniliprole; control was respectively achieved in 86%, 83%, 87% and 70% of the CPB populations using the DC's for each insecticide. The partial test result data for chlorantraniliprole similarly indicated that 100% (11 out of 11) of tested populations could still be considered controlled (Data not shown).In contrast, the partial test result data for thiamethoxam, clothianidin and cyantraniliprole indicated that 60% (3 out of 5), 67% (2 out of 3) and 50% (3 out of 6) of tested populations respectively, were controlled, indicating less than ideal levels of effectiveness (Data not shown). Regression analyses of percent mortality for imidacloprid with the other 4 compounds indicated a

moderate correlation with clothianidin (R^2=0.53) and thiamethoxam (R^2=0.32), but low correlation with chlorantraniliprole (R^2=0.04) and cyantraniliprole (R^2=0.15).

CONCLUSIONS: Insecticide-resistance is a continuing concern for Canadian potato growers. For over 15 years growers have relied heavily on foliar or soil application of imidacloprid and, more recently, the neonicotinoid insecticides thiamethoxam and clothianidin. As was observed in the 2008 and 2009 surveys, it appears that this reliance has led to reduced susceptibility to imidacloprid in a significant proportion of the populations surveyed (40 to 50%). The number of populations surveyed was greater in 2008 and 2009 but the proportion regarded as tolerant to imidacloprid has decreased from 45% in 2008 to 18% in 2009 and < 10% in 2010. This observation may partly be explained by the broader criteria for selection of CPB field sites in 2009 and 2010. The criteria did not exclusively include fields experiencing control failures after imidacloprid use as was the case for many of the 2008 collection sites. As baseline studies for the next generation anthranilic diamide compound, cyantraniliprole, was the focus of the 2009 and 2010 surveys, a broad selection of potato fields where CPB could be collected across the country was desired. Overall the number of CPB populations that are successfully controlled by imidacloprid has stayed relatively constant or perhaps increased over the past 3 years. This improvement may be due partly to the availability of insecticides with a different mode of action for resistance management.

The 2010 survey was also the third year where our findings show a moderate positive correlation between CPB mortality to imidacloprid, the 1st generation neonicotinoid, with clothianidin and thiamethoxam, 2nd generation neonicotinoid insecticides. This observation heightens the concern over potential development of cross-resistance among the 3 neonicotinoids tested. Continued surveillance is required along with increased implementation of resistance management strategies to prevent additional CPB control failures. Mortality of CPB exposed to chlorantraniliprole and cyantraniliprole, both members of the anthranilic diamide class of insecticide, had a low correlation with imidacloprid CPB mortality. While the potential for cross-resistance may currently be less with these compounds, an effective resistance management strategy to extend their use is still warranted.

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Table 1. Number of tested CPB populations in each province with < 30% mortality at the DC (LC_{95}) for 5 insecticides, 2010.

Province	Imidacloprid	Thiamethoxam	Clothianidin	Chlorantraniliprole	Cyantraniliprole
ON	2 / 14[1]	0 / 13	0 / 8	0 / 5	0 / 11
QC	0 / 3	0 / 3	0 / 1	0 / 1	0 / 2
NB	0 / 7	0 / 5	0 / 2	0 / 1	0 / 3
PEI	0 / 1	0 / 1	0 / 1	0 / 1	0 / 1
Total	2 / 25	0 / 22	0 / 12	0 / 8	0 / 17

[1] No. resistant populations / Total populations tested

Table 2. Number of tested CPB populations in each province with ≥ 70% mortality at the DC (LC_{95}) for 5 insecticides, 2010.

Province	Imidacloprid	Thiamethoxam	Clothianidin	Chlorantraniliprole	Cyantraniliprole
ON	9 / 14[1]	13 / 13	8 / 8	5 / 5	10 / 11
QC	0 / 3	2 / 3	0 / 1	1 / 1	0 / 2
NB	3 / 7	3 / 5	1 / 2	0 / 1	1 / 3
PEI	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Total	13 / 25	19 / 22	10 / 12	7 / 8	12 / 17

[1] No. susceptible populations / Total populations tested

2010 PMR REPORT # 10 **SECTION C: POTATOES**

CROP: Potato (*Solanum tuberosum*), cv. Chieftain
PEST: Wireworm (WW), *Melanotus* spp.
June beetle (JB) larvae, *Phyllophaga* spp.

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TITLE: PLANTING TREATMENTS FOR CONTROL OF DAMAGE TO POTATO TUBERS BY SOIL INSECTS, 2010

MATERIALS: BRIGADE 2 EC (bifenthrin 25.1% [w/w]), MATADOR 120 EC (λ-cyhalothrin 13.1% [w/w]), ACTARA 240 SC (thiamethoxam 21.6% [w/w]), PONCHO 600 FS (clothianidin 48.1% [w/w]), THIMET 15 G (phorate 15% [w/w]), MAXIM PSP (fludioxonil 0.5% [w/w]), LOROX L (linuron 40.7% [w/w], BRAVO 500 (chlorothalonil 40.4% [w/w]), ALLEGRO 500 F (fluazinam 40.0% [w/w]), IGNITE 15 SN (glufosinate ammonium 13.5% [w/w])

METHODS: Hard red, spring wheat, cv. Superb, for the attract and kill (AandK) treatment (Tmt. 8 - 170 seeds/m row) was commercially treated and received in April 2008; laboratory tests verified continued good (90%+) germination in April 2010. Seed potatoes were hand cut on 10 May. On 11 May, using a hand-operated mist-applicator, seed dressings (SD) (Table 1, Tmt. 6) were uniformly applied in 0.555 L/100 kg seed to cut seed potatoes contained in a 50 lb clear plastic bag. The bag was then closed and inverted 40 times to ensure even coating of all pieces. MAXIM PSP (500 g/100 kg seed) was then uniformly sprinkled over the top of the treated seed pieces in the bag which was then closed and again inverted 40 times to ensure even coating of all seed pieces. Seed pieces for all other treatments were similarly treated with MAXIM PSP only. After treatment, bags were opened and seed allowed to dry until planting.

On 12 May, single row plots were established in sandy loam soil near Rodney, Ontario (42° 33' 18.9" N; 81° 38' 49.6" W). Rows were planted on 1 m spacing. Individual plots measured 5 m long. With the exception of Tmt. 9, all treatments were replicated 4 times in a Randomized Complete Block design. To accommodate possible uneven WW distribution within the block, single untreated rows (Tmt. 9) were established so that every treated row was adjacent to an untreated row. Each replicate range thus contained 4 untreated rows. Replicate ranges were separated by 1 m fallow walkways which were also located at either end of the entire block.

The in-furrow granular (IFG)(Table 1, Tmt. 1) and AandK (Tmt. 8) treatments were hand applied in a 7-10 cm band in the bottom of the seed furrow before placement of seed pieces. Seed pieces were then hand planted at 20 cm spacing (25 seed pieces/plot) in all plots. In-furrow spray (IFS) treatments (Table 1, Tmts. 2-7) were applied in a 10-12 cm band over the seed pieces in the open seed furrow in 5 L/100 m row at 135 kPa, using a hand-held, CO_2-pressurized, RandD field-plot sprayer fitted with a single

8004EVS flat spray tip. Seed pieces were covered with soil, hilled to a height of ca. 10 cm and the hills lightly tamped to ensure good contact of seed pieces with soil. LOROX L (3.0 L/ha) was applied to the entire block on 17 May to control weeds. Plots were subsequently hilled on 18 June and weeds removed manually as required until harvest. To control foliar diseases, a tank mixture of BRAVO 500 + ALLEGRO 500 F (2.0 + 0.4 L/ha) was applied on 28 June. IGNITE 15 SN (3.0 L/ha) was applied to the entire block on 10 September to speed desiccation of potato vines and escaping weeds.

On 30 September, 139 days after planting, all potatoes from Hills 2-7 of each plot were carefully dug, placed in labelled burlap bags and returned to the laboratory. All tubers in each bag were washed and allowed to dry prior to grading. During grading, the 50 largest tubers from each plot were individually weighed and checked for feeding damage by soil insects; where tuber numbers were limited, all tubers $\geq$ 25 mm diameter were so evaluated. WW-damage was determined by counting numbers of blemishes (fresh WW feeding holes + healed WW feeding scars) on each tuber and then calculating the number of blemishes/10 tubers for each plot. The % WW-damaged tubers was also calculated for each plot. Tubers were also scored for the presence of feeding damage by JB-larvae. Since WW and JB were present throughout the block, the mean number of blemishes/tuber, the mean % WW-damaged tubers and the mean % JB-damaged tubers for all untreated plots in each replicate range were calculated and utilized for purposes of comparison of treatment effect. The observed impact of treatments on the number of WW- blemishes/tuber was analysed by Analysis of Variance (ANOVA); significance of observed differences among treatment means was then determined using a Least Significant Difference (LSD) means separation test. Results are presented as the mean number of WW blemishes/10 tubers. The % WW- and JB-damaged tubers were subjected to arcsine square root transformation prior to determination of statistical significance by ANOVA and LSD means separation test. Untransformed data are presented.

OBSERVATIONS: No significant phytotoxicity was observed following any planting treatment. Wheat seedlings growing from treated seed planted beneath potato seed pieces were stunted by application of LOROX L and wheat did not compete with growing potato plants. A total of 208 mm rainfall was recorded during the 139 days between planting and harvest; 42 mm was recorded within 21 days of planting. JB-feeding damage was not uniform across the block and occurred late in the season as evidenced by collection of numbers of "grubs" actively feeding on tubers at the time of harvest.

RESULTS: Impact of planting treatments on WW- and JB-damage to harvested potato tubers is shown in Table 2.

Although WW-damage to tubers was relatively low in this trial, damage was recorded in plots with no planting treatments across all ranges of the experimental block. An average of 12.1 WW-blemishes/10 tubers was recorded in plots with no planting treatment (Tmt. 9) while an average of 51.3% of harvested tubers was damaged by WW in those plots.

All treatments except IFS-application of either the low rate of bifenthrin (Tmt. 2) or the low rate of λ-cyhalothrin (Tmt. 4) significantly reduced the number of WW-blemishes/10 tubers in treated plots. Although there were no significant differences among effective treatments, the greatest reduction in WW-blemishes/10 tubers followed either IFG-application of the commercial standard, THIMET 15 G (phorate)(Tmt. 1) or IFS-application of the higher rate of bifenthrin (Tmt. 3); for both treatments WW-feeding damage was reduced by at least 75% to less than 3 blemishes/10 tubers. WW-feeding damage reductions for the remaining effective treatments ranged from 57.0% for IFS-application of thiamethoxam + λ-cyhalothrin (Tmt. 7) to 62.8% for IFS-application of the higher rate of λ-cyhalothrin (Tmt. 5).

The % of harvested tubers showing signs of WW-feeding damage was significantly reduced in all plots except those receiving IFS-application of the lower rate of λ-cyhalothrin (Tmt. 4). Fewer than 20% of tubers were damaged by WW in plots receiving either IFG-application of the commercial standard, THIMET 15 G (phorate)(Tmt. 1) or IFS-application of the higher rate of bifenthrin (Tmt. 3). Incidence of WW-damaged tubers ranged from 20.2% in plots planted with seed potatoes treated with clothianidin

followed by IFS-application of bifenthrin (Tmt. 6) to 26.5% in plots receiving IFS-application of the lower rate of bifenthrin (Tmt. 2). The relatively small differences in % damaged tubers in plots receiving effective treatments were not statistically significant.

Although present across the experimental block, JB-feeding damage was not distributed evenly. An average of 13.8% of tubers were damaged by JB in replicate Range 1. JB-feeding damage decreased significantly in higher replicate ranges, falling to an average of 2.7% in Range 4. Across all replicate ranges, the highest incidence of JB-feeding damage was recorded in plots receiving the experimental AandK treatment (Tmt. 8). JB-feeding damage was significantly higher in those plots than in plots receiving IFS-application of either rate of bifenthrin (Tmts. 2, 3) or IFS-application of the tank-mix combination of thiamethoxam + λ-cyhalothrin (Tmt. 7).

CONCLUSION: Under the conditions of this experiment, no treatment provided complete control of WW-feeding damage. However, in addition to IFG-application of the commercial standard, THIMET 15 G (phorate)(Tmt. 1), application of all treatments except IFS-application of λ-cyhalothrin @ 1.0 g a.i./100 m row, significantly reduced the incidence of WW-feeding damage in harvested potatoes. Further investigation of all treatments is thus warranted to refine rates of application.

Although uneven distribution prevented definitive conclusions about control of JB-feeding damage, fewer tubers were damaged by JB in plots receiving IFS-application of either bifenthrin or a tank mix combination of thiamethoxam + λ-cyhalothrin . Further investigation of the efficacy of these treatments for JB-control in potato is thus warranted.

Table 1. Planting treatments applied to potatoes for control of soil insect pests in mineral soil, Rodney, ON, 2010.

Tmt. No.	Treatment Applied			Rate Applied (/100 m row)	
	Insecticide	Formulation	Method[1]	a.i.	Formulation
1	phorate	THIMET 15 G	IFG	32.25 g	215.0 g
2	bifenthrin	BRIGADE 2 EC	IFS	2.0 g	8.4 ml
3	bifenthrin	BRIGADE 2 EC	IFS	3.0 g	12.6 ml
4	λ-cyhalothrin	MATADOR 120 EC	IFS	1.0 g	8.4 ml
5	λ-cyhalothrin	MATADOR 120 EC	IFS	2.0 g	16.8 ml
6	clothianidin + bifenthrin	PONCHO 600 FS + BRIGADE 2 EC	SD + IFS	12.5[2] g + 3.0 g	20.8 ml[2] + 12.6 ml
7	thiamethoxam + λ-cyhalothrin	ACTARA 240 SC + MATADOR 120 EC	IFS	1.06 g + 2.0 g	4.4 ml + 16.8 ml
8	experimental	experimental	A and K	confidential	confidential
9	no insecticide	CONTROL	---	---	----

[1] - Method of Application: AandK - Attract and Kill; SD - Seed Dressing; IFS - In Furrow Spray; IFG - In Furrow Granular

[2] - rate/100 kg seed potatoes; seed dressing applied to seed potatoes.

Table 2. Impact of planting treatments on damage to potato tubers by wireworm, primarily *Melanotus* spp., and June beetle larvae, *Phyllophaga* spp., in mineral soil, Rodney, ON, 2010.

	Wireworm (WW)				June Beetle (JB) Larvae	
	Blemishes/10 Tubers		Damaged Tubers		Damaged Tubers	
Tmt. No.	Number	% Reduction[2]	% Damaged	% Reduction[2]	% Damaged	% Reduction[2]
1	2.9 c[2]	76.0	17.1 b	66.9	8.7 abc	- 1.2
2	6.7 bc	44.6	26.5 b	48.3	3.7 c	57.0
3	2.7 c	77.7	16.5 b	67.8	3.1 bc	64.0
4	14.3 a	-18.2	48.0 a	6.4	8.9 ab	- 3.5
5	4.5 c	62.8	26.3 b	48.7	6.2 abc	27.9
6	4.7 c	61.2	20.2 b	60.6	5.8 abc	32.6
7	5.2 c	57.0	24.9 b	51.5	3.1 bc	64.0
8	4.8 c	61.2	25.3 b	50.7	12.2 a	- 41.9
9	12.1 ab	---	51.3 a	---	8.6 abc	---

[1] - Relative to values recorded CONTROL plots in absence of insecticide (Tmt. 9).
[2] - Means within a column followed by the same letter are not significantly different ($P \leq 0.05$) as determined using ANOVA and Least Significant Difference range test.

2010 PMR REPORT # 11 SECTION E: CEREALS, FORAGE CROPS and OILSEEDS

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

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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 insecticide and fungicide seed treatments. The trial was planted on 25 May as the sixth consecutive corn crop on a clay loam soil at the University of Guelph Ridgetown Campus and on 27 May as the second consecutive corn crop on a clay loam soil at Alvinston, ON. Trials were planted using a two-row cone-seeder at a rate of 8 seeds/m. Plots were 4 rows, spaced 0.76 m apart and 10 m long in a randomized complete block design with four replications. 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 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 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 in SAS v. 9.1 (SAS Institute, Cary, NC) using PROC MIXED with blocks as a random source of variance. 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.

OBSERVATIONS: Moderate to severe corn rootworm feeding was observed at the Ridgetown location; low injury levels were observed at the Alvinston location. Both trial locations experienced drought stress during the summer of 2010.

RESULTS: The plant stand of N45A-3000GT was significantly lower than all treatments except 35F40 + FORCE and 35F44 at the V1 and V2 stages at Ridgetown and Alvinston, respectively, and significantly lower than all other treatments on subsequent rating dates at the Ridgetown location (Tables 2 and 3). No

differences were observed in plant vigour at the Ridgetown location during the V1 to V5 stages, but when assessed at the V10 stage during a period of moisture stress, the rootworm-protected hybrids DKC 50-44 (VT3) and N45A-3000GT (Agrisure CB/RW) appeared significantly more vigourous than the DKC 50-48 (YGCB) + Poncho 250 and N45A-GT/CB/LL + Cruiser 250 hybrids lacking rootworm protection (Table 2). At the Alvinston location, no differences in plant vigour were measured at the V2 or V7 stages, but the DKC 50-45 (SS) plots appeared more vigourous than the DKC 50-48 (YGCB) + Poncho 1250 plots at the V5 stage (Table 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. N45A-GT/CB/LL (Agrisure CB) + Cruiser 250 (NIS=2.18), DKC 50-48 (YGCB) + Poncho 250 (NIS=2.10) and 35F40 (HXI) + Cruiser 250 (NIS=1.19) (Table 4). Rootworm feeding injury was significantly reduced in all other treatments containing insecticidal or transgenic rootworm protection, with no statistical differences among them (Table 4). At the Alvinston location, the greatest rootworm feeding injury was sustained by DKC 50-48 (YGCB) + Poncho 250 (NIS=0.22) and similar damage levels were also sustained by DKC 50-48 (YGCB) + Poncho 1250 or FORCE 3.0 G, 35F40 (HXI) + Cruiser 250, 1250, and FORCE 3.0G, and N45A-GT/CB/LL (Agrisure CB) + Cruiser 250, 1250, and FORCE 3.0 G (Table 4). Feeding damage was significantly lower in the DKC 50-44 (VT3) + Poncho 250, DKC 50-45 (SS) + Poncho 250, 35F44 (HXX) + Cruiser 250, and N45A-3000GT (Agrisure CB/RW) + Cruiser 250 treatments (Table 4).

Product consistency analysis of node-injury ratings at the Ridgetown location determined that the greatest reliability in rootworm protection was found among hybrids expressing transgenic insecticidal traits for rootworm control. The hybrids DKC 50-45 (SS) + Poncho 250, 35F44 (HXX) + Cruiser 250, DKC 50-44 (VT3) and N45A-3000GT (Agrisure CB/RW) + Cruiser 250 were most consistently protected and one treatment of a non-transgenic hybrid (35F40 (HXI)) treated with FORCE 3.0 G was found to have similar consistent protection (Table 4). No differences in product consistency were measured at the Alvinston location where rootworm injury was not severe. Fresh weight of shoots destructively sampled at Ridgetown was significantly greater in DKC 50-44 (VT3) + Poncho 250 than N45A-GT/CB/LL (Agrisure CB) + Cruiser 250 (Table 5). No other differences in shoot fresh weight were measured and no differences were found at Alvinston (Table 5). No differences in fresh weight of roots or plant height were measured among treatments at either location (Table 5).

The highest yields were achieved among treatments expressing transgenic insecticidal traits for rootworm control at Ridgetown, but only N45A-GT/CB/LL (Agrisure CB)+ Cruiser 250 yielded significantly lower than these treatments (Table 6). No differences were measured in yield at the Alvinston location where rootworm injury ratings were less than or equal to 0.26 in all unprotected treatments. The test weights of grain harvested from 35F40 and 35F44 plots were greater than those of DKC 50-48, 50-44, 50-45, N45A-GT/CB/LL and N45A-3000GT plots at the Ridgetown location (Table 6). At the Alvinston location, test weights of 35F40 + Cruiser 250 and 1250 as well as 35F44 + Cruiser 250 were greater than that of DKC 50-48 + Poncho 1250 (Table 6).

CONCLUSIONS: Corn hybrids expressing transgenic insecticidal traits for corn rootworm control provided the most consistent protection from rootworm feeding compared to insecticidal seed treatments and soil insecticide applications under severe rootworm infestation at the Ridgetown location. Although we observed a general trend of decreasing node-injury with increasing insecticide seed treatment rate and soil insecticide application, no statistical differences were measured among these treatments at the Ridgetown location. Yield increases of up to 24 percent were gained with hybrids expressing transgenic insecticidal traits for rootworm control over unprotected hybrids with low rates of neonicotinoid seed treatments at the Ridgetown location, but only the yield of N45A-GT/CB/LL (Agrisure CB) + Cruiser 250 was statistically lower than the rootworm-transgenic hybrids and 35F40 (HXI) + Cruiser 250 and FORCE 3.0 G. At the Alvinston location, transgenic hybrids with rootworm protection had significantly less root injury than hybrids without transgenic rootworm protection and the low rate of neonicotinoid seed treatments, but these differences did not contribute to increased yield under the low level of pest

pressure. Differences in test weight were likely due to genetic 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 2010.

Trait Brand Name	Corn Hybrid	CHU/RM	Lepidoptera-targeting event (protein)	Rootworm-targeting event (protein)
YieldGard Corn Borer® (YGCB)	DKC50-48	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	TC1507 (Cry 1F)	DAS-59122-7 (Cry 34/35 Ab1)
Agrisure® GT/CB/LL (Agrisure CB)	N45A-GT/CB/LL	3100/101	BT11 (Cry 1Ab)	None
Agrisure® 3000GT (Agrisure CB/RW)	N45A-3000GT	3100/101	BT11 (Cry 1Ab)	MIR 604 (mCry3A)

Table 2. Mean plant population and vigor of transgenic corn hybrids and insecticide combinations following a long-term continuous corn rotation at the University of Guelph Ridgetown Campus in 2010.

	Treatment	Rate (mg ai/seed)	Mean plant population (# plants/m)[1]			Mean plant vigour (0-100%)[1,2]			
			1 June (V1)	4 June (V1)	23 June (V5)	1 June (V1)	4 June (V1)	23 June (V5)	9 July (V10)
1	DKC 50-48 (YGCB) + Poncho 600 FS	0.25	7.3 a	7.5 a	7.6 a	93.8	95.0	83.8	80.0 b
2	DKC 50-48 (YGCB) + Poncho 600 FS	1.25	7.3 a	7.5 a	7.7 a	95.0	95.0	88.8	95.0 ab
3	DKC 50-48 (YGCB) + FORCE 3.0 G	37.5[3]	7.5 a	7.7 a	7.8 a	95.0	93.8	87.5	88.8 ab
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	7.6 a	7.6 a	7.7 a	95.0	93.8	92.5	98.8 a
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	7.6 a	7.6 a	7.8 a	97.5	93.8	88.8	90.0 ab
6	35F40 (HX1) + Cruiser 5 FS	0.25	7.4 a	7.4 a	7.6 a	92.5	93.8	88.8	88.8 ab
7	35F40 (HX1) + Cruiser 5 FS	1.25	7.5 a	7.6 a	7.8 a	93.8	93.8	87.5	86.3 ab
8	35F40 (HX1) + FORCE 3.0 G	37.5[3]	7.2 ab	7.4 a	7.7 a	93.8	93.8	88.8	88.8 ab
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	7.2 ab	7.5 a	7.8 a	93.8	93.8	87.5	88.8 ab
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	7.5 a	7.4 a	7.8 a	95.0	93.8	91.3	78.8 b
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	7.4 a	7.5 a	7.6 a	95.0	95.0	92.5	87.5 ab
12	N45A-GT/CB/LL (Agrisure CB) + FORCE 3.0 G	37.5[3]	7.4 a	7.4 a	7.6 a	96.3	95.0	92.5	88.8 ab
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	6.7 b	6.9 b	7.1 b	92.5	95.0	87.5	95.0 a
	se		0.15	0.11	0.08	1.18	1.34	3.56	3.16
	Pr >F		0.0009	0.0033	0.0001	0.1416	0.7852	0.8419	0.0024

[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 second-year corn at Alvinston, Ontario in 2010.

	Treatment	Rate (mg ai/seed)	Mean plant population (# plants/m)[1]		Mean plant vigour (0-100%)[1,2]		
			14 June (V2)	24 June (V4)	14 June (V2)	24 June (V4)	15 July (V7)
1	DKC 50-48 (YGCB) + Poncho 600 FS	0.25	7.3 a	7.6	87.5	75.0 ab	80.0
2	DKC 50-48 (YGCB) + Poncho 600 FS	1.25	7.3 a	7.6	80.0	63.8 b	71.3
3	DKC 50-48 (YGCB) + FORCE 3.0 G	37.5[3]	7.5 a	7.6	88.8	71.3 ab	71.3
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	7.6 a	7.6	85.0	85.0 ab	78.8
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	7.6 a	7.5	93.8	86.3 a	88.8
6	35F40 (HX1) + Cruiser 5 FS	0.25	7.4 a	8.0	86.3	85.0 ab	80.0
7	35F40 (HX1) + Cruiser 5 FS	1.25	7.5 a	7.4	87.8	81.3 ab	85.0
8	35F40 (HX1) + FORCE 3.0 G	37.5[3]	7.2 ab	7.5	87.8	85.0 ab	85.0
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	7.2 ab	7.5	82.5	73.8 ab	77.5
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	7.5 a	7.7	87.5	73.8 ab	75.0
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	7.4 a	7.5	90.0	78.8 ab	78.8
12	N45A-GT/CB/LL (Agrisure CB) + FORCE 3.0 G	37.5[3]	7.4 a	7.2	88.8	73.8 ab	85.0
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	6.7 b	6.8	91.3	85.0 ab	90.0
	se		0.15	0.28	3.46	4.97	5.50
	Pr >F		0.0009	0.4873	0.4251	0.0489	0.3194

[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 2010.

	Treatment	Rate (mg ai/seed)	Mean node-injury rating (0-3.00)[1,2]		Mean product consistency (0-100%)[1,3]	
			Ridgetown 13 July (V10)	Alvinston 15 July (V7)	Ridgetown 13 July (V10)	Alvinston 15 July (V7)
1	DKC 50-48 (YGCB) + Poncho 600 FS	0.25	2.10 a	0.22 a	0.0 c	58.3
2	DKC 50-48 (YGCB) + Poncho 600 FS	1.25	0.69 b	0.11 ab	8.3 bc	100.0
3	DKC 50-48 (YGCB) + FORCE 3.0 G	37.5[4]	0.58 b	0.14 ab	8.3 bc	87.5
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	0.45 b	0.07 b	66.7 ab	100.0
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	0.17 b	0.06 b	87.5 a	100.0
6	35F40 (HX1) + Cruiser 5 FS	0.25	1.19 ab	0.17 ab	0.0 c	79.2
7	35F40 (HX1) + Cruiser 5 FS	1.25	0.69 b	0.13 ab	20.8 bc	95.8
8	35F40 (HX1) + FORCE 3.0 G	37.5[4]	0.42 b	0.13 ab	33.3 abc	91.7
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	0.19 b	0.07 b	87.5 a	100.0
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	2.18 a	0.12 ab	8.3 bc	100.0
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	0.88 b	0.11 ab	20.8 bc	100.0
12	N45A-GT/CB/LL (Agrisure CB) + FORCE 3.0 G	37.5[4]	0.75 b	0.13 ab	0.0 c	100.0
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	0.50 b	0.05 b	33.3 abc	100.0
	se		0.24	0.027	12.08	0.09
	Pr >F		<0.0001	0.0045	<0.0001	0.0891

[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 2010.

	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]	
			Ridge-town	Alvinston	Ridge-town	Alvinston	Ridge-town	Alvinston
			13 July (V10)	15 July (V7)	13 July (V10)	15 July (V7)	1 July (V8)	15 July (V7)
1	DKC 50-48 (YGCB) + Poncho 600 FS	0.25	1.3 ab	1.1	0.4	0.4	95.9	129.9
2	DKC 50-48 (YGCB) + Poncho 600 FS	1.25	1.4 ab	0.9	0.6	0.4	96.5	112.6
3	DKC 50-48 (YGCB) + FORCE 3.0 G	37.5[4]	1.4 ab	0.9	0.6	0.3	94.5	108.3
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	1.9 a	1.1	0.7	0.4	104.4	127.6
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	1.6 ab	1.4	0.6	0.5	103.6	136.8
6	35F40 (HX1) + Cruiser 5 FS	0.25	1.8 ab	1.1	0.6	0.4	103.3	118.6
7	35F40 (HX1) + Cruiser 5 FS	1.25	1.5 ab	1.3	0.6	0.4	105.4	135.5
8	35F40 (HX1) + FORCE 3.0 G	37.5[4]	1.7 ab	1.5	0.7	0.4	103.3	125.0
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	1.7 ab	0.9	0.7	0.4	101.5	115.1
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	1.1 b	1.0	0.5	0.4	101.3	125.0
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	1.5 ab	1.2	0.6	0.6	103.6	125.3
12	N45A-GT/CB/LL (Agrisure CB) + FORCE 3.0 G	37.5[4]	1.4 ab	1.0	0.7	0.5	107.1	117.4
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	1.6 ab	1.3	0.6	0.5	103.3	129.3
	se		0.19	0.18	0.07	0.07	3.2	8.5
	Pr >F		0.0274	0.2426	0.1127	0.3530	0.1470	0.3754

[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 yield and test weight of transgenic corn hybrids and insecticide combinations following continuous corn rotations at Ridgetown and Alvinston, ON in 2010.

	Treatment	Rate (mg ai/seed)	Mean yield (T/ha)[1]		Mean test weight (kg/hL)[1]	
			Ridgetown 6 November (R6)	Alvinston 15 July (R6)	Ridgetown 6 November (R6)	Alvinston 15 July (R6)
1	DKC 50-48 (YGCB) + Poncho 600 FS	0.25	9.8 ab	9.2	76.9 cd	73.0 ab
2	DKC 50-48 (YGCB) + Poncho 600 FS	1.25	10.6 ab	9.5	76.6 d	70.9 b
3	DKC 50-48 (YGCB) + FORCE 3.0 G	37.5[2]	10.3 ab	8.6	76.2 d	72.1 ab
4	DKC 50-44 (VT3) + Cry 3Bb1 + Poncho 600 FS	0.25	11.6 a	9.3	77.0 cd	73.8 ab
5	DKC 50-45 (SS) + Cry 3Bb1 + Cry 34/34 Ab1 + Poncho 600 FS	0.25	11.7 a	9.5	76.5 d	73.3 ab
6	35F40 (HX1) + Cruiser 5 FS	0.25	11.2 a	9.6	79.9 a	74.8 a
7	35F40 (HX1) + Cruiser 5 FS	1.25	10.4 ab	9.0	79.0 ab	74.8 a
8	35F40 (HX1) + FORCE 3.0 G	37.5[2]	11.6 a	9.3	78.8 abc	74.0 ab
9	35F44 (HXX) + Cry 34/35 Ab1 + Cruiser 5 FS	0.25	11.7 a	9.7	79.2 ab	74.6 a
10	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	0.25	8.5 b	8.5	76.9 cd	73.0 ab
11	N45A-GT/CB/LL (Agrisure CB) + Cruiser 5 FS	1.25	10.0 ab	7.9	76.1 d	72.1 ab
12	N45A-GT/CB/LL (Agrisure CB) + FORCE 3.0 G	37.5[2]	9.5 ab	7.7	76.3 d	73.2 ab
13	N45A-3000GT (Agrisure CB/RW) + MIR 604 + Cruiser 5 FS	0.25	11.3 a	8.5	77.7 bcd	74.2 ab
	se		0.61	0.90	0.40	0.73
	Pr >F		0.0015	0.8739	<0.0001	0.0075

[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 of row applied in-furrow at planting.

2010 PMR REPORT # 12 **SECTION K: FRUIT**

CROP: Apples (*Malus domestica* Borkh.) cv. Empire

PEST: Black Root, *Botryosphearia obtusa* Schwein.) Shoemaker (anamorph *Sphaeropsis malorum* Berk.)

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TITLE: EFFICACY OF FUNGICIDE APPLICATION ON WOUNDED LIMBS OF APPLE TREES CV. EMPIRE TO PREVENT BLACK ROT CANKER DEVELOPMENT

MATERIALS: PRISTINE (25.2% boscalid + 12.8% pyraclostrobin), FLINT 50WG (50% trifloxystrobin)

METHODS: A 10 mm diameter wound was created with a cork borer on each of four limbs per Apple tree cv. Empire on M26 root stocks in a 15 year old experimental orchard at the Simcoe Horticulture Research Station, University of Guelph. The wounds were made on 30 July 2009 and immediately sprayed with either water, FLINT 50WG (50% trifloxystrobin) at a rate of 175 g in 500 L of water or PRISTINE (25.2% boscalid + 12.8% pyraclostrobin) at a rate of 1000 g in 250 L of water. The treatments were applied to the wounds by pressing the trigger twice on a 1 litre garden spray bottle containing either water or the fungicide solutions and directing the spray nozzle at the wound and surrounding tissue. The treatments were assigned to trees in a randomized complete block design replicated four times. 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 *Botryosphearia obtusa* growing on potato dextrose agar (PDA) was placed in each fungicide and water treated wound. The inoculated treated wounds were wrapped with polyethylene tape to keep the plug of mycelium in place and prevent the inoculated wound from drying. The polyethylene tape was removed on 17 August 2009 (18 days after treatment and inoculation). The length and width of the healing wound or the cankers that developed around wounds were measured on 17 August, 8 September, 30 September and 13 October 2009 (18, 40, 62 and 75 days after treatments respectively). Area of the healing wound or cankers was calculated using the formula for an ellipse (π (½ L x ½ W)) and the data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.8. Means separation was obtained by using Fisher's Protected LSD test at $P < 0.05$ level of significance.

RESULTS: Black rot cankers developed around water-treated wounds that were inoculated 1 hour later with *B. obtusa* (INOCULATED CHECK) and measured 18 days after inoculation (Table 1). Cankers that

formed around water-treated wounds inoculated with *B. obtusa* continued to increase in area 40, 62 and 75 days after inoculation. No canker development was observed around any of the wounds that were treated with PRISTINE 1 hour prior to inoculation with *B. obtusa* (Table 1). Wounds treated with PRISTINE began to produce callus and shrink 62 and 75 days after treatment and were statistically smaller than the area of the cankers that developed around wounds treated with water (INOCULATED CHECK) or FLINT 50WG and inoculated with *B. obtusa* 1 hour after treatment. Small cankers developed around wounds treated with FLINT 50WG that were inoculated with *B. obtusa* measured 18 days after inoculation and continued to increase very slowly in area up to 75 days after inoculation (Table 1). Wounds treated with FLINT 50WG prior to inoculation resulted in significantly smaller cankers than water-treated inoculated wounds (INOCULATED CHECK).

CONCLUSIONS: PRISTINE prevented black rot canker development around wounds when applied 1 hour prior to inoculation with *B. obtusa*. FLINT 50WG reduced black rot canker development for up to 75 days when applied to wounds 1 hour prior to inoculation with *B. obtusa* compared to the INOCULATED CHECK.

Table 1. The area of wounds and cankers that develop around wounds treated with PRISTINE or FLINT 50WG fungicide prior to inoculation with *B. obtusa* compared to wounds treated with water prior to inoculation with *B. obtusa* (INOCULATED CHECK).

	Area (mm) of wounds or cankers after treatment			
Treatment	18 days	40 days	62 days	75 days
INOCULATED CHECK	188.33 a[1]	264.94 a	277.20 a	277.99 a
PRISTINE	108.71 c	120.44 c	106.28 c	73.29 c
FLINT 50WG	124.24 b	165.14 b	192.82 b	184.69 b

[1] Figures in columns followed by the same letter are not significantly different using Fisher's Protected LSD test ($P<0.05$)

2010 PMR REPORT # 13 **SECTION K: FRUIT**

CROP: Apples (*Malus domestica* Borkh.) cv. Empire

PEST: Black Rot, (*Botryosphearia obtusa* Schwein.) Shoemaker (anamorph *Sphaeropsis malorum* Berk.)

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TITLE: EFFICACY OF FUNGICIDE APPLICATION ON WOUNDED LIMBS OF APPLE TREES CV. EMPIRE TO PREVENT BLACK ROT CANKER DEVELOPMENT

MATERIALS: PRISTINE (25.2% boscalid + 12.8% pyraclostrobin), SENATOR 70WP (70% thiophanate-methyl)

METHODS: A 10 mm diameter wound was created with a cork borer on each of four limbs per Apple tree cv. Empire on M26 root stocks in a 16 year old experimental orchard at the Simcoe Horticulture Research Station, University of Guelph. The wounds were made on 27 May 2010 and immediately sprayed with either water (check), SENATOR 70WP (70% thiophanate-methyl) at a rate of 500 g in 1000 L of water or PRISTINE (25.2% boscalid + 12.8% pyraclostrobin) at a rate of 1000 g in 250 L of water. The treatments were applied to the wounds by pressing the trigger on a 1 litre garden spray bottle containing either water or the fungicide solution and directing the spray nozzle at the wound and surrounding tissue. The treatments were assigned to trees in a randomized complete block design replicated four times. The treated wounds were allowed to dry for 1 hour prior to placing an 8 mm diameter plug of mycelia from the margin of a 7 day old colony of *Botryosphearia obtusa* growing on potato dextrose agar (PDA) in each fungicide treated wound and in four trees with wounded limbs treated with water (INOCULATED CHECK). An 8 mm diameter plug of PDA was placed in four trees with wounded limbs treated with water (NON- INOCULATED CHECK) for comparison. The inoculated and non-inoculated wounds were wrapped with polyethylene tape to keep the plug of mycelium in place and prevent the inoculated wound from drying. . The polyethylene tape was removed on 29 June 2010 (33 days after treatment). The length and width of the healing wound or cankers that developed were measured on 29 June, 27 July, 31 August and 6 October 2010 (33, 61, 96 and 132 days after treatments respectively. Area of the healing wound or cankers was calculated using the formula for an ellipse (π (½ L x ½ W)) and the data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.8. Means separation was obtained by using Fisher's Protected LSD test at $P < 0.05$ level of significance.

RESULTS: Wounds treated with water and inoculated with *B. obtusa* 1 hour later (INOCULATED CHECK) developed black rot cankers 33 days after inoculation (Table 1). Cankers that formed around water-treated wounds inoculated with *B. obtusa* began to produce callus and appeared to shrink 96 days after inoculation; however, the cankers began to slightly increase in area 132 days after inoculation. No canker development was observed around any of the wounds treated with either PRISTINE or SENATOR 70WP prior to inoculation with *B. obtusa* 1 hour after treatment or non-inoculated wounds (NON-

INOCULATED CHECK) (Table 1). Wounds that were treated with PRISTINE or SENATOR 70WP produce callus and began to shrink 33 days after treatment and were statistically smaller than the cankers that developed around wounds treated with water 1 hour prior to inoculation with *B. obtusa* when measured 33, 61, 96 and 132 days of treatment and inoculation. The area around non-inoculated wounds (NON-INOCULATED CHECK) were significantly smaller and appeared to initially shrink and heal better than wounds treated with SENATOR 70WP 33 days after treatment. However, no statistical difference in the area of wounds treated with PRISTINE or SENATOR 70WP and non-inoculated wounds (NON-INOCULATED CHECK) was observed 66, 96 or 132 days after treatment.

CONCLUSIONS: PRISTINE and SENATOR 70WP prevented the development of Black rot cankers when applied to wounds 1 hour prior to inoculation with *B. obtusa*.

Table 1. The area of wounds and cankers that developed around wounds treated with PRISTINE or SENATOR 70WP 1 hour prior to inoculation with *B. obtusa* compared to wounds treated with water 1 hour prior to inoculation with *B. obtusa* (INOCULATED CHECK) and water-treated non-inoculated wounds (NON-INOCULATED CHECK).

	Area (mm) of wounds or canker after treatment			
Treatment	33 days	61 days	96 days	132 days
INOCULATED CHECK	175.13 a[1]	188.01 a	112.32 a	118.33 a
SENATOR 70WP	140.24 b	56.93 b	33.39 b	30.82 b
PRISTINE	129.97 bc	35.53 b	25.46 b	22.54 b
NON-INOCULATED CHECK	120.33 c	41.77 b	31.96 b	26.85 b

[1] Figures in columns followed by the same letter are not significantly different using Fisher's Protected LSD test ($P<0.05$)

2010 PMR Report # 14 **SECTION K: FRUIT**

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

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TITLE: EFFECT OF PREHARVEST BOSCALID/PYRACLOSTROBIN AND PYRIMETHANIL APPLICATION FOR THE CONTROL OF POSTHARVEST BLUE MOLD IN 'EMPIRE' APPLES. 2009-10.

MATERIALS: PRISTINE (25.2% Boscalid and 12.8% Pyraclostrobin), SCALA SC (Pyrimethanil 400 g ai/L), MERTECT (45 % Thiabendazole) and SCHOLAR (50% Fludioxonil).

METHODS: During the 2009 growing season, a field trial was conducted at the Agriculture and Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. The preharvest treatments include: an unsprayed control, preharvest field applications of PRISTINE (1.2 kg/ha) applied 7 days preharvest and SCALA (pyrimethanil 800 g ai/ha) applied 14 days preharvest. Trees were treated with Scala on September 21, 2009 and with Pristine on September 30, 2009. Treatments were replicated 4 times with two trees per replicate, allocated in a completely randomized block design. The apple trees were sprayed with hand-operated gun sprayer at a pressure of 1034.25 kPa, 2.8-3 L of water per tree until runoff. Apples were harvested on October 6, 2009 and stored in cold storage at 0.5 - 2 ºC. On the same day, 12 apples from each of the replicate plots were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base, placed in mesh bags and placed in plastic crates. Wounded fruit were then inoculated with 20 µl conidial suspension ($1x10^4$ conidia/ml of water) of thiabendazole-resistant (TBZ-R) *Penicillium expansum* isolate PS-1R and placed back in cold storage at 0.5 - 2 ºC for 168 days. Postharvest treatments on apples that were treated with preharvest PRISTINE or SCALA include: control with no wound, control wound only, control with *P. expansum* at $1x10^4$ conidia/ml of water, SCHOLAR @ 1.2 g/L and MERTECT @ 1.15 g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The fruit from the postharvest treatments were also incubated for 167 days at 0.5-2 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. 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: Effect on postharvest blue mold of apples (Table 1): Apples treated with preharvest application of PRISTINE or SCALA had no blue mold disease in either wounded or unwounded apples. When inoculum was introduced in the wounds of the PRISTINE treated apples, complete control was observed up to 28 days and then disease increased to 27% at 56 days and 100.0% at 84 days. Similarly in the SCALA treated apples, for the first 56 days the disease was completely controlled and 3%, 40%, 40%, 50% disease was observed after 56, 84 , 111, 139 and 167 days, respectively. When a combination of postharvest application of SCHOLAR was applied to apples that were treated with preharvest application of PRISTNE or SCALA, a complete control of blue mold was observed for up to 167 days in cold

storage. As expected, MERTECT treatment was not effective against TBZ-resistant *P. expansum,* on apples, even on the apples that were treated with preharvest application of SCALA or PRISTINE.

Table 1. Effect of preharvest applications of PRISTINE and SCALA alone or in combination with postharvest SCHOLAR and MERTECT on the development of postharvest blue mold (*Penicillium expansum)* in 'Empire' apples, 2009-10.

Preharvest Application	Postharvest Treatment	Percentage incidence of blue mold (*Penicillium expansum* TBZ-R) at 0.5 - 2 °C after[1]					
		28 days	56 days	83 days	111 days	139 days	167 days
Control	No Wound	0.0 a[1,2]	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	*P. expansum* 1 x 10^4 conidia/ml	100.0 b	93.3 d	100.0 d	100.0 d	100.0 d	100.0 f
Control	*P. expansum* + SCHOLAR @ 0.6 g/L	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	10.0 d
Control	*P. expansum* + MERTECT @ 1.15 g/L	100.0 b	100.0 e	100.0 d	100.0 d	100.0 d	100.0 f
PRISTINE @ 1.2 kg/ha	No wound	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	6.6 c
PRISTINE @ 1.2 kg/ha	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
PRISTINE @ 1.2 kg/ha	*P. expansum* 1 x 10^4 conidia/ml	0.0 a	26.7 b	100.0 d	100.0 d	100.0 d	100.0 f
PRISTINE @ 1.2 kg/ha	*P. expansum* + SCHOLAR @ 0.6 g/L	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	3.3 b
PRISTINE @ 1.2 kg/ha	*P. expansum* + MERTECT @ 1.15 g/L	0.0 a	100.0 e	100.0 d	100.0 d	100.0 d	100.0 f
SCALA @ 0.8/ha	No wound	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
SCALA @ 0.8/ha	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
SCALA @ 0.8/ha	*P. expansum* 1 x 10^4 conidia/ml	0.0 a	0.0 a	3.3 b	40.0 b	40.0 b	50.0 d
SCALA @ 0.8/ha	*P. expansum* + SCHOLAR @ 0.6 g/L	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
SCALA @ 0.8/ha	*P. expansum* + MERTECT @ 1.15 g/L	0.0 a	50.0 c	86.7 c	90.0 c	90.0 c	100.0 f

[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, 83, 111, 139 and 167 days.

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

2010 PMR REPORT # 15 **SECTION K: FRUIT**

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

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TITLE: EFFECT OF PREHARVEST BOSCALID/PYRACLOSTROBIN AND PYRIMETHANIL APPLICATION FOR THE CONTROL OF POSTHARVEST GRAY MOLD IN 'EMPIRE' APPLES. 2009-10.

MATERIALS: PRISTINE (25.2% Boscalid and 12.8% Pyraclostrobin), SCALA SC (Pyrimethanil 400 g ai/L), MERTECT (45 % Thiabendazole) and SCHOLAR (50% Fludioxonil).

METHODS: During the 2009 growing season a field trial was conducted at the Agriculture and Agri-Food Canada Farm in Jordan Station, ON. Apple cv. 'Empire' was maintained according to standard orchard practices. The preharvest treatments include: an unsprayed control, preharvest field applications of PRISTINE (1.2 kg/ha) applied 7 days preharvest, and SCALA (pyrimethanil 800 g ai/ha) applied 14 days preharvest. Trees were treated with Scala on Septeber 21, 2009 and with Pristine on Sept 30, 2009. All fruit were harvested on September 30, 2009. Treatments were replicated 4 times with two trees per replicate, allocated in a completely randomized block design. The apple trees were sprayed with hand-operated gun sprayer at a pressure of 1034.25 kPa, 2.8-3 L of water per tree until runoff. Apples were harvested on October 6, 2009 and stored in cold storage at 0.5 - 2 ºC. On the same day, 12 apples from each of the replicate plots were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base, placed in mesh bags and placed in plastic crates. Wounded fruit were then inoculated with 20 µl conidial suspension ($1x10^4$ conidia/ml of water) thiabendazole-resistant (TBZ-R) *Botrytis cinerea* isolate BC-34R and placed back in cold storage at 0.5 - 2 ºC for 168 days. Postharvest treatments on apples that were treated with preharvest PRISTINE or SCALA include: control with no wound, control wound only, control with *P. expansum* at $1x10^4$ conidia/ml of water, SCHOLAR @ 1.2 g/L and MERTECT @ 1.15 g/L. Twelve fruit were used for each treatment and each treatment had four replicates. The fruit from the postharvest treatments were also incubated for 167 days at 0.5-2 °C. After incubation apples were evaluated for disease incidence once every 4 weeks. 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: Effect on postharvest gray mold of apples (Table 1): When inoculum was introduced in the wounds of the PRISTINE preharvest treated apples, complete control was observed up to 28 days and then the disease increased to 76.7%, 100%, 100%, 100% and 100% by 56, 84, 111, 139 and 167 days, respectively. The combination of MERTECT on apples that were treated with preharvest application PRISTINE also showed 50.0% at 56 and 96.7% at 84 days and 100% disease by day 111. When a combination of postharvest application of SCHOLAR was applied to apples that were treated with preharvest application of PRISTNE or SCALA, a complete control of gray mold was observed for up to

167 days in cold storage. As expected, MERTECT treatment was not effective against TBZ-resistant *B. cinerea* on apples, even on apples that had preharvest application of SCALA or PRISTINE.

Table 1. Effect of preharvest applications of PRISTINE and SCALA alone or in combination with postharvest SCHOLAR and MERTECT on the development of postharvest gray mold (*Botrytis cinerea*) in 'Empire' apples, 2009-10.

Preharvest Application	Postharvest Treatment	Percentage incidence of gray mold (*Botrytis cinerea* TBZ-R) at 0.5 - 2 °C after					
		28 days	56 days	83 days	111 days	139 days	167 days
Control	No Wound	0.0 a[1,2]	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	*B. cinerea* 1 x 10^4 conidia/ml	100.0 c	100.0 d	100.0 b	100.0 c	100.0 d	100.0 e
Control	*B. cinerea* + SCHOLAR @ 0.6/	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	*B. cinerea* + MERTECT @ 1.15 g/L	100.0 c	100.0 d	100.0 b	100.0 c	100.0 d	100.0 e
PRISTINE @ 1.2 kg/ha	No wound	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
PRISTINE @ 1.2 kg/ha	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
PRISTINE @ 1.2 kg/ha	*B. cinerea* 1 x 10^4 conidia/ml	0.0 a	76.7 b	100.0 b	100.0 c	100.0 d	100.0 e
PRISTINE @ 1.2 kg/ha	*B. cinerea* + SCHOLAR @ 0.6 g/L	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
PRISTINE @ 1.2 kg/ha	*B. cinerea* + MERTECT @ 1.15 g/L	50.0 b	96.7 c	100.0 b	100.0 c	100.0 d	100.0 e
SCALA @ 0.8/ha	No wound	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
SCALA @ 0.8/ha	Wound only	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
SCALA @ 0.8/ha	*B. cinerea* 1 x 10^4 conidia/ml	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	20.0 d
SCALA @ 0.8/ha	*B. cinerea* + SCHOLAR @ 0.6 g/L	0.0 a	0.0 a	0.0 a	0.0 a	10.0 b	10.0 b
SCALA @ 0.8/ha	*B. cinerea* + MERTECT @ 1.15 g/L	0.0 a	0.0 a	0.0 a	10.0 b	13.3 c	16.6 c

[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, 83, 111, 139 and 167 days.

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

2010 PMR REPORT # 16 **SECTION K: FRUIT**

CROP: Highbush Blueberry (*Vaccinium corymbosum* L.*)* cv. Duke
PEST: Botrytis Blossom Blight and Fruit Rot *(Botrytis cinerea* Pers.: Fr*)*

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TITLE: EFFICACY OF MOWETTER™ AS A SPRAY ADJUVANT TO FUNGICIDES FOR CONTROL OF BOTRYTIS BLIGHT OF HIGHBUSH BLUEBERRY

MATERIALS: FUNGINEX 190 EC (triforine 195 g/L), MOWETTER (DDAC 7.5%), TOPAS 250 EC (propiconazole 250 g/L), PRISTINE WG (boscalid 25.2%, pyraclostrobin 12.8%), SWITCH 62.5 WG FUNGICIDE (cyprodinil, 37.5%, fludioxonil, 25.0%)

METHODS: The trial was conducted in a 5-year-old field of highbush blueberry, cv. 'Duke' in Pitt Meadows, British Columbia. There were 4 replicates per treatment in a randomized complete block (RCB) design. Each plot measured 10 m long and rows were spaced 3 m apart, for a total plot area of 30 m^2, with 8 plants per plot. A commercial fungicide spray program was followed (Evergro Canada 2010 Blueberry Calendar, copyright Evergro Canada Ltd., Delta, BC, Canada). Four fungicides were tested in five applications: FUNGINEX 190 EC (triforine) at 3 L/ha applied at bud-break (post-pruning by the grower) on Feb. 22nd; TOPAS 250 EC (propiconazole) at 500 mL/ha applied 11 days later on March 5th; PRISTINE WG (boscalid/pyraclostrobin) at 1.3 kg/ha applied at 'pink tip' on March 31st and at full bloom on May 6th; and SWITCH 62.5 WG (cyprodinil/fludioxinil) at 775 g/ha applied at 50% bloom on April 23rd. Treatments were applied as foliar sprays with a CO_2 backpack sprayer at 40 psi (276 kPa) using a triple Teejet 8002VS nozzle boom, in a solution volume of 1000 L/ha and control plots were sprayed with water alone. On March 18, the entire trial area was sprayed by the grower with a combination of TOPAS (pyraclostrobin 250 g/L) at 500 mL/ha, DECIS 5EC (deltamethrin 150 mL/ha), Berry Bud Booster™ fertilizer (12 L/ha), plus MOWETTER™ at 4.0 mL/L and on June 1 with a combination of insecticides and fungicide: DELEGATE (spinetoram 25%), ADMIRE (imidacloprid, 250 g/L) and PRISTINE WG (boscalid 25.2% and pyraclostrobin 12.8%) at label rates, without MOWETTER™. Plants were evaluated for phytotoxicity; blossom blight and Botrytis stem canker incidence (at 50% bloom and at full bloom); as well as disease severity (= mean visual rating of disease severity on a scale of 0-9**,** where 0 = no disease and 9 = highest disease). Botrytis fruit rot was assessed at green fruit stage on June 7 and at ripe fruit stage (harvest) on July 6th. Storage rot was assessed on 800 healthy berries/plot harvested on July 5 and stored in boxes of 200 berries each at 4º C and assessed weekly for 6 weeks. Statistical analysis (ANOVA) was performed using CoStat, Version 6.303 CoHort Software, Monterey, California, USA, © 1998-2004 and means compared in Tukey's HSD at P=0.05.

RESULTS: Results are presented in Tables 1-4. *Botrytis cinerea* was the major blossom and fruit rot pathogen observed in the trial. Little or no Botrytis stem canker was observed. There was a very low incidence of mummyberry shoot blight and mummyberry on fruit. No other pathogens or insect pests were observed. Weather conditions in spring 2010 were highly favourable to botrytis blossom infection and fruit rot. Cool, rainy weather continued from February to the end of June. No phytotoxicity was observed in any treatment.

CONCLUSIONS: Under high disease pressure, a regular commercial spray program using half-rates of fungicides plus MOWETTER™ at 2.0 mL/L for 5 out of 7 fungicide applications, from bud-break (February 22) to full bloom (May 6), controlled Botrytis blossom blight and Botrytis fruit rot of highbush blueberry as well as the same program using the full rates of fungicides alone. Disease incidence and severity were not statistically different (Tukey's HSD at P=0.05) and yield was identical. Half-rates of fungicides alone reduced disease incidence and severity somewhat compared to the water control, but were not as effective as the full rates or half-rates plus MOWETTER™.

In refrigerated storage, the spray program using half-rates of fungicides plus MOWETTER™ at 2.0 mL/L controlled botrytis fruit rot as well as the full rates of fungicides alone for 3 weeks. From 4 to 6 weeks after storage, slightly more Botrytis rot was seen on the berries treated with the half-rate of fungicides plus MOWETTER™ than the full rates alone, but the percentage of rotted berries was still not statistically different from that with the full rates of fungicides alone, either in LSD at P=0.05 or in Duncan's MRT. The number of mummyberries remained low during storage.

No phytotoxicity was observed when MOWETTER was combined with FUNGINEX 190, PRISTINE WG, SWITCH 62.5 WG or TOPAS 250EC, or with DECIS 5EC and foliar fertilizer. Since disease control was equally as good with the combination as the full rates alone, no increased risk of disease resistance would be expected. At current prices, growers could save up to 34.5% by applying half-rates of fungicides plus MOWETTER™ at 2.0 mL/L, compared to full rates of fungicide alone.

Table 1. Botrytis blossom blight of highbush blueberry, cv. 'Duke' at 50 % bloom and 100% bloom.

Treatment	Mean # of Necrotic Blighted Blooms/Lateral Branch [1,2,3]		Mean # of Blossom Clusters with One or More Blighted Blooms, per Plant[1,2,4]		Mean # of Blighted Blooms per Plant[1,2,5]		Mean % Reduction in Botrytis Blossom Blight w.r.t the Control		Mean Disease Severity Visual Rating, 0-9, where 9 = Worst[1,2,6]	
	50 % bloom	100% bloom	50 % bloom	100% bloom	50 % bloom	100% bloom	50 % bloom	100% bloom	50 % bloom	100% bloom
CONTROL	7.8 a	11.3 a	17.2 a	51.0 a	13.4 a	57.6 a	-	-	6.9 a	7.8 a
FUNGICIDE HALF RATE	2.8 b	9.0 b	14.0a b	44.5 a	3.9 ab	40.0 a	70.9	31.6	4.9 ab	7.0 a
FUNGICIDE HALF RATE + MOWETTER	1.6 b	6.6 c	7.7 b	44.5 a	1.2 b	29.4 a	91.0	49.0	2.5 b	5.5 b
FUNGICIDE FULL RATE	2.6 b	7.5 bc	10.1a b	43.0 a	2.6 ab	32.2 a	80.6	44.1	4.2 ab	5.8 b

[1]Numbers in same column followed by same letter are not significantly different in Tukey's HSD at P=0.05.
[2]Mean of 4 replicates per treatment; 8 plants per plot; RCB design.
[3]Counted on 10 branches/plot; each lateral branch has approximately 10 blossom clusters.
[4]Counted on 5 central plants per plot.
[5] Number of blighted blooms per plant =.mean number of blossom clusters with blighted blooms per plant x mean number of blighted blooms per cluster (no. per lateral branch divided by 10) [Column 2 X Column 1/10].
[6]Visual rating of blight severity per plot on a scale of 0-9, where 0 = no disease and 9 = most severe symptoms.

Table 2. Botrytis fruit rot of highbush blueberry, cv. 'Duke' at green fruit stage.

Treatment	Mean # Green Berries with Botrytis Rot[1,2]	Mean % Reduction in Green Berry Botrytis Rot w.r.t the Control	Mean # Shoots with Mummyberry[1,2]
CONTROL	62.0 a (a)	-	3.8 a
FUNGICIDE HALF RATE	32.2 b (b)	48.1	2.8 ab
FUNGICIDE HALF RATE + MOWETTER	19.2 b (c)	69.0	0.2 b
FUNGICIDE FULL RATE	23.0 b (bc)	62.9	2.2 ab

[1]Mean of 4 replicates per treatment; 8 plants per plot; RCB design; counted on 5 central plants per plot.
[2]Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05 (Duncan's MRT in brackets).

Table 3. Botrytis fruit rot of highbush blueberry, cv. 'Duke' at harvest (ripe fruit stage).

Treatment	Mean % Ripe Berries with Botrytis Rot[1,2]	Mean % Reduction in Ripe Berry Botrytis Rot w.r.t the Control	Mean % Mummy-berries[1,2]	Mean % Reduction in the Number of Mummy-berries w.r.t the Control	Mean Estimated Yield (lbs/acre)[1,2,2]	Mean Estimated Yield (kg/ha)[1,2,3]
CONTROL	0.60 a (a)	-	0.554 a	-	5,186 a	5,834 a
FUNGICIDE HALF RATE	0.50 ab (a)	16.7	0.141 b	74.5	5,161 a	5,806 a
FUNGICIDE HALF RATE + MOWETTER	0.31 ab (ab)	48.3	0.020 b	96.4	6,546 a	7,364 a
FUNGICIDE FULL RATE	0.12 b (b)	80.0	0.005 b	99.1	6,491 a	7,302 a

[1]Mean of 4 replicates per treatment; 8 plants per plot; RCB design; counted on 5 central plants per plot.
[2]Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD (Duncan's MRT in brackets) at *P*=0.05.
[3]Yield was estimated by counting the number of berries per cluster and the number of clusters per plant, on five central plants per plot, and multiplying by the average weight per berry (on 800 berries per plot) to obtain the average weight of berries per plant and multiplying by the number of plants per acre.

Table 4. Mean percentage of Botrytis-rotted blueberry fruit per treatment in refrigerated storage.[1]

Treatment	Mean Percentage of Botrytis-rotted Berries per Box after:					
	1 Week Storage[2]	2 Weeks Storage[2]	3 Weeks Storage[2]	4 Weeks Storage[2]	5 Weeks Storage[2]	6 Weeks Storage[2]
CONTROL	0.28 a (a)	0.84 a (a)	2.34 a (a)	3.97 a (a)	7.88 a (a)	14.28 a (a)
FUNGICIDE HALF RATE	0.25 a (ab)	0.59 ab (ab)	2.16 ab (a)	3.88 a (a)	7.00 ab (ab)	12.38 ab (a)
FUNGICIDE HALF RATE + MOWETTER	0.06 b (b)	0.50 ab (ab)	1.50 bc (ab)	4.28 a (a)	6.91 ab (ab)	13.81 ab (a)
FUNGICIDE FULL RATE	0.13 ab (ab)	0.41 b (ab)	1.28 c (b)	2.72 a (a)	4.81 b (ab)	8.81 b (a)

[1]Mean of four replicates per treatment; RCB design; 4 boxes per plot; 200 berries per box; boxes stored at 4^{o} C.
[2]Numbers in the same column followed by the same letter are not significantly different in LSD (Duncan's MRT in brackets) at P=0.05.

2010 PMR REPORT # 17 **SECTION K: FRUIT**

CROP: Grape (*Vitis vinifera* L.) cv. Riesling
PEST: Powdery mildew (*Erysiphe necator* (Schw.) Burr.)

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TITLE: ASSESSMENT OF INSPIRE 250EC FOR CONTROL OF POWDERY MILDEW ON 'RIESLING' GRAPES, 2010.

MATERIALS: INSPIRE 250EC (difenoconazole) and NOVA 40W (myclobutanil).

METHODS: The trial was conducted in 2010 on fifteen-year-old 'Riesling' grapes in a vineyard on the Agriculture and Agri-Food Canada research farm in Jordan Station, Ontario. Vines were spaced 2.5 m apart between rows and 1.5 m apart within rows. Two rates of INSPIRE 250EC (43.8 g a.i./ha and 73 g a.i./ha) were compared to a single rate of NOVA 40W (80 g a.i./ha) and an untreated control. Each treatment was replicated four times and each treatment had 4-5 vines. The trial was arranged according to a randomized complete block design. The fungicides were applied in 2667 L of water per hectare with a Rittenhouse truck-mounted sprayer equipped with a Spraying Systems handgun fitted with a D-6 orifice plate at 200 psi. The first application occurred on 5 May (timed for bud-burst), followed by applications on 25 May, 15 June, 6 July, 23 July, 13 August and 1 September (timed for approximately three week intervals between applications). Assessments for phytotoxicity on the leaves occurred on 12 May, 1 June, 22 June, 13 July, 29 July, 20 August and 9 September by assessing 25 leaves per replicate per treatment. Assessments for disease incidence of powdery mildew (PM) on the grape leaves and bunches occurred on 28 June, 13 July, 29 July, 20 August and 9 September by assessing 25 leaves and 25 bunches per replicate per treatment for PM; the percentage of leaves and bunches infected with PM was recorded per replicate per treatment. Assessments for disease severity of PM on the grape leaves and bunches occurred on 28 June, 13 July, 29 July, 20 August and 9 September by visually estimating the percent infection of PM of each leaf and bunch of 25 leaves and 25 bunches per replicate per treatment; the estimated percent PM infection per leaf and bunch was recorded per replicate per treatment. Data were analyzed using ARM analysis of variance and means separated with a Tukey Test at P=0.05 significance level. The disease incidence of PM data on grape leaves of 13 July and 9 September were not homogeneous and were transformed using arcsine square root (%). The disease severity of PM data on grape leaves and the disease severity of PM data on grape bunches of 13 July were not homogeneous and were transformed using arcsine square root (%). The disease severity of PM data on grape leaves of 20 August were not homogeneous and were transformed using log (x+1). There were no phytotoxicity symptoms seen in any of the treatments during the growing season. The vineyard in which the trial was conducted has a history of very high PM disease pressure.

RESULTS: Data are presented in Tables 1 - 4. On 28 June 2010, there were no powdery mildew (PM) symptoms found on any grape leaves treated with any of the fungicides. On 13 July, 29 July and 20 August, all grape leaves treated with fungicides had a significantly lower incidence of PM compared to the untreated control; there were no significant differences among or between the fungicide treatments. On 9 September, grape leaves treated with either rate of INSPIRE (43.8 g a.i./ha and 73 g a.i./ha) had a significantly lower incidence of PM compared to the untreated control; grape leaves treated with the high rate of INSPIRE had a significantly lower incidence of PM than grape leaves treated with NOVA (Table 1).

On 13 July, grape leaves treated with the high rate of INSPIRE or NOVA had a significantly lower disease severity rating of PM compared to the control; there were no significant differences among or between the fungicide treatments. On 29 July, 20 August and 9 September, grapes leaves treated with any of the fungicides had a significantly lower disease severity rating of PM compared to the untreated control; there were no significant differences among or between any of the fungicide treatments (Table 2).

On 13 July, 29 July, 20 August and 9 September, there were no differences in the incidence of PM on grape bunches among or between any of the fungicide treatments and the control (Table 3).

On 13 July, grape bunches treated with any of the fungicides had a significantly lower disease severity rating of PM compared to the untreated control; there were no significant differences among or between any of the fungicide treatments. On 29 July, grape bunches treated with either rate of INSPIRE had a significantly lower disease severity rating of PM compared to the untreated control; there were no significant differences among or between any of the fungicide treatments. On 20 August and 9 September, there were no significant differences in the disease severity rating of PM on grape bunches among or between any of the fungicide treatments and the control. On 13 July, 29 July, 20 August and 9 September, although not significantly different from the other fungicide treatments, grape bunches treated with the high rate of INSPIRE had the lowest disease severity rating of any of the fungicide treatments (Table 4).

CONCLUSIONS: Applications of INSPIRE 250EC at both rates (43 g a.i./ha and 73 g a.i./ha) were effective in controlling the disease incidence and disease severity of powdery mildew (PM) on grape leaves throughout the entire growing season. Applications of INSPIRE 250EC at the high rate were effective in controlling the disease severity of PM on grape bunches early in the growing season, and although not statistically different from the untreated control, the disease severity of PM on grape bunches was reduced compared to the untreated control at the end of the growing season.

Table 1. Effect of INSPIRE 250EC on disease incidence of powdery mildew (PM) on 'Riesling' grape leaves.

Treatment[1]	Rate (g a.i. /ha)	Disease Incidence (%) of PM on grape leaves				
		28 June (13 days)[2]	13 July (7 days)	29 July (6 days)	20 August (7 days)	9 Sept (8 days)
INSPIRE 250EC	43.8	0.0 a[3]	25.0 b	32.0 b	47.0 b	35.0 bc
INSPIRE 250EC	73	0.0 a	16.0 b	14.0 b	33.0 b	12.0 c
NOVA 40W	80	0.0 a	22.0 b	1.0 b	64.0 b	70.0 ab
CONTROL	-	0.0 a	75.0 a	82.0 a	100.0 a	97.0 a

[1] In 2010, the fungicides were applied on 5 May, 25 May, 15 June, 6 July, 23 July, 13 August and 1 September.
[2] Number of days after third, fourth, fifth, sixth and seventh applications (15 June, 6 July, 23 July, 13 August and 1 September, respectively).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey test.

Table 2. Effect of INSPIRE 250EC on disease severity of powdery mildew (PM) on 'Riesling' grape leaves.

Treatment[1]	Rate (g a.i. /ha)	Disease Severity (%) of PM on grape leaves				
		28 June (13 days)[2]	13 July (7 days)	29 July (6 days)	20 August (7 days)	9 Sept (8 days)
INSPIRE 250EC	43.8	0.00 a[3]	8.82 ab	8.93 b	12.60 b	31.49 b
INSPIRE 250EC	73	0.00 a	6.20 b	6.17 b	8.46 b	11.67 b
NOVA 40W	80	0.00 a	7.27 b	6.89 b	10.26 b	33.41 b
CONTROL	-	0.00 a	27.69 a	22.55 a	60.00 a	80.09 a

[1] In 2010, the fungicides were applied on 5 May, 25 May, 15 June, 6 July, 23 July, 13 August and 1 September.
[2] Number of days after third, fourth, fifth, sixth and seventh applications (15 June, 6 July, 23 July, 13 August and 1 September, respectively).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey test.

Table 3. Effect of INSPIRE 250EC on disease incidence of powdery mildew (PM) on 'Riesling' grape bunches.

Treatment[1]	Rate (g a.i. /ha)	Disease Incidence (%) of PM on grape bunches				
		28 June (13 days)[2]	13 July (7 days)	29 July (6 days)	20 August (7 days)	9 Sept (8 days)
INSPIRE 250EC	43.8	0.00 a[3]	75.0 a	78.0 a	92.0 a	90.0 a
INSPIRE 250EC	73	0.00 a	69.0 a	71.0 a	88.0 a	81.0 a
NOVA 40W	80	0.00 a	71.0 a	85.0 a	93.0 a	90.0 a
CONTROL	-	0.00 a	100.0 a	94.0 a	96.0 a	96.0 a

[1] In 2010, the fungicides were applied on 5 May, 25 May, 15 June, 6 July, 23 July, 13 August and 1 September.
[2] Number of days after third, fourth, fifth, sixth and seventh applications (15 June, 6 July, 23 July, 13 August and 1 September, respectively).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey test.

Table 4. Effect of INSPIRE 250EC on disease severity of powdery mildew (PM) on 'Riesling' grape bunches.

Treatment[1]	Rate (g a.i. /ha)	Disease Severity (%) of PM on grape bunches				
		28 June (13 days)[2]	13 July (7 days)	29 July (6 days)	20 August (7 days)	9 Sept (8 days)
INSPIRE 250EC	43.8	0.00 a[3]	11.37 b	32.95 b	53.71 a	57.06 a
INSPIRE 250EC	73	0.00 a	7.45 b	18.60 b	26.64 a	37.26 a
NOVA 40W	80	0.00 a	9.93 b	37.22 ab	54.34 a	66.33 a
CONTROL	-	0.00 a	58.25 a	79.79 a	83.84 a	89.90 a

[1] In 2010, the fungicides were applied on 5 May, 25 May, 15 June, 6 July, 23 July, 13 August and 1 September.
[2] Number of days after third, fourth, fifth, sixth and seventh applications (15 June, 6 July, 23 July, 13 August and 1 September, respectively).
[3] Means of four replicates within a column followed by the same letter are not significantly different at $P<0.05$, Tukey test.

2010 PMR REPORT # 18 **SECTION K: FRUIT**

CROP: Peach (*Prunus persica*) cv. Redhaven
PEST: Brown rot (*Monilinia fructicola*)

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TITLE: EFFECT OF LIME SULPHUR ON THE CONTROL OF POSTHARVEST BROWN ROT *(MONILINIA FRUCTICOLA*) ON 'REDHAVEN' PEACHES, 2010.

MATERIALS: LIME SULPHUR (23% Lime sulphur)

METHODS: Immature fruit (14 days pre commercial harvest) were harvested on 05 August, 2010 from Agriculture and Agri-Food Canada research farm in Jordan Station, Ontario and stored at 0.5-2 °C. Mature fruit were harvested from the same plot on 19 August, 2010. On 20 August, the fruit were placed into plastic fruit inserts within a plastic tote and wounded by puncturing the peach once with a needle to a depth of 10 mm. Peaches were then inoculated with 15 μl of *Monilinia fructicola* ($1x10^4$ conidia/mL). After 5, 10 and 24 hours of inoculation, the peaches were sprayed with a 3.45 a.i. LIME SULPHUR solution. The control treatment did not receive any LIME SULPHUR. The fruit were incubated at 20 °C for 5 days. There were 8 fruit per replicate and 6 replicates per treatment. At the end of the incubation period, the following measurements, disease incidence, lesion diameter, percent lesion area with conidia were recorded. Fruit were considered decayed when a lesion developed on the fruit. The data obtained were analyzed by analysis of variance (ANOVA) using appropriate transformations and significance between means was separated by the Tukey test.

RESULTS: Results are presented in Table 1.

CONCLUSIONS: LIME SULPHUR treated peaches had significantly less brown rot than the untreated control. The comparison between immature and mature fruit showed that the mature fruit had higher disease incidence in both control and LIME SULPHUR treated peaches. There was no significant difference in brown rot incidence among LIME SULPHUR treatments, when comparing the different application times 5, 10, 24 hours after inoculation.

Table 1. Effect of lime sulphur on control of postharvest brown rot *Monilinia fructicola* on immature and mature fruit of 'Redhaven' peach. 2010.

Treatment post inoculation with *M. fructicola*	Brown rot after 5 days of inoculation	
	Immature fruit	Mature fruit
	Brown rot Incidence	Brown rot Incidence
Control, water only after 5 hours	62.5 b	56.3 b
Control, water only after 10 hours	66.7 bc	68.8 c
Control, water only after 24 hours	74.3 c	60.4 bc
LIME SULPHUR @ 15 ml/L after 5 hours	0 a	0 a
LIME SULPHUR @ 15 ml/L after 10 hours	0 a	0 a
LIME SULPHUR @ 15 ml/L after 24 hours	0 a	0 a

[1] Data represents the mean of six replicates.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at $P = 0.05$.

2010 PMR REPORT # 19 **SECTION K: FRUIT**

CROP: Peach (*Prunus persica*) cv. Harrow Diamond
PEST: Brown rot (*Monilinia fructicola*)

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TITLE: EFFECT OF LIME SULPHUR ON THE CONTROL OF POSTHARVEST BROWN ROT *(MONILINIA FRUCTICOLA*) ON 'HARROW DIAMOND' PEACHES, 2010.

MATERIALS: LIME SULPHUR (23% Lime sulphur)

METHODS: Immature fruit (14 days pre commercial harvest) were harvested on 13 July, 2010 from Agriculture and Agri-Food Canada research farm in Jordan Station, Ontario and stored at 0.5-2 °C. Mature fruit were harvested from the same plot on 27 July, 2010. On 28 July, the fruit were placed into plastic fruit inserts within a plastic tote and wounded by puncturing the peach once with a needle to a depth of 10 mm. Peaches were then inoculated with 15 µl of *Monilinia fructicola* ($1x10^4$ conidia/mL). After 5, 10 and 24 hours of inoculation, the peaches were sprayed with a 3.45 a.i. LIME SULPHUR solution. The control treatment did not receive any LIME SULPHUR. The fruit were incubated at 20 °C for 5 days. There were 8 fruit per replicate and 6 replicates per treatment. At the end of the incubation period, the following measurements, disease incidence, lesion diameter, percent lesion area with conidia were recorded. Fruit were considered decayed when a lesion developed on the fruit. The data obtained were analyzed by analysis of variance (ANOVA) using appropriate transformations and significance between means was separated by the Tukey test.

RESULTS: Results are presented in Table 1.

CONCLUSIONS: LIME SULPHUR treated peaches had significantly less brown rot than the untreated control. The comparison between immature and mature fruit showed that the mature fruit had higher disease incidence in both control and LIME SULPHUR treated peaches. There was no significant difference in brown rot incidence among LIME SULPHUR treatments, when comparing the different application times 5, 10, 24 hours after inoculation.

Table 1. Effect of lime sulphur on control of postharvest brown rot *Monilinia fructicola* on immature and mature fruit of 'Harrow Diamond' peach. 2010.

Treatment post inoculation with *M. fructicola*	Brown rot after 5 days of inoculation	
	Immature fruit	Mature fruit
	Brown rot Incidence	Brown rot Incidence
Control, water only after 5 hours	87.5 c [1,2]	95.8 b
Control, water only after 10 hours	83.3 bc	93.8 b
Control, water only after 24 hours	81.3 b	100 c
LIME SULPHUR @ 15 ml/L after 5 hours	2.1 a	8.3 a
LIME SULPHUR @ 15 ml/L after 10 hours	2.5 a	6.6 a
LIME SULPHUR @ 15 ml/L after 24 hours	2.1 a	8.3 a

[1] Data represents the mean of six replicates.
[2] Means within the column followed by the same letter are not significantly different according to the Tukey test at $P = 0.05$.

2010 PMR REPORT # 20 **SECTION K: FRUIT**

CROP: Strawberry cv. Jewel (*Fragaria* x *ananassa* Duchesne)
PEST: Black Root Rot, *Rhizoctonia fragariae* Husain and W.E. McKeen (teleomorph *Ceratobasidium* spp.)

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TITLE: EFFECT OF TIMING AND METHOD OF APPLICATION OF AZOXYSTROBIN AND FLUDIOXINIL ON THE SEVERITY ON THE INCIDENCE OF RHIZOCTONIA SPP. ASSOCIATED WITH BLACK ROOT ROT OF STRAWBERRY CV. JEWEL

MATERIALS: SCHOLAR 230 SC (230 g.a.i./L fludioxonil), QUADRIS FLOWABLE (250 g.a.i./L azoxystrobin)

METHODS: One year old strawberry cv. Jewel bare root transplants crowns were obtained from a reputable strawberry nursery. Some bare root transplants were dipped for 5 min. in a 400 L solution of QUADRIS FLOWABLE (230 ml formulated product/400 L of water), or SCHOLAR 230 SC (272 ml formulated product/400 L of water), or 400 L of water, allowed to dry for one hour and planted (14 May 2008) in separate plots in a natural field previously diagnosed with Black rot rot. Each plot consisted of two 6 m rows of strawberry transplants planted 30 cm apart in matted rows space 91 cm apart. Bare root strawberry transplants planted in separate plots were drenched with either QUADRIS FLOWABLE at 6 ml product/100 m of row in 1200 L water/ha (1.1 L product/ha), or SCHOLAR 230 SC at 6.5 ml product/100 m of row (1.2 L product/ha), or 1200 L/ha of water either immediately after planting (14 May 2008) or 8 days after planting (22 May 2008). The post-plant drenches were applied as a 20 cm band over the row to each of 2 rows per plot using a hand held wand sprayer (RandD Sprayers, Opelousas, LA) with a single adjustable cone nozzles propelled with CO_2 at 280 kPa using a water volume of 1200 L/ha. The treatments were replicated 4 times and arranged in a Randomized Complete Block Design. The strawberry crop was maintained using best management practices and weeded periodically using both mechanical and registered herbicide throughout the experiment.

Prior to treating and planting (14 May 2008), 32 bare root strawberry transplants were divided into 4 batches of 8 plants, washed and assessed for crown rot severity (0 = no disease; 1 = slight discolouration in crown; 2 = Slight crown rot - Small lesion 1- 5% crown rotted; 3 = Moderate Crown Rot lesion size 6-25% crown rotted; 4 = Severe Crown rot >25%; 5 = plants dead with crown completely rotted) and root rot severity (0 = no disease; 1 = 1-2 small lesions on roots; 2 = 1-3 completely rotted roots or 5-6 roots with small lesions; 3 = 4-6 completely rotted roots; 4 = 7-10 completely rotted roots; 5 = dead plant roots; all roots completed rotted). The crowns and a ten 1cm long root pieces with visible lesions/batch were

excised from the washed strawberry plants, surface disinfested in a 0.6% sodium hypochlorite solution for 2.5 minutes, rinsed in sterile water, plated on acidified potato dextrose agar (APDA) (Difco potato dextrose agar with 0.7 ml 50% lactic acid/L added after autoclaving) or water agar (10g/L Fisher Scientific laboratory grade agar per litre of deionized water) (WA), and incubated at 22^{o}C for 5 days. Fungal colonies that grew from the crown and root pieces were identified by morphological characteristics. Cultures identified as *Rhizoctonia* spp. were enumerated, subcultured and stored at 4^{o}C in vials containing Difco potato dextrose agar (PDA).

Ten strawberry plants with roots were randomly selected and carefully dug from each plot 21 (4 June 2008), 61 (16 July 2008), 91 (13 August 2008), 377 (25 May 2009), and 426 (13 July 2009) days after planting. The plants were washed free of soil and rated for crown rot (0-5) and root rot severity (0-5) as above. Ten crowns and ten 1cm long root pieces with visible lesions from the washed strawberry plants/plot were excised, surface disinfested, plated on APDA or WA, and incubated at 22^{o}C for 5 days as above. Fungal colonies that grew from the crown and root pieces were identified by morphological characteristics. Cultures identified as *Rhizoctonia* spp. were enumerated, subcultured and stored at 4^{o}C in vials containing PDA as above. Crown rot, root rot and incidence of *Rhizoctonia* spp. from crowns and root lesion progress curves were constructed from the data collected. Area under the crown rot severity progress curves (AUCRSC), area under the root rot severity progress curves (AURRSC), area under the incidence of *Rhizoctonia* spp. from crowns progress curve (AUIRhCC) and area under the incidence of *Rhizoctonia* spp. from root lesion progress curve (AUIRhRC) were calculated for each plot and tested for interactions between the fungicide treatments and method of application. The incidence of *Rhizoctonia* spp. from crowns and root lesions data was transformed using the arcsine transformation (X+0.1) to improve normality and additivity. A protected least significant difference test was used to detect differences among the means and transformed means at P=0.05; however, actual means are presented.

RESULTS: No significant interaction between treatment and application method and timing was detected in the ANOVA analysis, so data were combined and analyzed as main effects. Crown and root rot severity was low and *Rhizoctonia* spp. was not isolated from crown tissue or root lesions in strawberry transplants used in this experiment prior to planting. Crown rot and root rot severity progressed gradually over time throughout the experiment (Table 1, 2, 5and 6). The incidence of *Rhizoctonia* spp. progress more in crowns and roots of strawberry plants that were treated with water compared to plants treated with either QUADRIS FLOWABLE or SCHOLAR 230 SC (Table 3, 4, 7 and 8). None of the fungicide treatments significantly affect the progress of crown rot severity (Table 1); however, both QUADRIS FLOWABLE and SCHOLAR 230 SC significantly reduced the progress of root rot severity (Table 5) and incidence of *Rhizoctonia* spp. in crowns (Table 3) and root lesion compared to water (Table 7). Crown rot severity did not appear to be affected by the method or timing of application (Table 2) whereas root rot severity appeared to be slightly and consistently higher in plants that were drenched 8 days after planting (Table 6). The incidence of *Rhizoctonia* spp. appeared to progress more in crown tissue (Table 3) and root lesions (Table 7) towards the end of the experiment. Pre-dipping strawberry transplants significantly reduced the progress of root rot severity compared to a post-drench 8 days after planting but not immediately after planting (Table 6). No significant difference in the method and timing of application were observed for the progress of the crown rot severity (Table 2) or the incidence of *Rhizoctonia* spp. in strawberry root lesions (Table 8). However, a significantly lower incidence of *Rhizoctonia* spp. at the end of the experiment was observed in crowns grown from transplants drenched immediately after transplanting compared to crowns grown from transplants that received a preplant dip (Table 4).

Severe frost on several occasions during the spring of 2009 compromised yield assessments.

CONCLUSIONS: QUADRIS FLOWABLE and SCHOLAR 230 SC significantly reduced the progress of root rot severity and incidence of *Rhizoctonia* spp. in crowns and root lesion compared to water. No difference in the method and timing of application were observed for the progress of crown rot severity. Strawberry transplants treated with QUADRIS FLOWABLE and SCOLAR had a lower root rot severity (Table 5), incidence of *Rhizoctonia* spp. in crowns (Table 3) and root lesions (Table 7) compared to transplants treated with water throughout most of the experiment.

Table 1. The effect of QUADIRS FLOWABLE and SCOLAR 230 SC on the severity of Crown Rot in Strawberry cv Jewel and Area Under the Crown Rot Severity Progress Curve (AUCRSC).

Fungicide	Crown Rot Severity (0-5)						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUCRSC
UNTREATED WATER	1.1 a[1]	1.2 a	1.6 a	1.4 a	1.7 a	2.4 a	666.1 a
QUADRIS FLOWABLE	1.1 a	0.9 a	1.7 a	1.2 a	1.7 a	2.1 a	621.4 a
SCHOLAR 230 SC	1.1 a	0.9 a	1.5 a	1.3 a	1.4 a	2.1 a	593.5 a

[1.] Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 2. The effect of application method and timing on the severity of Crown Rot in Strawberry cv Jewel and Area Under the Crown Rot Severity Progress Curve (AUCRSC).

Application method and timing	Crown Rot Severity (0-5)						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUCRSC
PRE-PLANT DIP	1.1 a[1]	0.7 a	1.6 a	1.2 a	1.7 a	2.1 a	600.4 a
20 CM BAND OVER FURROW AT PLANTING	1.1 a	1.1 a	1.4 a	1.3 a	1.7 a	2.2 a	635.6 a
20 CM BAND OVER TRANSPLANTS 8 DAYS AFTER PLANTING	1.1 a	1.1 a	1.7 a	1.5 a	1.5 a	2.4 a	645.0 a

[1.] Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 3. The effect of QUADIRS FLOWABLE and SCOLAR 230 SC on the incidence of *Rhizoctonia* spp. in Strawberry cv Jewel crowns and Area Under the Incidence of *Rhizoctonia* from Crowns Progress Curve (AUIRhCC).

Fungicide	% Incidence of *Rhizoctonia* spp. in Crowns						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUIRhCC
UNTREATED WATER	0.0 a[1]	8.3 a	20.0 a	40.0 a	58.3 a	74.2 a	18862 a
QUADRIS FLOWABLE	0.0 a	0.0 a	5.8 b	8.3 b	22.5 b	58.3 ab	6719 b
SCHOLAR 230 SC	0.0 a	3.3 a	5.8 b	13.3 b	27.5 b	45.8 b	8142 b

[1.] % Incidence data was transformed using arcsine (X + 0.1) to improve normality and additivity, however, actual means are presented. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 4. The effect of application method and timing on the incidence of *Rhizoctonia* spp. in Strawberry cv Jewel crowns and Area Under the Incidence of *Rhizoctonia* Progress from Crowns Curve (AUIRhCC).

Application method and timing	% Incidence of *Rhizoctonia* spp. in Crowns						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUIRhCC
PRE-PLANT DIP	0.0 a[1]	5.0 a	7.5 a	21.7 a	35.8 a	69.2 a	11535 a
20 CM BAND OVER FURROW AT PLANTING	0.0 a	3.3 a	11.7 a	21.7 a	30.8 a	54.2 b	10425 a
20 CM BAND OVER TRANSPLANTS 8 DAYS AFTER PLANTING	0.0 a	3.3 a	12.5 a	18.3 a	41.7 a	55.0 ab	11763 a

% Incidence data was transformed using arcsine (X + 0.1) to improve normality and additivity, however, actual means are presented. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 5. The effect of QUADIRS FLOWABLE and SCOLAR 230 SC on the severity of Root Rot in Strawberry cv Jewel and Area Under the Root Rot Severity Progress Curve (AURRSC).

Fungicide	Root Rot Severity (0-5)						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AURRSC
UNTREATED WATER	1.8 a[1]	2.4 a	2.4 a	2.5 a	2.5 a	2.9 a	1058.3 a
QUADRIS FLOWABLE	1.8 a	2.1 b	2.5 a	2.1 b	2.1 b	2.5 b	912.4 b
SCHOLAR 230 SC	1.8 a	2.2 ab	2.4 a	2.2 b	2.4 a	2.6 b	968.7 b

1. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 6. The effect of application method and timing on the severity of Root Rot in Strawberry cv Jewel and Area Under the Root Rot Severity Progress Curve (AURRSC).

Application method and timing	Root Rot Severity (0-5)						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AURRSC
PRE-PLANT DIP	1.8 a[1]	1.9 c	2.3 a	2.1 a	2.3 a	2.6 b	944.0 b
20 CM BAND OVER FURROW AT PLANTING	1.8 a	2.2 b	2.4 a	2.3 a	2.3 a	2.7 ab	976.9 ab
20 CM BAND OVER TRANSPLANTS 8 DAYS AFTER PLANTING	1.8 a	2.5 a	2.5 a	2.4 a	2.4 a	2.8 a	1018.5 a

1. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 7. The effect of QUADIRS FLOWABLE and SCOLAR 230 SC on the incidence of *Rhizoctonia* spp. in Strawberry cv Jewel root lesions and Area Under the Incidence of *Rhizoctonia* from root lesions Progress Curve (AUIRhRC).

Fungicide	% Incidence of *Rhizoctonia* spp. in Root Lesions						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUIRhRC
UNTREATED WATER	0.0 a[1]	3.3 a	8.3 a	11.7 a	20.0 a	19.6 a	6066.5 a
QUADRIS FLOWABLE	0.0 a	1.7 a	0.8 b	0.0 b	5.4 b	12.9 a	1303.8 b
SCHOLAR 230 SC	0.0 a	5.0 a	0.8 b	0.0 b	5.4 b	7.9 a	1282.9 b

1. % Incidence data was transformed using arcsine (X + 0.1) to improve normality and additivity, however, actual means are presented. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

Table 8. The effect of application method and timing on the incidence of *Rhizoctonia* spp. in Strawberry cv Jewel root lesions and Area Under the Incidence of *Rhizoctonia* from root lesions Progress Curve (AUIRhRC).

Application method and timing	% Incidence of *Rhizoctonia* spp. in Root Lesions						
	05/14/08	06/04/08	07/16/08	08/13/08	05/25/09	07/13/09	AUIRhRC
PRE-PLANT DIP	0.0 a[1]	5.0 a	3.3 a	0.8 a	15.4 a	20.0 a	3473.1 a
20 CM BAND OVER FURROW AT PLANTING	0.0 a	1.7 a	3.3 a	3.3 a	6.3 a	11.7 a	2026.9 a
20 CM BAND OVER TRANSPLANTS 8 DAYS AFTER PLANTING	0.0 a	3.3 a	3.3 a	7.5 a	9.2 a	8.8 a	3153.1 a

1. % Incidence data was transformed using arcsine (X + 0.1) to improve normality and additivity, however, actual means are presented. Figures within columns followed by different letters are significantly different using a protected LSD (P<0.05).

2010 PMR REPORT # 21 **SECTION L: VEGETABLE and SPECIAL CROPS**

CROP: Carrot (*Daucus carota* subsp. *sativus* (Hoffm.) Arcang), cvs. Enterprise, Dominion
PEST: Sclerotinia rot of carrot (*Sclerotinia sclerotiorum* (Lib.) de Bary)

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TITLE: DEMONSTRATION OF CARROT FOLIAGE TRIMMING TECHNOLOGY FOR THE CONTROL AND MANAGEMENT OF *SCLEROTINIA SCLEROTIORUM* AND SCLEROTINIA ROT OF CARROTS IN ONTARIO, 2010

METHODS: The field trials were conducted at two sites in the Holland Marsh, Ontario in organic soil naturally infested with *Sclerotinia sclerotiorum*. Carrots, cv. Enterprise, were direct seeded (66 seeds/m) into raised hills 71 cm apart (pH 7.5, organic matter 49.9%) on 26 May (Site 1). At site 2, a commercial carrot field, carrots cv. Dominion, were seeded into raised hills 76 cm apart on 18 May. On 17 September (Site 1) and 24 September (Site 2) carrot foliage was trimmed using a tractor mounted custom built carrot trimmer. At Site 1, trimmed and untrimmed blocks were 6 hills wide, and 60 m long. At the commercial field (Site 2), two 12-hill wide blocks, ≈ 800 m long were trimmed, separated by 24 untrimmed hills ≈ 800 m in length. A replicated measurement t-Test design with four replicates per treatment was used at both sites. On 18 October (Site 1) and 8 October (Site 2), two 1.16 m sections of row were harvested to determine yield and a 2 m section was visually assessed for sclerotinia infection in petioles and in the between-row foliage mat. The incidence of sclerotinia rot on carrot foliage was evaluated as the percentage of plants in the assessment area that had at least one lesion per leaf or petiole. Pulled carrots were placed in plastic tote boxes, weighed to determine yield, stacked on pallets and stored in Filacell storage at ≈ 1° C, 95% RH. Storage assessments will be made every 2 months throughout the winter 2010-2011. Compared to the averaged previous 10 years, the air temperatures in 2010 were average for June (18.4°C), September (15.5°C) and October (9.4°C), above average for May (15.1°C), July (22.3°C) and August (21.1°C). The long term previous 10 year average temperatures were: May 13.1°C, June 18.4°C, July 20.0°C, August 19.3°C, September 15.5°C and October 8.9°C. Monthly rainfall was below the previous long term 10 year for May (51.7 mm), average for October (60.4 mm), and above average for June (170 mm), July (146 mm), August (74 mm) and September (95 mm). The long term previous 10 years average rainfall were: May 87 mm, June 74 mm, July 76 mm, August 57 mm, September 72 mm and October 58.3 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: As presented in Tables 1 and 2

CONCLUSIONS: Disease pressure was low at Site 1. No significant differences were found in percent infected with sclerotinia, average number of mats or in yield (Table 1). At Site 2 significant differences were found in percent of plants infected with sclerotinia (Table 2). Carrots that were trimmed with the carrot trimmer had a significantly lower percentage of carrots infected with sclerotinia than untrimmed carrots. In trimmed carrots, sclerotinia developed in the mat of dead leaves between the rows rather than in petioles attached to the plant as in the untrimmed carrots. There were no significant differences in average number of mats or in yield at Site 2 (Table 2).

ACKNOWLEDGEMENTS: Funding for this project was provided by the Risk Reduction Program of Agriculture and Agri-Food Canada and the OMAFRA/U niversity of Guelph Plant Production Systems Program.

Table 1. Field sclerotinia assessment and yield evaluation of canopy trimming with the carrot trimmer for the management of *Sclerotinia sclerotiorum*, at Site 1, Holland Marsh, Ontario, 2010.

Treatment	% Carrots Infected With Sclerotinia	Average Number of Mats[2]	Yield (t/ha)
Trimmed	1.5 ns[1]	1.0 ns	90.8 ns
Untrimmed	1.8	0.5	96.5

[1] ns indicated no significant differences were found among the treatments
[2] Number of mats indicates sclerotinia found in the dead leaves between the rows and not attached to a carrot.

Table 2. Percent sclerotinia and yield evaluation of canopy trimming with the carrot trimmer for the management of *Sclerotinia sclerotiorum,* at Site 2, Holland Marsh, Ontario, 2010.

Treatment	% Carrots Infected With Sclerotinia	Average Number of Mats[3]	Yield (t/ha)
Trimmed	0.0 a[1]	5.2 ns[2]	61.7 ns
Untrimmed	12.0 b	2.5	62.2

[1] Numbers in a column followed by the same letter were not significantly different at $P = 0.05$, Fisher's Protected LSD test.
[2] ns indicated no significant differences were found among the treatments
[3] Number of mats indicates sclerotinia found in the dead leaves between the rows and not attached to a carrot.

2010 PMR REPORT # 22 **SECTION L: VEGETABLE and SPECIAL CROPS**

CROP: Head lettuce (*Lactuca sativa* L.), cv. Mighty Joe
PEST: Downy mildew (*Bremia lactucae* Regel)

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TITLE: **EVALUATION OF FUNGICIDES FOR CONTROL OF DOWNY MILDEW (*BREMIA LACTUCAE*) ON LETTUCE, 2010**

MATERIALS: PRESIDIO® (fluopicolide 39.5%), RIDOMIL® GOLD MZ (metalaxyl-M 4% + mancozeb 64%), PHOSTROL® (mono- and dibasic sodium, potassium, and ammonium phosphites 53.6%), RANMAN 400 SC (cyazofamid 34.5%), REVUS® 250 SC (mandipropamid 23.3%), QGU 42 (Experimental, DuPont), SERENADE® MAX (*Bacillus subtilis* (QST 713 Strain) 7.3 x 10^9 CFU/g)

METHODS: Lettuce, cv. Mighty Joe, was seeded into 128-cell plug trays on 18 June, hand-transplanted (4 plants/m) into organic soil (pH ≈ 6.6, organic matter ≈ 72.3%) on 23 July at the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four 6 m long rows, 42 cm apart. Treatments were: PRESIDIO at 292 mL/ha, RIDOMIL GOLD MZ at 2.5 kg/ha, PHOSTROL at 4.3 L/ha, RANMAN 400 SC at 200 mL/ha, REVUS at 600 mL/ha, QGU 42 at 350 mL/ha and SERENADE MAX at 6.0 kg/ha. An untreated check was also included. Treatments were applied on 5, 12, 20 and 27 August 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 (boom). Prior to the 1st assessment, 10 plants to be assessed per experimental unit were randomly chosen and marked with stakes. Plants were assessed for disease incidence and severity. Disease severity was rated on a scale of 1 to 5: 0 = no lesions, 1 = 1 lesion, 2 = 2-5 lesions, 3 = 6-10 lesions, 4 = 11-15 lesions, 5 = >15 lesions on 25, 31 August and 7 September. These values were used to calculate the area under disease progress curve (AUDPC) and disease severity index (DSI). AUDPC was calculated using the following equation:

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

Where j is the order index for the times and n_j is the total number of assessments, y_j is the downy mildew severity rating at day t_j, y_{j+1} is the downy mildew severity rating at day t_{j+1} and $(t_{j+1} - t_j)$ is the number of days between two assessments. Disease severity index was determined using the following equation:

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

On 8 September, 20 heads from unmarked plants were harvested and trimmed to remove all leaves with visible downy mildew lesions. Untrimmed and trimmed weights were recorded to determine harvest and marketable weights. Percent marketable weight was calculated as the trimmed weight divided by the untrimmed weight. Compared to the averaged previous 10 years, the air temperatures in 2010 were average for June (18.4°C) and September (15.5°C), above average for May (15.1°C), July (22.3°C) and August (21.1°C). The long term previous 10 year average temperatures were: May 13.1°C, June 18.4°C, July 20.0°C, August 19.3°C and September 15.5°C. Monthly rainfall was below previous long term 10 years average for May (51.7 mm) and above average for June (170 mm), July (146 mm), August (74 mm)

and September (95 mm). The long term previous 10 year average rainfall averages were: May 87 mm, June 74 mm, July 76 mm, August 57 mm and September 72 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 Tukey's HSD test at $P = 0.05$ level of significance.

RESULTS: As presented in Tables 1 and 2

CONCLUSIONS: In 2010 disease pressure was high and increased over the assessment period. BREMCAST, the lettuce downy mildew forecasting model, predicted sporulation infection periods (SIP) during the growing season starting mid-July and the risk of developing downy mildew remained moderate to high until September. Lettuce downy mildew symptoms started to develop around mid to late July in the Holland Marsh.

Significant differences in downy mildew incidence and severity were found among the treatments. In general, downy mildew incidence and severity was lower in lettuce treated with PHOSTROL, RIDOMIL or QUG 42 than the remaining fungicides and the untreated check (Table 1). Season-long disease development, as indicated by the AUDPC, was lower in lettuce treated with PHOSTROL, RIDOMIL or QUG 42 than in lettuce treated with REVUS, PRESIDIO, RANMAN, SERENADE MAX and lettuce from the untreated check. Downy mildew incidence, severity and AUDPC in lettuce treated with fungicides PRESIDIO, RANMAN or SERENADE MAX was not better than the untreated check at any assessment date. However, AUDPC, disease incidence (25 Aug and 7 Sept assessments) and DSI (31 Aug assessment) on lettuce treated with REVUS was lower than the untreated check.

Significant differences were found in marketable yield and percent marketable weight among the treatments. Lettuce treated with the commercial standard RIDOMIL, and newer products QGU 42, REVUS and PHOSTROL had significantly higher marketable yield than lettuce treated with RANMAN, SERENADE MAX and the untreated check (Table 2). The marketable weight per head and percent marketable weight of lettuce treated with RANMAN or SERENADE MAX was similar to that of the untreated check (Table 2).

ACKNOWLEDGEMENTS: Funding for this project was provided by the Fresh Vegetable Growers of Ontario through the Farm Innovation Program (FIP) that is part of Growing Forward, a federal-provincial-territorial initiative. The FIP program is administered by the Agricultural Adaptation Council.

Table 1. Downy mildew (DM) incidence and disease severity ratings for lettuce, cv. Mighty Joe, treated with fungicides, grown at the Muck Crops Research Station, Holland Marsh, 2010.

Treatment	Rate (per ha)	DM Incidence (%)			Disease Severity Index			AUDPC[2]
		25 Aug	31 Aug	7 Sept	25 Aug	31 Aug	7 Sept	
PHOSTROL	4.3 L	12.5 a[1]	15.0 ab	7.5 a	5.0 a	5.0 a	2.0 a	2.7 a
RIDOMIL	2.5 kg	27.5 a	2.5 a	15.0 a	8.0 a	1.0 a	5.0 ab	2.4 a
QGU 42	350 mL	30.0 a	42.5 b	35.0 ab	9.5 a	16.5 a	14.0 ab	9.2 a
REVUS	600 mL	40.0 a	95.0 c	57.5 bc	15.0 a	51.5 b	31.5 b	25.3 b
PRESIDIO	292 mL	100.0 b	100.0 c	97.5 cd	69.5 b	75.0 bc	85.5 c	49.8 c
RANMAN	200 mL	87.5 b	100.0 c	100.0 d	65.0 b	87.0 c	93.5 c	54.4 c
SERENADE MAX	6.0 kg	100.0 b	100.0 c	100.0 d	78.5 b	88.5 c	100.0 c	58.0 c
Check	--	100.0 b	100.0 c	100.0 d	78.5 b	96.0 c	100.0 c	60.5 c

[1] Numbers in a column followed by a different letter were significantly different at $P = 0.05$, based on Tukey's HSD test.
[2]AUDPC = Area under the disease progress curve.

Table 2. Yield data for lettuce, cv. Mighty Joe, treated with fungicides, grown at the Muck Crops Research Station, Holland Marsh, 2010.

Treatment	Rate (per ha)	Marketable wt/head (g)	% Marketable Wt
RIDOMIL	2.5 kg	789.9 a[1]	74.8 a
QGU 42	350 mL	686.8 ab	75.2 a
REVUS	600 mL	667.0 ab	68.4 ab
PHOSTROL	4.3 L	656.8 ab	75.2 a
PRESIDIO	292 mL	582.4 bc	60.6 ab
RANMAN	200 mL	420.5 cd	64.1 ab
SERENADE MAX	6.0 kg	376.3 d	63.5 ab
Check	--	395.9 d	51.4 b

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

2010 PMR REPORT# 23 SECTION L: VEGETABLES and SPECIAL CROPS

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

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TITLE: EVALUATION OF RANCONA SEED TREATMENTS FOR CONTROL OF ONION SMUT IN YELLOW COOKING ONIONS, 2010

OBJECTIVE: To test film coated onion seed to control onion smut.

MATERIALS: RANCONA (ipconazole 41%), DITHANE (mancozeb 75%), PRO-GRO (thiram 50%, carboxin 30%), SEPRESTO (clothianidin 56.25%, imidacloprid 18.75%).

METHODS: Seed treatments for yellow cooking onions, cv. Pulsar, were evaluated in a field trial on organic soil (pH ≈ 5.8, organic matter ≈ 78.6%) naturally infested with *Urocystis colchici* at the Muck Crops Research Station, Holland Marsh, Ontario. Treatments were: DITHANE at 8.8 kg/ha, PRO-GRO at 2.0 g ai/100 g seed, RANCONA at 250, 150, 100, 50, 10 mg ai/100 g seed. An untreated check was also included. DITHANE was applied using a push V-belt seeder at a rate of 0.35 g/m. All seeds were treated with SEPRESTO 75WS (insecticide) at 6.15 g ai/100 g seed. Seeds were treated at Cornell University by Al Taylor. Treatments were replicated four times in a randomized complete block design. Each experimental unit consisted of four rows (42 cm apart), 5 m in length. All seed treatments were seeded on 4 May using a push-cone seeder. Three random 2 m sections were staked out, and germination counts were conducted on 25 and 31 May to determine initial stands prior to the first generation assessment. Plants were examined for onion smut (OS) or damage caused by other pests within the staked-out sections on a weekly basis throughout June and July. Damaged plants were rogued out and the cause recorded. At one (10 June), and three (7 June) true leaves, one of the 2m sections was harvested and bulbs and leaves were visually evaluated for OS. The remaining 2 m section was evaluated throughout the season in the same manner until plants reached maturity (30 September) to assess OS losses for the total season. On 20 September a 2.33 m section was harvested and on 17 November the bulbs were removed from storage, counted, and weighed to determine yield. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. Means separation was obtained by using Fisher's Protected LSD test at $P = 0.05$ level of significance.

RESULTS: As presented in Table 1 & 2

CONCLUSIONS: Significant differences were found in percent onion smut at the 1st and 3rd leaf stages but not at the mature bulb stage (Table 1). At the 1st leaf stage, onions grown from seeds treated with

RANCONA at 100 or 150 mg ai or RANCONA at 10 mg ai + PRO-GRO at 2000 mg ai had significantly fewer OS losses than onions grown from seeds treated with PRO-GRO alone, PRO-GRO + DITHANE, PRO-GRO + RANCONA at 150 mg ai or the untreated check. Onions grown from seeds treated with any rate of RANCONA either alone or in combination with PRO-GRO had significantly lower OS losses than PRO-GRO alone or the untreated check.

At the 3rd leaf stage, onions grown from seeds treated with any rate of RANCONA used alone had significantly fewer OS losses than onions grown from RANCONA at 150 mg ai + PRO-GRO, PRO-GRO alone or the untreated check.

At both the 1st and 3rd leaf stages, increasing rates of RANCONA when used alone or when combined with PRO-GRO did not improve OS control. Onions grown from seeds treated with RANCONA at 150 mg ai alone had significantly lower OS losses than RANCONA at 150 mg ai + PRO-GRO at both 1st leaf and 3rd leaf stages The addition of PRO-GRO to RANCONA as a seed treatment did not improve OS control and this may indicate that PRO-GRO interferes with RANCONA.

No significant differences were found in marketable yield or percent yield among the treatments (Table 2).

ACKNOWLEDGEMENT: Funding for this project was provided by Chemtura, the OMAFRA/University of Guelph Sustainable Production systems Program and the New York State Agricultural Experiment Station, Cornell University provided support for seed treatment application of new chemistry seed treatments.

Table 1. Percent onion smut (OS) for onions, cv. Pulsar, grown from seeds treated with various fungicides, grown at Muck Crops Research Station, Holland Marsh, Ontario, 2010.

Treatment	Rate (mg ai/100 g of seed)	% OS Losses within assigned 2 m sections		
		1st Leaf	3rd Leaf	Bulb Maturity
RANCONA	150	5.0 a[1]	27.5 a	7.7 ns[2]
RANCONA	100	11.0 a	30.3 a	5.3
PRO-GRO + RANCONA	2,000 + 10	12.3 a	31.6 ab	1.1
PRO-GRO + RANCONA	2,000 + 50	18.8 ab	36.5 ab	4.5
PRO-GRO + RANCONA	2,000 + 100	19.8 ab	33.8 ab	15.4
RANCONA	250	20.5 ab	28.8 a	11.9
PRO-GRO + RANCONA	2,000 + 150	36.0 bc	45.9 bc	14.4
PRO-GRO + DITHANE	2,000 + 8.8 kg/ha	42.0 cd	38.9 ab	12.9
PRO-GRO	2,000	56.1 d	55.5 c	22.1
Check	---	75.5 e	57.3 c	31.4

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

[2] ns= not significantly different, $P = 0.05$ Fisher's Protected LSD Test

Table 2. Marketable yield and size distribution for onions, cv. Pulsar, grown from seeds treated with various fungicides, grown at Muck Crops Research Station, Holland Marsh, Ontario, 2010

Treatment	Rate (mg ai/100 g of seed)	Marketable Yield (t/ha)	Size Distribution			
			% Jumbo (>76mm)	% Large (64-76mm)	% Medium (45-64mm)	% Small (<45mm)
PRO-GRO + RANCONA	2,000 + 50	62.4 ns[1]	41.6 ns	43.5 ns	14.8 ns	0.0 ns
RANCONA	100	61.7	31.8	64.2	4.0	3.8
PRO-GRO + RANCONA	2,000 + 10	58.7	24.8	43.7	31.5	0.0
RANCONA	250	57.5	45.7	38.5	15.7	0.0
RANCONA	150	52.5	37.1	50.4	12.4	0.0
PRO-GRO + RANCONA	2,000 + 100	50.4	58.2	23.6	14.4	0.0
PRO-GRO + RANCONA	2,000 + 150	49.6	53.0	38.6	8.3	0.0
PRO-GRO	2,000	41.9	55.6	31.0	11.7	1.7
PRO-GRO + DITHANE	2,000 + 8.8 kg/ha	32.7	78.8	18.6	2.6	0.0
Check	---	28.7	56.9	27.9	14.7	0.5

[1] ns= not significantly different, $P = 0.05$ Fisher's Protected LSD Test

2010 PMR REPORT # 24 **SECTION L: VEGETABLES and SPECIAL CROPS**

CROP: Spinach (*Spinacia oleracea* L.) cv. Melody

PEST: Anthracnose, (*Colletotrichum dematium* (Pers.) Grove f. sp. *spinaciae* (Ellis and Halst.) Arx)

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TITLE: EFFICACY OF PHOSPHONITE FUNGICIDES ON THE INCIDENCE AND SEVERITY OF ANTHRACNOSE ON SPINACH

MATERIALS: PHOSTROL (53.6% mono and dibasic sodium, potassium and ammonium phosphites), RAMPART (53% mono- and di- potassium salts of phosphorous acid), CONFINE (45.8% mono- and di-potassium salts of phosphorous acid), ALIETTE WDG SYSTEMIC FUNGICIDE (80% Fosetyl AL)

METHODS: Spinach cv. Melody was seeded on 17 August 2010 in 135 cm wide beds with 8 rows/bed and rows spaced 17 cm apart at a spinach farm north of Orangeville Ontario that had previously had anthracnose. PHOSTROL (53.6% mono and dibasic sodium, potassium and ammonium phosphites) at 5.8 L/ha; RAMPART (53% mono- and di- potassium salts of phosphorous acid) at 5.9 L/ha; CONFINE (45.8% mono- and di- potassium salts of phosphorous acid) at 6.9 L/ha; and ALIETTE WDG SYSTEMIC FUNGICIDE (80% Fosetyl AL) at 3.125 kg/ha were applied as foliar sprays in 250 L of water/ha on 31 August 2010 (2^{nd} leaf), 14 September 2010 (5^{th}-6^{th} leaf), and 20 September 2010 (7^{th}-8^{th} leaf), to 6m long plots using a hand held wand sprayer (RandD Sprayers, Opelousas, LA) with 3 adjustable cone nozzles spaced 30 cm apart, propelled with CO_2 at 280 kPa. A 6m long untreated area was left for comparison. The treatments were replicated 4 times and arranged in a Randomized Complete Block Design.

The number of leaves/plant, incidence of infected plants, incidence of infected leaves, severity of disease/plant (0=healthy, 1=1-10% of leaf area infected; 2= 11-25% leaf area infected; 3= 25-50% leaf area infected; 4=50-100% leaf are infected; and 5= systemic infection) and injury (0= no injury to 9= 100% leaf area injured) was evaluated on 10 randomly sampled plants/plot on 7 September 2010, 14 September 2010, 20 September 2010 and 5 October 2010. The incidence of anthracnose-infected plants and infected leaves data was transformed using the arcsine transformation to improve normality and additivity. Fisher's protected least significant difference (LSD) test was used to detect differences among the means and transformed means at P=0.05; however, actual means are presented.

RESULTS: Hot dry environmental conditions occurred during mid August through early September 2010. Applying a phosphonite fungicide did not affect the number of leaves produced by the spinach plant (Table 1). However, sunken white specks appeared on spinach leaves on 7 September 2010 that were sprayed 7 days earlier with ALIETTE WDG SYSTEMIC FUNGICIDE. The temperature was 27^{o}C at the time the fungicides were applied on August 31, 2010. Only the leaves exposed to the ALIETTE WDG SYSTEMIC FUNGICIDE application made on 31 August 2010 remained damaged throughout the experiment and new leaves that grew were not damaged despite applying ALIETTE WDG SYSTEMIC FUNGICIDE to the same plants two additional times during cooler weather conditions (Table 1). No damage was observed on leaves sprayed with the other phosphonite fungicides (Table 1).

The hot dry environmental conditions that occurred during mid-August through early September 2010 were not favourable for the infection and development of anthracnose in spinach (data not shown). However by mid September 2010, weather conditions became cool and wet in the region resulting in anthracnose developing throughout the experimental area and therefore only anthracnose data from the 20 September 2010 and 5 October 2010 evaluations are presented.

PHOSTROL, CONFINE and ALIETTE WDG SYSTEMIC FUNGICIDE significantly reduced the incidence of plants and leaves with anthracnose compared to the untreated check (Table 2). ALIETTE WDG SYSTEMIC FUNGICIDE also significantly reduced the incidence of leaves with anthracnose during 20 September 2010 but not on 5 October 2010 rating compared to the untreated check. RAMPART significantly reduced the incidence of leaves but not the incidence of plants with anthracnose. All phosphonite fungicides significantly reduced the severity of anthracnose (Table 2).

CONCLUSIONS: Phosphonite fungicides reduced the severity and incidence of anthracnose on spinach. ALIETTE WDG SYSTEMIC FUNGICIDE applied at the 2 leaf stage during hot temperatures (27^{o}C) caused leaf spotting on spinach leaves which remained damaged throughout the experiment. However, new leaves that grew were not damaged despite applying ALIETTE WDG SYSTEMIC FUNGICIDE to the same plots two additional times under more suitable environmental conditions.

Table 1. The number of leaves/plant and phytotoxicity (0-9) on spinach plants treated with phosphonite fungicides.

	Number of leaves/plant				Phytotoxicity (0-9)			
Treatment	7 Sept	14 Sept	20 Sept	5 Oct	7 Sept	14 Sept	20 Sept	5 Oct
Untreated	4.03 a[1]	5.65 a	7.10 a	8.83 a	0.00 b	0.00 b	0.00 b	0.00 b
PHOSTROL	3.95 a	5.70 a	6.55 a	8.55 a	0.00 b	0.00 b	0.00 b	0.00 b
RAMPART	3.88 a	5.78 a	6.75 a	8.35 a	0.00 b	0.00 b	0.00 b	0.00 b
CONFINE	3.80 a	5.83 a	6.38 a	8.60 a	0.00 b	0.00 b	0.00 b	0.00 b
ALIETTE WDG SYSTEMIC FUNGICIDE	3.93 a	5.40 a	6.78 a	8.93 a	2.98 a	1.60 a	1.35 a	0.23 a

[1] Figures in columns followed by the same letter are not significantly different using Fisher's Protected LSD test ($P<0.05$)

Table 2. Effect of phosphonite fungicides on the incidence and severity of anthracnose on spinach plants and leaves.

Treatment	% plants with Anthracnose[1]		% leaves with Anthracnose[1]		Disease Severity (0-5)	
	20 Sept	5 Oct	20 Sept	5 Oct	20 Sept	5 Oct
Untreated	20.00 a[2]	92.50 a	4.65 a	24.6 a	0.23 a	2.38 a
PHOSTROL	5.00 bc	72.50 b	0.73 c	15.5 b	0.05 bc	1.20 bc
RAMPART	15.00 ab	82.50 ab	2.58 b	15.3 b	0.15 ab	1.08 bc
CONFINE	10.00 abc	60.00 b	1.58 bc	11.3 b	0.08 bc	0.83 c
ALIETTE WDG SYSTEMIC FUNGICIDE	2.50 c	72.50 b	0.35 c	17.5 ab	0.03 c	1.50 b

[1] Data transformed using Arsine Transformation; however actual data presented
[2] Figures in columns followed by the same letter are not significantly different using Fisher's Protected LSD ($P<0.05$)

2010 PMR Report # 25 **SECTION L: VEGETABLE and SPECIAL CROPS**

CROP: Pepper squash (*Cucurbita maxima* Duchesne), cv. Mesa Queen
PEST: Powdery mildew (*Podospheara xanthii* syn. *Sphaerotheca fuliginea*)

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TITLE: PRODUCTS FOR CONTROL OF POWDERY MILDEW IN SQUASH, 2010

MATERIALS: FONTELIS (penthiopyrad 200 g L^{-1}), BRAVO 500 (chlorothalonil 500 g L^{-1}), DITHANE DG (mancozeb 75%), CABRIO (pyraclostrobin 20%), LUNA (fluopyram 500 g L^{-1}), REGALIA MAXX (extract of *Reynoutria sachalinensis* 20%), SERENADE MAX (*Bacillus subtilis* QST 713, 14.6%), MILSTOP (potassium bicarbonate 85%), QUINTEC (quinoxyfen 250 g L^{-1}), VIVANDO (metrafenone 500 g L^{-1}), INSPIRE (difenoconazole 23.2%)

METHODS: Squash was seeded with a cone seeder on June 2 at a rate of 3.3 seeds per meter at the Ridgetown Campus, University of Guelph. Row spacing was 3 m. Each treatment plot was 7 m long and consisted of one row. A randomized complete block design with 4 replications per treatment was used. Command 360 ME and Round UP were applied on June 2 for preplant weed control. Treatments were applied on July 18, 19, 27, Aug 4, 11, and 18 using a hand-held boom and CO_2 backpack (35 psi) with ULD 120-02 nozzles and water volume 200 L Ha^{-1}. LUNA was applied on July 19 and all other products were applied on July 18. Care was taken to avoid making spray applications when conditions were not ideal (ie. windy), and no signs of spray drift were evident in the trial. The trial was drip irrigated throughout the season as required. The incidence and severity of powdery mildew was assessed on Aug 5, 12, and 23. 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 leaves with powdery mildew symptoms 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 powdery mildew on infected leaves. Squash were harvested on Sept 13. All fruit were sorted into immature and mature categories, counted, and weighed. The number of fruit with sunscald injury was also recorded. Monthly rainfall for June, July, August, and September was 84.5 mm, 136.0 mm, 26.0 mm and 79.5 mm. Average maximum temperatures for June, July, August and September were 24.9 °C, 27.6 °C, 27.6 °C, and 22.2 °C and average minimum temperatures were 13.8 °C, 16.5 °C, 15.7 °C, 10.2 °C. Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Analysis of variance was conducted and means comparisons were performed when $P \leq 0.05$ using Duncan's new multiple range test.

RESULTS: Refer to Table 1 and Table 2.

CONCLUSIONS: LUNA, FONTELIS, VIVANDO, and QUINTEC provided the most consistent level of disease control under conditions of high disease pressure. Sunscald injury was reduced in the LUNA treatments, as compared to the nontreated control, which is an indication of better leaf cover in treatment LUNA. Treatments LUNA, QUINTEC, and VIVANDO also produced a higher number of squash than other treatments, and QUINTEC and VIVANDO had higher fruit weight than other treatments. INSPIRE, BRAVO + DITHANE, and CABRIO only provided a level of disease control that was better than the

nontreated control early in the season. Applications of REGALIA, SERENADE and MILSTOP did not reduce disease levels below those of the nontreated control on any assessment dates.

Table 1. Incidence of powdery mildew development and level of defoliation on squash leaves treated with different fungicides, Ridgetown, ON, 2010.

Treatment	Leaves Affected (%)			Defoliation (%)	
	Aug 5 [1]	Aug 12 [1]	Aug 23 [2]	Aug 12	Aug 23
Nontreated control	20.9 e [3]	28.1 d	78.9 d	30 d	73 b
FONTELIS @ 1.25 L Ha^{-1}	2.1 ab	2.7 a	39.8 c	0 a	23 a
BRAVO @ 4.8 L Ha^{-1} + DITHANE @ 3.25 L Ha^{-1}	4.0 bc	16.9 c	71.6 d	18 a-d	58 b
LUNA @ 150 mL Ha^{-1}	1.4 ab	1.2 a	12.5 a	3 ab	13 a
REGALIA @ 0.125% v/v	17.9 e	24.9 cd	76.1 d	23 cd	71 b
SERENADE @ 5 kg Ha^{-1}	16.8 e	23.3 cd	77.3 d	31 d	74 b
CABRIO @ 840 g Ha^{-1}	8.4 cd	18.1 c	74.1 d	21 bcd	69 b
MILSTOP @ 5.6 kg Ha^{-1}	13.5 de	23.3 cd	75.5 d	28 d	66 b
QUINTEC @ 370 mL Ha^{-1}	0.7 a	2.9 a	21.1 ab	0 a	20 a
VIVANDO @ 448 mL Ha^{-1}	4.2 bc	6.8 b	25.1 b	4 abc	20 a
INSPIRE @ 512 mL Ha^{-1}	2.9 ab	16.2 c	70.9 d	19 a-d	60 b

[1] Data was normalized using a square root transformation; the back transformed means are shown here.
[2] Data was normalized using an arcsine square root transformation; the back transformed means are shown here.
[3] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 2. Yield and incidence of sunscald on squash fruit in plots treated with different fungicides for management of powdery mildew, Ridgetown, ON, 2010.

Treatment	Yield		Sunscald	
	Number	Weight (kg)	Number [1]	Weight (kg) [1]
Nontreated control	32.5 b [2]	22.94 d	4.2 b	3.46 b
FONTELIS @ 1.25 L Ha^{-1}	41.0 b	31.17 bc	1.0 ab	0.94 ab
BRAVO @ 4.8 L Ha^{-1} + DITHANE @ 3.25 L Ha^{-1}	41.0 b	32.67 bc	2.1 ab	1.99 ab
LUNA @ 150 mL Ha^{-1}	53.5 a	38.46 ab	0.6 a	0.72 a
REGALIA @ 0.125% v/v	41.3 b	29.68 cd	1.8 ab	1.53 ab
SERENADE @ 5 kg Ha^{-1}	40.0 b	28.40 cd	1.9 ab	1.64 ab
CABRIO @ 840 g Ha^{-1}	41.3 b	31.03 bc	3.0 ab	2.49 ab
MILSTOP @ 5.6 kg Ha^{-1}	39.8 b	29.66 cd	3.0 ab	3.29 ab
QUINTEC @ 370 mL Ha^{-1}	63.5 a	43.96 a	1.0 ab	0.83 ab
VIVANDO @ 448 mL Ha^{-1}	54.8 a	40.52 a	1.0 ab	0.98 ab
INSPIRE @ 512 mL Ha^{-1}	40.8 b	30.46 cd	1.6 ab	1.47 ab

[1] Data was normalized using a square root transformation; the back transformed means are shown here.
[2] 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.

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2010 PMR REPORT # 26 **SECTION L: VEGETABLE and SPECIAL CROPS**

CROP: Tomato (*Solanum lycopersicum* L.), cv. H9909
PEST: Bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D), Bacterial speck (*Pseudomonas syringae* pv. *tomato*)

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TITLE: EVALUATION OF SPRAY PROGRAMS FOR MANAGEMENT OF BACTERIAL SPOT AND BACTERIAL SPECK IN TOMATO, 2010

MATERIALS: KASUMIN 2L (kasugamycin 2.3%), KOCIDE 2000 (copper hydroxide 53.8%), DITHANE (mancozeb 75%), SERENADE MAX (*Bacillus subtilis* QST 713, 14.6%), LI-700 (surfactant blend, 80%), REGALIA MAXX (extract of *Reynoutria sachalinensis* 20%)

METHODS: The trial was conducted at Ridgetown Campus, University of Guelph. Tomatoes were transplanted on May 21 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 1.5 m apart. Each treatment plot was 7 m long and consisted of one twin-row. The trial was setup as a randomized complete block design with 4 replications per treatment. Treatments were applied on May 21, 28, June 4, 9, 18, 25, July 2, 13, and 20 using a hand-held CO_2 sprayer (35 psi) with ULD 120-02 nozzles and water volume of 200 L Ha^{-1}. Care was taken to avoid spray drift by delaying applications when conditions were not ideal (ie. too windy). Dual Magnum II and Sencor were applied on May 16, and Sencor was applied on June 8 for weed control. Inoculum was prepared by growing *Xanthomonas gardneri* in LB broth and *Pseudomonas syringae* pv *tomato* (isolate DC 3000) in TS broth, for 5 days at room temperature. *X. gardneri* originated from the laboratory of Diane Cuppels, Ph.D., Agriculture and Agri-Food Canada. The trial was inoculated with *Pseudomonas syringae* pv. *tomato* (*Pstom*) (~1 x 10^7 CFU mL^{-1}) and *Xanthomonas gardneri* (~1 x 10^8 CFU mL^{-1}) on May 22, *X. gardneri* (~3.5 x 10^7 CFU mL^{-1}) on June 4 and *Pstom* and *X. gardneri* on July 12. Inoculum was diluted with tap water and applied over the entire trial in the evening using a hand-held CO_2 sprayer. Sylgard 309 was included in the inoculum mixture at a rate of 0.025% v/v. The concentration of bacteria was estimated using a spectrophotometer on May 22 and June 4. On July 12 40 mL of X. gardneri and Pstom inoculums was mixed in 8 L of water and 0.025% v/v Sylgard 309 and applied to the trial using the same methods as described previously. Revus (mandipropamid) was applied on June 12 and 22 for late blight protection. Admire (imidacloprid) was applied for Colorado potato beetle control on June 17. The trial was irrigated using a drip system as required during the growing season. The number of leaves with bacterial spot or speck lesions on five plants per plot was counted on June 22, 28, and July 20. Tomatoes were harvested from a 2m section of each plot on Aug 19; red fruit, green fruit, and rots were separated and weighed. Fifty green fruit were randomly selected and assessed for incidence of bacterial spot and speck. Monthly rainfall for May, June, July, and August was 122.2 mm, 84.5 mm, 136.0 mm, and 26.0 mm. Average maximum temperatures for May, June, July, and August were 20.7 °C, 24.9 °C, 27.6 °C, and 27.6 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, and 15.7 °C. Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Analysis of variance was conducted and means comparisons were performed when $P \leq 0.05$ using Duncan's new multiple range test.

RESULTS: Refer to Table 1 and Table 2. There were no differences among treatments for the incidence of tomato fruit with bacterial spot or bacterial speck lesions (data not shown).

CONCLUSIONS: KOCIDE + DITHANE provided the most consistent reduction of foliar symptoms, however all treatments except REGALIA MAXX applied alone provided some benefits. Disease pressure was relatively low in the trial, due to dry conditions at the end of July and in August. The high number of green fruit in the KOCIDE + DITHANE treatment is an indication that premature defoliation was avoided, as compared to all other treatments except KASUMIN, REGALIA MAXX + KOCIDE, and REGALIA MAXX alt. KOCIDE.The trial was sprayed with disease control products on nine occasions during the season. This is relatively high, however the results do provide some information on the potential for these products to reduce bacterial disease symptoms on foliage. Foliar bacterial disease management is important delay premature defoliation and early ripening in processing tomatoes.

Table 1. Number of infected leaves and area under the disease progress curve (AUDPC) on tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Number of infected leaves [1]			AUDPC[2]
	June 22 [3]	June 28	July 20	
Nontreated control	30.5 c [4]	12.8 bc	173.3 d	2175.8 d
KOCIDE @ 3.2 kg Ha^{-1}	17.8 abc	11.0 abc	97.5 bc	1279.8 bc
KOCIDE @ 3.2 kg Ha^{-1} + DITHANE @ 2.25 kg Ha^{-1}	7.0 a	4.5 a	32.3 a	438.8 a
SERENADE @ 3 kg Ha^{-1}	18.0 abc	8.5 abc	119.8 bc	1490.3 bc
KASUMIN @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	29.0 bc	14.3 c	106.5 bc	1458.0 bc
REGALIA @ 0.125% v/v	23.5 abc	12.5 bc	133.3 cd	1711.3 cd
SERENADE @ 3 kg Ha^{-1} + KOCIDE @ 3.2 kg Ha^{-1}	21.8 abc	12.5 bc	98.0 bc	1318.3 bc
KASUMIN @ 1.6 L Ha^{-1} + KOCIDE @ 3.2 kg Ha^{-1}	13.5 abc	5.8 ab	83.0 b	1034.0 b
SERENADE @ 3 kg Ha^{-1} alt. KOCIDE @ 3.2 kg Ha^{-1}	24.5 bc	10.5 abc	109.0 bc	1419.5 bc
KASUMIN @ 1.6 L Ha^{-1} alt. KOCIDE @ 3.2 kg Ha^{-1}	21.0 abc	11.0 abc	97.3 bc	1286.8 bc
REGALIA @ 0.125% v/v + KOCIDE @ 3.2 kg Ha^{-1}	12.0 ab	11.0 abc	76.0 b	1026.0 b
REGALIA @ 0.125% v/v alt. KOCIDE @ 3.2 kg Ha^{-1}	18.5 abc	13.8 bc	78.5 b	1111.5 b

[1] Number of infected leaves on five tomato plants per plot.
[2] AUDPC (area under the disease progress curve) was calculated using the following equation, where Y_i is number of infected leaves at day X_i and Y_{i-1} is number of infected leaves at day X_{i-1}: AUDPC = $\sum [((Y_i + Y_{i-1})(X_i - X_{i-1}))/2]$.
[3] Data was not normal and could not be normalized using a log or square root transformation.
[4] Numbers in a column followed by the same letter are not significantly different at at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 2. Yield of red, green and rotten tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Weight (kg)			
	Reds	Greens	Rots	Total
Nontreated control	26.52 ab [1]	2.96 b	0.43 b	29.91 ab
KOCIDE @ 3.2 kg Ha^{-1}	28.07 a	2.64 b	0.61 ab	31.32 a
KOCIDE @ 3.2 kg Ha^{-1} + DITHANE @ 2.25 kg Ha^{-1}	25.01 ab	5.43 a	1.32 a	31.75 a
SERENADE @ 3 kg Ha^{-1}	25.27 ab	2.42 b	0.74 ab	28.42 ab
KASUMIN @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	25.38 ab	3.23 ab	0.55 b	29.16 ab
REGALIA @ 0.125% v/v	25.79 ab	2.88 b	0.63 ab	29.29 ab
SERENADE @ 3 kg Ha^{-1} + KOCIDE @ 3.2 kg Ha^{-1}	25.83 ab	2.97 b	0.75 ab	29.55 ab
KASUMIN @ 1.6 L Ha^{-1} + KOCIDE @ 3.2 kg Ha^{-1}	27.51 ab	2.22 b	0.57 ab	30.30 ab
SERENADE @ 3 kg Ha^{-1} alt. KOCIDE @ 3.2 kg Ha^{-1}	28.06 a	3.04 b	0.66 ab	31.76 a
KASUMIN @ 1.6 L Ha^{-1} alt. KOCIDE @ 3.2 kg Ha^{-1}	25.34 ab	2.81 b	0.98 ab	29.13 ab
REGALIA @ 0.125% v/v + KOCIDE @ 3.2 kg Ha^{-1}	25.87 ab	3.64 ab	0.74 ab	30.25 ab
REGALIA @ 0.125% v/v alt. KOCIDE @ 3.2 kg Ha^{-1}	23.32 b	3.55 ab	0.75 ab	27.61 b

[1] 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.

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