# 2016 Pest Management Research Report (PMRR) 2016 Growing Season

# 2016 Rapport de recherches sur la lutte dirigée (RRLD) pour la saison 2016

Canada

**English**

# 2016 PEST MANAGEMENT RESEARCH REPORT

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

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[1] This is the 17th year that the Report has been issued a volume number. It is based on the number of years that it has been published. See history on page iii.

This annual report is designed to encourage and facilitate the rapid dissemination of pest management research results, particularly of field trials, amongst researchers, the pest management industry, university and government agencies, and others concerned with the development, registration and use of effective pest management strategies. The use of alternative and integrated pest management products is seen by the ECIPM as an integral part in the formulation of sound pest management strategies. If in doubt about the registration status of a particular product, consult the Pest Management Regulatory Agency, Health Canada, at 1-800-267-6315.

This year there were 23 reports. Agriculture and Agri-Food Canada is indebted to the researchers from provincial and federal departments, universities, and industry who submitted reports, for without their involvement there would be no report. Special thanks are also extended to the section editors for reviewing the scientific content and merit of each report.

Suggestions for improving this publication are always welcome.

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Procedures for the 2017 Annual PMR Report will be sent in fall, 2017. 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 2016 has been assigned a Volume number for the 17th 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 55.

An individual report will be cited as follows:
Author(s). 2016. Title. 2016 Pest Management Research Report - 2016 Growing Season. Agriculture and AgriFood Canada. April 2017. Report No. x. Vol. 55: pp-pp.

**Français**

**Rapport de recherches sur la lutte dirigée - 2016**

**Préparé par: Centre de la lutte antiparasitaire, Agriculture et Agroalimentaire Canada**
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**Titre officiel du document**
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[1]Ce numéro est basé sur le nombre d'année que le rapport a été publié. Voir l'histoire en page iv.

La compilation du rapport annuel vise à faciliter la diffusion des résultats de la recherche dans le domaine de la lutte antiparasitaire, en particulier les études sur la terrain, parmi les chercheurs, l'industrie, les universités, les organismes gouvernementaux et tous ceux qui s'intéressent à la mise au point, à l'homologation et à l'emploi de stratégies antiparasitaires efficaces. L'utilisation de produits de lutte intégrée ou de solutions de rechange est perçue par Le Comité d'experts sur la lutte intégrée (CELI) comme faisant partie intégrante d'une stratégie judicieuse en lutte antiparasitaire. En cas de doute au sujet du statut d'enregistrement d'un produit donné, veuillez consulter Santé Canada, Agence de réglementation de la lutte antiparasitaire à 1-800-267-6315.

Cette année, nous avons donc reçu 23 rapports. Les membres du Comité d'experts sur la lutte intégrée tiennent à remercier chaleureusement les chercheurs des ministères provinciaux et fédéraux, des universités et du secteur privé sans oublier les rédacteurs, qui ont fait la révision scientifique de chacun des rapports et en ont assuré la qualité.

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

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Des procédures pour le rapport annuel de 2017 seront distribuées à l'automne 2017. Elles seront aussi disponibles via 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. 2016. Titre. 2016 Rapport de recherche sur la lutte dirigée. Agriculture et Agroalimentaire Canada. Avril, 2017. Rapport n$^{o}$ x. vol. 55: pp-pp.

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**2016 PMR REPORT # 01** **SECTION B: VEGETABLES and SPECIAL CROPS - Insect Pests**

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

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**TITLE: EVALUATION OF INSECTICIDE TRAY DRENCHES AND SEED TREATMENTS FOR CONTROL OF ONION MAGGOT IN YELLOW COOKING ONIONS, 2016**

**MATERIALS:** PRO GRO (thiram 50%, carboxin 30%), TRIGARD (cyromazine 75%), SEPRESTO (clothianidin 56.25% + imidacloprid 18.75%), PYRINEX 480 EC (chlorpyrifos 480 g/L), VERIMARK (cyantraniliprole 200 g/L), DELEGATE WG 400 (spinetoram 25%)

**METHODS:** Various insecticide tray drenches and seed treatments for yellow cooking onion transplants were evaluated in a field trial conducted on organic soil (pH ≈ 7.1, organic matter ≈ 63.1%) naturally infested with *Delia antiqua* pupae at the Muck Crops Research Station, Holland Marsh, Ontario. On 15 April, onions were hand seeded, 3 seeds/cell, into 288-cell trays filled with soilless mix (Grower Mix, ASB Greenworld Ltd., Mount Elgin, ON). Seed treatments were: TRIGARD and SEPRESTO (proprietary commercial pellets). On 20 May, trays that had been seeded with onions, cv. La Salle in a PRO-GRO pellet, were drenched with 500 mL/tray of the following treatments: PYRINEX 480 EC at 1.6 mL/tray, VERIMARK at 4.32 mL/tray and DELEGATE at 3.75 g/tray. An untreated check of onions grown from the PRO-GRO pellet was also included. A randomized complete block design with four replicates per treatment was use. Each experimental unit consisted of 4 rows, spaced 40 cm apart, 6 m in length. Onions were transplanted on 24 May using a mechanical transplanter. Two randomly chosen 2 m sections and a 2.32 m yield section of row were staked out in each replicate. On 8 June, the number of plants within the 2 m sections were counted to determine initial stands. Beginning on 9 June, plants within the 2 m sections were examined for onion maggot losses or damage caused by other pests twice weekly. Damaged plants were removed and the cause recorded. Final destructive assessments of all remaining plants within the assigned 2 m sections were conducted on 5 July (three weeks after the end of the first generation peak), and on 17 August (three weeks after the second generation peak). On 2 September, onions from the 2.32 m yield section of row were harvested. On 15 October, onions were graded for size to determine yield.

Compared to the previous 10-year averages, air temperatures in 2016 were average for May (13.8°C), June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10-year average temperatures were: May 14.1°C, June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10-year average for May (45 mm), June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10-year rainfall averages were: May 68 mm, June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.10. Means separation was obtained using Fisher's Protected LSD Test at $P = 0.05$ level of significance.

**RESULTS & DISCUSSION:** Maggot damage was high in the trial. Onions lost to first generation maggot damage was 66% in the check. Onion transplants grown from the SEPRESTO and TRIGARD pellets and transplants grown from trays drenched with DELEGATE, VERIMARK or PYRINEX 480 EC had significantly fewer plants lost to onion maggot damage (6 – 0% losses) (Table 1).
By the end of the season, significant differences in maggot losses were observed among the treatments. Onions transplants treated with drench applications of DELEGATE and VERIMARK had fewer losses than onions treated with PYRINEX 480 EC, onions grown from the TRIGARD or the check (PRO GRO) pellet (Table 1).

Significant differences in yield and onions per meter were observed among the treatments (Table 2). Onions grown from transplants treated with VERIMARK or DELEGATE applied as a drench had higher yields than onions drenched with PYRINEX, or grown from the SEPRESTO pellet. All drench and pelleted treatments produced higher yields than onions grown from PRO GRO pellets.

**CONCLUSIONS:** All drench treatments and pelleted insecticides evaluated in the trial provided better protection from onion maggot damage and produced higher yields compared to untreated onions.

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

**Table 1.** Percentage of transplanted onions, cv. La Salle, lost due to maggot damage, treated with insecticide tray drenches and pelleted insecticides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Rate/tray | Method of Application[1] | % Onions Lost from Maggot Damage | |
|---|---|---|---|---|
| | | | 1st Gen[2] | Total Season[3] |
| DELEGATE | 3.75 g | 500 mL solution/tray | 0.0 a[4] | 1.8 a |
| VERIMARK | 4.3 mL | 500 mL solution/tray | 1.1 a | 1.8 a |
| SEPRESTO | -- | pellet | 6.3 a | 8.7 ab |
| PYRINEX 480 EC | 1.6 mL | 500 mL solution/tray | 4.2 a | 12.6 b |
| TRIGARD | -- | pellet | 6.4 a | 16.5 b |
| Check (PRO GRO) | -- | pellet | 66.0 b | 34.4 c |

[1] Trays were drenched on 20 May, 35 days after seeding and 4 days before transplanting.
[2] Onions in the 2 m staked out section were removed and assessed for maggot damage on 5 July
[3] Final assessment conducted on 17 August after the 2nd generation peak. Onions were lodged.
[4] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Fisher's Protected LSD test.

**Table 2.** Yield and size distribution for transplanted onions, cv. La Salle, treated with insecticide tray drenches and pelleted insecticides grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Application Method | Yield (t/ha) | Onions/m[1] | Size Distribution (%) | | |
|---|---|---|---|---|---|---|
| | | | | Jumbo (>76mm) | Can. No. 1 (45-76mm) | Cull (<45mm) |
| VERIMARK | 4.3 mL/tray | 74.6 a[2] | 26.3 a | 5.6 ns[3] | 92.8 ns | 1.6 ns |
| DELEGATE | 3.75 g/tray | 73.3 ab | 24.5 ab | 8.4 | 90.4 | 1.2 |
| TRIGARD | pellet | 57.3 bc | 20.7 b | 6.8 | 91.2 | 2.0 |
| SEPRESTO | pellet | 55.0 c | 25.2 ab | 0.0 | 97.7 | 2.3 |
| PYRINEX 480 EC | 1.6 mL/tray | 54.3 c | 23.6 ab | 3.4 | 93.4 | 3.3 |
| Check (PRO GRO) | pellet | 34.9 d | 11.9 c | 16.5 | 80.8 | 2.7 |

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

**2016 PMR REPORT # 02** **SECTION C: POTATOES - Insect Pests**

**CROP:** Potato (*Solanum tuberosum* L)
**PEST:** Potato psyllids *(Bactericera cockerelli*)

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**TITLE: OCCURRENCE OF POTATO PSYLLIDS IN MANITOBA**

**MATERIALS:** Yellow sticky cards

**METHODS:** Potato psyllids (PPs) can cause psyllid yellows in potatoes, resulting in chlorosis, stunted plants and small misshapen tubers. PPs can also transmit a bacterium-like pathogen known as *Candidatus* Liberbacter solanacearum (Lso), which causes zebra chip disease. PPs are able to survive temperatures well below freezing, but are not known to overwinter in Manitoba. They could be carried by winds to Canada from US states just south of the border, or may persist locally in very low numbers. Identification, scouting and monitoring programs have been initiated to determine occurrence in Canada.

In the 2016 growing season, thirteen potato fields in Manitoba were monitored from mid-June to the end of August. In each field, three to four yellow sticky cards were placed just above the crop canopy, about 5 meters into the crop and at least 100m apart; south side of the field was preferred if there were no trees. The cards were marked with field ID and dates (duration the cards were in the field). The cards were changed on a weekly basis, and after covering with the non-sticky paper, they were put in poly-bags and shipped to University of Lethbridge to determine the presence of potato psyllids. The PPs were then tested at the AAFC Lethbridge Research Center for the presence of Lso. Psyllids were removed from the sticky traps, and macerated in CTAB solution to extract DNA for polymerase chain reaction (PCR) tests for the presence of the Lso. Primers were specifically designed for highly stringent and specific PCR of the Lso DNA. The tests were 100% reliable in detecting Lso when present. All test results indicated that Lso was not present in the PPs captured in Manitoba.

**RESULTS:** As outlined in Table 1.
Adult PPs were found in 3 separate commercial potato fields in central and western parts of Manitoba, from mid-July to end of August, 2016. In Field 34-8 PPs were found in three separate weeks. None of the PPs tested positive for the zebra chip pathogen, Lso.

**CONCLUSIONS:** The presence of PPs in Manitoba has been confirmed. Trap captures in three separate weeks in the same potato field suggests that the PPs may be multiplying in the crop, or were blown in at regular intervals. Continued monitoring for PPs in Manitoba potato and tomato crops will help determine the population dynamics. Foliage monitoring in fields found positive for the PPs will help determine if there is local multiplication in season in Manitoba fields.

**ACKNOWLEDGEMENT:** This project, Zebra Chip and Potato Psyllid Survey and Monitoring in Canada, was funded in part by Growing Forward 2 (GF2), a federal-provincial-territorial initiative, Agriculture and Agri-Food Canada, the Canadian Horticultural Council, Potato Growers of Alberta,

Stuart Cairns Memorial Chipping Research Fund, and the University of Lethbridge. In Manitoba field work by V. Bisht (MB Agriculture), L. Thomson (Simplot), C. Robertson (McCain Foods), Potato Agronomy Consultants: S. Saunderson & D. White, and Keystone Potato Producers Association (O. Molina and G. Sloik).

**Table1.** Fields and dates of potato psyllids finds in Manitoba, 2016.

| **Field ID** | **Rural Municipality** | **Week of Collection [1]** |
|---|---|---|
| Field 34-8 | Norfolk-Treherne | July 12- July 18 |
| Field 34-8 | Norfolk-Treherne | Aug 3- Aug 9 |
| Field 34-8 | Norfolk-Treherne | Aug 23 - Aug 30 |
| Field C-Well | North Cypress-Langford | Aug 15 - Aug22 |
| Field C-Car | North Cypress-Langford | Aug 22 - Aug 29 |

[1] 1 = The week in which Potato Psyllid(s) were trapped on yellow sticky card.

**2016 PMR REPORT # 03** **SECTION C: POTATOES - Insect Pests**

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

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**TITLE: SURVEY FOR NEONICOTINOID AND SPINOSYN SUSCEPTIBILITY IN COLORADO POTATO BEETLE POPULATIONS IN CANADIAN POTATO FIELDS, 2011-2014**

**MATERIALS:** ACTARA 240SC (thiamethoxam 21.6%), TITAN (clothianidin 48%), ENTRUST SC (spinosad 22.5%), DELEGATE WG (spinetoram 25%).

**METHODS:** In 2011 and 2012, one and five CPB populations, respectively, were collected from conventionally managed potato fields in the following Canadian provinces: MB (x1); ON (x1); QC (x1); NB (x1) and PEI (x2). All six populations were tested for susceptibility by exposing replicate cohorts of neonates of each population to diet-incorporated spinetoram. Concentrations of 0, 0.25, 0.5, 1 and 2 ppm were used to estimate the concentration-mortality relationship and produce estimates of the 50% lethal concentration ($LC_{50}$) for the laboratory insecticide-susceptible strain (lab strain). Higher or lower concentrations of each insecticide were used for the six field-collected CPB strains to ensure a mortality range >0% and <100%. In 2014, CPB collected from an organic potato production site in QC were tested for susceptibility by exposing replicate cohorts of neonates to diet-incorporated spinosad and spinetoram. The spinosad concentrations of 0, 1, 2, 4, 5, 10 and 20 ppm were used to estimate the concentration-mortality relationship for the lab and QC strains. The spinetoram $LC_{50}$ (0.9 ppm) and $LC_{90}$ (3.5 ppm) concentrations previously determined for the lab strain as well as two lower, 0.1 and 0.2 ppm, and four higher, 6, 10, 15 and 30 ppm, were used in the bioassay tests. During the testing period, fresh potato-based agar diet was prepared every week to 2 weeks and batches were incorporated with the series of spinetoram and spinosad concentrations. Each concentration of molten diet was dispensed into a separate 32 well plastic bioassay tray. Cohorts of neonates (previously fed potato leaf tissue for 5 hours) were transferred to each diet well. At least four replicate trays were evaluated for spinetoram and spinosad with a minimum of 48 larvae tested per concentration. All bioassay trays were held in a growth chamber maintained at 25 ± 1°C, 65% ± 5% RH under a 16:8 L:D photoperiod. At mortality readings, larvae were nudged several times with a probe, turned over on their dorsal sides, and recorded as alive if they either advanced one step in a coordinated way or flipped back on their legs. Tests were repeated if control mortality exceeded 20% or if the concentration series did not produce an appropriate range of mortality around the 50% lethal level. Dose-response data generated through the diet bioassay were analyzed by probit analysis (Proc Probit, SAS Institute 2008) and used to model the concentration-mortality responses to estimate the response slope, 50% lethal concentrations, and fiducial limits (F.L.). Whether or not the F.L.s for each pair of $LC_{50}$ values overlapped was used to determine if there was a significant difference between the individual $LC_{50}$ values. Where significant difference between $LC_{50}$ values were found, resistance ratios (RR) were determined by dividing the $LC_{50}$ of the field strain by the $LC_{50}$ of the susceptible strain. Strains were classified as susceptible (RR<1), tolerant (1<RR<10), or resistant (RR > 10).

In 2013, CPB collections from 14 conventionally managed fields and one research farm in MB (x8), ON (x3), QC (x1), NB (x1) and PEI (x2) were tested with thiamethoxam. The eight MB populations were also tested with clothianidin. Thiamethoxam and clothianidin were suspended in water prepared by reverse osmosis (RO-water) to give a 1,000 ppm stock solution. Dilutions were subsequently made as required to give concentrations as low as 0.001 ppm. Leaf disks (43 mm diameter), punched from fresh leaves from potato plants grown in the greenhouse were immersed in the desired concentration of insecticide and allowed to dry on wire racks. Dry, treated disks were individually transferred to labelled, plastic 47 mm microbiological dishes. Five, early second instar CPB from the reference CPB culture (lab strain) were placed onto the leaf disc. The dish was then covered and transferred to a holding room at 27 ± 1°C, 65% ± 5% RH and 16:8 L:D. Mortality was counted either 2 days after treatment (DAT) for bioassays for thiamethoxam toxicity or 3 DAT for assays of clothianidin activity. A larva was recorded as alive if able to right itself when placed on its dorsal surface or to move 1 step forward when nudged with a small artist's brush. For each trial date, an average of four leaf-disc preparations was established for each tested concentration. Also for each series, control insects were placed on leaf-disks dipped in RO-water. Observed mortality was corrected for natural mortality using Abbott's correction and results for a series were discarded and the series repeated if mortality in control bioassays exceeded 10% for 2-day bioassays and 15% for 3-day bioassays. At least 3 separate series of bioassays were run with the lab strain at each of 6 concentrations for each insecticide giving a minimum of 60 larvae (3 bioassays x 4 replicates/bioassay x 5 larvae/replicate) for each concentration tested. Tested concentrations were selected based on preliminary trials to provide a range of 0%-100% mortality. Probit analysis of the data generated was then completed to develop regression lines and determine the discriminating concentration ($DC_{95}$) for the lab strain. For each field-collected population, for each insecticide, a minimum of at least 2-3 replicates of 5 insects was exposed to the $DC_{95}$ as described above, on 3 separate days. Corrected results for each population were averaged for presentation in the table of results.

**RESULTS:** As outlined in Tables 1, 2 and 3. All field strains collected in 2011-12 were found to have spinetoram $LC_{50}$ values greater than the lab strain, with at most a 2.5-fold resistance ratio (Table 1). For 5 of the 6 CPB field strains (except PEI-1) the F.L.s for the $LC_{50}$s determined for the 1$^{st}$ instar larvae did not overlap indicating there was a significant difference. In contrast, the resistance ratio determined for the 2014 field collected strain (QC-2) indicated the CPB were resistant to spinetoram (RR = 19.6) (Table 2). Mortality of the field strain at the spinetoram $LC_{50}$ value was 23-fold less than for the lab strain, although the lab strain mortality was greater than the expected 50%. The spinosad $LC_{50}$ value determined for QC-2 was greater than for the lab strain, with at most a 10-fold resistance ratio (Table 2). The larval mortality of the field strain remained lower than 70% even with a spinosad concentration of 20 ppm (data not shown).

The mortality of 2$^{nd}$ instar larvae from all field strains collected in 2013 exposed to the DC95 (0.23 ppm) for thiamethoxam ranged from 13.6% to 91.6%; the mean mortality for all 13 tested populations was 49% (Table 3). CPB populations have been considered susceptible to an insecticide if average mortality at the DC95 exceeded 70% while populations have been classed as resistant when average mortality at the DC95 fell below 30%. Based on these criteria, only 2 of 13 (15%) tested populations remained susceptible to thiamethoxam while 3 of 13 (23%) tested populations could be classified as resistant. Of the remaining 8 populations, all showed a reduced susceptibility to thiamethoxam (> 30% and < 70% mortality). As clothianidin was only registered for use on potato late in 2008, CPB from Manitoba had not been widely exposed to this second generation neonicotinoid insecticide by 2013. Mortality of 2$^{nd}$ instar larvae exposed for 72 hrs to the $DC_{95}$ (0.17 ppm) for this insecticide ranged from 29.6% to 93.3%; the mean mortality for all 8 tested populations was 68.3% (Table 3). Utilizing the criteria identified above, 5 of 8 (62.5%) of the tested CPB populations were susceptible to clothianidin while the mortality for one tested population fell below the threshold defining resistance.

**CONCLUSIONS:** The results of the 2012 survey, although limited in scope, provided evidence that Canadian CPB populations were susceptible to Delegate WG at that time. Prior to 2012, Delegate was not

used widely for potato pest control. Only one of the collection sites (ON-1) reported spinetoram use more than twice within the previous five years and only two applications of Success 480 SC. The resistance ratios determined for the six CPB strains collected (1 in 2011 and 5 in 2012) are considered low (1> RR < 10-fold). In contrast, the resistance ratios for the 2014 field collected strain (QC-2) were ~10- and 20-fold for Delegate WG and Entrust SC, respectively. These findings provide evidence that the QC-2 field population is resistant to spinosad and spinetoram. This should not be surprising as both products are within the same insecticide class, and cross-resistance is more likely to develop. To our knowledge Delegate WG has not been used widely for potato pest control; however, the longer history of Entrust use in organic potato production may have accelerated the selection pressure for spinosyn-resistance. No studies in Canada to date have reported cross-resistance among spinosyn products for CPB, but many examples exist of cross-resistance between spinosyns and other insecticide classes for different insects.

Results of the 2013 survey demonstrated reduced susceptibility to thiamethoxam for the Ontario, Quebec and New Brunswick populations (ON-3, 4; QC-3 and NB-2). Reduced susceptibility and imidacloprid-resistance has been documented in recent years in all three provinces. The exception to this was the ON-2 population which was collected from the AAFC London research field where insecticides are not applied regularly. The results for the 6 Manitoba populations tested were a departure from the survey results from previous seasons (2008-2011) where no populations were observed to be resistant or have reduced susceptibility to thiamethoxam. By the 2013 survey, two CPB populations (MB-5 and MB-6) were found to have reduced mortality to clothianidin, as well as thiamethoxam, and one CPB population (MB-8) was considered resistant to clothianidin along with reduced mortality to thiamethoxam. Similarly, both PEI populations (PEI-3 and 4) tested indicated a reduced susceptibility to thiamethoxam. Considering the similar modes of action of thiamethoxam and clothianidin, growers "hosting" those CPB populations should not expect prolonged reliable control by clothianidin. Reduced sensitivity to thiamethoxam is consistent with all neonicotinoids tested, reinforcing the Resistance Management strategy that all neonicotinoids should be considered one class and alternated with other compounds having a different mode of action. Growers and industry should exercise care and watchfulness to successfully maintain thiamethoxam and clothianidin in future Canadian CPB management programs.

**ACKNOWLEDGEMENT:** We gratefully acknowledge DAS Canada Inc., Syngenta Crop Protection Canada, Inc., and Bayer CropScience Canada, Inc. for providing partial financial support for summer assistance and field collection of CPB populations from growers, extension and industry personnel in 5 provinces.

**Table 1.** The diet-incorporation spinetoram $LC_{50}$ values (± F.L.) and resistance ratios (RR) determined for the 1st instar larvae from one lab susceptible Colorado potato beetle strain and six field strains collected in 2011/12.

| Strain | N[1] | Slope | $LC_{50}$ (F.L.[2]) | RR |
|---|---|---|---|---|
| Lab | 496 | 2.2 | 0.9 (0.75, 1.12) | |
| MB-1 | 420 | 2.8 | 1.7 (1.4, 2.1) | 1.9 |
| ON-1 | 482 | 3.1 | 1.8 (1.5, 2.1) | 2.0 |
| QC-1[3] | 408 | 2.1 | 2.3 (1.8, 2.9) | 2.5 |
| NB-1 | 436 | 3.8 | 1.3 (1.1, 1.5) | 1.4 |
| PEI-1 | 344 | 4.0 | 1.4 (1.2, 1.6) | 1.5 |
| PEI-2 | 332 | 8.3 | 1.1 (1.0, 1.2) | N.S.[4] |

[1]Total CPB tested includes controls, [2]F.L. = fiducial limits, [3]QC-1 population was collected in 2011 (all remaining populations were collected in 2012), [4]N.S. = no significant difference between $LC_{50}$ since F.L.s overlap.

**Table 2.** The diet-incorporation of spinetoram or spinosad $LC_{50}$ values (± F.L.) and resistance ratios (RR) determined for the 1st instar larvae from one lab susceptible Colorado potato beetle strain and one field strain collected in 2014.

| Insecticide | Strain | N[1] | Slope | $LC_{50}$ (F.L.[2]) | RR |
|---|---|---|---|---|---|
| Spinosad | Lab | 349 | 7.9 | 1.5 (N.A.[3]) | |
| | QC-2 | 204 | 3.1 | 14.7 (12.3, 18.6) | 9.8 |
| Spinetoram | Lab | 434 | 2.6 | 0.49 (0.37, 0.64) | |
| | QC-2 | 261 | 2.2 | 9.6 (8.0, 11.7) | 19.6 |

[1]Total CPB tested includes controls, [2]F.L. = fiducial limits, [3]N.A. = F.L. could not be determined.

**Table 3.** Percent average mortality of Colorado potato beetle 2nd instar larvae from 15 strains collected in 2013 exposed to the discriminating concentration (DC) for thiamethoxam ($DC_{95}$ = 0.23 ppm) and clothianidin ($DC_{95}$ = 0.17 ppm).

| Strain | Thiamethoxam | | Clothianidin | |
|---|---|---|---|---|
| | N[1] | % Avg. Mort. | N | % Avg. Mort |
| MB-2 | 110 | 64.5 | 100 | 81.3 |
| MB-3 | 70 | 71.4 | 70 | 88.3 |
| MB-4 | 195 | 29.7 | 70 | 86.0 |
| MB-5 | 65 | 38.5 | 118 | 34.7 |
| MB-6 | 10 | 50.0 | 15 | 40.0 |
| MB-7 | - | N.D.[2] | 30 | 93.3 |
| MB-8 | - | N.D. | 30 | 93.3 |
| MB-9 | 30 | 40.0 | 84 | 29.6 |
| ON-2 | 95 | 91.6 | - | N.D. |
| ON-3 | 235 | 13.6 | - | N.D. |
| ON-4 | 115 | 29.6 | - | N.D. |
| QC-3 | 105 | 40.0 | - | N.D. |
| NB-2 | 55 | 56.4 | - | N.D. |
| PEI-3 | 100 | 50.0 | - | N.D. |
| PEI-4 | 30 | 56.7 | - | N.D. |

[1]Total CPB tested includes controls, [2]N.D. = Mortality was not determined.

**2016 PMR REPORT # 04** **SECTION E: CEREALS, FORAGE CROPS and OILSEEDS - Insect Pests**

**CROP:** Alfalfa (*Medicago sativa*)
**PEST:** Alfalfa weevil, *Hypera postica* (Gyllenhal)

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**TITLE: LAB EVALUATION OF FOUR INSECTICIDES FOR THE CONTROL OF ALFALFA WEEVIL, 2016**

**MATERIALS:** beetleGONE! (19.5 kg/ 1000 L), BioCeres G WP (400 g/ 100 L), Entrust 80 W (30 mg/ 1000 mL), Silencer 120 EC (83 mL/ 200 L), all solutions 0.05% Triton-X 100.

**METHODS:** A laboratory trial was conducted using *Hypera postica* (Gyllenhal) larvae collected in the spring of 2016 from a field in southern Alberta (near Rosemary) with suspected resistance to synthetic pyrethrins. Four insecticides were evaluated against a water surfactant control (0.05% Triton-X 100). Late instar larvae (3rd and 4th instar) were randomly selected and placed in 35 mm petri dishes containing 4 mm leaf disks cut from plants in an untreated hay field of *Medicago sativa* (cv. unknown). Insecticides BioCeres G WP (*Beauveria bassiana* ANT, Anatis Bioprotection), beetleGONE! (*Bacillus thuringiensis galleriae* (Btg), Phyllom Bioproducts), Silencer 120 EC (lambda cyhalothrin, Adama Agricultural Solutions Canada) and Entrust WP (spinosad, Dow Agrisciences) were formulated to label rates using 0.05% Triton-X 100 surfactant solution. At time zero the leaf disks were dosed with a 2 µL aliquot of test article; leaf disks were left in the dishes for two days and then removed. After initial dosing, all leaf disks for all dishes were replaced daily with fresh untreated leaf disks collected from untreated plants. Surviving larvae were counted each day. Pupating larvae were removed from the trial. Data were evaluated by Kaplan-Meier survival analysis with right censoring for pupation events that occurred during the trial. The survival curve was calculated in Excel[1] using Real-Statistics' method[2]. The confidence intervals for the survival curves and log-rank test were calculated in Excel using Real-Statistics' method[3]. Survival statistics are calculated and graphed for the 6 day trial (Figure). Survival curves are statistically compared using the log-rank test. (Table)

**RESULTS:** As outlined in Figure and Table.

**CONCLUSIONS:** Only the spinosad-treated group (Entrust WP) show significantly different survival values than control. Lambda cyhalothrin, *Bacillus thuringiensis* (galleriae) and *B. bassiana* ANT treatment groups have similar survival rates to the control group. The alfalfa weevils collected for the study were taken from fields with suspected resistance to synthetic pyrethroids, specifically the reference product active ingredient lambda cyhalothrin.

[1] Microsoft Office Professional Plus 2016
[2] http://www.real-statistics.com/survival-analysis/kaplan-meier-procedure/survival-curve/
[3] http://www.real-statistics.com/survival-analysis/kaplan-meier-procedure/confidence-interval-for-the-survival-function/

**Figure**: Treatment group survival statistics

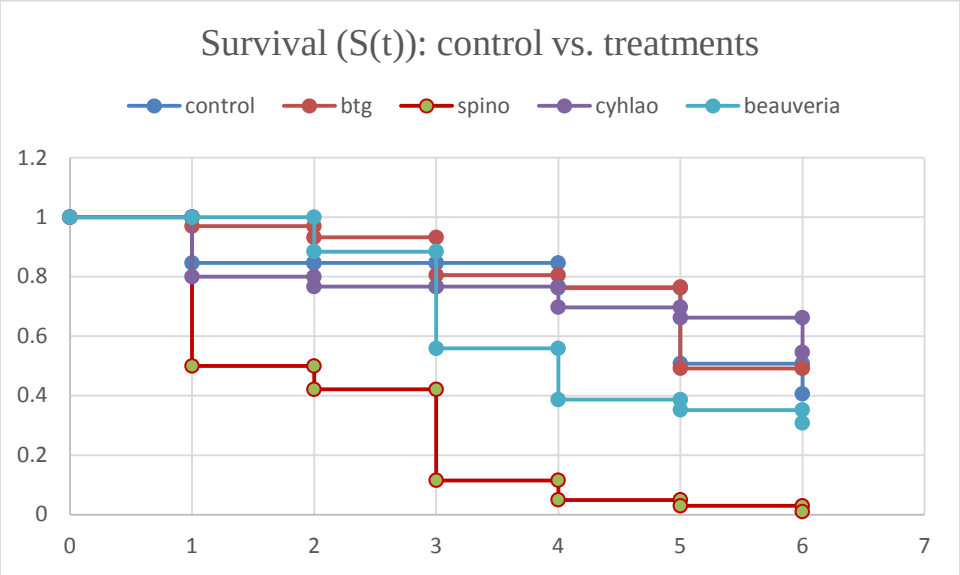


**Table**: Survival statistics at the 95% confidence level.

| | | | | S(t) | | | | |
|---|---|---|---|---|---|---|---|---|
| day | 0 | 1 | 2 | 3 | 4 | 5 | 6 | p-value (S(t)) |
| control | 1 | 0.846 | 0.846 | 0.846 | 0.761 | 0.508 | 0.406 | |
| *Bacillus thuringiensis* (Galleriae) | 1 | 0.969 | 0.932 | 0.805 | 0.765 | 0.492 | 0.492 | 0.695 |
| spinosad | 1 | 0.500 | 0.421 | 0.115 | 0.049 | 0.029 | 0.010 | 0.0002 |
| λ-cyhalothrin | 1 | 0.800 | 0.767 | 0.767 | 0.700 | 0.662 | 0.545 | 0.704 |
| *Beauveria bassiana* ANT | 1 | 1 | 0.885 | 0.559 | 0.387 | 0.352 | 0.308 | 0.329 |

All survival statistics within each treatment group fall within the 95% confidence interval with the exception of *Beauveria bassiana* at t=1. The confidence interval cannot be calculated at this time point because the standard error is zero (i.e. the survival statistic is 1).

**2016 PMR REPORT # 05** **SECTION E: CEREALS, FORAGE CROPS and OILSEEDS - Insect Pests**

**CROP:** Cereal crops: wheat and barley
**PEST:** Cereal aphids: specifically the English grain aphid, *Sitobion avenae* and Bird cherry-Oat aphid, *Rhopalosiphum padi*

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**TITLE: PARASITISM OF TWO CEREAL APHID SPECIES IN SASKATCHEWAN (2016)**

**METHODS:** A survey to identify and track populations of cereal aphid species and their natural enemies in cereal crops on the prairies to develop a dynamic action threshold (DAT) equation was undertaken in 2012 and 2013 (Wist et al. 2013, 2015, 2016) funded by the Pesticide Risk Reduction Program (PRRP). A new project to refine this DAT and create a smartphone app again funded by the PRRP began in 2015. As part of this survey, aphid mummies were collected and brought back to the laboratory to rear parasitoids and hyperparasitoids.
In 2016, a total of 20 fields at 9 sites in Saskatchewan and four fields at two sites in Manitoba were tracked for aphid population development with sweep nets. Fields were evaluated weekly from the beginning of June to the end of August. Aphid mummies were only evident in numbers high enough to collect in three of our surveyed wheat fields in Saskatchewan. Species determination of *Aphidius* parasitoids and hyperparasitoids were conducted with a stereomicroscope (Nikon SMZ25).

**RESULTS:** The first aphids (winged) were noted on June 17$^{th}$ 2016 in Melfort (five alates). By the end of June, alate English grain aphids (EGA), *Sitobion avenae*, had been found as far North as Meadowlake SK, and bird -cherry oat (BCO) aphids, *Rhopalosiphum padi*, were also present but in numbers smaller than EGA. Their coincident arrival suggests that both aphid species arrived together on the same winds. Aphid populations in 2016 were calculated "per tiller" in several fields in SK, where cereal aphids developed. There was an average of 4 EGA per head at the Outlook Research Farm and nearly 5 per head at the Saskatoon Research Farm, and a level of 5 aphids per head can reduce yield (Vereijken 1979) but is below the recommended economic threshold of 12 aphids per head (Gavloski and Olfert 2011).The economic threshold of EGA on cereals recommended in Western Canada is 12-15 aphids/tiller (Gavloski and Olfert, 2011; (Harper 1973)). The lower threshold of 5-10 aphids per head considers grain spoilage from aphid honeydew if the threshold is reached by the milk stage (Vereijken, 1979).
In 2016, the English Grain aphid dominated the cereal aphid complex (76%), the Birdcherry oat aphids comprised 23%, and the remaining 1% were greenbug aphids, *Schizaphis graminum*. The EGA green morph dominated the EGA sample with 81% green and 19% red. Field collected mummies were all of the brown *Aphidius* type (Pike 1997). Aphid mummies first appeared on Aug 5$^{th}$ 2016 but the overall percentage of parasitism was low (233 mummies/7346 aphids *100 = 3.17% parasitism in 2016). Parasitoid emergence was tracked from aphid mummies collected from three fields (Saskatoon, Outlook and Melfort Research Farms). With mummification starting on Aug 5$^{th}$, the first attacks by the *Aphidius* sp. (Hymenoptera: Braconidae) parasitoids that create brown mummies would have occurred approximately eight days prior in the last few days of July. All of the aphid mummies were EGA and their morphology corresponded to parasitism by the braconid genus *Aphidius* where the aphid mummies are globular and copper coloured (Powell 1982). Emergence from mummies was low (42% total, Table 1)

and may indicate that parasitoids had entered an overwintering diapause within mummies or that the high percentage of hyperparasitism resulted in the deaths of both primary and secondary parasitoids. Emergence of hyperparasitoids (hyperparasitism rate) was higher at the three sites than emergence of primary parasitoids (Saskatoon 60%, Melfort 70%, Outlook 71%). Of the primary parasitoids, *Aphidius avenaphis* dominated while *Asaphes suspensus* was the dominant hyperparasitoid and the dominant wasp emerging from aphid mummies (Table 1).

**Table 1.** Species and emerged vs. un-emerged mummies at three research farms in Saskatchewan. In brackets are the percentages of the total emerged and un-emerged mummies and percentage of species of those that emerged from aphid mummies.

| Species | **Saskatoon** (% of emergent wasps) | **Melfort** (% of emergent wasps) | **Outlook** (% of emergent wasps) | **Total** |
|---|---|---|---|---|
| *Aphidius avenaphis* (1°) | 6 (30%) | 2 (20%) | 2 (29%) | 10 (27%) |
| *Aphidius colemani* (1°) | 0 | 1 (10%) | 0 | 1 (3%) |
| *Aphidius ervi* (1°) | 2 (10%) | 0 | 0 | 2 (5%) |
| *Asaphes suspensus* (2°) | 7 (35%) | 2 (20%) | 5 (71%) | 14 (38%) |
| *Alloxysta* spp. (2°) | 5 (25%) | 5 (50%) | 0 | 10 (27%) |
| Emerged parasitoids | 20 (50%) | 10 (38%) | 7 (33%) | 37 (42%) |
| Un-emerged parasitoids | 20 (50%) | 16 (62%) | 14 (67%) | 50 (58%) |

**REFERENCES:**

Gavloski, J. and Olfert, O. 2011. Insect Mangement in Cereal Crops and Grain Corn. Western Committee on Crop Pests Guide to Integrated Control of Insect Pests of Crops **1(1)**: 1-14.

Harper, A.M. 1973. English grain aphid: effect on yield of wheat in Alberta. Journal of Economic Entomology **66(6)**: 1326.

Powell, W. 1982. The identification of hymenopterous parasitoids attacking cereal aphids in Britain. Systematic Entomology **7(4)**: 465-473. doi:10.1111/j.1365-3113.1982.tb00457.x.

Vereijken, P.H. 1979. Feeding and multiplication of three cereal aphid species and their effect on yield of winter wheat. Agricultural Research Reports **888**.

Wist, T., C. Olivier, A. Lukash, A. Pearce, and O. Olfert. 2013. Survey of predators and parasitoids of cereal aphids in Saskatchewan with notes on the presence of other crop pests, pp. 14-16. In D. Holmes [ed.], Pest Management research report. Agriculture and Agri-Food Canada, Ottawa, Canada.

Wist TJ, Olivier C, Gavloski J, Lukash A. Jeuland M, Olfert O. 2015. Survey of predators, parasitoids and populations of cereal aphids and an estimation of the economic threshold based on sweep netting in Saskatchewan 2013. Agriculture and Agri-food Canada Pest Management Research Reports: Biological Control Section 2015.

Wist TJ, VanBaaren J, Olfert O 2016. Red morph english grain aphids, *Sitobion avenae*, in wheat . Agriculture and Agri-food Canada Pest Management Research Reports: Cereals, Forgae Crops and Oilseeds Section 2016

**2016 PMR REPORT # 06** **SECTION H: PEST MANAGEMENT METHODS - BIOLOGICAL CONTROL**

**CROP:** Sweet Cherry
**PEST:** Spotted Wing Drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae)

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**TITLE: CANOPY SPRAYS OF MET52® TESTED AS A MEANS TO INFECT AND SUPPRESS ADULT SPOTTED WING DROSOPHILA WITH METARHIZIUM BRUNNEUM**

**MATERIALS:** MET52® (Novozymes BioAg Limited, Saskatoon, SK), *Metarhizium brunneum* strain F52

**METHODS:** Trials were conducted in a 7 x 26 mature tree planting of six cultivars of sweet cherries (Santina, Sonata, Skeena, Lapin, Sweetheart and Staccato). The cultivars were used as replications and half of the trees within each cultivar were treated with six weekly canopy sprays of MET52 (Novozymes, SA, Canada) in a randomized block design. The equivalent of $3.3 \times 10^6$ spores $ml^{-1}$ MET52 (1.5 L per tank) were applied as a spray to wet but not runoff with a canopy sprayer, on the mornings of June 8, 15, 22 and 29 as well as July 6 and 13, 2016. Precipitation occurred within 24 hours of the canopy treatments on June 8th (0.4 mm) and July 6th (0.2 mm). Rain also occurred within the week following each spray (weekly totals of 3.2 to 26.6 mm). The proportion of a sample of 25 randomly picked cherries that contained *Drosophila* eggs, was determined weekly in both the treatment and control blocks within each of the six cultivars. Larger harvest infestation assessments were made on 50 to 100 cherries randomly selected from each of five trees per cultivar and treatment at least one week after the ideal harvest date based on colour and Brix samples. Infestation by the western cherry fruit fly, *Rhagoletis indifferens* (Diptera: Tephritidae) were also assessed in the same cherries at harvest. A random sample of treated and control fruit was also collected one day after each field spray and exposed to colony *D. suzukii* in the laboratory to determine if the treatment of the fruit deterred oviposition. *Drosophila* traps that contained apple cider vinegar within a screened 250 ml plastic cup were placed within each of the treated and control blocks and all the flies were removed and the traps replaced weekly. *Drosophila suzukii* adults caught in the traps were counted, surface sterilized and plated on Potato Dextrose Agar to confirm the incidence of *M. brunneum* carried by the flies. The data were subjected to an analysis of variance and means were compared using Tukey's Student range test.

**RESULTS:** *Drosophila* egg counts in the sampled fruit were found to significantly increase over the season from 0 to 70 (±11.5) and 56 (± 7.8) % in the control and treatment blocks, respectively by mid-July (impact of time: $F_{6,77} = 26.22$; $P < 0.0001$) (Table 1). Treatment with MET52 did not have a significant ($P > 0.05$) impact on the weekly assessed levels of infestation when compared with the incidence of *Drosophila* eggs in the controls (Table 1). Mean *D. suzukii* infestation rates at harvest were generally higher in the control versus MET52 treatment blocks, however there were no significant differences between the mean infestations in the control and the MET52 treated cherries ($P > 0.05$) (Table 2). In the last two critical weeks of the treatments when *D. suzukii* oviposition greatly increased in the field a total of 15.8 and 12.2 mm of rain fell in the study field, which may have impacted the presence of

the spores on the fruit. Early warm temperatures in the region resulted in early maturation of sweet cherries. All of the cherry cultivars included in these trials reached Brix counts and colour that indicated that they should have been harvested by June 28th before significant numbers of wild spotted wing *Drosophila* eggs were found in the fruit.

A total of only two *D. suzukii* adults were captured within each of the control and treatment areas over the total 9 week trapping period from June 6 through August 2nd. Neither of the two flies was found to be infected with *M. brunneum*. The lack of trapped wild *D. suzukii* eliminated an evaluation of the percent of acquired *M. brunneum* infection within the wild population.

The treated fruit, when compared with the control fruit, picked one day after each field spray, did not significantly impact oviposition by colony *D. suzukii* in the laboratory ($P > 0.05$) indicating that the laboratory *D. suzukii* were not repelled by the presence of MET52 on the fruit. In only one of the six tests conducted over the season, did a single cultivar show a higher oviposition rate in the MET52 treated fruit versus the control.

**CONCLUSIONS:** The *D. suzukii* trap failed to capture sufficient wild adults to evaluate whether six weekly MET52 canopy sprays infected wild adults. The sprays did not deter laboratory *D. suzukii* from ovipositing in the MET52 treated cherries. Treatment with MET52 did not have a significant ($P > 0.05$) impact on the levels of infestation by wild *D. suzukii* when compared with the incidence of *Drosophila* eggs in the control.

**Table 1.** Mean percent cherries with *Drosophila* eggs in samples of 25 cherries from untreated control and MET52 treated blocks sampled weekly from June 7 to July 19, 2016 (6 cultivars).

| Date of sample | Mean % cherries with *Drosophila* eggs (± s.e.) | |
|---|---|---|
| | Control | MET52 |
| June 7, 2016 | 0 ± 0 a[1] | 0 ± 0 a |
| June 14, 2016 | 0.7 ± 0.7 a | 0 ± 0 a |
| June 21, 2016 | 0 ± 0 a | 0 ± 0 a |
| June 28, 2016 | 4.7 ± 3.2 a | 0.7 ± 0.7 a |
| July 5, 2016 | 20.3 ± 13.6 a | 3.4 ± 2.7 a |
| July 12, 2016 | 13.6 ± 7.0 a | 14.4 ± 5.9 a |
| July 19, 2016 | 70.0 ± 11.5 a | 56.0 ± 7.8 a |

[1]Means within date of sample followed by the same letter are not significantly different.

**Table 2.** Mean percent infested cherries in untreated control and MET52 treated blocks collected at least one week after ideal harvest date (5 trees sampled, 50 to 100 fruit inspected per tree).

| Cultivar | Date of sample | Best Harvest[2] | Mean % (± s.e.) infested with | | | |
|---|---|---|---|---|---|---|
| | | | *D. suzukii* | | *R. indifferens* | |
| | | | Control | MET52 | Control | MET52 |
| Santina | June 22 | June 14 | 1.5 ± 0.4 a[1] | 3.0 ± 1.2 a | 0.8 ± 0.3 a | 0.7 ± 0.3 a |
| Sonata | June 28 | June 21 | 1.6 ± 7.5 a | 0 ± 0 a | 0.8 ± 0.5 a | 0.4 ± 0.4 a |
| Skeena | July 7 | June 21 | 6.8 ± 2.2 a | 4.4 ± 1.6 a | 2.8 ± 1.4 a | 3.2 ± 1.2 a |
| Lapin | July 7 | June 21 | 5.2 ± 2.8 a | 4.8 ± 2.9 a | 1.6 ± 0.8 a | 1.2 ± 0.8 a |
| Sweetheart | July 13 | June 28 | 14.0 ± 4.2 a | 10.4 ± 3.4a | 4.8 ± 1.4 a | 5.2 ± 1.5a |
| Staccato | July 18 | June 28 | 32.0 ± 7.2 a | 15.2 ± 4.7 a | 14.0 ± 4.7 a | 2.4 ± 1.5 b |

[1]Means within fly species and cultivar followed by the same letter are not significantly different.
[2]Based on Brix and colour standards.

**2016 PMR REPORT # 07** **SECTION J: NEMATODES**

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

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**TITLE: THE EFFECT OF SOAKING BULB AND STEM NEMATODE INFESTED GARLIC CV. MUSIC CLOVES IN VELUM PRIME PRIOR TO PLANTING ON PLANT STAND, YIELD, NEMATODE DAMAGE AND MUMBER OF STEM AND BULB NEMATODE AT HARVESTED 2016**

**MATERIALS:** AGRI-MEK SC (84 g/L abamectin a.i.); VELUM PRIME (500 g/L fluopyram) a.i.); AGRAL 90 (92% nonylphenoxy polyethoxy ethanol)

**METHODS:** Seed garlic cloves cv. Music infested with stem and bulb nematode (310 nematodes/ g dry clove) were soaked in a solution of 0.35 ml of VELUM PRIME (500 g.a.i. fluopyram/L) per L of water (final concentration 0.175 g.a.i. fluopyram/L) for 2 and 4 hours; 0.7 ml of VELUM PRIME (500 g.a.i. fluopyram/L) per L of water (final concentration 0.35 g.a.i. fluopyram/L) for 2 and 4 hours; 1.4 ml of VELUM PRIME (500 g.a.i. fluopyram/L) per L of water (final concentration 0.7 g.a.i. fluopyram/L) for 2 and 4 hours; 0.858 ml of AGRI-MEK SC (84 g a.i. abamectin/L) per L of water (final concentration 0.072 g.a.i. abamectin/L water) + 0.25% AGRAL 90 (v/v) and WATER alone (20$^{o}$C) for 2 and 4 hours prior to planting. The treated garlic cloves were planted 5 cm deep, spaced 15 cm apart in 3 rows spaced 75 cm apart in plots arranged in a randomized complete block design with 4 replications at a commercial garlic farm near Scotland Ontario on 15 October 2015. NEMATODE-FREE seed garlic cloves were also planted as non-infested check for comparison. Emergence and plant stand was evaluated in the on 19 April, 19 May, 20 June and 13 July 2016. The garlic bulbs were harvested from plots, counted, rated for stem and nematode damage (0 = no damage; 1= slight damage; 2= moderate damage; 3= severe damage, 4= dead), and weighed on 13 July 2016. Stem and bulb nematodes were extracted from 10 randomly selected bulbs harvested from each plot by placing the bulbs on a Baermann funnels in a mist chamber for 24 hours. The nematodesextracted were identified to genus and enumerated. The garlic bulbs used for nematode extraction were dried at 80$^{o}$C for 72 hours to obtain the dry weight of the garlic bulbs. Nematode data was transformed using the Log (nematode/g dried bulb +1) to improve normality and additivity prior to statistical analysis; however, actual means are presented. All data was analysed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. A Protected LSD test was used to detect differences among the means at P=0.05.

**RESULTS:** Plant stands declined in all plots from April through July 2016 (Table 1). Final plant stand was significantly lower in plots planted with nematode infested garlic cloves that were soaked in WATER for 2 or 4 hours prior to planting compared to plots planted with nematode infested cloves soaked in a VELUM PRIME solution, regardless of the rate, for 2 or 4 hours, or AGRI-MEK SC solution for 4 hours prior to planting or plots planted with NEMATODE-FREE cloves. Garlic yields from plots planted with nematode infested cloves soaked in a VELUM PRIME solution for 2 or 4 hours, regardless of rate, or an

AGRI-MEK SC solution for 4 hours prior to planting or plots planted with NEMATODE-FREE cloves were significantly higher than from plots planted with nematode infested cloves soaked in WATER for 2 or 4 hours (WATER) prior to planting (Table 2). Total number of bulbs and number of marketable bulbs harvested from plots planted with nematode infested cloves soaked in a VELUM PRIME solution for 2 or 4 hours regardless of rate, an AGRI-MEK SC solution for 4 hours prior to planting or plots planted with NEMATODE-FREE cloves were significantly higher than from plots planted with nematode infested cloves soaked in WATER for 2 or 4 hours prior to planting (Table 2). Stem and bulb nematode damage and number of *D. dipsaci* were significantly lower in bulbs harvested from plots planted with nematode infested cloves soaked in a VELUM PRIME solution for 2 or 4 hours regardless of rate or AGRI-MEK SC solution for 4 hours prior to planting or plots planted with NEMATODE-FREE cloves compared to bulbs harvested from plots planted with nematode infested cloves soaked in WATER for 2 or 4 hours prior to planting (Table 2). All rates of VELUM PRIME used to soak nematode infested cloves prior to planting significantly reduced stem and bulb nematode damage and number of *D. dipsaci* in bulbs at harvest compared to soaking nematode infested cloves in WATER prior to planting (Table 2).

**CONCLUSIONS:** Soaking garlic cloves infested with stem and bulb nematode in a solution of VELUM PRIME or AGRI-MEK SC prior to planning significantly reduced stem and bulb nematode populations, and damage in harvested bulbs and increased yield weight, total number of bulbs and marketable number of bulbs harvested equivalent to harvested yields, nematode damage and populations in bulbs harvested from plots planted with NEMATODE-FREE seed.

**ACKNOWLEDGMENT:** Funding for this project was provided by Horticulture Crops Ontario.

**Table 1.** The effect of soaking stem and bulb nematode infested garlic cloves cv. Music in WATER, VELUM PRIME at 1.25 ml, 2.5 ml, and 5.0 ml /L water for 2 or 4 hours or in AGRI-MEK SC at 0.858 ml/L water for 4 hours just prior to planting compared to planting NEMATODE-FREE cloves in the fall 2015 on the % plant stand.

| Treatment | Soaking Rate ml/L $H_2O$ | Soaking Time hours | % Plant Stand[1] 19 April | 19 May | 20 June | 13 July |
|---|---|---|---|---|---|---|
| **NEMATODE-FREE** | NA | NA | 94.2 a[2] | 78.3 a | 67.5 abc | 65.0 ab |
| **AGRI-MEK SC + AGRAL 90** | 0.858 + 0.25% | 4 | 84.2 a | 73.3 ab | 70.0 ab | 66.7 ab |
| **WATER** | NA | 2 | 72.5 a | 50.0 c | 48.3 c | 47.5 b |
| **WATER** | NA | 4 | 80.8 a | 58.3 bc | 56.7 bc | 50.8 b |
| **VELUM PRIME** | 0.35 | 2 | 83.3 a | 71.7 ab | 68.3 abc | 66.7 ab |
| **VELUM PRIME** | 0.35 | 4 | 84.2 a | 76.7 a | 74.2 ab | 72.5 a |
| **VELUM PRIME** | 0.7 | 2 | 86.7 a | 80.0 a | 76.7 a | 71.7 a |
| **VELUM PRIME** | 0.7 | 4 | 88.3 a | 76.7 a | 72.5 ab | 70.8 a |
| **VELUM PRIME** | 1.4 | 2 | 90.8 a | 80.8 a | 80.8 a | 79.2 a |
| **VELUM PRIME** | 1.4 | 4 | 90.8 a | 78.3 a | 76.7 a | 70.8 a |

1. Data was transformed using the Arcsine (% stand count/100) to improve normality and additivity prior to statistical analysis however, actual means are presented
2. Figures within columns followed by the same letter are not significantly different using Protected LSD test ($P<0.05$)

**Table 2.** The effect of soaking stem and bulb nematode infested garlic cloves cv. Music in WATER, VELUM PRIME at 1.25 ml, 2.5 ml, and 5.0 ml /L water for 2 or 4 hours or in AGRI-MEK SC at 0.858 ml/L water for 4 hours just prior to planting compared to planting NEMATODE-FREE cloves in the fall 2015 on number of bulbs harvested, number of marketable bulbs harvested, yield weight, nematode damage and number of D. *dipsaci*/g dried bulb at harvest.

| Treatment | Soaking Rate ml/L $H_2O$ | Soaking Time hours | Mean number of bulbs harvested per plot | Mean number of marketable bulbs harvested per plot | Yield (g/plot) | Nematode Damage (0-4)[1] | *D. dipsaci* per g dried bulb at harvest[2] |
|---|---|---|---|---|---|---|---|
| **NEMATODE-FREE** | NA | NA | 19.5 ab[3] | 18.8 a | 1387.3 a | 1.5 a | 0.3 b |
| **AGRI-MEK SC + AGRAL 90** | 0.83 + 0.25% | 4 | 20.0 ab | 20.0 a | 1315.4 a | 1.4 a | 0.3 b |
| **WATER** | NA | 2 | 14.3 b | 5.0 b | 517.2 b | 3.1 b | 263.5 a |
| **WATER** | NA | 4 | 15.3 ab | 5.0 b | 609.7 b | 3.0 b | 238.8 a |
| **VELUM PRIME** | 0.35 | 2 | 20.0 ab | 19.5 a | 1192.7 a | 1.4 a | 0.3 b |
| **VELUM PRIME** | 0.35 | 4 | 21.8 ab | 20.8 a | 1415.2 a | 1.2 a | 0.0 b |
| **VELUM PRIME** | 0.7 | 2 | 21.5 ab | 21.3 a | 1452.8 a | 1.2 a | 0.8 b |
| **VELUM PRIME** | 0.7 | 4 | 21.3 ab | 20.3 a | 1311.7 a | 1.3 a | 0.0 b |
| **VELUM PRIME** | 1.4 | 2 | 23.8 a | 23.3 a | 1579.3 a | 1.0 a | 2.8 b |
| **VELUM PRIME** | 1.4 | 4 | 21.2 ab | 20.3 a | 1295.7 a | 1.3 a | 0.0 b |

1. Nematode damage: 0 = no damage; 1= slight damage; 2= moderate damage; 3= severe damage, 4= dead
2. Data was transformed using the Log (No. of nematodes/g dried bulb +1) to improve normality and additivity prior to statistical analysis however, actual means are presented
3. Figures within columns followed by the same letter are not significantly different using Protected LSD test ($P<0.05$)

**2016 PMR REPORT # 08** **SECTION J: NEMATODES**

**CROP:** Garlic (*Allium sativum* L.), cv. Music
**PEST:** Stem and bulb nematode, (*Ditylenchus dipsaci* (Kühn) Flilipjev)

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**TITLE: EVALUATION OF VARIOUS PRODUCTS FOR CONTROL OF STEM AND BULB NEMATODE IN GARLIC, 2015 - 2016**

**MATERIALS:** AGRI-MEK SC (abamectin 84 g/L), AGRI-MEK EC (abamectin 19 g/L), MOVENTO 240 SC (spirotetramat 240 g/L), NIMITZ 480 EC (fluensulfone 480 g/L), NIMITZ 15 G (fluensulfone 15%), VELUM PRIME (fluopyram 500 g/L), HASTEN (methyl and ethyl oleate 71.44%)

**METHODS:** A trial was established on organic soil (pH ≈ 7.1, organic matter ≈ 63.1%) at the Muck Crops Research Station, Holland Marsh, Ontario using garlic, cv. Music, infested with stem & bulb nematode (≈ 15 *Ditylenchus dipsaci* per g of dry root). The bulbs were cracked into individual cloves and used as seed. Each experimental unit consisted of 1 row, 3 m in length, spaced 40 cm apart with 10 cm in-row spacing. A randomized complete block design with four replicates per treatment was used. Treatment methods, products and rates are as described in Table 1. The check consisted of untreated garlic seed. The soak treatments were completed on 8 October, 2015, seed was allowed to dry and on 9 October, 2015 garlic in all treatments were hand-planted. On 30 May and 21 June, 2016, the heights of ten plants in succession per replicate were measured and recorded. On 12 & 13 July, 2016 all plants from each replicate were removed and bulbs assessed for stem & bulb nematode damage and sorted into classes based on a scale of 0 to 4 where 0 = no damage, 1 = slight damage, i.e. 10 – 24% root plate missing roots, 2 = moderate damage, i.e. 25 – 50% root plate missing roots, 3 = severe damage, i.e. >50% root plate missing roots, 4 = desiccated bulb with rotten root plate. The disease severity index (DSI) was calculated using the following formula:

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

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

**RESULTS:** Garlic grown from seed soaked in VELUM PRIME had significantly less stem & bulb nematode incidence and lower nematode damage severity compared to all other treatments (Table 2). Significant differences in plant heights were observed among the treatments (Table 2). On 21 June, garlic grown from seed soaked in VELUM PRIME, AGRI-MEK SC or AGRI-MEK EC were significantly taller than garlic treated with NIMITZ formulations (soak, in-furrow and drench treatments), garlic treated with foliar sprays of MOVENTO and untreated garlic. Significant differences in plant height are a result of improved early season control of nematodes.

**CONCLUSIONS:** VELUM PRIME reduced the incidence of stem and bulb nematode damage. Both formulations of AGRI-MEK also improved control compared to the untreated garlic.

**ACKNOWLEDGMENT:** Funding was provided by the California Garlic and Onion Research Advisory Board.

**Table 1.** Products and application methods used to treat garlic, cv. Music, grown from infested seed at Muck Crops Research Station, Holland Marsh, Ontario, 2015-16.

| Trt # | Application at Planting (9 Oct) | Method of App'n | Rates | Spring Application (3 May) | Method of App'n | Rate |
|---|---|---|---|---|---|---|
| 1 | check | no treatment | -- | -- | -- | -- |
| 2 | AGRI-MEK EC | 4 hr soak[1] | 3.76 mL/L | -- | -- | -- |
| 3 | AGRI-MEK SC | 4 hr soak | 0.9 mL/L | -- | -- | -- |
| 4 | AGRI-MEK SC | 4 hr soak | 1.7 mL/L | -- | -- | -- |
| 5 | VELUM PRIME | 4 hr soak | 1.67 mL/L | -- | -- | -- |
| 6 | NIMITZ 480 EC | 4 hr soak | 20 mL/L | -- | -- | -- |
| 7 | NIMITZ 480 EC | Drench[2] | 6 mL/L | NIMITZ 480 EC | drench[4] | 6 mL/L |
| 8 | NIMITZ 15G | In-furrow[3] | 0.768 g/m | NIMITZ 480 EC | drench | 6 mL/L |
| 9 | VELUM PRIME | Drench[2] | 0.5 mL/L | VELUM PRIME | drench[2] | 0.5 mL/L |
| 10 | -- | -- | -- | MOVENTO | Foliar[5] | 400 mL/ha |

[1] Garlic seed was placed in a net bag, submerged in 10 L of solution.
[2] Drench applications at planting were applied over seed before covering using a beaker at the rate of 40 mL/m.
[3] In-furrow application was made by hand to the open furrow.
[4] Drench applications were made to the base of the plant using a beaker at the rate of 40 mL solution per m.
[5] Foliar applications were made on 3, 18 May, 1 & 15 June using a $CO_2$ back pack sprayer equipped with a single TeeJet 8003 fan nozzle at the spray rate of 500 L/ha.

**Table 2.** Stem and bulb nematode incidence and plant heights for garlic, cv. Music, grown from infested seed, treated with various fungicides and insecticides and grown at Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Trt # | Product | App'n Method | % Nematode Incidence | DSI[2] | Height (cm) | |
|---|---|---|---|---|---|---|
| | | | | | 30 May | 21 June |
| 5 | VELUM PRIME | Soak | 60.1 a[1] | 29.9 a | 59.7 a | 61.2 a |
| 3 | AGRI-MEK SC | Soak | 85.1 b | 68.9 b | 55.5 a | 55.2 ab |
| 2 | AGRI-MEK EC | Soak | 90.9 bc | 77.5 bcd | 56.7 a | 53.7 ab |
| 4 | AGRI-MEK SC | 2 x rate soak | 92.1 bc | 77.8 bcd | 52.9 a | 44.0 bc |
| 9 | VELUM PRIME | Drench | 93.7 bc | 74.2 bc | 53.6 a | 49.7 abc |
| 1 | Check | No treatment | 95.2 bc | 86.5 cde | 43.2 b | 38.9 cd |
| 6 | NIMITZ 480 EC | Soak | 96.7 bc | 86.1 cde | 41.9 b | 39.7 cd |
| 10 | MOVENTO | Foliar | 100.0 c | 89.8 de | 42.0 b | 40.3 cd |
| 7 | NIMITZ 480 EC | Drench | 100.0 c | 92.6 e | 39.3 b | 24.6 e |
| 8 | NIMITZ 15G & NIMITZ 480 EC | In-furrow & drench | 100.0 c | 94.2 e | 39.9 b | 29.0 de |

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

[2] Disease Severity Index (DSI) was determined using the following equation:

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

**2016 PMR REPORT # 09** **SECTION K: FRUIT - Diseases**

**CROP:** Apple (*Malus domestica* Borkh.), cv. Empire
**PEST:** Bitter Rot (*Colletotrichum acutatum* JH Simmonds)

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**TITLE: THE EFFICACY OF CALCIUM CHLORIDE FOR BITTER ROT MANAGEMENT IN APPLES (2016)**

**MATERIALS:** CALCIUM CLORIDE (83-87% Ca), ALLEGRO 500F (40% fluazinam), PRISTINE WG (25.2% boscalid + 12.8% pyraclostrobin), AGRAL 90 (92% nonylphenoxy polyethoxy ethanol)

**METHODS:** Apple trees cv. Empire in an established orchards near Simcoe, Ontario were sprayed with either DISTILLED WATER at 1000 L/ha, HARD WATER (0.1 mg of Ca/L) at 1000 L/ha (0.1 g Ca/ha), CALCIUM CLORIDE (3.9 kg/ha equivalent to 1.4 kg Ca/ha) + 0.1% AGRAL 90 (92% nonylphenoxy polyethoxy ethanol), ALLEGRO 500F at 1 L/ha (500 g fluazinam/ha) or PRISTINE WG at 1.2 kg/ha (302 g boscalid + 154 g pyraclostrobin/ha) in 1000 L of distilled water/ha on 6 July, 15 July, 26 July, 9 August, 17 August, and 30 August, 2016. Separate single apple trees were left UNTREATED for comparison. Treatments were assigned to trees randomly in a complete block design and replicated 4 times. The treatments were applied using a Solo Mist Blower 451 to the single tree/plot with an untreated tree between each treated tree. The trees were assessed for leaf damage on 19 September 2016 using a scale of 0-10 (0 = no damage, 10 = 100% severe leaf burning and defoliation). Ten leaves (200 g) and 10 fruit were sampled from each tree on 19 September 2016 and analyzed for % Calcium (Ca) (w/w). Twenty-five apples were harvested from each treated tree on 19 September 2016 and assessed for disease incidence, number of bitter rot lesions/fruit and % fruit surface area with bitter rot lesion. All data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.9. A Protected LSD test was used to detect differences among the means at $P = 0.05$.

**RESULTS:** Symptoms of burning or phytotoxicity were not observed on any treated or untreated tree (data not shown). Fruit harvested from trees treated with ALLEGRO 500F or PRISTINE WG had significantly lower incidence of bitter rot infected fruit and fewer bitter rot lesions/fruit compared to fruit harvested from trees treated with DISTILLED WATER, HARD WATER or UNTREATED trees (Table 1). Trees treated with CALCIUM CLORIDE + AGRAL 90 also had fewer fruit with bitter rot compared to fruit harvested from trees treated with DISTILLED WATER, HARD WATER or UNTREATED trees but the difference was not significant. However, fruit harvested from trees treated with CALCIUM CLORIDE + AGRAL 90 had significantly fewer bitter rot lesions than fruit harvested from trees treated

with DISTILLED WATER or UNTREATED trees. The % area of fruit with bitter rot lesions tended to be lowest from trees treated with CALCIUM CLORIDE + AGRAL 90, ALLEGRO 500F or PRISTINE WG compared to fruit from trees treated with DISTILLED WATER or UNTREATED, however the differences were not statistically significant (Table 1). Very low levels of Ca were detected in fruit and leaf tissue at harvest (Table 1). Leaf tissue had significantly higher levels of Ca than fruit tissue at harvest. The % Ca in leaf or fruit tissue at harvest was not significantly different among the treated or UNTREATED trees. Leaves collected from trees treated with CALCIUM CLORIDE + AGRAL 90 tended to have slightly higher % Ca than leaves from trees treated with ALLEGRO 500F, PRISTINE WG, DISTILLED WATER, HARD WATER or UNTREATED trees but this difference was not statistically significant.

**CONCLUSIONS:** PRISTINE WG and ALLEGRO 500F applied to apple trees cv. Empire every 10 to 14 days significantly reduced the incidence of bitter rot and number of lesions/fruit at harvest. CALCIUM CLORIDE at 3.9 kg/ha + AGRAL 90 applied to apple trees cv. Empire every 10 to 14 days suppressed the incidence of bitter rot and significantly reduced the number of lesions/fruit. CALCIUM CLORIDE + AGRAL 90 did not appear to cause damage to apple trees cv. Empire or significantly increase Ca levels in fruit or leaf tissue at harvest.

**Table1.** The effect of applying DISTILLED WATER, HARD WATER, CALCIUM CLORIDE + 0.1% AGRAL 90, ALLEGRO 500F or PRISTINE WG to apple trees cv. Empire every 10-14 days on the incidence of bitter rot, number of fruit with lesions, area of fruit with lesions and % Ca in apple cv Empire leaf and fruit tissue at harvest-.

| Treatment | Rate | % Incidence of bitter rot | Number of bitter rot lesions/fruit | % Area of fruit with bitter rot lesions | % Ca | |
|---|---|---|---|---|---|---|
| | | | | | Leaf (w/w) | Fruit (w/w) |
| **UNTREATED** | NA | 65.0 a | 3.0 a | 2.3 a | 1.4 a | 0.05 a |
| **DISTILLED WATER** | 1000 L/ha | 65.8 a | 3.3 a | 2.8 a | 1.5 a | 0.05 a |
| **HARD WATER (0.1mg Ca/L)** | 1000 L/ha | 58.3 a | 2.0 ab | 2.0 a | 1.3 a | 0.04 a |
| **CALCIUM CHLORIDE + AGRAL 90** | 3.9 kg/ha + 0.1% | 41.7 ab | 1.3 b | 1.5 a | 1.9 a | 0.04 a |
| **ALLEGRO 500F** | 1 L/ha | 29.2 b | 1.0 b | 1.5 a | 1.4 a | 0.05 a |
| **PRISTINE WG** | 1.2 kg/ha | 23.3 b | 1.0 b | 1.8 a | 1.4 a | 0.04 a |

Figures within columns followed by different letters are significantly different using a Protected LSD test ($P<0.05$)

**2016 PMR REPORT # 10** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENT IN COMBINATION WITH GRAS COMPOUNDS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'MCINTOSH' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* 4-6, BIOSAVE (*Pseudomonas syringae*), Sodium Bicarbonate (Anachemia), Calcium Chloride (Fisher Scientific), Salicylic Acid (Sigma), SCHOLAR (20.4% Fludioxonil, Syngenta).

**METHODS:** A postharvest study was conducted using 'McIntosh' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 14, 2015 and stored at 4ºC until ready for processing. On September 24, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On September 25, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Botrytis cinerea* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the pathogen (*B. cinerea*, Bc-34R) and/or the required concentration of *Pseudomonas fluorescens* strain 4-6, BIOSAVE, GRAS compounds or fungicide. Three compounds, Sodium Bicarbonate (SBC), Calcium Chloride ($CaCl_2$), and Salicylic Acid (SA), Generally Recognised as Safe (GRAS), were tested in this study. The treatments were as follows: (1) Water as control with and without *B. cinerea*, (2) Sodium Bicarbonate at 5 g/L with and without *B. cinerea*, (3) Salicylic Acid at 0.1 g/L with and without *B. cinerea*, (4) Calcium Chloride at 10g/L with and without *B. cinerea*, (4) *P. syringae* (BIOSAVE) at 1.59 g/L with and without *B. cinerea*, (5) *P. fluorescens* strain 4-6, $1x10^9$ CFU/mL and SBC, $CaCl_2$ or SA at the above mentioned concentrations with and without *B. cinerea*, and (6) SCHOLAR (Fludioxonil 20.4%) at 0.6 g/L with *B. cinerea*. Ten apples were used for each replicate and each treatment had three replicates. The apples were incubated for 114 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides on the shelf-life of the fruit, after first fruit disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for gray mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA. All pair-wise multiple

comparison procedures were determined using Tukey test. Only data obtained from treatments containing pathogen were analysed.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments. The control (with *B. cinerea*) had the highest gray mold incidence at all observation points. The positive control treatment, SCHOLAR at 0.6 g/L had a complete control of gray mold for up to 114 days and in shelf-life study. After 4 weeks of incubation, in 'McIntosh' apples, the percent disease incidence in the combination of *P. fluorescens* strain 4-6 and the GRAS compounds treatments ranged between 0 - 20% and was significantly lower than the control treatment with *B. cinerea* ($P = 0.001$). With the exception of SA, the two GRAS compounds treated alone had higher disease incidence. The treatments of antagonists, *P. fluorescens* 4-6 and BIOSAVE, had 6.7% and 30% incidence of gray mold, respectively. The combination treatments of *P. fluorescens* strain 4-6 and each of the GRAS compounds had better control than the treatment of either *P. fluorescens* strain 4-6 or GRAS compounds alone in cold storage. The combination of antagonist *P. fluorescens* 4-6 and $CaCl_2$ was the best treatment for the control of gray mold in this study. With the exception of *P. fluorescens* strain 4-6 and $CaCl_2$ and SCHOLAR treatments, a high disease incidence was observed in all other treatments for up to 144 days after incubation.

**Table 1**. Effect of *Pseudomonas fluorescens* 4-6 in combination with different GRAS compounds on the control of postharvest gray mold (*Botrytis cinerea*) in 'McIntosh' apples, 2015-16.

| | Percent Disease Incidence [a] | | | | |
|---|---|---|---|---|---|
| Treatment | 29 days[b] | 56 days | 84 days | 114 days | Shelf-Life Study[c] |
| Water + *B. cinerea* [d] | 56.7 e [e] | 86.7 h | 90.0 gh | 90.0 h | 93.3 f |
| Sodium Bicarbonate @ 5 g/L + *B. cinerea* | 53.3 f | 90.0 h | 96.7 h | 96.7 i | 96.7 g |
| Salicylic Acid @ 0.1g/L + *B. cinerea* | 0.0 a | 36.7 c | 36.7 c | 43.3 c | 50.0 c |
| Calcium Chloride @ 10g/L + *B. cinerea* | 10.0 c | 43.3 d | 46.7 d | 53.3 d | 63.3 d |
| BIOSAVE @ 1.59 g/L+ *B. cinerea* | 30.0 e | 66.7 f | 73.3 f | 73.3 g | 73.3 e |
| *P. fluorescens*[f] strain 4-6 + *B. cinerea* | 6.7 b | 60.0 e | 70.0 f | 70.0 f | 76.7 e |
| Sodium Bicarbonate @ 5 g/L + *P. fluorescens* strain 4-6 + *B. cinerea* | 10.0 c | 60.0 e | 63.3 e | 63.3 e | 63.3 d |
| Salicylic Acid @ 0.1g/L + *P. fluorescens* strain 4-6 + *B. cinerea* | 20.0 d | 80.0 g | 86.7 g | 90.0 h | 90.0 f |
| Calcium Chloride @ 10g/L *P. fluorescens* strain 4-6 + *B. cinerea* | 0.0 a | 20.0 b | 20.0 b | 20.0 b | 20.4 b |
| SCHOLAR @ 0.6g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage
[d] *B. cinerea* was used at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[f] *P. fluorescens* strain 4-6 was used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 11** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENT IN COMBINATION WITH GRAS COMPOUNDS ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'MCINTOSH' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* strain 4-6, BIOSAVE (*Pseudomonas syringae*), Sodium Bicarbonate (Anachemia), Calcium Chloride (Fisher Scientific), Salicylic Acid (Sigma), SCHOLAR (20.4% Fludioxonil, Syngenta).

**METHODS:** A postharvest study was conducted using 'McIntosh' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 14, 2015 and stored at 4ºC until ready for processing. On September 21, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On September 22, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Penicillium expansum* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the pathogen *P. expansum* (Pe-S) and/or the required concentration of the *P. fluorescens* strain 4-6, BIOSAVE, GRAS compounds or fungicide. Three compounds, Sodium Bicarbonate (SBC), Calcium Chloride ($CaCl_2$), and Salicylic Acid (SA), Generally Recognised as Safe (GRAS), were tested in this study. The treatments were as follows: (1) Water as control with and without inoculum, (2) Sodium Bicarbonate at g/L with and without inoculum of *P. expansum*, (3) Salicylic Acid at 0.1 g/L with and without *P. expansum* , (4) Calcium Chloride at 10 g/L with and without *P. expansum*, (4) *P. syringae* (BIOSAVE) at 1.59 g/L with and without *P. expansum*, (5) *P. fluorescens* strain 4-6, $1x10^9$ CFU/mL with and/or without *P. expansum* and or SBC, $CaCl_2$ and SA at the above mentioned concentrations, and (6) SCHOLAR (Fludioxonil 20.4%) at 0.6 g/L with *P. expansum*. Ten apples were used for each replicate and each treatment had three replicates. The apples were incubated for 84 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides on the shelf-life of the fruit, after the initial disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for blue mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA. All pair-wise multiple

comparison procedures were determined using Tukey test. Only data obtained from treatments containing pathogen were analysed.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments. The water control (with *P. expansum*) had the highest blue mold incidence at all observation points. After the 84-day incubation period, with the exception of SCHOLAR, all treatments reached 73 - 100% disease incidence and, as a result, shelf-life study was not conducted. The positive control fungicide treatment, SCHOLAR at 0.6 g/L, had a complete control of blue mold for up to 29 days and had only 3.3% of disease incidence when the experiment was concluded at 84 days after treatment. After 4 weeks of incubation, the percent blue mold incidence in the combination of *P. fluorescens* strain 4-6 and each of the GRAS compounds (SBC, SA and $CaCl_2$) treatments ranged between 0 - 13.3% of disease incidence and was significantly lower than the *P. expansum* control treatment ($P = 0.001$). With the exception of SA, the two GRAS compounds, SBC and $CaCl_2$, applied alone had higher disease incidence. The antagonist *P. fluorescens* strain 4-6 and BIOSAVE applied alone had 10% and 33% incidence of blue mold, respectively. The treatments with a combination of *P. fluorescens* strain 4-6 and each of the GRAS compounds had better control of blue mold than either the antagonists or GRAS compounds treated alone in cold storages. With the exception of SCHOLAR, a high disease incidence was observed in all the treatments at 56 days and 84 days after incubation.

**Table 1**. Effect of *Pseudomonas fluorescens* strain 4-6 alone or in combination with different GRAS compounds on the control of postharvest blue mold (*Penicillium expansum*) in 'McIntosh' apples, 2015-16.

| | Percent blue mold incidence[a] | | |
|---|---|---|---|
| Treatment | 29 days[b] | 56 days | 84 days |
| Water + *P. expansum* [c] | 40.0 e [d] | 100.0 f | 100.0 d |
| Sodium Bicarbonate @ 5 g/L + *P.expansum* | 53.3 f | 100.0 f | 100.0 d |
| Salicylic Acid @ 0.1g/L + *P. expansum* | 63.3 g | 100.0 f | 100.0 d |
| Calcium Chloride @ 10g/L + *P. expansum* | 6.7 b | 93.3 d | 96.7 c d |
| BIOSAVE @1.59 g/L + *P.expansum* | 33.3 d | 100.0 f | 100.0 d |
| *P. fluorescens* strain 4-6 [e] + *P. expansum* | 10.0 b | 100.0 f | 100.0 d |
| Sodium Bicarbonate @ 5 g/L + *P. fluorescens* strain 4-6 + *P. expansum* | 6.7 b | 77.5 c | 93.3 c |
| Salicylic Acid @ 0.1g/L + *P. fluorescens* strain 4-6 + *P. expansum* | 13.3 cd | 96.7 e | 100 |
| Calcium Chloride @ 10g/L *P. fluorescens* strain 4-6 + *P. expansum* | 0.0 a | 69.6 b | 73.0 b |
| SCHOLAR @ 0.6g/L + *P. expansum* | 0.0 a | 3.3 a | 3.3 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] *P. expansum* was used at a concentration of $1x10^4$ spores/mL
[d] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[e] *P. fluorescens* was used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 12** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENT IN COMBINATION WITH GRAS COMPOUNDS ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'GALA' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* 4-6, BIOSAVE (*Pseudomonas syringae*), Sodium Bicarbonate (Anachemia), Calcium Chloride (Fisher Scientific), Salicylic Acid (Sigma), SCHOLAR (20.4% Fludioxonil, Syngenta).

**METHODS:** A postharvest study was conducted using 'Gala' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 14, 2015 and stored at 4ºC until ready for processing. On October 14, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On October 15, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Botrytis cinerea* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the pathogen, Thiabendazole (TBZ) -sensitive *B. cinerea* (Bc-S), and/or the required concentration of the biocontrol bacteria, chemical or fungicide. Three compounds, Sodium Bicarbonate (SBC), Calcium Chloride ($CaCl_2$), and Salicylic Acid (SA), Generally Recognised as Safe (GRAS), were tested in this study. The treatments were as follows: (1) Water as control with and without *B. cinerea*, (2) Sodium Bicarbonate at 5 g/L with and without *B. cinerea*, (3) Salicylic Acid at 0.1 g/L with and without *B. cinerea*, (4) Calcium Chloride at 10g/L with and without *B. cinerea*, (4) *P. syringae* (BIOSAVE) at 1.59 g/L with and without *B. cinerea*, (5) *P. fluorescens* strain 4-6, $1x10^9$ CFU/ml with and without *B. cinerea* and or SBC, $CaCl_2$ and SA at the above mentioned concentrations, and (6) SCHOLAR (Fludioxonil 20.4%) at 0.6 g/L with *B. cinerea*. Ten apples were used for each replicate and each treatment had three replicates. The apples were incubated for 147 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides on the shelf-life of the fruit, after disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH and incubated for 7 days. The fruits were again evaluated for gray mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root

transformation before subjected to ANOVA. All pair-wise multiple comparison procedures were determined using Tukey test. Only data obtained from treatments containing pathogen were analysed.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments. The control (with *B. cinerea*) had the highest gray mold incidence at all observation points. The positive control fungicide treatments, SCHOLAR at 0.6 g/L had a complete control of gray mold for up to 147 days and in shelf-life study. After 4 weeks of incubation, in 'Gala' apples, the percent disease incidence in the combination of *P. fluorescens* strain 4-6 and each of the GRAS compounds (SBC, SA and $CaCl_2$) treatments ranged between 3 - 26.7 % and was significantly lower than the pathogen only positive control ($P = 0.001$). With the exception of SA, the two GRAS compounds SBC and $CaCl_2$ applied alone had higher disease incidence. The treatment of antagonist *P. fluorescens* strain 4-6 and BIOSAVE had 6.7% and 30% incidence of gray mold, respectively. The combination treatments of *P. fluorescens* strain 4-6 with each of the three GRAS compounds had better control than either *P. fluorescens* strain 4-6 or any of the GRAS compounds treated alone in cold storages until 147 days after incubation and shelf-life study. A combination of the antagonist *P. fluorescens* 4-6 and SBC was the most effective treatment for management of gray mold in this study for up to 147 days. With the exception of SCHOLAR treatment, a high disease incidence was observed in all the treatments for up to 147 days after incubation.

**Table 1**. Effect of *Pseudomonas fluorescens* 6 in combination with different GRAS compounds on the control of postharvest gray mold (*Botrytis cinerea*) in 'Gala' apples, 2015-16.

| | Percent Gray Mold Disease Incidence [a] | | | | | |
|---|---|---|---|---|---|---|
| Treatment | 28 days[b] | 57 days | 85 days | 113 days | 147 days | Shelf-life Study[c] |
| Water Control + *B. cinerea* [d] | 96.7 h [e] | 100.0 h | 100.0 g | 100.0 f | 100.0 f | 100.0 g |
| Sodium Bicarbonate @ 5 g/L+ *B. cinerea* | 70.0 g | 90.0 f | 96.7 fg | 96.7 e | 96.7 ef | 96.7 g |
| Salicylic Acid @ 0.1g/L + *B. cinerea* | 46.7 f | 93.3 f | 93.3 f | 93.3 e | 93.3 e | 96.7 g |
| Calcium Chloride @ 10g/L + *B. cinerea* | 66.7 g | 96.7 gh | 100.0 g | 100.0 f | 100.0 f | 100.0 g |
| BIOSAVE @ 1.59 g/L + *B. cinerea* | 0.0 a | 20.0 b | 50.0 c | 57.8 c | 57.8 c | 73.3 e |
| *P. fluorescens* 4-6 [f] + *B. cinerea* | 23.3 d | 73.3 e | 73.3 e | 73.3 d | 73.3 d | 86.7 f |
| Sodium Bicarbonate @ 5 g/L + *P. fluorescens* 4-6 + *B. cinerea* | 3.3 b | 20.0 b | 20.0 b | 20.0 b | 23.3 b | 30.0 b |
| Salicylic Acid @ 0.1g/L + *P. fluorescens* 4-6 + *B. cinerea* | 13.3 c | 60.0 d | 70.0 e | 73.3 d | 76.7 d | 76.7 d |
| Calcium Chloride @ 10g/L *P. fluorescens* 4-6 + *B. cinerea* | 26.7 e | 50.0 c | 56.7d | 56.7 c | 56.7 c | 66.7 c |
| SCHOLAR @ 0.6g/L + B. cinerea | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage. Not done for treatments with pathogen.
[d] *B. cinerea* treatments were used at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[f] *P. fluorescens* strain 4-6 was used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 13** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS IN COMBINATION WITH GRAS COMPOUNDS ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'GALA' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* strain 4-6, BIOSAVE (*Pseudomonas syringae*), Sodium Bicarbonate (Anachemia), Calcium Chloride (Fisher Scientific), Salicylic Acid (Sigma), SCHOLAR (20.4% Fludioxonil, Syngenta).

**METHODS:** A postharvest study was conducted using 'Empire' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 17, 2015 and stored at 4ºC until ready for processing. On October 6, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On October 7, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with inoculum of *Penicillium expansum* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the pathogen thiabendazole sensitive *P. expansum,* (Pe-S) and/or the required concentration of the biocontrol bacterium, *P. fluorescens* strain 4-6, BIOSAVE, GRAS compounds, chemical or fungicide. Three compounds, Sodium Bicarbonate (SBC), Calcium Chloride ($CaCl_2$), and Salicylic Acid (SA), Generally Recognised as Safe (GRAS), were tested in this study. The treatments were as follows: (1) Water as control with and without *P. expansum*, (2) Sodium Bicarbonate at 5g/L with and without *P. expansum*, (3) Salicylic Acid at 0.1 g/L with and without *P. expansum*, (4) Calcium Chloride at 10g/L with and without *P. expansum*, (4) *P. syringae* (BIOSAVE) at 1.59g/L with and without *P. expansum*, (5) *P. fluorescens* strain 4-6 at $1x10^9$ CFU/ml with and without *P. expansum* and/or SBC, $CaCl_2$ SA at the above mentioned concentrations, (6) SCHOLAR (Fludioxonil 20.4%) at 0.6g/L with *P. expansum*. Ten fruit were used for each replicate and each treatment had three replicates. The apples were incubated for 147 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides on the shelf-life of the fruit, after the disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for blue mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA.

All pair-wise multiple comparison procedures were determined using Tukey test. Only data obtained from treatments containing pathogen were analysed.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments. The control (with *P. expansum* ) had the highest blue mold incidence at all observation points. The positive control fungicide treatment, SCHOLA at 0.6 g/L had a complete control of blue mold. At 28 days after treatment, all the treatments had 0 - 3.3% blue mold incidence and the control had 76.7%. At 57 days, the combination of antagonist *P. fluorescens* strain 4-6 and each of the GRAS compounds (SBC, SA and $CaCl_2$) treatments had lower disease incidence than the GRAS compounds applied alone. With the exception of fungicide treatment, SCHOLAR, an increase in disease incidence was observed in all treatments after 85 days of incubation. The combination treatments of antagonist *P. fluorescens* strain 4-6 and each of the GRAS compounds had better control than the treatment of either *P. fluorescens* strain 4-6 or GRAS compounds alone.

**Table 1**. Effect of *Pseudomonas fluorescens* strain 4-6 alone or in combination with different GRAS compounds on the control of postharvest blue mold (*Penicillium expansum*) in 'Gala' apples, 2015-16.

| | Percent blue mold incidence[a] | | | | | |
|---|---|---|---|---|---|---|
| Treatment | 28 days[b] | 57 days | 85 days | 113 days | 147 days | Shelf-life Study[c] |
| Water Control + *P. expansum* [d] | 76.7 c [e] | 96.7 h | 96.7 g | 96.7 f | 100.0 g | 100.0 e |
| Sodium Bicarbonate @ 5 g/L + *P. expansum* | 0.0 a | 80.0 g | 83.3 f | 83.3 e | 86.7 e | 90.0 c |
| Salicylic Acid @ 0.1g/L + *P. expansum* | 3.3 b | 90.0 h | 100.0 g | 100.0 f | 100.0 g | 100.0 e |
| Calcium Chloride @ 10g/L+ *P. expansum* | 0.0 a | 63.3 f | 86.7 f | 86.7 e | 93.3 f | 96.7 d |
| BIOSAVE @ 1.59 g/L + *P. expansum* | 0 .0a | 0.0 a | 13.3 b | 60.0 c | 86.7 e | 100.0 e |
| *P. fluorescens* strain 4-6 [f] + *P. expansum* | 0 .0a | 20.0 c | 53.3 d | 63.3 cd | 73.3 c | 90.0 c |
| Sodium Bicarbonate @ 5 g/L + *P. fluorescens* strain 4-6 + *P. expansum* | 0.0 a | 10.0 b | 23.3c | 33.3 b | 50.0 b | 83.3 b |
| Salicylic Acid @ 0.1g/L + *P. fluorescens* strain 4-6 + *P. expansum* | 3.3 b | 30.0 d | 53.3 d | 73.3 e | 76.7 d | 90.0 c |
| Calcium Chloride @ 10g/L *P. fluorescens* strain 4-6 + *P. expansum* | 0.0 a | 36.7 e | 63.3 e | 66.7 d | 73.3 c | 80.0 b |
| SCHOLAR @ 0.6g/L + *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage. Not done for treatments with pathogen.
[d] *P. expansum* was at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[f] *P. fluorescens* strain 4-6 was used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 14** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS IN COMBINATION WITH CHEMICAL FUNGICIDES ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'EMPIRE' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* strain 4-6, *Pseudomonas fluorescens* strain 1-112, SCHOLAR (20.4% Fludioxonil, Syngenta), MERTECT (Thiabendazole 45%, Syngenta).

**METHODS:** A postharvest study was conducted using 'Empire' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 21, 2015 and stored at 4ºC until ready for processing. On October 19, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On October 19, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with inoculum of *Botrytis cinerea* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL of the pathogen (thiabendazole sensitive *B. cinerea*, Bc-S) and/or the required concentration of the biocontrol bacterium, *P. fluorescens* strain 4-6 or *P. fluorescens* strain 1-112 or fungicide.. The treatments were as follows: (1) Water as control with and without *B. cinerea*, (2) *P. fluorescens* strain 4-6 at $1x10^9$ CFU/mL, (3) *P. fluorescens* strain 1-112 at $1x10^9$ CFU/ mL, (4) *P. fluorescens* strain 4-6 and strain 1-112 at $1x10^9$ CFU/ mL, (5) SCHOLAR at half the recommended rate, at 0.3g/L, (6) MERTECT at half the recommended rate, at 0.575 g/L, (7) SCHOLAR at 0.3 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/mL, (8) ) MERTECT at 0.575 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/ mL. All the treatments contained the pathogen. Ten apples were used for each replicate and each treatment had three replicates. The apples were incubated for 115 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides or biocontrol bacteria on the shelf-life of the fruit, after the disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for gray mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA. All pair-wise multiple comparison procedures were determined using Tukey test.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments on ‘Empire’ apples. The control (with *B. cinerea* ) had the highest gray mold incidence at all observation points. The two antagonist strains, *P. fluorescens* strain 4-6 and strain 1-112 when treated alone had the next highest gray mold incidence. The combination of two antagonist strains, *P. fluorescens* strain 4-6 and strain 1-112, treatment had significantly lower gray mold disease incidence than that of either of the strains. All the combination treatments with the antagonist, *P. fluorescens* strain 4-6 or strain 1-112, and half rate of the commercially recommended rates of the chemical fungicides MERTEC or SCHOLAR had complete control of gray mold up to 115 days in cold storage and in the subsequent shelf-life study. The positive chemical fungicide controls, MERTEC or SCHOLAR also had complete control of gray mold.

**Table 1**. Effect of two strains of *Pseudomonas fluorescens* in combination with chemical fungicides on the control of postharvest gray mold (*Botrytis cinerea*) in 'Empire' apples, 2015-16.

| | Percent Gray Mold Disease Incidence[a] | | | | |
|---|---|---|---|---|---|
| Treatment | 28 days[b] | 56 days | 83 days | 115 days | Shelf-life Study[c] |
| *Control with inoculum (B. cinerea)*[d] | 86.7 e[e] | 96.7 d | 96.7 e | 96.7 e | 96.7 c |
| *P. fluorescens* strain 4-6 [e] + *B. cinerea* | 36.7 c | 63.3 c | 73.3 d | 73.3 d | 73.3 c |
| *P. fluorescens* strain 1-112 [e] + *B. cinerea* | 46.7 d | 66.7 c | 66.7 c | 66.7 c | 70.8 c |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + *B. cinerea* | 30.0 b | 53.3 b | 56.7 b | 56.7 b | 56.7 b |
| *P. fluorescens* strain 4-6 + MERTECT @ 0.575 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + SCHOLAR @ 0.3 g/L + *B. cinerea* | 0 .0 a | 0 .0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P .fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| SCHOLAR @ 0.3 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| MERTECT @ 0.575 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage
[d] *B. cinerea* was used at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[f] The strains *P. fluorescens* 4-6 or 1-112 were used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 15** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS IN COMBINATION WITH CHEMICAL FUNGICIDES ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'EMPIRE' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* strain4-6, *Pseudomonas fluorescens* strain 1-112, SCHOLAR (20.4% Fludioxonil, Syngenta), MERTECT (Thiabendazole 45 %, Syngenta).

**METHODS:** A postharvest study was conducted using 'Empire' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 21, 2015 and stored at 4ºC until ready for processing. On October 19, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On October 19, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Penicillium expansum* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the pathogen thiabendazole sensitive *P. expansum* (Pe-S) and/or the required concentration of the biocontrol bacterium, *P. fluorescens* strain 4-6 or *P. fluorescens* strain 1-112 or fungicide.. The treatments were as follows: (1) Water as control with and without *P. expansum*, (2) *P. fluorescens* strain 4-6 at $1x10^9$ CFU/ mL, (3) *P. fluorescens* strain 1-112 at $1x10^9$ CFU/ mL, (4) *P. fluorescens* strain 4-6 and strain 1-112 at $1x10^9$ CFU/ mL, (5) SCHOLAR at half the recommended rate, at 0.3 g/L, (6) MERTECT at half the recommended rate, at 0.575 g/L, (7) SCHOLAR at 0.3 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/ mL, (8) MERTECT at 0.575 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/ mL. All the treatments contained pathogen. Ten fruits were used for each replicate and each treatment had three replicates. The apples were incubated for 115 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides or biocontrol bacteria on the shelf-life of the fruit, after the disease incidence evaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for gray mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA. All pair-wise multiple comparison procedures were determined using Tukey test.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments on 'Empire' apples. The control (with *B. cinerea* ) had the highest blue mold incidence at all observation points. The two antagonist strains, *P. fluorescens* 4-6 and 1-112, when treated alone had the next highest blue mold incidence. The combination treatment of two antagonist strains, *P. fluorescens* 4-6 and 1-112, had significantly lower blue mold disease incidence than either of the bacterial strains. All the combination treatments with the antagonist, *P. fluorescens* strain 4-6 or strain 1-112, and half rate of the commercially recommended rates of the chemical fungicides MERTECT or SCHOLAR had complete control of blue mold up to 115 days in cold storage. In the shelf-life study, except for the treatment of *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + SCHOLAR at 0.3 g/L which had 10.4% disease incidence, all the other treatments with the antagonist strains, *P. fluorescens* 4-6 and 1-112 and chemical fungicide combinations had complete control in the subsequent shelf-life study. The positive chemical fungicide controls, MERTECT or SCHOLAR also had complete control of blue mold.

**Table 1**. Effect of two strains of *Pseudomonas fluorescens* in combination with chemical fungicides on the control of postharvest blue mold (*Penicillium expansum*) in 'Empire' apples, 2015-16.

| | Percent Disease Incidence[a] | | | | |
|---|---|---|---|---|---|
| Treatment | 28 days[b] | 56 days | 83 days | 115 days | Shelf Study[c] |
| *Control with Inoculum (P. expansum[d])* | 10.0 b[e] | 86.7 e | 86.7 d | 86.7 d | 90.0 e |
| *P. fluorescens* strain 4-6[f] + *P. expansum* | 10.0 a | 30.0 c | 70.0 c | 70.0 c | 86.7 d |
| *P .fluorescens* strain 1-112[f] + *P. expansum* | 20.0 c | 66.7 d | 83.3 d | 83.3 d | 86.7 d |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 | 0.0 a | 10.0 b | 40.0 b | 56.7 b | 63.3 c |
| *P. fluorescens* strain 4-6 + MERTECT @ 0.575 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + SCHOLAR @ 0.3 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 10.4 b |
| SCHOLAR @ 0.3 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| MERTECT @ 0.575 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage
[d] *P. expansum* was used are at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[f] The strains of *P. fluorescens* were used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 16** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS IN COMBINATION WITH CHEMICAL FUNGICIDES ON THE CONTROL OF POSTHARVEST GRAY MOLD IN 'MCINTOSH' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* 4-6, *Pseudomonas fluorescens* 1-112, SCHOLAR (20.4% Fludioxonil, Syngenta), MERTECT (Thiabendazole 45 %, Syngenta).

**METHODS:** A postharvest study was conducted using 'McIntosh' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 14, 2015 and stored at 4ºC until ready for processing. On September 28, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. September 29, 2015, the apples were punctured once with a nail-tapered probe to a depth of 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Botrytis cinerea* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL of the thiabendazole (TBZ) –resistant pathogen (*B. cinerea*, Bc34R) and/or the required concentration of the biocontrol bacterium, *P. fluorescens* strain 4-6 or *P. fluorescens* strain 1-112 , or fungicide. The treatments were as follows: (1) Water as control with and without *B. cinerea*, (2) *P. fluorescens* strain 4-6 at $1x10^9$ CFU/mL (3) *P. fluorescens* strain 1-112 at $1x10^9$ CFU/mL (4) *P. fluorescens* strain 4-6 and 1-112 at $1x10^9$ CFU/mL (5) SCHOLAR at half the recommended rate, at 0.3g/L, (6) MERTECT at half the recommended rate, at 0.575 g/L, (7) SCHOLAR at 0.3 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/mL, (8) MERTECT at 0.575 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/ mL. All the treatments contained pathogen. Ten fruit were used for each replicate and each treatment had three replicates. The apples were incubated for 115 days at 4°C and evaluated for disease incidence approximately once every 4 weeks. Fruits were considered diseased when a lesion is developed on the fruit. 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 subjected to ANOVA. All pair-wise multiple comparison procedures were determined using Tukey test.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments on 'McIntosh' apples. The control (with *B. cinerea*) had the highest gray mold incidence at all observation points. The

treatments of two antagonists *P. fluorescens* strain 4-6 and strain 1-112 applied alone had the next highest gray mold incidence. The combination of two antagonists, *P. fluorescens* strain 4-6 and strain 1-112 had significantly lower gray mold disease incidence than that of either of the bacterial strains. All the combination treatments with the antagonist, *P. fluorescens* strain 4-6 or strain 1-112, and half rate of the commercially recommended rates of the chemical fungicide SCHOLAR had complete control of gray mold up to 115 days in cold storage. The positive chemical control, SCHOLAR also had complete control of gray mold. As expected, MERTECT was ineffective against TBZ-resistant *B. cinerea* in the treatments with MERTECT alone or in combination of MERTECT and the two antagonists, *P. fluorescens* strain 4-6 and strain 1-112 .

**Table 1**. Effect of two strains of *Pseudomonas fluorescens* in combination with chemical fungicides on the control of postharvest gray mold (*Botrytis cinerea*) in 'McIntosh' apples, 2015-16.

| | Percent Gray Mold Disease Incidence[a] | | | |
|---|---|---|---|---|
| Treatment | 30 days[b] | 59 days | 84 days | 115 days |
| *B. cinerea* [c] | 63.3 f [d] | 96.7 f | 96.7 g | 96.7 g |
| *P. fluorescens* strain 4-6 [e] + *B .cinerea* | 26.7 d | 73.3 e | 63.3 e | 63.3 d |
| *P. fluorescens* strain 1-112 [e] + *B. cinerea* | 33.3 e | 73.3 e | 73.3 f | 76.7 f |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112+ *B. cinerea* | 3.3 b | 40.0 b | 40.0 c | 43.3 b |
| *P. fluorescens* strain 4-6 + MERTECT @ 0.575 g/L+ *B.cinerea* | 16.7 c | 63.3 d | 66.7 e | 70.0 e |
| *P. fluorescens* strain 4-6 + SCHOLAR @ 0.3 g/L+ *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L+ *B. cinerea* | 20.0 c | 50.0 c | 53.3 d | 57.4 c |
| *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L+ *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P .fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L+ *B. cinerea* | 3.3 b | 50.0 c | 53.3 d | 76.7 f |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L+ *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| SCHOLAR @ 0.3 g/L + *B. cinerea* | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| MERTECT @ 0.575 g/L + *B. cinerea* | 3.3 b | 50.0 c | 53.3 d | 76.7 f |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] *B. cinerea* was used at a concentration of $1x10^4$ spores/mL
[d] Means within the column followed by the same letter are not significantly different according to the Tukey test (P = 0.05)
[e] The strains, *P. fluorescens* 4-6 or 1-112 were used at a concentration of $1x10^9$ cfu/mL

**2016 PMR REPORT # 17** **SECTION K: FRUIT - Diseases**

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

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**TITLE: EFFECT OF BIOLOGICAL CONTROL AGENTS IN COMBINATION WITH CHEMICAL FUNGICIDES ON THE CONTROL OF POSTHARVEST BLUE MOLD IN 'MCINTOSH' APPLES, 2015-16.**

**MATERIALS:** *Pseudomonas fluorescens* strain 4-6, *Pseudomonas fluorescens* strain 1-112, SCHOLAR (20.4% Fludioxonil, Syngenta), MERTECT (Thiabendazole 45 %, Syngenta).

**METHODS:** A postharvest study was conducted using 'McIntosh' apples which were obtained from trees maintained according to standard orchard practices at the Agriculture and Agri-Food Canada Farm in Jordan Station, Ontario. Apples were harvested on September 14, 2015 and stored at 4 ºC until ready for processing. On September 28, 2015, 50 apples at a time were surface disinfested in 40 L of a 0.6% sodium hypochlorite and 0.001% Tween 20 solution for 4 minutes followed by a 4 minute rinse in water. After the surface disinfestation, the apples were allowed to air dry before being placed into mesh bags, ten per bag. The bags were placed into plastic crates and stored overnight in cold storage at 4ºC. On September 29, 2015, the apples were punctured once with a nail-tapered probe 5 mm deep and 4 mm wide at its base. Wounded fruit were then drenched for 30 seconds with the inoculum of *Penicillium expansum* and/or treatments. Each treatment consisted of 1 L of inoculum containing $1x10^4$ spores/mL water of the thiabendazole ( TBZ)-sensitive pathogen *P. expansum* (Pe-S) and/or the required concentration of the biocontrol bacterium, *P. fluorescens* strain 4-6 or *P. fluorescens* strain 1-112, or fungicide. The treatments were as follows: (: (1) Water as control with and without inoculum, (2) *P. fluorescens* strain 4-6 at $1x10^9$ CFU/mL, (3) *P. fluorescens* strain 1-112 at $1x10^9$ CFU/mL, (4) *P. fluorescens* strain 4-6 and strain1-112 at $1x10^9$ CFU/mL, (5) SCHOLAR at half the recommended rate, at 0.3g/L, (6) MERTECT at half the recommended rate, at 0.575 g/L, (7) SCHOLAR at 0.3 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/mL, (8) MERTECT at 0.575 g/L with one or both of the *P. fluorescens* strains at $1x10^9$ CFU/mL. Ten fruits were used for each replicate and each treatment had three replicates. The apples were incubated for 115 days at 4°C and were evaluated for disease incidence approximately once every 4 weeks. To determine the efficacy of fungicides or biocontrol bacteria on the shelf-life of the fruit, after the fruit disease incidenceevaluations following incubation in cold storage, the fruits were placed at 20°C and 85% RH, and incubated for 7 days. The fruits were again evaluated for gray mold incidence (percent infected apples). Fruits were considered diseased when a lesion is developed on the fruit. The general linear model (GLM) procedures were used for the analysis of variance (ANOVA; SigmaStat 2.0 for Windows, SPSS Science, Chicago, IL). Data recorded as percentage were subjected to arcsine square-root transformation before subjected to ANOVA. All pair-wise multiple comparison procedures were determined using Tukey test.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** Significant differences were observed among the treatments on 'McIntosh' apples. The control (with *P. expansum*) had the highest blue mold incidence at all observation points. At 30 days after treatment, with the exception of the control treatment, all the other treatments had good control of blue mold. At 59 to 115 days after treatment, the two antagonist strains, *P. fluorescens* strain 4-6 and strain 1-112, when treated alone had the next highest blue mold incidence. The combination of two antagonist strains, *P. fluorescens* 4-6 and 1-112, treatments had significantly lower blue mold disease incidence than the treatments of either of the bacterial strains. All the combination treatments with the antagonist *P. fluorescens* strain 4-6 or strain 1-112 and at the half rate commercially recommended rates of the chemical fungicide MERTECT or SCHOLAR had complete control of blue mold up to 115 days in cold storage. The positive chemical fungicide treatment, MERTECT or SCHOLAR also had complete control of blue mold.

**Table 1**. Effect of two strains of *Pseudomonas fluorescens* in combination with chemical fungicides on the control of postharvest blue mold (P*enicillium expansum*) in 'McIntosh' apples, 2015-16.

| | Percent Disease Incidence [a] | | | | |
|---|---|---|---|---|---|
| Treatment | 30 days[b] | 59 days | 84 days | 115 days | Shelf Study[c] |
| Control with Inoculum (*P. expansum* [d]) | 13.3 c [e] | 90.0 d | 96.7 e | 100.0 f | 100.0 f |
| *P. fluorescens* strain 4-6 [f]+ *P. expansum* | 3.3 b | 30.0 c | 63.3 c | 73.3 d | 90.0 e |
| *P. fluorescens* strain 1-112 [f] + *P. expansum*+ *P. expansum* | 0.0 a | 33.3 c | 73.3 d | 86.7 e | 93.3 e |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112+ *P. expansum* | 0.0 a | 20.0 b | 40.0 b | 56.7 c | 73.3 d |
| *P. fluorescens* strain 4-6 + MERTECT @ 0.575 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + SCHOLAR @ 0.3 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 6.7 b | 10.0 c |
| *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 b |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + MERTECT @ 0.575 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| *P. fluorescens* strain 4-6 + *P. fluorescens* strain 1-112 + SCHOLAR @ 0.3 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| SCHOLAR @ 0.3 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |
| MERTECT @ 0.575 g/L+ *P. expansum* | 0.0 a | 0.0 a | 0.0 a | 0.0 a | 0.0 a |

[a] Data represent the mean of three replicates.
[b] Number of days apples stored at 4ºC after treatment.
[c] 7 days at 20ºC after 4ºC storage
[d] *P. expansum* was used at a concentration of $1x10^4$ spores/mL
[e] Means within the column followed by the same letter are not significantly different according to the Tukey test
[f] The strains, *P. fluorescens* 4-6 or 1-112 were used at a concentration of $1x10^9$ cfu/m

**2016 PMR REPORT #18** **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

**CROP:** Celery (*Apium graveolens*), cv. TZ 6200
**PEST:** Celery anthracnose (*Colletotrichum fioriniae*)

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**TITLE: EVALUATION OF FUNGICIDES FOR THE CONTROL OF CELERY LEAF CURL (ANTHRACNOSE), 2016**

**MATERIALS:** ALLEGRO (fluazinam 40.0%), BRAVO ZN (chlorothalonil 500 g/L), FLINT (trifloxystrobin 50%), QUADRIS FLOWABLE (azoxystrobin 250 g/L), SWITCH (cyprodinil 37.5%, fludioxinil 25.5%)

**METHODS:** The trial was conducted on organic soil at the Muck Crops Research Station (pH ≈ 5.9, organic matter ≈ 66%), Holland Marsh, Ontario. Celery, cultivar TZ6200, was seeded in the greenhouse on 7 May, and transplanted in the field on 24 June, with in-row plant spacing of 18 cm. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of 3 rows, 55 cm apart and 5 m in length. Treatments were: BRAVO ZN at 2.4 L/ha, FLINT at 210 g/ha, ALLEGRO at 1.16 L/ha, SWITCH at 975 g/ha, and QUADRIS FLOWABLE at 1,120 mL/ha. An untreated check was also included. Fungicide treatments were applied on 6, 15, & 23 August and 6 & 16 September using a $CO_2$ backpack sprayer equipped with four TeeJet 8002VS fan nozzles spaced 40 cm apart and calibrated to deliver 400 L/ha at 275 kPa. The trial was inoculated with *Colletotrichum fioriniae* produced from freshly collected diseased celery leaves, grown on V8 agar at 25°C and allowed to colonize the plate. On 9 August, conidia were scraped from the plates and added to sterile water and diluted to a concentration of 100,000 spores/mL. Tween 20 was added as a surfactant. Four liters of the condia suspension was immediately sprayed evenly over the entire trial area using a $CO_2$ backpack sprayer to inoculate the trial. On 17 August, plants in the inside row in each replicated plot were counted. On 17 & 22 August the counted plants were visually examined for disease symptoms and numbers recorded. On 12 October, 15 celery plants were harvested from the center row of each replicate and trimmed to 40 cm. After trimming, plants were inspected for the presence of anthracnose based on visual symptoms such as leaf cupping and petiole twisting and the presence of lesions in the heart of the celery, sorted into marketable and unmarketable categories, counted and weighed to determine marketable yield. Compared to the previous 10 year averages, air temperatures in 2016 were average for June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10-year average temperatures were: June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10-year average for June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10-year rainfall averages were: June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. All data were analyzed using the General Analysis of Variance function of Statistics V.10. Means separation was obtained using Fisher's Protected LSD test with $P = 0.05$ level of significance.

**RESULTS:** as presented in Table 1
**CONCLUSIONS:** Significant differences in leaf curl incidence and percent marketable were found among the treatments when trimmed celery was assessed on 12 October (Table 1). All fungicides reduced

the incidence of anthracnose compared to the untreated check. No significant differences in anthracnose incidence were observed among the treatments at in-field assessments on 17 & 22 August and no significant differences in the weight per marketable head were found among the treatments (Table 1).

**ACKNOWLEDGMENT:** Funding for this project was provided by the Fresh Vegetable Growers of Ontario.

**Table 1.** Leaf curl incidence and % marketable for celery, cv. TZ 6200, inoculated with *Colletotrichum fioriniae* and grown at Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Leaf Curl Incidence (%)[1] | | | % Marketable | Wgt/Mkb Head (g) |
|---|---|---|---|---|---|
| | 17 Aug | 22 Aug | 12 Oct | | |
| ALLEGRO | 1.7 ns[2] | 35.2 ns | 8.3 a[3] | 66.9 a[3] | 923.4 ns |
| BRAVO ZN | 4.2 | 23.7 | 9.8 a | 57.2 a | 893.5 |
| SWITCH | 5.8 | 22.6 | 13.3 a | 60.9 a | 903.2 |
| FLINT | 4.1 | 23.4 | 16.7 a | 59.4 a | 964.2 |
| QUADRIS | 2.5 | 18.3 | 21.7 a | 57.6 ab | 903.5 |
| Check | 9.2 | 25.3 | 40.0 b | 44.4 b | 969.9 |

[1] Celery was assessed for leaf curl incidence in the field 17 & 22 August and on 15 trimmed plants harvested on 12 October.
[2] ns = no significant difference among the treatments
[3] Numbers in a column followed by the same letter are not significantly different at $P = 0.05$, Fisher's Protected LSD Test.

**2016 PMR REPORT # 19** **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

**CROP:** Celery (*Apium graveloens* L.) cv. TZ 6200
**PEST:** Leaf Curl Anthracnose, *Colletotrichum fioriniae* ((Marcelino & Gouli) R.G. Shivas & Y.P. Tan)

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**TITLE: EVALUATION OF WEATHER-BASED FORECASTING MODELS TO MANAGE LEAF CURL ON CELERY CROPS IN ONTARIO**

**MATERIALS:** QUADRIS FLOWABLE (25.0% azoxystrobin), SWITCH 62.5WG (cyprodinil 37.5% and fludioxonil 25.0%)

**METHODS:** The trial was conducted in 2016 at the Muck Crops Research Station in the Holland Marsh, Ontario. Celery cultivar TZ 6200 was seeded into 288-cell plug trays on 6 May and was grown in a greenhouse for 8 weeks. On 28 June, celery was transplanted using a mechanical transplanter into the field in organic soil. A Randomized Complete Block Design with four replicates per treatment was used. Each main plot consisted of two subplots, with a total of six rows that were 55 cm apart, 5 meters in length and had in-row spacing of 15 cm. Fungicide QUADRIS FLOWABLE (azoxystrobin 25.0%, Syngenta Crop Protection Canada) was alternated with SWITCH 62.5WG (cyprodinil 37.5% and fludioxonil 25.0%, Syngenta Crop Protection Canada). QUADRIS FLOWABLE was applied at a rate of 1.12 L/ha and SWITCH 62.5WG was applied at 1 kg/ha. Spray timing was determined using: BOTCAST (Botrytis leaf blight forecasting) with at a Cumulative Disease Severity Index value of 21, and TOMCAST at Disease Severity Value threshold of 15. All forecasting models were compared to a 7 to 10-day CALENDAR spray program and a non-treated CONTROL. Leaf wetness and temperature data was collected from a weather station on site within a nearby field. The border rows of each treatment were inoculated with *Colletotrichum fioriniae* ($1 \times 10^5$ spores/ml), plus the surfactant Tween 20, on 28 July. Two litres of the spore suspension were sprayed using a $CO_2$ backpack sprayer fitted with four fan-type TeeJet 8002 nozzles, where the rate was applied at 10 mL per meter. The inner four rows were visually assessed weekly for the presence of leaf curl, and disease severity was rated within 1.5 meters per row using a 0 - 5 scale, where 0 = no symptoms, 1 = 1-10%, 2 = 10-25%, 3 = 25-50%, 4 = 50-75%, and 5 = >75% of plant area showing leaf curl and petiole anthracnose symptoms. Disease scale values were used to determine the disease severity index (DSI) with the following equation:

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

Celery was harvested on 4 October, and a total of 20 plants with five per row were assessed. Marketable weight was first determined by removing stalks with lesions or discarding plants with crown rot and weighing only disease-free plants after trimming to marketable length (40 cm). The percent marketable by weight was determined by dividing the marketable weight by the total weight, which was the weight of the marketable and unmarketable tissue. The marketable weight per plant was determined by dividing the marketable weight by the number of marketable plants in each replicate plot.
Compared to the previous 10 year averages, air temperature in 2016 were average for May (13.8°C), June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10 year average temperatures were: May 14.1°C, June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10 year average for May (45 mm), June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10 year rainfall averages were: May 68 mm, June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. All statistical analyses were performed using the General Analysis of Variance function of Statistix 10. Means separation was obtained using a Fisher's LSD with $P < 0.05$ level of significance.

**RESULTS:** Data are presented in Table 1.

**CONCLUSION:** Disease incidence and severity (DSI) were significantly lower in both the TOMCAST and CALENDAR spray program treatments, relative to the BOTCAST and CONTROL treatments (Table 1). TOMCAST provided the same amount of control as the CALENDAR spray program, for both incidence and severity, and resulted in the same percent marketable weight, which were both significantly higher than the BOTCAST and no-spray CONTROL treatments (Table 2). The weight per plant was not significantly different among the treatments and the no-spray CONTROL. However, diseased plants in both the BOTCAST and no-spray CONTROL treatments were generally discarded due to the severe lesion development and/or presence of crown rot (Table 1). The number of fungicide applications was reduced from seven in the CALENDAR spray program to five for TOMCAST. BOTCAST only triggered one fungicide spray, late in the season. Although BOTCAST had the highest cost savings, this forecasting model was not a good predictor for leaf curl as levels of disease were higher and the percentage of marketable yield by weight was lower than that of TOMCAST. The CALENDAR spray program and TOMCAST both controlled leaf curl to manageable levels, but the cost of using TOMCAST was lower.

**Table 1.** The number of sprays, estimated cost savings, disease incidence, disease severity, percent marketable yield by weight and weight per plant for forecasting spray treatments for management of leaf curl on celery, cv. TZ 6200, at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Application date (DAFA)[1] | No. Sprays | Savings ($/ha)[2] | Incidence (%)[3] | DSI (%)[4] | Market. by Wt. (%) | Wt./Plant (kg) |
|---|---|---|---|---|---|---|---|
| TOMCAST | 0, 10, 20, 35, 49 | 5 | $364 | 13 a[5] | 9 a | 99 a | 0.87 ns[6] |
| CALENDAR | 0, 10, 20, 28, 38, 49, 58 | 7 | 0 | 9 a | 6 a | 98 a | 0.85 |
| BOTCAST | 58 | 1 | $1093 | 41 b | 39 b | 70 b | 0.85 |
| CONTROL | -- | 0 | -- | 37 b | 38 b | 64 b | 0.78 |

[1] DAFA = Days after first spray; first fungicide application was on 26 July for both TOMCAST and the CALENDAR spray program treatments (first application = 0 days)
[2] Savings relative to the CALENDAR spray program: QUADRIS FLOWABLE = $130.96/ha, and SWITCH 62.5WG = $233.29/ha
[3] Incidence measured one week prior to harvest
[4] Disease severity index (DSI) measured one week prior to harvest
[5] Numbers in a column followed by the same letter are not significantly different at $P < 0.05$, based on Fisher's LSD test
[6] Not significantly different at $P < 0.05$, Fisher's LSD test

**2016 PMR REPORT # 20** **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

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

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**TITLE: EVALUATION OF VARIOUS FUNGICIDES FOR CONTROL OF STEMPHYLIUM LEAF BLIGHT ON ONIONS, 2016**

**MATERIALS:** DITHANE (mancozeb 75.0%), FONTELIS (penthiopyrad 200 g/L), LUNA TRANQUILITY (fluopyram 125 g/L, pyrimethanil 375 g/L), PRISTINE (pyraclostrobin 25.2%, boscalid 12.8%), QUADRIS TOP (azoxystrobin 200 g/L, defenoconazole 125 g/L), SECARDIS (fluxapyroxad 300 g/L), SYN A196449B (experimental)

**METHODS:** Onions, cv. La Salle, grown as transplants, (3 seeds per plug) were transplanted on 26 May into organic soil (organic matter ≈ 67.3%, pH ≈ 6.8) using a mechanical transplanter near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each experimental unit consisted of eight rows (40 cm apart), 6 m in length. Treatments were: LUNA TRANQUILITY at 1.2 L/ha, FONTELIS at 1.4 L/ha, QUADRIS TOP at 1.0 L/ha, DITHANE at 3.25 kg/ha, SECARDIS at 333 mL/ha, PRISTINE at 1.3 kg/ha and SYN A19649B at 375 mL/ha. An untreated check was also included. Treatments were applied on 15, 26, July, 4 and 11 August using a tractor-mounted sprayer fitted with AI TeeJet Air Induction Even Flat spray tips (AI9503 EVS) at 550 kPa to deliver 500 L solution/ha. On 30 June, onions in two 2 m sections of row were counted and marked with stakes in order to determine percent diseased. On 30 June, 8, 19, and 29 July, leaves of onions in the counted 2 m sections were visually examined for stemphylium symptoms and the number of diseased plants was recorded. On 8 August, all onions in one of the 2 m sections were pulled from each replicate. Leaves were removed and green leaves sorted into classes based on the percentage of the leaf area infected with stemphylium. The six classes were: no disease, 1-10% infected, 11-25%, 26-50%, 51-75% and >75% infected with stemphylium. These classes were used to determine the disease severity index (DSI) using the following formula:

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

On 24 September, the onions in two 2.32 m sections of row were pulled from the middle six rows for a yield sample. Onions were weighed and graded for size on 19 October to determine yield. Compared to the previous 10-year averages, air temperatures in 2016 were average for May (13.8°C), June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10-year average temperatures were: May 14.1°C, June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10-year average for May (45 mm), June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10-year rainfall averages were: May 68 mm, June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. Data were analyzed using the General Analysis of Variance function of Statistix V.10. Means separation was obtained by using Fisher's Protected LSD test at $P = 0.05$ level of significance.

**RESULTS:** as presented in Tables 1 & 2

**CONCLUSIONS:** In 2016, disease pressure was low and by 9 August, incidence ranged from 29 - 44%. No significant differences in the incidence or severity of stemphylium were observed among the treatments (Table 1). No significant differences in yield or percent marketable were found among the treatments (Table 2).

**Table 1.** Stemphylium disease ratings for onions, cv. La Salle, treated with various fungicides and grown near Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Stemphylium Incidence (%)[1] | | | 9 Aug Leaf Rating[2] | | |
|---|---|---|---|---|---|---|
| | 30 Jun | 8 Jul | 19 Jul | 29 Jul | % Diseased | DSI[3] |
| QUADRIS TOP | 0.0 ns[4] | 0.0 ns | 1.0 ns | 3.9 ns | 29.9 ns | 19.6 ns |
| Check | 0.0 | 0.0 | 2.1 | 6.0 | 30.5 | 20.5 |
| DITHANE | 0.0 | 0.0 | 0.3 | 7.8 | 40.7 | 27.1 |
| SECARDIS | 0.0 | 0.0 | 0.3 | 8.8 | 39.6 | 26.3 |
| SYN A19649B | 0.0 | 0.0 | 1.0 | 9.9 | 44.3 | 27.6 |
| LUNA TRANQUILITY | 0.0 | 0.0 | 1.6 | 11.3 | 33.9 | 23.7 |
| PRISTINE | 0.0 | 0.0 | 0.7 | 13.9 | 34.1 | 20.9 |
| FONTELIS | 0.0 | 0.0 | 1.8 | 14.8 | 31.0 | 20.3 |

[1] Based on in-field ratings using # plants with stemphylium/# plants assessed = stemphylium incidence (%)

[2] Leaves were sorted into the following classes: 0 = 0%, 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4 = 51-75%, 5 = >75% of the leaf area diseased.

[3] Disease Severity Index (DSI) was determined using the following equation:

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

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

**Table 2.** Yield data for onions, cv. La Salle, treated with experimental fungicides and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Treatment | Yield (t/ha) | % Mkb | Size Distribution (%)[1] | | |
|---|---|---|---|---|---|
| | | | Jumbo (>76 mm) | Can No.1 (45-76 mm) | Cull (<45 mm) |
| LUNA TRANQUILITY | 28.3 ns[2] | 81.4 ns | 2.7 ns | 78.7 ns | 18.6 ns |
| QUADRIS TOP | 28.1 | 84.7 | 6.5 | 78.2 | 15.3 |
| SECARDIS | 27.8 | 82.0 | 2.0 | 80.0 | 18.0 |
| PRISTINE | 27.7 | 82.9 | 3.6 | 79.3 | 17.1 |
| FONTELIS | 24.9 | 78.1 | 2.2 | 75.9 | 21.9 |
| SYN A19649B | 23.7 | 76.1 | 2.1 | 74.0 | 23.9 |
| DITHANE | 20.9 | 72.1 | 0.7 | 71.4 | 27.9 |
| check | 26.2 | 77.4 | 2.9 | 74.4 | 22.6 |

[1] Percentage was determined by weight
[2] ns = no significant differences were found among the treatments

**2016 PMR REPORT #21** **SECTION L: VEGETABLES and SPECIAL CROPS - Diseases**

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

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**TITLE: CONTROL OF STEMPHYLIUM LEAF BLIGHT ON ONIONS USING VARIOUS SPRAY TIPS AND PRESSURES, 2016**

**MATERIALS:** LUNA TRANQUILITY (fluopyram 125 g/L, pyrimethanil 375 g/L), SYLGARD 309 (siloxylated polyether 76%, surfactant mixture 24%)

**METHODS:** Onions, cv. La Salle, grown as transplants (3 seeds per plug) were transplanted on 26 May into organic soil (organic matter ≈ 67.3%, pH ≈ 6.8) using a mechanical transplanter near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each experimental unit consisted of eight rows (40 cm apart), 6 m in length. Treatments were various nozzles and spray equipment as described in Table 1 used to apply LUNA TRANQUILITY at 1.2 L/ha with and without SYLGARD 309 using a 500 L/ha spray volume. An untreated check was also included. Treatments were applied on 12, 13, 20, July, 5 and 15 August. On 30 June, onions in two 2 m sections of row were counted and marked with stakes as assessment areas. On 14, 22, and 29 July, leaves of onions plants in the staked out 2 m sections were visually examined for stemphylium leaf blight symptoms and the number of diseased plants was recorded. On 3 August, all onions in one of the 2 m sections were pulled from each replicate. Leaves were removed and green leaves sorted into classes based on the percentage of the leaf area infected with stemphylium. The six classes were: no disease, 1-10% infected, 11-25%, 26-50%, 51-75% and >75% infected with stemphylium. These classes were used to determine the disease severity index (DSI) using the following formula:

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

On 30 August, the onions in two 2.32 m sections of row were pulled from the middle two rows for a yield sample. Onions were weighed and graded for size on 13 October to determine yield. Compared to the previous 10 year averages, air temperatures in 2016 were average for May (13.8°C), June (18.7°C), and above average for July (22.0°C) August (22.6°C), September (17.4°C) and October (10.9°C). The 10-year average temperatures were: May 14.1°C, June 18.7°C, July 21.0°C, August 19.8°C, September 15.8°C and October 9.4°C. Monthly rainfall was below the 10-year average for May (45 mm), June (39 mm), July (51 mm), August (58 mm), September (25 mm), and October (41 mm). The 10-year rainfall averages were: May 68 mm, June 85 mm, July 96 mm, August 71 mm, September 82 mm and October 73 mm. Data were analyzed using the General Analysis of Variance function of Statistix V.10. Means separation was obtained by using Fisher's Protected LSD test at $P = 0.05$ level of significance.

**RESULTS:** In 2016, the weather was hot and dry and stemphylium disease pressure in the Holland Marsh was low. From 14 to 29 July stemphylium incidence increased from 0 to 9% in untreated onions. When leaves were removed and assessed on 3 August, stemphylium incidence among all treatments ranged from 13 - 21% and significant differences in stemphylium incidence were found among the

treatments (Table 2). Onions sprayed with LUNA TRANQUILITY + SYLGARD using 620 kPa spray pressure had significantly less stemphylium incidence and lower severity than onions sprayed using 620 kPa (no SYLGARD), the $CO_2$ backpack sprayer and untreated onions.
No significant differences in yield or percent marketable were found among the treatments (Table 3).

**CONCLUSIONS:** Good coverage of the onion leaves is important in control of stemphylium leaf blight. The combination of the highest pressure and the addition of SYLGARD provided the best control.

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

**Table 1.** Equipment, boom pressure, and spray nozzle type used to apply LUNA TRANQUILITY on onions, cv. La Salle, grown near Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Equipment | Pressure (kPa) | Spray Nozzle | Surfactant |
|---|---|---|---|
| Tractor mounted plot sprayer | 620 (90 psi) | AI 9503 | SYLGARD 309[4] |
| Tractor mounted plot sprayer | 275(40 psi) | AI 9504 | -- |
| Tractor mounted plot sprayer | 275 (40 psi) | AI 9504 | SYLGARD 309 |
| Tractor mounted plot sprayer | 620 (90 psi) | AI 9503 | -- |
| $CO_2$ backpack sprayer | 275 (40 psi) | DG 8002VS | -- |
| Check | -- | -- | -- |

**Table 2.** Stemphylium disease ratings for onions, cv. La Salle, treated using various spray nozzles and pressures and grown near Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Pressure (kPa) | Spray Nozzle | Surfactant | Stemphylium Incidence (%)[1] | | | 3 Aug Leaf Rating[2] | |
|---|---|---|---|---|---|---|---|
| | | | 14 Jul | 22 Jul | 29 Jul | % Diseased | DSI[3] |
| 620 (90 psi) | AI 9503 | SYLGARD 309[4] | 0.0 ns[5] | 5.0 ns | 9.3 ns | 13.0 a[6] | 9.1 a |
| 275(40 psi) | AI 9504 | -- | 0.0 | 4.4 | 9.8 | 14.3 ab | 10.3ab |
| 275 (40 psi) | AI 9504 | SYLGARD 309 | 0.0 | 3.5 | 5.8 | 16.5 abc | 11.2 abc |
| 620 (90 psi) | AI 9503 | -- | 0.0 | 5.9 | 13.6 | 19.3 bc | 12.5 bcd |
| $CO_2$ Backpack | DG 8002VS | -- | 0.0 | 4.0 | 8.5 | 19.4 bc | 13.7 cd |
| Check | -- | -- | 0.0 | 5.7 | 9.3 | 21.3 c | 15.1 d |

[1] Based on in-field ratings using # plants with stemphylium/# plants assessed = stemphylium incidence (%)
[2] Leaves were sorted into the following classes: 0 = 0%, 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4 = 51-75%, 5 = >75% of the leaf area diseased.
[3] Disease Severity Index (DSI) was determined using the following equation:

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

[4] SYLGARD 309 was applied at a rate of 0.25% v/v.
[5] ns indicates no significant differences were found among the treatments
[6] Numbers in a column followed by the same letter are not significantly different at *P*=0.05, Fisher's Protected LSD Test.

**Table 3.** Yield data for onions, cv. La Salle, treated using various spray nozzles and pressures and grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2016.

| Pressure (kPa) | Spray Nozzle | Surfactant | Size Distribution (%)[1] | | | Yield (t/ha) |
|---|---|---|---|---|---|---|
| | | | Jumbo (>76 mm) | Can No.1 (45-76 mm) | Cull (<45 mm) | |
| 620 (90 psi) | AI 9503 | -- | 6.6 ns[2] | 81.7 ns | 11.7 ns | 32.2 ns |
| 275 (40 psi) | AI 9504 | -- | 6.0 | 83.9 | 10.1 | 33.6 |
| $CO_2$ Backpack | TeeJet 8002 | -- | 5.5 | 83.3 | 11.3 | 31.5 |
| 620 (90 psi) | AI 9503 | SYLGARD 309[3] | 7.1 | 86.6 | 6.1 | 32.4 |
| 275 (40psi) | AI 9504 | SYLGARD 309 | 0.9 | 81.3 | 7.7 | 33.0 |
| Check | -- | -- | 7.9 | 83.5 | 8.6 | 36.5 |

[1] Percentage was determined by weight
[2] ns = no significant differences were found among the treatments
[3] SYLGARD 309 was applied at a rate of 0.25% v/v.

**2016 PMR REPORT #22** **SECTION O: CEREALS, FORAGE CROPS, and OILSEEDS - Diseases**

**CROP:** Canola (*Brassica napus* L.) cvs. ACS N39, InVigor 5030
**PEST:** Clubroot (*Plasmodiophora brassicae* Woronin)

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**TITLE: THE EFFECT OF AGTIV (*GLOMUS INTRARADICES*) ON CLUBROOT DEVELOPMENT IN CANOLA**

**MATERIALS:** AGTIV, *Glomus intraradices* Schenk and Smith (Glomerales: Glomeraceae)

**METHODS:** ACS N39 and InVigor 5030 were seeded on August 2, 2016 in a randomized complete block design with 8 blocks of 4 treatments with 3 rows (2.5 m long) per treatment. Treatments included: 1) ACS N39 treated with water, 2) InVigor 5030 treated with water, 3) ACS N39 treated with AGTIV (*Glomus intraradices*), and 4) InVigor 5030 treated with AGTIV. A seeder was used with its back chain tied up in order to keep the seed exposed on top of the soil before the treatment was applied. Treatments were applied on the same day as seeding with a single TecJet yellow 8002 nozzle calibrated to deliver 250 L $ha^{-1}$. Twenty mL of AGTIV (Premier Tech), which contains *G. intraradices* spores, was mixed with 9.5 L of water and applied at 25 mL $m^{-1}$. This was double the recommended rate for onions. Six-week-old plants were uprooted and examined for clubbing on September 14, 2016. Clubroot incidence (CI: % of plants with clubs) and disease severity (0-3 scale) were assessed. Disease severity index (DSI) was calculated using the following equation:

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

The CI and DSI data were analyzed using the Factorial Analysis of Variance function of Statistix 10.0. CI and DSI were arcsine transformed prior to analysis, however the untransformed data (mean ± standard deviation) are presented.
Compared to the previous 10-year averages, air temperature in 2016 was above average for August (22.6 °C) and September (17.4 °C). The 10-year temperature averages were 19.8 °C for August and 15.8 °C for September. Monthly rainfall was below the 10-year average for August (58 mm) and September (25 mm). The 10-year rainfall averages were 71 mm for August and 82 mm for September.

**RESULTS:** As outlined in Table 1.

**CONCLUSIONS:** AGTIV does not reduce clubroot development in canola under high disease pressure.

**Table 1.** Levels of clubroot incidence (%) and severity (disease severity index, %) for canola (*Brassica napus*) cvs. ACS N39 and InVigor 5030 treated with water or AGTIV.

| Treatment | Cultivar | Clubroot incidence (%)[1] | Disease severity index (%)[1] |
|---|---|---|---|
| Water | ACS N39 | 89 ± 9 ns[2] | 86 ± 10 ns |
| | InVigor 5030 | 89 ± 14 | 86 ± 17 |
| AGTIV | ACS N39 | 88 ± 17 | 85 ± 21 |
| | InVigor 5030 | 90 ± 9 | 66 ± 6 |

[1] The mean of four replicates is presented ± standard error.
[2] ns = not significant. Means were not significantly different based on Tukey's Honest Significant Difference (HSD) test at $P < 0.05$.

**2016 PMR REPORT # 23** **SECTION Q: GREENHOUSE CROPS, ORNAMENTALS AND TURF - Diseases**

**CROP:** Weigela **(***Weigela* Thunb. x *hybrida)*
**PEST:** Foliar nematode (*Aphelenchoides* sp.)

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**TITLE: CHEMICAL AND BIOLOGICAL TREATMENTS FOR CONTROL OF FOLIAR NEMATODES IN AN ORNAMENTAL NURSERY CROP, 2016**

**MATERIALS:** MAJESTENE (heat-killed *Burkholderia* sp. strain A396), GRANDEVO (C*hromobacterium subtsugae* strain PRAA4-1), LUNA PRIVILEGE (fluopyram, 500g/L), HYPOASPIS-SYSTEM BIOBEST (*Hypoaspis miles = Stratiolaelaps scimitus*), PYLON Miticide-Insecticide (chlorfenapyr, 240g/L)

**METHODS:** In August-October 2016, treatments were evaluated for control of foliar nematodes on a highly susceptible *Weigela* hybrid at a commercial nursery in the British Columbia Fraser Valley, using natural inoculum. Each plant was in a 4inch (10cm) pot in a commercial growth medium (65%, 5% sawdust, 10% perlite, 5% rice hulls, 15% coir) with a rice-hull surface mulch. Each plot consisted of 15 plants in a flat, with one flat per replicate and 4 replicates per treatment arranged in a randomized complete block (RCB) design. Prior to the first application on August 9, the plant foliage was cut back and all leaves with nematode lesions were removed and placed on the soil under the plants, to ensure pest pressure. MAJESTENE (heat-killed *Burkholderia sp.),* GRANDEVO (*Chromobacterium subtsugae)* and LUNA PRIVILEGE (fluopyram) were applied three times each: first as a drench followed by two applications as foliar sprays. The registered standard, PYLON (chlorfenapyr, PCP# 30666) was applied as a foliar spray in all three applications as per label. The first application of all treatments was made on Aug. 9; the second 14 days later on Aug. 23, and the third 17 days later on Sept. 9. Drenches were applied in a solution volume of 5mL/plant (75mL/plot; 300mL/$m^2$) and foliar sprays in 1000-2000L/ha, as the crop grew, using a $CO_2$ back-pack sprayer equipped with a single nozzle boom and Teejet 8004XR nozzles at 30psi (207kPa). For each application, the four flats in each treatment were placed in a $1m^2$ area for spraying then returned to the randomized plot design. HYPOASPIS SYSTEM-BIOBEST (*Hypoaspis miles = Stratiolaelaps scimitius)* was applied twice by sprinkling ¼ of a 5L container, by weight (approximately 125,000 mites), per plot, directly onto the moist surface of the potting mix on Aug. 9 and 23. At each application, the check plants were drenched or sprayed with water alone. The plants were overhead-irrigated by the grower as needed and no other pesticides or fertilizers were applied. The percentage of leaf area with foliar nematode lesions was rated weekly on the Horsfall-Barratt scale of 0-11, where 0 = no disease, 1 = 0-3% leaf area affected; 2 = 3-6%; 3 = 6-12%; 4 = 12-25%; 5 = 25-50%; 6 = 50-75%; 7 = 75-88%; 8 = 88-94%; 9 = 94-97%; 10 = 97-100%; 11 = 100%. H-B ratings were transformed to % disease following the standard grade formula of Redman, King and Brown (1982), *i.e.*, grade 0=1.17%, grade 1=2.34%, grade 2=4.68%, grade 3=9.37%, grade 4=18.75%, grade 5=37.5%, grade 6=62.5%, grade 7=81.25%, grade 8=90.63%, grade 9=95.31%, grade 10=97.66%, grade 11=98.82%. At the end of the trial, on Oct. 4, the number of live *Aphelenchoides* nematodes was counted under the microscope in a sample of three leaves per plant with nematode lesions. Data was analyzed statistically (ANOVA) using CoStat, Version 6.400, 2008, CoHort Software, Monterey, California, USA, ©1998-2008 and treatment means were compared in Tukey's HSD at P=0.05.

**RESULTS:** As in Tables 1 and 2.

**CONCLUSIONS:** Under high pest pressure on a highly susceptible weigela crop, three applications of LUNA PRIVILEGE or GRANDEVO, each applied as an initial soil drench followed by two foliar sprays, 14 days apart, reduced the mean percentage of leaf area with foliar nematode lesions by 80-90% compared to the water-sprayed check, and had significantly fewer live nematodes in leaf lesions up to 30 days after the last application. PYLON at the maximum label rate for foliar nematodes (3 foliar sprays at 0.78mL/L) was not statistically different from LUNA PRIVILEGE or GRANDEVO, but had approximately 3 times more live nematodes in leaf lesions at the end of the trial. MAJESTENE reduced the % of leaf area affected by foliar nematode lesions similarly, up to 15 days after the last application, but was not significantly different from the check in the last two weeks and, at the end of the trial, had significantly more live nematodes in leaf lesions than the LUNA, GRANDEVO or PYLON treatments.

Two applications of HYPOASPIS-SYSTEM™ BIOBEST (*Hypoaspis miles=Straeolaelaps scimitus*), 14 days apart, at a very high rate, reduced the percentage of leaf area with foliar nematode lesions by 90% compared to the check, up to 50 days after the last application, and had the fewest live nematodes in leaf lesions at the end of the trial. Future trials are planned to determine the minimum effective rate of *S. scimitus.*

No phytotoxicity was observed in any treatment.

**Table 1.** Mean percentage of leaf area per plot with foliar nematode lesions: visual rating on the Horsfall-Barratt scale transformed to percentages.[1, 2]

| Treatment Product Rate | No. App. & Interval | 16-Aug | 23-Aug | 30-Aug | 06-Sept | 14-Sept | 20-Sept | 28-Sept | 04-Oct |
|---|---|---|---|---|---|---|---|---|---|
| Check (water) | 3 @ 14d | 2.0 ± 0.6 a | 6.4 ± 3.5 a | 12.9 ± 7.0 a | 18.7 ± 13.3 a | 50.0± 27.5 a | 48.4 ± 22.0 a | 35.9 ± 30.7 a | 56.3± 34.0 a |
| MAJESTENE 20mL/L | 3 @ 14d | 1.8 ± 0.7 a | 2.6 ± 1.5 b | 2.6 ± 1.5 b | 3.5 ± 1.5 b | 5.3± 2.9 b | 7.0± 2.7 b | 21.0 ± 11.8 ab | 27.3± 23.9 ab |
| GRANDEVO 3.6g/L | 3 @ 14d | 1.5 ± 0.6 a | 1.8 ± 0.7 b | 2.0 ± 0.6 b | 2.0 ± 0.6 b | 6.4± 3.5 b | 5.9 ± 2.3 b | 8.2 ± 7.0 b | 10.5± 5.9 b |
| LUNA PRIVILEGE 0.5L/ha | 3 @ 14d | 1.2 ± 0.0 a | 1.5 ± 0.6 b | 1.5 ± 0.6 b | 1.5 ± 0.6 b | 3.5± 3.9 b | 3.5 ± 1.4 b | 5.3 ± 2.9 b | 5.9± 4.1 b |
| HYPOASPIS-SYSTEM 5L/$m^2$ | 2 @ 14d | 1.5 ± 0.6 a | 1.5 ± 0.6 b | 1.2 ± 0.0 b | 1.5 ± 0.6 b | 1.8± 0.7 b | 1.8 ± 0.7 b | 2.9 ± 1.2 b | 1.8± 0.7 b |
| PYLON 0.78mL/L | 3 @ 14d | 1.5 ± 0.6 a | 1.8 ± 0.7 b | 2.6 ± 1.5 b | 2.9 ± 1.2 b | 14.1± 15.8 b | 9.9 ± 6.7 b | 7.6 ± 7.5 b | 9.4± 6.6 b |

[1] Mean and standard deviation of 15 plants per plot; four replicates per treatment; RCB design.
[2] Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.

**Table 2:** Mean number of live nematodes in leaf lesions 30 days after the last application.[1, 2]

| Treatment | Product Rate Applied | No. of Applications and Interval | Mean Number of Live Nematodes |
|---|---|---|---|
| Check (water) | - | 3 x 14 days | 105.3 ± 52.7 ab |
| MAJESTENE (*Burkholderia*) | 20ml/L | 3 x 14 days | 140.1 ± 113.8 a |
| GRANDEVO (*Chromobacterium*) | 3.6 g/L | 3 x 14 days | 13.0 ± 19.8 c |
| LUNA PRIVILEGE (fluopyram) | 0.5L/ha | 3 x 14 days | 15.1 ± 11.8 c |
| HYPOASPIS-SYSTEM BIOBEST | 5L/$m^2$ | 2 x 14 days | 2.9 ± 5.1 c |
| PYLON (chlorfenapyr) | 0.78mL/L | 3 x 14 days | 48.9 ± 52.3 bc |

[1] Mean and standard deviation of three leaves per plot; four replicates per treatment; RCB design.
[2] Numbers in the same column followed by the same letter are not significantly different in Tukey's HSD at P=0.05.