Pest Management Strategies in Processing Tomatoes, 2010 – Final Report

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Key Findings / Summary of Results

A. BACTERIAL DISEASE MANAGEMENT

A1. Determine the efficacy of different copper formulations for bacterial disease control (p. 5-8)

All copper products effectively reduced the level of defoliation. This was different from results in 2009, where Kocide 2000 and Kocide 3000 had more leaf cover than the other copper formulations. The number of infected leaves, and the amount of disease accumulated during the season for Parasol FL was not statistically different from the nontreated control, indicating that this product may not be as effective as Kocide 2000, Kocide 3000, Parasol WP, Copper 53W, and Copper Spray. This result is similar to 2009, where Parasol FL was no different than the nontreated control in most assessments of foliar bacterial disease. None of the treatments effectively reduced the incidence of bacterial spot on fruit as compared to the nontreated control.

A2. Determine if using combinations of Kasumin and Kocide, and Serenade Max and Kocide, improve bacterial disease control (p. 9-14)

We compared spray programs with Kasumin, Serenade Max, and Regalia MAXX to standard Kocide 2000 or Kocide 2000 + Dithane treatments. Regalia MAXX is a plant defense inducer and labelled for bacterial spot management in the United States. Spray programs included product tank mixes with Kocide 2000 or alternating programs with Kocide 2000. Kocide 2000 + Dithane provided the most consistent level of control for foliar symptoms of bacterial spot and speck, however all treatments except Regalia MAXX applied alone provided some benefits. Disease pressure was relatively low in the trial, due to dry conditions at the end of July and in August. The high number of green fruit in the Kocide + Dithane treatment is an indication of premature defoliation in all other treatments except Kasumin, Regalia MAXX + Kocide, and Regalia MAXX alt. Kocide. In 2009, conditions for disease development were more favourable, Serenade Max reduced the number of infection sites early in the season but there was no difference in defoliation later in the season. In a separate trial in 2009, Kasumin + Agral 90 also reduced the level of defoliation resulting from bacterial disease. Regalia MAXX was not included in 2009 evaluations.

A3. Evaluate plant growth regulators and plant defense activators for management of bacterial disease

Actigard and Sumagic (see supplementary report)

We were are to secure additional funding from Syngenta and Valent to conduct two trials evaluating combinations of the plant defense activator Actigard and the plant growth regulator Sumagic on two processing tomato cultivars. Actigard should be available in the Canadian marketplace in 2011, and Valent is pursuing the registration of Sumagic in Canada. The first trial evaluated the ability of Actigard and Sumagic applied in the greenhouse to reduce disease levels in the field after transplanting. In the second trial, Sumagic was applied in the greenhouse, and Actigard was applied in the field, according to US product label instructions.

Applications of Actigard with Sumagic were more effective when both products were applied in the greenhouse, and there is some data to suggest that applications of Actigard, in combination with Sumagic, were more effective than using Actigard alone. For example, the AUDPC for foliar bacterial spot and speck in Trial 1 for Actigard-TSH4 was 55% lower than the nontreated-TSH4, which was not statistically significant, but the Actigard+Sumagic-TSH4 was 73 percent lower than the nontreated-TSH4, which was statistically significant. Similarly, Actigard+Sumagic-H9909 was the only treatment to have fewer lesions than the nontreated-H9909 on July 5, 15, and 23. In Trial 2, the AUDPC value for Actigard+Sumagic-H9909 was 66 percent lower than the nontreated-H9909, and this was statistically different, whereas the Actigard-H9909 treatment was 47 percent lower than the nontreated-H9909, and this was not statistically different. For cv. TSH4, the AUDPC values for Actigard+Sumagic-TSH4 and Actigard-TSH4 were 51 and 55 percent lower than the nontreated-TSH4. Actigard and Sumagic do not appear to have any negative effects on tomato colour, soluble solids, or pH levels.

The data demonstrate few differences among treatments for tomato growth parameters in the field, although we did observe less foliar growth in the weeks following transplanting, in tomatoes treated with Actigard and Sumagic in the greenhouse. Transplants treated with Sumagic in Trial 1 were on average 2.5 cm shorter than those not treated with the plant growth regulator.

Regalia MAXX (see section A2)

We also included the plant defense activator Regalia MAXX in our bacterial disease efficacy trial (see A2). This is an extract of giant knotweed and is labelled for bacterial spot suppression on tomato in the United States.

B. FUNGAL DISEASE MANAGEMENT

B1. Evaluation of new fungicides (p. 15-18)

Under conditions of low disease pressure, all fungicide treatments except Bravo, Inspire + Bravo, and Regalia MAXX + Bravo reduced the number of leaves with early blight symptoms. Quadris + Bravo, Cabrio + Bravo, Lance + Bravo, Inspire + Bravo, Cabrio, and Quadris had the lowest incidence of anthracnose, and Quadris + Bravo, Cabrio + Bravo, Lance + Bravo, Inspire + Bravo, Cabrio, Quadris, Cabrio + Lance, and Regalia MAXX + Bravo had the lowest severity of anthracnose, when the last fungicide application was made 14 days before harvest. In 2009, Bravo, Quadris, and Cabrio were included in evaluation trials and were all effective at reducing the incidence of anthracnose, when the last fungicide application was made 15 days before harvest.

C. FOLIAR DISEASE MANAGEMENT

C1. Evaluate the efficacy of various spray programs for bacterial and fungal disease control (p. 19-24)

Treatments that included Kocide + Dithane tended to have less bacterial disease on foliage than treatments without Dithane, however these differences were not always statistically significant, and all treatments provided some advantage in reducing bacterial disease levels below those in the nontreated control. All treatments reduced levels of bacterial disease on green tomato fruit, and the incidence and severity of anthracnose. Treatments including Quadris did not provide an advantage for managing anthracnose compared to treatments with Bravo only, however the last fungicide application was made more than three weeks prior to harvest. In our other trial evaluating new fungicide products (see B1), the incidence of anthracnose in tomatoes treated with Quadris was lower than those treated with Bravo; however in 2009 there was again no difference between Bravo and Quadris. We were not able to assess the effectiveness of these spray programs at managing early blight due to the extremely low levels of this disease in the trial.

D. INSECT MANAGEMENT

D1. Resistance management for Colorado potato beetle: new products and different application methods (p. 25-31)

We had a healthy population of Colorado potato beetles this year and were able to successfully complete this trial. Admire (in-furrow) and HGW86 SE (foliar) provided the most effective and consistent control of CPB larvae and resulted in limited foliar damage. HGW86 SC (in-furrow) and Coragen (foliar) also tended to provide good control, but differences with the nontreated control were not statistically significant. HGW86 and Coragen are both in insecticide Group 28, and for resistance management purposes represent an alternative to Admire and Assail, which are both in Group 4.

A. BACTERIAL DISEASE MANAGEMENT

TITLE: Efficacy of copper formulations for the control of bacterial spot in processing tomatoes, 2010

PEST(S): Bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D)

MATERIALS: Kocide 2000 (copper hydroxide 53.8%), Kocide 3000 (copper hydroxide 46.1%), Parasol WP (copper hydroxide 50%), Parasol FL (copper hydroxide 24.4%), Copper 53W (tri-basic copper sulphate 53%), Copper Spray (copper oxychloride 50%)

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Tomato transplants cv. H9909 were transplanted into twin-rows on May 17 using a mechanical transplanter at a rate of 3 plants per metre. Each set of twin-rows were spaced 1.5m apart. Each treatment plot was 7m long and consisted of one twin-row. The trial was setup as a randomized complete block design, with 4 replications per treatment. Treatments were applied on May 19, 26, June 4, 9, 18, 24, July 1, 10, and 16, except for treatment Copper 53W which was not applied on July 16. Treatments were applied using a 1.5m boom hand-held CO_2 sprayer (35 psi) with XULD 120-02 nozzles and water volume of 200 L Ha^{-1}. The trial was inoculated with bacterial spot Group D on May 21 and June 4.

The trial was irrigated using a drip irrigation system as required throughout the growing season. Admire was applied on June 1 and 17 for Colorado potato beetle management. Bravo was applied on June 12, and Revus was applied on June 22 for late blight management. Pounce was applied on July 26 for tomato hornworm management.

Bacterial spot was assessed on June 21, 29, July 20, and Aug 13 by counting the number of infected leaves on five plants in each plot. Disease severity was also assessed using a scale from 0 to 3, where 0 = no lesions, 1 = a few lesions (~ 5% leaf area), 2 = moderate infection (15% leaf area), 3 = heavy infection (25% leaf area).

Tomatoes were harvested on Aug 30 from a 2m section in each plot; red fruit, green fruit, and rots were weighed. Fifty of the green fruit were randomly selected and assessed for bacterial spot and speck. In some cases, there were less than fifty green fruit available to select, and in these cases all harvested fruit were assessed and the incidence of infect fruit was calculated.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using a log, square root, or arcsine square root transformation. Analysis of variance was conducted and means comparisons were performed when $P \leq 0.05$ using Duncan's new multiple range test.

Monthly rainfall for May, June, July, and August was 122.2 mm, 84.5 mm, 136.0 mm, and 26.0 mm. Average maximum temperatures for May, June, July, and August were 20.7 °C, 24.9 °C, 27.6 °C, and 27.6 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, and 15.7 °C.

RESULTS: Treatment Parasol WP had fewer leaves infected with bacterial spot on June 21 than the nontreated control (Table 1). On June 29, there were no differences among treatments, however on July 20, all treatments except Parasol FL had fewer infected leaves than the nontreated control. The amount of disease accumulated during the season (AUDPC or area under the disease progress curve) in all copper treatments except Parasol FL was lower than the nontreated control. Disease severity did not vary among treatments, however defoliation was higher in the nontreated control than in all copper treatments (Table 2). The weight of rotten fruit in Kocide 2000, Parasol WP, and Copper Spray was higher than the nontreated control (Table 3). None of the copper treatments were different from the nontreated control for the weight of red, green, or total amount of tomatoes. There were no differences among treatments for the incidence of bacterial spot on fruit (Table 4).

CONCLUSIONS: All copper products effectively reduced the level of defoliation. However the number of infected leaves, and the amount of disease accumulated during the season for Parasol FL was not statistically different from the nontreated control, indicating that this product may not be as effective as Kocide 2000, Kocide 3000, Parasol WP, Copper 53W, and Copper Spray. None of the treatments effectively reduced the incidence of bacterial spot on fruit. There were no differences among treatments for total yield, or yield of red and green tomatoes.

Table 1. Number of leaves infected with bacterial spot on five tomato plants in plots treated with different copper formulations for bacterial disease management, Ridgetown, ON, 2010.

Treatment	No. Infected Leaves			AUDPC
	June 21 [a]	June 29	July 20	
Nontreated control	20.5 b [b]	19.0 ns	53.0 c	933.0 b
Kocide 2000 @ 2.52 kg Ha^{-1}	8.5 ab	11.8	24.3 ab	460.0 a
Kocide 3000 @ 1.96 kg Ha^{-1}	6.1 ab	18.3	25.0 ab	565.1 a
Parasol WP @ 2.25 kg Ha^{-1}	3.3 a	6.5	23.8 ab	354.6 a
Parasol FL @ 2.3 L Ha^{-1}	10.3 ab	14.8	38.8 bc	659.8 ab
Copper 53W @ 4.5 kg Ha^{-1}	5.7 ab	11.3	28.8 ab	490.0 a
Copper Spray @ 4.0 kg Ha^{-1}	13.2 ab	13.5	20.3 a	467.4 a

[a] Data was normalized using a log transformation; the back transformed means are shown here.

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

Table 2. Defoliation and severity of foliar bacterial spot symptoms on five tomato plants in plots treated with different copper formulations for bacterial disease management, Ridgetown, ON, 2010.

Treatment	Severity (0 to 3)			Defoliation (%)
	June 21	June 29	July 20	Aug 13
Nontreated control	1.3 ns [a]	1.5 ns	1.3 ns	25.0 b
Kocide 2000 @ 2.52 kg Ha^{-1}	1.0	1.0	1.3	5.0 a
Kocide 3000 @ 1.96 kg Ha^{-1}	1.0	1.0	1.3	10.0 a
Parasol WP @ 2.25 kg Ha^{-1}	1.0	1.0	1.3	6.3 a
Parasol FL @ 2.3 L Ha^{-1}	1.3	1.0	1.3	10.0 a
Copper 53W @ 4.5 kg Ha^{-1}	1.0	1.3	1.3	12.5 a
Copper Spray @ 4.0 kg Ha^{-1}	1.0	1.3	1.3	7.5 a

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

Table 3. Tomato yield in tomatoes treated with different copper formulations for bacterial disease management, Ridgetown, ON, 2010.

Treatment	Yield (kg)			
	Reds	Greens	Rots	Total
Nontreated control	23.15 ns [a]	0.90 ab	0.40 a	24.44 ns
Kocide 2000 @ 2.52 kg Ha^{-1}	22.73	1.20 ab	1.19 b	25.11
Kocide 3000 @ 1.96 kg Ha^{-1}	22.49	0.70 b	0.86 ab	24.04
Parasol WP @ 2.25 kg Ha^{-1}	23.14	1.50 a	1.31 b	25.95
Parasol FL @ 2.3 L Ha^{-1}	25.88	1.13 ab	0.97 ab	27.97
Copper 53W @ 4.5 kg Ha^{-1}	23.00	0.53 b	1.07 ab	24.96
Copper Spray @ 4.0 kg Ha^{-1}	21.82	0.81 ab	1.34 b	23.96

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

Table 4. Incidence of bacterial spot on green tomato fruit treated with different copper formulations for bacterial disease management, Ridgetown, ON, 2010.

Treatment	No. Infected Fruit
Nontreated control	58.8 ns [a]
Kocide 2000 @ 2.52 kg Ha^{-1}	62.0
Kocide 3000 @ 1.96 kg Ha^{-1}	69.0
Parasol WP @ 2.25 kg Ha^{-1}	73.2
Parasol FL @ 2.3 L Ha^{-1}	73.3
Copper 53W @ 4.5 kg Ha^{-1}	63.0
Copper Spray @ 4.0 kg Ha^{-1}	54.0

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

TITLE: Evaluation of spray programs for the control of bacterial spot and bacterial speck in tomato, 2010

PEST(S): Bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D), Bacterial speck (*Pseudomonas syringae* pv. *tomato*)

MATERIALS: Kasumin 2L (kasugamycin 2.3%), Kocide 2000 (copper hydroxide 53.8%), Dithane (mancozeb 75%), Serenade Max (*Bacillus subtilis* QST 713, 14.6%), LI-700 (surfactant blend, 80%), Regalia MAXX (extract of *Reynoutria sachalinensis* 20%)

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Tomato transplants cultivar H9909 were transplanted on May 21 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 1.5m apart. Each treatment plot was 7m long and consisted of one twin-row. The trial was setup as a randomized complete block design, with 4 replications per treatment. Treatments were applied on May 21, 28, June 4, 9, 18, 25, July 2, 13, and 20 using a hand-held CO_2 sprayer (35 psi) with ULD 120-02 nozzles and water volume of 200 L Ha^{-1}. The trial was inoculated with bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D) on June 4 and bacterial speck (*Pseudomonas syringae* pv. *tomato*) on July 12. Revus (mandipropamid) was applied on June 12 and 22 for late blight protection. Admire (imidacloprid) was applied for Colorado potato beetle control on June 17. The trial was irrigated using a drip irrigation system as required during the growing season.

The number of leaves with bacterial spot lesions on five plants per plot was counted on June 22, 28, and July 20. Disease severity was also rated using a scale of 0 to 3, where 0 = no lesions, 1 = a few lesions (~ 5% leaf area), 2 = moderate infection (~15% leaf area), and 3 = heavy (> 25% leaf area).

Tomatoes were harvested from a 2m section of each plot on Aug 19; red fruit, green fruit, and rots were separated and weighed. Fifty green fruit were randomly selected and assessed for incidence of bacterial spot and speck on Aug 19.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using a log, square root, or arcsine square root transformation. Analysis of variance was conducted mean comparisons were performed when $P \leq 0.05$ using Duncan's new multiple range test.

Monthly rainfall for May, June, July, and August was 122.2 mm, 84.5 mm, 136.0 mm, and 26.0 mm. Average maximum temperatures for May, June, July, and August were 20.7 °C, 24.9 °C, 27.6 °C, and 27.6 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, and 15.7 °C.

RESULTS: Kocide + Dithane had consistently fewer leaves infected with bacterial disease than the nontreated control and Kasumin on June 22, 28, and July 20, and for the total amount of disease observed during the season (AUDPC or area under the disease progress curve) (Table 1). Treatment Regalia MAXX + Kocide also had fewer infected leaves than the nontreated control on June 22, but not Kocide alone and not Regalia MAXX alone. On July 20, and for AUDPC, all treatments except Regalia MAXX alone had fewer infected leaves than the nontreated control. There was a trend that Regalia MAXX + Kocide resulted in fewer infected leaves on July 20, and lower AUDPC, but this difference was not statistically significant.

Disease severity in treatment Kocide + Dithane was lower than the nontreated control, Kasumin, Regalia MAXX, Serenade Max + Kocide, and Regalia MAXX + Kocide on June 22 (Table 2). However on June 28 there was no difference among treatments, and on July 20 disease severity for treatment Kocide + Dithane was only lower than the nontreated control and Regalia MAXX alone.

Total tomato yield was higher in treatment Kocide, Kocide + Dithane, and Serenade Max + Dithane than Regalia MAXX alt. Kocide (Table 3). Treatment Kocide + Dithane had more green fruit than all other treatments except Kasumin, Regalia MAXX + Kocide, and Regalia MAXX alt. Kocide.

There was no difference among treatments for the percentage of green fruit with bacterial spot or speck symptoms (Table 4).

CONCLUSIONS: Kocide + Dithane provided the most consistent level of control for foliar symptoms of bacterial spot and speck, however all treatments except Regalia MAXX applied alone provided some benefits. Disease pressure was relatively low in the trial, due to dry conditions at the end of July and in August. The high number of green fruit in the Kocide + Dithane treatment is an indication of premature defoliation in all other treatments except Kasumin, Regalia MAXX + Kocide, and Regalia MAXX alt. Kocide.

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

Treatment	Number of infected leaves [a]			AUDPC
	June 22 [b]	June 28	July 20	
Nontreated control	30.5 c [c]	12.8 bc	173.3 d	2175.8 d
Kocide 2000 @ 3.2 kg Ha^{-1}	17.8 abc	11.0 abc	97.5 bc	1279.8 bc
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane @ 2.25 kg Ha^{-1}	7.0 a	4.5 a	32.3 a	438.8 a
Serenade Max @ 3 kg Ha^{-1}	18.0 abc	8.5 abc	119.8 bc	1490.3 bc
Kasumin @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	29.0 bc	14.3 c	106.5 bc	1458.0 bc
Regalia MAXX @ 0.125% v/v	23.5 abc	12.5 bc	133.3 cd	1711.3 cd
Serenade Max @ 3 kg Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	21.8 abc	12.5 bc	98.0 bc	1318.3 bc
Kasumin @ 1.6 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	13.5 abc	5.8 ab	83.0 b	1034.0 b
Serenade Max @ 3 kg Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	24.5 bc	10.5 abc	109.0 bc	1419.5 bc
Kasumin @ 1.6 L Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	21.0 abc	11.0 abc	97.3 bc	1286.8 bc
Regalia MAXX @ 0.125% v/v + Kocide 2000 @ 3.2 kg Ha^{-1}	12.0 ab	11.0 abc	76.0 b	1026.0 b
Regalia MAXX @ 0.125% v/v alt. Kocide 2000 @ 3.2 kg Ha^{-1}	18.5 abc	13.8 bc	78.5 b	1111.5 b

[a] Number of infected leaves on five tomato plants per plot.

[b] Data was not normal and could not be normalized using a log or square root transformation.

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

Table 2. Disease severity and percent defoliation on tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Disease severity rating [a]		
	June 22	June 28	July 20
Nontreated control	2.0 d [b]	0.8 ns	3.3 c
Kocide 2000 @ 3.2 kg Ha^{-1}	1.3 abc	1.0	2.0 abc
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane @ 2.25 kg Ha^{-1}	0.8 a	0.8	1.5 a
Serenade Max @ 3 kg Ha^{-1}	1.3 abc	0.8	2.8 abc
Kasumin @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	1.5 bcd	0.8	2.3 abc
Regalia MAXX @ 0.125% v/v	2.0 d	1.0	3.0 bc
Serenade Max @ 3 kg Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	1.3 abc	1.0	2.0 abc
Kasumin @ 1.6 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	1.0 ab	0.5	2.5 abc
Serenade Max @ 3 kg Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	1.8 cd	1.0	2.5 abc
Kasumin @ 1.6 L Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	1.3 abc	1.0	2.5 abc
Regalia MAXX @ 0.125% v/v + Kocide 2000 @ 3.2 kg Ha^{-1}	1.0 ab	0.8	1.8 ab
Regalia MAXX @ 0.125% v/v alt. Kocide 2000 @ 3.2 kg Ha^{-1}	1.5 bcd	0.8	2.3 abc

[a] Disease severity was rated on five plants per plots using a scale of 0 to 3, where 0 = no lesions, 1 = a few lesions (~ 5% leaf area), 2 = moderate infection (~15% leaf area), and 3 = heavy (> 25% leaf area).

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

Table 3. Yield of red, green and rotten tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Weight (kg)			
	Reds	Greens	Rots	Total
Nontreated control	26.52 ab [a]	2.96 b	0.43 b	29.91 ab
Kocide 2000 @ 3.2 kg Ha^{-1}	28.07 a	2.64 b	0.61 ab	31.32 a
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane @ 2.25 kg Ha^{-1}	25.01 ab	5.43 a	1.32 a	31.75 a
Serenade Max @ 3 kg Ha^{-1}	25.27 ab	2.42 b	0.74 ab	28.42 ab
Kasumin @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	25.38 ab	3.23 ab	0.55 b	29.16 ab
Regalia MAXX @ 0.125% v/v	25.79 ab	2.88 b	0.63 ab	29.29 ab
Serenade Max @ 3 kg Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	25.83 ab	2.97 b	0.75 ab	29.55 ab
Kasumin @ 1.6 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	27.51 ab	2.22 b	0.57 ab	30.30 ab
Serenade Max @ 3 kg Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	28.06 a	3.04 b	0.66 ab	31.76 a
Kasumin @ 1.6 L Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	25.34 ab	2.81 b	0.98 ab	29.13 ab
Regalia MAXX @ 0.125% v/v + Kocide 2000 @ 3.2 kg Ha^{-1}	25.87 ab	3.64 ab	0.74 ab	30.25 ab
Regalia MAXX @ 0.125% v/v alt. Kocide 2000 @ 3.2 kg Ha^{-1}	23.32 b	3.55 ab	0.75 ab	27.61 b

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

Table 4. Percentage of tomatoes with bacterial spot on the fruit treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Incidence of Spot (%)
	Green Fruit
Nontreated control	48 ns [a]
Kocide 2000 @ 3.2 kg Ha^{-1}	50
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane @ 2.25 kg Ha^{-1}	41
Serenade Max @ 3 kg Ha^{-1}	48
Kasumin @ 1.6 L Ha^{-1} + LI-700 @ 0.25% v/v	46
Regalia MAXX @ 0.125% v/v	47
Serenade Max @ 3 kg Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	40
Kasumin @ 1.6 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	45
Serenade Max @ 3 kg Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	49
Kasumin @ 1.6 L Ha^{-1} alt. Kocide 2000 @ 3.2 kg Ha^{-1}	43
Regalia MAXX @ 0.125% v/v + Kocide 2000 @ 3.2 kg Ha^{-1}	51
Regalia MAXX @ 0.125% v/v alt. Kocide 2000 @ 3.2 kg Ha^{-1}	55

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

B. FUNGAL DISEASE MANAGEMENT

TITLE: Products for the control of fungal disease in tomato, 2010

PEST(S): early blight (*Alternaria solani*), anthracnose (*Colletotrichum coccodes*)

MATERIALS: Bravo 500 (chlorothalonil 500g L^{-1}), Quadris Flowable (azoxystrobin 250 g L^{-1}), Cabrio (pyraclostrobin 20%), Lance (boscalid 70%), Regalia MAXX (extract of *Reynoutria sachalinensis* 20%), Inspire (difenoconazole 23.2%)

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Tomato transplants variety H9909 were transplanted into twin rows on May 17 using a mechanical transplanter at a rate of 3 plants per metre. Each twin row was spaced 1.5m apart. Each treatment plot was 7m long and consisted of one twin row. The trial was setup as a randomized complete block design, with 4 replications per treatment. Treatments were applied on June 23, July 7, 16, 26, Aug 6, and 17 using a hand-held CO2 sprayer with nozzles ULD 120-02, and a water volume of 200 L Ha^{-1}. The trial was inoculated with a slurry of leaves with early blight symptoms on July 28, as few natural symptoms were present at the time.

Revus (mandipropamid) was applied on June 12 and 22 to protect against late blight. Admire (imidacloprid) was applied on June 1 and 17 for Colorado potato beetle control. The trial was irrigated throughout the growing season as required.

Early blight was not detected in the trial until mid-August. The number of infected leaves was counted on Aug 12.

Tomatoes were harvested from a 2m section of each plot on Sept 1; red fruit, green fruit, and rots were separated and weighed. Fifty of the harvested fruit were randomly selected and assessed for anthracnose after 2 days in storage by sorting into the following classes: 0 = no lesions, 1 = one lesion, 2 = two to three lesions, 3 = four or more lesions. A disease severity index (DSI) was calculated using the following equation:

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

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Analysis of variance was conducted using Duncan's new multiple range test and mean comparisons were performed when $P \leq 0.05$.

Monthly rainfall for May, June, July, August, and September was 122.2 mm, 84.5 mm, 136.0 mm, 26.0 mm and 79.5 mm. Average maximum temperatures for May, June, July, August and September were

20.7 °C, 24.9 °C, 27.6 °C, 27.6 °C, and 22.2 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, 15.7 °C, 10.2 °C.

RESULTS: All fungicide treatments except Bravo, Inspire, and Regalia MAXX + Bravo had fewer leaves with early blight symptoms than the nontreated control (Table 1). Cabrio + Lance also had fewer leaves with early blight symptoms than Bravo.

The incidence and severity (DSI) of anthracnose on tomato fruit in the nontreated control was higher than all fungicide treatments except Lance, Regalia MAXX, and Inspire (Table 2). Treatment Quadris + Bravo had a lower incidence of anthracnose than Bravo, Lance, Regalia MAXX, Cabrio + Lance, Inspire, and Regalia MAXX + Bravo. Similarly, the severity of anthracnose in treatments Quadris + Bravo and Cabrio + Bravo was lower than treatments Bravo, Lance, Regalia MAXX, and Inspire.

There were no differences among treatments for the yield of red, green, or total tomato fruit harvested (Table 3). The lowest number of rots was recorded in treatment Quadris + Bravo, and this value was statistically lower then Regalia MAXX and Inspire, but not the nontreated control.

CONCLUSIONS: Under conditions of low disease pressure, all fungicide treatments except Bravo, Inspire + Bravo and Regalia MAXX + Bravo reduced the number of leaves with early blight symptoms. Quadris + Bravo, Cabrio + Bravo, Lance + Bravo, Inspire + Bravo, Cabrio, and Quadris had the lowest incidence of anthracnose, and Quadris + Bravo, Cabrio + Bravo, Lance + Bravo, Inspire + Bravo, Cabrio, Quadris, Cabrio + Lance, and Regalia MAXX + Bravo had the lowest severity of anthracnose.

Table 1. Percentage of leaves with early blight symptoms in tomatoes treated with different fungicides, Ridgetown, ON, 2010.

Treatment	No. Leaves with Early Blight
	Aug 12
Nontreated control	20.3 c [a]
Bravo 500 @ 3.2 L Ha^{-1}	15.8 bc
Quadris @ 500 mL Ha^{-1}	6.8 ab
Cabrio @ 840 g Ha^{-1}	9.0 ab
Lance @ 315 g Ha^{-1}	8.3 ab
Cabrio @ 840 g Ha^{-1} + Lance @ 315 g Ha^{-1}	5.5 a
Regalia Maxx @ 0.25% v/v	10.3 ab
Inspire @ 512 mL Ha^{-1}	8.8 ab
Inspire @ 292 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	12.5 abc
Cabrio @ 840 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	8.0 ab
Quadris @ 500 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	7.5 ab
Lance @ 315 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	7.3 ab
Regalia Maxx @ 0.25% v/v + Bravo 500 @ 3.2 L Ha^{-1}	14.5 abc

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

Table 2. Anthracnose incidence and disease severity index on fruit, in tomatoes treated with different fungicides for management of early blight, Ridgetown, ON, 2010.

Treatment	Infected Fruit (%)	DSI
Nontreated control	55.0 de [a]	35.3 cd
Bravo 500 @ 3.2 L Ha^{-1}	22.5 c	15.7 b
Quadris @ 500 mL Ha^{-1}	19.5 ab	10.7 ab
Cabrio @ 840 g Ha^{-1}	19.5 ab	10.3 ab
Lance @ 315 g Ha^{-1}	61.0 e	45.8 e
Cabrio @ 840 g Ha^{-1} + Lance @ 315 g Ha^{-1}	18.5 bc	10.2 ab
Regalia Maxx @ 0.25% v/v	45.0 d	29.0 c
Inspire @ 512 mL Ha^{-1}	57.5 e	42.8 de
Inspire @ 292 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	17.0 abc	10.5 ab
Cabrio @ 840 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	8.5 ab	4.7 a
Quadris @ 500 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	5.0 a	2.3 a
Lance @ 315 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	14.5 abc	9.8 ab
Regalia Maxx @ 0.25% v/v + Bravo 500 @ 3.2 L Ha^{-1}	21.0 bc	11.8 ab

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

Table 3. Harvest weight for red, green, and rotted fruit in tomatoes treated with different fungicides for management of early blight, Ridgetown, ON, 2010.

Treatment	Weight (kg)			
	Reds	Greens	Rots	Total
Nontreated control	20.19 ns [a]	1.13 ns	1.03 a-d	22.35 ns
Bravo 500 @ 3.2 L Ha^{-1}	19.23	0.78	0.85 a-d	20.85
Quadris @ 500 mL Ha^{-1}	22.62	0.91	0.77 a-d	24.29
Cabrio @ 840 g Ha^{-1}	18.20	0.78	0.64 bcd	19.61
Lance @ 315 g Ha^{-1}	17.51	0.68	1.18 abc	19.36
Cabrio @ 840 g Ha^{-1} + Lance @ 315 g Ha^{-1}	21.36	1.10	0.97 a-d	23.42
Regalia Maxx @ 0.25% v/v	20.63	0.98	1.31 ab	22.91
Inspire @ 512 mL Ha^{-1}	21.73	0.90	1.46 a	24.09
Inspire @ 292 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	21.62	0.78	0.67 bcd	23.07
Cabrio @ 840 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	22.87	0.84	0.57 bcd	24.27
Quadris @ 500 mL Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	21.29	1.28	0.32 d	22.88
Lance @ 315 g Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	19.67	0.79	0.49 cd	20.93
Regalia Maxx @ 0.25% v/v + Bravo 500 @ 3.2 L Ha^{-1}	22.39	0.80	1.09 a-d	24.27

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

C. FOLIAR DISEASE MANAGEMENT

TITLE: Evaluation of spray programs for the control of bacterial and fungal diseases in tomato, 2010

PEST(S): Bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D), Bacterial speck (*Pseudomonas syringae* pv. *tomato*), early blight (*Alternaria solani*), anthracnose (*Colletotrichum coccodes*)

MATERIALS: Kocide 2000 (copper hydroxide 53.8%), Dithane (mancozeb 75%), Bravo 500 (chlorothalonil 500g L^{-1}), Quadris Flowable (azoxystrobin 250 g L^{-1})

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Tomato transplants cultivar H9909 were transplanted on May 17 using a mechanical transplanter at a rate of 3 plants per metre. Rows were spaced 1.5m apart. Each treatment plot was 7m long and consisted of one twin-row. The trial was setup as a randomized complete block design, with 4 replications per treatment. Treatments were applied on May 19, 26, June 4, 9, 17, 24, July 1, 10, 16, 26, and Aug 4 using a hand-held CO_2 sprayer (35 psi) with ULD 120-02 nozzles and water volume of 200 L Ha^{-1}. The trial was inoculated with bacterial spot (*Xanthomonas gardneri* syn. *Xanthomonas campestris* pv. *vesicatoria* Group D) and bacterial speck (*Pseudomonas syringae* pv. *tomato*) on May 21 and *X. gardneri* on June 4. Admire (imidacloprid) was applied for Colorado potato beetle control on June 1 and 17, and Pounce (permethrin) was applied on July 26 for tomato hornworm control. The trial was irrigated using a drip irrigation system as required during the growing season.

The number of leaves with bacterial spot lesions on five plants per plot was counted on June 21, 29, and July 20. Disease severity was also rated using a scale of 0 to 3, where 0 = no lesions, 1 = a few lesions (~ 5% leaf area), 2 = moderate infection (~15% leaf area), and 3 = heavy (> 25% leaf area). Early blight was not assessed because infection levels were extremely low and leaf drop or defoliation was very limited.

Tomatoes were harvested from a 2m section of each plot on Aug 30; red fruit, green fruit, and rots were separated and weighed. Fifty green fruit were randomly selected and assessed for incidence of bacterial spot and speck. Fifty of red fruit were randomly selected and assessed for anthracnose after 2 days in storage by sorting into the following classes: 0 = no lesions, 1 = one lesion, 2 = two to three lesions, 3 = four or more lesions. A disease severity index (DSI) was calculated using the following equation:

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

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq$

0.05) were transformed using a log, square root, or arcsine square root transformation. Analysis of variance was conducted mean comparisons were performed when $P \leq 0.05$ using Duncan's new multiple range test.

Monthly rainfall for May, June, July, and August was 122.2 mm, 84.5 mm, 136.0 mm, and 26.0 mm. Average maximum temperatures for May, June, July, and August were 20.7 °C, 24.9 °C, 27.6 °C, and 27.6 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, and 15.7 °C.

RESULTS: The number of tomato leaves infected with bacterial spot or speck in treatments Kocide + Dithane followed by Bravo + Kocide, and Kocide + Dithane followed by Bravo were lower than the nontreated control on June 21 (Table 1). On June 29, all treatments had fewer infected leaves than the nontreated control, and on July 20, only treatment Kocide + Dithane followed by Bravo + Kocide had fewer infected leaves than the nontreated control. For AUDPC (total disease during the season or area under the disease progress curve) and disease severity, treatments that included Dithane tended to have lower disease levels, but these differences were rarely statistically significant (Tables 1 & 2). Defoliation was lower in all treatments as compared to the nontreated control (Table 2).

There were no differences among treatments for red, green, and total tomato yield (Table 3). The number of rotten tomatoes in all fungicide treatments except Kocide + Dithane followed by Bravo + Kocide was lower than in the nontreated control.

All fungicide treatments had fewer green fruit infected with bacterial spot or speck than in the nontreated control (Table 4). Treatment Kocide + Dithane followed by Bravo alt. Quadris also had lower incidence of bacterial disease on fruit than treatments Kocide + Dithane followed by Bravo and Kocide + Bravo followed by Bravo. The incidence in severity of anthracnose in all fungicide treatments was lower than the nontreated control.

CONCLUSIONS: Treatments that include Kocide + Dithane tended to have less bacterial disease on foliage than treatments without Dithane, however these differences were not always statistically significant, and all treatments provided some advantage in reducing disease levels below those in the nontreated control. All treatments reduced levels of bacterial disease on green tomato fruit, and the incidence and severity of anthracnose. Treatments including Quadris did not provide an advantage for managing anthracnose compared to treatments with Bravo only, however the last fungicide application was made more than three weeks prior to harvest. We were not able to assess the effectiveness of these spray programs at managing early blight due to the extremely low levels of this disease in the trial.

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

Treatment	Application Timing [a]	Number of infected leaves [b]			AUDPC [d]
		June 21 [c]	June 29	July 20	
Nontreated control		14.1 c [e]	40.0 b	73.3 b	1412.1 b
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	3.2 ab	13.8 a	19.0 a	409.9 a
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	9.4 bc	19.3 a	27.8 ab	616.5 a
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	2.9 a	9.3 a	66.5 b	842.4 a
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	6.6 abc	20.8 a	61.8 ab	973.3 ab
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	5.5 abc	22.0 a	37.0 ab	726.5 a
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	7.6 abc	19.0 a	48.8 ab	823.4 a
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				

[a] A = May 19, B= May 26, C = June 4, D = June 9, E = June 17, F = June 24, G = July 1, H = 10, I = 16, J = 26, and K = Aug 4

[b] Number of infected leaves on five tomato plants per plot.

[c] Data was transformed using a log transformation; the back transformed means are shown here.

[d] AUDPC = area under the disease progress curve.

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

Table 2. Disease severity and percent defoliation on tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Application Timing [a]	Disease severity rating [b]			Defoliation (%)
		June 21	June 29	July 20	Aug 13
Nontreated control		2.3 b [c]	2.5 b	1.8 ns	17.5 c
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	0.8 a	1.5 ab	1.3	1.3 ab
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	2.0 b	1.5 ab	1.3	0.0 a
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	0.8 a	1.0 a	1.3	2.5 ab
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	1.5 ab	1.3 a	1.5	7.5 b
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	1.0 a	2.0 ab	1.3	5.0 ab
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				
Kocide 2000 @ 3.2 kg Ha^{-1}	A, B, C	1.5 ab	1.5 ab	1.5	2.5 ab
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				

[a] A = May 19, B= May 26, C = June 4, D = June 9, E = June 17, F = June 24, G = July 1, H = 10, I = 16, J = 26, and K = Aug 4.

[b] Disease severity was rated on five plants per plots using a scale of 0 to 3, where 0 = no lesions, 1 = a few lesions (~ 5% leaf area), 2 = moderate infection (~15% leaf area), and 3 = heavy (> 25% leaf area).

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

Table 3. Yield of red, green and rotten tomatoes treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Application Timing [a]	Weight (kg)			
		Reds	Greens	Rots	Total
Nontreated control	-	19.10 ns [b]	0.51 ns	0.76 a	20.36 ns
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	23.95	1.17	0.54 ab	25.66
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	20.73	1.23	0.36 bcd	22.31
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	22.12	0.74	0.25 cd	23.10
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	20.91	0.82	0.18 d	21.91
Bravo 500 @ 3.2 L Ha^{-1}	D - K				
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	23.10	0.66	0.45 bc	24.20
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				
Kocide 2000 @ 3.2 kg Ha^{-1}	A, B, C	22.30	0.73	0.22 cd	23.25
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J				
Quadris @ 500 mL Ha^{-1}	E, G, I, K				

[a] A = May 19, B= May 26, C = June 4, D = June 9, E = June 17, F = June 24, G = July 1, H = 10, I = 16, J = 26, and K = Aug 4.

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

Table 4. Percentage of tomatoes with bacterial spot or speck, and incidence and severity of anthracnose, on the fruit treated with different products for control of bacterial spot and speck, Ridgetown, ON, 2010.

Treatment	Application Timing [a]	Spot or Speck on Green Fruit (%)	Anthracnose	
			Incidence (%) [b]	Severity (DSI)
Nontreated control	-	44.7 c [c]	35.0 b	20.7 b
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	24.9 ab	9.5 a	8.8 a
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K			
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	26.5 ab	6.8 a	3.2 a
Bravo 500 @ 3.2 L Ha^{-1} + Kocide 2000 @ 3.2 kg Ha^{-1}	D - K			
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	31.7 b	3.7 a	2.5 a
Bravo 500 @ 3.2 L Ha^{-1}	D - K			
Kocide 2000 @ 3.2 kg Ha^{-1} + Bravo 500 @ 3.2 L Ha^{-1}	A, B, C	33.8 b	7.0 a	3.3 a
Bravo 500 @ 3.2 L Ha^{-1}	D - K			
Kocide 2000 @ 3.2 kg Ha^{-1} + Dithane DG @ 2.25 kg Ha^{-1}	A, B, C	18.2 a	5.3 a	3.3 a
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J			
Quadris @ 500 mL Ha^{-1}	E, G, I, K			
Kocide 2000 @ 3.2 kg Ha^{-1}	A, B, C	24.3 ab	8.3 a	4.3 a
Bravo 500 @ 3.2 L Ha^{-1}	D, F, H, J			
Quadris @ 500 mL Ha^{-1}	E, G, I, K			

[a] A = May 19, B= May 26, C = June 4, D = June 9, E = June 17, F = June 24, G = July 1, H = 10, I = 16, J = 26, and K = Aug 4.

[b] Data was transformed using a log transformation; the back transformed means are shown here.

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

D. INSECT MANAGEMENT

TITLE: Products for control of Colorado potato beetle in tomatoes, 2010

PEST: Colorado Potato Beetle (*Leptinotarsa decemlineata*)

MATERIALS: Decis 5 EC (deltamethrin 50g L^{-1}), Coragen (rynaxypyr 200 g L^{-1}), HGW86 SC (cyantraniliprole 200 g L^{-1}), HGW86 SE (cyantraniliprole 100 g L^{-1}), MBI-203 (unknown), Admire (imidacloprid 240 g L^{-1}), Rimon (novaluron 10%)

METHODS: The trial was initiated at Ridgetown Campus, University of Guelph. Tomato cultivar 'Bugbait' was transplanted into twin-rows on May 27 using a mechanical transplanter. Bugbait was developed by Jim Dick, Tomato Solutions, and is more attractive to Colorado Potato Beetle (CPB) than other cultivars. Rows were spaced 1.5m apart, and within row spacing was 33cm. Each plot consisted of one 7m twin-row (approximately 40 plants per plot). The trial was established as a randomized complete block design with 4 replications per treatment.

In-furrow treatments were applied at the time of planting using 23 mL of water per shoe per meter. The applications were applied using CO_2 pressure of 30psi. Foliar treatments were applied on May 28, June 18, July 6, and July 29 using a hand-held CO_2 sprayer (35 psi) with ULD 120-02 nozzles and water volume of 200 L Ha^{-1}. The trial was irrigated using a drip irrigation system as required during the growing season.

Protectant pesticide applications were made for foliar bacterial disease on June 8 using Parasol WP (copper) and June 19 using Kocide 2000 (copper). Bravo 500 was applied on June 12, July 26, and Aug 10 for late blight protection. The trial was irrigated throughout the season as required using a drip irrigation system.

The number of CPB adults, small larvae, large larvae, and egg masses in each plot were counted on June 1, 10, 16, 21, 30, July 5, 7, 14, 21, 28, and Aug 2 as appropriate. Percent defoliation was also assessed on July 13. All tomatoes in one 2m section per plot were harvested on Sept 7 and 8. Tomatoes were sorted into reds, greens, and rots and the weight of each category was recorded.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed. Analysis of variance was conducted and means comparisons were performed when $P \leq 0.05$, with Duncan's new multiple range test.

Monthly rainfall for May, June, July, August, and September was 122.2 mm, 84.5 mm, 136.0 mm, 26.0 mm and 79.5 mm. Average maximum temperatures for May, June, July, August and September were 20.7 °C, 24.9 °C, 27.6 °C, 27.6 °C, and 22.2 °C and average minimum temperatures were 9.4 °C, 13.8 °C, 16.5 °C, 15.7 °C, 10.2 °C.

RESULTS: There were no differences among insecticide treatments and the nontreated control for the number of CPB adults and egg masses observed (Table 1 & 2). The lowest numbers of CPB larvae were observed in the Admire (in furrow) and HGW86 SE on July 21, 28, and Aug 2 (Table 3). There treatments had fewer larvae than the nontreated control, Admire (foliar), Decis, MOI-203 on all three dates, and fewer larvae than Rimon on July 21 and Aug 2.

Defoliation levels in treatments Admire (in-furrow) and HGW86 SE were lower than the nontreated control and MOI-203 on June 30 (Table 4). On July 13, HGW86 SE also recorded less defoliation than all other treatments. The percentage of plants with feeding damage was also lower in treatments Admire (in-furrow) and HGW86 SE on July 13.

Tomato yield in treatment Rimon was higher than the nontreated control, Coragen, Decis, and MOI-203 (Table 5).

CONCLUSIONS: Admire (in-furrow) and HGW86 SE provided the most effective and consistent control of CPB larvae and resulted in limited foliar damage. HGW86 SC and Coragen also tended to provide good control, but differences with the nontreated control were not statistically significant.

Table 1. Adult Colorado Potato Beetle counts in tomatoes treated with different insecticides, Ridgetown, 2010.

Treatment	Application Method	CPB Adults											
		June 1	June 3	June 10	June 16	June 21	June 30	July 5	July 7	July 14	July 21	July 28	Aug 2
Nontreated control	-	0.0 a	0.5 ns	0.8 ns	0.5 ns	0.0 ns	1.8 b	4.8 b	4.0 b	13.5 ab	17.0 ns	3.8 a	1.5 ab
Admire @ 10 mL per 100 m row	In furrow	0.0 a	0.0	0.0	0.3	0.0	0.0 a	1.3 a	1.8 ab	7.8 a	9.8	4.5 a	2.0 ab
HGW86 SC 1000 mL Ha^{-1}	In furrow	0.0 a	0.0	0.0	0.8	0.0	0.0 a	2.3 ab	2.5 ab	9.0 ab	12.3	5.3 a	3.3 b
Admire @ 200 mL Ha^{-1}	Foliar	0.0 a	0.0	0.5	1.0	0.0	0.5 ab	0.8 a	0.0 a	12.5 ab	15.3	2.8 a	0.5 a
HGW86 SE @ 1000 mL Ha^{-1}	Foliar	0.0 a	0.3	0.5	0.8	0.0	0.0 a	0.8 a	0.3 a	5.5 a	14.8	10.5 b	2.0 ab
Rimon @ 820 mL Ha^{-1}	Foliar	0.0 a	0.0	0.3	0.0	0.3	0.8 ab	1.5 a	1.8 ab	10.5 ab	15.3	3.0 a	0.8 a
Coragen @ 375 mL Ha^{-1}	Foliar	0.0 a	0.5	0.3	0.3	0.3	1.5 ab	1.8 a	3.5 b	16.3 b	18.3	4.3 a	2.5 ab
Decis @ 150 mL Ha^{-1}	Foliar	0.3 ab	0.0	0.0	0.3	0.0	0.3 ab	0.3 a	3.5 b	7.8 a	20.0	3.3 a	0.5 a
MOI-203 @ 10 L Ha^{-1}	Foliar	0.5 b	0.0	0.3	0.5	0.0	0.0 a	0.0 a	2.0 ab	12.5 ab	21.8	2.5 a	0.8 a

[a] Data is this column were normalized using a log transformation; data presented here are the back transformed means.

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

Table 2. Egg mass counts for Colorado Potato Beetle in tomatoes treated with different insecticides, Ridgetown, 2010.

Treatment	Application Method	CPB Egg Masses								
		June 1	June 3	June 10 [a]	June 16	June 21	June 30	July 7	July 14	July 21
Nontreated control	-	0.5 ns	0.5 ns	1.5 ns	1.0 ns	0.3 ns	0.0 ns	0.3 ns	0.3 ns	1.8 ab
Admire @ 10 mL per 100 m row	In furrow	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.5	1.0 a
HGW86 SC 1000 mL Ha^{-1}	In furrow	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.3 ab
Admire @ 200 mL Ha^{-1}	Foliar	0.0	0.0	1.2	0.0	0.0	0.0	0.3	0.0	2.3 ab
HGW86 SE @ 1000 mL Ha^{-1}	Foliar	0.0	0.0	1.2	0.0	0.8	0.0	0.0	0.0	0.5 a
Rimon @ 820 mL Ha^{-1}	Foliar	0.0	0.0	1.2	0.5	0.0	0.0	0.0	0.0	1.8 ab
Coragen @ 375 mL Ha^{-1}	Foliar	0.0	0.5	1.3	1.3	0.0	0.0	0.0	0.0	4.8 b
Decis @ 150 mL Ha^{-1}	Foliar	0.5	0.0	1.5	0.3	0.0	0.0	0.0	0.3	2.3 ab
MOI-203 @ 10 L Ha^{-1}	Foliar	0.0	0.3	1.7	0.8	0.3	0.0	0.0	0.3	2.5 ab

[a] Data is this column were normalized using a log transformation; data presented here are the back transformed means.

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

Table 3. Larvae counts for Colorado Potato Beetle in tomatoes treated with different insecticides, Ridgetown, 2010.

Treatment	Application Method	CPB Larvae										
		June 1	June 10 [a]	June 16 [a]	June 21 [a]	June 30	July 5 [a]	July 7 [a]	July 14	July 21	July 28 [b]	Aug 2 [a]
Nontreated control	-	0.0 ns [c]	5.0 b	6.1 ab	2.1 ns	7.0 a-d	1.9 ab	1.3 ab	0.5 ns	18.9 bc	158.5 bc	18.9 bc
Admire @ 10 mL per 100 m row	In furrow	0.0	0.0 a	0.0 a	0.0	1.4 ab	0.0 a	0.0 a	0.0	2.2 a	30.0 a	2.2 a
HGW86 SC 1000 mL Ha^{-1}	In furrow	0.0	0.0 a	1.2 a	0.0	2.2 abc	2.1 ab	1.8 ab	0.0	4.1 ab	86.3 ab	4.1 ab
Admire @ 200 mL Ha^{-1}	Foliar	0.0	1.2 a	2.3 ab	0.0	1.2 ab	0.0 a	0.0 a	0.0	27.2 c	168.0 bc	27.2 c
HGW86 SE @ 1000 mL Ha^{-1}	Foliar	0.0	0.0 a	1.2 a	0.0	0.0 a	0.0 a	0.0 a	0.0	1.3 a	30.0 a	1.3 a
Rimon @ 820 mL Ha^{-1}	Foliar	0.0	0.0 a	3.5 ab	1.2	8.1 bcd	2.1 ab	1.4 ab	0.0	12.0 bc	126.8 abc	12.0 bc
Coragen @ 375 mL Ha^{-1}	Foliar	0.0	1.5 a	3.6 ab	1.6	3.4 a-d	1.4 a	0.0 a	0.0	4.8 ab	84.3 ab	4.8 ab
Decis @ 150 mL Ha^{-1}	Foliar	0.0	0.0 a	13.0 a	3.3	14.3 cd	8.6 c	3.0 b	0.3	27.6 c	231.8 c	27.6 c
MOI-203 @ 10 L Ha^{-1}	Foliar	0.0	2.6 ab	3.8 ab	2.7	21.6 d	6.3 bc	3.4 b	0.0	30.0 c	240.8 c	30.0 c

[a] Data is this column were normalized using a log transformation; data presented here are the back transformed means.

[b] Data is not normal and could not be normalized using a log or square root transformation.

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

Table 4. Feeding damage on tomatoes treated with different soil applied insecticides for Colorado Potato Beetle management at the time of transplanting, Trial 1, Ridgetown, 2010.

Treatment	Application Method	Plants with Feeding Damage (%)	Defoliation (%)	
		July 13	June 30	July 13 [a]
Nontreated control	-	49.2 c	17.5 b	11.1 b
Admire @ 10 mL per 100 m row	In furrow	15.2 a	2.5 a	7.1 b
HGW86 SC 1000 mL Ha^{-1}	In furrow	23.3 ab	5.0 ab	6.5 b
Admire @ 200 mL Ha^{-1}	Foliar	18.2 ab	5.0 ab	6.7 b
HGW86 SE @ 1000 mL Ha^{-1}	Foliar	5.0 a	0.0 a	1.2 a
Rimon @ 820 mL Ha^{-1}	Foliar	23.7 ab	7.5 ab	7.5 b
Coragen @ 375 mL Ha^{-1}	Foliar	22.2 ab	5.0 ab	8.2 b
Decis @ 150 mL Ha^{-1}	Foliar	46.9 c	12.5 ab	9.4 b
MOI-203 @ 10 L Ha^{-1}	Foliar	38.5 bc	17.5 b	8.0 b

[a] Data is this column was normalized using a square root transformation; back transformed means are shown here.

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

Table 5. Yield for tomatoes treated with different soil applied insecticides for Colorado Potato Beetle management at the time of transplanting, Trial 1, Ridgetown, 2010.

Treatment	Application Method	Yield (kg)			
		Reds	Greens [a]	Rots	Total
Nontreated control	-	10.45 bc	0.55 cd	0.11 ns	11.11 bc
Admire @ 10 mL per 100 m row	In furrow	13.61 ab	0.76 bcd	0.19	14.55 ab
HGW86 SC 1000 mL Ha^{-1}	In furrow	11.32 abc	1.13 abc	0.11	12.56 abc
Admire @ 200 mL Ha^{-1}	Foliar	12.73 abc	0.99 abc	0.10	13.82 abc
HGW86 SE @ 1000 mL Ha^{-1}	Foliar	13.10 abc	1.21 abc	0.23	14.53 ab
Rimon @ 820 mL Ha^{-1}	Foliar	14.90 a	1.34 ab	0.20	16.43 a
Coragen @ 375 mL Ha^{-1}	Foliar	10.41 bc	1.53 a	0.16	12.09 bc
Decis @ 150 mL Ha^{-1}	Foliar	9.63 c	0.63 bcd	0.11	10.36 c
MOI-203 @ 10 L Ha^{-1}	Foliar	11.20 abc	0.20 d	0.13	11.53 bc

[a] Data is this column is not normal and could not be normalized using a log or square root transformation.

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