FARM INNOVATION PROGRAM

FIP 1058

DISEASE MANAGEMENT OF VEGETABLES WITH FORECASTING, RESISTANT LINES AND NEW FUNGICIDES

RESEARCHER

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EXECUTIVE SUMMARY

Downy mildew diseases can be extremely destructive and are difficult to control when weather conditions are favourable for disease development. If uncontrolled, downy mildew can cause a complete crop loss of lettuce and onions.

Effective disease control depends on effective fungicides, but these must be applied before infection takes place, to be effective. There are downy mildew forecasting systems for onions (Downcast) and lettuce (Bremcast) but it is very important to know if there are spores in the region near the crop, for the forecasting systems to be most effective. We have been cooperating with Dr. Odile Carisse at AAFC in Quebec to test spore trapping with rotorods as a means to predict the risk of botrytis blight of onion. Implementing the rotorod spore traps could be even more useful to determine the risk of onion downy mildew and other downy mildew diseases. The presence and flux of lettuce downy mildew was monitored at Simcoe Research Station using the rotorod spore traps. Very few spores were captured on the spore traps in August. Spore counts increased in September and the first lettuce downy mildew incidence was recorded on 1 September.

Effective fungicides are crucial for control of downy mildew diseases. There are some new fungicides in the system that may be very effective for onion and lettuce downy mildews. One is Presidio, which is not yet registered in Canada. Other new materials that need more testing are Revus, Reason, Acrobat, Serenade, QGU 42, Phostrol and a new biocontrol, Polyversum. In this project Ridomil, QGU 42, Phostrol and Aliette had exhibited relatively better control of lettuce downy mildew at both locations; while presidio provided intermediate control at Simcoe. No

onion downy mildew developed on the trial and thus no differences were observed among the fungicides.

Resistant plants are an excellent method of disease control. Two resistant onion cultivars have been released by Bejo Seeds. These cultivars were evaluated in this project for resistance, yield and quality. However, no onion downy mildew incidence was observed at the trial site. Thus no differences were observed among the cultivars

OVERALL PROJECT OBJECTIVES REACHED

The overall goal of the project was to improve disease management of downy mildew diseases of vegetable crops, to reduce losses and improve quality. This was done by:

a) Improving disease forecasting, and hence effective control of downy mildew diseases of vegetable crops in Ontario, through the use of rotorod traps.
b) Identifying effective reduced-risk fungicides for control of downy mildew diseases.
c) Evaluating the two new onion cultivars that are resistant to downy mildew, to confirm resistance and determine if they are well adapted to Ontario growing conditions.

All objectives have been completed

ACTIVITIES UNDERTAKEN TO REACH THE PROJECT OBJECTIVES

This project was conducted in the field trials at the Muck Crops Research Station (MCRS) and Simcoe Research Station (SRS). Evaluation of fungicides for lettuce downy mildew control was conducted at two site, the MCRS and SRS. The evaluation of fungicides for onion downy mildew control and evaluation of cultivars for onion downy mildew resistance was conducted at the MCRS.

1. CONTROL OF ONION DOWNY MILDEW

1.1 COMPARISON OF VARIOUS FUNGICIDES FOR CONTROL OF DOWNY MILDEW (*PERONOSPORA DESTRUCTOR*) IN ONIONS, 2010

MATERIALS AND METHODS: Onions, cv. Hamlet, were direct seeded (34 seeds/m) on 6 May using aStanhay Precision Seeder into organic soil (organic matter ≈ 69%, pH ≈ 6.6) at the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each replicate consisted of eight rows (42 cm apart), 5 m in length. Treatments were applied on 29 July, 6 and 13 August using a CO_2 backpack sprayer equipped with 4 TeeJet 11002 fan nozzles spaced 40 cm apart and calibrated to deliver

400 L/ha at 240 kPa (boom). The treatments were: ALIETTE at 2.8 kg/ha, RANMAN at 200 mL/ha, REVUS + AGRAL 90 (non-ionic adjuvant) at 600 mL + 0.125% v/v, REASON at 400 mL/ha, RIDOMIL alternated with ALIETTE at 2.5 or 2.8 kg/ha, MANCOZEB at 3.25 kg/ha, PRESIDIO + MANCOZEB at 292 mL + 3.25 kg/ha respectively, CABRIO at 840 g/ha, SERENADE MAX at 6.0 kg/ha, PHOSTROL at 4.3 L/ha and QGU 42 at 350 mL/ha. An untreated check was also included. Recommended control procedures for weeds and insects were followed. On 23 August, 25 plants from the middle 6 rows per replicate were pulled. Leaves were examined for downy mildew lesions and the numbers of lesions, dead and green leaves were counted and recorded. On 10 September onions in two 2.32 m sections of row from each replicate were pulled for a yield sample. The onions were weighed and graded for size on 18 November.

1.2 COMPARISON OF VARIOUS ONION CULTIVARS FOR RESISTANCE TO DOWNY MILDEW (*PERONOSPORA DESTRUCTOR*) IN ONIONS, 2010

MATERIALS AND METHODS: Onions of cultivars Yankee (Bejo Seeds Inc.), Hamlet, Ricochet, Mars (Seminis Vegetable Seeds), Tahoe (Norseco Inc.) and Stanley (Solar Seeds Inc.) were direct seeded (34 seeds/m) using a Stanhay Precision Seeder (Hamlet, Ricochet, Mars, Tahoe and Stanley) and a V-belt push seeder (Yankee) on 11 May, into organic soil (organic matter ≈ 49.9%, pH ≈ 7.5) near the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block arrangement with four replicates per treatment was used. Each experimental unit consisted of four rows, 42 cm apart, 6 m in length. Recommended control procedures for weeds and insects were followed. On 31 August, plants in two randomly selected 1/2 m sections of row per replicate were pulled. Plants were counted, leaves examined for downy mildew lesions and the numbers of lesions, dead and green leaves were counted and recorded. On 13 September onions in two 2.32 m sections of row from each replicate were pulled for a yield sample. The onions were weighed and graded for size on 17 November.

Compared to the averaged previous 10 years, the air temperatures in 2010 were average for June (18.4°C) and September (15.5°C), above average for May (15.1°C), July (22.3°C) and August (21.1°C). The long term previous 10 year average temperatures were: May 13.1°C, June 18.4°C, July 20.0°C, August 19.3°C and September 15.5°C. Monthly rainfall was below the previous long term 10 years average for May (51.7 mm) and above average for June (170 mm), July (146 mm), August (74 mm) and September (95 mm). The long term previous 10 year average rainfall averages were: May 87 mm, June 74 mm, July 76 mm, August 57 mm and September 72 mm.

2. CONTROL OF LETTUCE DOWNY MILDEW

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

Field trials were conducted at the Muck Crops Research Station and at Simcoe Research Station to evaluate fungicides for control of lettuce downy mildew.

2.1 MATERIALS AND METHODS (Muck Crops Research Station) Lettuce, cv. Mighty Joe, was seeded into 128-cell plug trays on 18 June, hand-transplanted (4 plants/ m) into organic soil (pH ≈ 6.6, organic matter ≈ 72.3%) on 23 July at the Muck Crops Research Station, Holland Marsh, Ontario. A randomized complete block design with four replicates per treatment was used. Each experimental unit consisted of four 6 m long rows, 42 cm apart. Treatments were: PRESIDIO at 292 mL/ha, RIDOMIL GOLD MZ at 2.5 kg/ha, PHOSTROL at 4.3 L/ha, RANMAN 400 SC at 200 mL/ha, REVUS at 600 mL/ha, QGU 42 at 350 mL/ha and SERENADE MAX at 6.0 kg/ha. An untreated check was also included. Treatments were applied on 5, 12, 20 and 27 August using a CO_2 backpack sprayer equipped with four TeeJet 11002 fan nozzles spaced 40 cm apart and calibrated to deliver 400 L/ha at 240 kPa (boom). Prior to the 1st assessment, the 10 plants per experimental unit to be assessed were randomly chosen and marked with stakes. Plants were assessed for disease incidence and severity. Disease severity was rated on a scale of 1 to 5: 0 = no lesions, 1 = 1 lesion, 2 = 2-5 lesions, 3 = 6-10 lesions, 4 = 11-15 lesions, 5 = >15 lesions on 25, 31 August and 7 September. These values were used to calculate the area under disease progress curve (AUDPC) and disease severity index (DSI). AUDPC was calculated using the following equation:

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

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

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

On 8 September, 20 heads from unmarked plants were harvested and trimmed to remove all leaves with visible downy mildew lesions. Untrimmed and trimmed weights were recorded to determine harvest and marketable weights. Percent marketable weight was calculated as the trimmed weight divided by the untrimmed weight. Compared to the averaged previous 10 years, the air temperatures in 2010 were average for September (15.5ºC), above average for July (22.3ºC) and August (21.1ºC). The long term previous 10 year average temperatures were: July 20.0ºC, August 19.3ºC and September 15.5ºC. Monthly rainfall was above previous long term 10 years average July (146 mm), August (74 mm) and September (95 mm). The long term previous 10 year average rainfall averages were: July 76 mm, August 57 mm and September 72 mm.

2.2 MATERIALS AND METHODS (Simcoe Research Station): Mighty Joe iceberg head lettuce was seeded on 15 July into 128 cell plastic plug trays filled with a commercial soil-less mix. Transplants were planted into the field on 13 August using a mechanical transplanter. Fertilizers were applied before planting as 80 kg/ha N, K_2O, P_2O_5 as 10-10-10 and 30 kg/ha N as ammonium nitrate (34% N). Weeds were controlled with Kerb 50WSP (propyzamide) applied 5 days after planting at a rate of 2.2 kg/ha. Soil type was a Scotland sandy loam (1.8 % organic matter, pH 7.2). Plots were 7 m long and 3 rows wide with rows spaced 50 cm apart and plants spaced 30 cm apart in the row. A randomized complete block design with four replicates per treatment was used.

RIDOMIL GOLD MZ 68WG (2.5 kg/ha), ALIETTE (2.8 kg/ha), RANMAN 400SC (0.15 L/ha) + AGRAL 90, PHOSTROL (2.9 L/ha), REASON 500SC (400 mL/ha), ACROBAT 50WP (450 g/ha), SERENADE MAX (1.5 kg/ha), RIDOMIL GOLD MZ 68WG (2.5 kg/ha) alternated with ALIETTE (2.8 kg/ha), PRESIDIO (280 mL/ha), REVUS (600 mL/ha), QGU 42 250 (mL/ha) plus an untreated control. Products were applied according to the label. The adjuvant AGRAL 90 (0.125%v/v) and HALT (7mL/500L) were used for all applications of REVUS and RANMAN. Fungicides were applied using a CO_2 backpack sprayer equipped with three TeeJet XR8004VS nozzles spaced 50 cm apart and calibrated to deliver 300 L/ha water at 220 kPa. The fungicides RANMAN, SERENADE MAX, PHOSTROL and QGU 42 were applied on 18, 26 August, 2, 10, 17, 23 September; fungicides ALIETTE and RIDOMIL alternated ALIETTE were applied on18, 26 August, 2, 10, 17 September, fungicides PRESIDIO, REVUS and REASON were applied on 18, 26 August, 2, 10 September and ACROBAT was applied on 18, 26 August, and 2 September.

To monitor lettuce downy mildew spores presence and flux, a rotorod spore trap was placed above the lettuce canopy of one of the untreated checks. Spore trap rods were placed in the field and evaluated under the microscope three days a week, from 20 August to 15 September.

Plants were assessed for downy mildew incidence and severity on 19, 26 August, 1, 8, 15, 23, 30 September. Disease incidence was evaluated on all plants in the middle row of each plot. Disease severity was assessed on 12 plants selected randomly and marked with stakes in each plot just before the first assessment. Lettuce downy mildew severity was assessed using a 0-5 scale where: 0= no lesions/ leaf, 1= 1 lesion/leaf, 2= 2 to 5 lesions/leaf, 3=6 to10 lesions/leaf, 4= 11-15 lesions/leaf, 5= > 15 lesions/leaf. Disease ratings were used to calculate the disease severity index (DSI) using the equation:

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

The inside 5 m of the middle row of each plot was harvested on 7 October. Total untrimmed and trimmed weight was recorded and trimmed heads were graded into marketable (firm and fully developed heads) and unmarketable (undeveloped heads, split, insect damage, soft rot) categories. Trimmed lettuce leaves from all treatments were assessed for downy mildew incidence and severity on October 11, 12 and 14 using the same rating scale used for the weekly disease assessments. Disease ratings were used to calculate foliage disease incidence and disease severity index using the DSI formula above.

Air temperatures in the 2010 growing season were above normal in May (16.9), June (19.4°C), July (22.6°C), August (21.5°C), September (16.7°C) and October (10.3°C). The 30 year normal average temperatures were: May 12.5°C, June 18.1°C, July 20.5°C, August 19.5°C, September 15.5°C, October 9.6°C. Monthly rainfall was below normal in May (65 mm) and above normal in June (164 mm), July (189 mm), August (140 mm), September (133 mm) and October (89 mm). The 30 year normal rainfall totals were: May (74 mm), June (82 mm) July (77 mm) August (80 mm), September (89 mm) and October (73 mm).

Analyses and interpretation of data

Data were analyzed using the General Analysis of Variance function of the Linear Models section of Statistix V.9 and the General Linear Model procedure of SAS ver. 9.2. Means separation was obtained using Fisher's Protected LSD test at P = 0.05 level of significance. Marketable yield and size distribution as dependent variable were compared with disease variables as independent variables using linear correlation analysis.

OUTPUTS CREATED AS A RESULT OF THE ACTIVITIES UNDERTAKEN

See Appendix A for results of the research trials.

PROJECT INPUTS USED TO COMPLETE THE ACTIVITIES

A total of four staff members and six summer students were involved in this project. All FIP funding has been utilized. A full accounting of the project's financial status will be sent by the Universioty of Guelph-Office of Research.

BENEFITS & IMPACT

Results of this project are consistent with the expected short term results. Similar results in efficacy of fungicides in controlling lettuce downy mildew were observed at the two locations.

Final results were satisfactory. However, onion downy mildew did not occur at the research plots and thus efficacy of the fungicides tested and the susceptibility/resistance of the cultivars to downy mildew could not be determined.

Downy mildew can cause severe yield losses under favourable weather conditions if no control measures are applied. The public will benefit from the project as the project will result in consistent yield and quality of vegetable crops such as onions and lettuce. The presence and flux of downy mildew spores can be monitored using the rotorod spore traps. Thus, growers can make informed decisions at appropriate times. Where resistant onion lines are acceptable, this will reduce the cost per acre to the grower, since no fungicides have to be applied to control onion downy mildew. This project evaluated 11 products for efficacy in controlling onion and lettuce downy mildew diseases. Products were identified that may have potential for registration. This will be of great benefit to lettuce and onions growers by providing more options for controlling downy mildew diseases thus increasing yield and quality.

The project assessed implementation of rotorod spore traps to track available downy mildew spores in the air and its relations with incidence of downy mildew diseases.

Success in the long term will be measured by effective disease control with the use of reduced-risk fungicides only when necessary. It will also be measured by the application of the disease monitoring methods in IPM programs, such as the program in the Holland Marsh, and by the number of growers using the information from disease forecasting.

The information provided by this initiative will be used by growers to increase the quality and yield of their crops by using the appropriate fungicides and by timing fungicide application effectively. Additional research has been supported by the FVGO and chemical companies. AAFC Minor Use funding has been requested to pursue the registration of some of the new materials

The project will result in consistent yield and quality of vegetable crops such as lettuce and onions. Where resistant lines are acceptable, this will reduce the cost per acre to the grower, since no fungicide will have to be applied to control onion downy mildew. Where fungicides are used, the grower will have higher income, since there will be less crop loss to downy mildew.

TARGET AUDIENCE AND TOTAL NUMBER OF PEOPLE REACHED BY THIS PROJECT

The target audiences of the project were 200 onion growers and 100 growers of lettuce and related leafy greens. The total number of people reached by this project was 200 through oral presentation and ~450 through annual reports. Project results are posted on the muck crops research station web site and the NUMBER OF HITS on the website is available in request from university of Guelph.

CONCLUSION & FINAL COMMENTS

This project was successful. Lettuce downy mildew developed in plots at both locations and we were able to get a good assessment of disease, yield and the efficacy of the fungicides. Disease pressure and time of disease incidence on lettuce was not the same at the two locations. Disease pressure was higher at the Muck Crops Research Station plots than lettuce plots at the Simcoe Research Station. This could be due to differences in time of occurrence of favourable weather conditions for disease development. However, Similar results in efficacy of fungicides in controlling lettuce downy mildew were observed at the two locations. Ridomil, QGU 42, Phostrol and Aliette had exhibited relatively better control of lettuce downy mildew at both locations; while presidio provided intermediate control at Simcoe Research Station. The new products (Phostrol and QGU 42) performed better than some of the registered products in lettuce downy mildew control and could be used in rotation once the products are registered.

The use of rotorod spore trpas to monitor lettuce downy mildew spore presence and flux was effective in tracking the initial incidence of spores. At Simcoe Research Station lettuce plots, very few downy mildew spores were observed on 20 August and first downy mildew lesions were recorded on 1 September. Thus, implementing spore traps will enable growers to identify if their crops are at risk.

No onion downy mildew was found in the trial. Thus it was not possible to determine the effect of fungicides on onion downy mildew as well as the resistance/susceptibility of different onion cultivars to downy mildew. Hence, repeating the trial would give us a chance to evaluate the fungicides and onion cultivars to control onion downy mildew.

APPENDIX A: RESULTS AND DISCUSSION

1. CONTROL OF ONION DOWNY MILDEW

1.1 COMPARISON OF VARIOUS FUNGICIDES FOR CONTROL OF DOWNY MILDEW (*PERONOSPORA DESTRUCTOR*) IN ONIONS, 2010.

RESULTS: No downy mildew was found in this trial, which resulted in no significant differences among the treatments (Table 1). No significant differences in the number of dead or healthy leaves were observed among the treatments. No significant differences were found in yield, percent marketable or size distribution among the treatments (Table 2). However, there was negative correlation (r = -0.7, P = 0.01) between number of green leaves/plant and the proportion of small (culls) onions. All products tested were non-phytotoxic on the crop.

CONCLUSIONS: In 2010 onion downy mildew pressure was very low. DOWNCAST, the onion downy mildew predictive model predicted a sporulation infection period around mid-July. The first downy mildew was confirmed in onion fields in the Holland Marsh east of highway 400 in late July. The risk remained low to moderate. The disease did not spread to other locations in the Marsh.

Table 1. Downy mildew (DM) rating, number of green and dead leaves per plant for onions, cv. Hamlet, treated with various fungicides grown at the Muck Crops Research Station, Holland Marsh, Ontario, 2010.

Treatment	Rate/ha	DM lesions/plant	Green leaves/plant	Dead leaves/plant
CABRIO	840 g	0.0 ns[1]	4.7 ns	3.3 ns
ALIETTE	2.8 kg	0.0	4.4	3.3
Check	--	0.0	4.1	3.5
PHOSTROL	4.3 L	0.0	4.1	3.8
PRESIDIO+DITHANE	292 mL+3.25 kg	0.0	4.8	3.9
REVUS + AGRAL 90	600 ml + 0.125% v/v	0.0	4.1	3.9
REASON	400 mL	0.0	5.1	4.1
RANMAN	200 mL	0.0	4.0	4.2
SERENADE MAX	6.0 kg	0.0	3.7	4.3
RIDOMIL alternated with ALIETTE[2]	2.5 or 3.25 kg	0.0	3.7	4.5
DITHANE	3.25 kg	0.0	3.7	4.6
QGU 42	350 mL	0.0	3.1	4.6

[1] ns indicates there were no significant differences found among the treatments.

[2]RIDOMIL MZ was applied on 29 July and 13 August and ALIETTE was applied on 6 August.

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

Treatment	Rate/ha	Marketable Yield (t/ha)	Size Distribution % Jumbo (>76 mm)	% Large (64 - 76 mm)	% Medium (45 – 64 mm)	% Small (<44 mm)
CABRIO	840 g	45.9 ns[1]	1.2 ns	29.5 ns	57.2 ns	12.1 ns
PRESIDIO+DITHANE	292mL+ 3.25 kg	44.1	1.8	32.9	57.4	8.0
RIDOMIL alternated with ALIETTE[2]	2.5 or 3.25 kg	44.0	3.2	31.9	50.2	14.8
ALIETTE	2.8 kg	42.3	0.6	26.8	63.3	9.4
REVUS + AGRAL 90	600 ml + 0.125% v/v	41.3	1.4	30.7	58.9	9.0
PHOSTROL	4.3 L	37.9	1.5	22.1	61.9	14.5
DITHANE	3.25 kg	36.6	1.5	24.2	59.6	14.8
SERENADE MAX	6.0 kg	34.8	2.1	18.2	64.6	15.1
QGU 42	350 mL	34.7	0.0	23.2	57.1	19.7
REASON	400 mL	34.7	1.3	29.1	58.3	11.3
RANMAN	200 mL	32.5	0.0	20.2	64.5	15.3
Check	--	32.4	0.0	15.3	66.5	18.3

[1] ns indicates there were no significant differences found among the treatments.

[2]RIDOMIL MZ was applied on 29 July and 13 August and ALIETTE was applied on 6 August

Funding was provided by the Bradford Cooperative and Storage Ltd. through the Holland Marsh Growers' Association, the Fresh Vegetable Growers of Ontario through the Farm Innovation Program (FIP) that is part of Growing Forward, a federal-provincial-territorial initiative. The FIP program is administered by the Agricultural Adaptation Council.

1.2 COMPARISON OF VARIOUS ONION CULTIVARS FOR RESISTANCE TO DOWNY MILDEW (*PERONOSPORA DESTRUCTOR*) IN ONIONS, 2010

RESULTS: No downy mildew was found in the trial, which resulted in no significant differences among the cultivars in number of dead leaves per plant (Table 1). Significant differences were found among the cultivars in green leaves per plant (Table 1). Yankee, Stanley, Tahoe, Mars, and Hamlet had significantly more green leaves per plant than Ricochet. Significant differences in marketable yield and percent size distribution s were found among the cultivars (Table 2). Onion cultivars Mars, Ricochet and Stanley had higher marketable yield than Tahoe and Yankee. Hamlet had higher marketable yield than cultivar Yankee. The proportion of large size (64-76 mm) onions was higher in cultivar Mars than the remaining cultivar. There was no correlation between yield variables and number of dead leaves.

CONCLUSIONS: In 2010 onion downy mildew pressure was very low. DOWNCAST, the onion downy mildew predictive model, predicted a sporulation infection period around mid-July. The first downy mildew was confirmed on onion fields in the Holland Marsh east of highway 400 in late July. The risk remained low to moderate. The disease did not spread to other locations in the Marsh. The differences in marketable yield and percent size distributions observed in this trial may be related to plant stand and differences in phenotype rather than to downy mildew damage. The variation in number of green leaves per plant could also be associated with diseases other than downy mildew such as stemphylium leaf blight, purple blotch or botrytis leaf blight.

Table 1. Downy mildew (DM) ratings and number of green and leaves per plant for various onion cultivars grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2010.

Cultivar	DM lesions/plant	Green leaves/plant	Dead leaves/plant
Yankee	0.0 ns[1]	2.8 a[2]	6.8 ns
Stanley	0.0	2.4 a	6.4
Tahoe	0.0	2.4 a	5.9
Mars	0.0	2.2 a	6.7
Hamlet	0.0	1.9 a	6.8
Ricochet	0.0	0.4 b	7.0

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

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

Table 2. Comparison of marketable yield and size distribution of onion cultivars with various degrees of resistance to downy mildew, grown near the Muck Crops Research Station, Holland Marsh, Ontario, 2010.

Cultivar	Marketable Yield		Size Distribution			
	t/ha	bushel/A	% Jumbo (> 76 mm)	% Large (64 - 76 mm)	% Medium (45 - 64 mm)	% Small (< 45 mm)
Mars	44.6 a[1]	721.6 a	2.5 ns	35.5 a	52.4 b	9.7 a
Ricochet	38.4 a	621.8 a	0.0	11.3 b	72.1 ab	16.6 ab
Stanley	38.3 a	620.2 a	0.0	9.5 b	73.3 ab	17.2 ab
Hamlet	37.3 ab	602.9 ab	0.0	1.5 b	76.1 a	22.5 ab
Tahoe	24.2 bc	391.6 bc	1.1	3.6 b	66.0 ab	29.4 ab
Yankee	22.6 c	366.3 c	0.0	1.2 b	65.2 ab	33.7 b

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

Funding was provided by the Bradford Cooperative and Storage Ltd. through the Holland Marsh Growers' Association, the Fresh Vegetable Growers of Ontario through the Farm Innovation Program (FIP) that is part of Growing Forward, a federal-provincial-territorial initiative. The FIP program is administered by the Agricultural Adaptation Council.

3. CONTROL OF LETTUCE DOWNY MILDEW

3.1 EVALUATION OF FUNGICIDES FOR CONTROL OF DOWNY MILDEW (*BREMIA LACTUCAE*) ON LETTUCE, 2010: At the Muck Crops Research Station

RESULTS: Significant differences in downy mildew incidence and severity were found among the treatments. Downy mildew incidence (25 and 31 August assessment) and severity was lower in lettuce treated with PHOSTROL, RIDOMIL and QUG 42 than the remaining fungicides and the untreated check (Table 1). The disease progress indicated by the AUDPC remained lower in lettuce treated with PHOSTROL, RIDOMIL and QUG 42 than lettuce treated with REVUS, PRESIDIO, RANMAN, SERENADE MAX and the untreated check. Downy mildew incidence, severity and AUDPC in lettuce treated with fungicides PRESIDIO, RANMAN and SERENADE MAX was not better than the untreated check at any assessment date. However, AUDPC, disease incidence (25 Aug and 7 Sept assessments) and DSI (31 Aug assessment) on lettuce treated with REVUS was lower than the untreated check.

Significant differences were found in marketable yield and percent marketable weight among the treatments. Lettuce treated with the commercial standard RIDOMIL, QGU 42, REVUS, PHOSTROL and PRESIDIO had significantly higher marketable yield than lettuce treated with RANMAN, SERENADE MAX and the untreated check (Table 2). No significant differences in marketable weight per head and percent marketable weight were found among lettuce treated with PRESIDIO, RANMAN, SERENADE MAX and the untreated check (Table 2).

CONCLUSIONS: In 2010 disease pressure was high and increased over the assessment period. BREMCAST, the lettuce downy mildew forecasting model, predicted sporulation infection periods (SIP) during the growing season starting mid-July and the risk of developing downy mildew remained moderate to high until September. Lettuce downy mildew symptoms started to develop around mid to late July in the Holland Marsh including the MCRS's trial plots. Application of PHOSTROL, RIDOMIL and QGU 42 had reduced the progress of downy mildew between plants within plots and of each infected plant. This resulted in a relatively higher marketable weight per head than RANMAN, SERENADE MAX and the untreated check. The products that performed well in reducing downy mildew incidence and severity could be used in rotation with other management strategies once they are registered.

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

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

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

[2]AUDPC = Area under the disease progress curve.

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

Treatment	Rate (per ha)	Harvest wt/head[1] (g)	Number of marketable heads	Marketable wt/head[2] (g)	% Marketable Wt[3]
RIDOMIL	2.5 kg	987.9 a[4]	18.8 a	789.9 a	74.8 a
QGU 42	350 mL	775.9 abc	17.0 ab	686.8 ab	75.2 a
REVUS	600 mL	794.1 ab	16.3 ab	667.0 ab	68.4 ab
PHOSTROL	4.3 L	694.3 bcd	16.0 ab	656.8 ab	75.2 a
PRESIDIO	292 mL	565.8 bcde	13.5 ab	582.4 bc	60.6 ab
RANMAN	200 mL	451.3 de	13.8 ab	420.5 cd	64.1 ab
SERENADE MAX	6.0 kg	395.5 e	13.5 ab	376.3 d	63.5 ab
Check	--	506.4 cde	11.3 b	395.9 d	51.4 b

[1]Average of 20 lettuce heads

[2]Average of marketable heads

[3]% marketable weight = (total marketable weight/harvest weight) x 100

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

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

2.1 EVALUATION OF FUNGICIDES FOR CONTROL OF DOWNY MILDEW (*BREMIA LACTUCAE*) ON LETTUCE, 2010: At Simcoe Research Station

2.2

RESULTS: Very few downy mildew (DM) spores were captured on the spore trap during the month of August (Appendix B). Spore counts increased in September and the first lettuce DM lesions were recorded on 1 September. Disease incidence was low during the first 2 evaluations (8, 15 September) but disease pressure increased and was moderately high (79%) by the end of the trial (Table 1). At the 15 September assessment, there were no significant differences in lettuce DM incidence and severity among the treatments; however the untreated check had numerically higher incidence and severity values. At the 23 September evaluation, lettuce treated with QGU 42, ALIETTE, RIDOMIL alone or alternated with ALIETTE, REASON, PRESIDIO, REVUS and PHOSTROL had significantly lower disease incidence and severity than the untreated check. At the 30 September evaluation, lettuce treated with QGU 42, ALIETTE, RIDOMIL alternated with ALIETTE and REASON had lower disease incidence than lettuce treated with RANMAN, ACROBAT, SERENADE and the untreated check. Disease severity (30 Sep assessment) was also lower in lettuce treated with QGU 42, ALIETTE, RIDOMIL alternated with ALIETTE and REVUS than lettuce treated with RANMAN, ACROBAT, SERENADE and the untreated check. On these dates no disease was recorded on lettuce treated with QGU 42 and symptoms did not appear in plots treated with ALIETTE until 30 September. There were significant differences in DM incidence and severity of the trimmed lettuce foliage evaluated after harvest. Downy mildew incidence and severity on trimmed foliage was highest on the untreated check, with no significant differences between the untreated check and the RANMAN, SERENADE, ACROBAT, ALIETTE, PHOSTROL and REVUS treatments (Table 2). Foliage of lettuce treated with QGU 42, RIDOMIL alone and RIDOMIL alternated with ALIETTE had significantly lower downy mildew incidence and severity than ACROBAT, SERENADE, RANMAN and the untreated check. PRESIDIO and REASON provided intermediate control with incidence and severity values significantly lower than the untreated check. No significant differences were found in % marketable heads or weight per head among treatments (Table 3).

CONCLUSIONS: Lettuce DM onset occurred late in the growing season, therefore, disease pressure was not very high, reaching a maximum of 79% towards crop harvest. No DM symptoms were recorded when QGU 42 was applied and very low disease was recorded on lettuce treated with ALIETTE alone or alternated with RIDOMIL and PRESIDIO. REASON, REVUS, and PHOSTROL provided intermediate control. Downy mildew was high on the untreated check and on plants treated with RANMAN, SERENADE and ACROBAT. However, this does not necessarily mean that the product was ineffective. Due to limitations in the number of applications allowed and pre-harvest intervals on the label, the last applications of ACROBAT occurred on 2 September and REASON, REVUS on 10 September. This left 3-5 weeks between the last application and harvest when the plants may not have been adequately protected and likely resulted in higher disease severity at harvest. In a commercial operation, these products would have been used in a rotation with other fungicides. We chose not to do this in order to determine the efficacy of individual products. In future studies, additional treatments could be added to test the products in a rotation with other fungicides. All treatments resulted in similar lettuce head weights and percent of marketable heads. This suggests that overall, DM symptoms were not severe enough to impact yield.

Table 1. Incidence and disease severity ratings of downy mildew in lettuce, cv. Mighty Joe, treated with various fungicides, grown at the Simcoe Research Station, Simcoe, ON, 2010.

Treatment	Rate (per ha)	DM Incidence (%)			Disease Severity Index[3]		
		15 Sept	23 Sept	30 Sept	15 Sept	23 Sept	30 Sept
Check	--	18.0 ns[1]	71.5 a[2]	86.4 a	6.3 ns	59.6 a	79.2 a
SERENADE	1.5 kg	8.7	36.3 ab	63.1 ab	3.7	38.3 ab	62.5 a
ACROBAT	450 g	2.2	35.3 ab	52.3 abc	1.2	27.5 ab	50.8 ab
RANMAN + AGRAL 90	0.15 L + 0.125%v/v	5.2	32.8 ab	52.5 abc	1.7	28.7 ab	50.8 ab
RIDOMIL	2.5 kg	2.1	6.7 b	17.2 bcd	1.2	6.6 b	12.9 bc
PHOSTROL	2.9 L	0.0	6.5 b	7.6 cd	0.0	6.2 b	7.5 bc
REVUS + AGRAL 90	600 mL + 0.125%v/v	0.0	4.5 b	5.5 cd	0.0	1.7 b	2.9 c
PRESIDIO	280 mL	0.0	3.2 b	7.4 cd	0.0	3.3 b	8.7 bc
REASON	400 mL	0.0	1.1 b	3.3 d	0.0	0.8 b	4.6 bc
RIDOMIL alternated with ALIETTE	2.5 kg 2.8 kg	0.0	1.1 b	3.2 d	0.0	0.8 b	1.2 c
ALIETTE	2.8 kg	0.0	0.0 b	1.1 d	0.0	0.0 b	1.7 c
QGU42	250 mL	0.0	0.0 b	0.0 d	0.0	0.0 b	0.0 c
Msd .05		19.11	53.58	48.40	8.94	50.65	47.75

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

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

[3] $DSI = \frac{[(\text{class no.})(\text{ no.of leaves in each class})]}{(\text{total n0.leaves per sample})(\text{n0.classes}-1)} \times 100$

Table 2. Incidence and severity of downy mildew (DM) on trimmed leaves at harvest of lettuce, cv. Mighty Joe, treated with various fungicides, grown at the Simcoe Research Station, Simcoe, ON 2010.

Treatment	Rate (per ha)	DM incidence (%)	Disease Severity Index[2]
Check	--	57.8 a[1]	49.7 a
RANMAN + AGRAL 90	0.15 L + 0.125%v/v	53.6 ab	43.6 ab
SERENADE	1.5 kg	52.7 ab	43.9 ab
ACROBAT	450 g	47.6 abc	40.6 abc
ALIETTE	2.8 kg	34.0 abcd	30.3 abcd
PHOSTROL	2.9 L	30.5 abcd	26.5 abcd
REVUS + AGRAL 90	600 mL + 0.125%v/v	27.8 abcd	24.8 abcd
REASON	400 mL	24.4 bcd	20.1 bcd
PRESIDIO	280 mL	20.8 cd	18.6 bcd
RIDOMIL alternated with ALIETTE	2.5 kg 2.8 kg	16.8 d	15.0 cd
RIDOMIL	2.5 kg	12.6 d	11.0 d
QGU42	250 mL	11.6 d	10.4 d
Hsd .05		30.44	27.42

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

[2] DSI= $\frac{[(\text{class no.})(\text{ no.of leaves in each class})]}{(\text{total n0.leaves per sample})(\text{n0.classes}-1)}$ x100

Table 3. Yield data for lettuce cv. Mighty Joe, treated with various fungicides for control of downy mildew, grown at the Simcoe Research Station, Simcoe, ON, 2010.

Treatment	Rate (per ha)	% Marketable	Weight per head (g)
PHOSTROL	2.9 L	90.4 ns[1]	575.7 ns
RANMAN +AGRAL 90	0.15 L + 0.125%v/v	89.1	531.7
REASON	400 mL	89.1	530.1
RIDOMIL alternated with ALIETTE	2.5 kg 2.8 kg	88.4	554.2
PRESIDIO	280 mL	86.3	512.5
SERENADE	1.5 kg	83.8	586.0
ACROBAT	450 g	83.7	548.0
RIDOMIL	2.5 kg	82.4	559.9
REVUS + AGRAL 90	600 mL + 0.125%v/v	82.4	494.1
ALIETTE	2.8 kg	81.5	599.5
Check	--	79.1	516.7
QGU42	250 mL	78.3	518.7
Hsd .05		21.65	270.9

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

Appendix B: Lettuce downy mildew spore counts at the Simcoe Research Station, 2010.

Date Evaluated*	**Rod A**	**Rod B**	**Date Evaluated†**	**Rod A**	**Rod B**
August 20, 2010	4	5	September 3, 2010	8	10
August 23, 2010	4	5	September 6, 2010	-	-
August 25, 2010	3	5	September 8, 2010	17	18
August 27, 2010	5	3	September 10, 2010	-	-
August 30, 2010	3	4	September 13, 2010	98	92
September 1, 2010	7	6	September 15, 2010	78	76

*Spore traps were placed in the field and evaluated weekly on Monday, Wednesday and Friday, from 10 AM to 12) noon. Missing evaluation dates were due to rain, plot being sprayed or battery malfunction.

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