Powdery Mildew Control and Resistance Management in Fresh-Market Pumpkins in New Jersey

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An applied research trial screening fungicides for powdery mildew (Erysiphe cichoracearum) control in fresh market pumpkins ('Solid Gold') in New Jersey was conducted at the Rutgers Snyder Research and Extension Farm, Pittstown, NJ during 2013. Our goal was to evaluate which fungicides were most efficacious for the control of powdery mildew, while maintaining optimal marketability, on pumpkin in northern New Jersey. Powdery mildew resistance to commonly used fungicides at weekly applications were also evaluated.

Pumpkins are an important crop in New Jersey agriculture with 31.1 million pounds produced on 2,300 acres at a value of 6.4 million dollars (2010 NASS data http://www.nass.usda.gov). Ensuring that farmers have the best methodology and knowledge of fungicide efficacy necessary to control disease is crucial to keeping pumpkins an economically sustainable crop.

Powdery mildew is a fungal disease that affects a wide variety of crops, including cucurbits. Leaves of pumpkin plants affected by powdery mildew develop lesions on top and bottom leaf surfaces, stems, and handles. As the disease progresses, leaves turn yellow, die and eventually collapse. If the plants defoliate prematurely, yield can be reduced. The loss and weakening of foliage can expose the fruit to sunburn, as well as contribute to deformities and undesirable/diseased handles, which can impact yield and the potential marketability (fruit quality) of the fruit.

A field trial was established utilizing a completely randomized design with ten treatments, four replications. Forty 20ft. x 10ft. plots were planted with 5 plants each spaced 2 feet apart. Hills were hand thinned to one plant per hill. The pumpkin variety 'Solid Gold', from Rupp Seeds, Wauseon, OH, was planted. Seed was pre-treated for cucumber beetle and soil born diseases with a proprietary seed treatment, FarMore®LI400 for Cucurbits from Syngenta, containing Cruiser® FS insecticide, Apron XL®, Maxim®, and Dynasty® fungicides.

On June 20, 2013 the field was prepared with primary tillage using chisel plowing. Triple -15, was broadcast at 675 lbs. per acre based on soil test recom-

Fungicide treatments (Bravo treatments actually were the generic formulation Chloronil 720).

Untreated Control (UTC)
3 pt. Bravo + 6 fl. oz. Quintec alternating with 3 pt. Bravo + 5 oz. Rally
3 pt. Bravo + 18.5 oz. Pristine alternating with 3 pt. Bravo + 5 oz. Rally
16 fl. oz. Fontellis alternating with 6 fl. oz. Quintec
3 pt. Bravo + 16 oz. Cabrio
3 pt. Bravo + 5 oz. Rally
3 pt. Bravo + 6 fl. oz. Quintec
3 pt. Bravo + 5 lbs. Microsulf Sulfur 80W alternating with 3lbs. Manzate Pro-Stick + 5 lbs. Microsulf Sulfur
3 pt. Bravo + 3.4 fl. oz. Torino
3 pt. Bravo + 20 fl. oz. Inspire Super

Photo 1. Fungicide application

protocol calls for treatments to begin when one lesion per fifty leaves is observed. This threshold was reached and treatments were begun on August 2, 2013. Treatments were applied on a weekly basis, for a total of eight applications ending on September 19, 2013 (refer to the fungicide treatment list).

To control downy mildew in the research plots and to prevent competing with powdery mildew, a weekly maintenance fungicide control program was overlaid on the plots. Sprays of 2.75 oz. Presido®/A alternated with 4 oz. Ranman®/A were applied season long beginning July 11 when downy mildew was detected in central NJ. This was earlier than normal; downy mildew treatments in Northern New Jersey typically begin later in August.

mendations and disked into the top 8 inches of soil, followed by roller harrowing to firm the seedbed. The pumpkin seeds were planted on June 21, 2013 utilizing a water wheel trans-planter with no water. Following seeding, the field was treated with 1.3 pints/acre of Dual II Magnum® herbicide applied between rows followed by 6 pints per acre of Strategy™ herbicide broadcast over top of the entire seedbed the same day. The field was irrigated with a traveling gun to apply the equivalent of 0.75 acre-inches of water to activate the herbicide.

Weekly scouting for powdery mildew following Rutgers Pumpkin IPM protocol to determine treatment start date commenced five weeks post-planting. The

Photo 2. Pumpkin trial 6 weeks after planting.

Table 1. Effects of various fungicide treatments on pumpkin fruit size, incidence of decay and bad handles, mildew incidence on leaves, and canopy quality rating, Rutgers Snyder Farm, 2013. All plots were 10 feet by 20 feet. Plants were thinned to a final density of five per plot.

				Mildew rating (1-5) on leaf (26-Sep)		Canopy quality rating (1-5)		
Treatment	Average weight (lbs)	Decay (%)	Bad handles (%)	Top	Bottom	26-Aug	10-Sep	26-Sep
Untreated control	22.1 abc	32 a	24 a	5.0 a	5.0 a	3.1 a	4.5 a	5.0 a
Bravo/Quintec alternating with Bravo/Rally	23.2 abc	3 b	3 b	1.0 c	2.5 d	1.3 b	1.3 c	2.5 e
Bravo/Pristine alternating with Bravo/Rally	18.7 c	0 b	0 b	2.0 bc	3.8 c	1.5 b	2.8 b	4.3 abc
Fontellis alternating with Quintec	21.8 abc	11 ab	0 b	1.0 c	1.8 d	1.5 b	1.5 c	3.5 cd
Bravo/Cabrio	24.4 ab	12 ab	0 b	3.0 b	4.8 ab	1.8 b	4.5 a	5.0 a
Bravo/Rally	22.7 abc	4 b	0 b	1.7 bc	4.0 bc	1.0 b	2.0 bc	4.3 abc
Bravo/Quintec	22.5 abc	0 b	0 b	1.0 c	2.3 d	1.3 b	1.5 c	3.0 de
Bravo/Sulfur alternating with Mancozeb/Sulfur	22.7 abc	6 b	0 b	3.0 b	4.3 abc	1.0 b	2.3 bc	4.8 ab
Bravo/Torino	21.3 bc	3 b	0 b	1.8 bc	4.5 abc	1.0 b	1.3 c	4.0 bc
Bravo/Inspire Super	26.7 a	0 b	4 b	2.8 bc	4.5 abc	1.5 b	2.8 b	5.0 a

*Mean within a column not followed by a common letter are significantly different at odds of 19 to 1 (Duncan's New Multiple Range Test, $P = 0.05$).

Table 2. Effects of various fungicide treatments on pumpkin yield (total, marketable, green, and potential marketable), Rutgers Snyder Farm, 2013. Sound green fruit likely would develop orange color, so potential marketable yield was calculated as the marketable yield plus the green yield. All yield data represent harvests from five plants in a 20 square-foot plot.

	Total yield		Marketable yield		Green yield		Potential marketable yield	
Treatment	Number	Pounds	Pounds	Percent	Pounds	Percent	Pounds	Percent
Untreated control	6.5 ab	146 abc	59 c	44 b	0 c	0 b	59 c	73 b
Bravo/Quintec alternating with Bravo/Rally	8.3 a	193 a	134 ab	73 a	49 a	22 a	182 a	95 a
Bravo/Pristine alternating with Bravo/Rally	7.5 ab	135 bc	125 ab	93 a	10 bc	7 ab	134 ab	100 a
Fontellis alternating with Quintec	8.3 a	177 abc	132 ab	75 a	26 abc	14 ab	158 ab	89 a
Bravo/Cabrio	5.5 b	132 c	114 b	88 a	0 c	0 b	114 b	88 a
Bravo/Rally	8.0 a	181 abc	158 a	88 a	16 abc	8 ab	174 a	96 a
Bravo/Quintec	7.0 ab	155 abc	130 ab	85 a	25 abc	15 ab	155 ab	100 a
Bravo/Sulfur alternating with Mancozeb/Sulfur	7.3 ab	165 abc	137 ab	85 a	17 abc	9 ab	153 ab	95 a
Bravo/Torino	8.8 a	186 ab	143 ab	79 a	37 ab	19 a	180 a	98 a
Bravo/Inspire Super	5.3 b	138 bc	124 ab	90 a	9 bc	6 ab	133 ab	96 a

*Mean within a column not followed by a common letter are significantly different at odds of 19 to 1 (Duncan's New Multiple Range Test, $P = 0.05$).

Photo 3. Untreated control.

Photo 5. Fontellis plus Quintec.

Photo 4. Chloronil 720 plus Quintec alternating with Chloronil 720 plus Rally (standard NJ treatment).

Photo 6. Chloronil 720 plus Quintec.

Treatments were applied using a PTO driven Hardy Sprayer utilizing a diaphragm pump and spray boom mounted on an International Harvester Super A tractor. A fixed boom mounted with with 8003XR flat fan nozzles with #50 stainless steel (comp 304) mesh screens in with plastic nozzle bodies. Nozzles were mounted at 18" spacing. All treatments were applied at 70 PSI traveling at 2.5 mph applying 49 GPA.

Treatment plots were rated for powdery mildew and canopy cover, Figure 1. Canopy was subjectively

Photo 7. Chloronil 720 plus Torino.

rated on a 1-5 scale. Rating dates were August 26, September 10 and September 26. Fruit was harvested on September 27. Data collected at harvest included marketable fruit weight, green fruit weight (less than 50% orange =unmarketable), number of decayed fruit (unmarketable), and % fruit with good handles, Table 1.

Because some treatments resulted in delayed harvest (green fruit) we coined the term, "Potential Marketable Yield" (Table 2). Commercial growers typically wait until the leaves deteriorated and all fruit orange before fruit is harvested. Sound green fruit likely would develop orange color, so potential marketable yield was calculated as the marketable yield plus the green yield. (Figure 3)

Highest Potential Marketable Yield was Treatment 2 -Bravo®/Quintec® alternated with Bravo/Rally® 182 lbs per plot followed by Bravo/Torino™ at 180 lbs./plot and Bravo/Rally® at 174 lbs./plot (Table 2). Lowest Potential Marketable Yield was the Untreated control at 59 lbs./ plot followed by Bravo/Cabrio® at 114 lbs./ plot, Bravo/Super Inspire® at 133 lbs./plot and Bravo/ Pristine® at 134 lbs./plot.

In analyzing the data, a relationship between canopy and weight of green fruit was observed; the lower the canopy rating (more green leaves), the higher the weight of green fruit (Figure 3), meaning maturity was delayed. The results show that the best fungicide treatments kept the canopy greener longer, fruit greener and thus delayed maturity. Our criteria for harvest was 50 or more of the fruit had to be solid orange

Treatment 2, Bravo/Quintec alt. Bravo/Rally, had the highest quality canopy rating of powdery mildew

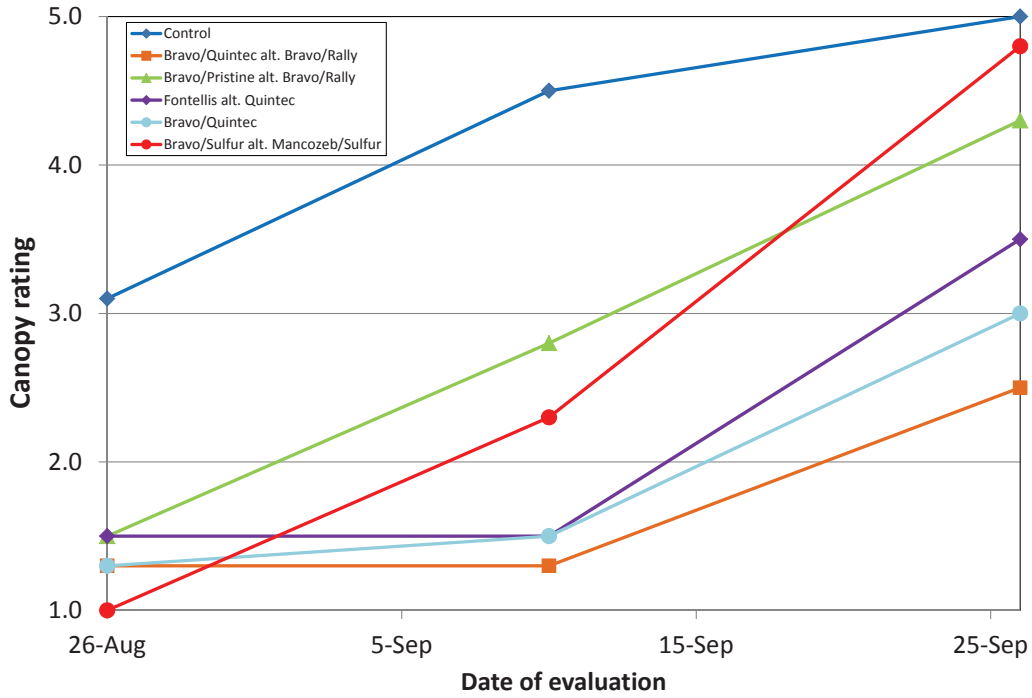

Figure 1. Canopy ratings of plants treated with various fungicide programs in 2013 at the Rutgers Snyder Farm. Ratings: 1=0-20%, 2=21-40%, 3=41-60%, 4=61-80%, and 5=81-100% of the canopy missing due to powdery mildew.

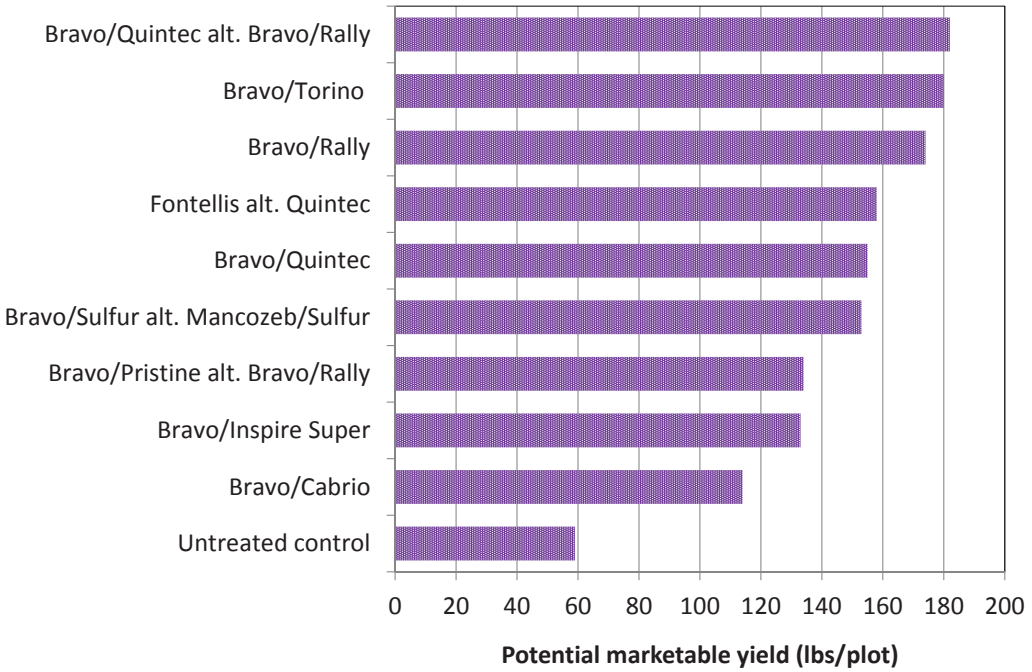

Figure 2. Per-plot yields of pumpkin plants treated with various fungicide programs in 2013 at the Rutgers Snyder Farm. Each plot was 10x20 feet and included five plants.

through harvest at 2.5 (Table 1, Figure 1-lower numbers are better), followed by Bravo/Quintec at 3.0 and Fontelis® alternated with Quintec at 3.5. Poorest canopy quality was Untreated Control at 5, Bravo/Cabrio at 5 and Bravo/ Inspire Super (5=no canopy left).

Powdery Mildew was rated at three different times, approximately two weeks apart at the end of the season. Both tops and bottoms of the leaves were rated separately. Powdery Mildew exhibits initial symptoms on the leaf bottoms, as the spray from flat fan nozzles spraying down from a boom does not give as good coverage on the bottom leaf surface. The best Powdery Mildew control on the leaf bottoms on 26-September was Fontelis® alternating with Quintec® at 1.8, Bravo/Quintec at 2.3, Bravo/Quintec alternated with Bravo/Rally at 2.5 (Table 1 - lower numbers better). The poorest Powdery Mildew control on the leaf bottoms on 26 September was Untreated Control at 5, Bravo/Cabrio at 4.8, Bravo/Torino at 4.5 and Bravo/Inspire Super at 4.5 (Table 1).

All treatments significantly improved handle quality compared to the untreated control (Table 1). The

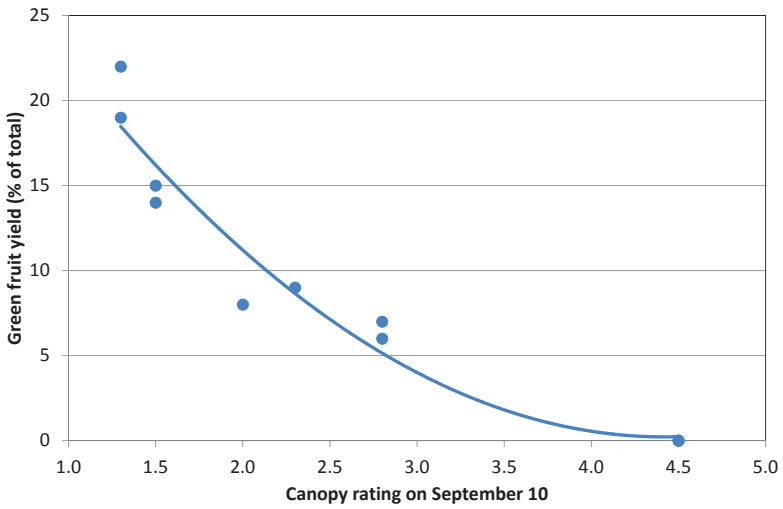

Figure 3. The relationship between canopy (rating on September 10) and the percent green fruit. A rating of 1 means that only 0-10% of the canopy is missing due to powdery mildew; whereas, a rating of 5 means that 80-100% is missing.

highest incidence of decay among treated plots were seen in Treatments 4 and 5, Fontelis alternating with Quintec and Bravo/Cabrio with 11% and 12% incidence decay, respectively, compared to 32% with the untreated control. Decay appeared to be caused by phytophora, and would not be impacted with the fungicides in this trial

Conclusions

Powdery mildew can be effectively controlled throughout growing season with weekly applied fungicides once the powdery mildew threshold is met.

Maintaining good canopy cover with green foliage allows the fruit to fully mature with healthy handles and increase in size for greater marketable yield.
Maintaining healthy foliage full season allows farmers to maximize yield.

The highest Potential Marketable Yields were from plots treated with Bravo®/Quintec® alternated with Bravo®/Rally®, followed by the treatment Bravo®/Torino™, then Bravo®/Rally®

Cabrio®, Pristine® and Inspire Super™ all show resistance to Powdery Mildew and should not be used to control Powdery Mildew. Rally® is also showing signs of resistance buildup and should be only used in combination and rotated weekly.

Grower Recommendations for New Jersey and New England

- Once the powdery mildew threshold is met (when one powdery mildew lesion per fifty leaves) begin weekly fungicide sprays.
- Consider rotating your systemic fungicides with each weekly application.
- Consider using a rotation of systemic fungicides from 3-4 different FRAC groups, never apply the same one two times in a row, always combine with a protectant fungicide.
- Always use one of the protectant fungicides Bravo®, Mancozeb, Copper for resistance management combined with the weekly systemic.
- Maintain fungicide sprays to keep the canopy foliage healthy until the majority of fruit is mature
- Remove the fruit promptly from the field when mature to avoid phytophora infection of the fruit.

Pumpkin harvest at Rutgers Snyder Farm, Pittstown, NJ.

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