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## **IR-4 Ornamental Horticulture Program Rust Efficacy: A Literature Review**

*Cronartium ribicola*  
*Gymnosporangium clavipes*  
*Gymnosporangium juniperi-virginianae*  
*Gymnosporangium libocedri*  
*Phragmidium* sp.  
*Puccinia arachidis*  
*Puccinia emaculata*  
*Puccinia hemerocallidis*  
*Puccinia malvacearum*  
*Puccinia veronicae-longifoliae*  
*Uromyces apendiculatus*

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## Abstract

From 2000 to 2011, numerous products representing 30 active ingredients were tested as foliar applications against several genera and species of pathogens causing rust on ornamentals and food crops (Tables 1 and 2). These genera/species tested included: *Cronartium ribicola*, *Gymnosporangium libocedri*, *G. clavipes*, *G. juniperi-virginiana*, *Phragmidium* sp., *Puccinia hemerocallidis*, *P. pelargonii-zonalis*, *P. malvacearum*, *P. emaculata*, *P. veronica-longifoliae*, *P. arachidis* and *Uromyces appendiculatus*. Although there were insufficient data for definitive conclusions, new products like SP2169, Tourney (metconazole), LEM-17 (penthioapyrad) and Topguard (flutriafol) - looked promising. The products registered on ornamentals - Banner (propiconazole), Compass O (trifloxystrobin), Eagle (mycobutanil), Heritage (azoxystrobin), Insignia (pyraclostrobin), Pageant (boscalid+pyraclostrobin), Prostar (flutolanil) and Trinity (triticonazole) - generally performed well. Tank-mix combinations with mancozeb generally improved rust control.

## Introduction

In 2010, IR-4 initiated a high priority project to determine efficacy of several fungicides on pathogens causing rust to obtain data supporting current and future registrations. There are many different species causing rust diseases on ornamentals and an extensive project may be required to generate sufficient efficacy data. We reviewed available ornamental and food crops trials published in Fungicide & Nematicide Tests and Plant Disease Management Reports to check efficacy of experimental and registered fungicides on species causing rust diseases. This report is a brief summary of available data from 11 ornamental and 30 food crops trials conducted from 2000 to 2011. The source of report is included under each data table. Three trials from the IR-4 project are included in this report. Additional data will be added when received from researchers.

## Materials and Methods

From 2000 to 2011, numerous products representing 30 active ingredients were tested as foliar applications against several genera and species of pathogens causing rust on ornamentals and vegetables (Table 1 and Table 2). These genera/species tested included: *Cronartium ribicola*, *Gymnosporangium libocedri*, *G. clavipes*, *G. juniperi-virginianae*, *Phragmidium* sp., *Puccinia hemerocallidis*, *P. pelargonii-zonalis*, *P. malvacearum*, *P. emaculata*, *P. veronica-longifoliae*, *P. arachidis*, and *Uromyces apendiculatus*. Treatments were generally applied as preventative sprays. Researchers used a minimum of four replications. Disease severity and incidence were recorded at various intervals after initial application. Phytotoxicity or lack of it was generally noted in the reports. Fifteen researchers were involved in the testing (Appendix 1).

Products were supplied by their respective manufacturers.

For IR-4 testing, the following protocols were used: 10-026 and 11-013. Please visit <http://ir4.rutgers.edu/ornamental/OrnamentalDrafts.cfm> to view and download these protocols.

**Table 1. List of Products and Rates Tested on Ornamental Plants from 2001 to 2011.**

Active Ingredient(s)	Ornamental Horticulture		Trade Name for Food Use	Rate(s) Tested	# Trials
	Trade Name(s)	Manufacturer(s)			
Acibenzolar	n/a	Syngenta	Actigard	0.25 oz per 100 gal 0.75 oz per 100 gal	2
Azoxystrobin	Heritage	Syngenta	Abound, Amistar, Quadris	4 oz per acre 2 oz per 100 gal 4 oz per 100 gal	5
<i>Bacillus subtilis</i>	Rhapsody	AgraQuest	Serenade	2 oz per 100 gal	1
Boscalid+Pyraclostrobin	Pageant	BASF	BAS 516, Pristine	6 oz per 100 gal 12 oz per 100 gal 18.5 oz per 100 gal	3
Captan	Captan	Arysta, Drexel, etc.	Captan	1 lb per 100 gal	1
Chlorothalonil	Daconil	Syngenta,	Bravo	1.4 lb per acre 1.4 lb per 100 gal 30 fl oz per 100 gal	3
Copper Hydroxide	CuPro, Champ DF, Nu-Cop	SePro, NuFarm, MicroFlo	Kocide	0.75 lb per 100 gal	1
Fenarimol	Rubigan	Gowan	Rubigan	4 fl oz per 100 gal	1
Fludioxonil+mefenoxam	Hurricane	Syngenta	Apron Maxx	1.5 oz per 100 gal	1
Flutolanil	ProStar	Bayer	Contrast, Convoy	6 oz per 100 gal 8 fl oz per acre	3
Mancozeb	Dithane, Manzate, Protect	Cleary, Dow, UPI	Dithane, Manzate	2 lb per 100 gal	1
Metconazole	Tourney	Valent	Caramba	2 oz per 100 gal	3
Myclobutanil	Eagle	Dow	Nova, Rally	12 fl oz per acre 8 oz per 100 gal 100 fl oz per 100 gal	7
Propiconazole	Banner Maxx	Syngenta	Tilt	8 fl oz per acre 8 fl oz per 100 gal 40 fl oz per 100 gal 100 fl oz per 100 gal	7
Pyraclostrobin	Insignia, BAS 500	BASF	Cabrio, Headline	2 oz per 100 gal 8 oz per 100 gal	4
SP2169	SP2169	SePro		12.3 fl oz per 100 gal 24.6 fl oz per 100 gal	1
Tebuconazole	Torque	Cleary	Elite, Folicur	0.75 fl oz per gal	1

Thiophanate-methyl	3336, 6664	Cleary, OHP	Topsin	16 oz per 100 gal 20 fl oz per 100 gal	2
Triadimefon	Bayleton, Strike	Bayer, OHP	Bayleton	2 oz per acre 2 oz per 100 gal 3 oz per 100 gal 5.5 oz per 100 gal	5
Trifloxystrobin	Compass	OHP	Flint	4 oz per acre 1 oz per 100 gal 2 oz per 100 gal 4 oz per 100 gal	5
Triflumizole	Terraguard	Chemtura	Procure	8 oz per acre 8 oz per 100 gal	2
Triticonazole	Trinity	BASF, Bayer	Charter	1 fl oz per 100 gal 2 fl oz per 100 gal 4 fl oz per 100 gal 6.4 fl oz per 100 gal	5

**Table 2. List of Products and Rates Tested on Food Crops from 2000 to 2011.**

Active Ingredient(s)	Trade Name(s)	Ornamental Horticulture		Rate(s) Tested	# Trials
	Food Use	Trade Name(s)	Manufacturer(s)		
Azoxystrobin	Abound, Amistar, Quadris	Heritage	Syngenta	2, 3 and 4 oz per acre 6.1 fl oz per acre	5
<i>Bacillus subtilis</i>	Serenade	Rhapsody	AgraQuest	2 and 8 lb per acre	3
BAS 639	BAS 639		BASF	4.08, 5.7 and 9.14 fl oz per acre	1
BAS 9150	BAS 9150		BASF	2.74 and 7 fl oz per zcre	1
Boscalid+Pyraclostrobin	BAS 516, Pristine	Pageant	BASF	0.35 and 0.9 lb per acre	4
Chlorothalonil	Bravo	Daconil	Syngenta	1.5 and 3 pt per acre 1.3, 2 and 2.6 lb per acre	5
Citrex	Citrex	Citrex	Citrex	30 fl oz per acre	1
Copper Hydroxide	Kocide	CuPro, Champ DF, Nu-Cop	SePro, NuFarm, MicroFlo	7.5 lb per acre	2
Fenarimol	Rubigan	Rubigan	Gowan	2.25 and 3 fl oz per 100 gal	2
Fenbuconazole	Indar, Enable	n/a	n/a	2 oz per acre	9
Fluoxastrobin	Evito	Disarm	Arysta	3.5 fl oz per 100 gal	1
Flutolanil	Contrast, Convoy	ProStar	Bayer	8 fl oz per acre	1
Flutriafol	Topguard	n/a	n/a	3.5, 7, 10, 13 and 26 fl oz per acre 3.3 fl oz per 100 gal	5
Mancozeb	Dithane, Manzate	Dithane	Dow	1, 3 and 4 lb per acre	16



	Penncozeb			0.75 and 1 lb per 100 gal	
Myclobutanil	Nova, Rally	Eagle, Immunox	Dow	2.5, 4 and 5 oz per acre 0.6, 1, 1.5 1.7 and 2 oz per 100 gal	24
Penthiopyrad	Fontelis, LEM-17	n/a	n/a	3.5 and 5 fl oz per acre 14.4, 20.6 and 30.7 fl oz per acre 4.8, 6.6 and 6.9 fl oz per 100 gal	5
Potassium Phosphite	Prophyt	Vital	Helena, Phoenix	4 pt per acre	2
Propiconazole	Tilt	Banner	Syngenta	4 fl oz per acre	2
Prothioconazole	Proline, Provost	n/a	n/a	8 fl oz per 100 gal	1
Pyraclostrobin	Cabrio, Headline, BAS 500	Insignia, BAS 500	BASF	0.875 lb per acre 0.25 lb per 100 gal	8
Trifloxystrobin	Flint	Compass	Bayer	0.5 and 2 oz per acre 0.5 and 0.67 oz per 100 gal	14

## Results

### Comparative Efficacy on *Cronartium ribicola*

From 2003 through 2007, Turechek, et al with Cornell University conducted six experiments to determine efficacy on *Cronartium ribicola* (white pine blister rust) on black currant (2 trials) currant (2) and gooseberry (2). All products were applied as dilute spray to drip. Results of black currant trials showed the demethylation inhibitor (DMI) products Indar and Nova, Kocide, and the strobilurins Cabrio and Heritage providing the best control (Table 3 and Table 4). The organic products Citrex and Serenade provided significant, but inferior, disease reduction. Similarly, data from trials on black and red currants in 2005 and 2007 showed the DMI products Indar and Nova providing excellent control of white pine blister rust (Table 5, Table 6 and Table 7). Cabrio alternated with Nova also provided excellent control. ProPhyt and Serenade provided significant, but inferior, disease reduction; alternating either product with Nova provided much improved disease control. Gooseberry trials in 2005 and 2007 (Table 8 and Table 9) further confirmed the results of the black and red currant trials. No phytotoxicity was observed from any treatment.

**Table 3. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Black Currant (*Ribes nigrum*) ‘Ben Alder’, Turechek, NY, 2003.**

Treatment	Rate Per Acre	% Disease Incidence <sup>x</sup>	
		31 Jul	11 Sep
Amistar (azoxystrobin)	3 oz	47.1 bc	100.0 d
Cabrio (pyraclostrobin)	0.875 lb	52.2 cd	99.0 cd
Cabrio + Nova	0.875 lb + oz	36.7 abc	41.9 ab
Dithane (mancozeb)	4 lb	40.3 abc	98.9 cd
Kocide (copper hydroxide)	7.5 lb	28.6 ab	98.8 cd
Kocide + Nova	7.5 lb + 5 oz	28.3 ab	45.4 ab
Indar (fenbuconazole)	2 oz	21.3 a	77.5 bcd
Nova (myclobutanil)	5 oz	28.8 ab	27.4 a
Untreated	-	91.6 f	83.8 cd

\* Not an IR-4 Experiment: F&N Tests Vol 59:SMF032. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05). Application timings were as follows: 21 May, 13, 18 Jun, and 1, 14, 27 Aug.

**Table 4. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Black Currant (*Ribes nigrum*) ‘Ben Alder’, Turechek, NY, 2004.**

Treatment	Rate Per Acre	% Disease Incidence <sup>x</sup>		% Defoliation
		31 Jul	11 Sep	11 Sep
Cabrio (pyraclostrobin)	14 oz	8.33 ab	96.8 bc	11.8 abc
Citrex (citrex)	30 fl oz	26.50 cd	100.0 c	85.0 de
Dithane (mancozeb)	4 lb	0.00 a	100.0 c	6.3 abc
Indar (fenbuconazole)	2 oz	0.00 a	80.0 a	0.0 a
Kocide (copper hydroxide)	7.5 lb	1.19 a	100.0 c	3.3 ab
Kocide alt. Nova	7.5 lb alt 5 oz	0.00 a	100.0 c	13.5 abc
Nova (myclobutanil)	5 oz	1.25 a	83.5 ab	0.0 a
Serenade ( <i>Bacillus subtilis</i> )	8 lb	19.44 bc	91.8 abc	71.3 c
Untreated	-	73.78 f	100.0 c	100.0 e

\* Not an IR-4 Experiment: F&N Tests Vol 60:SMF020. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

**Table 5. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Black Currant (*Ribes nigrum*) ‘Ben Alder’, Heidenreich, NY, 2005.**

Treatment	Rate Per Acre	Timing <sup>y</sup>	%Disease Incidence <sup>x</sup>		% Necrosis	% Defoliation
			14 Jul	13 Sep	13 Sep	13 Sep
Cabrio (pyraclostrobin) alt. Nova	14 oz alt. 5 oz	1	0.00 a	2.74 a	0.14 a	0.00 a
Indar (fenbuconazole)	2 oz	1	0.00 a	5.95 a	0.01 a	0.14 a
Indar (fenbuconazole)	2 oz	2	0.00 a	4.59 a	0.86 a	0.00 a
Nova (myclobutanil)	5 oz	1	0.00 a	0.60 a	0.00 a	0.00 a
Nova (myclobutanil)	5 oz	2	0.00 a	4.38 a	2.00 a	0.00 a
Nova alt. Cabrio	5 oz alt. 0.875 lb	1	0.00 a	1.91 a	0.00 a	0.00 a
Untreated	-	-	49.60 b	69.72 d	81.29 b	76.43 b

\* Not an IR-4 Experiment: F&N Tests Vol 61:SMF022. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

<sup>y</sup> Timings: Program 1= 14-day intervals: 19 May, 2, 16, 30 Jun; 14, 28 Jul; and 11, 25 Aug.

Program 2= 21-day intervals: 26 May; 9, 30 Jun; 21 Jul; and 4, 25 Aug.

**Table 6. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Red Currant (*Ribes rubrum*) ‘Red Lake’, Heidenreich, NY, 2005.**

Treatment	Rate Per Acre	Timing <sup>y</sup>	% Disease Incidence <sup>x</sup>		% Necrosis	% Defoliation
			14 Jul	13 Sep	13 Sep	13 Sep
Cabrio (pyraclostrobin) alt. Nova	14 oz alt. 5 oz	1	0.00 a	0.00 a	0.01 a	0.00 a
Indar (fenbuconazole)	2 oz	1	0.17 a	0.00 a	0.00 a	0.14 a
Indar (fenbuconazole)	2 oz	2	0.00 a	0.00 a	0.00 a	0.00 a
Nova (myclobutanil)	5 oz	1	0.00 a	0.00 a	0.67 a	0.00 a
Nova (myclobutanil)	5 oz	2	0.00 a	0.00 a	0.44 a	0.00 a
Nova alt. Cabrio	5 oz alt. 14 oz	1	0.00 a	0.00 a	0.00 a	0.00 a
Untreated	-	-	3.80 b	66.67 b	28.29 b	11.43 b

\* Not an IR-4 Experiment: F&N Tests Vol 61:SMF022. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

<sup>y</sup> Timings: Program 1= 14-day intervals: 19 May, 2, 16, 30 Jun; 14, 28 Jul; and 11, 25 Aug.

Program 2= 21-day intervals: 26 May; 9, 30 Jun; 21 Jul; and 4, 25 Aug.

**Table 7. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Black Currant (*Ribes nigrum*) ‘Ben Alder’ and Red Currant (*Ribes rubrum*) ‘Red Lake’, Cox, NY, 2007.**

Treatment	Rate Per Acre	% Disease Incidence <sup>x</sup> 29 Aug	
		Black Currant	Red Currant
Nova alt. Cabrio	5 oz alt. 14 oz	1.3 ± 0.5 e	5.0 ± 1.7 h
ProPhyt (potassium phosphite)	4 pt	6.7 ± 0.9 bc	28.3 ± 7.2 e
ProPhyt alt. Nova	4 pt alt 5 oz	1.7 ± 0.3 e	14.0 ± 3.5 gh
Serenade ( <i>Bacillus subtilis</i> ) + Biotune	2 lb	5.2 ± 0.6 bcd	29.5 ± 13.1 de
Serenade + Biotune alt. Nova	2 lb alt 5 oz	2.3 ± 0.4 de	13.4 ± 4.1 fg
Untreated	-	20.8 ± 1.3 a	80.0 ± 14.5 a

\* Not an IR-4 Experiment: PDM Reports Vol 2:STF033. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

Applications were started on 1 May (10% bloom) and continued at 14-day intervals until green berry for a total of 8 applications.

**Table 8. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Gooseberry (*Ribes grossularia*) ‘Achilles’, Heidenreich, NY, 2005.**

Treatment	Rate Per Acre	Timing <sup>y</sup>	% Disease Incidence <sup>x</sup>
			13 Sep
Cabrio (pyraclostrobin) alt. Nova	14 oz alt. 5 oz	1	1.98 b
Indar (fenbuconazole)	2 oz	1	0.00 b
Indar (fenbuconazole)	2 oz	2	0.00 b
Nova (myclobutanil)	5 oz	1	0.00 b
Nova (myclobutanil)	5 oz	2	0.00 b
Nova alt. Cabrio	5 oz alt. 14 oz	1	0.00 b
Untreated	-	-	28.57 a

\* Not an IR-4 Experiment: F&N Tests Vol 61:SMF021. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

<sup>y</sup> Timings: Program 1= 14-day intervals: 19 May, 2, 16, 30 Jun; 14, 28 Jul; and 11, 25 Aug.

Program 2= 21-day intervals: 26 May; 9, 30 Jun; 21 Jul; and 4, 25 Aug.

**Table 9. \* Efficacy on White Pine Blister Rust (*Cronartium ribicola*) on Gooseberry (*Ribes grossularia*) ‘Achilles’, Cox, NY, 2007.**

Treatment	Rate Per Acre	% Disease Incidence <sup>x</sup>
		29 Aug
Nova alt. Cabrio	5 oz alt. 14 oz	2.3 ± 0.9 e
ProPhyt (potassium phosphite)	4 pt	11.7 ± 1.1 bc
ProPhyt alt. Nova	4 pt alt 5 oz	4.6 ± 0.4 ef
Serenade ( <i>Bacillus</i> ) + Biotune	2 lb	11.9 ± 1.2 bc
Serenade + Biotune alt. Nova	2 lb alt 5 oz	5.6 ± 0.6 def
Untreated	-	30.8 ± 1.7 a

\* Not an IR-4 Experiment: PDM Reports Vol 2:STF034. Not all products tested included in table.

<sup>x</sup> Means within a column not followed by a common letter are significantly different (Fisher’s Protected LSD, P=0.05).

Applications were started on 1 May (10% bloom) and continued at 14-day intervals until green berry for a total of 8 applications.

### **Comparative Efficacy on *Gymnosporangium* spp.**

In 2006 and 2010, Pscheidt conducted experiments examining various products applied as spray for the control of Pacific Coast pear rust; (*Gymnosporangium libocedri*) on serviceberry (*Amelanchier canadensis*). Treatments were applied every 2 weeks from 22 March to 2 May in 2006; in 2010, treatments were applied every 2 or 3 weeks from 13 March to 13 May. In 2006, fungicide-treated trees had significantly less rust on leaves and fruit than nontreated trees (Table 10). Banner MAXX, Compass, Eagle, Heritage, and Terraguard provided excellent control; Bravo and Strike were inferior. In 2010, all treatments, except Contrast, significantly reduced a high disease pressure (Table 11). Compass and Eagle were the best treatments. No phytotoxicity was observed from any treatment.

**Table 10. \* Efficacy on Pacific Coast Pear Rust; (*Gymnosporangium libocedri*) on Serviceberry (*Amelanchier canadensis*), Pscheidt, OR, 2006.**

Treatment	Rate Per Acre	% Leaves With Rust <sup>x</sup>		% Fruits With Rust
		15 May	20 Jul	16 May
Banner (propiconazole)	8 fl oz	0.00 c	41.2 a	0.00 c
Bravo (chlorothalonil)	22.4 oz	11.2 b	25.7 a	11.8 b
Compass (trifloxystrobin)	4 oz	0.7 c	34.8 a	0.7 c
Eagle (myclobutanil)	12 fl oz	0.8 c	33.0 a	0.0 c
Eagle alt. Compass	12 fl oz alt. 4 oz	0.8 c	25.8 a	0.5 c
Heritage (azoxystrobin)	4 oz	0.2 c	33.2 a	0.3 c
Strike (triadimefon)	2 oz	11.5 b	34.8 a	9.0 bc
Terraguard (triflumizole)	8 oz	0.7 c	37.2 a	0.0 c
Untreated	-	58.8 a	---**	78.5 a

\* Not an IR-4 Experiment: PDM Reports Vol 1:PF042. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

\*\* Shoots from nontreated trees were not examined as trees were in poor shape due to winter injury and high rust pressure.

**Table 11. Efficacy on Pacific Coast Pear Rust; (*Gymnosporangium libocedri*) on Serviceberry (*Amelanchier canadensis*), Pscheidt, OR, 2010.**

Treatment	Rate Per 100 Gal	Time of Application <sup>y</sup>	% Leaves With Rust <sup>x</sup> 25 May	Whole Canopy Rating (0-5) <sup>z</sup> 16 Jun
Banner (propiconazole)	8 fl oz	A, C, E and G	8.3 bc	1.0 b
Banner alt. Compass (trifloxystrobin)	8 fl oz 4 oz	A, D alt. B, F	20.5 bc	1.5 b
Cabrio (pyraclostrobin)	8 oz	A, B, D and F	37.8 b	1.5 b
Compass	4 oz	A, B, D and F	5.0 c	1.1 b
Contrast (flutolanil)	6 oz	A, C, E and G	74.3 a	3.4 a
Eagle (myclobutanil)	12 fl oz	A, B, D and F	1.3 c	1.0 b
Pristine (boscalid+pyraclostrobin)	12 oz	A, B, D and F	37.0 b	1.9 b
Tourney (metconazole)	2 oz	A, C, E and G	12.0 bc	1.1 b
Untreated	-	-	89.0 a	3.9 a

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

<sup>y</sup> Treatment were applied on A = 13 Mar (floral bud break), B = 24 Mar (60% bloom), C = 31 Mar (full bloom), D = 7 Apr (petal fall), E = 21 Apr, F = 6 May and G = 13 May.

<sup>z</sup> Whole tree canopy rating: 0 = full, healthy canopy, 1 = less than 5% rust, 2 = rust easily seen on many leaves, 3 = severe rust, shoot deformation and slight defoliation, 4 = 50 to 90% foliage lost to rust with severe shoot deformation, and 5 = dead

From 2002 to 2011, several trials on apples (*Malus domestica*) were conducted by Rosenberger in New York, Yoder in Virginia and Sutton in North Carolina to determine efficacy on cedar apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*). Fungicides were usually tested in tank-mixes or spray programs with other fungicides to test efficacy on different apple diseases. Treatments targeted for rusts were applied early in the season generally from tight cluster to third cover spray timings.

From 2002 to 2010, Rosenberger conducted eight trials in New York. A 2002 trial showed BAS 500, BAS 516, Dithane, Flint alt. Nova + Dithane and Nova + Dithane providing good control both of cedar-apple and quince rusts (Table 12). In a 2003 trial, Pristine controlled rust diseases as well as the DMI fungicides Nova and Rubigan (Table 13). In a 2005 trial, the strobilurin Flint and the DMI fungicides Nova and Flutriafol provided excellent control of cedar-apple rust (Table 14). Two trials in 2006 showed the DMI products Enable and Nova, and a new product LEM-17 providing excellent control of rusts (Table 15 and Table 16). Flint was slightly inferior. In 2007, Indar and Nova again provided good control of both rusts; Flint was inferior (Table 17). Results of a 2008 trial showed Flint, Indar and Manzate providing effective control of both rusts (Table 18). In a 2010 trial where most of the rust recorded on 29 Jun may have resulted from infections that occurred after the last application of the test fungicides, Fontelis and the Rally/Dithane program provided excellent control (Table 19). All treatments provided excellent control of quince rust. No phytotoxicity was observed from any treatment.

From 2002 to 2011, Yoder conducted eight trials in Virginia. A 2003 trial showed the DMI's Nova and Rubigan, and the strobilurins Flint and Pristine providing excellent control of both cedar-apple and quince rusts (Table 20). In a 2006 trial, Enable and Flint provided effective control of both rusts, while LEM-17 and Manzate were generally weaker on cedar-apple rust (Table 21). In 2007, Flint, Nova and a new DMI Topguard provided excellent control of cedar-apple rust (Table 22). Similarly, a new DMI Topguard and the standard Rally + Dithane provided excellent control of cedar-apple and quince rusts in 2008 (Table 23). In 2010 and 2011 trials, Rally + Penncozeb looked superior to Flint (Table 24 - Table 27). No phytotoxicity was observed from any treatment.

Sutton conducted a trial in 2010 to determine the efficacy of Flint, Pristine, BAS 639, BAS 9150 and Topguard + Captan for cedar apple rust (*Gymnosporangium juniperi-virginianae*) and other apple diseases (Table 28). All products provided excellent control of a light rust pressure. No phytotoxicity was observed from any treatment.

**Table 12. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2002.**

Treatment	Rate Per 100 Gal	% Golden Delicious with Cedar Apple Rust <sup>x</sup>		% Fruit with Quince Rust	
		Terminal Leaves 16 Jul	Fruit 26 Sep	Jersey Mac 22 Jul	Redcort 5 Sep
BAS 500 (pyraclostrobin)	0.25 lb	13.7 ab	0.2 a	1.5 ab	0.0 a
BAS 516 (boscalid + pyraclostrobin)	0.35 lb	15.6 b	1.9 bc	1.9 b	0.6 a
Dithane (mancozeb)	1 lb	12.8 ab	1.0 ab	0.3 ab	0.0 a
Flint (trifloxystrobin) alt. Nova + Dithane	0.67 alt. 1.5 oz + 1 lb	11.4 ab	1.0 ab	0.0 a	0.7 a
Nova (myclobutanil) + Dithane	1.5 oz + 1 lb	10.4 a	1.0 ab	0.0 a	0.0 a
Untreated	-	70.7 e	7.3 d	47.2 c	10.4 b

\* Not an IR-4 Experiment: F&N Tests Vol 58:PF019. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 13. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2003.**

Treatment	Rate Per 100 Gal	% Golden Delicious with Cedar Apple Rust <sup>x</sup>	% Fruit with Quince Rust	
		Terminal Leaves 30 Jun	Jersey Mac 16 Jun	Golden Delicious 24 Sep
Dithane (mancozeb)	1 lb	3.2 bc	0.4 ab	6.5 b
Dithane + Nova (myclobutanil)	1 lb + 1.5 oz	0.0 a	0.0 a	0.5 ab
Dithane + Rubigan (fenarimol)	1 lb + 3 fl oz	0.7 ab	0.0 a	0.0 a
Pristine (boscalid + pyraclostrobin)	4.8 oz	1.0 ab	0.8 ab	1.5 ab
Untreated	-	32.1 e	11.0 e	15.7 c

\* Not an IR-4 Experiment: F&N Tests Vol 59:PF017. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 14. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), 'Golden Delicious', Rosenberger, NY, 2005.**

Treatment	Rate Per 100 Gal	% Cedar Apple Rust <sup>x</sup>		
		Cluster Leaves 13 Jun	Fruitlet Stems 13 Jun	Terminal Leaves 28 Jul
Dithane (mancozeb)	1 lb	0.7 a	0.0 a	11.8 ab
Dithane + Flutriafol (flutriafol)	1 lb + 3.3 fl oz	0.0 a	0.0 a	3.6 a
Flint (trifloxystrobin)	0.67 oz	0.7 a	0.0 a	5.7 ab
Flutriafol	3.3 fl oz	0.0 a	0.0 a	10.2 ab
Nova (myclobutanil)	1.5 oz	0.0 a	0.0 a	3.8 a
Untreated	-	87.9 c	20.3 b	71.5 c

\* Not an IR-4 Experiment: F&N Tests Vol 61:PF022. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 15. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2006.**

Treatment	Rate Per 100 Gal	% Golden Delicious with Cedar Apple Rust <sup>x</sup>	% Fruit with Quince Rust	
		Terminal Leaves 8 Aug	Jersey Mac 13 Jun	Redcort 12 Sep
Dithane (mancozeb)	1 lb	4.8 bc	0.6 a	0.0 a
Dithane + Nova (myclobutanil)	1 lb + 1.7 oz	0.4 a	0.0 a	0.0 a
Dithane + Enable (fenbuconazole)	1 lb + 2.67 fl oz	0.5 a	0.0 a	0.0 a
Enable	2.67 fl oz	1.4 ab	0.0 a	0.0 a
Flint (trifloxystrobin)	0.67 oz	6.2 cd	1.6 a	3.3 abc
Untreated	-	46.4 f	32.2 b	4.1 bc

\* Not an IR-4 Experiment: PDM Reports Vol 1:PF020. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 16. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2006.**

Treatment	Rate Per 100 Gal	% Cedar Apple Rust <sup>x</sup>			% Fruit with Quince Rust		
		J-Mac Leaves 13 Jun	G-Gold Leaves 6 Jul	G-Gold Fruit 18 Aug	Jersey Mac 13 Jun	Jersey Mac 11 Aug	Ginger Gold 18 Aug
LEM -17 (penthioopyrad)	4.8 fl oz	7.6 a	7.5 abc	0.7 abc	0.0 a	0.4 a	0.0 a
LEM-17	6.9 fl oz	14.4 abc	6.3 abc	1.3 bcd	0.0 a	0.0 a	0.0 a
Manzate (mancozeb)	1 lb	13.8 ab	7.9 bc	2.1 cd	0.0 a	0.0 a	1.3 a
Nova (myclobutanil)	1.67 oz	14.9 abc	2.7 a	0.7 abc	0.0 a	0.0 a	0.0 a
Nova + Manzate	1.67 oz + 1 lb	11.5 ab	3.1 ab	0.0 a	0.0 a	0.0 a	0.0 a
Untreated	-	28.8 c	54.4 d	47.4 e	76.2 b	38.0 b	16.7 b

\* Not an IR-4 Experiment: PDM Reports Vol 1:PF021. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 17. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2006.**

Treatment	Rate Per 100 Gal	% Golden Delicious Leaves with Cedar Apple Rust <sup>x</sup> 9 Jul	% Jerseymac Fruit with Quince Rust 30 Jul
Dithane (mancozeb)	1 lb	15.4 def	0.0 a
Dithane + Nova (myclobutanil)	1 lb + 1.7 oz	1.6 a	0.0 a
Dithane + Indar (fenbuconazole)	1 lb + 2.67 fl oz	1.6 a	0.0 a
Flint (trifloxystrobin)	0.67 oz	13.3cd	1.0 b
Indar	2.67 fl oz	12.6cd	0.0 a
Nova (myclobutanil)	1.7 oz	10.5bc	0.0 a
Untreated <sup>y</sup>	-	60	2.5

\* Not an IR-4 Experiment: PDM Reports Vol 2:PF026. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

<sup>y</sup> Control plots were not included in the analysis of variance.

**Table 18. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2008.**

Treatment	Rate Per 100 Gal	% Ginger Gold with Cedar Apple Rust <sup>x</sup>		% Fruitlets With Rust <sup>y</sup>	% Fruits With Quince Rust <sup>y</sup>
		Terminal Leaves	Fruit		
Flint (trifloxystrobin)	0.67 oz	2.5 a	0.0 a	1.9 a	3.5 ab
Indar (fenbuconazole)	2.67 oz	3.4 a	1.0 a	0.4 a	2.0 a
Manzate (mancozeb)	1 lb	5.2 ab	1.5 a	1.9 a	4.7 ab
Untreated	-	28.3 d	4.7 a	57.7 c	75.1 d

\* Not an IR-4 Experiment: PDM Reports Vol 3:PF018. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

<sup>y</sup> Average of 2 cultivars Ginger Gold and Jerseymac.



**Table 19. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Rosenberger, NY, 2010.**

Treatment	Rate Per 100 Gal	% Golden Delicious Leaves with Cedar Apple Rust <sup>x</sup> 29 Jun	% Jerseymac Fruit with Quince Rust 21 Jul
Dithane (mancozeb)	16 oz	16.7 d	0.0 a
Fontelis (penthiopyrad) + BioCover MLT Oil	6.6 fl oz	3.3 ab	0.0 a
Rally (myclobutanil) + Dithane rot. Dithane	2 oz + 16 oz rot. 16 oz	1.3 a	0.3 ab
Untreated	-	67.6 e	54.4 c

\* Not an IR-4 Experiment: PDM Reports Vol 5:PF012. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's protected LSD (P=0.05).

**Table 20. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Yoder, VA, 2003.**

Treatment	Rate Per 100 Gal	% Leaves with Cedar Apple Rust <sup>x</sup>		% Fruit with Quince Rust on Red Delicious 16 Sep
		G. Delicious 7 Jul	Rome 17 Jul	
Flint (trifloxystrobin)	0.5 oz	<1 a	2 a	0 a
Nova (myclobutanil)	1 oz	0 a	<1 a	1 a
Pristine (boscalid + pyraclostrobin)	0.225 lb	<1 a	1 a	1 a
Rubigan (fenarimol)	2.25 fl oz	0 a	1 a	0 a
Untreated	-	10 c	23 b	10 b

\* Not an IR-4 Experiment: F&N Tests Vol 59:PF029. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, (P=0.05).

**Table 21. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Yoder, VA, 2006.**

Treatment	Rate Per Acre	% Leaves with Cedar Apple Rust <sup>x</sup>			% Fruit with Quince Rust		
		G- Deli 13 Jun	York 6 Jul	Idared 18 Aug	G- Deli 13 Jun	York 6 Jul	Idared 18 Aug
Enable (fenbuconazole)	8 fl oz	1 ab	<1 a	1 ab	0 a	0 a	3 ab
Flint (trifloxystrobin)	2 oz	1 ab	<1 a	1 ab	4 ab	0 a	4 ab
LEM -17 (penthiopyrad)	14.4 fl oz	3 b-d	5 bc	2 bc	0 a	0 a	1 a
LEM-17	20.6 fl oz	1 ab	8 cd	<1 ab	0 a	0 a	1 a
LEM-17	30.7 fl oz	3 b-d	8 cd	1a-c	5 ab	0 a	1 a
Manzate (mancozeb)	3 lb	14 f	12 d-f	9 d	5 bc	0 a	0 a
Untreated	-	41 g	44 g	33 e	17d	4 b	15 c

\* Not an IR-4 Experiment: PDM Reports Vol 1:PF034. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, (P=0.05).

**Table 22. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), Yoder, VA, 2007.**

Treatment	Rate Per Acre	% Infection with Cedar Apple Rust <sup>x</sup>		
		Idared Leaves	Ginger Gold Leaves	Ginger Gold Fruit
Flint (trifloxystrobin)	2 oz	0 a	0 a	0 a
Nova (myclobutanil)	4.5 oz	0 a	0 a	0 a
Topguard (flutriafol)	3.5 fl oz	0 a	0 a	0 a
Topguard	7 fl oz	0 a	0 a	0 a
Topguard	13 fl oz	0 a	0 a	0 a
Topguard	26 fl oz	0 a	0 a	0 a
Untreated	-	5 b	10 b	8 b

\* Not an IR-4 Experiment: PDM Reports Vol 2:PF034. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 23. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) and Quince Rust (*G. clavipes*) on Apple (*Malus domestica*), Yoder, VA, 2008.**

Treatment	Rate Per Acre	% Leaves with Cedar Apple Rust <sup>x</sup>			% Fruit with Quince Rust	
		Idared 20 Jun	G- Deli 16 Jun	York 2 Jul	Idared 22 Sep	G- Deli 18 Sep
Rally (myclobutanil) + Dithane (mancozeb)	5 oz + 3 lb	<1 ab	<1 a	0 a	0 a	0 a
Topguard (flutriafol)	3.5 fl oz	0 a	0 a	<1 ab	0 a	0 a
Topguard	7 fl oz	0 a	<1 a	<1 ab	0 a	0 a
Topguard	13 fl oz	0 a	0 a	<1 ab	0 a	1 a
Untreated	-	9 c	22 c	23 c	17 c	11 b

\* Not an IR-4 Experiment: PDM Reports Vol 3:PF004. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 24. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), Yoder, VA, 2010.**

Treatment	Rate Per Acre	% Leaves with Cedar Apple Rust <sup>x</sup>		
		Idared 22 Jun	York 1 Jul	Golden Del. 30 Jul
Flint (trifloxystrobin)	2 oz	0 a	<1 ab	2 ab
Flint + Penncozeb (mancozeb)	2 oz + 3 lb	3 cde	4 de	8 cd
Flint + Rally (myclobutanil)	2 oz + 2.5 oz	<1 ab	0 a	1 a
Rally + Penncozeb	5 oz + 3 lb	<1 ab	<1 abc	1 a
Untreated	-	11 f	35 j	41 g

\* Not an IR-4 Experiment: PDM Reports Vol 5:PF035. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 25. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), Yoder, VA, 2010.**

Treatment	Rate Per 100 Gal	% Infected Leaves		No. Lesions Per Leaf		% Infected Fruits
		Rome 3 Jun	G. De 19 Jul	Rome 3 Jun	G. Del 19 Jul	Rome 29 Sep
Flint (trifloxystrobin)	0.5 oz	16 d	8 b	0.9 a	0.3 a	0 a
Flint + Rally (myclobutanil)	0.5 oz + 0.6 oz	1 ab	<1 a	0.1 a	<0.1 a	0a
Rally + Penncozeb (mancozeb)	1.25 oz + 12 oz	2 ab	1 a	<0.1 a	<0.1 a	0 a
Untreated	-	58 g	41 e	5.8 c	3.3 d	5 b

\* Not an IR-4 Experiment: PDM Reports Vol 5:PF043. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 26. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), Yoder, VA, 2011.**

Treatment	Rate Per Acre	% Leaf Infection with Cedar Apple Rust <sup>x</sup>		
		Idared	Golden Delicious	York
Flint (trifloxystrobin)	2 oz	0 a	<1 a	4 c-e
Rally (myclobutanil) + Penncozeb (mancozeb)	5 oz + 3 lb	0 a	<1 a	6 a-e
Topguard (flutriafol)	10 fl oz	0 a	<1 a	0 a
Untreated	-	16 b	24 c	42 g

\* Not an IR-4 Experiment: PDM Reports Vol 6:PF033. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 27. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), Yoder, VA, 2011.**

Treatment	Rate Per 100 Gal	Cedar Apple Rust <sup>x</sup>			
		% Leaves		Lesions/Leaf	
		Rome	G. Delicious	Rome	G. Delicious
Flint (trifloxystrobin)	0.5 oz	13 b	17 cd	0.67 ab	0.52 a-c
Rally (myclobutanil) + Penncozeb (mancozeb)	1.25 oz + 12 oz	<1 a	<1 a	<0.01 a	<.01 a
Untreated	-	55 d	47 e	2.60 d	2.47 d

\* Not an IR-4 Experiment: PDM Reports Vol 3:PF004. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

**Table 28. \* Efficacy on Cedar Apple Rust (*Gymnosporangium juniperi-virginianae*) on Apple (*Malus domestica*), ‘Rome Beauty’, Sutton, et al, NC, 2010.**

Treatment	Rate Per Acre	% Infected Leaves <sup>x</sup>
BAS 639	4.08 fl oz	0.0 c
BAS 639 + Sylgard	4.08 fl oz	0.0 c
BAS 639 + Sylgard	5.7 fl oz	0.0 c
BAS 639 + Sylgard	9.14 fl oz	0.0 c
BAS 9150 + Sylgard	2.74 fl oz	0.0 c
BAS 9150 + Sylgard	7 fl oz	0.0 c
Flint (trifloxystrobin) + Sylgard	0.5 oz	0.8 bc
Pristine (boscalid + pyraclostrobin) + Sylgard	14.4 oz	0.5 c
Topguard (flutriafol) + Captan	13 fl oz + 4 lb	0.0 c
Untreated	-	16.4 a

\* Not an IR-4 Experiment: PDM Reports Vol 5:PF011. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Waller-Duncan K-ratio t-test, ( $P=0.05$ ).

### **Comparative Efficacy on *Phragmidium* sp.**

In 2003, Pscheidt conducted an experiment examining various products applied as spray for the control of rust; (*Phragmidium* sp.) on rose (*Rosa* sp.). Treatments were applied every 2 weeks from March 17 to May 2. Immunox provided excellent control of rust; Daconil and Terraguard were not effective (Table 29). No phytotoxicity was observed from any treatment.

**Table 29. \* Efficacy on Rust (*Phragmidium* sp.) on Rose (*Rosa* sp.) ‘Pink Simplicity’, Pscheidt, OR, 2003.**

Treatment	Rate Per Gal	% Leaves with Rust <sup>x</sup> 22 May
Daconil (chlorothalonil)	0.30 fl oz	52.6 b
Immunox (myclobutanil)	1 fl oz	0.2 d
Terraguard (triflumizole)	0.08 oz	46.8 b
Untreated	-	56.8 b

\* Not an IR-4 Experiment: F&N Tests Vol 59:PF027. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD ( $P=0.05$ ).

### **Comparative Efficacy on *Puccinia* spp.**

From 2004 to 2007, three trials were conducted in Georgia to determine the efficacy of several fungicides against daylily rust (*Puccinia hemerocallidis*) on daylily (*Hemerocallis* sp.). In 2004, Buck tested DMI consumer fungicide products (Table 30). Bayer Disease Control, Bonide, Immunox and the standard Banner MAXX all provided excellent control when applied as a preventative (Table 30). Bonide, Ortho Rose Pride, and Banner MAXX significantly reduced lesion development when applied 7-day post infection. Williams-Woodward in 2004 conducted a trial with systemic fungicides Heritage, BAS 500, Compass and Strike, and protectant fungicides Daconil Ultrex, Kocide 2000, and Rhapsody (Table 31). Fungicide applications were applied preventatively before rust pustules were evident beginning 6 Feb and continued every 7 days until 26 Mar. All fungicide treatments reduced rust pustule development (Table 31). The systemic fungicides provided somewhat greater control than the protectant fungicides. In 2007,

Buck evaluated Insignia, Pageant and Trinity fungicides for management of daylily rust (Table 32). Based on disease evaluation 14 days post-inoculation, both rates of Insignia and Pageant provided excellent control of daylily rust when applied up to 21 days prior to inoculation with the fungus. Trinity was comparable only when applied on the day of inoculation. No phytotoxicity was observed from any treatment.

**Table 30. \* Efficacy on Daylily Rust (*Puccinia hemerocallidis*) on Daylily (*Hemerocallis* sp.), ‘Leebea Orange Crush’ Buck, GA, 2004.**

Treatment	Rate Per Gal	Lesions Per Cm Leaf at Fungicide Application Timings <sup>x</sup>	
		Preventative <sup>y</sup>	Curative <sup>z</sup>
Banner (propiconazole)	0.4 fl oz	0.1 b	1.9 b
Bayer Disease Control (tebuconazole)	0.75 fl oz	0.0 b	4.0 ab
Bonide (propiconazole)	1 fl oz	0.1 b	1.6 b
Immunox (myclobutanil)	1 fl oz	0.1 b	4.0 ab
Untreated	-	10.3 a	7.0 a

\* Not an IR-4 Experiment: PDM Reports Vol 3:OT018.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

<sup>y</sup> Preventative = plants were treated with fungicides and inoculated with urediniospores 4 h after treatment.

<sup>z</sup> Curative = plants were treated with fungicides 7 d after inoculation with urediniospores.

**Table 31. \* Efficacy on Daylily Rust (*Puccinia hemerocallidis*) on Daylily (*Hemerocallis* sp.), ‘Pardon Me’ Williams-Woodward, GA, 2004.**

Treatment	Rate Per 100 Gal	No. Rust Pustules Per Leaf <sup>x</sup> 2 Apr
BAS 500 (pyraclostrobin)	2 oz	1.1 a
Compass (trifloxystrobin)	1 oz	2.8 ab
Compass	2 oz	3.2 ab
Daconil Ultrex (chlorothalonil)	1.4 lb	4.3 ab
Heritage (azoxystrobin) + Nu-Film	2 oz	0.5 a
Kocide 2000 (copper hydroxide)	0.75 lb	4.7 ab
Rhapsody ( <i>Bacillus subtilis</i> )	2 oz	5.5 ab
Strike (triadimefon)	2 oz	2.9 ab
Untreated	-	12.7 c

\* Not an IR-4 Experiment: F&N Tests Vol 60:OT033. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Tukey’s HSD means separation test (P = 0.05).

**Table 32. \* Efficacy on Daylily Rust (*Puccinia hemerocallidis*) on Daylily (*Hemerocallis* sp.), ‘Leebea Orange Crush’ Buck, GA, 2007.**

Treatment	Rate Per 100 Gal	% Leaf Area with Rust Lesions <sup>x</sup> at Application Timings			
		Day of Inoculation	7 Days Prior	14 Days Prior	21 Days Prior
Insignia (pyraclostrobin)	2 oz	0.0 b	0.4 c	0.8 c	1.1 b
	4 oz	0.4 b	0.0 c	0.0 c	0.0 b
Pageant (boscalid + pyraclostrobin)	6 oz	0.0 b	0.0 c	0.0 c	0.0 b
	18.5 oz	0.0 b	0.0 c	0.0 c	1.5 b
Trinity (triticonazole)	2 oz	0.0 b	8.4 ab	4.9 bc	15.0 a
	6.4 oz	0.0 b	4.5 bc	7.9 ab	19.8 a
Untreated	-	11.5 a	11.5 a	11.5 a	11.5 ab

\* Not an IR-4 Experiment: PDM Reports Vol 3:OT017.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher’s protected LSD (P=0.05).

Giesler in 2001 conducted a trial to test the efficacy of several fungicides to control hollyhock rust (*Puccinia malvacearum*) on hollyhock (*Alcea rosea*). Five applications were made at 2-week intervals starting 20 July. Bayleton + Nu-Film, the higher rate of EXP 80318C + Nu-Film and Immunex were the best treatments in this study (Table 33). A second trial in 2002 confirmed the effective control of hollyhock rust from Bayleton and EXP 80318C (Table 34). In both trials, treatments with surfactant caused some leaf burning under abnormally high temperatures (over 90 and 95 F).

In 2010, Becker evaluated several experimental and registered fungicides to control hollyhock rust on hollyhock (Table 35). Plants were treated and inoculated following treatment on July 10; retreatment and inoculation occurred on August 1. All fungicides provided statistically improved control of rust on old and young leaves following inoculation. Following a second application, and when a substantial number of pustules were already present, all fungicides except Protect, Rubigan, Banner Maxx, and 3336 provided significant reduction in the number of rust pustules per leaf.

**Table 33. \* Efficacy on Hollyhock Rust (*Puccinia malvacearum*) on Hollyhock (*Alcea rosea*), Giesler, NE, 2001.**

Treatment	Rate Per 100 Gal	Disease Severity <sup>x **</sup>		
		6 Sep	17 Sep	26 Sep
Bayleton (triadimefon) + Silwet	5.5 oz	0.5	1.3	1.8
EXP 80318C (triticonazole)	2 fl oz	1.5	4.5	7.3
EXP 80318C + Silwet	1 fl oz	1.0	3.3	4.5
EXP 80318C + Silwet	2 fl oz	0.8	2.0	2.5
Funginex (triforine)	100 fl oz	0.5	2.0	3.3
Immunex (propiconazole)	100 fl oz	0.0	1.0	1.5
Untreated	-	4.0	7.3	7.7
LSD ( $P = 0.05$ )		1.0	1.5	1.7

\* Not an IR-4 Experiment: F&N Tests Vol 57:OT013. Not all products tested included in table.

<sup>x</sup> Mean separation based on Fisher’s protected LSD (P=0.05).

\*\* Disease rating scale of 1-10, where: 1 = approximately 10% of the foliage area with necrosis; 5 = approximately 50% foliage with symptoms, and 10 = 100% foliage with symptoms.

**Table 34. \* Efficacy on Hollyhock Rust (*Puccinia malvacearum*) on Hollyhock (*Alcea rosea*), Giesler, NE, 2002.**

Treatment	Rate Per 100 Gal	Disease Severity <sup>x **</sup>		
		21 Aug	4 Sep	19 Sep
Bayleton (triadimefon) + Sticker	5.5 oz	3.8	3.8	4.8
EXP 80318C (triticonazole)	2 fl oz	3.8	3.8	4.8
EXP 80318C + Sticker	1 fl oz	4.8	4.8	6.8
EXP 80318C + Sticker	2 fl oz	4.0	4.0	5.3
Orthenex (triforine+acephate)	100 fl oz	3.5	3.5	3.3
Untreated	-	7.0	6.8	7.5
LSD ( $P = 0.05$ )		1.9	1.9	1.7

\* Not an IR-4 Experiment: F&N Tests Vol 58:OT002. All products tested not included in table.

<sup>x</sup> Mean separation based on Fisher's protected LSD ( $P=0.05$ ).

\*\* Disease rating scale of 1-10, where: 1 = approximately 10% of the foliage area with necrosis; 5 = approximately 50% foliage with symptoms, and 10 = 100% foliage with symptoms.

**Table 35. Efficacy on Hollyhock Rust (*Puccinia malvacearum*) on Hollyhock (*Alcea rosea*), Becker, NY, 2010.**

Treatment	Rate Per 100 Gal	Number of Rust Pustules Per Leaf <sup>x</sup>		
		On Older Leaves 8/1/10	On Youngest Leaves 8/1/10	On All Leaves 9/1/10
3336 WP (thiophanate-methyl)	16 oz	0.40 d	0.20 b	77.00 bc
Actigard 50WG (acibenzolar)	0.75 oz	4.20 cd	0.60 b	57.00 c
Banner Maxx (propiconazole)	8 fl oz	9.00 bcd	0.60 b	70.00 bc
Bayleton (triadimefon)	3 oz	1.00 d	0.00 b	3.20 d
Captan 50WP (captan)	1 lb	10.40 bc	0.60 b	61.00 c
Compass 50WDG (trifloxystrobin)	4 oz	0.00 d	0.00 b	5.80 d
Eagle 2EW (myclobutanil)	12 fl oz	0.20 d	0.00 b	47.00 c
Heritage ( azoxystrobin)	4 oz	0.00 d	0.00 b	1.20 d
Hurricane (fludioxonil+mefenoxam)	1.5 oz	13.00 b	1.80 b	2.80 d
Insignia 20WG (pyraclostrobin)	8 oz	0.00 d	0.00 b	12.40 d
Pageant (boscalid+pyraclostrobin)	12 oz	14.20 b	1.60 b	2.00 d
Prostar 70WP (flutolanil)	6 oz	1.80 d	0.40 b	18.40 d
Protect 75DF (mancozeb)	2 lb	1.00 d	0.00 b	71.00 bc
Rubigan AS (fenarimol)	4 fl oz	1.80 d	0.80 b	102.00 a
Tourney (metconazole)	2 oz	3.20 cd	0.20 b	14.20 d
Trinity (triticonazole)	4 fl oz	0.60 d	0.20 b	22.40 d
Untreated	-	34.00 a	6.00 a	91.00 ab

<sup>x</sup> Means followed by same letter do not differ significantly based on Student-Newman-Keul ( $P=0.10$ ).

Kirk in 2011 evaluated several experimental and registered fungicides to control Veronica rust (*Puccinia veronica-longifoliae*) on speedwell (*Veronica longifolia*). All treatments significantly reduced foliar rust with one application throughout the trial (Table 36). The treatments with the greatest efficacy included Banner Maxx, Compass O, Eagle, Prostar, SP2169, Tourney and Heritage all applied regularly. No phytotoxicity was observed from any treatment.

**Table 36. Efficacy on Veronica Rust (*Puccinia veronica-longifoliae*) on Speedwell (*Veronica longifolia*), 'Blazing Candles' Kirk, MI, 2011.**

Treatment	Rate Per 100 Gal	Application Timing <sup>y</sup>	Foliar Rust (%) <sup>x</sup>		
			34 DAT <sup>z</sup>	48 DAT	55 DAT
Actigard 50WP (acibenzolar)	0.25 oz	A, D, F	1.4 ab	7.1 b	21.1 b
Armada 50WP (trifloxystrobin+triadimefon)	3 oz	A, C, E, G	0.7 bc	0.7 cde	3.5 de
Banner Maxx 1.3EC (propiconazole)	8 fl. oz	A, C, E, G	0.0 c	0.3 de	0.7 f
Compass 50WDG (trifloxystrobin)	4 oz/A	A, B, D, E, F, H	0.0 c	0.0 e	1.5 ef
Eagle 1.67EW (myclobutanol)	12 fl. oz	A, B, D, E, F, H	0.1 bc	0.1 e	1.0 f
Heritage 50WDG (azoxystrobin)	0.9 oz	A	1.3 abc	5.8 b	16.2 bc
Heritage 50WDG	4 oz	A, B, D, E, F, H	0.1 bc	0.3 de	1.2 ef
Prostar 70WDG (flutolanil)	6 oz	A, C, E, G	0.0 c	0.1 e	1.0 f
SP2169 1.04SC	12.3 fl. oz	A, C, E, G	0.1 bc	0.3 de	1.7 ef
	24.6 fl. oz	A, C, E, G	0.1 bc	0.1 e	2.0 ef
Tourney 480SC (metconazole)	2 fl. oz	A, C, E, G	0.0 c	0.0 e	2.0 ef
Trinity 50WDG (triticonazole)	4 oz	A, C, E, G	0.4 bc	3.5 bc	5.5 d
Non-inoculated Check	-	-	1.9 ab	2.8 bcd	11.2 c
Inoculated Check	-	-	5.0 a	18.6 a	43.5 a

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's LSD (P=0.05).

<sup>y</sup> Application dates: A= 6 Jul (at transplanting); B= 14 Jul; C= 21 Jul; D= 28 Jul; E= 11 Aug; F= 18 Aug; G= 25 Aug; H= 1 Sep

<sup>z</sup> DAT = days after transplanting

Hagan in 2011 conducted a trial to test the efficacy of several fungicides to control rust (*Puccinia emaculata*) on switchgrass (*Panicum virgatum*). Fungicide treatments were applied to drip at 2-wk intervals from 1 Jun until 6 Sep. Rust severity was visually rated on 24 Jun, 20 Jul, Aug 21 and 23 Sep. All treatments significantly reduced rust severity, with Eagle and Heritage providing the best control (Table 37).

**Table 37. \* Efficacy on Rust (*Puccinia emaculata*) on Switchgrass (*Panicum virgatum*), 'Dallas Blues', Hagan, AL 2011.**

Treatment	Rate Per 100 Gal	Rust Severity Rating <sup>x, **</sup> 9/23/11
3336 4.5F	20 fl oz	7.3 b
Banner MAXX 1.3MEC	8 fl oz	6.7 c
Eagle 40W	8 oz	4.4 d
Heritage 50WDG	4 oz	5.1 d
Untreated	-	8.0 a

\* Not an IR-4 Experiment: PDM Reports Vol 6:OT011. Not all products tested included in table.

<sup>x</sup> Means followed by same letter do not differ significantly based on Fisher's Protected LSD (P = 0.05).

\*\* Rating scale of 1-10 where 1 = no disease and 10 = all leaves dead.



In 2009, Hagan conducted a trial to determine the efficacy of fungicides on peanut rust (*Puccinia arachidis*) on peanuts (*Arachis hypogaea*). Fungicides were usually tested in spray programs with other fungicides to test efficacy on different peanut diseases. Spray programs of Bravo/Evito, Bravo/Provost and Bravo/Convoy + Bravo provided inferior rust control compared to season-long spray of Bravo standard (Table 38).

**Table 38. \* Efficacy on Peanut Rust (*Puccinia arachidis*) on Peanut (*Arachis hypogaea*), ‘Georgia Green’ and ‘Florida 07’, Hagan, AL, 2009.**

Treatment	Rate Per Acre	Application Timing <sup>y</sup>	Disease Rating <sup>z</sup> 24 Sep	Yield (lb/A)
Bravo (chlorothalonil)	24 fl oz	1-7	2.8	5360
Bravo Bravo + Convoy (flutolanil)	24 fl oz 24 + 8 fl oz	1, 2, 7 3-6	3.6	5261
Bravo Evito (fluoaxastrobin) + NIS	24 fl oz 3.5 fl oz	1, 2 3-7	5.1	4840
Bravo Provost (prothioconazole)	24 fl oz 8 fl oz	1, 2, 7 3-6	4.0	5314
LSD			0.7	524

\* Not an IR-4 Experiment: PDM Reports Vol 4:FC038. All products tested not included in table.

<sup>x</sup> Mean separation based on Fisher’s protected LSD (P=0.05).

<sup>y</sup> Fungicide applications were made on 1 = 6 Jul, 2 = 20 Jul, 3 = 4 Aug, 4 = 18 Aug, 5 = 2 Sep, 6 = 10 Sep, and 7 = 28 Sep.

<sup>z</sup> Rust rated using the ICRISAT 1-9 rating scale (1 = no disease, 9 = plants severely affected, 80-100% leaves withering).

### **Comparative Efficacy on *Uromyces appendiculatus***

From 2000 to 2006, five trials were conducted to determine the efficacy of several fungicides against bean rust (*Uromyces appendiculatus*) on dry and snap beans (*Phaseolus vulgaris*). Data from an experiment conducted by Gross in 2000 showed the DMI’s Folicur and Tilt providing better rust control than Cuprofix and Maneb (Table 39). In 2001, Schwartz conducted a trial on dry bean to determine efficacy of Flint, Headline, Quadris, Tilt, Maneb and Bravo (Table 40). All treatments significantly reduced rust incidence for 7, 14 and 21 days after application when applied at the first sign of disease in the field. In 2004, Raid conducted two trials on snap beans to determine the efficacy of Amistar, Bravo and Nova on rust and powdery mildew. Fungicides were applied on 28 April, 4 and 12 May. In both trials, Amistar provided excellent control of severe rust infections; Nova was slightly inferior and Bravo provided poor control (Table 41 and Table 42). In 2006, Raid examined the efficacy of Amistar, Bravo, LEM 17, Nova and Sulfur on rust (Table 43). Fungicides were applied on 8 and 15 May. Similar to previous trials, Amistar again provided the best control of a moderate rust pressure, followed by Nova and LEM 17, and Bravo and Sulfur providing only marginal control.

No phytotoxicity was observed from any treatment on snap beans. In the dry bean trials, Tilt caused some phytotoxicity but yield was not reduced.

**Table 39. \* Efficacy on Bean Rust, (*Uromyces appendiculatus*) on Dry Bean (*Phaseolus vulgaris*) ‘Topaz’, Gross, ND, 2000.**

Treatment <sup>y</sup>	Rate Per Acre	Severity <sup>x</sup>				Yield (Lb/A)
		13 Jul	20 Jul	27 Jul	3 Aug	
Cuprofix (copper sulfate)	3 lb	3.2	5.8	21.9	40.0	431
Folicur (tebuconazole) + Induce	4 fl oz	2.5	2.5	2.5	11.6	669
Folicur + Induce	6 fl oz	2.5	2.5	2.5	9.7	617
Maneb (mancozeb)	2 lb	3.2	5.8	16.8	29.0	565
Tilt (propiconazole)	4 fl oz	2.5	2.5	2.5	12.9	720
Untreated	-	4.5	7.1	29.7	58.5	432
LSD		0.7	1.0	3.2	4.5	225

\* Not an IR-4 Experiment: F&N Tests Vol 56:FC32.

<sup>x</sup> Severity is based on pustules per square in. of leaf area averaged over 40 leaves. Mean separation based on SAS ANOVA of GLM LSD (P=0.05).

<sup>y</sup> Treatments applied 6 and 13 Jul.

**Table 40. \* Efficacy on Bean Rust, (*Uromyces appendiculatus*) on Dry Bean (*Phaseolus vulgaris*) ‘Bill Z’, Schwartz, CO, 2001.**

Treatment <sup>y</sup>	Rate Per Acre	No. of Rust Pustules/ 20 leaves			Yield (Lb/A)
		16 Aug	23 Aug	30 Aug	
Bravo Zn (chlorothalonil)	3 pt	1.24	41.8	10.0	1637
Flint (trifloxystrobin)	2 oz	0.08	1.75	7.55	1645
Headline (pyraclostrobin)	9.2 fl oz	0.70	93.5	9.69	1447
Maneb (mancozeb)	2 lb	0.84	20.5	13.4	1559
Quadris (azoxystrobin)	6.2 fl oz	0.05	0.75	9.65	1750
Tilt (propiconazole)	4 fl oz	0.10	4.25	8.56	1541
Untreated	-	10.7	408	106	1328
LSD (P= 0.05)		1.55	39.25	5.48	325

\* Not an IR-4 Experiment: F&N Tests Vol 57:FC02. Not all products tested included in table.

<sup>y</sup> Treatments mixed with Latron and applied on 19 Jul, 26 Jul, 2 Aug and 9 Aug.

**Table 41. \* Efficacy on Bean Rust, (*Uromyces appendiculatus*) on Snap Bean (*Phaseolus vulgaris*) ‘Bronco’, Raid, FL, 2004.**

Treatment	Rate Per Acre	Rust Rating <sup>x</sup>	Yield (Crates/A)
Amistar (azoxystrobin)	2 oz	0.0 g	403 a
Amistar	4 oz	0.0 g	389 a
Bravo (chlorothalonil)	1.3 lb	6.9 c	249 c
Bravo	2.6 lb	5.4 d	310 b
Nova (myclobutanil)	2.5 oz	2.2 e	366 a
Nova	5 oz	0.6 f	362 a
Sulfur	7 lb	7.4 b	263 bc
Untreated	-	10.0 a	177 d

\* Not an IR-4 Experiment: F&N Tests Vol 60:V112.

<sup>x</sup> Scale of 0 to 10, with 0 = no rust pustules and 10 being entire canopy infected with severe rust. Means followed by same letter do not differ significantly based on Fisher’s LSD (P=0.05).

**Table 42. \* Efficacy on Bean Rust, (*Uromyces appendiculatus*) on Snap Bean (*Phaseolus vulgaris*) 'Bronco', Raid, FL, 2004.**

Treatment	Rate Per Are	Rust Rating <sup>x</sup>	Yield (Crates/A)
Amistar (azoxystrobin)	3 oz	0.6 f	462 a
Bravo (chlorothalonil)	2 lb	6.6 c	314 cd
Nova (myclobutanil)	2.5 oz	2.6 d	417 ab
Untreated	-	10.0 a	195 e

\* Not an IR-4 Experiment: F&N Tests Vol 60:V113. Not all products tested included in table.

<sup>x</sup> Scale of 0 to 10, with 0 = no rust pustules and 10 being entire canopy infected with severe rust. Means followed by same letter do not differ significantly based on Fisher's LSD (P=0.05).

**Table 43. \* Efficacy on Bean Rust, (*Uromyces appendiculatus*) on Snap Bean (*Phaseolus vulgaris*) 'Bronco', Raid, FL, 2006.**

Treatment	Rate Per Are	Rust Rating <sup>x</sup>	Yield (Crates/A)
Amistar (azoxystrobin)	3 oz	0.6 f	411 a
Bravo (chlorothalonil)	2 lb	7.1 b	383 a
LEM 17 (penthioopyrad)	3.5 fl oz	5.0 c	392 a
LEM 17	5 fl oz	4.0 d	396 a
Nova (myclobutanil)	4 oz	3.1 e	403 a
Sulfur	6 lb	7.9 b	382 a
Untreated	-	10.0 a	367 a

\* Not an IR-4 Experiment: PDM Reports Vol 1:V096.

<sup>x</sup> Scale of 0 to 10 relative to the untreated check (i.e. 0= total control, 10=no control). Means followed by same letter do not differ significantly based on Fisher's LSD (P=0.05).

### **Efficacy Summary by Product/Active Ingredient**

A brief efficacy summary for select products is given below, with a reminder that there are very limited published data available to draw definitive conclusions for each product/pest species. Products were selected based on interest in most of these products for testing for a rust efficacy project undertaken in 2010.

**Azoxystrobin.** Amistar provided some, but less effective control than the DMI's Indar and Nova, of white pine blister rust (*Cronartium ribicola*) in a black currant trial. In a serviceberry trial, Heritage provided excellent control of Pacific Coast pear rust (*Gymnosporangium libocedri*). It provided excellent control of daylily rust (*Puccinia hemerocallidis*) in a daylily trial, hollyhock rust (*P. malvacearum*) in a hollyhock trial, and Veronica rust (*P. veronica-longifoliae*) in a speedwell trial. Quadris provided excellent control of bean rust (*Uromyces appendiculatus*) in a dry bean trial, and Amistar provided excellent control in 3 snap bean trials.

**Boscalid+Pyraclostrobin.** This product, tested as BAS 516 or Pristine, provided good to excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*) in 4 apple trials. Similarly, Pageant provided excellent control of daylily rust (*Puccinia hemerocallidis*) in one daylily trial. However, a trial on serviceberry showed Pristine providing mediocre control of Pacific Coast pear rust; (*Gymnosporangium libocedri*). A trial on hollyhock showed Pageant providing good control of

hollyhock rust (*P. malvacearum*).

**Flutolanil.** This active ingredient, tested as Contrast, provided no control of Pacific Coast pear rust; (*Gymnosporangium libocedri*) in a serviceberry trial. A trial on hollyhock showed Prostar providing good control of rust (*Puccinia malvacearum*) It provided excellent control of Veronica rust (*P. veronica-longifoliae*) in a speedwell trial. Convoy tested in combination with Bravo provided inferior control of peanut rust (*P. arachidis*) compared to Bravo standard in one trial.

**Flutriafol.** Topguard, a new DMI fungicide, provided good to excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*) in 4 apple trials.

**Metconazole.** Tourney provided good control of Pacific Coast pear rust (*Gymnosporangium libocedri*) in a serviceberry trial and of hollyhock rust (*Puccinia malvacearum*) in a hollyhock trial. Control of Veronica rust (*P. veronica-longifoliae*) was excellent in a speedwell trial.

**Myclobutanil.** Nova provided good to excellent control of white pine blister rust (*Cronartium ribicola*) on black currant (2 trials) currant (2) and gooseberry (2); Nova generally was the best treatment. Similarly, Eagle provided excellent control of Pacific Coast pear rust (*Gymnosporangium libocedri*) in 2 serviceberry trials. In 12 apple trials, Nova generally provided excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*); the combination of Nova + Dithane is generally considered the standard treatment. Immunox was the best treatment for rust (*Phragmidium* sp.) in a rose trial. It provided excellent control of daylily rust (*Puccinia hemerocallidis*) in one daylily trial and of hollyhock rust (*Puccinia malvacearum*) in a hollyhock trial when applied as preventative. It provided excellent control of Veronica rust (*P. veronica-longifoliae*) in a speedwell trial. Efficacy of Nova on bean rust (*Uromyces apendiculatus*) was fair to good in 3 snap bean trials.

**Penthiopyrad.** This experimental product tested as LEM-17 or Fontelis provided good to excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*) in 3 apple trials. It provided poor control of bean rust (*Uromyces apendiculatus*) in one snap bean trial.

**Propiconazole.** Banner provided excellent control of Pacific Coast pear rust (*Gymnosporangium libocedri*) in 2 serviceberry trials, and Veronica rust (*Puccinia. veronica-longifoliae*) in a speedwell trial. Also it provided excellent control of daylily rust (*P. hemerocallidis*) when applied as preventative in one daylily trial. Banner or Immunex provided mediocre to good control of hollyhock rust (*P. malvacearum*) in two hollyhock trials. Tilt provided good to excellent control of bean rust (*Uromyces apendiculatus*) in 2 dry bean trials.

**Pyraclostrobin.** Cabrio provided good control of white pine blister rust (*Cronartium ribicola*); alternate sprays or combination with Nova provided better efficacy in 6 currant and gooseberry trials. However, it provided mediocre control of Pacific Coast pear rust (*Gymnosporangium libocedri*) in a serviceberry trial. BAS 500 provided good to excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*) in one apple trial. BAS 500 or Insignia provided excellent control of daylily rust (*Puccinia hemerocallidis*) in 2 daylily trials. A trial on hollyhock showed Insignia providing good control of rust (*P. malvacearum*). Efficacy on bean rust (*Uromyces apendiculatus*) was good in one dry bean trial.

**SP2169.** This active ingredient provided excellent control of Veronica rust (*Puccinia. veronica-longifoliae*) in a speedwell trial.

**Trifloxystrobin.** Compass provided excellent control of Pacific Coast pear rust (*Gymnosporangium libocedri*) in 2 serviceberry trials. Also, it provided good control of daylily rust (*Puccinia hemerocallidis*)

in one daylily trial, and excellent control of hollyhock rust (*P. malvacearum*) in a hollyhock trial and Veronica rust (*P. veronica-longifoliae*) in a speedwell trial. In 11 apple trials, Flint generally provided excellent control of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and quince rust (*G. clavipes*) though slightly inferior to myclobutanil. Efficacy on bean rust (*Uromyces appendiculatus*) was excellent in one dry bean trial.

**Triticonazole.** Trinity provided excellent control of daylily rust (*Puccinia hemerocallidis*) when applied on the day of disease inoculation but poor to no control when applied 7 to 21 days prior to inoculation in one daylily trial. EXP 80318C + NuFilm or Trinity alone provided fair to good control of hollyhock rust (*Puccinia malvacearum*) in three hollyhock trials. Control of Veronica rust (*P. veronica-longifoliae*) was mediocre in a speedwell trial.

### **Phytotoxicity**

No phytotoxicity was observed with the products listed above with the exception of Bayleton and EXP 80318C causing some leaf burning on hollyhock when mixed with surfactant under abnormally high temperatures (over 90 and 95 F). Tilt also caused some phytotoxicity to dry beans but yield was not reduced.

**Table 44. Summary of Efficacy By Product**

Note: Table entries are sorted by crop Latin name. Only those IR-4 trials received by 5/15/2012 are included in the table below.

PR#	Product (Active Ingredients)	Target	Crop	Production Site	Researcher	Year	Application Type	Results	File Name	EPA Reg ?
31175	3336 WP (50%) (Thiophanate-methyl)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy after 1st applic, poor after 2nd, with 16 oz per 100 gal applied at 21-day interval.	20111209a.pdf	N
31176	Acibenzolar-S-methyl (Acibenzolar-S-methyl)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Good efficacy after 1st applic, poor after 2nd, with 0.75 oz per 100 gal applied at 21-day interval.	20111209a.pdf	N
31367	Acibenzolar-S-methyl (Acibenzolar-S-methyl)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Poor control with 0.25 oz per 100 gal applied 3 times.	20120514c.pdf	N
31365	Armada (Trifloxystrobin + triademefon)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Good control with 3 oz per 100 gal applied 4 times.	20120514c.pdf	N
29657	Banner MAXX (Propiconazole)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Good control at 8 fl oz per 100 gal applied 4 times at 3-week intervals.	20101206a.pdf	N
29673	Banner MAXX (Propiconazole)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Mediocre efficacy after 1st applic, poor after 2nd, with 8 fl oz per 100 gal applied at 21-day interval.	20111209a.pdf	N
30558	Banner MAXX (Propiconazole)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 8 fl oz per 100 gal applied 4 times.	20120514c.pdf	N
31174	Bayleton 50WDS (Triademefon)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy with 3 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N

PR#	Product (Active Ingredients)	Target	Crop	Production Site	Researcher	Year	Application Type	Results	File Name	EPA Reg ?
31177	Captan (Captan)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Poor efficacy with 1 lb per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
29658	Compass 0 50WDG (Trifloxystrobin)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Excellent control at 4 oz per 100 gal applied 4 times at 2-week intervals.	20101206a.pdf	N
29674	Compass 0 50WDG (Trifloxystrobin)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy with 4 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
30559	Compass 0 50WDG (Trifloxystrobin)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 4 oz per acre applied 6 times.	20120514c.pdf	N
29659	Eagle 20 EW (Myclobutanil)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Excellent control at 12 fl oz per 100 gal applied 4 times at 2-week intervals.	20101206a.pdf	N
29675	Eagle 20 EW (Myclobutanil)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy after 1st applic, mediocre after 2nd, with 12 fl oz per 100 gal applied at 21-day interval.	20111209a.pdf	N
30560	Eagle 20 EW (Myclobutanil)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 12 fl oz per 100 gal applied 6 times.	20120514c.pdf	N
29681	Heritage (Azoxystrobin)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy with 4 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
31366	Heritage (Azoxystrobin)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 4 oz per 100 gal applied 6 times.	20120514c.pdf	N
29682	Hurricane (fludioxonil + mefonaxam)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Mediocre efficacy after 1st applic, excellent after 2nd, with 1.5 oz per 100 gal applied at 21-day interval.	20111209a.pdf	N

PR#	Product (Active Ingredients)	Target	Crop	Production Site	Researcher	Year	Application Type	Results	File Name	EPA Reg ?
29662	Insignia 20WDG (Pyraclostrobin)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Fair control at 8 oz per 100 gal applied 4 times at 2-week intervals.	20101206a.pdf	N
29676	Insignia 20WDG (Pyraclostrobin)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Good efficacy with 8 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
29663	Pageant 38WG (Boscalid + Pyraclostrobin)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Fair control at 12 oz per 100 gal applied 4 times at 2-week intervals.	20101206a.pdf	N
29677	Pageant 38WG (Boscalid + Pyraclostrobin)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Mediocre efficacy after 1st applic, excellent after 2nd, with 12 oz per 100 gal applied at 21-day interval.	20111209a.pdf	N
29660	ProStar 50WP (Flutaloni)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Did not significantly reduce incidence and severity at 6 oz per 100 gal applied 4 times at 3-week intervals.	20101206a.pdf	N
29678	ProStar 50WP (Flutaloni)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Good efficacy with 6 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
30561	ProStar 50WP (Flutaloni)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 6 oz per 100 gal applied 4 times.	20120514c.pdf	N
31172	Protect T/O (Mancozeb)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy after 1st applic, poor after 2nd, with 2 lb per 100 gal applied at 21-day interval.	20111209a.pdf	N
30078	Rotation: Banner Maxx / Compass O (Propiconazole / Trifloxystrobin)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Good control at 8 fl oz and 4 oz per 100 gal applied 4 times at 2-week intervals.	20101206a.pdf	N
31173	Rubigan AS (Fenarimol)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Excellent efficacy after 1st applic, poor after 2nd, with 4 fl oz per 100 gal applied at 21-day interval.	20111209a.pdf	N



PR#	Product (Active Ingredients)	Target	Crop	Production Site	Researcher	Year	Application Type	Results	File Name	EPA Reg ?
30562	SP2169 (SP2169)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 12.3 and 24.6 fl oz per 100 gal applied 4 times.	20120514c.pdf	N
29661	Tourney 50WDG (Metconazole)	Gymnosporangium libocedri (Gymnosporangium libocedri)	Shadbush Serviceberry (Amelanchier canadensis)	Field In-Ground	Pscheidt	2010	Foliar	Severe disease pressure. Good control at 2 oz per 100 gal applied 4 times at 3-week intervals.	20101206a.pdf	Y
29679	Tourney 50WDG (Metconazole)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Good efficacy with 2 oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	Y
30563	Tourney 50WDG (Metconazole)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Excellent control with 2 fl oz per 100 gal applied 4 times.	20120514c.pdf	Y
29680	Trinity 2SC (Triticonazole)	Rust, Hollyhock (Puccinia malvacearum)	Hollyhock (Alcea rosea)	Field Container	Becker	2010	Foliar	Good efficacy with 4 fl oz per 100 gal applied twice at 21-day interval.	20111209a.pdf	N
30564	Trinity 2SC (Triticonazole)	Rust, Veronica (Puccinia veronicae-longifoliae)	Speedwell, Brooklime (Veronica sp.) V. longifolia 'Blazing Candles'	Field Container	Kirk	2011	Foliar	Good control with 4 oz per 100 gal applied 4 times.	20120514c.pdf	N

## Appendix 1: Contributing Researchers

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## **Appendix 2: Submitted Data**

The IR-4 reports in this Appendix cover multiple PR numbers and are arranged alphabetically by the researchers' last names. Only those reports received by 5/15/2012 are included.

These reports can also be found at [www.rutgers.ir4.edu](http://www.rutgers.ir4.edu) by searching under the Rust Disease Efficacy project.