Project Name: Powdery Mildew Efficacy

New		**Ongoing**		**Completed**	X	**Duration if ongoing or completed:**	1981-1985, 2012-2017, 2020-2021

Project Description:

Powdery mildew has routinely surfaced in the biennial survey of grower needs. While 15 classes and subclasses for fungal mode of action are currently available, growers continue to have difficulty managing powdery mildew diseases.

Research Project Abstract (if available):

Abstract from 2017 Powdery Mildew Efficacy Summary
In this review of literature published from 1999 to 2016, 99 products representing 57 active ingredients were screened in greenhouse and field experiments against several species causing powdery mildew on ornamentals. These pathogens included: *Erysiphe azaleae, Erysiphe knautiae, Erysiphe lagerstroemia, Erysiphe lonicerae var. lonicerae, Erysiphe monardae, Erysiphe polygoni, Erysiphe pulchra, Golovinomyces cichoracearum, Oidium* spp., *Podosphaera pannosa,* and *Podosphaera xanthii*. The established products like 3336, Banner MAXX, Compass, Eagle, Heritage, Insignia, Pageant, Pipron, and Terraguard generally provided consistent efficacy. Although there were insufficient data for definitive conclusions, several new products included in the IR-4 efficacy experiments looked promising. These include IKI-309, Mural, NF-149, and Orkestra. Other products in this research - F9110, Mettle, Milstop, Regalia and ZeroTol - provided generally inconsistent results. Milsana was ineffective in IR-4-sponsered research. Other new products that looked promising include Picatina and other pydiflumetofen products (Picatina Flora and Picatina Gold). Further research is needed to obtain additional efficacy data to recommend actions to register or amend labels for these pathogens.

Target Species (Phytotoxicity, or common and Latin name of arthropod, pathogen, weed):

Erysiphe	*Podosphaera*
Golovinomyces	*Uncinula*
Microsphaera	

Please note: powdery mildew taxonomy has shifted so some may have both current and former genera listed

Target Crops (list tested crops if ongoing or completed project)

Begonia (*Begonia sp.*)	Rhododendron (*Rhododendron sp.*)
Elegant Zinnia (*Zinnia elegans*)	Rose (*Rosa sp.*)
Lilac, Common (*Syringa vulgaris*)	Sweet Pea (Lathyrus odoratus)
Narrowleaf Zinna (*Zinnia angustifolia*)	

Target Product(s)(list tested products or numbered compounds if ongoing or completed project)

Banner MAXX	Heritage	Orkestra Intrinsic
Bayleton 25WP	IKF-309	Problad Verde, Regime (F9110)
Bayleton 50WP	Magus	Regalia O5 (MOI-10605)
Baytan (KWG 0519) 25DF	Mettle	SP2770 10WP
Benlate 50WP	Milban 39EC	Stargus
CGA 71818 10W	MilStop	Tank Mix: MilStop + Cease
F9944	Mural (A18126B) WDG	Tilt 3.6E (CGA 64250 3.6E)
Funginex (Triforine 18.2)	NF-149	ZeroTol

Product Registration and Research Status			
	Fully Screened (also includes standards	**Partially Screened through IR-4** [1]	**Need Data Across Species ?**
Labeled Generally & Commercialized	3336 WP Affirm Armada 50WP Banner MAXX Bayleton 50WDG Cease Copper compounds [2] Daconil Ultrex Double Nickel LC Eagle 20EW Heritage Insignia Mural Pageant Regalia Tourney ZeroTol	Regime	
Labeled Generally But NOT Commercialized			
Labeled for Specific Diseases& Commercialized	Actinovate Compass 0 50WDG Cygnus Disarm 480SC Orkestra Pipron Terraguard		Torque Triact 70 Trinity
Labeled for Specific Diseases but NOT Commercialized			
Not yet registered or Labeled	IKI-309 NF-149 Picatina Picatina Flora Picatina Gold		
No longer available for development	SP 2770		

* IR-4 Data contributed to registration decision – either adding pest to label or not pursuing further research

1 At least one species screened fully

2 Including but not limited to Camelot O, CuPRO, Kocide, Junction, Nu-Cop, Phyton 27

Area	**Characteristic**	**Pro**	**Con**
Availability & effectiveness of alternative management tools	Powdery mildew diseases can be prone to resistance development and new classes of chemistry are a critical component	x	
	A couple new active ingredients are available in current and new MOA classes	x	
	Several different genera cause powdery mildew diseases and performance may not be similar	x	x
	Many classes are currently available for growers		x
	Better things to do with IR-4 funding		x
	No identified biological tools with optimal efficacy	x	x
Damage potential of target	Major pest for growers	x	
Performance and crop safety of proposed products (from other systems)			

Compatibility with IPM, resistance management programs			
Economics			
Geographic distribution			
Manufacturer interest in labeling products			
Other	Future need - maybe	x	

IR-4 Efficacy Trials to Date

Average rating on a scale of 1 – 5 with 1 = 0 to about 50% efficacy (not effective) and 5 = 95 to 100 efficacy (very effective); minimum to maximum rating; number of trials (See table on next page). For product/insect combinations that are blank, IR-4 has not screened this combination.

'Labeled' indicates that this disease species or genera is listed on the label. A rating of 2 or lower is considered unacceptable efficacy (*red text*). A rating of 3 or higher is considered commercially acceptable (black text). Non-labeled, completed product/disease combinations (3 or more trials) with an average rating of 3 or higher are highlighted with **green text**. For disease/product combinations that are blank, IR-4 has not screened this combination.

MOA Class	Product (Active Ingredients)	Powdery mildew, Azalea (*Erysiphe azaleae*)	Powdery Mildew, Cucurbit, Zinnia (*Golovinomyces/ Erysiphe cichoracearum*)	Powdery Mildew, Lilac (*Microsphaera lonicerae*)	Powdery Mildew, Rose (*Podosphaera pannosa*)
FRAC 1	Benlate 50WP (Benomyl)			**5.0 (5 - 5) n1**	
FRAC 3	Banner MAXX (Propiconazole)			3.0 (3 - 3) n1 Labeled	
	Bayleton 25WP (Triadimefon)	3.5 (3 - 4) n2 Labeled	5.0 (5 - 5) n1 Labeled	5.0 (5 - 5) n1 Labeled	4.0 (4 - 4) n1 Labeled
	Bayleton 50WP (Triadimefon)		**5.0 (5 - 5) n1**		
	Baytan 25DF (Triadimenol)	**4.0 (4 - 4) n1**			
	CGA 71818 10W (Penconazole)	**5.0 (5 - 5) n1**			
	Funginex (Triforine 18.2) (Triforine)		**5.0 (5 - 5) n1**		
	Mettle (Tetraconazole)			*2.0 (1 - 3) n2*	
	Tilt 3.6E (Propiconazole)		**5.0 (5 - 5) n1**		
FRAC 5	Milban 39EC (Dodemorph)	3.0 (3 - 3) n1 Labeled	5.0 (5 - 5) n1 Labeled		
FRAC 7 + FRAC 11	Orkestra Intrinsic (Fluxapyroxad + pyraclostrobin)		3.0 (3 - 3) n1 Labeled	5.0 (5 - 5) n1 Labeled	
FRAC 11	Heritage (Azoxystrobin)		3.0 (3 - 3) n1 Labeled	3.0 (3 - 3) n1 Labeled	
FRAC 11 + FRAC 7	Mural WDG (Azoxystrobin + benzovindiflupyr)		4.0 (3 - 5) n2 Labeled	4.0 (3 - 5) n2 Labeled	
FRAC BM01	EcoSwing (Swinglea glutinosa)		*1.0 (1 - 1) n1*		
	Problad Verde (Banda de Lupinus albus doce (BLAD))		*2.0 (2 - 2) n1*		
	Regalia O5 (MOI-10605) (Extract of Reynoutria sachalinensis)			*1.0 (1 - 1) n1 Labeled*	
	Regime (Banda de Lupinus albus doce (BLAD))		*1.0 (1 - 1) n2 Labeled*	*1.0 (1 - 1) n2 Labeled*	
	TXC2020 (Thyme oil)		*1.0 (1 - 1) n1*		
FRAC NC	MilStop (Potassium bicarbonate)			3.0 (3 - 3) n1 Labeled	
	ZeroTol (Hydrogen dioxide)			*1.0 (1 - 1) n1 Labeled*	
FRAC NC + IRAC UNF	Tank Mix: MilStop + Cease (potassium bicarbonate + Bacillus subtilis)			*1.0 (1 - 1) n1*	
FRAC U6	NF-149 (Cyflufenamid)		**3.0 (3 - 3) n2**	**3.5 (2 - 5) n2**	
FRAC U13	Gatten (Flutianil)		**5.0 (5 - 5) n1**		
IRAC 21A	Magus (Fenazaquin)			**5.0 (5 - 5) n1**	

MOA Class	Product (Active Ingredients)	Powdery mildew, Azalea (*Erysiphe azaleae*)	Powdery Mildew, Cucurbit, Zinnia (*Golovinomyces/ Erysiphe cichoracearum*)	Powdery Mildew, Lilac (*Microsphaera lonicerae*)	Powdery Mildew, Rose (*Podosphaera pannosa*)
IRAC UNF & FRAC BM02	Stargus (Bacillus nakamurai strain F727)		*1.0 (1 - 1) n1 Labeled*		
unknown	IKF-309 (IKF-309)		**3.5 (2 - 5) n2**		
unknown	MBI 121 (MBI 121)		*2.0 (2 - 2) n1*		
unknown	SP2700 WP (SP2700)		*2.0 (2 - 2) n1*		
unknown	TDA-NC-1 (TDA)		*1.0 (1 - 1) n1*		
unknown	XDE-659 (XDE-659)		*2.0 (2 - 2) n1*		

Registered and Experimental Products for Powdery Mildew Management

FRAC Class	Fungicides (active ingredients)	Registered Use Site(s)	REI	*Erysiphe* spp.	*Golovinomyces* spp.	*Podosphaera* spp.	*Uncinula astraliana*
Registered Products							
1	3336, OHP 6672, etc. (thiophanate methyl)	G, I, L, N, S	12 h	F-E	F-E	-	E
3	Avelyo, BAS 750 (mefentrifluconazole)	G, I, L, N, S	12 h	-	-	-	-
	Banner MAXX, etc. (propiconazole)	N	12 h	P-E	F-E	G	-
	Bayleton, Strike (triadimefon)*	G, N	12 h	F-G	P-E	P	-
	Eagle, Systhane, etc. (myclobutanil)	G, N	24 h	F-E	G-E	F-E	E
	Rubigan (fenarimol)	G,N	12 h	F	G	-	-
	Terraguard (triflumizole)	G, I, N, S	12 h	F-E	F-E	F-E	-
	Torque, Tebuconazole SC T&O Fungicide, etc. (tebuconazole)	N	12 h	E	E	-	-
	Tourney (metconazole)	N	12 h	E	G-E	E	E
	Trinity (triticonazole)	G, I, L, N,S	12 h	G	**G**	G	-
5	Pipron (piperalin)	G	12 h	E	E	G	-
7	Picatina, A19649B (pydiflumetofen)	G, I, L, N, S	-	G-E	-	-	-
7 + 11	Broadform (fluopyram + trifloxystrobin)	G, I, L, N, S	12 h	-	-	-	-
7 + 11	Orkestra, BAS703 (fluxapyroxad + pyraclostrobin)	G, L, N,S	12 h	E	G	-	-
9 + 12	Palladium (cyprodinil+fludioxonil)	G, L, N, S	12 h	F-E	-	G, E	-
11	Compass (trifloxystrobin)	G, I, L, N, S	12 h	G, E	F-E	F, E	-
	Cygnus (kresoxym-methyl)	G, L, N, S	12 h	P	P-E	E	-
	Disarm (fluoxastrobin)	G, I, N, S	12 h	-	-	P	-
	Heritage (azoxystrobin)	G, L, N, S	4 h	P-E	P-E	P-G	E
	Insignia/Empress (pyraclostrobin)**	**	12 h	G-E	F-E	P-F	
11 + 3	Alibi Flora (azoxystrobin + difenoconazole)	G, L, N, S	12 h	-	-	-	-
	Strike Plus (trifloxystrobin + triadimefon)	G, N	12 h	-	-	-	-
11 + 7	Mural (azoxystrobin+benzovindiflupyr)	G, I, L, N, S	12 h	G-E	G	-	E
	Pageant Intrinsic (pyraclostrobin+boscalid)	G, I, L, N,S	12 h	P-E	E	F-E	G, E
12 + 7	Picatina Flora (fludioxonil+pydiflumetofen)	G, I, L, N, S	-	E	-	-	-
19	Affirm (polyoxin D zinc salt)	G, L, N, S	4 h	-	-	-	-
BM01	Triact 70, Trilogy, etc. (neem oil extract)	G, I, L, N, S	4 h	P-E	P-E	E	-
BM02	Actinovate (*Streptomyces lydicus)*	G, I, L, N, S	1 h	G, F	-	-	-
	Cease, Serenade Optimum, etc. (*Bacillus subtilis*)	G, I, N, S	4 h	P-E	P-G	P	-
	Double Nickel LC, Sentinel (*Bacillus amyloliquefaciens* strain D747)	G, I, N, S	4 h	-	-	E	-
	PlantShield, RootShield (*Trichoderma harzianum*)	G, N, S	0 h	P-G	P-G	P	-
	Stargus, MBI 110 (*Bacillus amyloliquifaciens* strain F727)	G, N, S	4 h	-	-	-	-
M1	Badge (copper hydroxide+copper oxychloride)	G, N, S	48 h	-	-	-	-
	Basicop, Cuprofix (copper sulfate)	G, N, S	48 h	-	-	-	-

Information presented is based on the best data available on *September 17, 2021*.

Registered and Experimental Products for Powdery Mildew Management

FRAC Class	Fungicides (active ingredients)	Registered Use Site(s)	REI	*Erysiphe* spp.	*Golovinomyces* spp.	*Podosphaera* spp.	*Uncinula astraliana*
	Camelot, etc. (copper octanoate)	G, I, N, S	4 h	E	P	-	-
	Champ, Champion, Kentan, Kocide, etc.(copper hydroxide)	G, I N, S	48 h	E	E	-	-
	Copper Count-N, etc. (copper ammonium complex)	G, I N, S	12 h	E	-	-	-
	Nordox (cuprous oxide)	G, I, N, S	24 h	-	-	-	-
	Phyton 27 (copper sulfate pentahydrate)	G, I, N	24 h	G-E	P	-	-
M1 + M3	Junction (copper hydroxide+mancozeb)	G, N	24 h	P-E	P	-	-
M2	Microthiol Disperss etc. (sulfur)	G, N	24 h	G-E	P-G	-	-
M3	Ziram (ziram)	G,N	48 h	-	-	-	-
M3 + 1	Zyban (mancozeb+thiophanate methyl)	G, N	24 h	E	G	E	-
M3 + 3	Clevis (mancozeb+myclobutanil)	G, N	24 h	-	-	-	-
M5	Daconil Ultrex, etc. (chlorothalonil)	G, L, N, S	12 h	F-E	P-E	?	-
M5 + 1	Consyst, Spectro (chlorothalonil+thiophanate methyl)	G, I, N	12 h	-	P	-	-
M5 + 3	Concert (chlorothalonil+propiconazole)	N	12 h	G-E	-	-	E
P05	Regalia (extract of *Reynoutria sachalinensis*)	G, I, L, N, S	4 h	P-G	E	P	-
P07	M-Pede (potassium salts of fatty acids)	G	12 h	-	-	-	-
	Fosphite, Rampart, etc. (phosphorus acid salts)	G, N	4 h	G	G	-	-
NC	Armicarb, Kaligreen, Milstop, etc. (potassium bicarbonate)	G, I, L, N, S	4, 1 h	F-E	F-E	G	-
NC	JMS Stylet Oil, SuffOil-X, etc. (mineral oil, paraffinic oil)	G, N	4 h	P-E	E	-	-
NC	Sil-Matrix (potassium silicate)	G, N	4 h	-	-	-	-
NC	ZeroTol (hydrogen dioxide+peroxyacetic acid)	G, I, N	0 h	P-G	P-G	P	-
-	Cinnacure (cinnamaldehyde)	G, N	4 h	-	-	-	-
-	Kleengrow (Didecyl dimethyl ammonium chloride)	G	48 h	F	-	-	-
Experimental Products							
3	Mettle (tetraconazole)	TBD	12 h	P-G	G	-	-
7	Indemnify (fluopyram) ***	TBD	-	-	-	-	-
	Indiflin (inpyrfluxam)	TBD					
7 + 3	Postiva (pydiflumetofen + difenoconazole)	TBD	-	P-E	-	E	-
50	IKF-309 (pyriofenone)	TBD	-	-	F-E	-	-
BM01	Regime (*Lupinus* extract)	TBD	-	P-G	P	-	-
BM02	Integral Pro, Serifel (*Bacillus amyloliquefaciens* strain MBI 600)	TBD	4 h	G-E	P	-	-
	Zorda (*Bacillus amyloliquefaciens*)	TBD	-	-	-	-	-
U6	NF-149 (cyflufenamid)	TBD	4 h	F-E	G	-	-
U13	Gatten (flutianil)	TBD	12 h	G	-	-	-
-	A20259G (adepydin)	TBD	-	-	E	-	-
-	BAS 9747 (BAS 9747)	TBD	-	-	P	-	-
-	F9944 (F9944)	TBD	-	-	-	-	-
-	GF-4031 (GF-4031)	TBD	-	-	-	-	-

Information presented is based on the best data available on *September 17, 2021*.

FRAC Class	Fungicides (active ingredients)	Registered Use Site(s)	REI	*Erysiphe* spp.	*Golovinomyces* spp.	*Podosphaera* spp.	*Uncinula astraliana*
-	OHPF-1902 (OHPF-1902)	TBD	-	G-E	G	-	-
-	OHPF-1904 (OHPF-1904)	TBD	-	E	E	-	-
-	SP2770 (SP2770)	TBD	-	-	-	-	-

Registered Use Sites: G = Greenhouse; L = Lath House; I = Indoors; N = Nursery; S = Shade House; TBD = To Be Determined
Application Method: D = Drench; S = Spray
Efficacy: E = clearly statistically equivalent or better than untreated non-inoculated and/or clearly statistically different than untreated inoculated; G = statistically different from untreated inoculated and untreated non-inoculated; F = statistically equivalent to both untreated inoculated and untreated non-inoculated; P = statistically equivalent to untreated inoculated. For trials without non-inoculated check, efficacy determined on author's conclusions, % control or comparisons to standard product(s).

Efficacy ratings taken from the 2017 Powdery Mildew Efficacy summary (81 PDMR efficacy reports – 31 Erysiphe, 36 Golovinomyces, 11 Podosphaera, and 3 Uncinula) and 3 IR-4 report (Erysiphe) and 11 2018-2020 PDMR reports. Note that the genera in this table are the current names for powdery mildew pathogens that infect ornamental horticulture crops. Please refer to Table 1 of the 2017 Powdery Mildew Efficacy summary for a short list of historical and current names.

* Will be replaced with Armada 50WDG/Strike Plus (triadimefon + trifloxystrobin).
** Insignia is labeled for use in landscape and turf use only. Empress Intrinsic has replaced Insignia for use in production ornamentals applied as drench to control soil-borne diseases caused by *Fusarium*, *Phytophthora*, *Pythium* and *Rhizoctonia* spp.
*** Bayer supports testing.
**** No longer available for development.

Updated: 9/17/2021