Review of Powdery Mildew Management

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https://www.vegetables.cornell.edu/pest-management/disease-factsheets/

Cornell CALS
College of Agriculture and Life Sciences

Cornell Vegetables

Resources for commercial growers

Disease factsheets and articles

If you were a big fan of the pioneering Vegetable MD Online website, much of that content has been moved here. We are in the process of moving over the rest.

- **(LIHREC)** indicates information from the Long Island Horticultural Research and Extension Center Vegetable Pathology website.
- List also **includes some herbs** (parsley, basil) and **abiotic disorder**
- Some content is available as printer-friendly .pdf versions.

Diseases and management practices affecting multiple crops

- Phytophthora Blight and Its Management in Cucurbit Cr Other Vegetables
- Reduced-tillage for Managing Phytophthora Blight and C Borne Pathogens
- Biofumigation for Managing Phytophthora Blight and Ot Borne Pathogens
- White Mold and Its Management in Cabbage, Beans, and Vegetables
- Diseases of Winter Greens: Downy Mildews, Powdery M Cladosporium Leaf Spot, and Root Rot
- Table: Fungicides for Cucurbit Crops
- Table: Mobile Fungicides for Managing Three Major Cuc Diseases: Powdery Mildew, Downy Mildew, and Phytoph
- Weeds and Crops Susceptible to Viruses in the Northeas
- Disease-resistant varieties
- Managing Pathogens Inside Seed with Hot Water
- Treatments for Managing Bacterial Pathogens in Vegetal
- Do Rotations Matter within Disease Management Progra
- Cropping Sequences and Root Health
- On-Farm Soil Bioassays for Assessing Root Pathogens
- General Guidelines for Managing Fungicide Resistance
- When is the Best Time to Apply Fungicides for Foliar Dis
- Managing Diseases With Sulfur: Is There A Role For Bur Evaporators?
- Organic Management of Vegetable Diseases
- Biopesticides for Organic and Conventional Disease Mar Vegetables
- Copper Fungicides for Organic and Conventional Diseas Management in Vegetables
- Minimizing Injury from Copper Fungicides

Diseases and management practices affecting specific crops

Arugula

- Downy mildew (LIHREC)
- Powdery mildew (LIHREC)

Asparagus

- Herbicide injury (LIHREC)

Basil

- Basil downy mildew

Beans

- Anthracnose
- Bacterial brown spot
- Bacterial diseases
- Chimera (genetic disorder) (LIHREC)
- Ozone injury (LIHREC)
- Phytophthora blight
- Tomato chlorotic spot virus (TCSV)
- Virus diseases of snap and dry beans

Beets and Swiss Chard

- Alternaria leaf spot
- Bacterial leaf spot
- Cercospora leaf spot
- Cercospora leaf spot (LIHREC)
- Phoma leaf spot and root rot
- Rhizoctonia crown and root rot

Carrots

- Leaf blight diseases
- Powdery mildew (LIHREC)

Celery

- Anthracnose
- Septoria leaf spot (LIHREC)

Corn (sweet)

- Sweet corn diseases and control measures
- Common corn smut (LIHREC)

Crucifers (aka brassicas and cole crops)

- Alternaria leaf spot of brassicas
- Alternaria leaf spot of brassicas (LIHREC)
- Bacterial leaf spot on cauliflower (LIHREC)
- Black leg on kale (LIHREC)
- Black rot on Brussels sprouts (LIHREC)
- Black rot on cabbage (LIHREC)
- Black rot on ornamental kale and ornamental cabbage (LIHREC)
- Cabbage chimera (genetic disorder) (LIHREC)
- Clubroot of crucifers
- Clubroot on bok choi (LIHREC)
- Diseases of winter greens: downy mildew, Cladosporium leaf spot, Botrytis crown rot and root rot
- Downy mildew on cabbage (LIHREC)
- Downy mildew on seedlings (LIHREC)
- Fusarium yellows of cabbage & related crops
- Head rot (soft rot) of broccoli (LIHREC)
- Heat stress damage to broccoli heads (LIHREC)
- Powdery mildew (LIHREC)
- Virus diseases of crucifers

Cucurbits

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- Angular leaf spot (LIHREC)
- Anthracnose
- Anthracnose (LIHREC)
- Bacterial leaf spot (renamed Xanthomonas leaf spot) (LIHREC)
- Choanephora fruit rot (LIHREC)
- Downy mildew
- Fusarium crown rot and fruit rot of pumpkin (LIHREC)
- Fusarium fruit rot of other cucurbits (LIHREC)
- Gummy stem blight and black rot (LIHREC)
- Ozone injury (LIHREC)
- Phytophthora blight
- Plectosporium blight (LIHREC)
- Powdery mildew
- Pythium fruit rot (LIHREC)
- Pythium root rot (LIHREC)
- Scab
- Sunscald of pumpkin and winter squash (LIHREC)
- Virus diseases of cucurbits
- White mold on cucurbits (LIHREC)
- Xanthomonas leaf spot (formerly Bacterial leaf spot)

Dill

- Cercosporoid leaf blight (LIHREC)

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Cucurbit Powdery Mildew

Updated: June 2022 Printer-friendly .pdf version of the management information on this page.

See also:

- Newsletter articles:
  Why Manage Cucurbit Powdery Mildew?
  Managing Cucurbit Powdery Mildew Organically – Key Points for Success [Updated 2022-01-25]
  Managing Cucurbit Powdery Mildew Conventionally – Key Points for Success [Updated 2022-01-25]
  Conventional Fungicide Recommendations for Cucurbit Powdery Mildew
- LIHREC Cucurbit powdery mildew photo gallery (**includes diagnostic images**)
- Research on powdery mildew conducted at LIHREC.
- Guidelines on managing cucurbit powdery mildew in 2022.
- Podcast: Avoiding the Powdery Mildew Blues – Meg McGrath, plant pathologist at Cornell's Long Island Horticultural Research and Extension Center, discusses how with other members of the Great Lakes Vegetable Working Group on 24 June 2020. This and other recordings are in the green-bordered box at the bottom of this page.
- Listen to Meg McGrath talk about managing powdery mildew in a teleconference hosted by Steve Bogash of Marrone Bio Innovations on 22 July 2020. Dial 515-604-9875. At prompts enter 832191 for access code and 14 for reference number.
- Results from research on fungicide resistance in the cucurbit powdery mildew pathogen
- Targeted Fungicides for Cucurbit Powdery Mildew
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Topics on this page:

Cucurbit Powdery Mildew

Integrated Disease Management
Cucurbit Powdery Mildew

- Resistant varieties provide limited (pumpkin, squash) to excellent (cucumber, cantaloupe) suppression.
- Onset coincides with start of fruiting.
- Many biopesticides and protectant fungicides (sulfur, chlorothalonil) effective on upper leaf surfaces.
- Targeted fungicides can be excellent.

  Effective on lower leaf surface.

  Resistance is major issue.

  Isolates with multi-fungicide resistance.

  Inherent differences in efficacy including within FRAC group

Betternut 1744

Copyright © Rupp Seeds

Powdery mildew tolerant. Developed by Rupp breeders. Slightly larger than Betternut 900 for farm markets and roadside stands.

Taybelle PM

Copyright © Seminis

A direct conversion from Taybelle to include intermediate resistance to powdery mildew.

HARRIS SEEDS EST 1879

Pumpkin Gladiator

Our #1 variety! Its improved disease protection and grower-preferred fruit size have made Gladiator the number one variety of growers across the country. Raised next to other varieties in field comparisons, Gladiator shows improved homozygous intermediate resistance to powdery mildew. The round, deep orange fruit have moderate ribbing and measure 13" wide x 12" high. Gladiator's long handles are thick and firmly rooted to the 20 to 25 lb. fruit. Vigorous, semi-vine plants produce good yields of these classic, attractive pumpkins that are uniform for size and shape. US Patent 7,166,772.

Squashes and Pumpkins

Intermediate resistance

Powdery mildew tolerant

Homozygous best

control improved with fungicides

Cantaloupe: Race specific resistance. Excellent but specific

Arangina

Arangina is a delicious mid-season ESL Italian melon. Strong plant vigor with good and uniform fruit setting. The fruit is blocky shaped, hard course netting, deep green sutures, dark orange flesh with great firmness and small cavity. Outstanding eating quality. Harvest indicator is when rind changes colors.

Disease Resistance

Fusarium Wilt (0,1,2)

Powdery Mildew (1,2)

Athena

Firm flesh, harvest closer to slip than Super Star. Resembles Saticoy. Excellent disease tolerance.

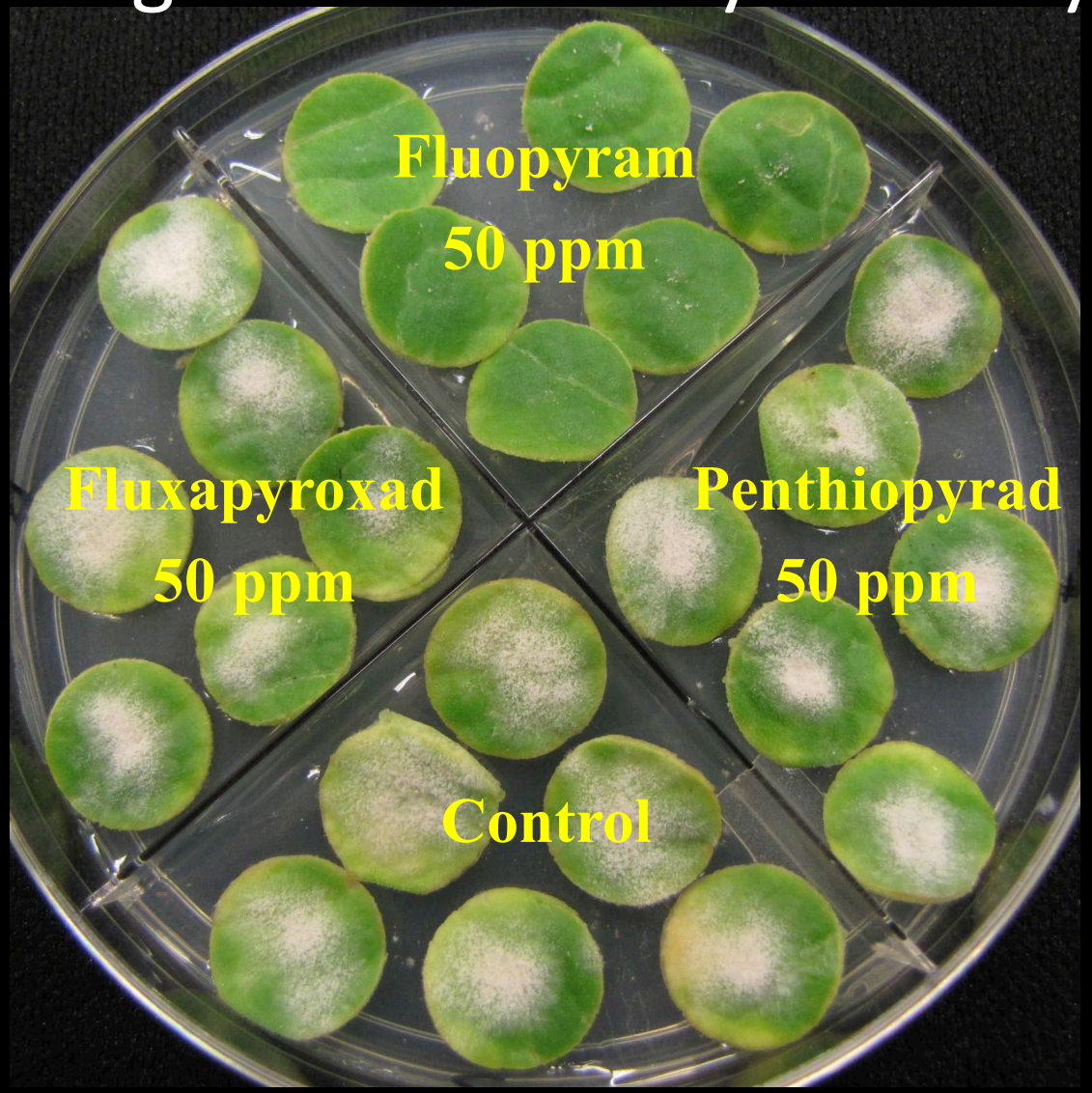
Disease Resistance

Fusarium Wilt 0,1,2

Powdery Mildew 1,2,3,5

Fungicide Evaluation - Pumpkin

Fungicide Sensitivity Bioassay



Fungicides - Cucurbit Powdery Mildew

Fungicide Group	FRAC Code	Fungicide	Active Ingredient	Registered In U.S.	Resistance In U.S.
MBC	1	Benlate	benomyl	1972	1967
DMI	3	Bayleton	triadimefon	1984	1990s
QoI	11	Quadris	azoxystrobin	1999	2002
DMI	3	multiple	multiple	2000-	
SDHI	7	Pristine	boscalid + QoI	2003	2009
Aza-naphthalene	13	Quintec	quinoxyfen	2007	2015
Phenyl-acetamide	U6	Torino	cyflufenamid	2012	2017
Aryl-phenyl-ketone	50	Vivando	metrafenone	2014	
SDHI	7	Luna series	fluopyram	2016	
Cyano-methylene-thiazolidines	U13	Gatten	flutianil	2018	

Fungicide Resistance - Cucurbit Powdery Mildew

MBC fungicides (FRAC 1) – resistance common, single gene.

QoI fungicides (11) – resistance common, single gene.

DMI fungicides (3) - resistance partial. Also range in inherent activity: Proline and Procure most effective. Cevya least.

SDHI fungicides (7) – resistance common to Endura (Pristine, Fontelis, Merivon). partial to Luna Experience, Miravis Prime and Aprovia Top; recommended.

Quintec (13) – resistance detected since 2015. Variable occurrence partly due to use. Efficacy can be impacted.

Torino (U6) – resistance detected since 2017. Variable occurrence partly due to use. Efficacy can be impacted.

Vivando (50) - reduced sensitivity. Prolivo mixed results.

Multi-fungicide resistant isolates detected.

Powdery Mildew Isolate Bioassays – Fungicides

Endura (7)	500 ppm (= field rate)
Torino (U6)	50 ppm (= field rate)
Quintec (13)	200 ppm (= field rate)
Rally (3)	40, 80 ppm (field rate = 300 ppm)
Vivando (50)	50, 150 ppm (field rate = 600 ppm)
Luna Privilege (7)	50, 150 ppm (field rate = 390 ppm)

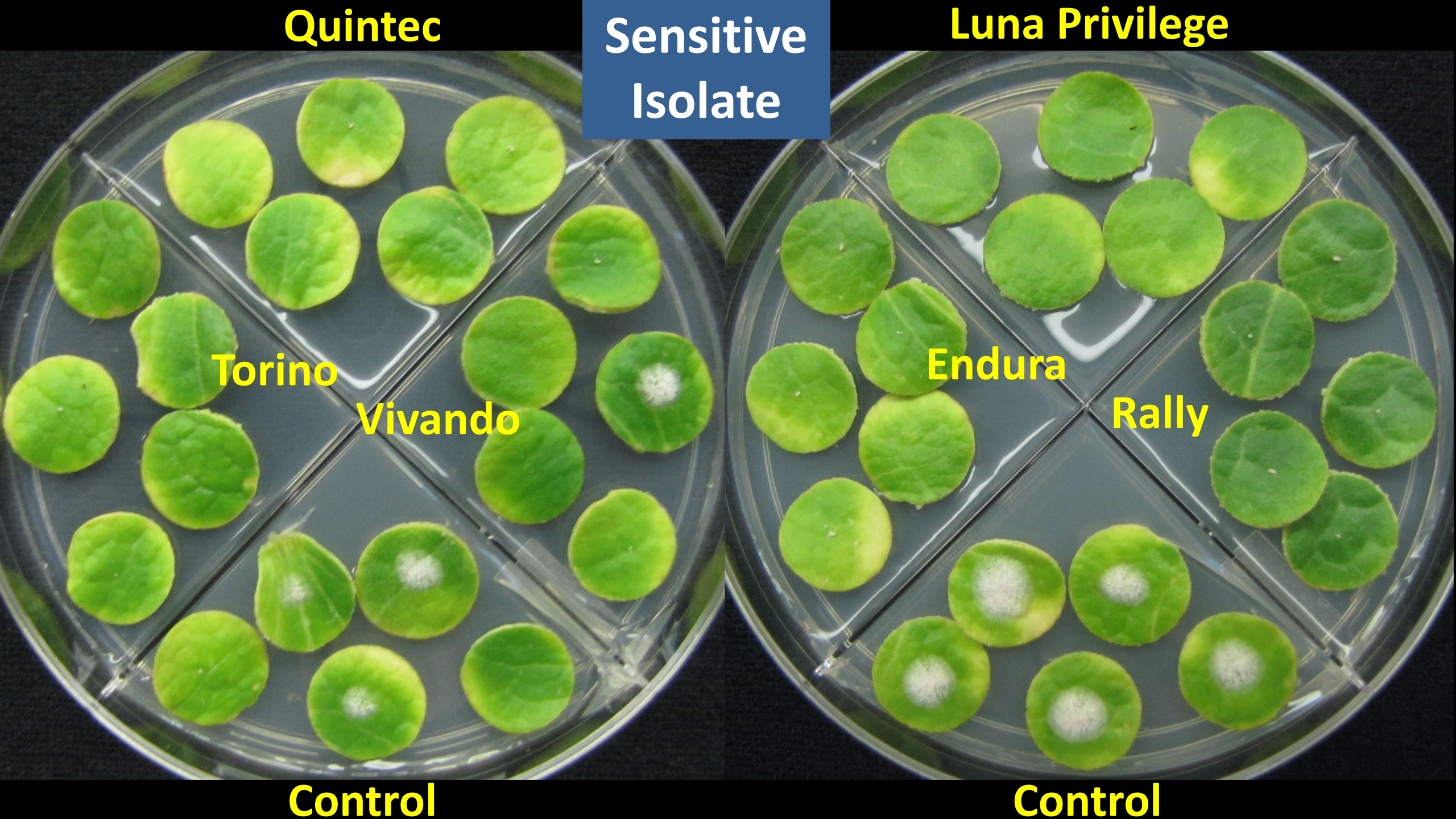
Resistant

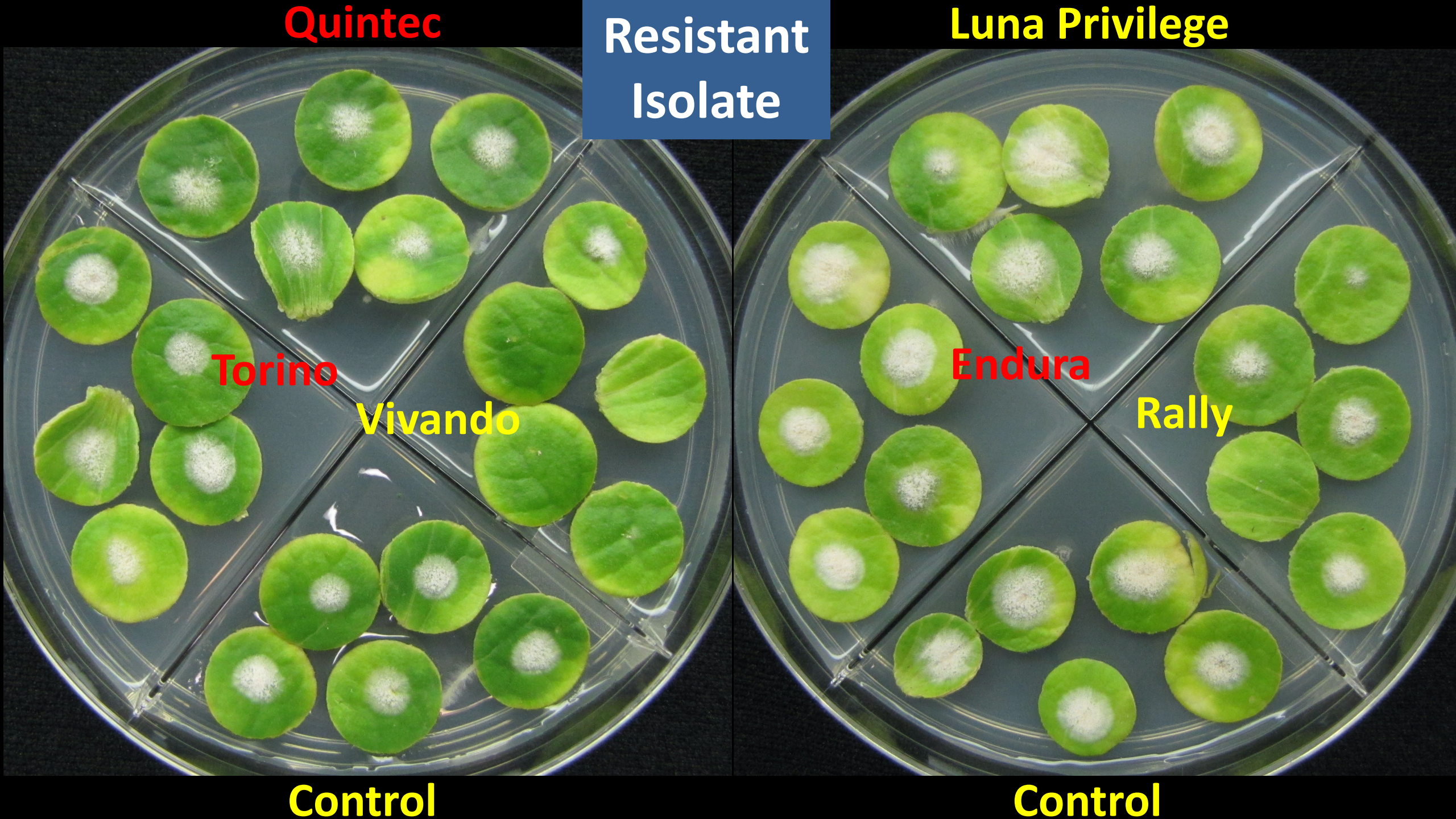
Reduced Sensitivity

Field rate = highest label rate applied at 50 gpa.

Luna Privilege used instead of Luna fungicides labeled for this use because Luna Experience and Luna Sensation have another AI.

Fungicide resistance is result of change in single or multiple genes.


Quintec
Sensitive Isolate
Luna Privilege
Torino
Vivando
Endura
Rally
Control
Control


Quintec
Resistant Isolate
Luna Privilege
Torino
Vivando
Endura
Rally
Control
Control

Fungicide Resistance Occurrence in Powdery Mildew Isolates from Cucurbit Crops, Eastern NY, 2021

	Percent Resistant Isolates		
Powdery Mildew Fungicides used	Torino	Quintec	Endura
Just protectants (copper, chlorothalonil)	0	0	14

Fungicide Resistance Occurrence in Powdery Mildew Isolates from Cucurbit Crops, Eastern NY, 2021

	Percent Resistant Isolates		
Powdery Mildew Fungicides used	Torino	Quintec	Endura
Just protectants (copper, chlorothalonil)	0	0	14
Quintec, Vivando, Vivando (all applied with protectants)	0	0	56

Fungicide Resistance – Powdery Mildew - Eastern NY, 2021

Powdery Mildew Fungicides used	Resistant Isolates (%)		
	Torino	Quintec	Endura
Just protectants (copper, chlorothalonil) **	0	0	14
Quintec, Vivando, Vivando *	0	0	56
Vivando, Quintec, Rhyme, Vivando, Quintec *	0	67	67
Quintec, Vivando, Quintec + Vivando *	67	100	100
Quintec, Rhyme, Prolivo, Gatten, Prolivo, Quintec, Prolivo, Gatten * **	71	71	86

* all applied with protectants

** Fields about 2 miles apart

Fungicide Resistance – Powdery Mildew - Eastern NY, 2021

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	Torino	Quintec	Endura
Just protectants (copper, chlorothalonil)	0	0	0
Quintec, Vivando, Vivando *	0	0	14
Vivando, Quintec, Rhyme, Vivando, Quintec *	0	67	67
Quintec, Vivando, Quintec + Vivando *	50	100	100
Quintec, Rhyme, Prolivo, Gatten, Prolivo, Quintec, Prolivo, Gatten *	71	71	86
Gatten, Vivando, Gatten *	11	11	44

* all applied with protectants

Fungicide Resistance - Cucurbit Powdery Mildew

Resistant isolates are fit. Found in plantings not treated.

Frequency of resistance in a planting can change with fungicide use during a season.

Applying a fungicide ineffective due to resistance may not be evident when other fungicides used are effective.

Pathogen isolates with resistance to multiple fungicide chemistry groups have been found increasingly. Until 2022??

All 2020 isolates found to be resistant to Quintec were also resistant to Torino, Endura, and QoI fungicides.

Expect resistance to develop to additional fungicides.

Fungicide Resistance - Cucurbit Powdery Mildew

2022 Preliminary Results:

76 isolates tested. 37 resistant to Endura.

6 resistant to Torino. 8 resistant to Quintec.

JUST ONE MULTI-FUNGICIDE RESISTANT ISOLATE SO FAR!!

Fungicides used: Quintec applied once in 1 crop.

Vivando or Prolivo. Rhyme, Inspire Super. Miravis Prime

Fungicide Programs - Cucurbit Powdery Mildew

Proline, Vivando, Proline, Vivando, Procure, Vivando

Vivando, Vivando, Aprovia Top, Aprovia Top, Vivando

FRAC: 50 3 3 + 7 7

Others: Prolivo Rhyme Luna Experience Miravis Prime

leftover Quintec or Torino 1 application

Gatten has not been as effective in efficacy trials.

Start preventive (start of fruit formation) or at threshold (1 of 50 older leaves)

Apply with protectant:

sulfur, mineral oil, chlorothalonil, biopesticide

organic Biopesticides

Cucurbit Mildews + Other Diseases

Double Nickel. *Bacillus amyloliquefacinens* strain D747
Taegro 2. *Bacillus amyloliquefaciens* strain FZB24
Serifel. *Bacillus amyloliquefacinens* strain MBI 600
LifeGard. *Bacillus mycoides* isolate J
Sonata. *Bacillus pumilus* strain QST 2808
Aviv. *Bacillus subtilis* strain IAB/BS03
Companion. *Bacillus subtilis* strain GB03
Serenade. *Bacillus subtilis* strain QST 713
LALSTOP G46 / Prestop. *Gliocladium catenulatum* J1446
Romeo. cerevisane (cell walls of *Saccharomyces cerevisiae*)
Howler. *Pseudomonas chlororaphis* strain AFS009

Carb-O-Nator. potassium bicarbonate
Kaligreen. potassium bicarbonate
MilStop. potassium bicarbonate

Regalia. extract of giant knotweed.
EcoSwing. extract of *Swinglea glutinosa.*
Problad Verde. Banda de Lupinus albus doce.
ECOWORKS. cold pressed neem oil.
Rango. cold pressed neem oil.
TerraNeem. cold pressed neem oil.
Trilogy. extract of neem oil.
Timorex Act. tea tree oil.
Thymox Control. thyme oil.
GreenFurrow BacStop. several botanical oils.
GreenFurrow EF400. several botanical oils.
Mildew Cure. several botanical oils.
Sporan EC². several botanical oils.

Sil-MATRIX. potassium silicate
OSO. polyoxin D zinc salt
PerCarb. sodium carbonate peroxyhydrate
Seican. cinnamaldehyde

Role of Biopesticides in Cucurbit Disease MGT

Organic production.

Good coverage important because of contact activity.

Conventional production:

In place of contact fungicides (chlorothalonil, copper) tank mixed with targeted fungicides.

Applied in place of targeted fungicides.

Preventive and late season best.

Biopesticide Efficacy – Powdery Mildew - Pumpkin

% Control based on AUDPC on both leaf surfaces 2022

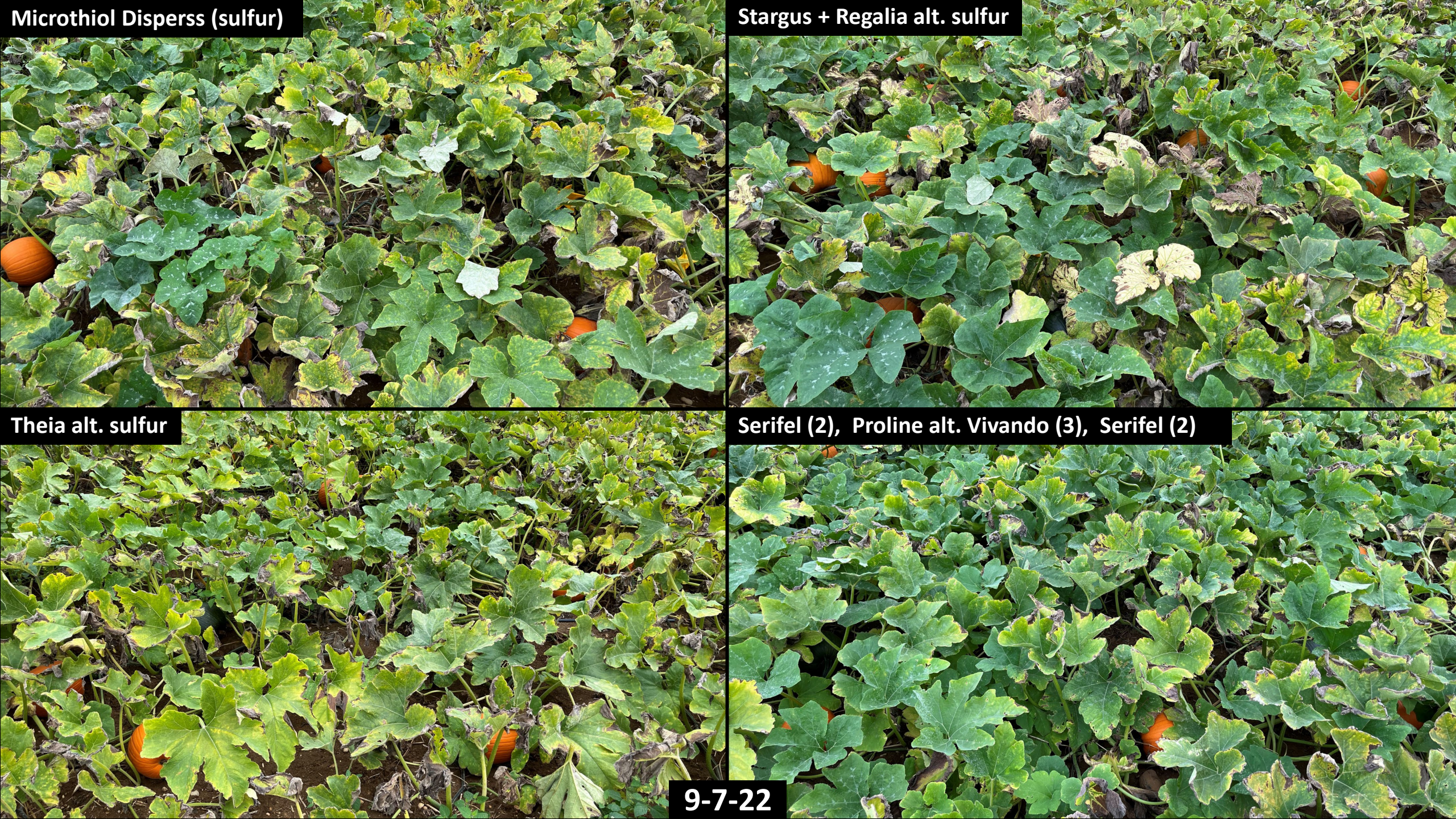
Fungicide (7-day)	Upper		Lower	
Serifel	69	b	27	abc
Stargus + Regalia	71	bc	17	ab
Trillium	73	bc	24	abc
Theia	76	bc	24	abc
Microthiol Disperss (sulfur)	99	d	33	bc
Stargus + Regalia alt. sulfur	96	d	35	bc
Theia alt. sulfur	96	d	37	bc

Trial conducted on powdery mildew intermediate resistant 'Bayhorse Gold'.
First application 21 July before powdery mildew seen.
Values in column with same letter not statistically different. a=ineffective.


Biopesticides & Conventional Fungicides
Powdery Mildew on Pumpkin
8-5-22


Control
Microthiol Disperss
Serifel
Theia
9-7-22


Stargus + Regalia
Trillium
Serifel
Theia
9-7-22


Microthiol Disperss (sulfur)
Stargus + Regalia alt. sulfur
Theia alt. sulfur
Serifel (2), Proline alt. Vivando (3), Serifel (2)
9-7-22

Biopesticide Efficacy – Powdery Mildew - Pumpkin

% Control based on AUDPC on both leaf surfaces 2022

Fungicide (7-day)	Upper		Lower	
Theia (2), Proline alt Vivando (3), Theia (2)	95	c	83	b
Serifel (2), Proline alt Vivando (3), Serifel (2)	93	bc	87	b
TACT (2), Proline alt Vivando (3), TACT (2)	91	bc	84	b
Proline alt Vivando (3)	68	b	83	b
Proline alt Vivando alt Procure (5)	99	c	90	b

Trial conducted on powdery mildew susceptible 'Gold Challenger'.
First application 21 July before powdery mildew seen.
TACT = Timorex ACT
Values in column with same letter not statistically different. a=ineffective.


Control
Serifel, Proline, Vivando
sulfur, Proline, Vivando
Proline, Vivando (3 apps)
Proline, Vivando, Procure (5 apps)
9-7-22


Control
Serifel, Proline, Vivando
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9-12-22

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Topics on this page:

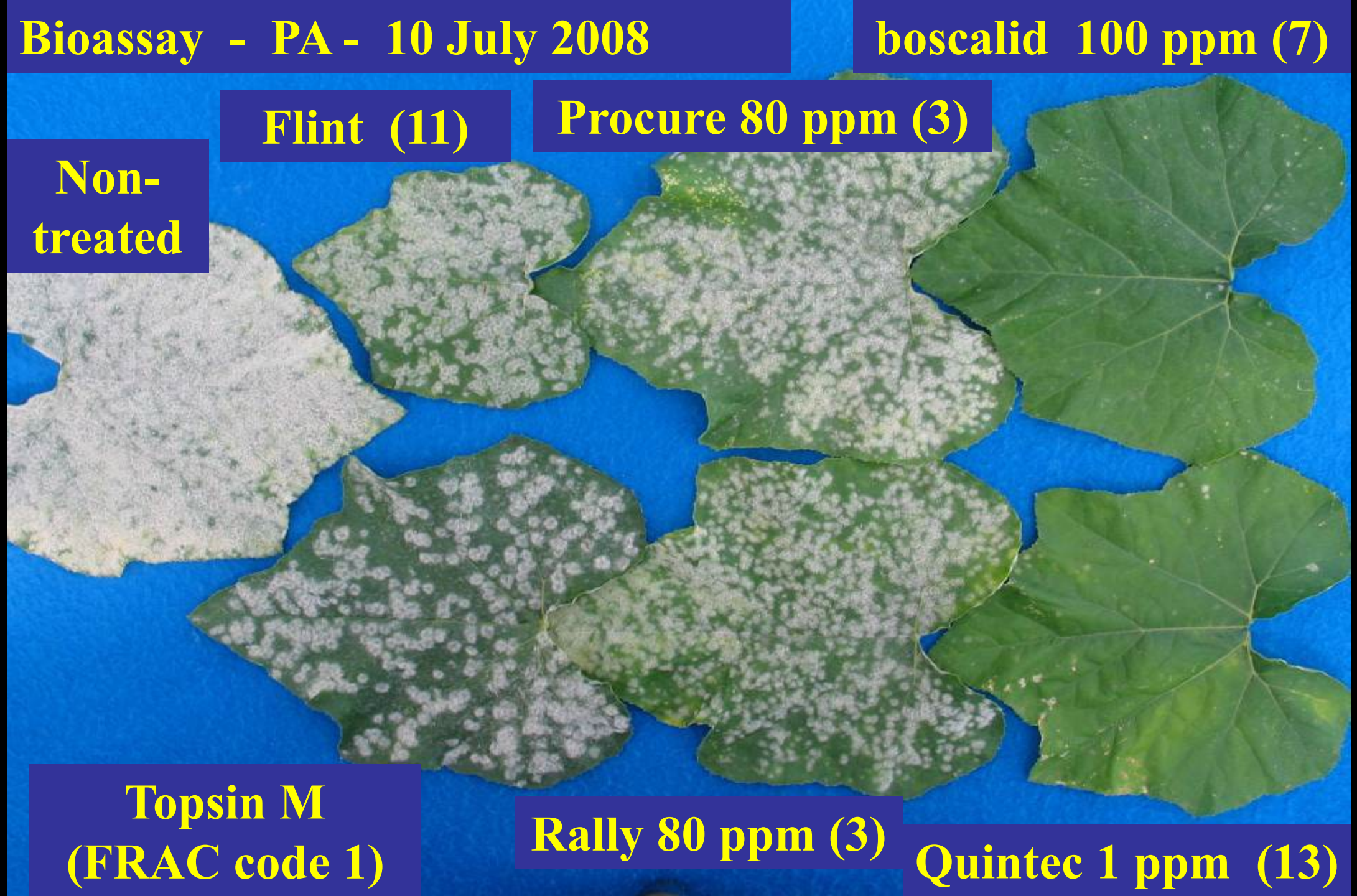
Table contains many conventional fungicides labeled for diseases of cucurbit crops, approximate cost per acre of an application, number of acres that can be treated with the package size available, and diseases labeled. Most products listed have mobility and/or targeted activity. The last three are contact protectant fungicides.

Fungicide	Price	Unit	Rate/A	Unit	Cost/A	Pkg Size	A/treated	AB	AL	A	ALS	BLS	DM	F	GSB	PhB	PIB	PM	S
Actigard	$57.08	oz	0.5-1	oz	$29-57	8 oz	8-16				R	R	L					L	L
Aprovia Top 1.62 EC	$389.91	gal	10.5-13.5	fl oz	$32-41	1 gal	9.5-12.2	R	R	R					R		R		R
Curzate 60 DF	$57.16	lb	3.2-5	oz	$11-18	4 lb	12.8-20						R						
Elumin 4 SC	$467.99	gal	8	fl oz	$29	1 gal	16						R			R			
Endura	$92.11	lb	6.5	oz	$37	6.5 lb	16	R							nr			nr	
Forum 4.17 SC	$391.96	gal	6	fl oz	$18	1 gal	21.3						R/nr			R			
Gatten	$125	qt	6-8	fl oz	$23-31	1 qt	4-5.3											R	
Gavel 75 DF	$12.49	lb	1.5-2	lb	$19-25	30 lb	15-20						R			R			
Inspire Super 2.82 EW	$325.13	gal	16-20	fl oz	$41-51	1 gal	6.4-8.0	R	R	R					R		R	nr	
Luna Experience 3.34 SC	$5.93	oz	6-17	fl oz	$36-101	32 oz	1.9-5.3		R	R					R			R	
Miravis Prime 3.34 SC	$569.08	gal	9.2-11.4	fl oz	$41-51	2.5 gal	28.1-34.8	R	R						R			R	R
Omega	$506.68	gal	0.75-1.5	pt	$48-95	2.5 gal	13.3-26.7		R				R		R	R			
Orondis Gold	$1,838.30	case			$92-184											R			
Orondis Opti	$210.49	gal	1.75-2.5	pt	$46-66	2.5 gal	8.0-11.4						R						
Orondis Ultra	$1,018.50	gal	5.5-8	fl oz	$44-64	1 gal	16.0-23.3									R			
Phiticide (phosphorus acid)	$21.40	gal	2.5-5	pt	$7-13	2.5 gal	4.0-8.0						nr			R			
Presidio 4 SC	$350.93	qt	3-4	fl oz	$33-44	1 qt	8.0-10.7						R/nr			R			
Previcur Flex 6F	$92.09	gal	1.2	pt	$14	2.5 gal	16.7						R/nr						
Pristine 38 WG	$3.90	oz	12.5-18.5	oz	$49-72	120 oz	6.5-9.6											nr	
Procure 480 SC	$113.69	qt	4-8	fl oz	$14-28	1 qt	4.0-8.0											R	
Proline 480 SC	$655.94	gal	5.7	fl oz	$29	2.5 gal	56.1							R	R			R	
Prolivo	$4.40	oz	4-5	fl oz	$18-22	32 oz	6.4-8.0											nr	
Quintec 2.08 SC	$4.46	oz	4-6	fl oz	$18-27	30 oz	5-7.5											R	
Rally 40 WSP	$3.93	oz	2.5-5	oz	$10-20	20 oz	4-8											nr	
Ranman 400 SC	$1,180.93	gal	2.1-2.75	fl oz	$19-25	1 qt	11.6-15.2						R			R			
Revus	$505	gal	8	fl oz	$32	1 gal	16.0						R/nr			R			
Rhyme 2.08 SC	$3.46	oz	5-7	fl oz	$17-24	50 oz	7.1-10.0								R			R	
Switch	$6.96	oz	11-14	oz	$77-97	28 oz	2-2.5	R	R						R			L	
Tanos 50 DF	$57.65	lb	8	oz	$29	7.5 lb	15						nr						
Torino 0.85 SC	$8.94	oz	3.4	oz	$30	34 oz	10.0											nr	
Vivando 2.5 SC	$311.87	gal	15.4	fl oz	$38	1 gal	8.3											R	
Zampro 525SC	$3.30	oz	14	fl oz	$46	140 oz	10.0						R			R			
Zing! 4.9 SC	$97.91	gal	36	fl oz	$28	2.5 gal	8.9						R			R			

are YOU awake for Questions?!?

In-Field Seedling Bioassay

- detecting fungicide resistance
- conducted in commercial crops and research fields


Bioassay - PA - 10 July 2008
boscalid 100 ppm (7)
Flint (11)
Procure 80 ppm (3)
Non-treated
Topsin M (FRAC code 1)
Rally 80 ppm (3)
Quintec 1 ppm (13)