Evaluation of fungicide programs for management of bunch rot of grapes: 2023 field trials

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Summer bunch rot/sour rot and Aspergillus Vine Canker of Grapevine

Current Management Options

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BACKGROUND: Summer bunch rot (SBR) is a disease complex affecting grapes caused by multiple organisms such as *Botrytis cinerea, Aspergillus tubingensis*, *A. carbonarius*, *A. niger*, *Alternaria* sp. *Cladosporium* sp., *Rhizopus* sp., and *Penicillium* sp. (Fig. 1-2). Ripening berries (> 8° Brix) are susceptible to infection by these fungi that frequently enter through injuries caused by insects or birds, mechanical injury (especially during mechanical leaf removal), or scars caused by powdery mildew (Fig. 3). SBR is more prevalent in the warmer areas of central and southern San Joaquin Valley, whereas Botrytis bunch rot (only by *Botrytis* spp.) is more common in the cooler northern San Joaquin Valley and coastal production areas. Recently, sour rot (or melting decay) has separately been characterized from SBR, differing by the presence of yeasts and acetic acid bacteria that produce a vinegar-like smell. Both yeast and bacteria can be spread by vinegar fruit flies (*Drosophila*) that are attracted to the rotting clusters (Fig. 2B). By the time sour rot has developed, it is often difficult to determine the primary cause. Our studies have shown that these Aspergillus species associated with SBR can also cause Aspergillus vine canker (AVC) on grapevine wood (Fig. 4), a disease different from common grapevine trunk diseases. A single vine can harbor multiple *Aspergillus* species located on different parts of the vine, including the trunk, cordon, and spurs.

SYMPTOMS: Summer bunch rot can be recognized by masses of black, brown, or green spores on the surface of the berries (Fig. 2, 3), leakage of berry juices, and the presence of vinegar flies. Symptoms include hairline cracks in the berry skin, watery discoloration of berries, and general berry breakdown. Decay continues to develop slowly under cold storage conditions.
Aspergillus vine canker can be easily distinguishable by their premature senescence of leaves during the fall, while healthy vines are still green (Fig. 4A). Black sporulation at the surface and underneath the bark of affected tissues is very common (Fig. 4D). Internally, a brown discoloration is evident in the xylem near the margin of the cankers (Fig. 4B), whereas the areas under the sporulation show necrosis and black discoloration near the bark (Fig. 4C). In severe cases, the canker can girdle most of the vascular area.

LIFE CYCLE: Botrytis overwinters as sclerotia in mummified berries on the vine, ground, or dormant canes. The disease may first appear as shoot blight following frequent spring rains; flowers can become infected during bloom (Bulit and Dubos, 1988). In infected fruits, disease symptoms are latent until late in the season. As sugar concentration increases in the berry, the fungus resumes growth and infects the entire fruit, often resulting in berry splitting and sporulation on the fruit surface (Flaherty et al,. 1992). Free water is a requirement for the pathogen, and favorable conditions include humidity exceeding 90% and temperatures between 15-27° (Bulit and Dubos; 1988, Gubler et al. 2008; Steel et al., 2011). Along with leaf removal and other cultural controls, good spray coverage with a synthetic fungicide is currently the most effective form of disease management.

MANAGEMENT: Canopy management practices such as shoot thinning, hedging, and leaf removal can be used to manage canopy density when appropriate. Removal of basal leaves immediately after berry set can significantly reduce disease incidence and severity. In warmer growing areas, excessive leaf removal may result in sunburned fruit. This condition worsens when leaves are removed later in the season, especially on canopies with southern and western afternoon exposures. Our laboratory annually examines the efficacy of fungicide treatment programs to prevent and control these complex diseases using synthetic, biological, and organic fungicides. Results from these trials can be found on our lab website at https://ucanr.edu/sites/eskalenlab

Figure 1. Summer bunch rot symptoms on table grape

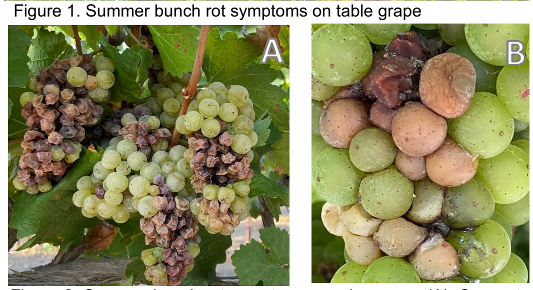

Figure 2. Summer bunch rot symptoms on wine grape (A). Sour rot and fruit flies (B).

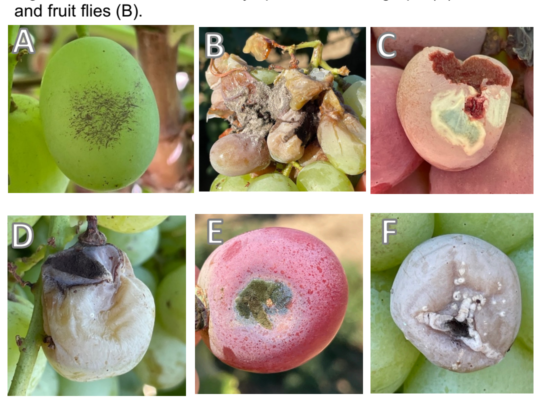

Figure 3. Various summer bunch rot/sour rot symptoms on berries (B-F). Powdery mildew scar (A), Botrytis (B), Penicillium (C), Aspergillus (D), Cladosporium (E), yeast (F).

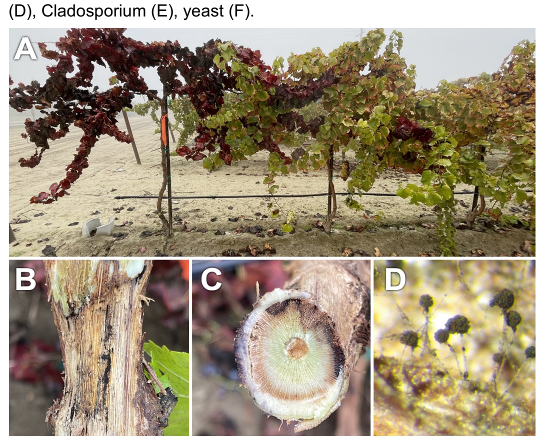

Figure 4. Symptoms of Aspergillus Vine Canker of grapes in California. Premature senescence of the canopy during the fall (A). Sporulation on cankered tissue (B). Cross-section of a trunk showing cankers (C). Sporulation of black aspergilli on decayed berries (D).

In this trial, we examined the efficacy of 47 experimental and registered fungicide treatment programs (Table 1) for control of Botrytis bunch rot and sour rot in Riesling vineyard in Clarksburg in 2023

Materials and Methods

A. Experimental design

Table 1. Experimental design

Experimental design	Completely randomized design with 5 replicates		
Experimental unit	3 adjacent vines = 1 plot		
Row and tree spacing	11 ft (row) and 5 ft (vine)	Plot unit area	165 ft^2
Area/treatment	825 ft^2 or 0.01956 acre/treatment (5 replicates = 1 treatment)		
Fungicide Applications, Volume water/Acre	A bloom, May 25th, 100 gallons = 1.5152 gal/5 reps B pre-close, June 22th, 150 gallons = 2.2727 gal/5 reps C veraison, August 6st, 150 gallons = 2.2727 gal/5 reps D pre-harvest, August 23rd, 150 gallons = 2.2727 gal/5 reps		
Equipment	Stihl SR 430 Backpack Sprayers		

B. Experimental treatments

The treatments described in this report were conducted for experimental purposes only and crops treated in a similar manner may not be suitable for commercial or other use.

C. Vine Management

During the application period, vines were irrigated by drip irrigation. Sucker shoot removal and leafing were done during the duration of trial.

C. Data Collection and Statistics

Daily temperature and precipitation were obtained from a CIMIS weather station in Sacramento Valley (Station 243). The temperature data is shown in Figure 1.

Disease was assessed on September 18th. Bunch rot (Botrytis Bunch Rot and Sour Rot) incidence and severity were assessed in each treatment by evaluating twenty-five random clusters. Incidence was defined as the proportion of clusters in a plot having bunch rot. Severity was determined by estimating the percentage of area of a cluster that was infected; the severity value of all clusters was then averaged to give a plot-wide estimate of disease severity. Mean incidence and severity values for each treatment were computed. Trial models were analyzed using the ANOVA Tests for data. Means comparisons were made using Fisher's LSD with α=0.05.

E. Map

N →

R1	R2	R3	R4	R5	R6	R7	R8
12-Y	50-B+G	23-RS+R	21-R	10-OKS	11-ONS	8-OC+O	15-YC
3-KD	24-RC+R	25-RKD	48-B+K	48-B+K	8-OC+O	23-RS+R	16-YKD
38-BKD	41-Pu	15-YC	5-KC	2-K	12-Y	9-OKD	7-OS+O
6-O	45-PKD	27-RKC	38-BKD	6-O	41-Pu	7-OS+O	47-PKC
40-BKC	15-YC	3-KD	37-BC	x	43-PWS	5-KC	26-RKS
14-YS	9-OKD	46-PKS	18-YKC	x	33-GKC	36-BS	14-YS
43-PWS	21-R	22-RD	46-PKS	x	50-B+G	25-RKD	x
33-GKC	30-GS	41-Pu	22-RD	x	6-O	47-PKC	x
11-ONS	48-B+K	16-YKD	44-PWC	10-OKS	35-BD	27-RKC	x
35-BD	26-RKS	16-YKD	1-W	33-GKC	34-B	24-RC+R	32-GKS
x	24-RC+R	8-OC+O	32-GKS	21-R	19-YRD	38-BKD	34-B
x	49-B+Y	17-YKS	10-OKS	18-YKC	24-RC+R	46-PKS	7-OS+O
15-YC	14-YS	22-RD	6-O	39-BKS	12-Y	6-O	42-PWD
24-RC+R	11-ONS	9-OKD	33-GKC	4-KS	20-YRS	42-PWD	11-ONS
10-OKS	13-YD	1-W	28-G	26-RKS	2-K	2-K	50-B+G
49-B+Y	36-BS	12-Y	25-RKD	39-BKS	47-PKC	44-PWC	15-YC
21-R	29-GD	28-G	31-GKD	25-RKD	43-PWS	50-B+G	3-KD
40-BKC	4-KS	2-K	36-BS	x	29-GD	1-W	32-GKS
4-KS	35-BD	36-BS	14-YS	x	19-YRD	35-BD	5-KC
48-B+K	33-GKC	41-Pu	19-YRD	40-BKC	45-PKD	11-ONS	42-PWD
29-GD	49-B+Y	31-GKD	17-YKS	1-W	5-KC	9-OKD	17-YKS
18-YKC	38-BKD	20-YRS	13-YD	26-RKS	31-GKD	29-GD	48-B+K
49-B+Y	17-YKS	26-RKS	9-OKD	43-PWS	43-PWS	12-Y	8-OC+O
13-YD	21-R	27-RKC	50-B+G	27-RKC	39-BKS	46-PKS	10-OKS
27-RKC	2-K	42-PWD	19-YRD	18-YKC	5-KC	39-BKS	4-KS
22-RD	37-BC	14-YS	32-GKS	8-OC+O	40-BKC	30-GS	45-PKD
42-PWD	7-OS+O	19-YRD	x	20-YRS	47-PKC	44-PWC	16-YKD
46-PKS	36-BS	45-PKD	4-KS	22-RD	7-OS+O	28-G	3-KD
	47-PKC	30-GS	28-G	39-BKS	41-Pu	37-BC	49-B+Y
			31-GKD	17-YKS			34-B
				3-KD			23-RS+R
				35-BD			
				13-YD			

Color	
Blue	B
Green	G
Black	K
Orange	O
Pink	P
Purple	PU
Red	R
Yellow	Y
White	W
Gray	N

Pattern	
Checker	C
Dot	D
Stripe	S

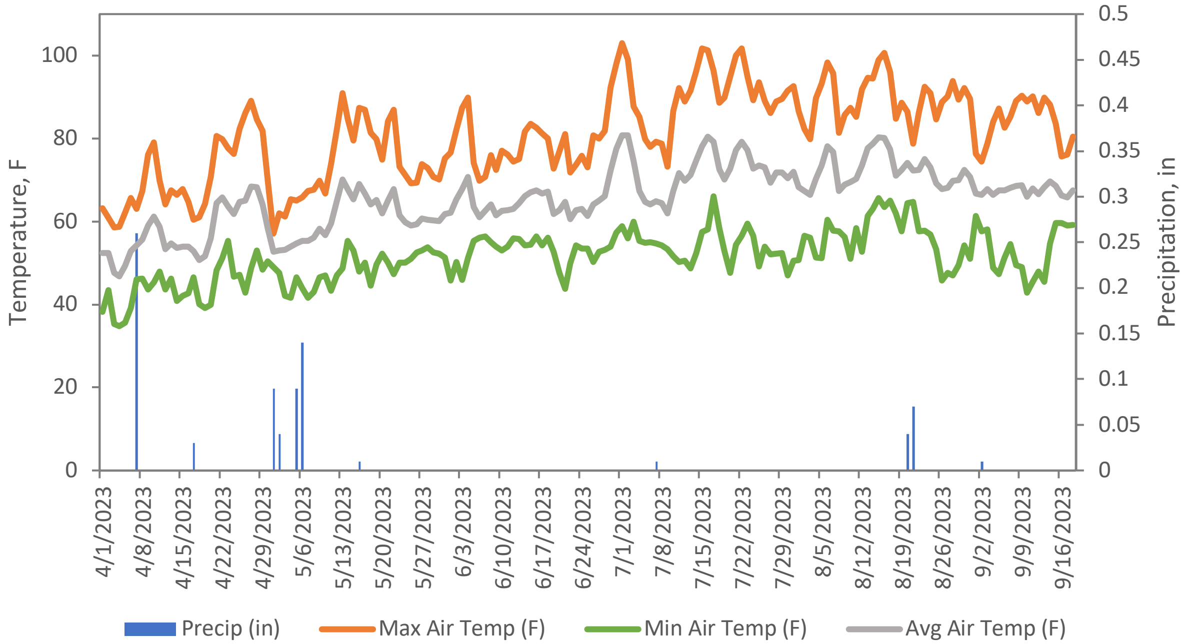

Figure 1. Average daily temperature (°C) and precipitation (mm) from May 1st to September 18th, 2023 from CIMIS station 243 Sacramento Valley CA.

F. Pictures of Treatments

Pictures of each treatment can be reached by clicking on the active link on each trial number in the result tables.

G. Results

Table 2. Disease incidence and severity. Product names are followed by rate (per acre) Treatment means followed by the same letter are not significantly different according to Fisher's LSD at α=0.05

Treatment [x]			Application time [y]	Bunch rot on the clusters [z]	
Pictures	Flag	Rate/Acre		Incidence, %	Severity, %
40	BKC	Evoca 3 lb + Activator-90 16 fl oz/100 gal Pristine 23 oz Elevate 16 oz	A,D B C	8.0 a	1.0 a
50	B+G	SA-0650004 28 fl oz Vangard WG 10 oz SA-0650004 28 floz Ph-D 6.2 oz + Syl-Coat 4 fl oz	A B C D	14.4 ab	0.9 a
29	GD	Miravis Prime 13.4 fl oz + Dyne-Amic 0.125% v/v Vangard 10.0 oz + Dyne-Amic 0.125% v/v Switch 14.0 oz + Dyne-Amic 0.125% v/v	A, C B D	15.2 a-c	1.4 a
42	PWD	Mevalon 55 fl oz Vangard WG 10 oz Elevate 50WDG 1 lb Ph-D 6.2 oz + Syl-Coat 4 fl oz	A B C D	16.0 a-d	1.0 a
6	O	V6M-5-7 27.4 fl oz + Dyne-Amic 0.125%v/v	A,B,C,D	17.6 a-e	1.8 a

30	GS	Vangard 10.0 oz+ Dyne-Amic 0.125% v/v Miravis Prime 13.4 fl oz + Dyne-Amic 0.125% v/v	A, D B, C	17.6	a-e	2.0	a
27	RKC	Kaligreen 5lb	A,B,C,D	20.0	a-g	2.6	a-c
41	Pu	Evoca 3 lb + Activator-90 16 fl oz Elevate 16 oz	A, B, D C	20.0	a-g	0.9	a
15	YC	Stargus 2 qt	A,B,C,D	20.8	a-g	1.4	a
35	BD	ApF23002 64 fl oz + Dyne-Amic 0.125% v/v Switch 14 oz Elevate 16 oz	A, C B D	20.8	a-g	2.2	ab
2	K	Switch 14 oz Pristine 23 oz Elevate 16 oz	A,D B C	23.2	a-h	2.4	ab
5	KC	Serenade 4 qts + Dyne-Amic 0.125% v/v	A,B,C,D	23.2	a-h	2.4	ab
14	YS	CX-10490 14 fl oz	A,B,C,D	23.2	a-h	4.1	a-d
18	YKC	Howler EVO 1.5 lb + Dyne-Amic 0.125% v/v Switch 62.5 WD 14 oz/A + Dyne-Amic 0.125% v/v Howler EVO 1.25 lb + Dyne-Amic 0.125% v/v Elevate 1 lb + Dyne-Amic 0.125% v/v	A B C D	23.2	a-h	2.8	a-c
32	GKS	ApF23002 64 fl oz + Kinetic 0.125% v/v	A,B,C,D	23.2	a-h	1.3	a
38	BKD	Evoca 3 lbs Pristine 23 oz Elevate 16 oz	A,D B C	23.2	a-h	3.5	a-d
48	B+K	Mevalone 55 fl oz Vangard WG 10 oz Elevate 50WDG 1 lb Mevalone 55 fl oz + Syl-Coat 4 fl oz	A B C D	23.2	a-h	2.1	ab
4	KS	NAI-9090 (BEC-60) 3 qt + Dyne-Amic 0.125% v/v	A,B,C,D	24.0	a-i	5.0	a-d
21	R	Fun-Thyme 0.5% v/v	A,B,C,D	24.0	a-i	2.7	a-c
39	BKS	Evoca 3 lbs Elevate 16 oz	A,B,D C	24.0	a-i	1.6	a
20	YRS	X7N68-R009 16 fl oz	A,B,C,D	24.8	a-j	5.7	a-d
22	RD	B-Red 1% v/v	A,B,C,D	24.8	a-j	4.3	a-d
24	RC+R	Cinnaction (OR-489-E) 50 fl. oz + Attitude (OR-278F) 32 fl oz	A,B,C,D	26.4	b-k	3.2	a-c
25	RKD	NSTKI-037 4 lb	A,B,C,D	27.2	b-k	4.1	a-d
33	GKC	ApF23002 64 fl oz + Kinetic 0.125% v/v Switch Elevate	A,C B D	27.2	b-k	2.1	ab
34	B	ApF23002 64 fl oz + Kinetic 0.125% v/v ApF23002 64 fl oz + Dyne-Amic 0.125% v/v	A B,C,D	27.2	b-k	1.9	a
13	YD	Milagrum Plus (OR-488) 60 fl. oz + Vintre (OR-009E)32 fl oz	A,B,C,D	28.0	b-k	2.0	a
36	BS	Hydrogen perocside 30% 12.8 fl oz/100 gal + Fitor 25.6 fl oz/100 gal + Phosful 12.8 fl oz/100 gal	A,B,C,D	28.0	b-k	5.9	a-d
47	PKC	ProBlad Verde 45 fl oz/a	A,B,C,D	28.0	b-k	2.8	a-c
17	YKS	Serenade ASO 4 qt + Dyne-Amic 0.125% v/v Switch 62.5 WD 14 oz + Dyne-Amic 0.125% v/v Elevate 1 lb + Dyne-Amic 0.125% v/v	A,C B D	28.8	b-k	2.8	a-c
43	PWS	Mevalone 55 fl oz Vangard WG 10 oz Ph-D 6.2 oz + Syl-Coat 4 floz	A,C B D	29.6	b-k	4.2	a-d
45	PKD	WE2097-1 0.5% V/V + Antero-EA 1pt	A,B,C,D	30.4	b-k	7.4	b-d
46	PKS	WE1891-1 2.5lb + WE2097-1 0.5% V/V + Antero-EA 1pt	A,B,C,D	30.4	b-k	7.6	cd
49	B+Y	SA-0650004 28 fl oz Vangard WG 10 oz Elevate 50WDG 1 lb Ph-D 6.2 oz + Syl-Coat4 fl oz	A B C D	30.4	b-k	3.1	a-c
12	Y	Milagrum Plus (OR-488) 60 fl. oz + Oroboost (OR-097A) 32 fl oz	A,B,C,D	31.2	b-k	2.8	a-c

16	YKD	MBI-1P1 0.5 qt	A,B,C,D	32.0	c-k	4.2	a-d
31	GKD	Mevalone 55 fl oz + Kinetic 0.125% v/v Switch 14 oz Elevate 16oz	A,C B D	32.0	c-k	5.1	a-d
8	OC+O	OSO 6.5 fl oz	A,B,C,D	32.8	d-k	4.1	a-d
11	ONS	Thymic (OR-491) 50 fl. oz + Attitude (OR-278F) at 32 fl oz	A,B,C,D	34.4	e-k	6.1	a-d
19	YRD	Howler EVO 1.25 lb + Rovral 1.5 lb + Dyne-Amic 0.125% v/v Switch 14 oz + Dyne-Amic 0.125% v/v Elevate 1 lb + Dyne-Amic 0.125% v/v	A,C B D	34.4	e-k	3.1	a-c
28	G	Luna Experience: 8.6 fl oz Pristine 23 oz Elevate 16 oz Berezi 5 lb	A B C D	34.4	e-k	5.4	a-d
44	PWC	WE1891-1 2.5 lb + Infolium-EA 1pt	A,B,C,D	35.2	f-k	6.7	b-d
7	OS+O	OSO 13 fl oz	A,B,C,D	36.0	g-k	2.5	ab
10	OKS	Thymic (OR-491) 50 fl. oz + Oroboost (OR-097A) 32 fl oz	A,B,C,D	36.8	g-k	3.4	a-c
23	RS+R	Thymic (OR-491-B) 50 fl. oz + Oroboost (OR-097A) 32 fl oz	A, B,C,D	36.8	g-k	4.1	a-d
1	W	Untreated control	A,B,C,D	38.4	h-k	7.8	d
3	KD	NAI-9090 (BEC-60) 2 qt + Dyne-Amic 0.125% v/v	A,B,C,D	40.8	i-k	4.6	a-d
9	OKD	CX-10490 7 fl oz	A,B,C,D	41.6	jk	5.1	a-d
26	RKS	NSTKI-037 6 lb	A,B,C,D	42.4	k	5.0	a-d

[x] Products with a '+' sign in between indicates a tank mix

[y] Fungicide application times were A= bloom (May 25), B = pre-bunch closure (Jun 22), C= veraison (Aug 6), D= pre-harvest (Aug 23)

[z] Means followed by the same letter within a column are not significantly different according to Fisher's LSD with α=0.05.

Acknowledgements

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Appendix: Materials

Product	Active ingredient(s) and concentration	Manufacturer or distributor	Chemical class (Frac Code)
Activator-90	proprietary	Biotaly's	N/A
Antero-EA	Castor oil ethoxylate, Nonylphenol, formaldehyde resin, propoxylated	Wilbur-Ellis Company LLC	adjuvant
ApF23002	proprietary	Meese	N/A
ApF23002	proprietary	Meese	N/A
Attitude (OR-278F)	Citric acid (15.9%)	Oro-Agri	adjuvant
Berezi	proprietary	NovaSource	N/A
B-Red	proprietary	Agrosphere	N/A
Cinnaction (OR-489-E)	proprietary	Oro-Agri	N/A
CX-10490	proprietary	Certis USA	N/A
Dyne-Amic	polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of c16-c18 fatty acids (99%)	Helena Agri-Enterprises, LLC	adjuvant
Elevate	fenhexamid	Arysta LifeScience North America LLC	KRI (17)
Evoca	proprietary	Biotaly's	N/A
Fitor	proprietary	Innako	N/A
Fun-Thyme	proprietary	Agrospheres	N/A
Howler EVO	Pseudomonas Chlororaphis Strain AFS009 (50%)	AgBiome Innovations, Inc.	BM (2)
Hydrogen perocside	proprietary	Innako	N/A
Infolium-EA	Alcohol Ethoxylate Phosphate Ester (98.02%)	Wilbur-Ellis Company LLC	adjuvant
Kaligreen	Potassium bicarbonate (81.9%)	OAT Agrio Co	NC
Kinetic	polyoxyethylene-polyoxypropylene copolymer, polyether modified (99%) heptamethyltrisiloxane	Helena Agri-Enterprises, LLC	adjuvant
Luna Experience	fluopyram (17.54%), tebuconazole (17.54%)	Bayer CropScience	SDHI (7)/DMI-triazole (3)
MBI-1P1	proprietary	ProFarm	N/A
Mevalone	Thymol (6.42%), Geraniol (6.42%), Eugenol (3.21%)	Sipcam Agro USA	BM (1)
Milagrum Plus (OR-488)	Bacillus subtilis strain IAB/BS03 (0.30%)	Oro-Agri	N/A
Miravis Prime	fludioxonil (21.4%), pydiflumetofen (12.8%)	Syngenta Crop Protection, LLC	phenylpyrroles (12) / SDHI (7)
NAI-9090 (BEC-60)	proprietary	Nichino	N/A
NSTKI-037	proprietary	NovaSource	N/A

Oroboost (OR-097A)	Alcohol Ethoxylate (13.58%)	Oro-Agri	N/A
OSO	Polyoxin D zinc sal (5%)	Certis USA	polyoxins (19)
Ph-D	Polyoxin D zinc sal (11.3%)	UPL NA Inc.	polyoxins (19)
Phosful	proprietary	Innako	N/A
Pristine	pyraclostrobin (12.8%), boscalid (25.2%)	BASF	QoI(11)/SDHI (7)
ProBlad Verde	extract from the cotyledons of lupine plantlets (“BLAD”) 20%	CEV, S.A.	BM (1)
Rovral	Iprodione 41.6%	FMC Corporation	dicarboximides (2)
SA-0650004	proprietary	Sipcam Agro USA	N/A
Serenade ASO	*Bacillus subtilis* qst 713 (26%)	Bayer CropScience	microbial (44, NC)
Stargus	Bacillus amyloliquefacien (96.4%)	Marrone Bio Innovations, Inc.	microbial (44, NC)
Switch	cyprodinil (37.5%), Fludioxonil (25.0%)	Syngenta Crop Protection, LLC	AP (9)/ Phenylpyrroles (12)
Syl-Coat	polyether-polymethylsiloxane-copolymer and polyether (100%)	Wilbur-Ellis Company LLC	adjuvant
Thymic (OR-491)	Thyme Oil (10%)	Oro-Agri	N/A
Thymic (OR-491B)	Thyme Oil (10%)	Oro-Agri	N/A
V6M-5-7	proprietary	Corteva	N/A
Vangard WG	Cyprodinil (75%)	Syngenta Crop Protection, LLC	AP (9)
Vintre (OR-009E)	Alcohol Ethoxylate (8.15%)	Oro-Agri	N/A
WE1891-1	proprietary	Wilbur-Ellis Company LLC	N/A
WE2097-1	proprietary	Wilbur-Ellis Company LLC	N/A
X7N68-R009	proprietary	FMC Corporation	N/A