Cornell Cooperative Extension
Eastern NY Commercial Horticulture Program

Biofungicide, Biorational, and Copper Fungicide Programs to Manage Alternaria Leaf Spot and Head Rot in Broccoli

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Summary

Despite grower efforts to implement best cultural practices like crop rotation, production of marketable organic brassica crops in the Hudson Valley is limited by Alternaria Leaf Spot/Crown Rot. Numerous low risk "biorational" fungicide products are allowed in organic production. One of the obstacles that organic growers face in managing diseases like Alternaria is discerning which, if any, of these "biorational" materials are effective. Although growers have been including these products in their disease management strategies, most have not observed clear results.

With support from the Hudson Valley Farm Hub, Cornell Cooperative Extension's Eastern New York Commercial Horticulture regional vegetable specialists Ethan Grundberg and Teresa Rusinek conducted a series of field trials at the Farm Hub to address gaps in organic management of brassica diseases. After three years of applied field research that began in 2020, the researchers have come to the following conclusions:

Key Findings

- Programs with Oso (polyoxin D zinc salt, Certis USA) at 6.5 fl oz/ac significantly reduced Alternaria severity and increased marketable broccoli yield
- Reducing biofungicide/biorational applications from 7 on a weekly schedule over the full production period to 3 or 5 later in the production cycle did not result in decreased control in 2022 (dry year) when using Oso
- Rotate Oso with Badge X2 (1.8 lbs./ac) or tank mix of Stargus (3 qt/ac) + Regalia (2 qt/ac) for resistance management
- Reducing biofungicide/biorational applications can reduce costs without sacrificing Alternaria disease control on foliage or crowns
- Rotating Oso applications with a Stargus + Regalia tank mix can reduce or eliminate copper fungicide applications

Photo Above: Site of 2023 Bio-rational Brassica Disease Management Trial at the Hudson Valley Farm Hub

Photo Below: Alternaria Crown Rot Disease on Broccoli

Full Report Follows

Background

Brassica crops, like broccoli, are susceptible to numerous plant pathogens. Black Rot (BR), Downy Mildew (DM) and Alternaria Leaf Spot/Crown Rot (ALS), are among the most common and destructive diseases of brassica crops grown in the Northeast. Production of marketable organic brassica crops in the Hudson Valley is limited by these pervasive diseases despite grower efforts to implement best cultural practices like crop rotation and improving air flow in crops by adjusting planting spacing. A number of low risk "biorational" products are allowed in organic production and are labeled to manage these diseases. One of the obstacles that organic growers face in managing the three diseases is discerning which, if any, of these disease control materials are effective. Although growers have been including these products in their disease management strategies, most have not observed clear results.

With support from the Hudson Valley Farm Hub (HVFH), Cornell Cooperative Extension's Eastern New York Commercial Horticulture (ENYCHP) regional vegetable specialists Ethan Grundberg and Teresa Rusinek conducted a series of field trials to address gaps in brassica disease organic management. In 2020, the researchers evaluated nine biorational fungicides on broccoli produced at HVFH: two plant-based materials- Regalia (extract of Knotweed) and Trilogy (extract of Neem); three mineral based materials- PerCarb (Sodium Carbonate/Hydrogen Peroxide), Cueva, and Badge X2 (both copper-based materials); and four *Bacillus* (bacteria) derived materials- Serenade, LifeGard, Double Nickel 55, and Stargus. ALS was overwhelmingly the primary disease affecting the trial broccoli in 2020. Under these high-pressure conditions, none of the biorational products alone provided acceptable levels of suppression.

Photo above: Alternaria disease lesions on broccoli leaves contain spores that later colonize broccoli crowns.

Results from the 2020 screening trial supported what both private industry and researchers have concluded about managing other diseases with biorational products: biorationals alone are typically insufficient to manage intense disease pressure, especially difficult to control pathogens like those that cause ALS. Instead, more researchers and growers are experiencing greater success managing plant diseases with biorationals by using those products in rotation with more aggressive chemistries and as tank-mix companions to other products. Analysis of data collected in the 2020 trials at the farm hub revealed trends toward lower disease severity in plots treated with Badge X2, Regalia, Stargus, and Double Nickel. Those products were included in the 2021 Farm Hub trial programs along with several newly released OMRI-listed biorational products, including: Theia (*Bacillus subtilus* strain AFS032321), Howler (*Pseudomonas chlororaphis* strain AFS009), and Oso (polyoxin D zinc salt). A total of 22 biorational programs that rotated through different chemistries and tank-mixing compatible products were evaluated in 2021 with the goal of collecting data to help inform and develop more robust season-long bio-rational programs. Oso had the lowest numerical AUDPC (disease) ratings and among the highest in marketable yield in the 2021 Farm Hub trial. Similar results were reported from a 2021 trial in Geneva NY, led by Cornell pathologist Chris Smart. The focus in year three of this project was on evaluating 7 weeklong programs built on best performers from 2022 and 2021 while following best resistance management practices. Programs were designed using the lower rate of OSO @ 6.5 fl.oz either alternating or in tank mix combinations with other biorational fungicides to demonstrate efficacy at a cost that is economically feasible for most growers. We examined the efficacy of several reduced fungicide application programs that further reduce costs and copper fungicide applications.

Methods

The field trial was hosted by the Hudson Valley Farm Hub in Hurley, NY (41.918901, -74.082975) in a field with Unadilla silt loam soil. 'Emerald Crown' broccoli was seeded on July 11 into 72-cell propagation trays and kept in the greenhouse until moved outdoors to harden off on August 1. Seedlings were planted with a water wheel transplanter on August 5 at 12" in-row spacing and 3 rows per bed approximately 12" apart. Plots were 15 bed feet long and separated by a 5-bed foot planted buffer. Plots were arranged in a randomized complete block design with 4 replicates. Supplemental overhead irrigation was necessary immediately after transplant. Weeds were managed with hand tools. Entrust (spinosad) was applied at 6 fl oz/acre August 31 to suppress flea beetles and Deliver (*Bacillus thuringiensis* kurstaki) was applied at 1 lb/acre September 16 to control lepidopteran pests. A bed of downy mildew susceptible cauliflower 'Amazing' was planted around the perimeter and down the center of the trial field 25 days prior to the broccoli transplanting to encourage DM development in the trial broccoli.

Treatments were applied weekly on August 11, 19 and 26, September 2, 9,16 and 26. All fungicide applications were made using a CO_2-powered backpack sprayer calibrated to deliver 39 gallons/acre of spray solution at 40 psi with four twin turbojet nozzles (TTJ60-8003VS) spaced 15" apart. The OMRI-listed adjuvant Attach (pinene polymers) was used at a rate of 16 fl oz/100 gal in all treatments, including to spray the untreated control.

Alternaria leaf spot (ALS) was evaluated by estimating the percentage of symptomatic leaf area on nine individual plants per plot. Ratings were made every other week on August 19, September 2, 16, and 29. Disease severity data were used to calculate area under the disease progress curve (AUDPC). ALS severity on broccoli heads and harvest weights were measured over two harvest dates on Sept 29 and 30. 10 crowns per plot were harvested over the 2-day period and weighed on an Ohaus Catapult 1000 compact bench scale with 0.02 lb. resolution, measured with a Fowler 54-100-512-BT electronic calipers with 0.0005"/0.01mm resolution, and visually assessed to estimate the percentage of florets with head rot symptoms.

AUDPC and yield data were analyzed using a general linear model and means were compared using Tukey's Honestly Significant Difference (HSD) test at $p = 0.05$ in JMP Pro (JMP Pro v 17.0.0, SAS Institute, Cary, NC). Crown disease severity data were analyzed using a general linear mixed model (PROC MIXED) in SAS Studio (SAS Studio v 3.81 SAS Institute, Cary, NC), with a Poisson distribution. Similarly, treatment means were compared using Tukey's HSD at p=0.05.

Average monthly air temperatures (°F) were 74.6 in August and 64.1 in September. Rainfall (in.) was 3.05 in August and 6.00 in September. Natural inoculum of ALS was the only source of inoculum for this trial. Average precipitation was somewhat lower than the 6-year average in August and somewhat higher in September. In the trial, ALS pressure was moderate as was crown disease severity. A photo of representative broccoli crowns from each treatment is provided in this report to visually demonstrate the severity of crown disease. Comprehensive results are presented in the tables below. Treatment N, Regalia+Stargus (weeks 1,2,3,5) Oso (weeks 4,6,7), was the only treatment with a statistically significantly lower AUDPC (foliar disease rating) value from the untreated control. Treatment N was also the only treatment with an average percent crown disease severity that was significantly different from the untreated control. Treatment N had the highest marketable yield in the trial, a difference that was significantly different from the untreated control.

Treatment	Products and Rates*
A = 1	UTC (water and Attach at 0.125% v/v dilution)
B = 2	Badge X2 @ 1.35 lbs./acre
C = 3	Oso @ 6.5 fl oz/acre
D = 4	Badge X2 @ 1.35 lbs./acre PLUS Oso @ 6.5 fl oz/acre
E = 5	Badge X2 @ 1.35 lb./acre PLUS Regalia @ 2 qt/acre
F = 6	Badge X2 @ 1.35 lbs./acre PLUS EcoSwing @ 32 fl oz/acre
G = 7	Badge X2 @ 1.80 lbs./acre weeks 1,2,3,5
H = 8	Badge X2 @ 1.8 lbs./acre weeks 1,2,3,5; Oso @ 6.5 fl oz/acre weeks 4,6,7
I = 9	Carb-O-Nator @ 5 lbs./100 gal weeks 1,2,3,5; Oso @ 6.5 fl oz/acre weeks 4,6,7
J = 10	Badge X2 @ 1.8 lbs./acre weeks 1,2,3,5; EcoSwing @ 32 fl oz/acre weeks 4,6,7
K = 11	Badge X2 @ 1.80 lbs./acre PLUS Regalia@ 2 qt/acre weeks 1,2,3,5
L = 12	Badge X2 @ 1.80 lbs./acre PLUS Regalia @ 2 qt/acre weeks 1,2,3,5; Stargus @ 3 qt/acre weeks 4,6,7
M = 13	Badge X2 @ 1.80 lbs./acre PLUS Regalia@ 2 qt/acre weeks 1,2,3,5; Oso @6.5fl oz/acre weeks 4,6,7
N = 14	Regalia @ 2 qt/acre PLUS Stargus @ 3 qt/acre weeks 1,2,3,5; Oso @6.5fl oz/acre weeks 4,6,7
O = 15	Badge X2 @ 1.80 lbs./acre weeks 3,5; Badge X2 @ 1.80 lbs./acre PLUS Oso @ 6.5 fl oz/acre weeks 4,6,7
P = 16	Badge X2 @ 1.80 lbs./acre week 5; Badge X2 @ 1.80 lbs./acre PLUS Oso @ 6.5 fl oz/acre weeks 6,7
* All treatments included Attach at 0.125% v/v dilution	

	AUDPC	Marketable Yield (lbs.)	Percent Marketable Yield (%)	Crown Disease Severity (%)
A- UTC	279.92 a	1.09 de	15.78 cd	35.4 a
B- Badge	126.03 bcde	3.55 bcde	49.89 abcd	5 abc
C- Oso	108.19 de	6.7 ab	88.10 a	0.63 c
D- Badge+Oso	117.26 cde	5.65 abc	73.47 ab	2.5 bc
E- Regalia+Badge	224.29 ab	4.01 abcde	60.07 abc	7.03 abc
F- Badge+EcoSwing	204.21 abc	3.76 abcde	49.8 abcd	7.4 ab
G- Badge (wks 1,2,3,5)	209.17 ab	0.51 e	7.57 d	23.13 a
H- Badge (wks 1,2,3,5)- Oso (wks 4,6,7)	106.96 de	4.7 abcde	60.00 abc	3.33 abc
I- Carb-O-Nator (wks 1,2,3,5) Oso (wks 4,6,7)	147.21 abcde	5.04 abcd	63.28 abc	5.75 abc
J- Badge (wks 1,2,3,5) EcoSwing (wks 4,6,7)	163.88 abcd	1.12 de	15.85 cd	17.43 ab
K- Regalia+Badge (wks 1,2,3,5)	196.94 abc	1.47 cde	22.64 cd	18.83 ab
L- Regalia+Badge(wks1,2,3,5) Stargus (wks4,6,7)	182.61 abc	1.95 cde	25.32 bcd	18.4 ab
M-Regalia +Badge (wks 1,2,3,5) Oso (wks 4,6,7)	179.43 abc	4.53 abcde	58.75 abc	4.48 abc
N- Regalia+Stargus (wks 1,2,3,5) Oso (wks 4,6,7)	100.26 de	7.96 a	88.44 a	1.55 c
O- Badge (wks 3,5)- Badge+Oso (wks 4,6,7)	91.38 e	6.7 ab	91.72 a	0.83 c
P- Badge (wk 5), Badge+Oso (wks 6,7)	113.85 cde	6.51 ab	88.87 a	1.35 bc
p value	0.00404	<0.0001	<0.0001	<0.0001

[v] Numbers within each column followed by the same letter are not significantly different from each other based on Tukey's HSD at p = 0.05

[w] Area under the disease progress curve was calculated from August 19 to September according to the formula: $\sum n\ i=1[(Ri+1 + Ri)/2]\ [ti+1 – ti]$, where R = disease severity rating (% of leaf surface affected) at the ith observation, ti = time (days) since the previous rating at the ith observation, and n = total number of observations. Values were calculated based on the average percent disease severity across the plot.

[x] Harvest weight was recorded on September 29 and 30, representing the total weight of 10 heads.

[y] The average percent marketable yield was calculated by dividing the weight of crowns with less than 3% visual disease symptoms at harvest by the total weight of all crowns harvested per plot (10). [z] Head disease severity was assessed over the harvest period September 29 and 30.

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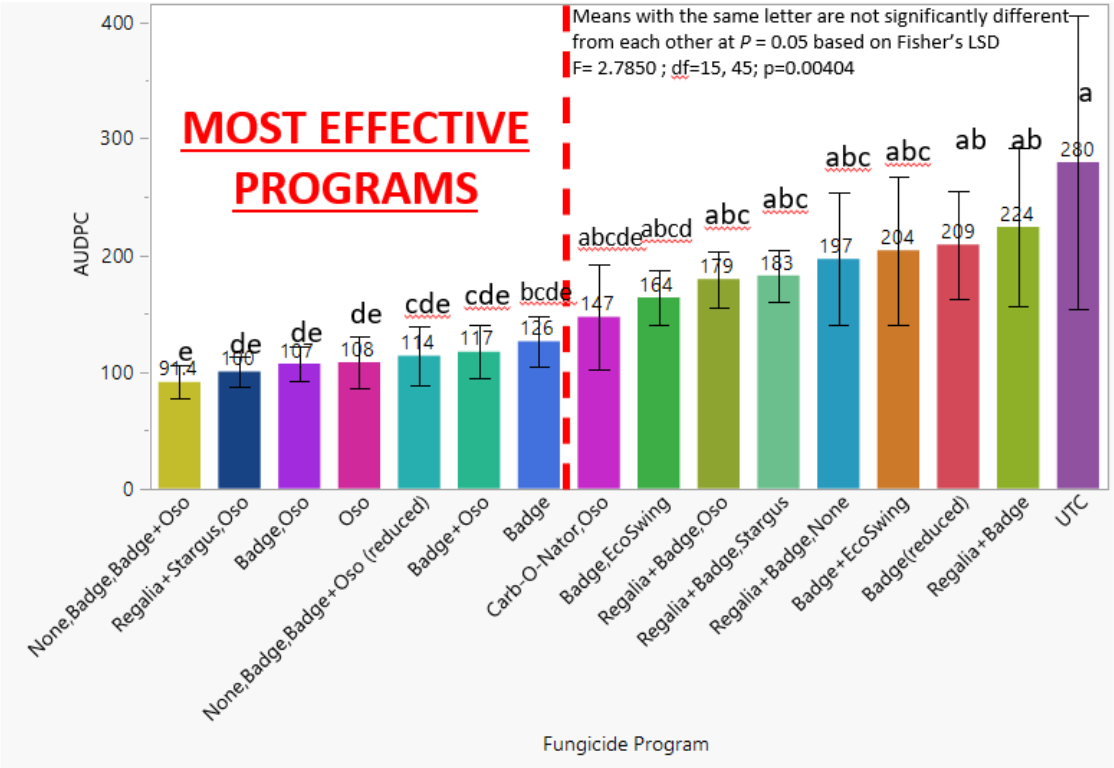
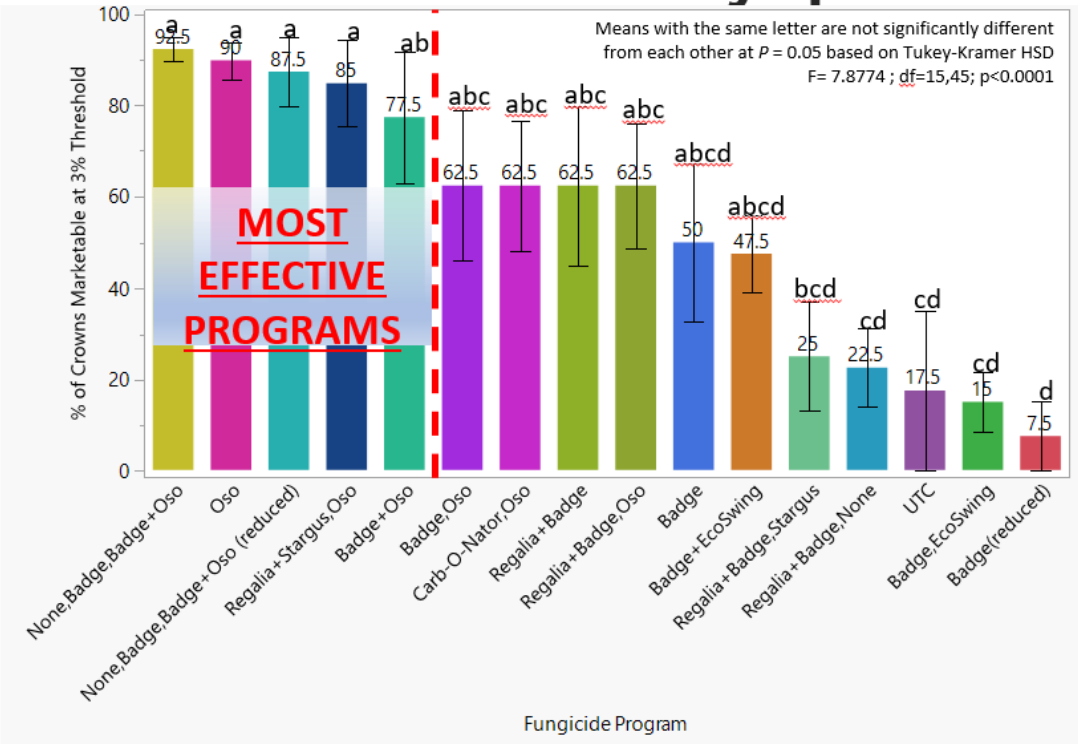
2022 Broccoli Biofungicide AUDPC Values



Marketable Crowns at 3% Visual Symptoms Threshold



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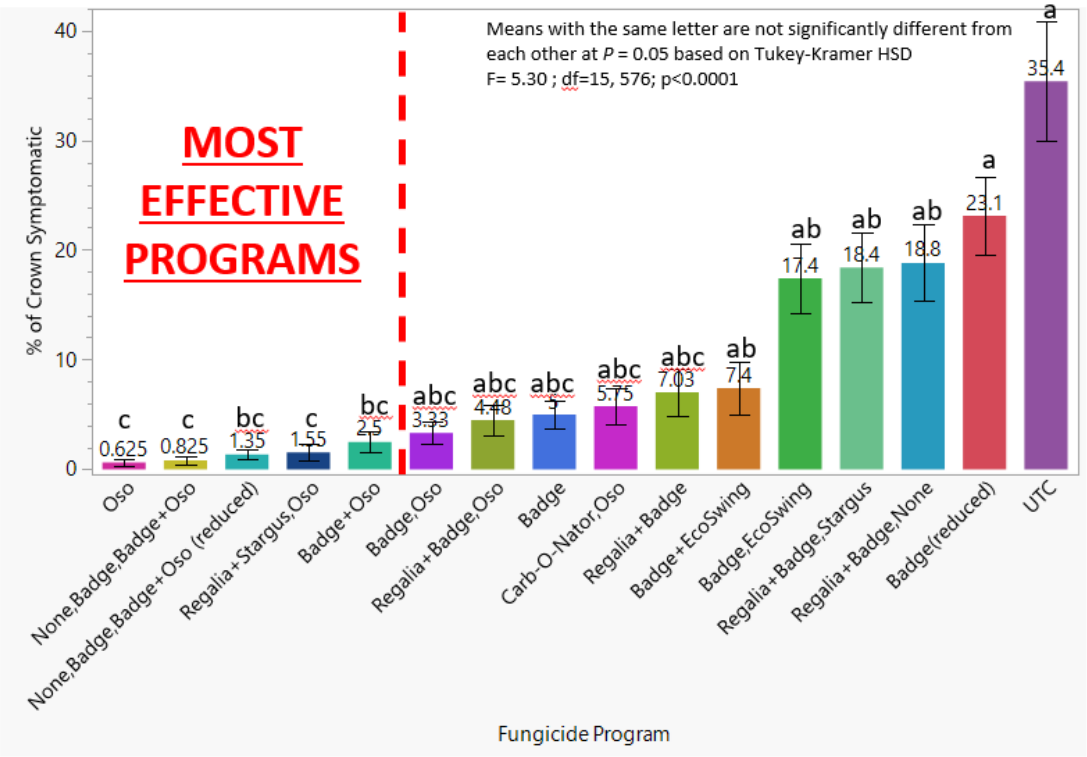
Crown Disease Severity Ratings

%of Crown w/ Disease Symptoms at Harvest



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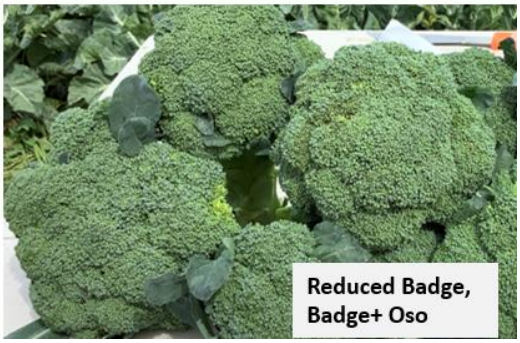
Visual Representation of Most Effective Foliar and Crown Disease Management Treatments Vs. UTC



Organic Fungicide Spray Program Cost Estimate for Alternaria Management in Brassicas

% Marketable Crop (3% Crown Disease Threshold)	92.50%	90%	87.50%	85%	50%
Week 1	None	Oso	None	Regalia+Stargus	Badge
Week 2	None	Oso	None	Regalia+Stargus	Badge
Week 3	Badge	Oso	None	Regalia+Stargus	Badge
Week 4	Badge+Oso	Oso	None	Oso	Badge
Week 5	Badge	Oso	Badge	Regalia+Stargus	Badge
Week 6	Badge+Oso	Oso	Badge+Oso	Oso	Badge
Week 7	Badge+Oso	Oso	Badge+Oso	Oso	Badge
Fungicide Sum	$183.00	$225.50	$117.10	$449.98	$102.90
Adjuvant Cost	$8.80	$15.40	$6.60	$15.40	$15.40
Total Program Cost Per Acre	$191.80	$270.90	$123.70	$465.38	$118.30

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Blue Biorational Programs

Research Question How well do weekly applications of Oso and Badge perform to manage disease in broccoli? Establish baseline of individual product efficacy to better understand potential impacts of tank mixes and rotation programs incorporating multiple modes of action.

Analysis- Only Oso had statically significantly lower AUDPC (foliar disease ratings) compared to the untreated control (UTC) and statistically significantly higher yield in pounds and percent marketable yield. Both Badge and Oso programs had a significantly lower % crown disease severity compared to the UTC, but the Oso treatment severity was significantly lower than Badge program.

	Program 1	Program 2	Program 3
Week 1	**UTC**	**Badge**	**Oso**
Week 2	**UTC**	**Badge**	**Oso**
Week 3	**UTC**	**Badge**	**Oso**
Week 4	**UTC**	**Badge**	**Oso**
Week 5	**UTC**	**Badge**	**Oso**
Week 6	**UTC**	**Badge**	**Oso**
Week 7	**UTC**	**Badge**	**Oso**

Blue Programs	AUDPC	Marketable Yield (lbs.)	Marketable Yield (%)	Crown Disease Severity (%)
A- UTC	279.92 a	1.09 a	15.78 b	35.4 a
B- Badge	126.03 ab	3.55 ab	49.89 ab	5.00 b
C- Oso	108.19 b	6.70 b	88.10 a	0.63 c
p value	0.02142	0.0161	0.0452	<0.0001

Red Biorational Programs

Research Question -Compared to either Oso or Badge alone, how do weekly tank mix combinations of Oso + Badge, Regalia + Badge, and EcoSwing + Badge perform? Is that added cost of the second product in tank mix cost effective?

Analysis- No statistically significant difference of AUDPC comparing the red programs to Oso or Badge alone, though the programs including Oso were numerically the lowest. The programs Regalia + Badge, and EcoSwing + Badge had numerically higher AUDPC and Crown Disease Severity than the Badge alone program. The Oso only and Badge + Oso programs were the only programs that had statistically significantly higher marketable yield and statistically significantly lower percent crown disease ratings compared to the UTC. However, there was no statistically significant difference in any of the ratings between Oso alone or Oso tank mix with Badge. There was no significant difference in any of the ratings between Badge alone or Badge + Regalia or Badge + Ecoswing.

Discussion: Based on data analysis, there is no advantage to tank mixing Oso, EcoSwing, or Regalia with Badge, therefore the added cost of tank mixing would not be cost effective. The trend we observed of higher numerical (not statically significant) AUDPC and crown disease severity ratings when Ecoswing or Regalia are tank mixed with Badge suggest there may be an incompatibility issue causing tissue injury that encourages Alternaria colonization.

	Program 4	Program 5	Program 6
Week 1	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 2	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 3	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 4	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 5	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 6	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**
Week 7	**Badge+OSO**	**Regalia+Badge**	**Badge+EcoSwing**

Red Programs	**AUDPC**	**Marketable Yield (lbs.)**	**Marketable Yield (%)**	**Crown Disease Severity (%)**
A- UTC	279.92	1.09 b	15.78 b	35.40 a
B- Badge	126.03	3.55 ab	49.89 ab	5.00 ab
C- Oso	108.19	6.70 a	88.10 a	0.63 b
D-Badge+Oso	117.26	5.65 a	73.47 ab	2.50 b
E- Badge +Regalia	224.29	4.01 ab	60.07 ab	7.03 ab
F- Badge+EcoSwing	204.21	3.76 ab	49.80 ab	7.40 ab
p value	0.09339	0.0049	0.0312	0.001

Yellow Biorational Programs

Data from previous years have suggested that applying Badge alone in alternating weeks controlled Alternaria as well as weekly applications of tank mixes of Badge and biorationals.

Research Question 1) How does program performance of a Badge ALT None program change when the Badge is frontloaded, and fewer applications are made during crown development?

Analysis- AUDPC of the front-loaded reduced Badge program is significantly higher than the weekly Badge program. Crown disease severity is numerically higher for the reduced Badge program at 23.13% vs. 5% for the weekly Badge program; however, the difference was not statically significant. There are similar trends for marketable yield and percent marketable yield as well.

Discussion- In our trial, incidence of Alternaria significantly increased on foliage when Badge was front-loaded, and fewer applications were made during crown development. Additionally, there was a substantial increase in percent crown disease and a decrease in marketable yield.

Research Question 2)- Can programs integrate early Badge applications with later season biorational applications to improve disease suppression?

Analysis- The weekly Badge program and the Badge alt with Oso program had statistically significantly lower AUDPC (foliar disease ratings) than Badge reduced and the UTC programs. The Badge alt with EcoSwing program AUDPC was not significantly lower than the reduced Badge or UTC program. Marketable Yield lbs. only Badge alt Oso gives significantly higher yield and significantly lower Crown Disease Severity when compared to the reduced badge program and UTC.

Discussion-Data analysis suggests that integrating Badge applications with later season applications of Oso can improve disease suppression when compared to a reduced late season Badge program. We did not see improved disease suppression in the Badge alternated with EcoSwing treatments.

Research Question 3) – Can Carb-O-Nator be used in place of Badge for growers without sacrificing efficacy for growers interested in reducing copper use?

Analysis- There was no statistically significant difference in the AUDPC or crown disease severity ratings between Badge alt Oso and Carb-O-Nator alt Oso. However, the AUDPC and crown disease severity in the Carb-O-Nator alt Oso treatment was numerically higher than the Badge alt Oso treated plots. There was no statistically significant difference in marketable yield between the two treatments.

Discussion- Results from this trial indicate that there is no significant difference in Alternaria disease incidence when Carb-O-Nator, rather than Badge, is used in a program with Oso and would be a viable disease management program for growers interested in reducing copper use.

	Program 7	Program 8	Program 9	Program 10
Week 1	**Badge**	**Badge**	**Carb-O-Nator**	**Badge**
Week 2	**Badge**	**Badge**	**Carb-O-Nator**	**Badge**
Week 3	**Badge**	**Badge**	**Carb-O-Nator**	**Badge**
Week 4	**None**	**Oso**	**Oso**	**EcoSwing**
Week 5	**Badge**	**Badge**	**Carb-O-Nator**	**Badge**
Week 6	**None**	**Oso**	**Oso**	**EcoSwing**
Week 7	**None**	**Oso**	**Oso**	**EcoSwing**

Yellow Programs	AUDPC	Marketable Yield (lbs.)	Marketable Yield (%)	Crown Disease Severity (%)
A- UTC	279.92 a	1.09 b	15.78 bc	35.4 a
B- Badge	126.03 c	3.55 ab	49.89 abc	5 abc
C- Oso	108.19 c	6.70 a	88.10 a	0.63 d
G- Badge(reduced)	209.17 ab	0.51 b	7.57 c	23.13 a
H- Badge, Oso	106.96 c	4.7 a	60.00 ab	3.33 cd
I- Carb-O-Nator,Oso	147.21 bc	5.04 a	63.28 ab	5.75 bcd
J- Badge, EcoSwing	163.88 abc	1.12 b	15.85 bc	17.43 ab
p value	0.01719	0.00003	0.0002	<0.0001

Purple Biorational Programs

Research Question 1)- Compared to the yellow programs, is there any benefit to tank mixing Badge with a biorational fungicide (Regalia) when applications are made on the same schedule as in the yellow programs? Is the co-application and addition of a second product cost effective?

Analysis- There was a numeric trend toward lower AUDPC and percent crown disease as well as higher marketable yields when tank mixing Regalia with Badge compared to a reduced program of Badge alone. Additionally, there was no difference in disease severity or marketable yield between the UTC, the 7 spray Badge only, 7 spray Regalia tank mix with Badge, Badge reduced sprays and Badge + Regalia reduced sprays.

Discussion- Results indicate that there is no clear benefit to tank mixing Regalia with Badge in either a reduced spray program or a full season (7 spray program) to manage Alternaria disease in broccoli production.

Research Question 2) Does the biorational selected for alternation (Oso vs Stargus) impact the performance of the programs alternated with Regalia+Badge?

Analysis- There was no significant statistical difference in AUDPC, marketable yield, or crown disease severity between programs 12 and 13 that alternate either Oso or Stargus on weeks 4, 6, 7 and program 11 that did not include a birational on weeks 4, 6, 7. The program alternating with Oso did show a notable numerical trend to lower percent crown disease severity and higher marketable yield compared to programs 11 (alternating none) and 12 (alternating Stargus). The only program in this series that performed statistically significantly better than the UTC was Regalia + Stargus alternating with Oso on weeks 4,6,7.

	Program 11	Program 12	Program 13	Program 14
Week 1	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Stargus**
Week 2	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Stargus**
Week 3	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Stargus**
Week 4	**NONE**	**Stargus**	**Oso**	**Oso**
Week 5	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Badge**	**Regalia+Stargus**
Week 6	**NONE**	**Stargus**	**Oso**	**Oso**
Week 7	**NONE**	**Stargus**	**Oso**	**Oso**

Purple Programs	AUDPC$_w$	Marketable Yield (lbs)$_x$	Marketable Yield (%)$_y$	Crown Disease Severity (%)$_z$
A- UTC	279.92 a	1.09 b	18.39 bc	35.40 a
B- Badge	126.03 ab	3.55 ab	51.40 abc	5.00 ba
E- Regalia +Badge	224.29 ab	4.01 ab	61.85 ab	7.03 ba
G- Badge (wks1,2,3,5)	209.17 ab	0.51 b	8.23 c	23.13 a
K- Regalia +Badge (wks1,2,3,5)	196.94 ab	1.47 b	22.23 bc	18.83 a
L- Regalia +Badge (wks1,2,3,5) Stargus (wks 4,6,7)	182.61 ab	1.95 b	27.22 bc	18.4 a
M-Regalia +Badge (wks 1,2,3,5) Oso (wks 4,6,7)	179.43 ab	4.53 ab	58.16 ab	4.48 ba
N- Regalia +Stargus (wks 1,2,3,5) Oso (wks 4,6,7)	100.26 b	7.96 a	88.74 a	1.55 b
p value	0.00924	0.0005	0.00016	<0.0001

Green Biorational Programs

Research Question- Can delaying the initiation of a fungicide program comprised of the best performers from previous years (Badge and Oso) provide comparable levels of disease control to weekly applications of copper or tank mixes of copper and biorationals?

Analysis- None of the analyses resulted in statistically significant difference between the programs that delayed initiation of a fungicide spray (including the delayed and reduced program 16) to programs of weekly fungicide applications of Badge, Oso, or Badge + Oso.

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	Program 15	Program 16
Week 1	**None**	**None**
Week 2	**None**	**None**
Week 3	**Badge**	**None**
Week 4	**Badge+Oso**	**None**
Week 5	**Badge**	**Badge**
Week 6	**Badge+Oso**	**Badge+Oso**
Week 7	**Badge+Oso**	**Badge+Oso**

Green Programs	AUDPC	Marketable Yield (lbs)	Percent Marketable Yield (%)	Crown Disease Severity (%)
A- UTC	279.92	1.085 b	15.78 b	35.4 a
B- Badge	126.03	3.545 ab	49.89 ab	5.0 ab
C- Oso	108.19	6.7 a	88.10 a	0.63 c
D- Badge+Oso	117.26	5.65 a	73.47 ab	2.50 bc
O- None,Badge,Badge+Oso	91.38	6.7 a	91.72 a	0.83 bc
P- None,Badge,Badge+Oso (reduced)	113.85	6.51 a	88.87 a	1.35 bc
p value	0.16838	0.0008	0.0076	<0.0001