



COLLEGE OF
AGRICULTURE &
NATURAL RESOURCES

Strawberry Botrytis: Species, Fungicide Sensitivity and Spray program

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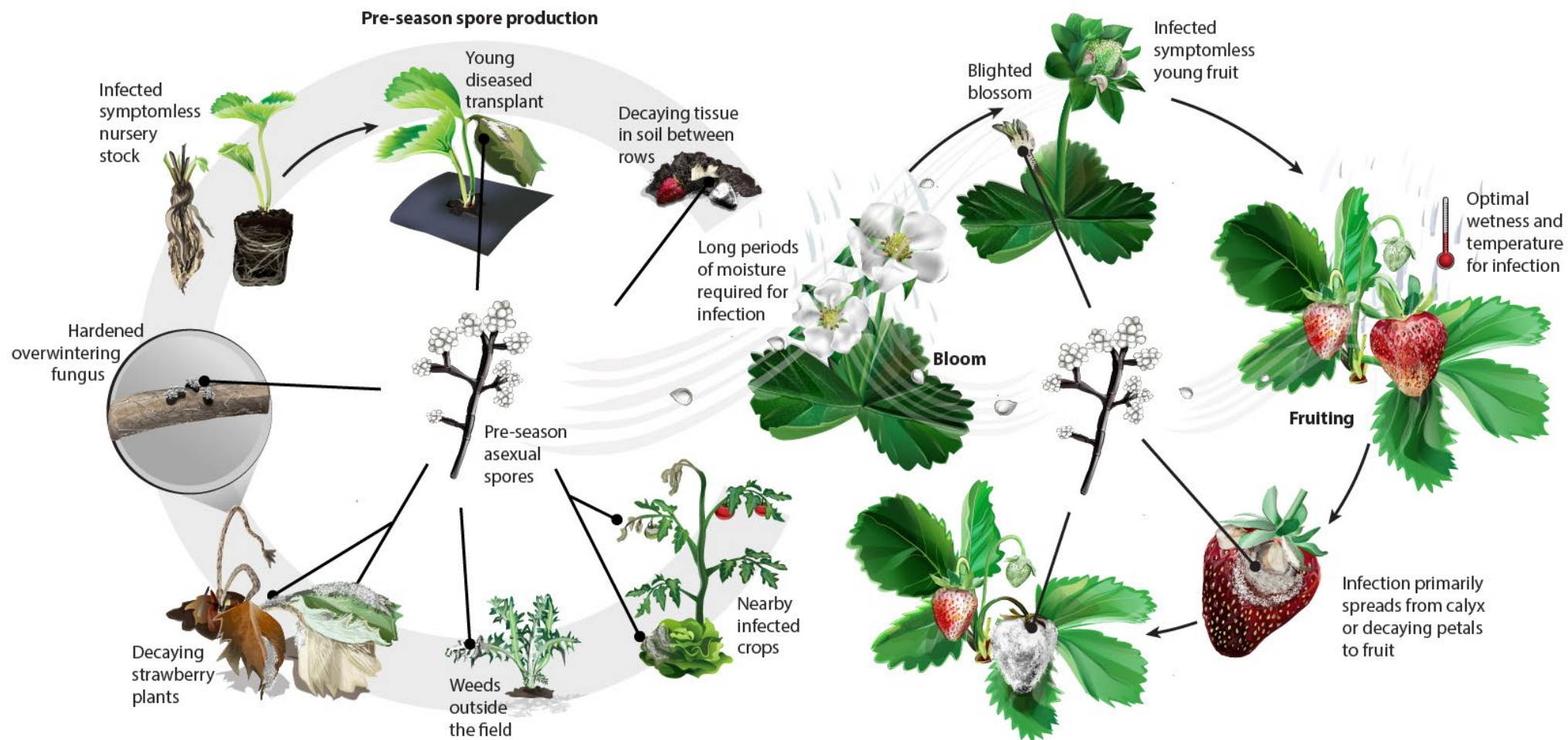
Gray mold (*Botrytis*)



- Usually causes fruit rot
 - Infects through flowers at bloom, but also direct
- Sometimes can cause crown rot
- Dispersed by wind and splashing water
- Favored by wet and cool conditions
- Relies on chemical control

Gray mold (*Botrytis*)

Gray mold on strawberry

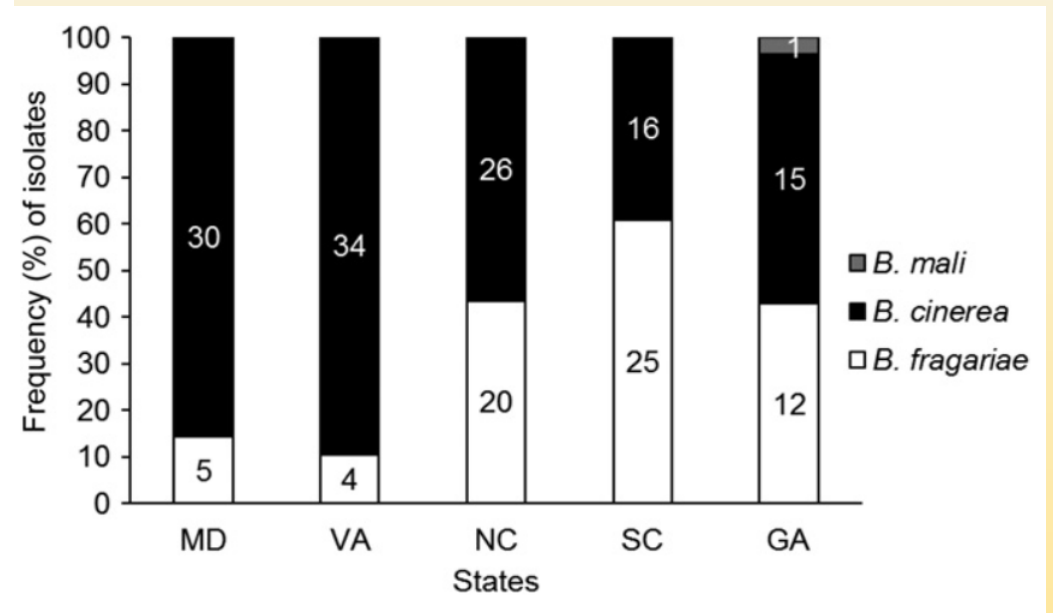
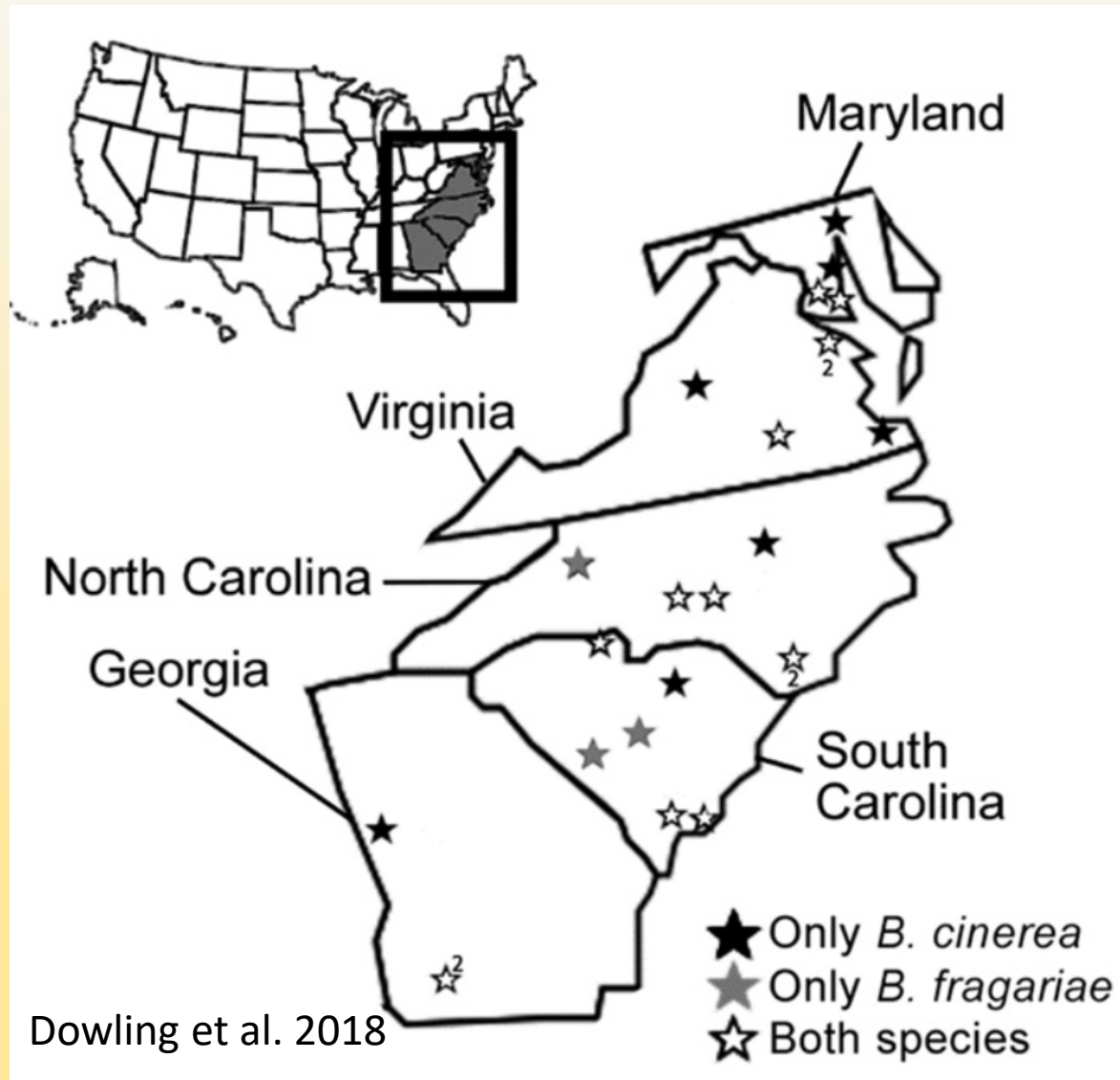


Botrytis spp. Affecting Strawberries

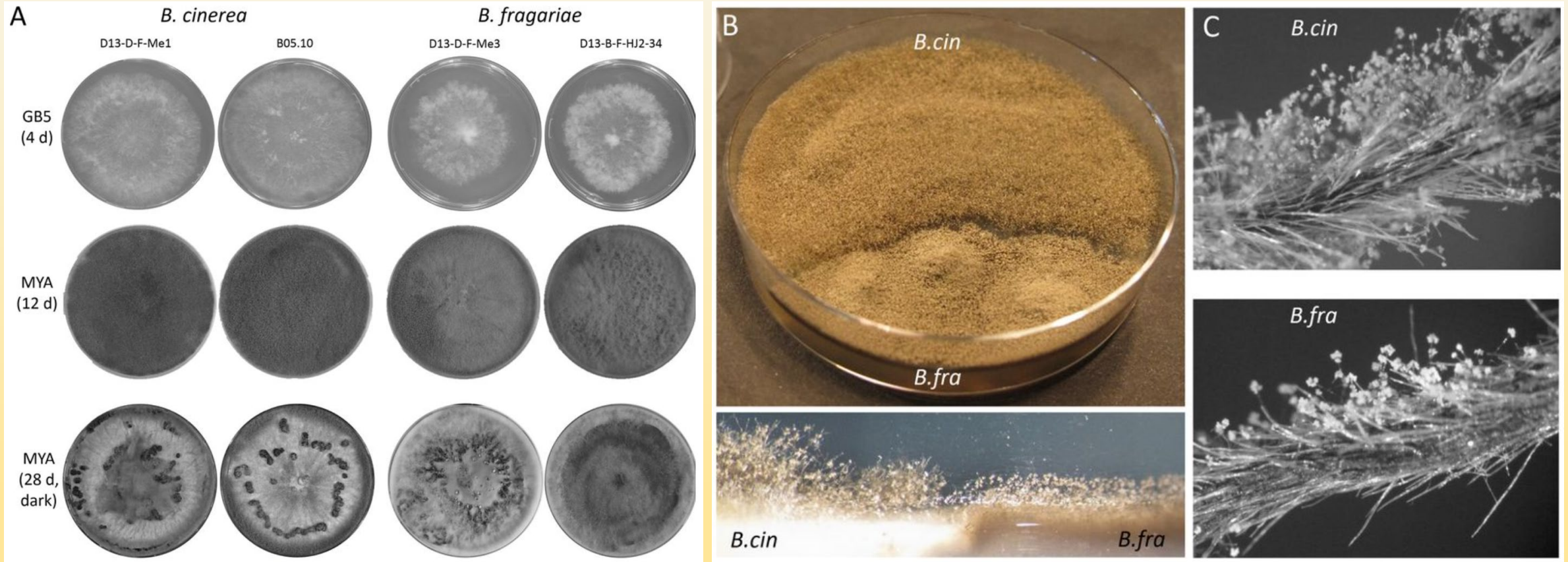
- *B. cinerea*
 - Causal agent of strawberry gray mold
- *B. fragariae*
 - Recently discovered species, isolated primarily from blossoms and some fruit (Dowling et al. 2017)
- Other species
 - *B. mali* (1%) (Dowling et al. 2017)



Collection locations and species found within the five states surveyed



Growth behavior and morphology of *B. fragariae* and *B. cinerea*.



Rupp et al. 2017

Aggressiveness of *B. fragariae* on strawberry and others

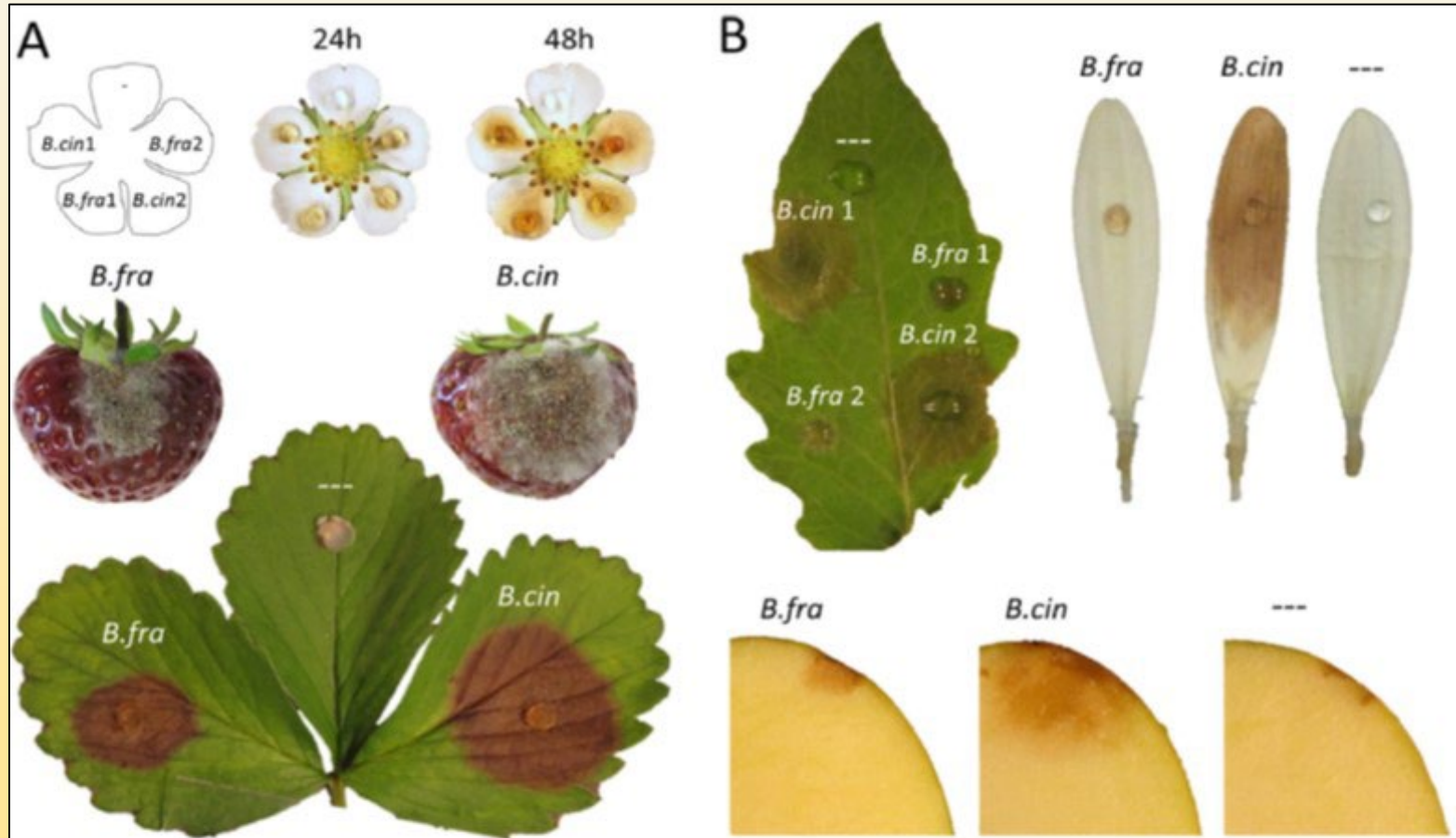
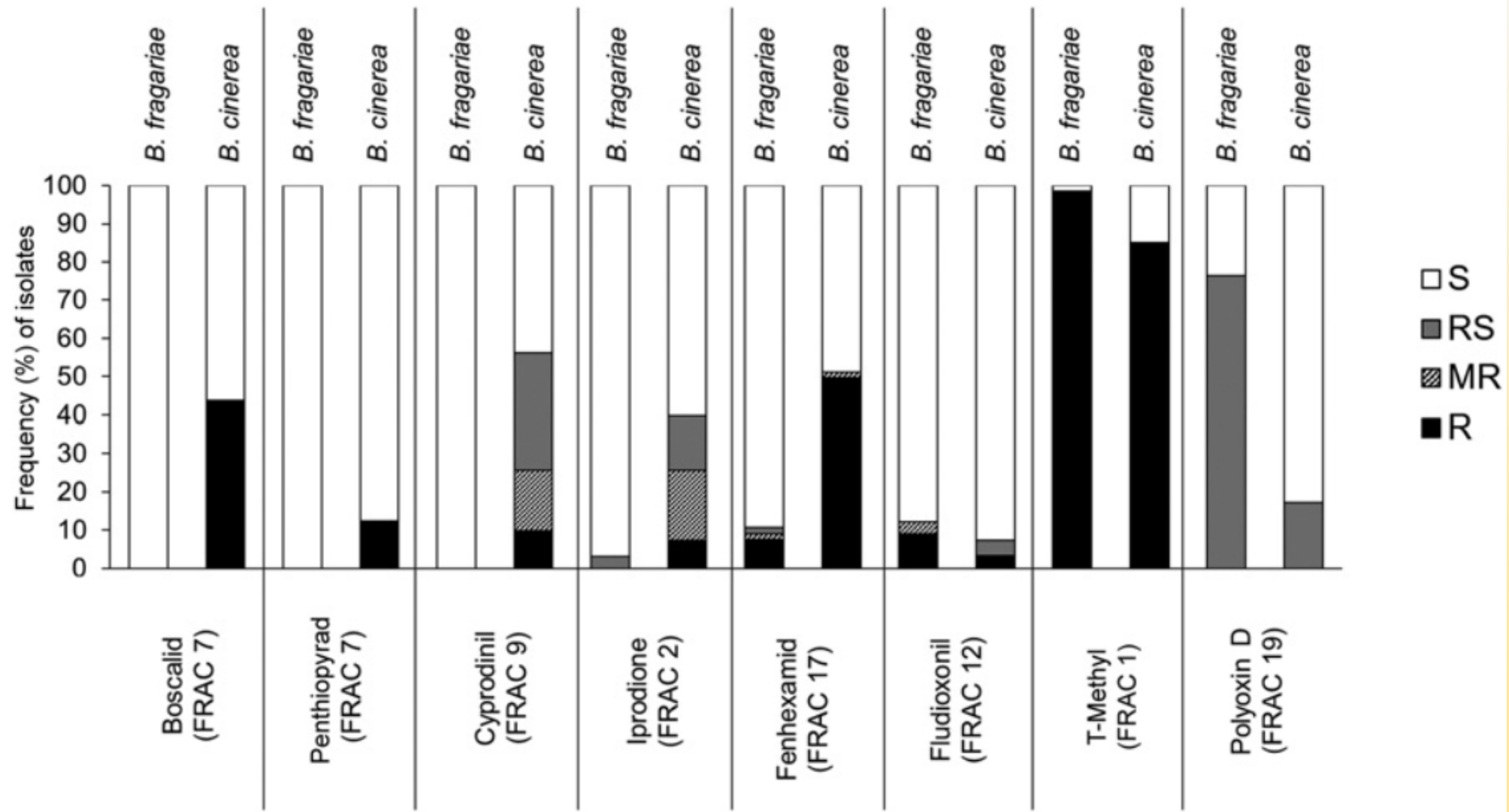
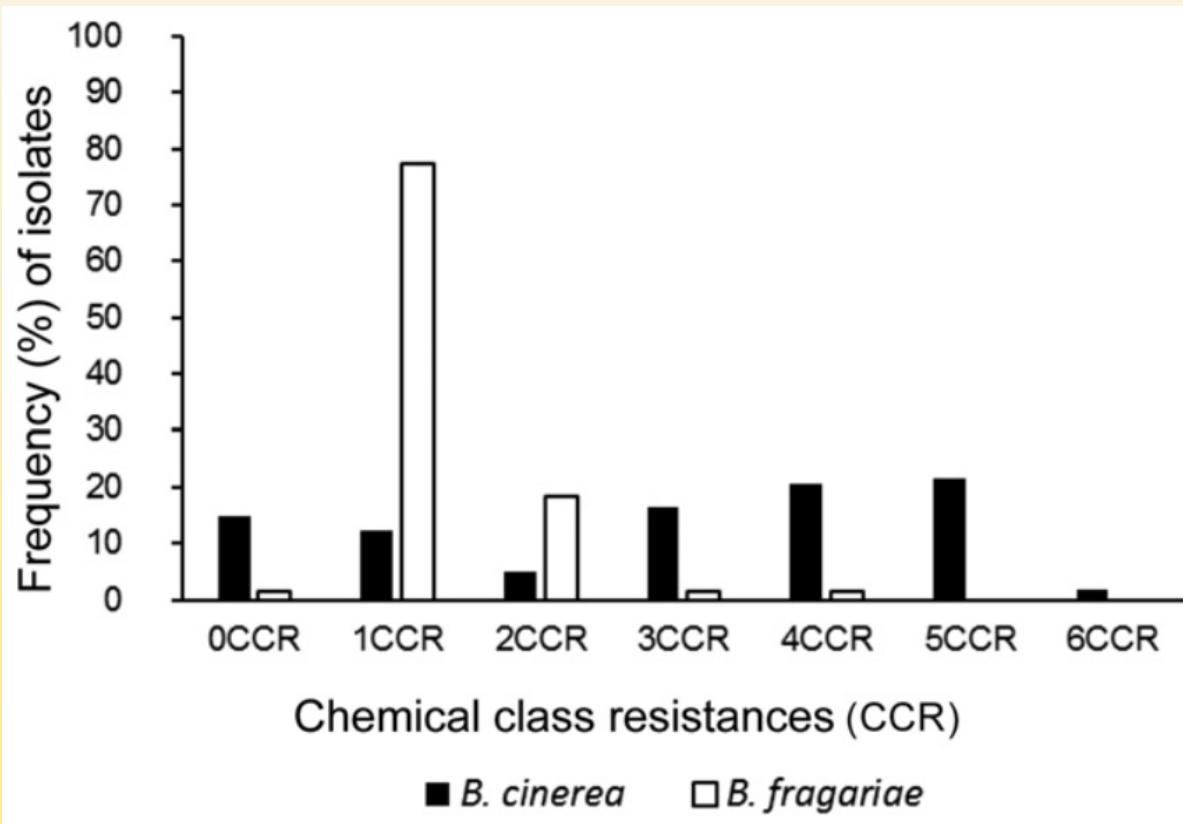


Fig. 2. Symptoms induced by *B. cinerea* and *B. fragariae*. (A) on strawberries; (B) on tomato leaf, *Gerbera* petals, and apple fruit (adapted from Rupp et al. 2017).

- Compared with *B. cinerea*, *B. fragariae* appeared to be slightly more aggressive on strawberry flowers
- On non-strawberry tissues, *B. fragariae* was shown to be unable to cause lesions or form very small lesions



Frequency of multiple chemical class resistance (CCR)

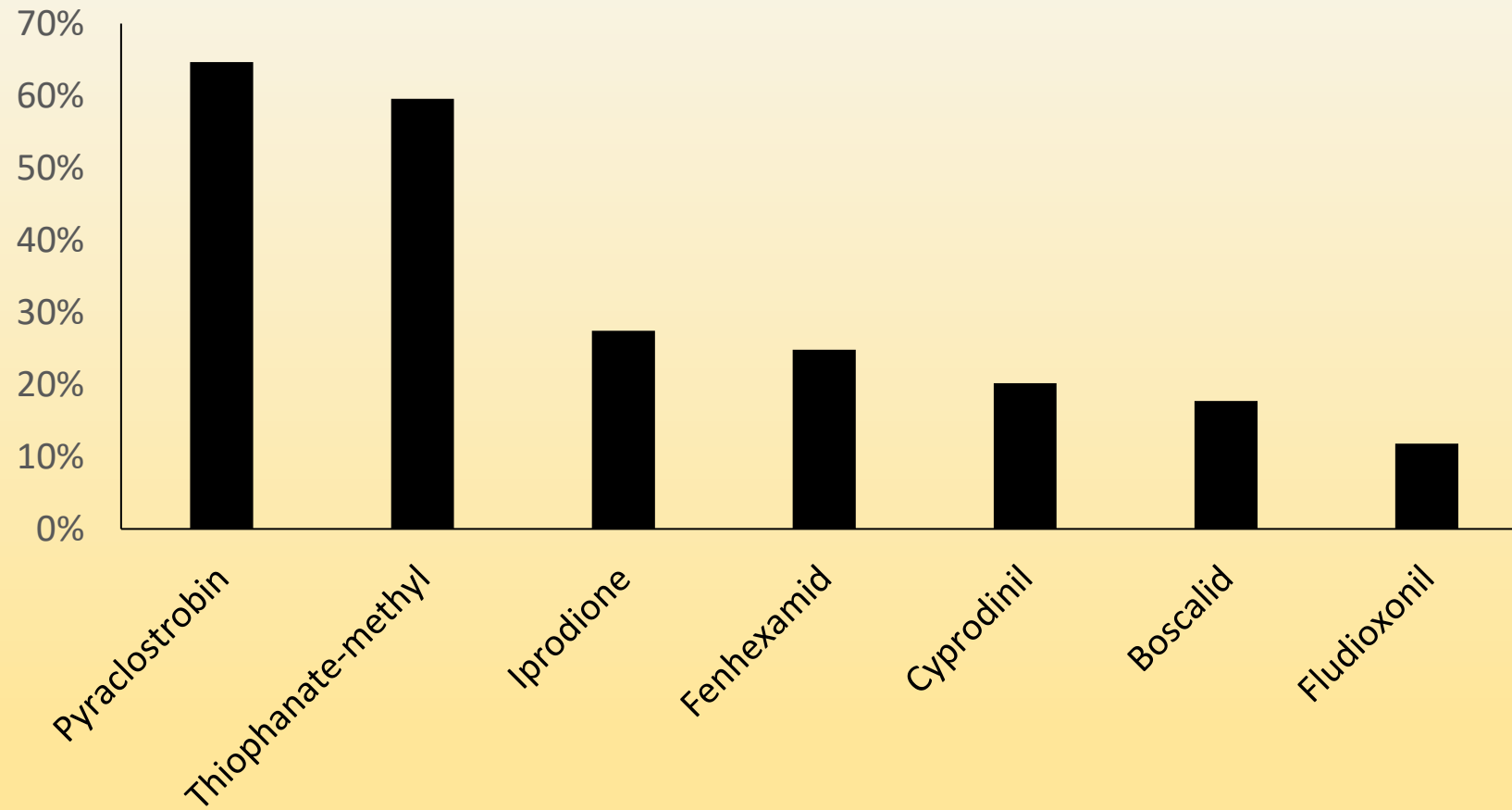


Most frequent phenotypes associated with different CCR

Number of		Fungicide ^a						CCR
<i>B. fragariae</i>	<i>B. cinerea</i>	Tm	Fe	Cy	Bo	Ip	Fl	
1	18	S	S	S	S	S	S	0CCR
51	23	R	S	S	S	S	S	1CCR
6	0	R	S	S	S	S	R	2CCR
6	3	R	R	S	S	S	S	2CCR
0	8	R	R	R	S	S	S	3CCR
1	0	R	S	S	S	R	R	3CCR
0	11	R	R	R	R	S	S	4CCR
1	0	R	R	S	S	R	R	4CCR
0	24	R	R	R	R	R	S	5CCR
0	3	R	R	R	R	R	R	6CCR

^a Sensitive (S), reduced sensitive (RS), moderately resistant (MR), and resistant (R). Fungicide names are abbreviated as follows: Tm = thiophanate-methyl, Fe = fenhexamid, Cy = cyprodinil, Bo = boscalid, Ip = iprodione, Fl = fludioxonil.

***Frequency of Fungicide Resistance in Botrytis from MD
(2021/2022)***



Take-Home Message

- Resistance in *Botrytis* spp. isolates is common to most of the chemical groups of fungicides labelled for strawberry
- Newer SDHI (FRAC 7) such as Luna Tranquility, Merivon and FRAC 12 product Switch have less resistance issues at this point
- Thiram or Captan has pretty good efficacy for Botrytis, and should be the backbone of spray programs
- Perhaps targeting Bf more so than Bc at bloom, fungicide choices could be tailored to the differences between their resistance frequency.

Polyoxin D Zinc Salt GROUP 19 FUNGICIDE

OSO[®] 5%SC FUNGICIDE

For Control of Fungal Diseases of Listed Vegetable and Fruit Crops

 CAN BE USED IN ORGANIC PRODUCTION

ACTIVE INGREDIENT:	
Polyoxin D zinc salt	5.0%
OTHER INGREDIENTS:	95.0%
TOTAL:	100.0%

Contains 7.03 ounces of active ingredient per gallon.

**KEEP OUT OF REACH OF CHILDREN
CAUTION**

See attached booklet for additional Precautionary Statements,
First Aid Statements, Directions for Use, and Storage and Disposal Statements.

SHAKE WELL BEFORE USE

Net Contents:
1 Quart (32 Fluid Ounces)

EPA Reg. No. 68173-4-70051
EPA Est. No. 70051-CA-001
Lot Number:

Distributed by: Certis U.S.A. L.L.C.
9145 Guilford Road, Suite 175
Columbia, MD 21046-1883
800-250-5024

CERTIS

Product Item Code: 154510
Packaging Item Code: 550550
rev20200405 ESL20200221



GROUP 19 FUNGICIDE

Ph-D[®]
fungicide

For control or suppression of listed diseases on cucurbit vegetables, citrus fruit group, fruiting vegetables, ginseng*, grapes, hops, pome fruits, root and tuber vegetables, leafy vegetable group, berry and small fruit, strawberries, stone fruits, pomegranates, tree nuts, stalk, stem and leaf petiole vegetable group, and non-bearing vine fruit and fruit and nut trees grown in interiorscapes.

ACTIVE INGREDIENT:	_____	% BY WT.
Polyoxin D zinc salt.	11.3%	
OTHER INGREDIENTS:	88.7%	
TOTAL:	100.0%	

Registered for a variety of fruit and veg crops (PHI = 0
days, REI = 4hrs)



(PHI = 1 day; REI = 4 hrs)



Polypeptide derived from sweet lupine plants

Powdery Mildew
Botrytis
Alternaria..

(PHI = 0 day; REI = 4 hrs)



Pseudomonas chlororaphis strain AFS009

Phytophthora
Botrytis
Anthracnose..

Registered for a variety of fruit and veg crops

Fungicide trial in 2015

Multi-site fungicides

- **Captan** (FRAC M4)
- **Thiram** (FRAC M3)

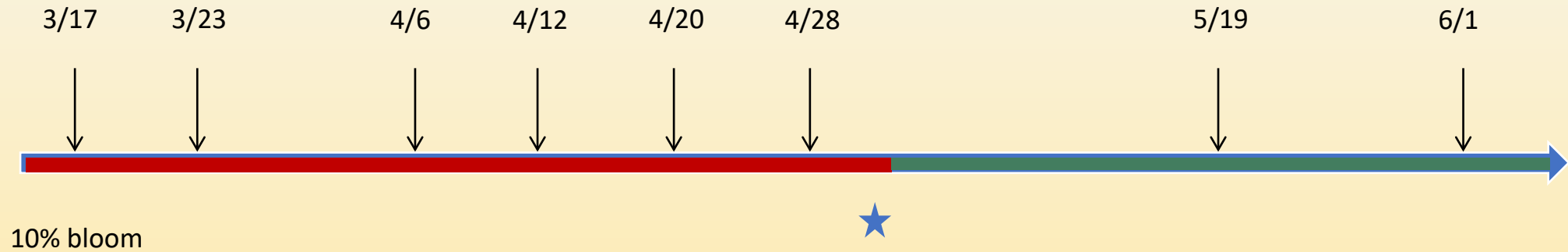


Bush N Vine Farms, York SC

Biological/Soft materials:

- **PH-D** (Polyoxin D; FRAC 19)
- **Howler** (*Pseudomonas chlororaphis* strain AFS009; FRAC BM02)
- **Fracture** (or ProBLAD; FRAC BM01)-----
polypeptide derived from sweet lupine plants

Spray and pick dates



→ Fungicide application

★ First pick

High Botrytis risk

Low Botrytis risk

Botrytis fruit rot incidence

Treatment and rate/A	Botrytis fruit rot		
	Preharvest		Postharvest
	High pressure	Low pressure	
Captec 4L (2.25 qt)	31.8 b	6.8 a	4.7 ab
Thiram 24/7 (2.6 qt)	19.5 b	5.6 a	3.4 bc
PhD (6.2 oz)	27.5 b	7.3 a	5.7 a
Howler (low rate) + CapSil (9 floz/100 gal)	56.4 ab	8.3 a	5.4 a
Howler (high rate) + CapSil (9 floz/100 gal)	48.6 ab	8.3 a	5.4 a
Fracture (25.6 oz)	46.5 ab	5.8 a	5.4 a
Non-treated control	70.8 a	7.0 a	6.2 a

Rotating/blocking biorational/biological fungicides with conventional fungicides, 2021

Biorational/Biologicals:

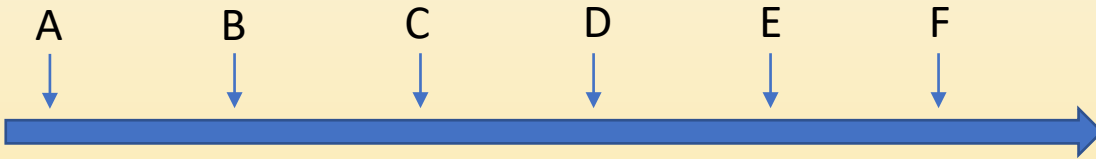
Botrystop

Regalia

Conventional:

Switch

Captan



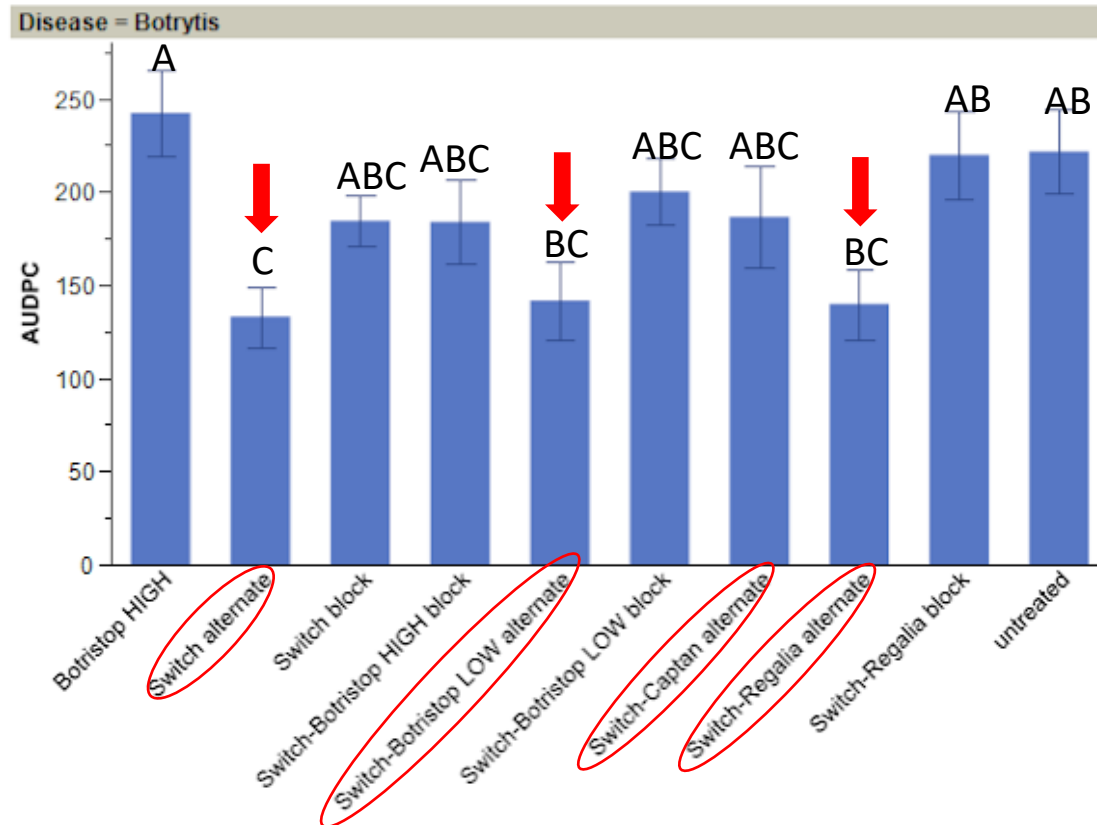
Rotational spray schedules

- Switch (ACE) rotates with captan (BDF)
- Switch (ACE) rotates with Botrystop (BDF)
- Switch (ACE) rotates with Regalia (BDF)
- Switch (ACE)

Blocking spray schedules

- Switch (ABC) blocks with Botrystop Low (DEF)
- Switch (ABC) blocks with Botrystop High (DEF)
- Switch (ABC) blocks with Regalia (DEF)
- Switch (ABC)
- Botrystop (A-F)





Rotational spray schedules

- Switch (ACE) rotate with captan (BDF)
- Switch (ACE) rotate with Botristop (BDF)
- Switch (ACE) rotate with Regalia (BDF)
- Switch every 2 weeks (ACE)

Blocking spray schedules

- Switch (ABC) block with Botristop Low (DEF)
- Switch (ABC) block with Botristop High (DEF)
- Switch block (ABC) with Regalia (DEF)
- Switch (ABC)
- Botristop along High (A-F)

Conclusion

- Thiram and Switch are very effective against gray mold
- Captan and Ph-D were pretty good and comparable
- Fracture (ProBLAD) and Howler had somewhat efficacy against Botrytis, while efficacy of Regalia or BotryStop was not evident.
- Under low disease pressure, fungicide activity lasts longer

Neopestalotiopsis

Causes a leaf blotch, crown rot, fruit rot

“2018/19: 5 farms in FL, 1 nursery in NC

2019/20: 20 farms in FL, 2 sites of the same nursery in NC

2020/21: Everywhere in FL, mostly in fields had the issue in the previous season

2021/22: Not as bad as the previous year (weathers have been good)”

---Dr. Natalia Peres from UF



Baggio et al. 2020
Plant Disease

Differentiation from other diseases

- Rapid progression during wet conditions (noticeable decline in days)
- Black pycnidia are typically produced in the center of lesions
- Most growers who thought they had it actually had other more traditional diseases

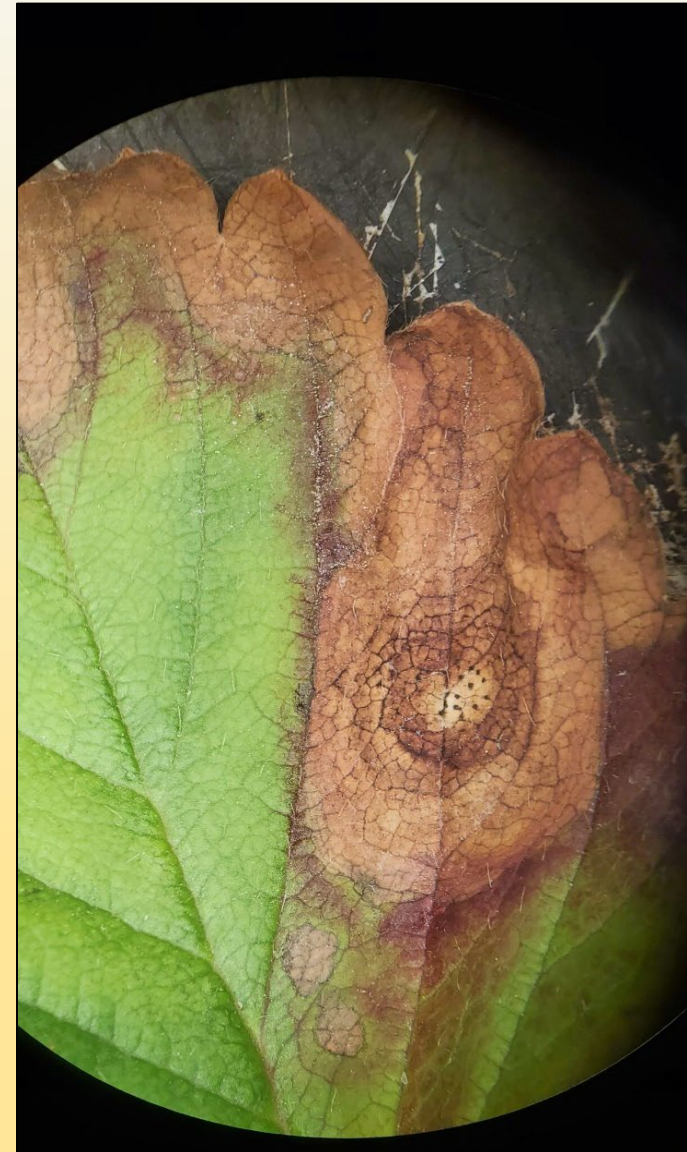


Photo: Kathy Demchak

Cultural Controls

- Avoid introducing the disease (Not taking the chance!!!)
- Sanitation/Leaf removal (when dry)
- Work in less-affected areas first to avoid spread

Chemical Controls

- Thiram SC, Switch or Miravis Prime
- Omega/Bravo are most effective; Bravo is labeled for nurseries, Omega is in the process, but will not be for fruit production

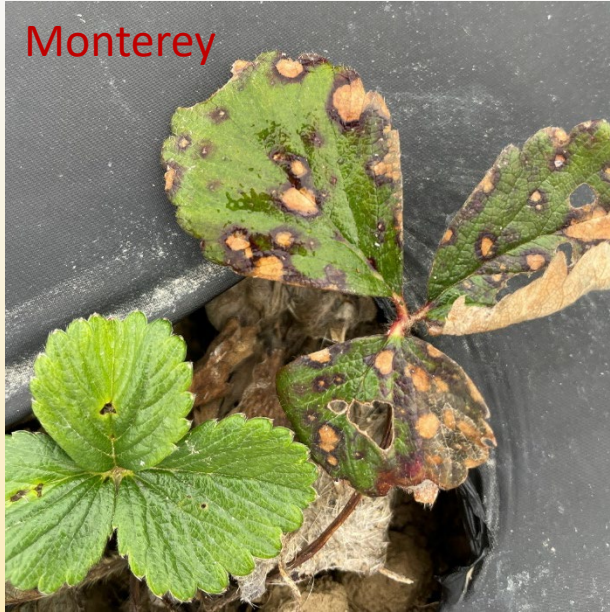
Fungicides are only partially effective; multiple applications likely to be necessary

When they came in... Planting date: Sep 24, 2021



Pictures taken: Nov 23, 2021

Monterey



San Andreas



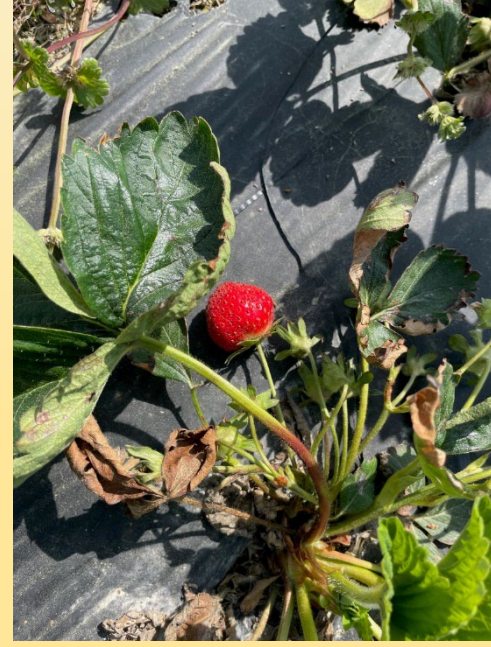
Chandler



Sweet Charlie



Pics taken: 04/25/2022



Pics taken: 03/16/2022



Strawberry anthracnose

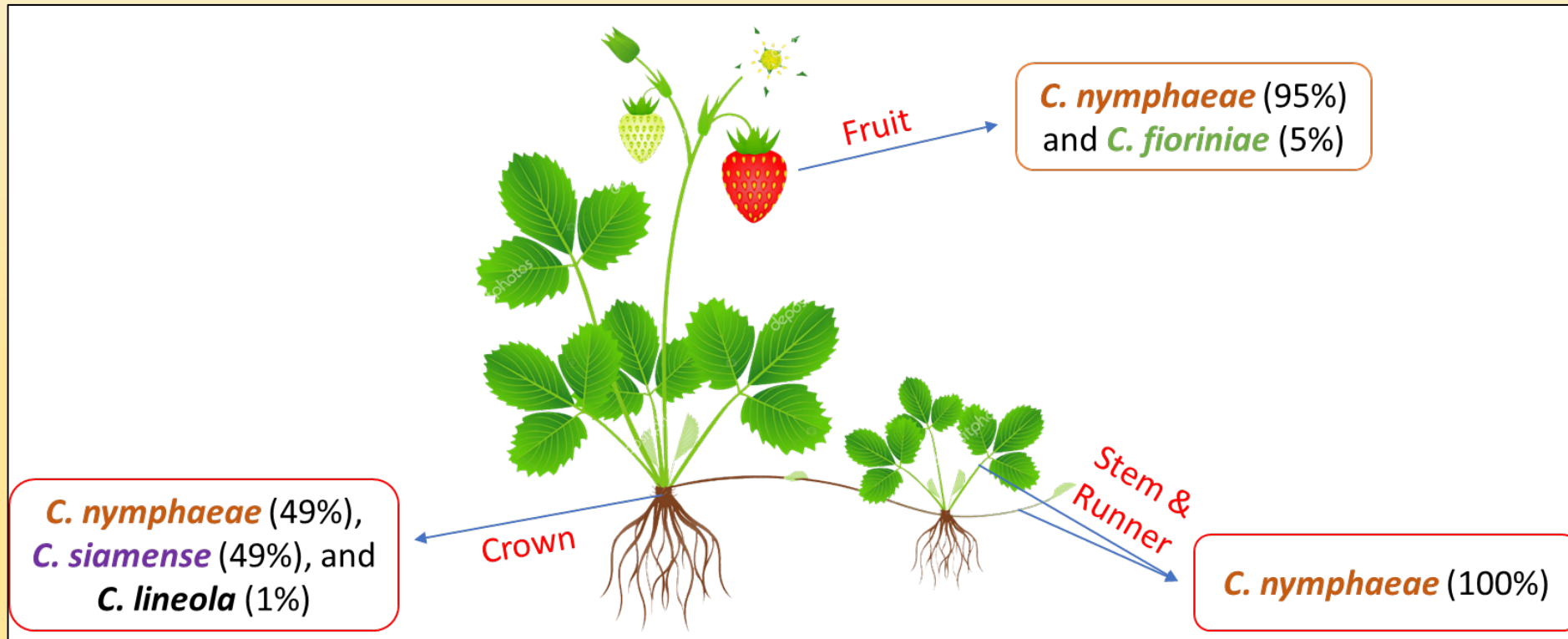
- A major fungal disease on strawberries, caused by species within *Colletotrichum acutatum* & *C. gloeosporioides* complexes.
- Disease infection is usually favored by **extended moisture** and **warm** conditions.
- Symptoms normally referred to as **black spot** on upper parts of the plant. **Bright orange** sporulation typically occurs on mature fruit.
- **Crowns** can also be infected, causing severe stunting or plant death (**ACR**).



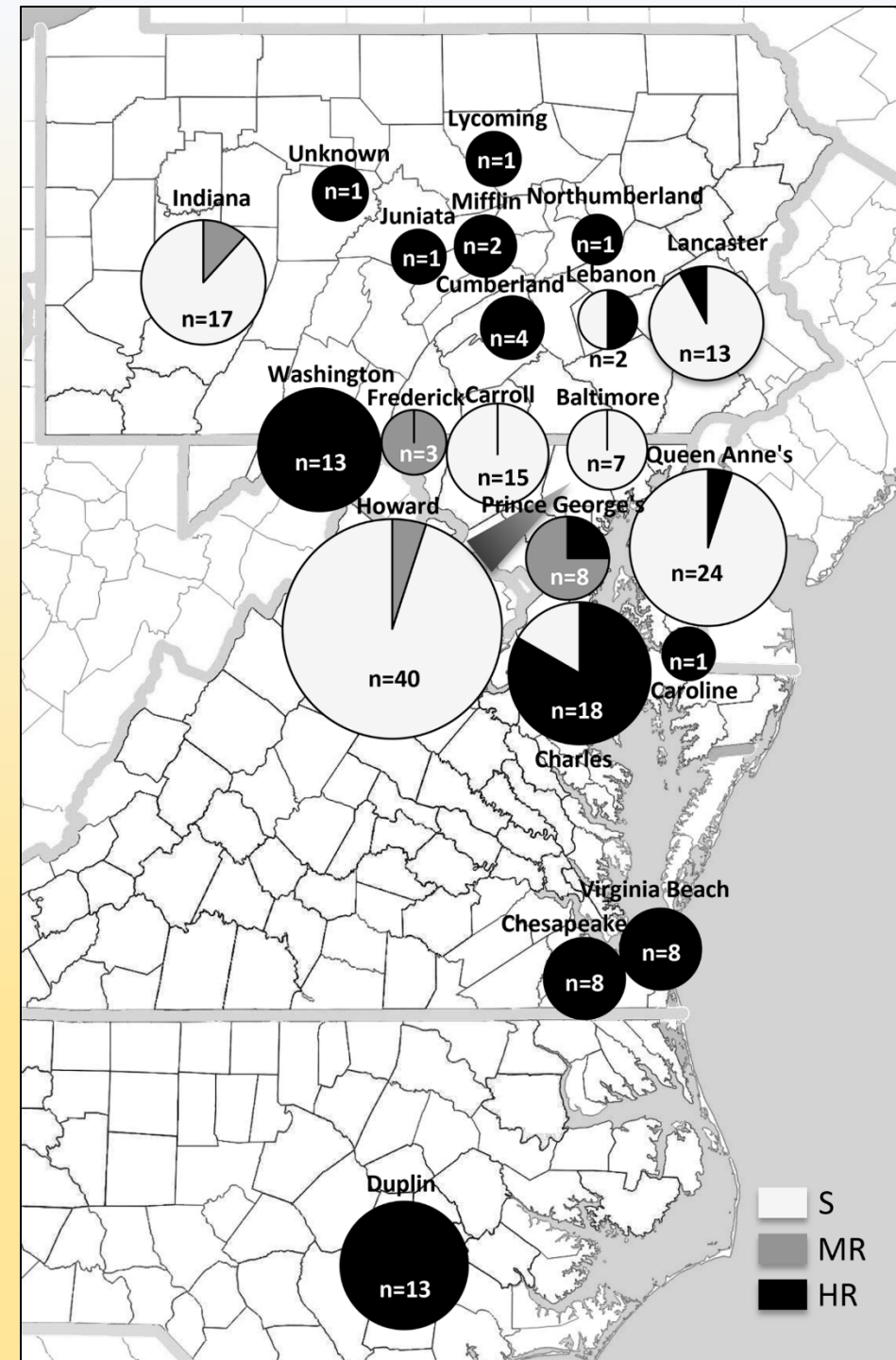
Photo by Madeline Dowling
<http://phytographics.com/>

What species do we have here?

State	<i>C. acutatum</i>		<i>C. gloeosporioides</i>		Total
	<i>C. nymphaeae</i>	<i>C. fioriniae</i>	<i>C. siamense</i>	<i>C. lineola</i>	
Maryland	121	6	2	-	129
Pennsylvania	36	2	3	1	42
Virginia	9	-	7	-	16
North Carolina	13	-	-	-	13
Total	179	8	12	1	200



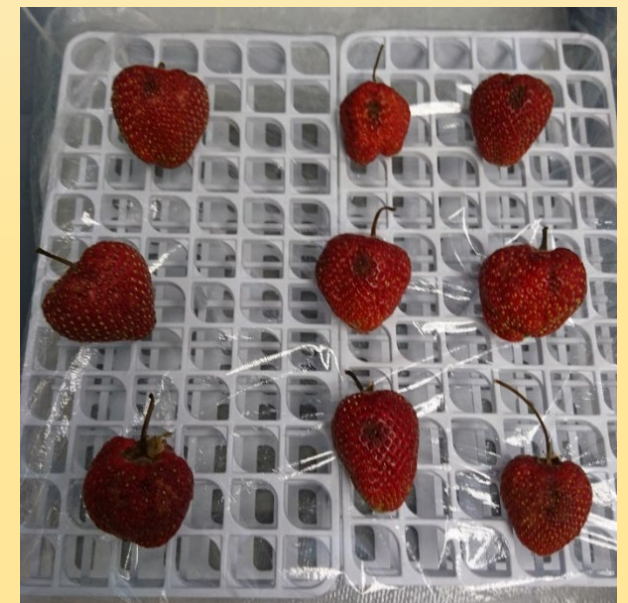
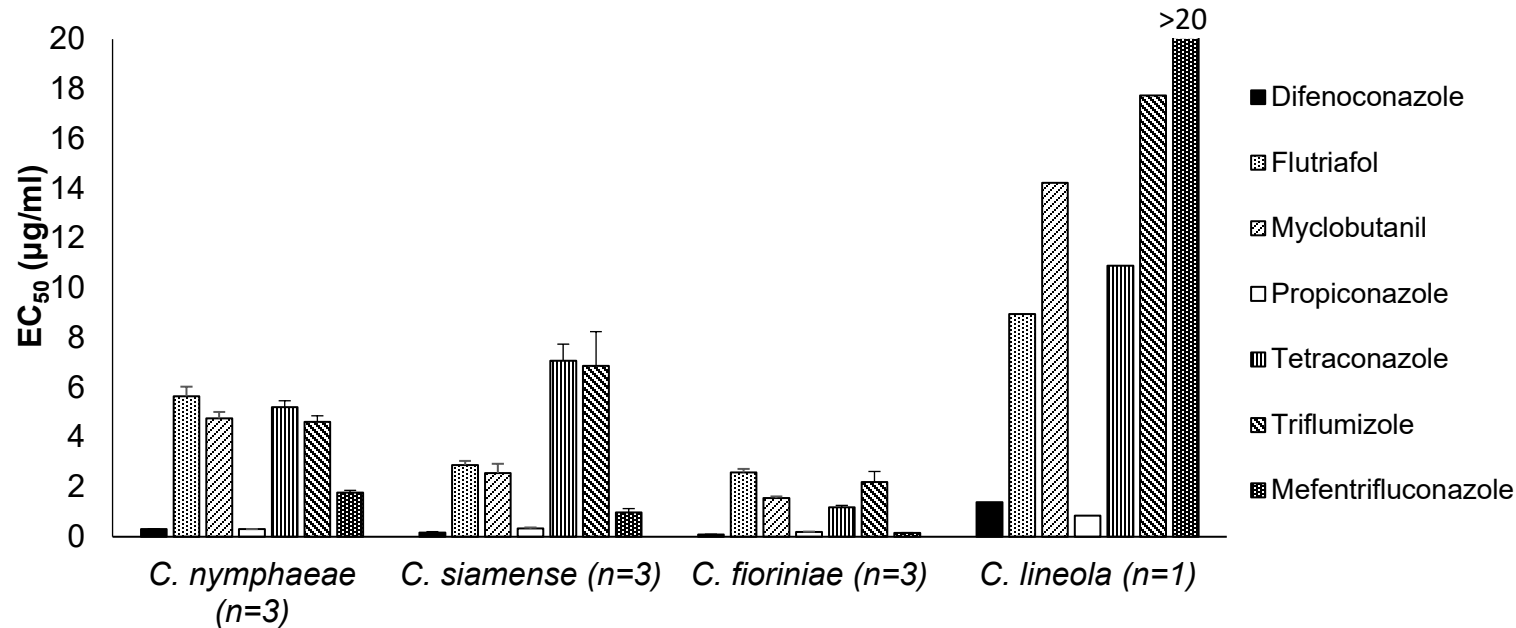
Resistance to strobilurin fungicides (group 11) in anthracnose strains



Major chemical classes of fungicides labelled on strawberry

- ~~• FRAC 1: (Thiophanate-methyl; Topsin M)~~
- ~~• FRAC 2: (Iprodione; Rovral)~~
- FRAC 3: (a variety of a.i. available; Rally, Tilt, Mettle etc.)
- FRAC 7: (multiple a.i. available; Pristine, Fontelis etc.)
- ~~• FRAC 11: (multiple a.i. available; Pristine, Abound etc.)~~
- FRAC 12: (fludioxonil; Switch)

Sensitivity to FRAC 3 (DMI) fungicides



Fungicide treatment	Lesion diameter (mm)
Control (water)	14.1 a
Propiconazole	2.8 c
Triflumizole	14.1 a
Mefentrifluconazole	13.3 a
Triflumizole + Mefentrifluconazole mixture 1:10	6.6 b
Switch	0.00 d

Any new or existing fungicides that may offer some efficacy?

Sensitivity of *Colletotrichum* isolates to FRAC 7 (SDHI) fungicides (mycelial growth)

Species and isolates	EC ₅₀ (µg mL ⁻¹) of fungicide:				
	Bos-	Fluxapy-	Penthio-	Fluopy-	Benzovin-
<i>C. gloeosporioides</i>					
Niitaka 3	>100	>100	2.6	>100	0.2
5-2-1	>100	>100	1.9	>100	<0.1
5-2-2	>100	>100	1.8	>100	<0.1
Nagasaki 1	>100	>100	0.8	>100	<0.1
Nagasaki 2	>100	>100	0.7	>100	<0.1
19002	>100	>100	1.6	>100	<0.1
Cg_RR12-1	>100	>100	1.2	>100	<0.1
Cg_SE12-2	>100	>100	1.1	>100	<0.1
Cg_EY12-2	>100	>100	2.6	>100	<0.1
Cg_RR12-4	>100	>100	1.1	>100	<0.1
Ca_EY12-1	>100	>100	2.0	>100	<0.1
<i>C. acutatum</i>					
GC2-1	>100	>100	0.3	>100	<0.1
AAU811-3	>100	>100	0.5	>100	<0.1
CO4-35	>100	>100	1.2	>100	<0.1

- Bos: Pristine
- Fluxapy: Merivon
- Penthio: Fontelis
- Fluopy: Luna series
- Benzovin: Aprovia (not labeled on strawberry)

Ishii et al., 2016
(Pest Manag. Sci.)

Fungicides evaluated:

Cevya (4.0 fl oz) + Induce (0.125% v/v)

Cevya (5.0 fl oz) + Induce

Mibelya (6.0 fl oz) + Induce

Merivon (4.0 fl oz) + Induce

Captan 4L (3.0 qt)

Location: Wye REC, Queenstown MD
Spring/Summer 2020

Cevya: mefentrifluconazole (FRAC 3)

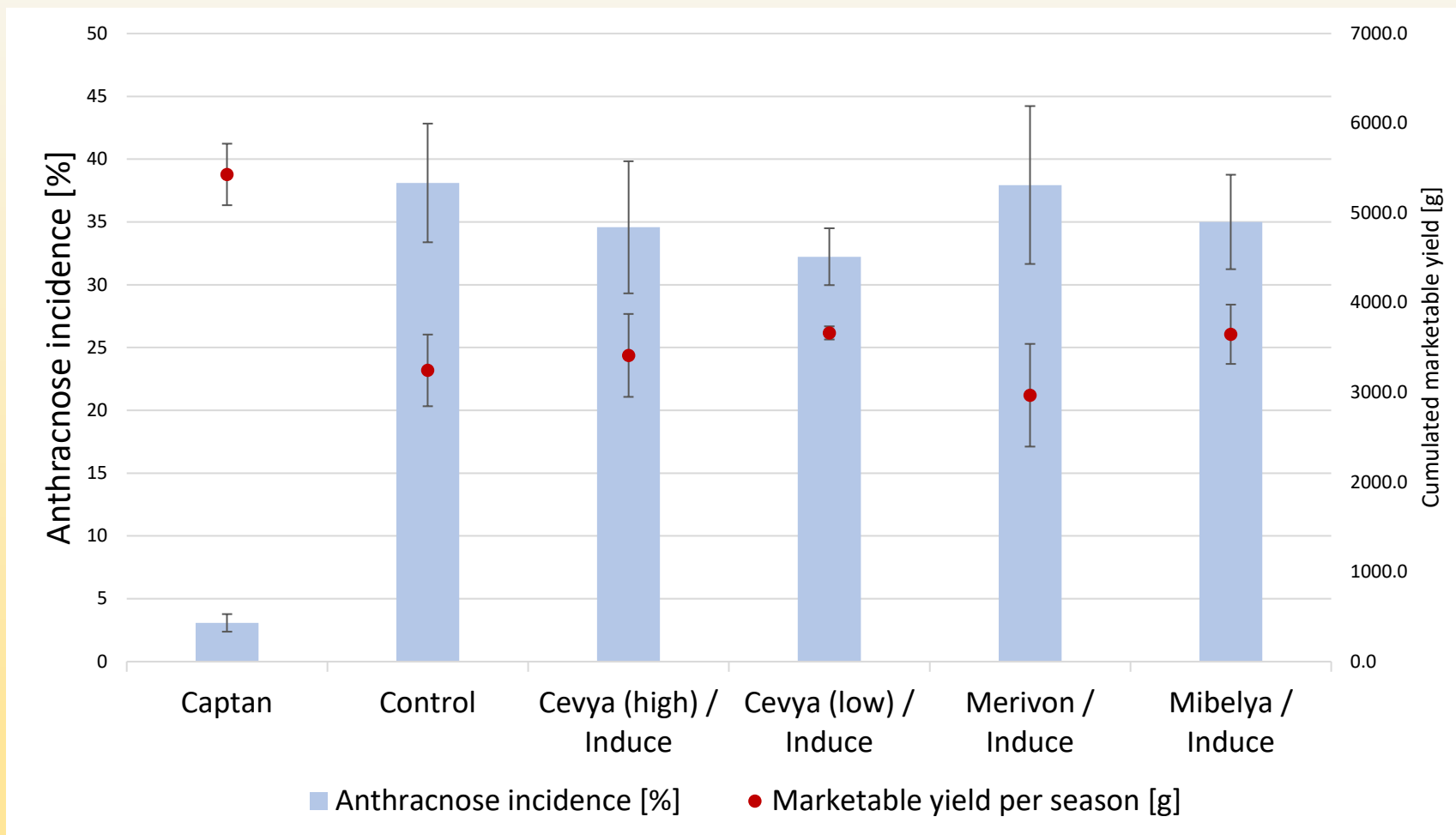
Mibelya: mefentrifluconazole (FRAC 3) + fluxapyroxad (FRAC 7)

Merivon: fluxapyroxad (FRAC 7) + Pyraclostrobin (FRAC 11)

Application dates	
1st (10-20% bloom)	3/26/2020
2nd	4/2/2020
3rd	4/9/2020
4th	4/16/2020
5th	4/23/2020
6th	4/30/2020
7th (1st pick)	5/7/2020
8th	5/15/2020



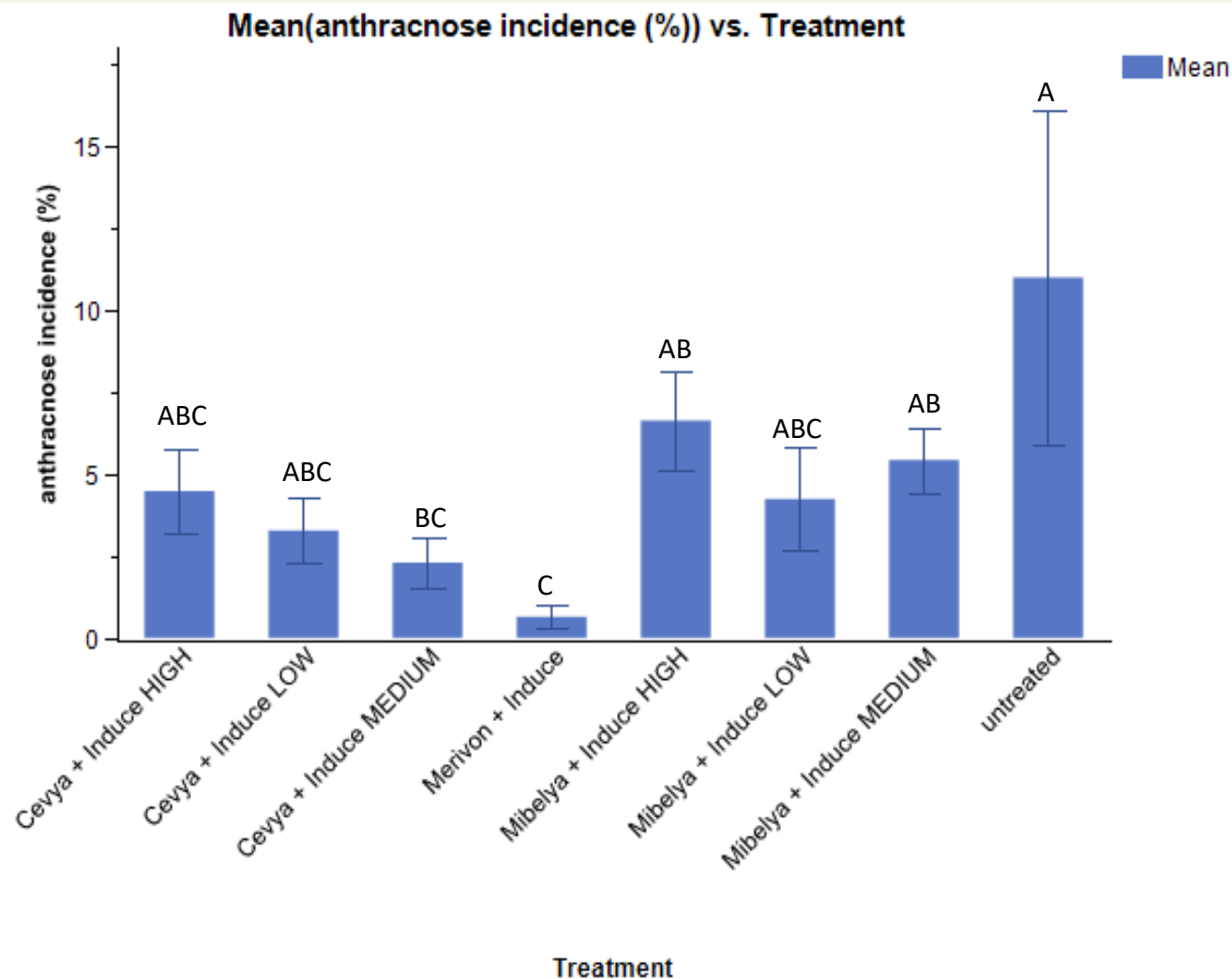
Means from 7 picks (pre-harvest)



Repeated in 2021, with a few more rates

Treatments

- Cevya (4.0 fl oz) + Induce (0.125% v/v)
- Cevya (5.0 fl oz) + Induce
- **Cevya (10.0 fl oz) + Induce**
- Mibelya (6.0 fl oz) + Induce
- **Mibelya (8.0 fl oz) + Induce**
- **Mibelya (20.0 fl oz) + Induce**
- Merivon (4.0 fl oz) + Induce



Conclusion

- Captan is effective against anthracnose, without selecting for resistance
- The new DMI fungicide Cevya (mefentrifluconazole) offers somewhat efficacy, but not as effective as captan
- Certain DMIs (e.g. Tilt and Quadris Top) and Fontelis may be useful
- Merivon or other strobilurin fungicides would work if NO fungicide resistance

