Blueberry and Strawberry Disease Issues

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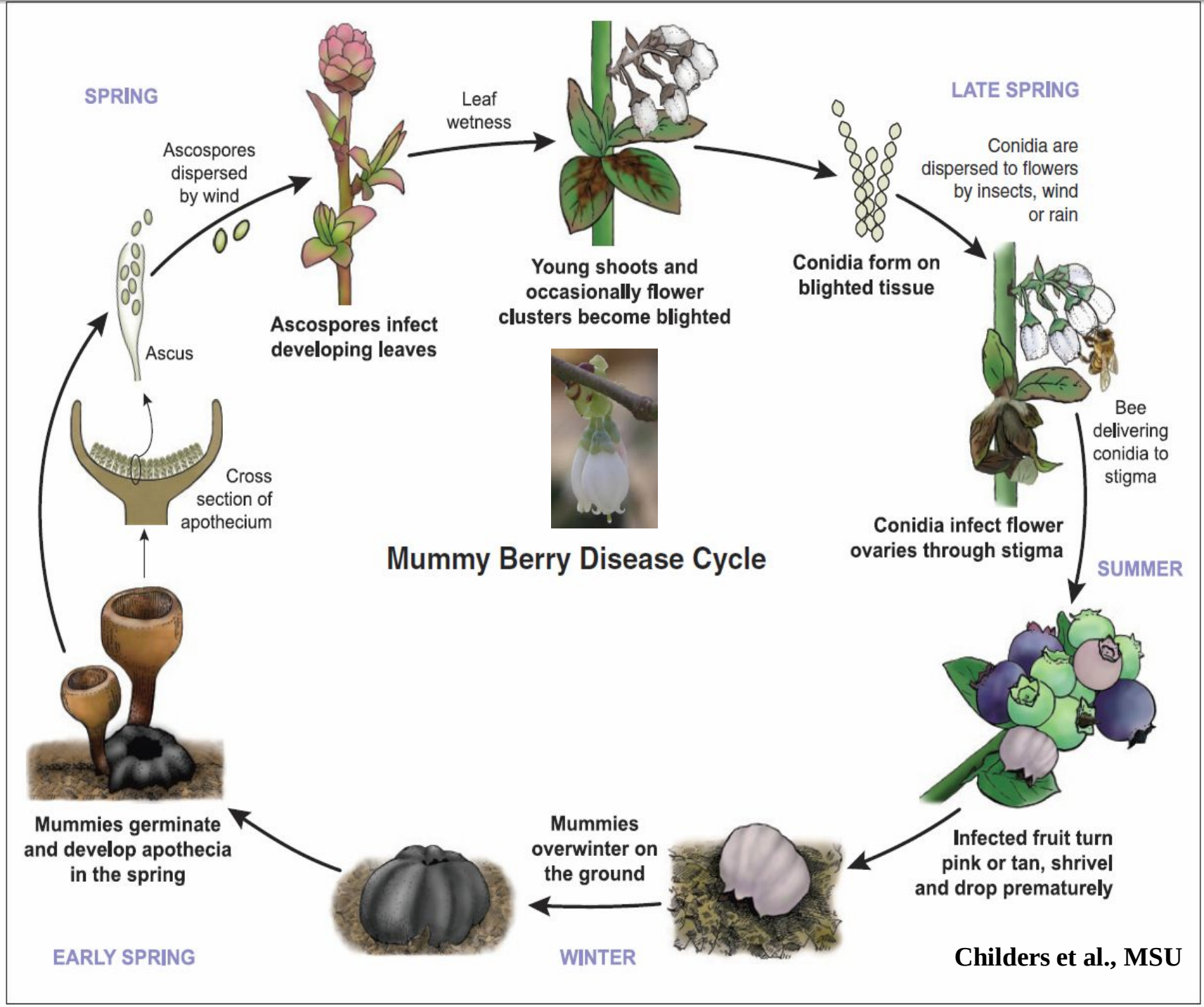
Handout- Fungicide Resistance Guide

Fungicide	Active Ingredient(s)	FRAC CODE	Resistance Risk	Angul leaf spot	Anthrac fruit rot	Anthrac crwn rot	Gray mold	Phytoph root rot	Powdery mildew	REI (h) / PHI (d)
				L	H	H	H*	L*	H	
fixed copper	fixed copper	M1	L	x						24h/0d
Thiram	thiram	M3	L		x		x			24h/3d
Captan	captan	M4	L		x		x			24h/1d
Captevate	captan + fenhexamid	M4 + 17	L		x		x			24h/0d
Topsin M	thiophanate-methyl	1	H*			x	x			12h/1d
Rovral	iprodione	2	M*				x			24h/-
Rally	myclobutanil	3	M						x	24h/0d
Procure	triflumizole	3	M						x	12h/1d
Ultra Flourish	mefenoxam	4	H*					x		12h/0d
MetaStar	metalaxyl	4	H*					x		not rec
Ridomil Gold	mefenoxam	4	H*					x		12h/0d
Fontelis	penthiopyrad	7	H*				x			12h/0d


SPRING
Ascospores dispersed by wind
Ascus
Cross section of apothecium
Ascospores infect developing leaves
Leaf wetness
Young shoots and occasionally flower clusters become blighted
LATE SPRING
Conidia are dispersed to flowers by insects, wind or rain
Conidia form on blighted tissue
Bee delivering conidia to stigma
Conidia infect flower ovaries through stigma
SUMMER
Infected fruit turn pink or tan, shrivel and drop prematurely
WINTER
Mummies overwinter on the ground
EARLY SPRING
Mummies germinate and develop apothecia in the spring
Mummy Berry Disease Cycle
Childers et al., MSU

Indar, Orbit, or Tilt

and

Pristine

Effect of fungicide treatments on the incidence of primary and secondary infection by *Monilinia vaccinii-corymbosi* on 'Brightwell' rabbiteye blueberry in Alma, GA (2003).

Treatment	Rate/A	Avg. number of strikes per bush	Avg. number of mummies per m^2
Untreated control	---	50.3 ± 8.3 a	10.7 ± 0.31 a
Abound	12.4 fl oz	30.2 ± 8.4 ab	8.9 ± 0.31 abc
CaptEvate	5.25 lb	44.6 ± 8.5 ab	9.7 ± 0.32 ab
Indar	2 oz	5.3 ± 8.3 c	3.7 ± 0.31 cd
Omega	12 fl oz	22.3 ± 8.3 bc	6.1 ± 0.31 abcd
Orbit	6 fl oz	6.2 ± 8.5 c	4.3 ± 0.32 bcd
Pristine	20 oz	8.4 ± 8.4 c	3.1 ± 0.32 d
Scala	18 fl oz	38.9 ± 8.3 ab	11.4 ± 0.31 a
Topsin-M + Captan	1 lb + 5 lb	41.1 ± 8.3 ab	8.5 ± 0.31 abc

Applications were made on 28 February (pre-bloom), 8 March (1% bloom), and 14 March (20% bloom) via airblast sprayer in 50 gal/acre water.

Stanaland, Brannen, and Scherm; 2003

Indar and Rots

Treatment and rate/A (applied at late green tip, full bloom and blossom drop)	Fruit rot (% incidence of *C. acutatum*) *TRIAL 1*	Fruit rot (% incidence of *C. acutatum*) *TRIAL 2*
Unsprayed Check	30.0 a	48.5 a
Indar 75WP 2.0 oz	49.0 b	73.5 b

A.M.C. Schilder et al., Michigan State University; 1999 and 2000

Ripe Rot Trial Results

Treatment and Rate/Acre (applied at pink bud, early bloom and full bloom)	Fruit rot (% incidence of *C. acutatum*) *Harvest 1*	Fruit rot (% incidence of *C. acutatum*) *Harvest 2*	Fruit rot (% incidence of *C. acutatum*) *Harvest 3*
Unsprayed Check	38.7 a	23.0 a	11.5 a
Benlate 50WP 1.0 lb + Captan 75WG 3.0 lb	4.5 b	2.0 d	2.3 b
Indar 75WP 2.0 oz + Latron B-1956 8.0 fl oz + Captan 75WG 3.0 lb	9.0 b	6.2 d	9.8 a
Indar 75WP 2.0 oz	22.4 ab	12.3 c	6.8 ab
Indar 75WP 2.0 oz + Latron B-1956 8.0 fl oz	38.6 a	18.4 ab	12.1a

P=0.05

W.O. Cline and B.K. Bloodworth, NC State; 1999

Captan actually does a lot for us, and it should probably be applied with Indar, since there is pretty strong evidence that Indar alone may increase rots – may be more problematic in southern highbush varieties.

Botrytis Blossom Blight

Botrytis Blight and Fruit Rot
(*Botrytis cinerea*)

- Problem in prolonged cool, wet conditions.
- Losses are due to blossom blight and fruit rot, as well as reduced fruit buds for the next year.
- Frost or cold damage during bloom, as well as poor pollination, encourages the disease.
- Cool, wet conditions are all that is required. <u>The blighted blooms will cause twig blight.</u>

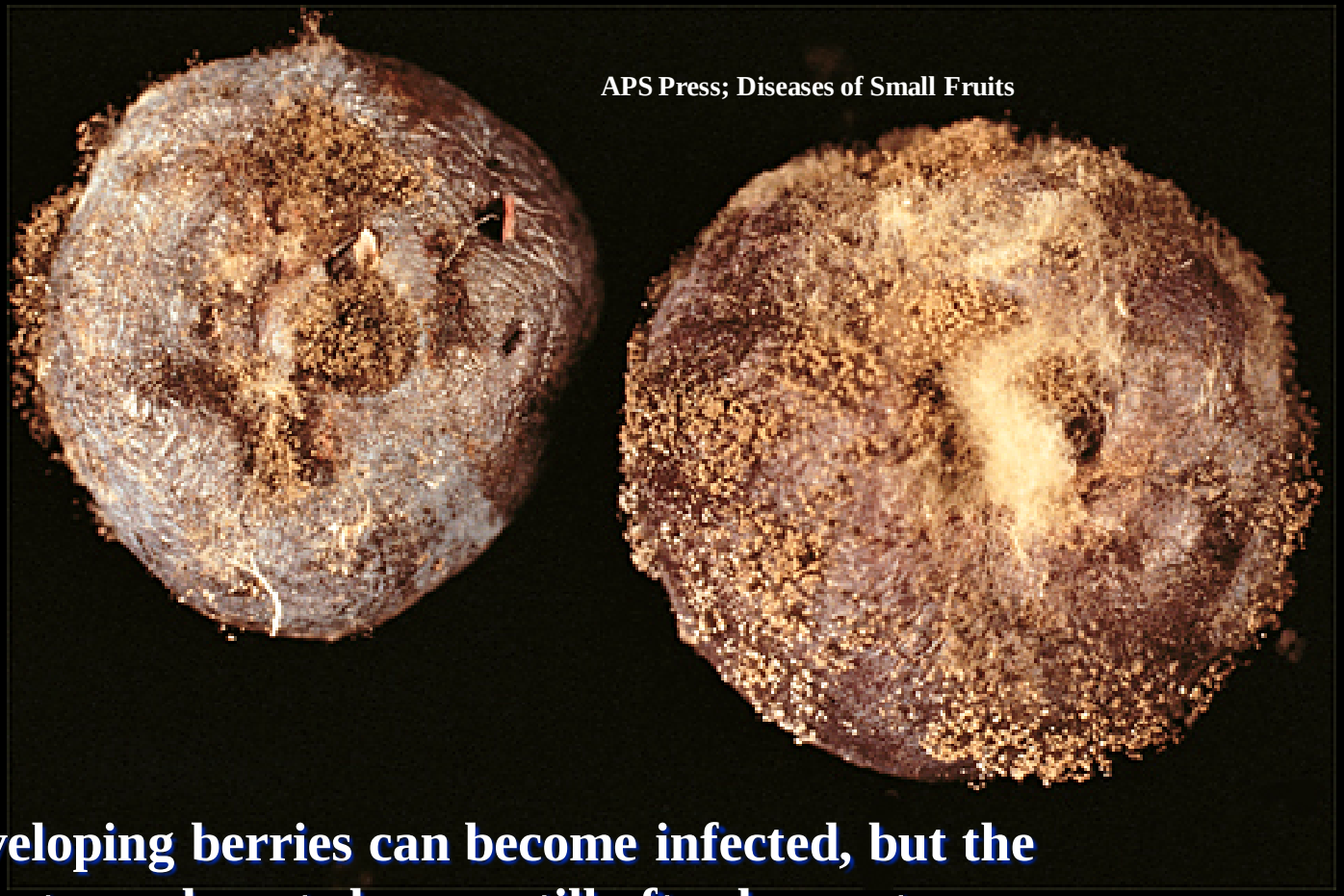
What to do about Botrytis Blight and Fruit Rot

(*Botrytis cinerea*)

- Monitor during bloom. Many producers always apply fungicides for Botrytis.
- Apply fungicidal sprays, if conditions warrant, during bloom.
- Maintain adequate air flow, and do not overfertilize with nitrogen fertilizers in the spring (creating succulent growth).

APS Press; Diseases of Small Fruits

Overwintering Botrytis Sclerotia



Developing berries can become infected, but the symptoms do not show up till after harvest.

Switch, Elevate, CaptEvate, Pristine, and Captan are registered for control of Botrytis blossom blight.

Primary Blueberry Rots

- Anthracnose (Ripe) Rot (*Colletotrichum acutatum* and *Colletotrichum gloeosporioides*)
- Alternaria Fruit Rot (*Alternaria tenuissima*)

Anthracnose (Ripe) Rot

Note salmon-colored
Spores on infected fruit

Alternaria Fruit Rot

Often the calyx end is
Covered with greenish,
Black mycelium

Alternaria Fruit Rot

"*Alternaria* spp., fungi. Although not as common as ripe rot, this disease has caused severe losses in some Oregon fields. Infections can occur any time between late bloom through fruit maturity. Infections remain quiescent (latent) until fruit ripens. The disease often is not seen in the field but develops in storage or in transit to market."

Oregon State University

Alternaria Fruit Rot

"In post-harvest experiments, 96% of alternaria rot infections occurred through the stem scar of the berry. This indicates that most alternaria infections are not initiated until after fruit is harvested, because the stem scar is only exposed when berries are detached."

Bill Cline; North Carolina State University

Post-Harvest Cooling and Rots

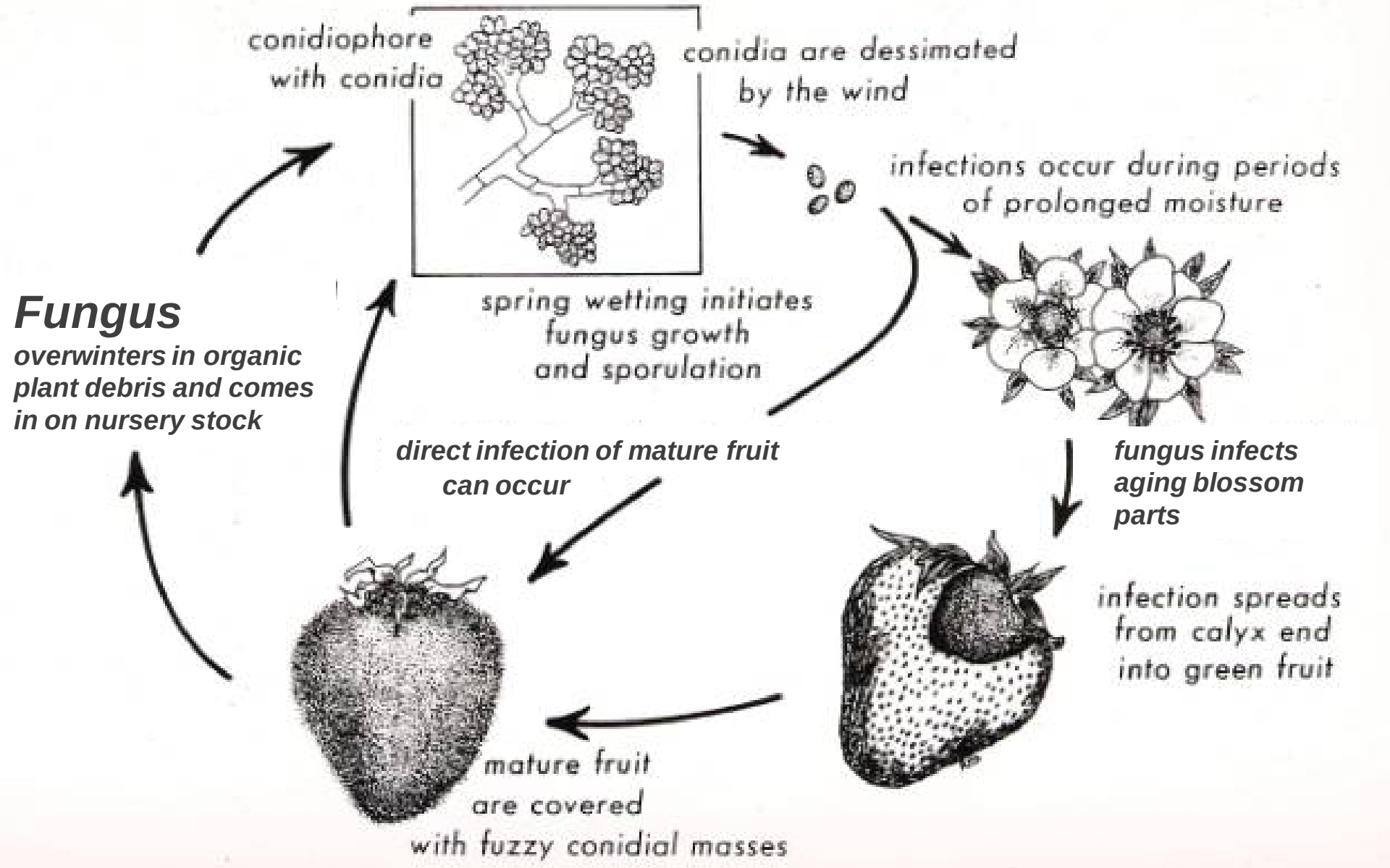
“Postharvest Cooling has given the most consistent control of postharvest decay. Cooling the fruit after harvest retains quality and prolongs shelf life. Cool as quickly as possible to 40° F (5° C) or lower, but not below 32°F (0° C). If cooled promptly and kept cool, quality blueberries packaged ready for retail sale can be expected to hold up well at 32° F (0° C) for 2 weeks and at 40° F (5° C) for 1 week, but only for 2 days at 70° F (21° C). Forced-air cooling is the most satisfactory method for quickly reducing the temperature of palletized blueberry fruit in consumer-ready containers.”

Bill Cline; North Carolina State University

Rot Control

- Fungicide sprays (Switch™, Abound™, Cabrio™, Pristine ™, and Captan) and rapid cooling immediately following harvest provide for control.
- Infection can take place at any time on the fruit, but critical times appear to be bloom, post-bloom and preharvest.

Gray mold of Strawberry



Gray Mold Disease of Strawberry

Botrytis cinerea

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

HIGH RISK pathogen for fungicide resistance development

Mode of Action	Group name	Characteristic
Methionine biosynthesis	Anilinopyrimidines (FRAC 9)	Single site
Mitosis and cell division	M Benzimidazole Carbamates (FRAC 1)	
Signal transduction	Dicarboxamides (FRAC 3)	
Membrane sterol biosynthesis	Hydroxyanilides (FRAC 17)	
Respiration	Quinone Outside Inhibitors (FRAC 11)	
Signal transduction	Phenylpyrroles (FRAC 12)	
Respiration	Succinate Dehydrogenase Inhibitors (FRAC 7)	
	Dithiocarbamates	Multi-site
	Phthalimides	

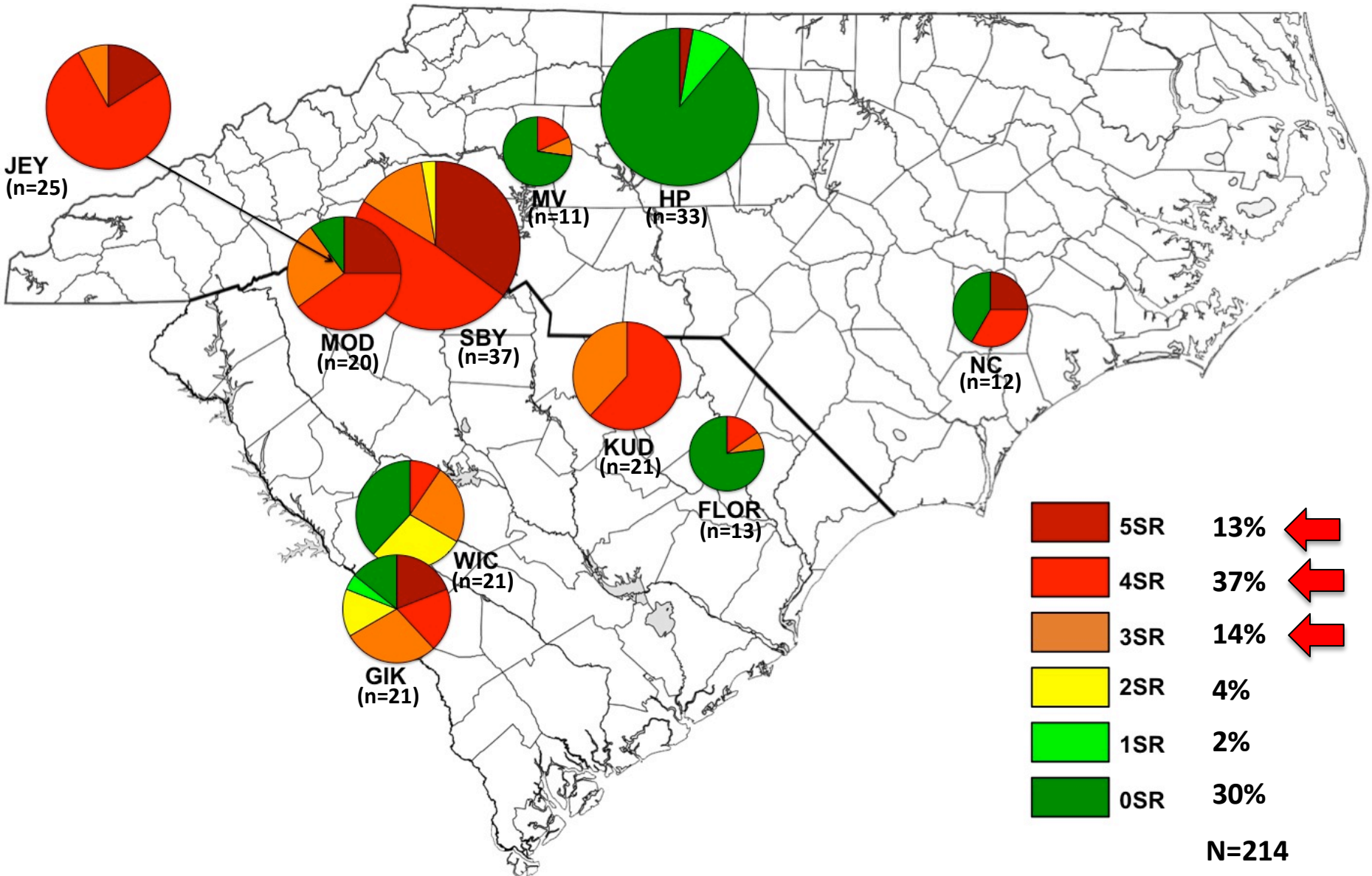
In vivo Fungicide Resistance Assay

Topsin M

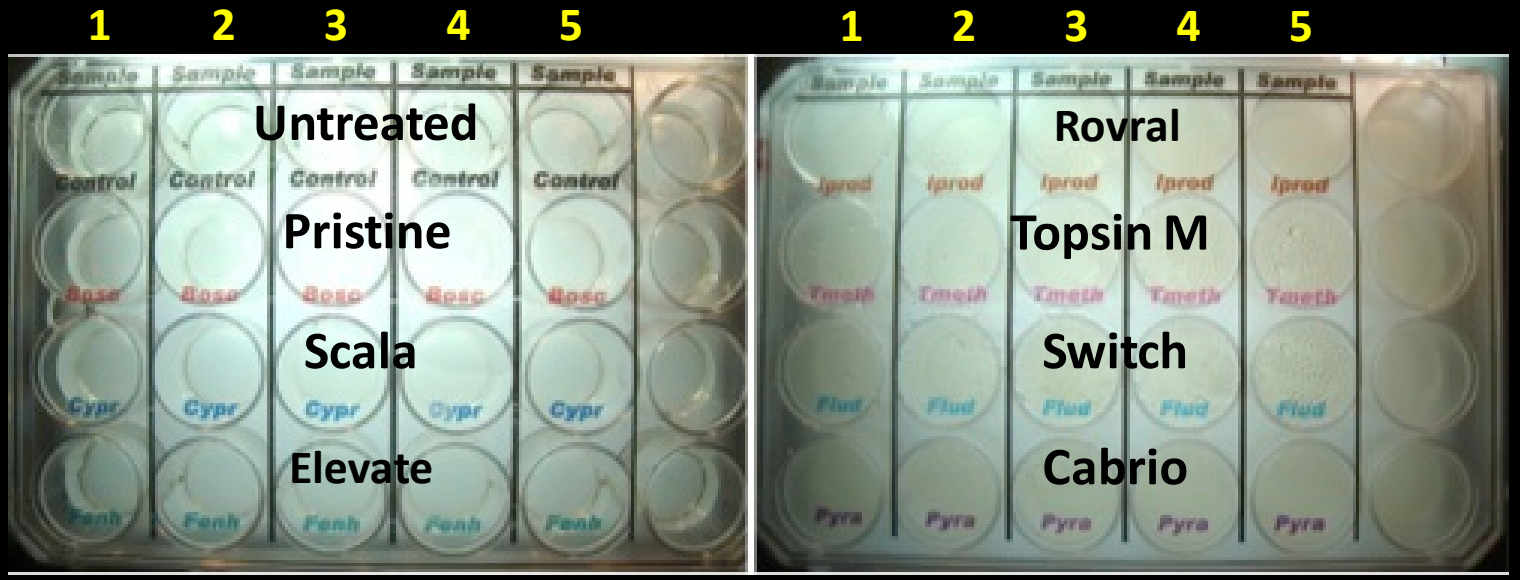
Sensitive strain

Resistant strain

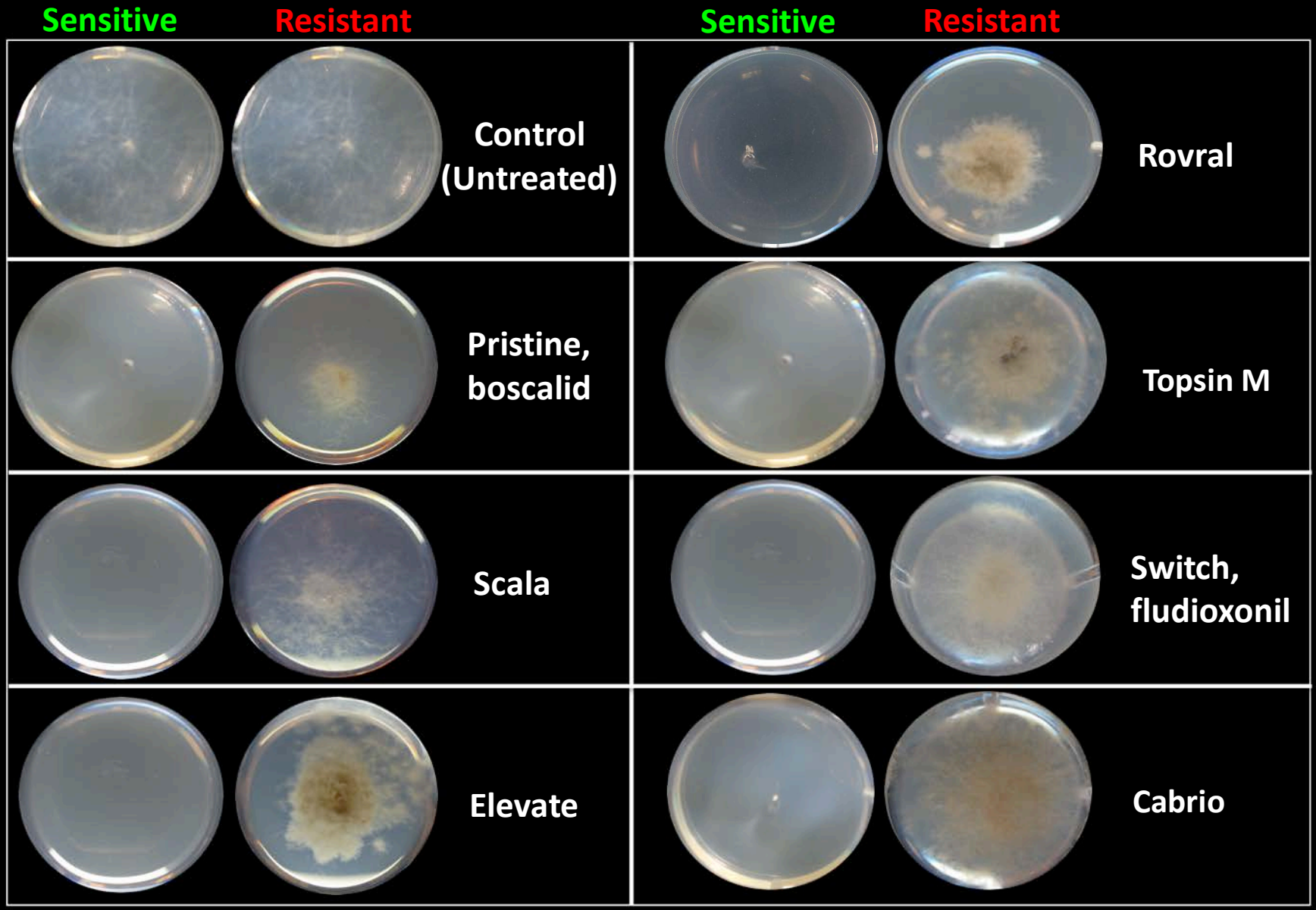
Multifungicide Resistance in *B. cinerea* from strawberry (North and South Carolina)



Fungicide Resistance Monitoring



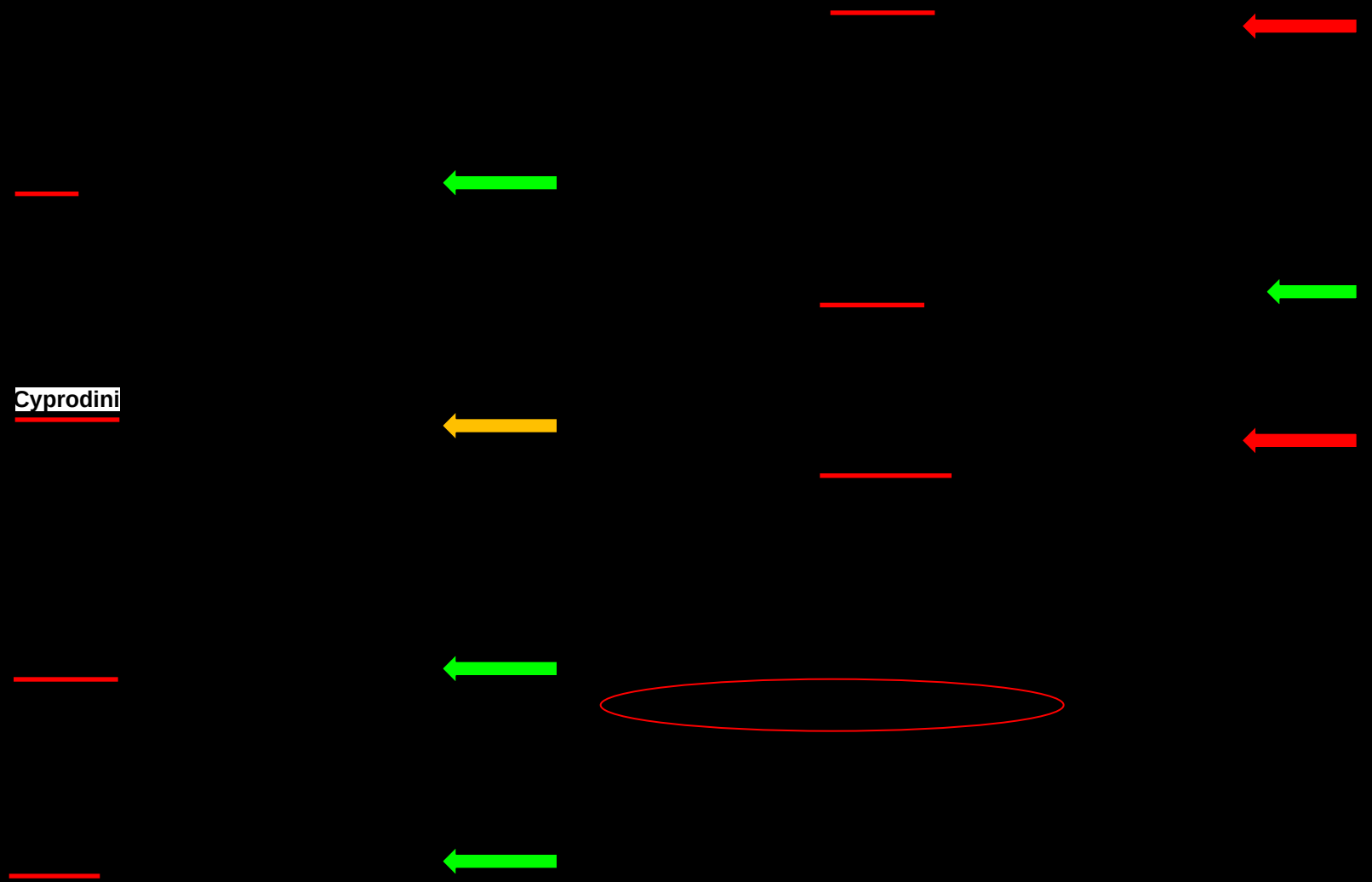
Growth after 4 days



Resistance Risk Assessment

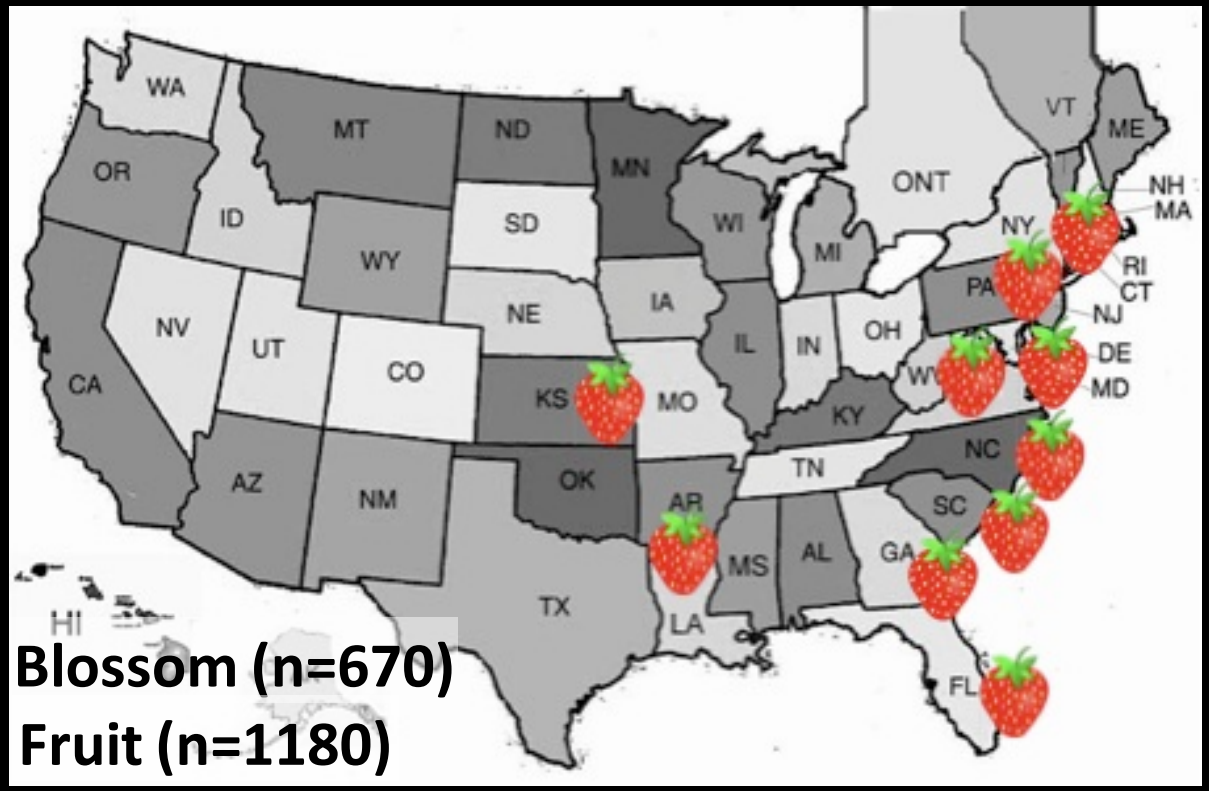
Number or resistant strains per sample (n=10)	Resistance risk
0	None to low
1 (10%)	Moderate
2 (20%) or more	High

Recommendation report is sent for each farm



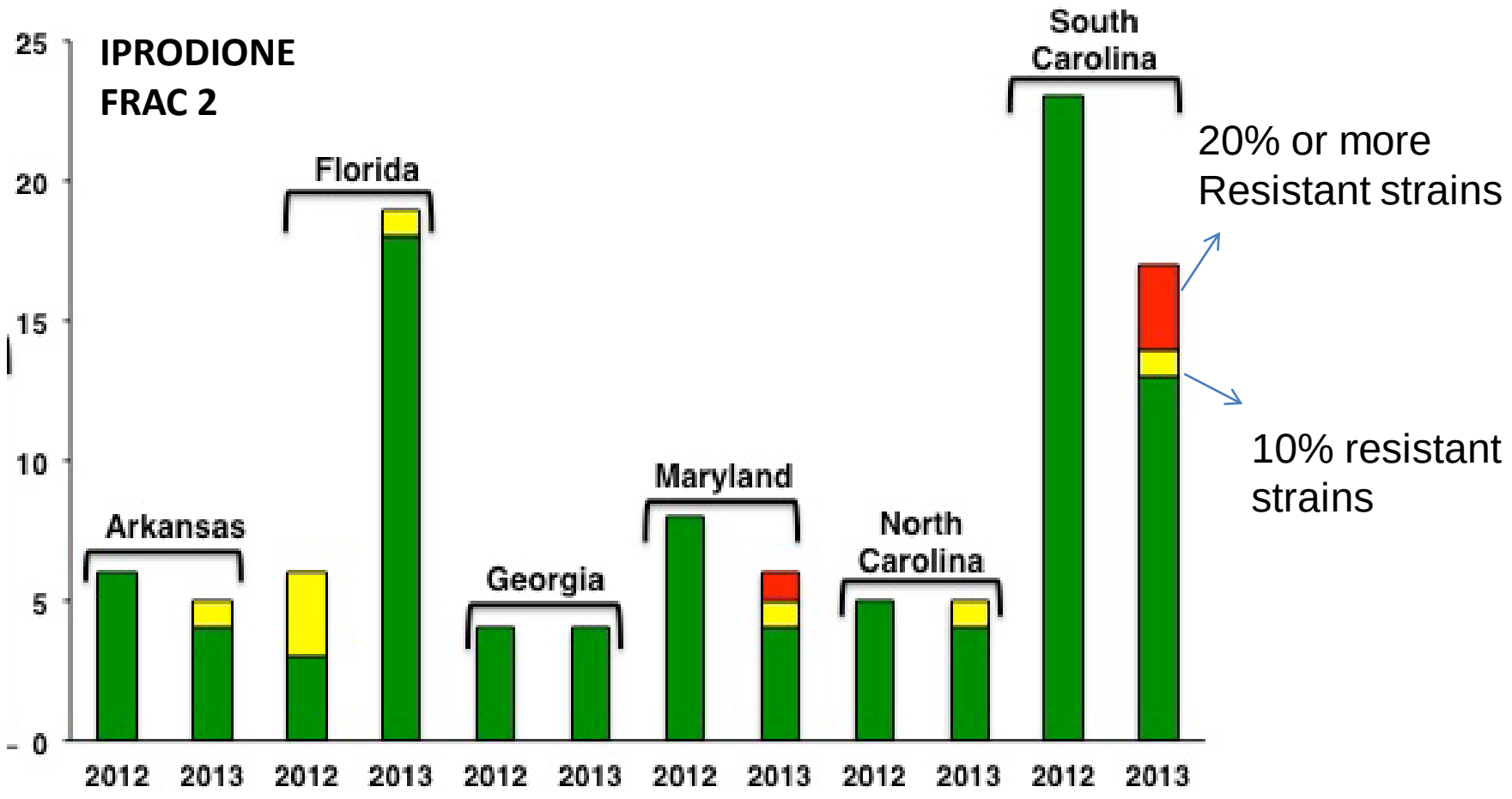
Fungicide Resistance Monitoring

In 2012 and 2013, a total of 1850 isolates of *B. cinerea* were collected from 185 strawberry fields in 10 states



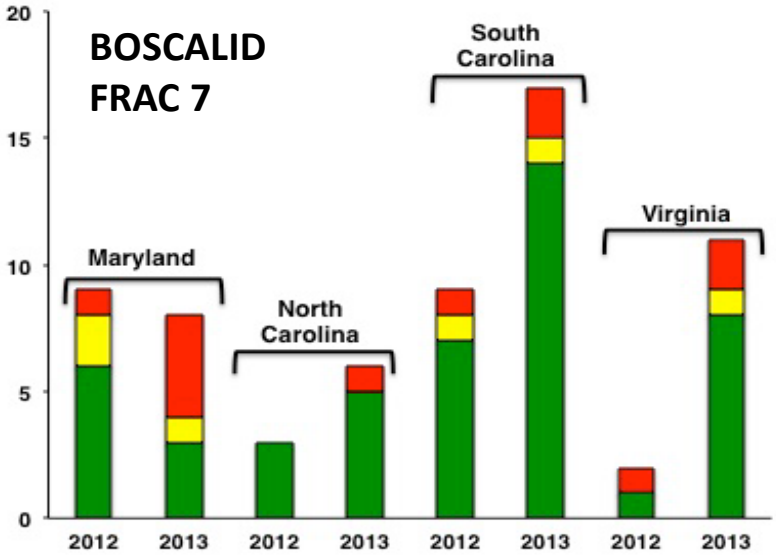
Locations with 10% or more than 20% resistant *Botrytis cinerea* isolates

Rovral

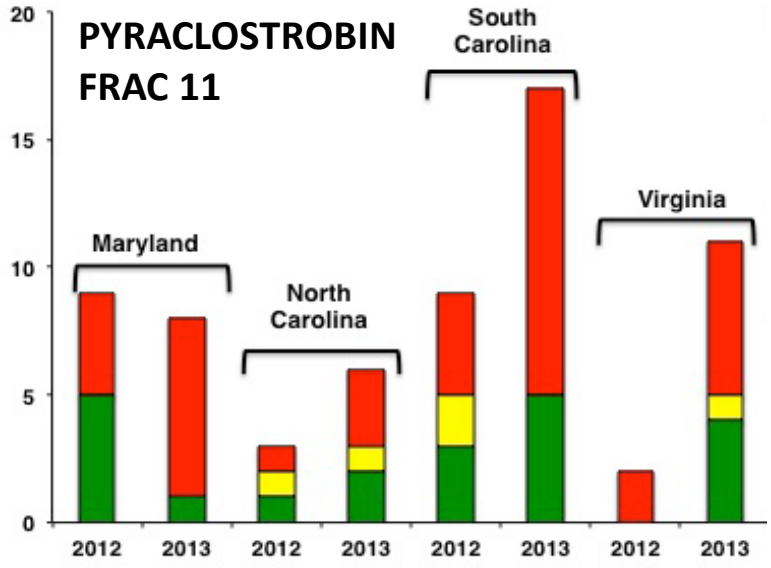


Locations with 10% or more than 20% resistant *Botrytis cinerea* isolates

Pristine



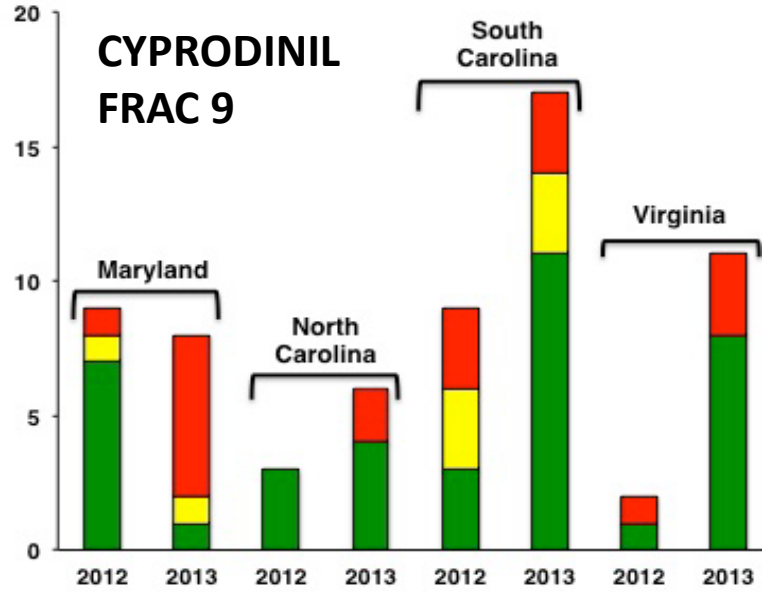
Cabrio

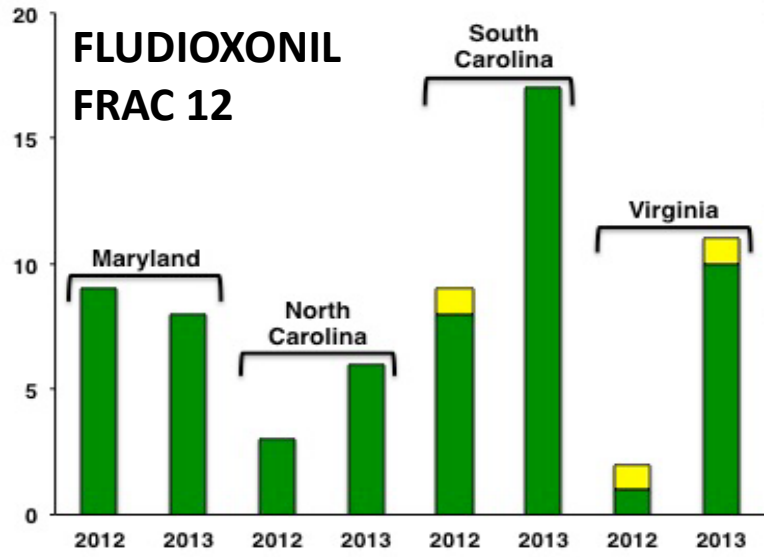


Locations with 10% or more than 20% resistant *Botrytis cinerea* isolates

Scala

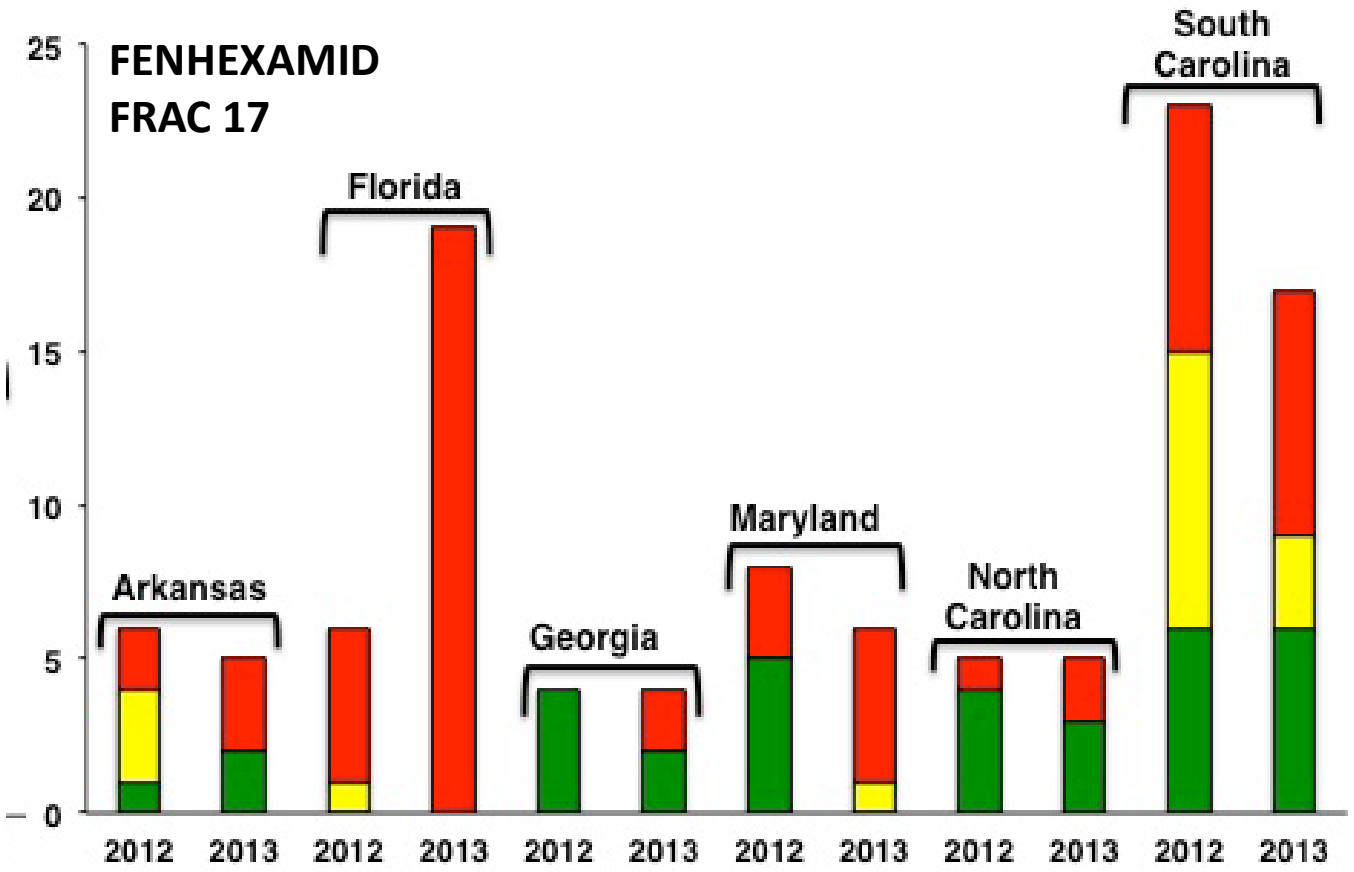
Switch





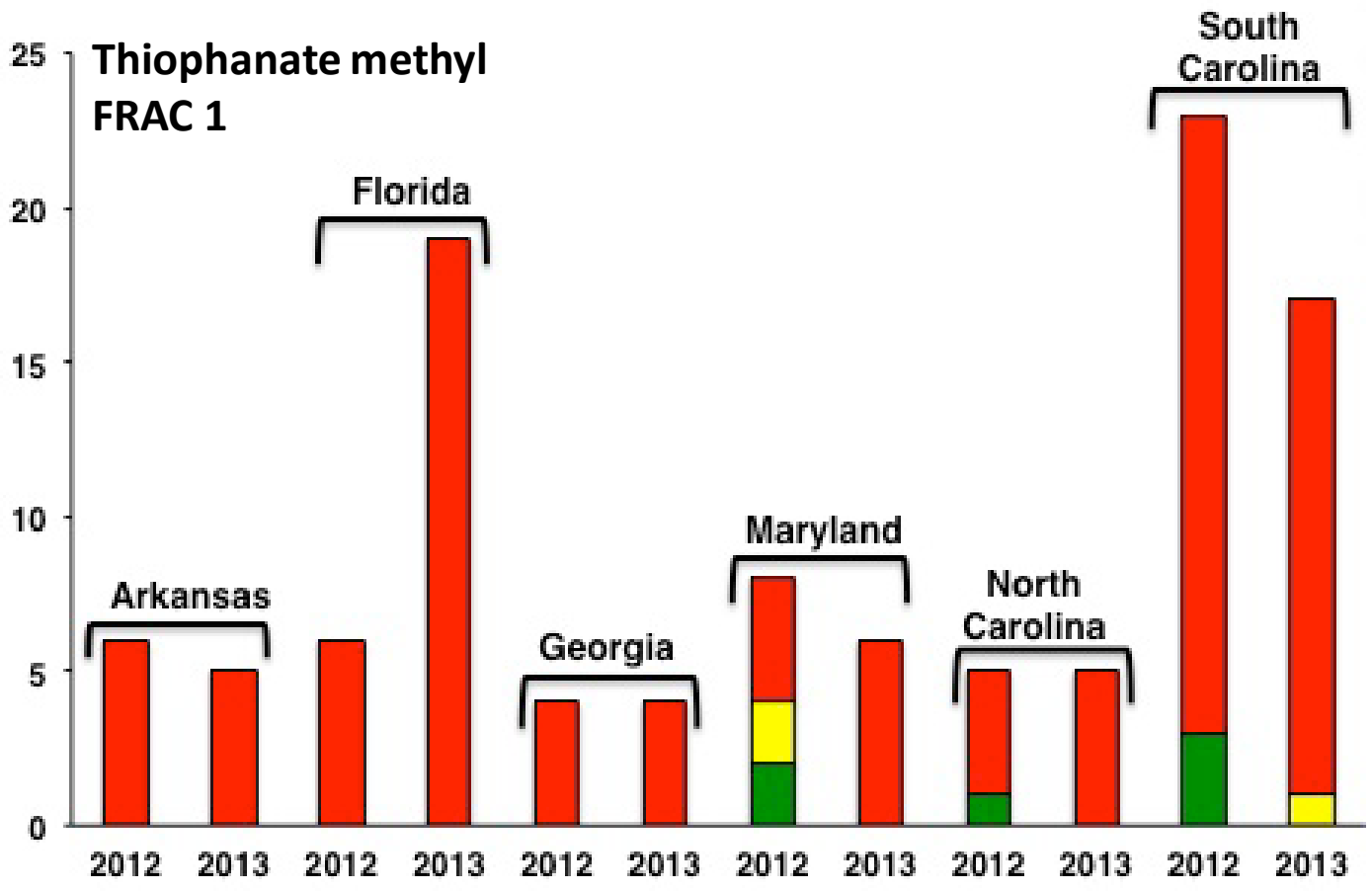
Locations with 10% or more than 20% resistant *Botrytis cinerea* isolates

Elevate

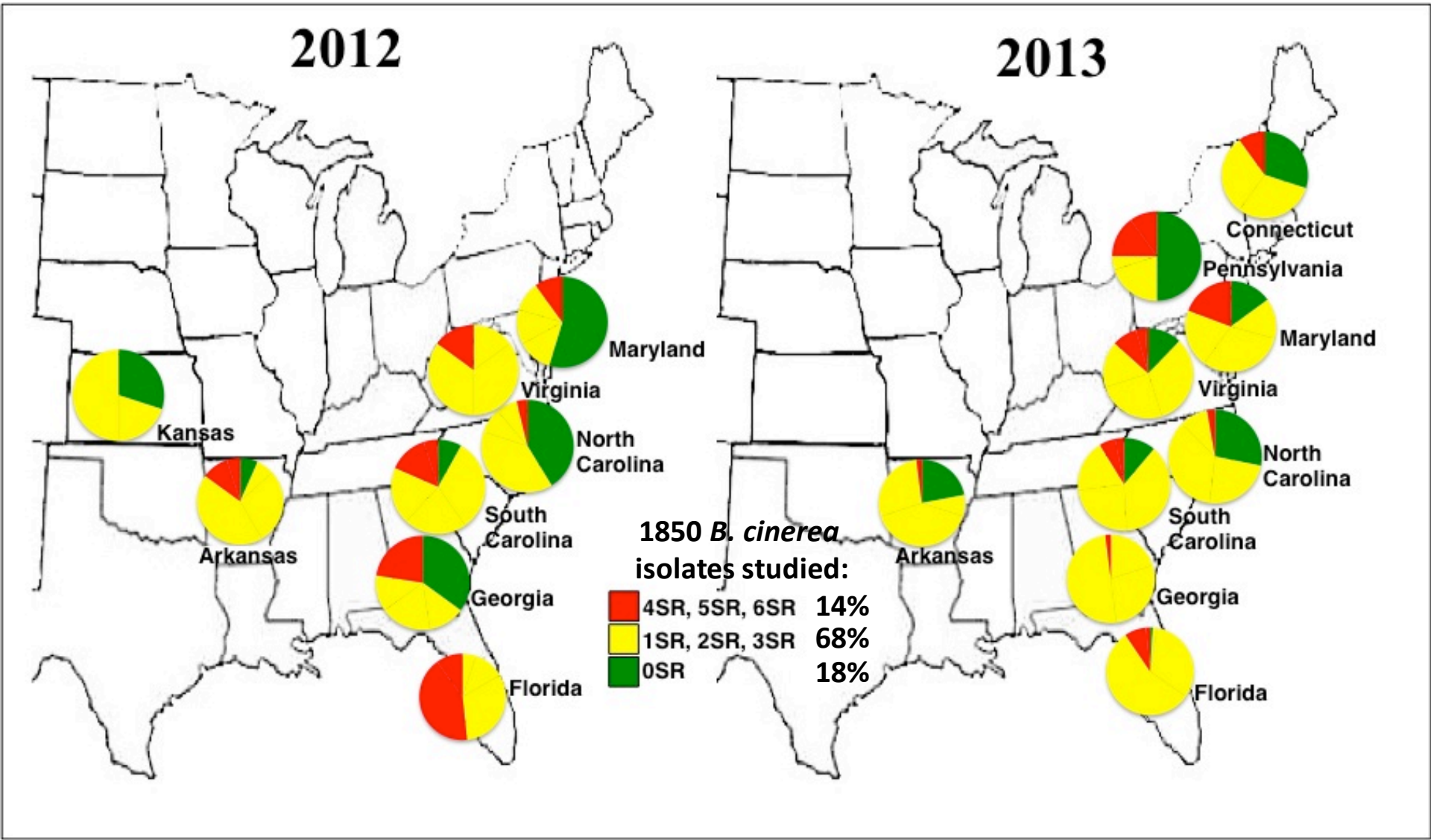


Locations with 10% or more than 20% resistant *Botrytis cinerea* isolates

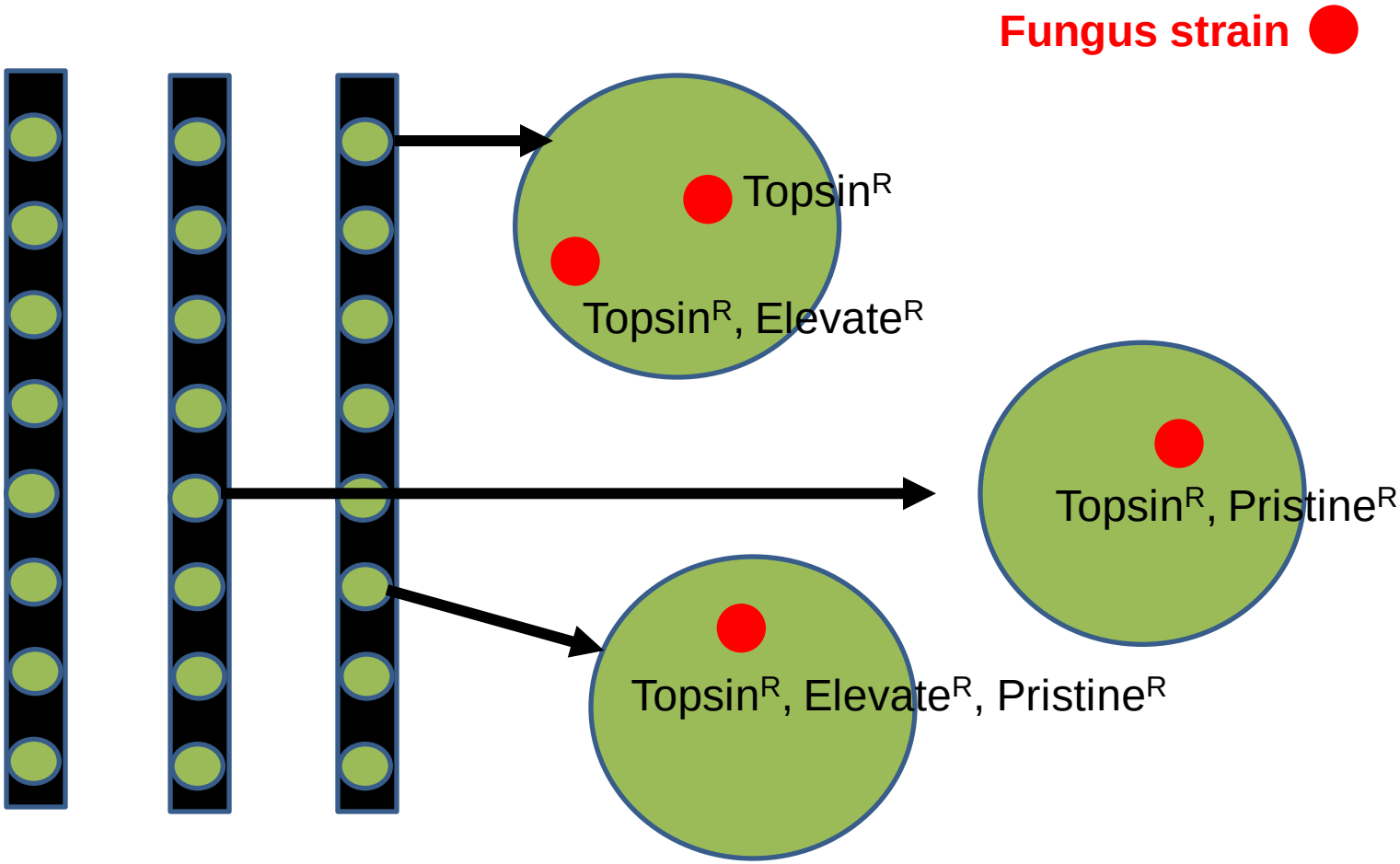
Topsin M



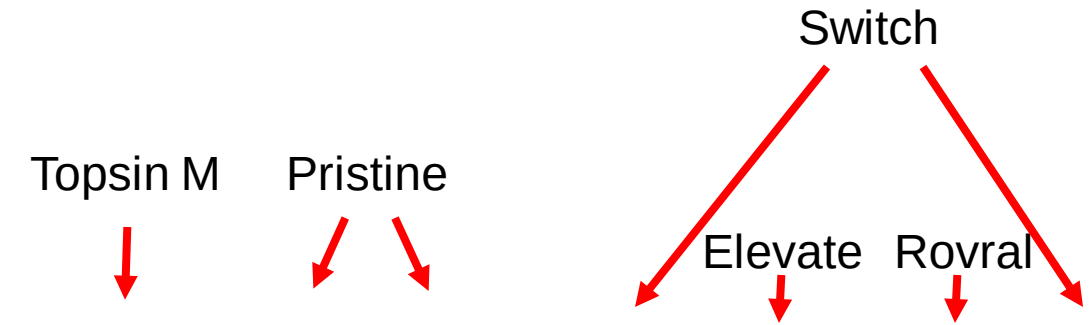
Management is becoming more complicated due multifungicide resistance



Resistance Mosaic at the Farm Level

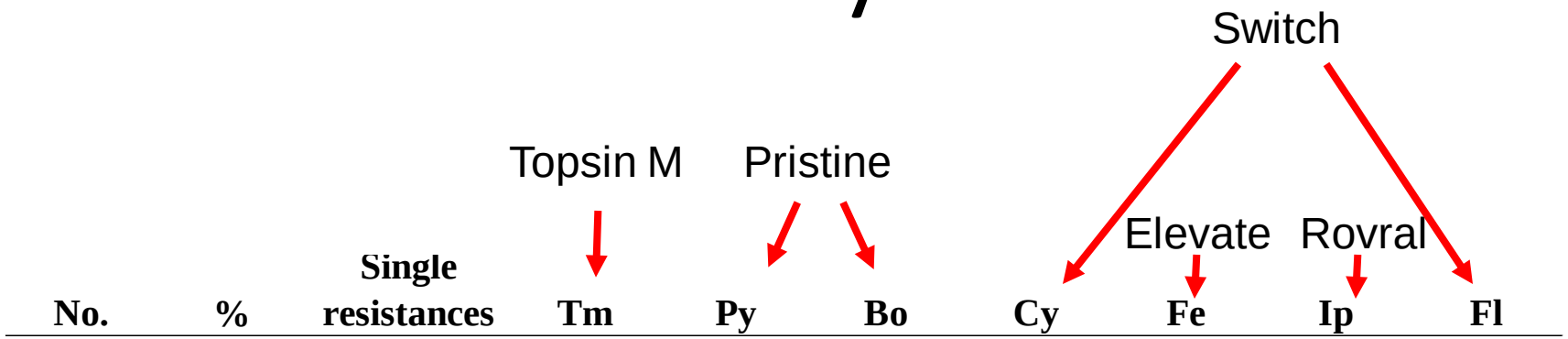


Strawberry fields



No.	%	Single resistances	Tm	Py	Bo	Cy	Fe	Ip	Fl
65	30.4	0SR	S	S	S	S	S	S	S
4	1.9	1SR	**R**	S	S	S	S	S	S
3	1.4	2SR	**R**	S	S	**R**	S	S	S
6	2.8	2SR	**R**	**R**	S	S	S	S/LR	S
3	1.4	3SR	**R**	**R**	S	**R**	S	LR	S
26	12.1	3SR	**R**	**R**	**R**	S	S	S/LR	S
11	5.1	4SR	**R**	**R**	**R**	S	**R**	S/LR	S
1	0.5	4SR	**R**	**R**	**R**	S	S	**R**	S
67	31.3	4SR	**R**	**R**	**R**	**R**	S	S/LR	S
3	1.4	5SR	**R**	**R**	**R**	**R**	S	**R**	S
25	11.7	5SR	**R**	**R**	**R**	**R**	**R**	S/LR	S

Blackberry fields

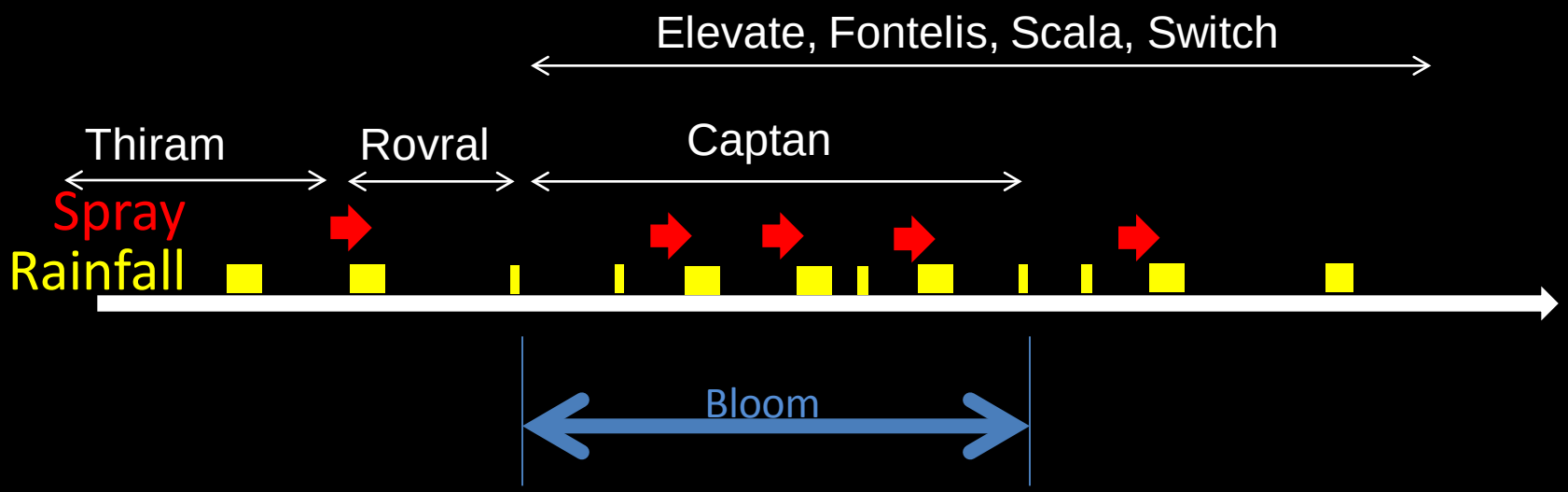


No.	%	Single resistances	Tm	Py	Bo	Cy	Fe	Ip	Fl
56	28.3	0SR	S	S	S	S	S	S	S
1	0.5	1SR	S	**R**	S	S	S	S	S
24	12.1	1SR	**R**	S	S	S	S	S	S
1	0.5	3SR	**R**	S	S	S	S	**R**	**LR**
1	0.5	2SR	**R**	S	**R**	S	S	S	S
3	1.5	2SR	**R**	**R**	S	S	S	S/LR	S
1	0.5	3SR	**R**	**R**	S	S	**R**	S	S
2	1.0	5SR	**R**	**R**	S	**R**	S	**R**	**MR**
70	35.4	3SR	**R**	**R**	**R**	S	S	S/LR	S
21	10.6	4SR	**R**	**R**	**R**	S	**R**	S/LR	S
2	1.0	4SR	**R**	**R**	**R**	S	S	**R**	S
14	7.1	4SR	**R**	**R**	**R**	**R**	S	S/LR	S
2	1.0	5SR	**R**	**R**	**R**	**R**	**R**	S/LR	S

Multifungicide resistant gray mold in your fields have one thing in common, THEY ARE ALL RESISTANT TO FRAC 1 (Topsin M). In other words, with each Topsin M application you will select for genotypes that are also resistant to Elevate, Scala, Pristine, Switch.

Do not use FRAC 1's any longer!

Spray when needed rather than calendar-based and use the right products



Summary

- **Spray less**
  - Best resistance management strategy
  - Concentrate on bloom sprays and stretch intervals during dry weather
- Use **Thiram/Captan** as much as possible and use others only if resistance profile allows
  - Both have pretty good 24 h after infection activity
- Do not use FRAC 1 products (**Topsin M)** any longer (ineffective and selects for multifungicide resistance)

Summary continued…

- Use tank mix of captan plus either **Elevate, or Switch, or Fontelis)** if infection risk is high (>24 hrs of rain during bloom)
  - Submit early flower sample for resistance profiling to Clemson
  - If resistance profile is unknown, rotate chemical classes.

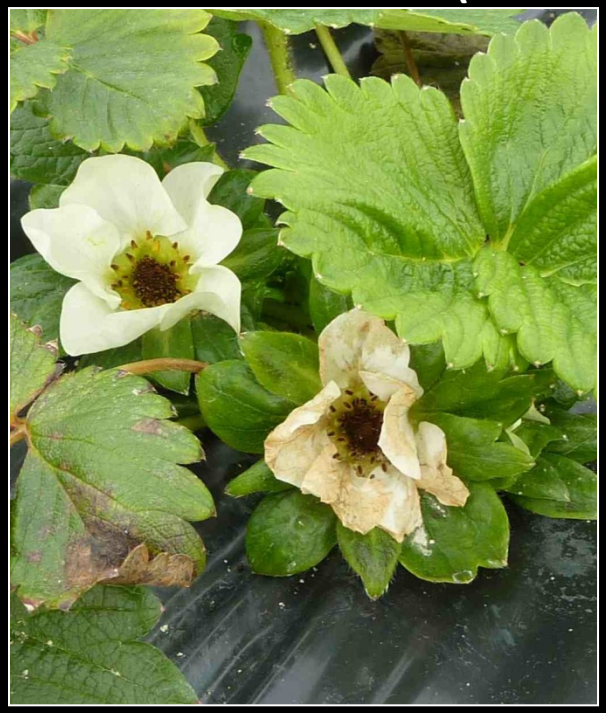
- Use FRAC 7/11 **combination products** (Pristine) **ONLY IF** gray mold **AND** anthracnose become a problem
  - Anthracnose is only a problem in 1 of 7 years on average
  - FRAC 11 has become completely ineffective for most gray mold
  - mixture may unnecessarily select for QoI resistance in anthracnose pathogen

Collecting and Mailing Gray Mold Samples for Fungicide Resistance Profile

Best timing: January and February, prior to full bloom

Flowers { **Send 20 to 40 dead strawberry flowers**

(infected flower appear to decline more readily after frost)



After incubation
22ºC-2 days

Mail swabs + your contact info to:

Guido Schnabel
Clemson University
105 Collings St./220 BRC
Clemson, SC 29634

Request FRAC List, PDMR Efficacy Chart, Resistance Profiling Instructions

E-mail: schnabe@clemson.edu

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