

Fungicide Usage for 2013: The When, What, and How

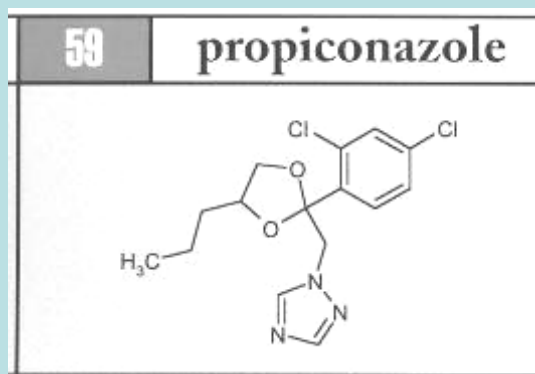
David F. Ritchie, Department of Plant Pathology

Brown Rot



Blossom Blight

Orbit 3.6EC



Generics: PropiMax 3.6EC
Bumper 3.6EC

Scab



General Strategy for Control of Peach Diseases

FOR SUCCESSFUL DISEASE CONTROL

**Cannot wait until the disease is observed to begin
applying controls!!!**

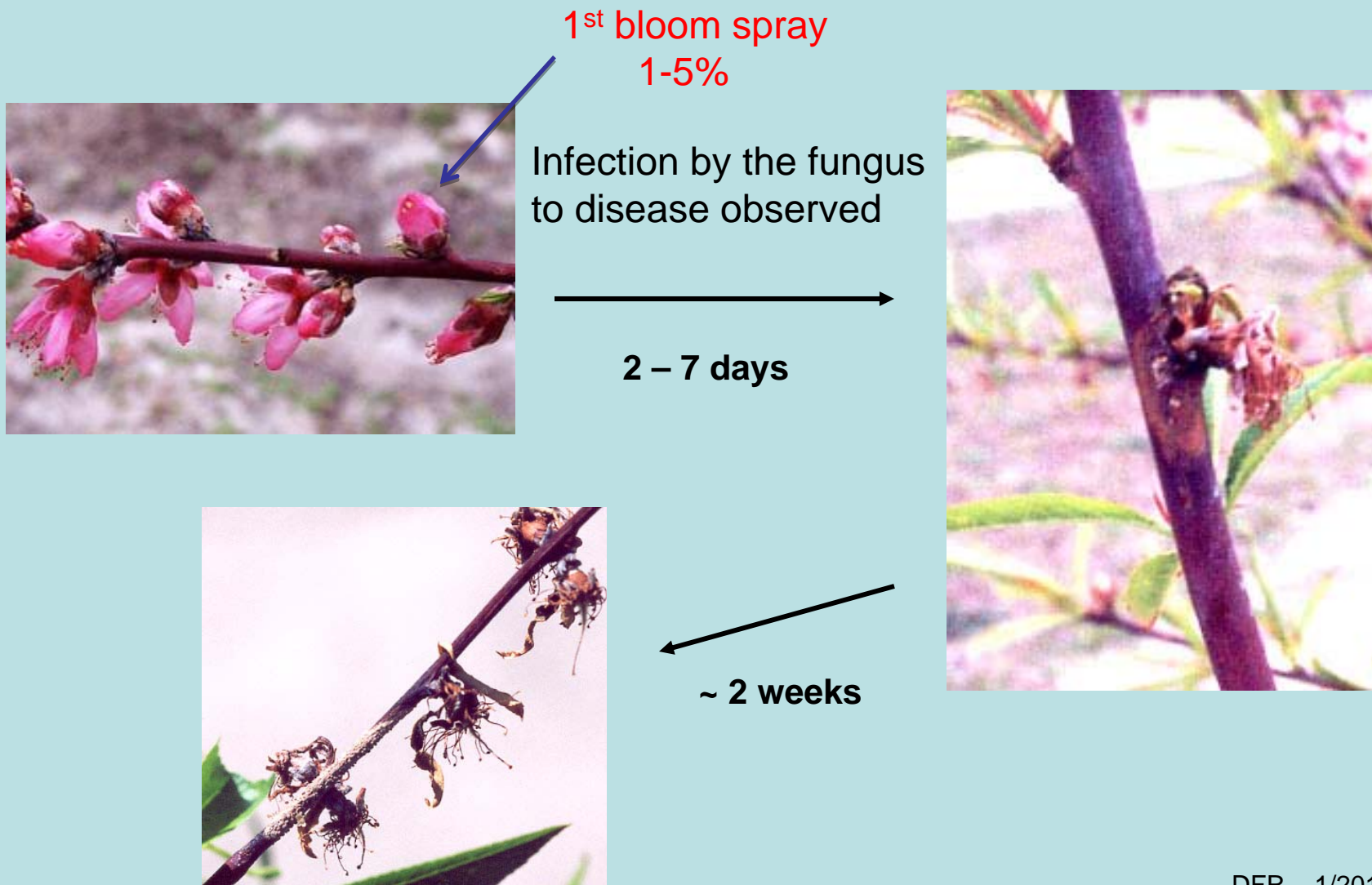
THUS – To achieve successful disease control, ACTION must be taken at some earlier time before the disease is observed.

This time is influenced by the ENVIRONMENT
the PATHOGEN, and
the HOST.

AND

Correct use of the appropriate control(s).

The When -- Blossom Blight



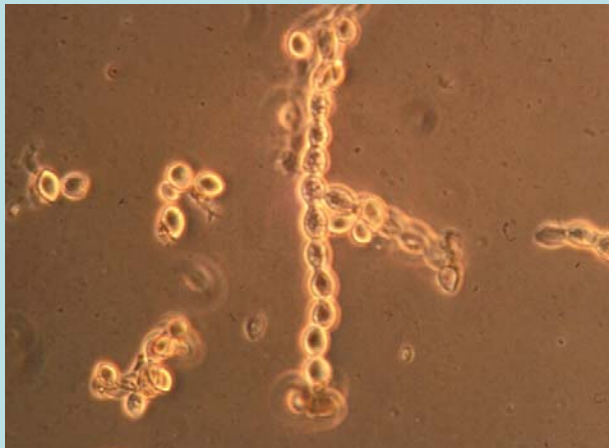
WHAT are the Conditions for Blossom Blight Infection?



“mummies” from previous season



weather conditions (>12 hours)



fungal spores



susceptible blossoms

Peach Scab



Can become severe particularly mid-season and later varieties



The When -- Peach Scab



Shuck split
to
Shucks off



Approximately
pit-hardening

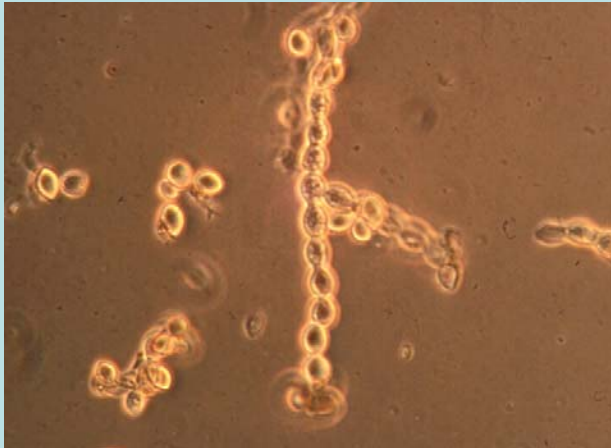


There is a period of about 5- 6 weeks after infection before lesions are first observed. In NC, end of May to mid-June.



Brown Rot

Brown rot fungal spores



The When -- Brown Rot



Green

Start preharvest sprays just as fruit start to change color. Weather conditions will determine if 1 or more applications will be needed.

Use one of the more effective fungicides for brown rot.



First “color change”

“HOUSTON, We’ve Got A Problem” –

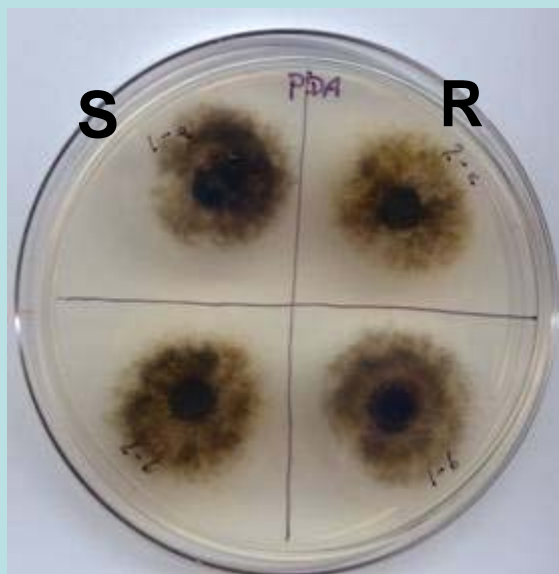
1974 television film about the Apollo 13 spaceflight

**“SOUTHEASTERN AND NORTH CAROLINA
PEACH GROWERS,**

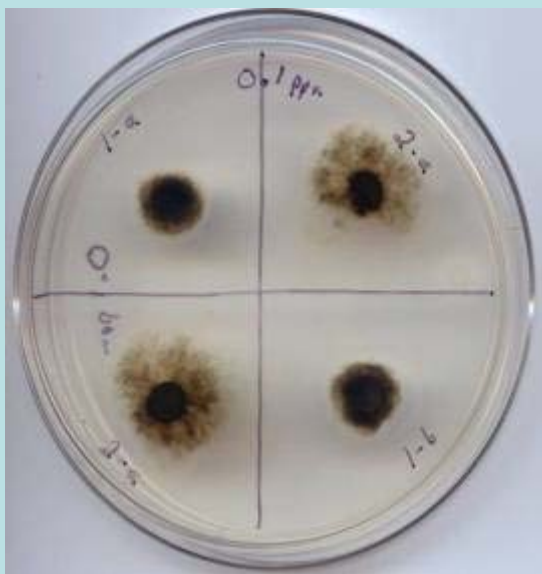
We’ve Got A Problem”

Fungicide Resistance in the brown fungus

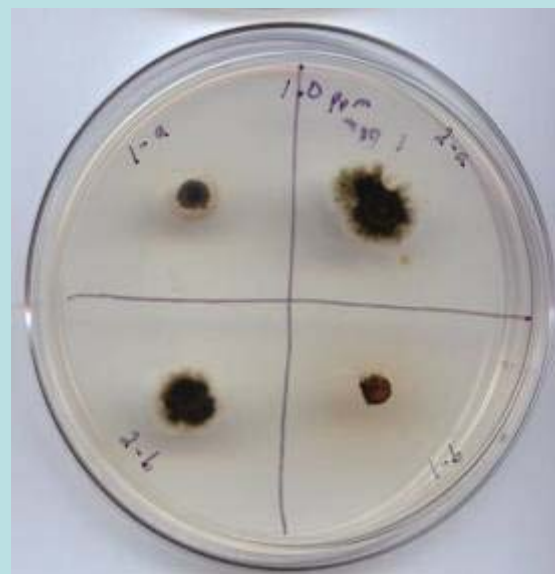
Reference Strains – Sensitive & Resistant to propiconazole



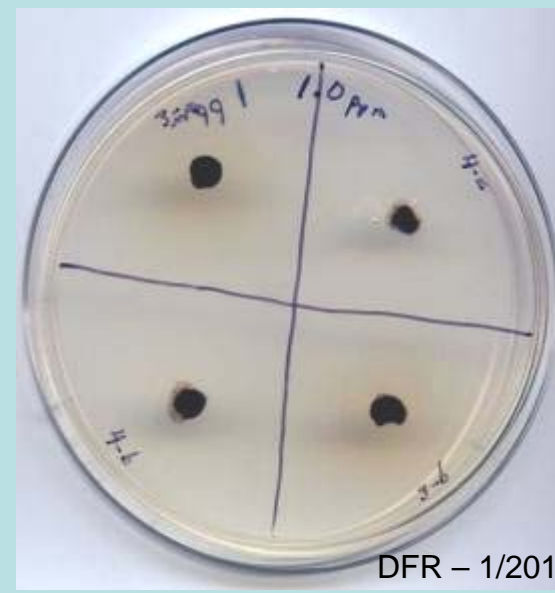
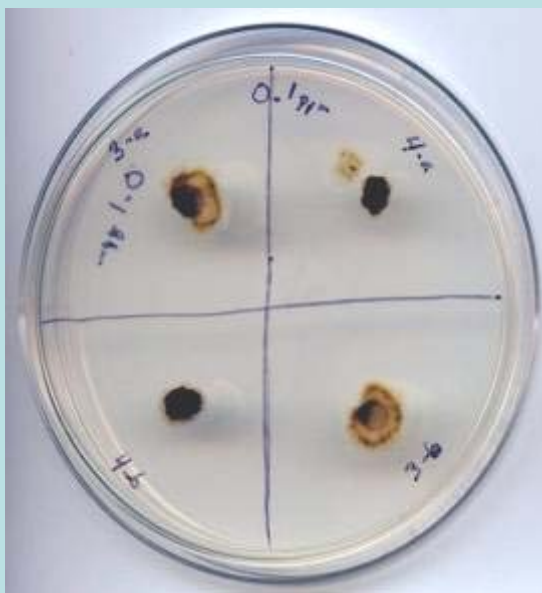
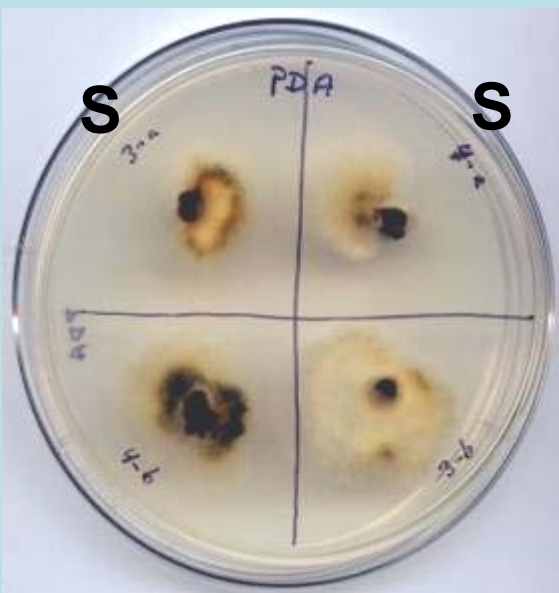
0 ppm



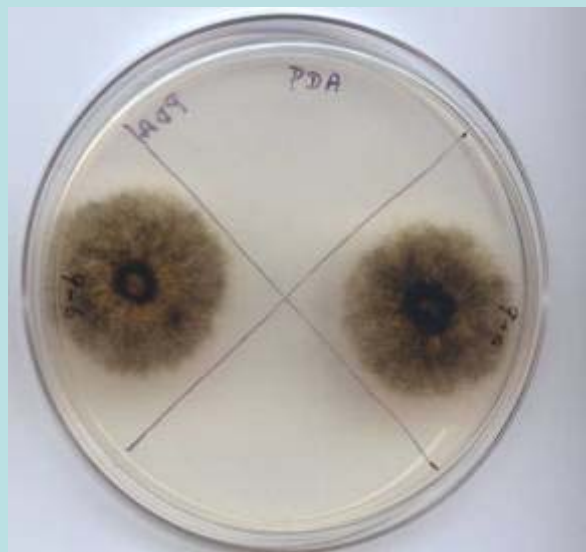
0.1 ppm



1.0 ppm



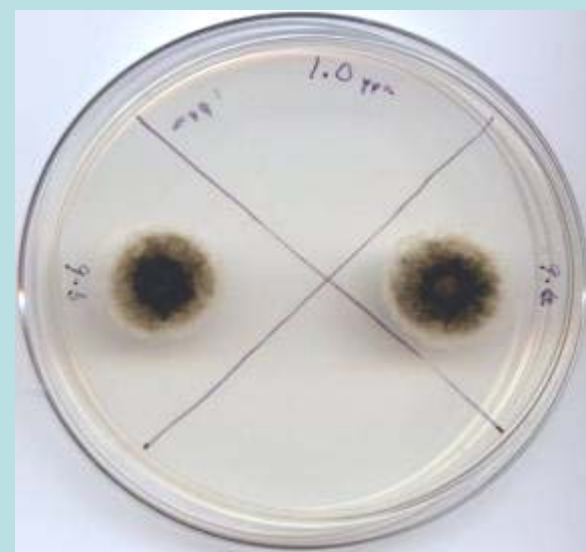
Decreased Sensitivity (resistance) to propiconazole (Orbit)



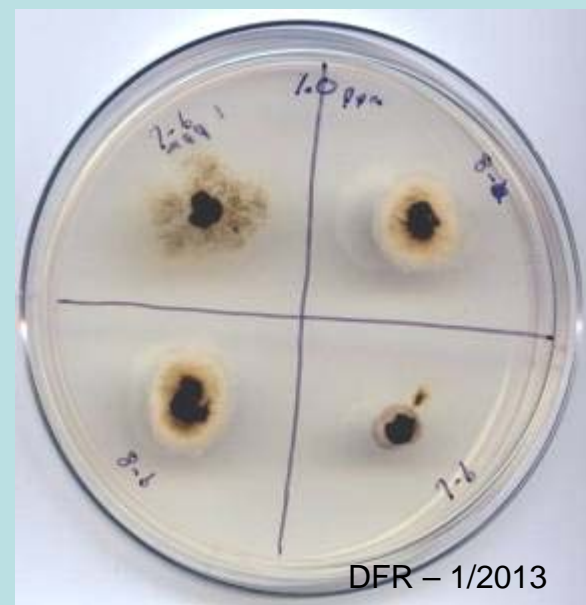
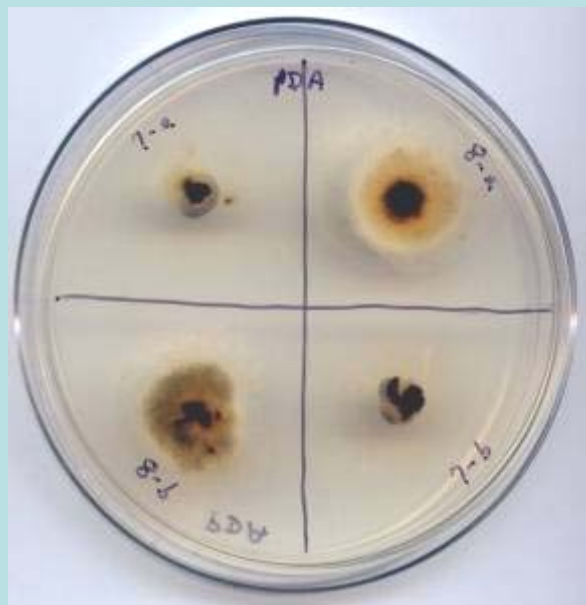
0 ppm



0.1 ppm



1.0 ppm



Sensitivity of *M. fructicola* isolates to propiconazole (Orbit, PropiMax, Bumper)

EC₅₀ = concentration (ppm) that inhibits the fungal growth by 50%

STANDARDS:

<i>Isolate</i>	EC ₅₀
GADL3-03 (GA 2003)	0.042 ppm
8-1 (NC 1981)	0.049 ppm
Bmpc7 (GA 2006)	0.624 ppm

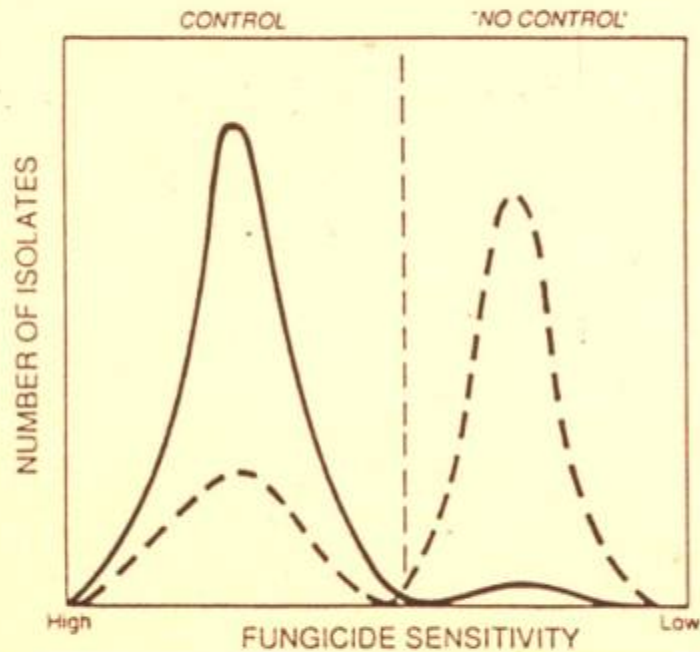
FARM #2:

<i>Isolate</i>	EC ₅₀
#11	1.000 ppm
#15	>1.000 ppm

FARM #1:

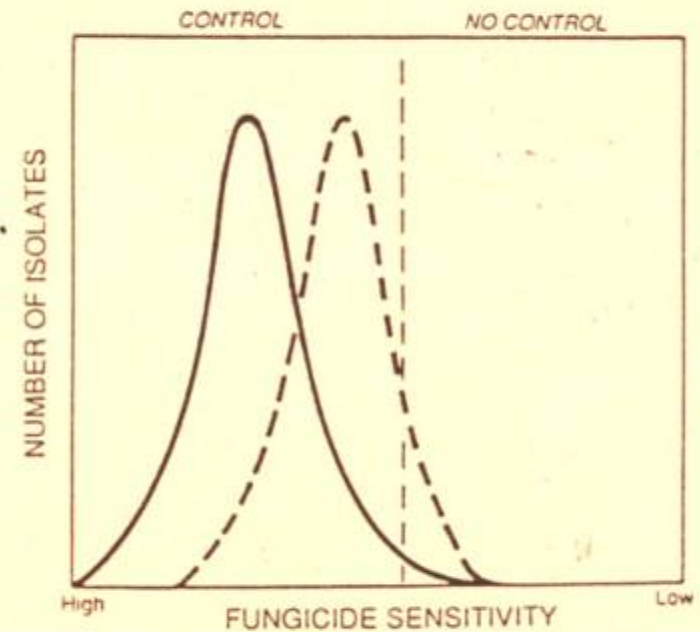
<i>Isolate</i>	EC ₅₀
#10 (2012)	>1.000 ppm
#20 (2012)	>1.000 ppm
#24 (2009)	0.502 ppm
#26 (2009)	0.039 ppm
#29 (2009)	0.623 ppm

DEVELOPMENT OF FUNGICIDE RESISTANT POPULATIONS



QUALITATIVE RESISTANCE

e.g., Topsin M
Thiophanate Methyl



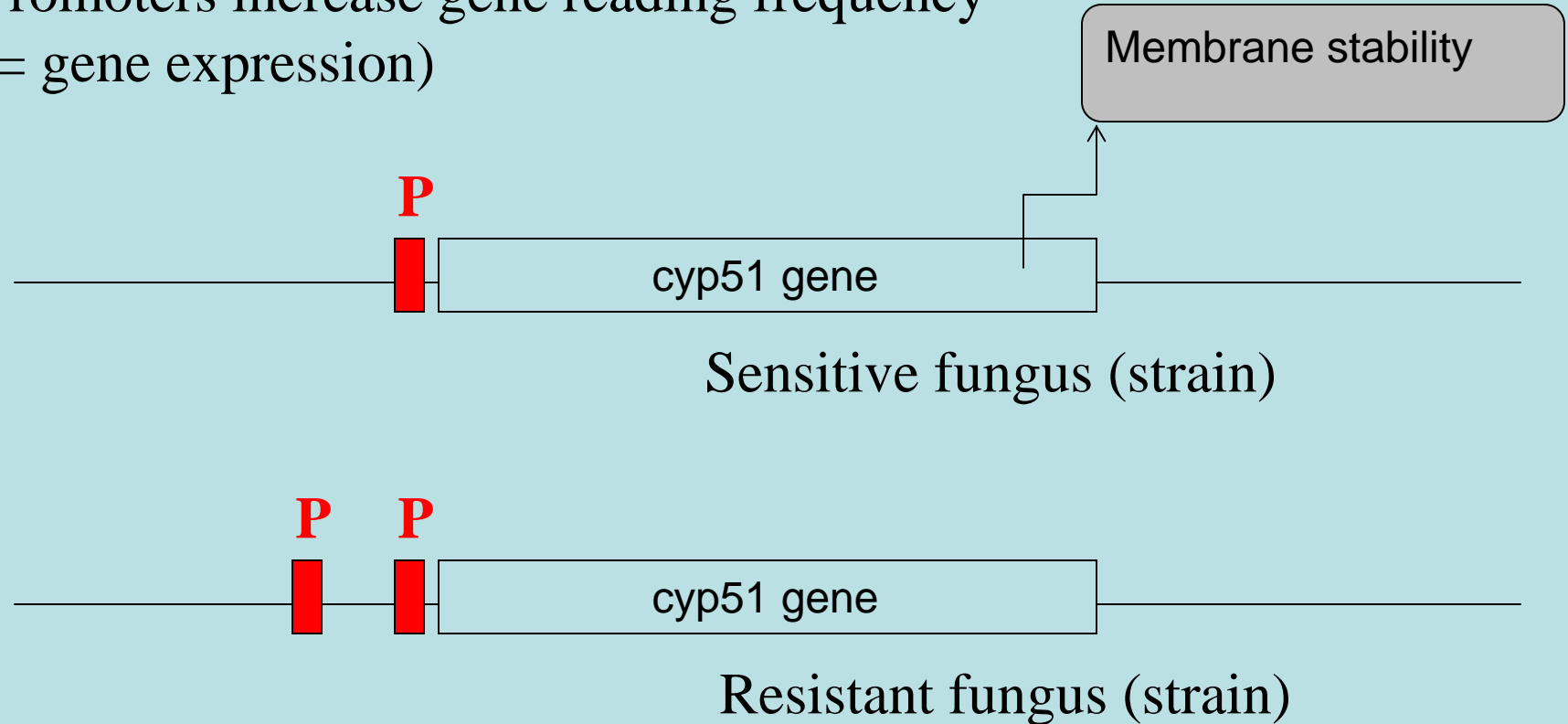
QUANTITATIVE RESISTANCE

e.g., Orbit, PropiMax,
Indar, Elite

DMI (e.g.Orbit) resistance in the brown rot fungus

Guido Schnabel, Clemson University

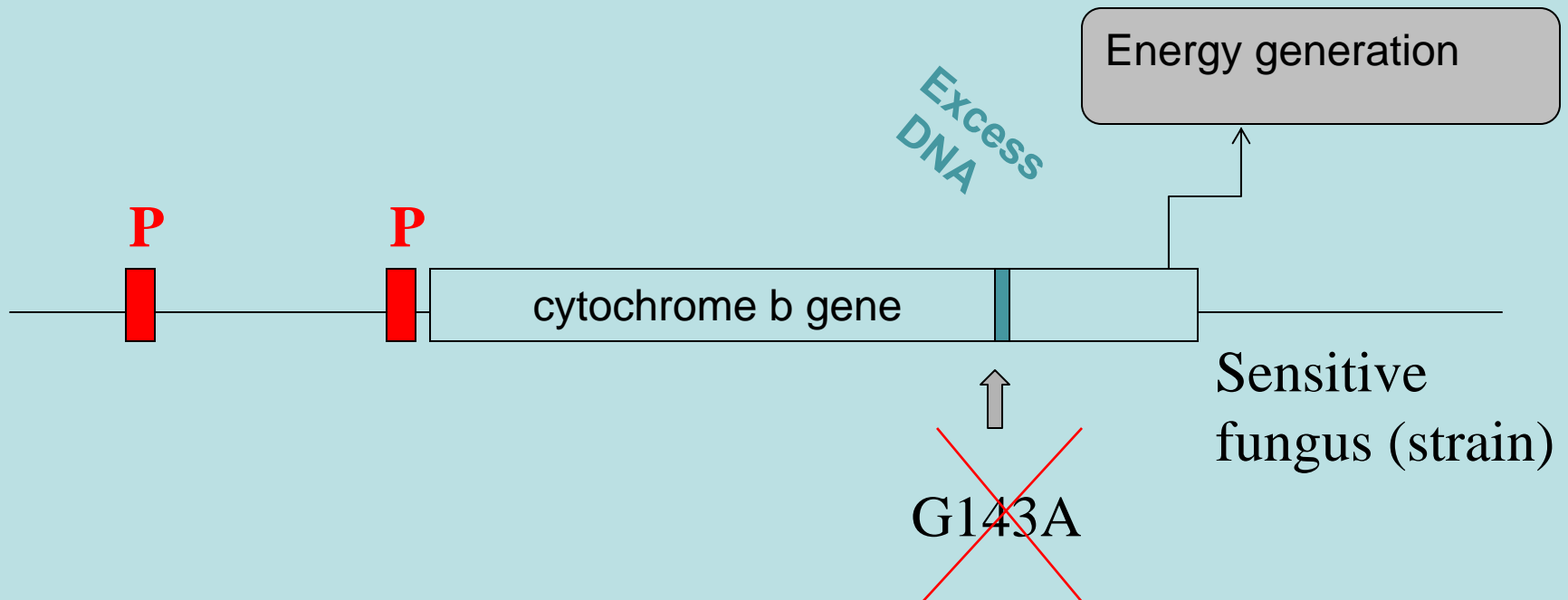
Promoters increase gene reading frequency
(= gene expression)



QoI (e.g. Abound) resistance difficult for the brown rot fungus

Guido Schnabel, Clemson University

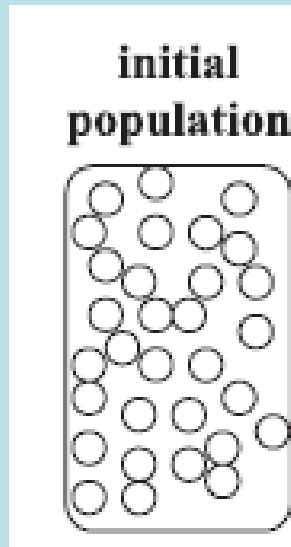
Mutation change in key amino acid would make protein disfunctional



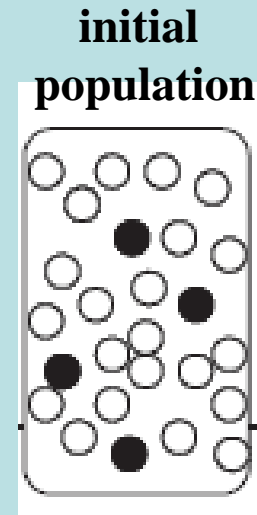
SDHI (Pristine, Merivon) resistance caused outbreak in a SC orchard

Guido Schnabel, Clemson University

Resistance mechanism is still unknown, but many wild-type isolates are naturally resistant



Number of strains
resistant to DMIs



Number of strains
resistant to SDHIs

Summary and Conclusions

Guido Schnabel, Clemson University

- Frequent applications of fungicides selects for resistance even during dry seasons
- Resistance has evolved in the Southeast and may cause devastating control failure during long periods of wet weather
- Resistance management therefore is important even in dry years

The What – Selecting Fungicides

RELATIVE EFFECTIVENESS OF DISEASE CONTROL CHEMICALS FOR PEACHES AND NECTARINES

(--- = ineffective ; ++++++ = superior; +++++ = very effective; n/a = does not apply)

[FRAC CODE] Fungicide or Bactericide and Product/Acre (100-125 gal water/acre)	DAYS for* PHI and HOURS (REI)	Leaf Curl	Blossom Blight	Brown Rot	Scab	Rhizopus Rot	Bacterial Spot
[11] azoxystrobin (Abound) 2.08F -12 fl oz	0 (4)	n/a	+++	+++	++++	n/a	n/a
[11] azoxystrobin+[3]difenoconazole (Quadris Top) -14 fl oz	0 (12)	n/a	++++	+++++	++++	n/a	n/a
[M4] captan (Captan) 50WP, 4L - 5 lb, 2.5 qt	0 (24)	n/a	++	+++	+++++	---	n/a
[M5] chlorothalonil (Bravo Weather Stik, Equus, Echo) 6F- 4.0 pt	n/a (12)**	++++	+++	n/a	++++	n/a	n/a
[M1] copper (Kocide 2000, 3000, Cuprofix Ultra 40D, Nordox 75WG) - 4-8 lb***	n/a (24)	+++	n/a	n/a	n/a	n/a	+++
[9] cyprodinil (Vangard) 75WG - 5.0 oz	n/a (12)	n/a	++++	n/a	---	n/a	n/a
[9] cyprodinil+[3] difenoconazole (Inspire Super) -18 fl oz	0 (12)	n/a	++++	+++++	+++	n/a	n/a
[14] dicloran (Botran) 75WP - 3.0 lb	10 (12)	n/a	++	+++	---	+++	n/a
[M7] dodine (Syllit) 65WP- 2 lb + captan [M4] (Captan) 50WP - 4 lb	15 (96)	++	++	+++	++++	n/a	+
[3] fenbuconazole (Indar) 75WSP, 2F - 2.0 oz, 6.0 fl oz	0 (12)	n/a	++++	+++++	+++	n/a	n/a
[M3] ferbam (Ferbam Granuflo) 76DF - 4.5 lb	21 (24)	+++++	n/a	n/a	n/a	n/a	n/a
[3] flutriafol (Topguard) -14.0 fl oz	7 (12)	n/a	++++	++++	n/a	n/a	n/a
[2] iprodione (Rovral) 50WP, 4L - 1.5 lb, 1.5 pt	n/a**** (24)	n/a	++++	n/a****	---	n/a	n/a
[3] metconazole (Quash 50) WDG - 3.5 oz	14 (12)	n/a	++++	+++++	+++	?	n/a
[3] myclobutanil (Rally) 40WP - 5.0 oz	0 (24)	n/a	++++	+++	---	n/a	n/a
[41] oxytetracycline (FireLine, Mycoshield) 17WP-- 0.75 lb	21 (12)	n/a	---	---	---	---	+++
[7] penthiopyrad (Fontelis) -- 20 fl oz	0 (12)	n/a	+++	++++	++	n/a	n/a
[3] propiconazole (Orbit, PropiMax, Bumper) 3.6EC - 4.0 fl oz	0 (12)	n/a	++++	+++++	+	n/a	n/a
[11] pyraclostrobin+[7] boscalid (Pristine) 38WG - 14.5 oz	0 (12)	n/a	++++	+++++	++	n/a	n/a
[11] pyraclostrobin+[7] fluxapyroxad (Merivon) - 6.5 fl oz	0 (12)	n/a	++++	+++++	+++	++	n/a
[9] pyrimethanil (Scala SC) -18 fl oz	30 (12)	n/a	++++	n/a	---	n/a	n/a
[M2] sulfur (numerous formulations) - 10 lb	0 (24)	n/a	++	++	+++	---	n/a
[3] tebuconazole (Elite, Orius, Tebuzol) 45WP - 5.0 oz	0 (12)	n/a	++++	+++++	++	n/a	n/a
[3] tebuconazole + trifloxystrobin [11] (Adament) 50WG - 5.0 oz	1 (12)	n/a	++++	+++++	+++	?	n/a
[1] thiophanate-methyl (Topsin M) 70WP, WSP - 1.5 lb	1 (48)	n/a	++++	++++	+++++	n/a	n/a
[11] trifloxystrobin (Gem) 500SC - 3.8 fl oz	1 (12)	n/a	+++	n/a	+++++	n/a	n/a
[M3] ziram (Ziram) 76DF - 4.0 lb	14 (48)	++++	+	+	+	---	+

[FRAC CODE] = Fungicide Resistance Action Committee. Numbers and letters distinguish the fungicides according to their cross-resistance behavior.

Fungicides having the same FRAC number have a similar mode of action and are prone to cross resistance, thus not good mixing or alternating partners.

* PHI = preharvest interval (DAYS between last spray and harvest); REI = reentry interval (HOURS between last spray and reentry without using personal protective equipment (PPE). **ALWAYS CHECK/READ LABELS BEFORE USE.**

** REI is 12 hours for chlorothalonil, but see label for precautions related to risk for eye damage and required protection.

*** This rate of copper is for use only as a dormant spray. See information on copper (Dormant Spray) for use against bacterial spot. **** Rovral is not registered for use after petal fall.

FRAC CODE

SPECIMEN LABEL

Abound^{LM}

Flowable Fungicide

Broad spectrum fungicide for control of plant diseases

GROUP 11 FUNGICIDES

Active Ingredient:

Azoxystrobin: methyl (E)-2-{2-[6-(2-cyanophenoxy)
pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate* 22.9%
Other Ingredients: 77.1%

Total: 100.0%

Contains 2.08 lbs. of active ingredient per gallon

*IUPAC

**KEEP OUT OF REACH OF CHILDREN.
CAUTION**

BASF
The Chemical Company

GROUP 7 11 FUNGICIDE

Pristine[®]
fungicide

For use in berries, bulb vegetables, carrots, grapes, pistachio, tree
nuts, stone fruits and strawberries

ACTIVE INGREDIENT:

Pyraclostrobin, (carbamic acid, [2-[[[1-(4-chlorophenyl)-1H-pyrazol-3-yl]oxy]
methyl]phenyl]methoxy-, methyl ester) 12.8%
Boscalid, 3-pyridinecarboxamide, 2-chloro-N-(4'-chloro(1,1'-biphenyl)-2-yl) 25.2%
Inert ingredients 62.0%

Total 100.0%
0.128 oz. (0.008 lb.) of pyraclostrobin in 1 oz. of **Pristine**
0.252 oz. (0.0158 lb.) of boscalid in 1 oz. of **Pristine**

EPA Reg No. 7969-199

EPA Est. No.

**KEEP OUT OF REACH OF CHILDREN
CAUTION/PRECAUTION**

(No aerial application in

NORTH CAROLINA TEST

2012 Fungicide Results				Brown rot (mean percent)			
Treatment and product/acre	Fruit with peach scab (mean percent)			Number fruit at harvest 31 May			
	Total	1-10 lesions	>10 lesions		5 dph storage	8 dph storage	Under tree 12 Jun
1- Non-treated check	61.8 a ^{2/}	26.0 a	35.5 a	7.5 a	53.6 a	76.4 a	69.4 a
2- Bravo Weather Stik 6F 3.25 pt ss/so Captec 4L 2.0 qt 1&2C Tebuzol 45DF 4.0 oz 1&2PH	2.2 d	1.5 c	0.7 b	1.3 b	3.6 c	12.9 c	18.8 b
3- Merivon 500SC 4.0 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.0 d	0.0 c	0.0 b	0.3 b	1.4 c	1.4 c	3.3 bc
4- Merivon 500SC 5.5 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.0 d	0.0 c	0.0 b	0.3 b	0.0 c	0.7 c	2.8 bc
5- Merivon 500SC 6.5 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.0 d	0.0 c	0.0 b	0.3 b	0.0 c	0.7 c	1.6 c
6- Pristine 38WG 12 oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	3.6 cd	3.6 bc	0.0 b	0.3 b	1.4 c	3.6 c	8.9 bc
7- Quadris Top 2.71SC 10 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.0 d	0.0 c	0.0 b	1.3 b	2.9 c	6.4 c	6.1 bc
8- Quadris Top 2.71SC 14 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.7 d	0.7 c	0.0 b	1.3 b	4.3 c	7.1 c	7.1 bc
9- Inspire Super 2.82EW 20 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	0.0 d	0.0 c	0.0 b	0.3 b	0.7 c	3.6 c	5.0 bc
10- Fontelis 1.67F 20 fl oz ss/so, 1C, 1&2PH Captec 4L 2.0 qt 2C	9.3 b	5.0 b	4.3 b	1.5 b	2.9 c	5.7 c	13.6 bc
P value	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001

^{2/} Means within the same column followed by the same letter do not differ significantly, Fisher's LSD at $\alpha=0.05$.

^{3/} ne = not evaluated

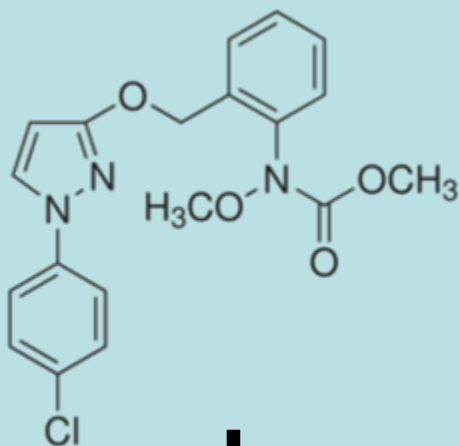
2012 Brown Rot Data – Georgia

Phil Brennen, Univ. GA

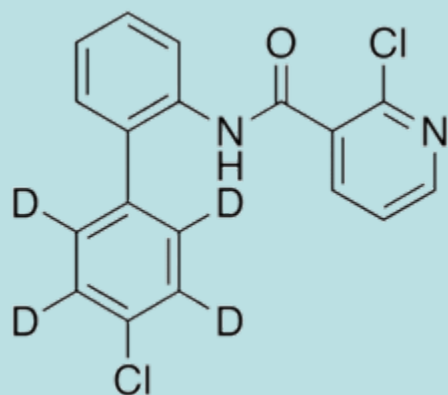
Treatment and rate/A	Post-harvest brown rot incidence* (% infected fruit)	
	4 days after harvest	7 days after harvest
Untreated Control	84.1 a	90.5 a
Pristine 38WDG 14.5 oz	9.5 de	31.8 de
Topguard SC 3.5 fl oz.....	68.3 ab	74.6 ab
Topguard SC 7.0 fl oz.....	60.3 b	73.0 ab
Topguard SC 14.0 fl oz.....	58.7 b	63.5 bc
Topguard SC 28.0 fl oz.....	36.5 c	47.6 cd
IKF-5411SC 13.7 fl oz.....	28.6 cd	52.4 bcd
IKF-5411SC 17.1 fl oz.....	30.2 c	54.0 bcd
Merivon SC 6.5 fl oz.....	0.0 e	1.6 f
Elite WP 8 oz.....	0.0 e	7.9 ef
LSD ($\alpha = 0.05$)	20.5	24.1

Pristine

pyraclostrobin (FRAC 11)



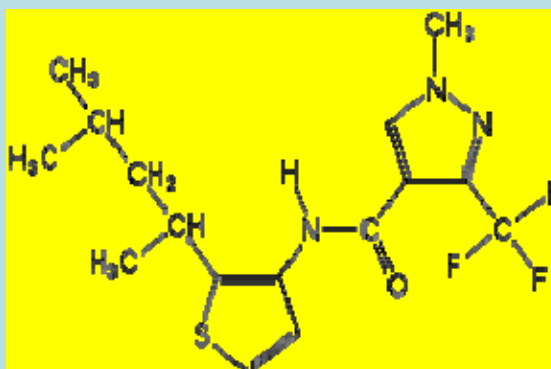
boscalid (FRAC 7)



Fontelis

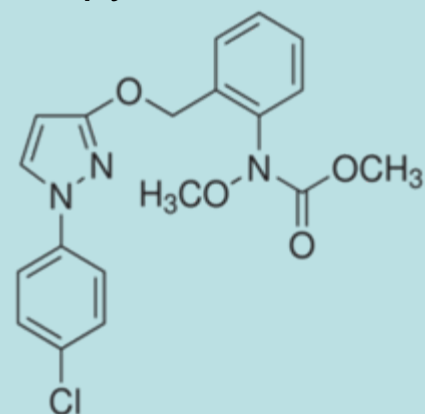
Quinone outside Inhibitors
(QoIs)

penthiopyrad (FRAC 7)

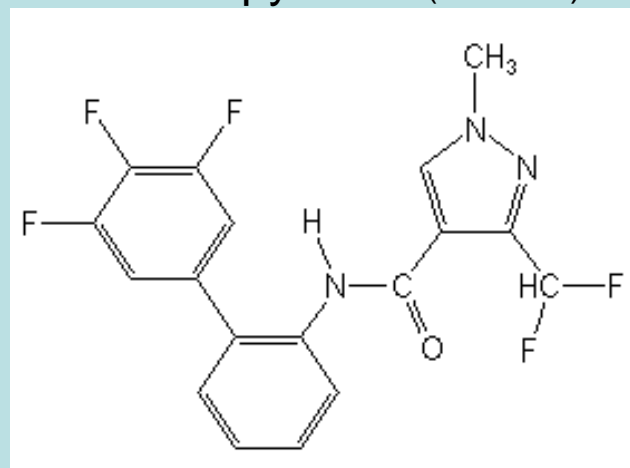


Merivon

pyraclostrobin (FRAC 11)



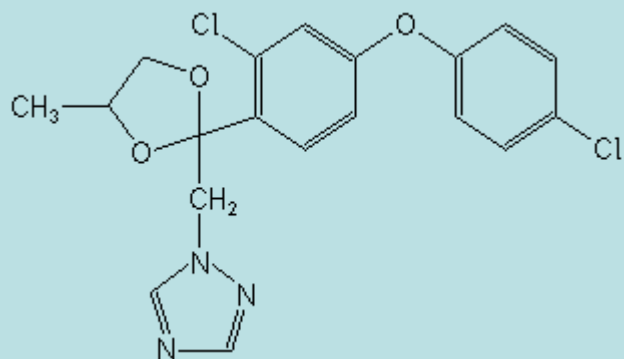
fluxapyroxad (FRAC 7)



Succinate DeHydrogenase Inhibitors (**SDHIs**)

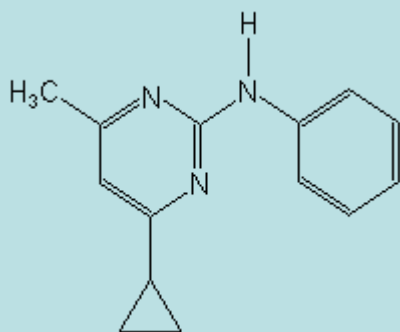
INSPIRE SUPER

difenoconazole (FRAC 3)



+

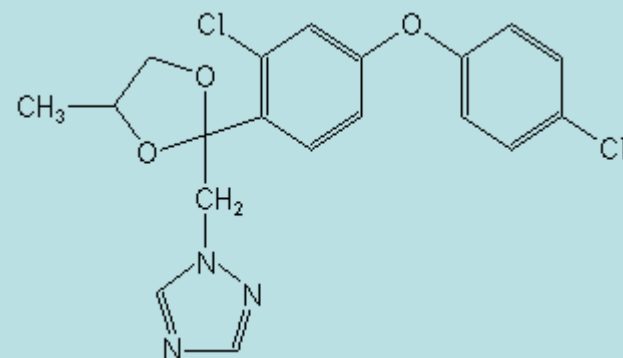
cyprodinil (FRAC 9)



DMIs

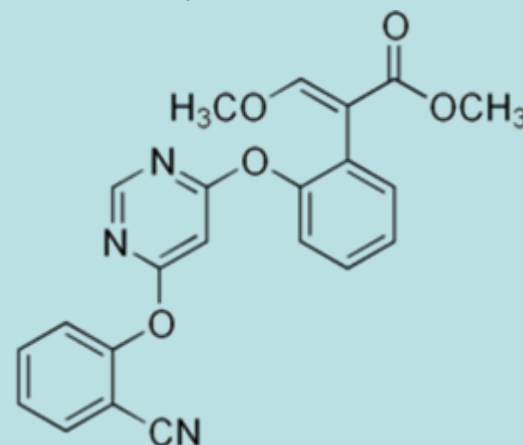
QUADRIS TOP

difenoconazole (FRAC 3)



+

azoxystrobin (FRAC 11)



Pristine versus Merivon

Phil Brennen, Univ. GA

13 comparisons; 5 states

Brown rot incidence

(Pristine = 21.4; Merivon = 9.2)

Merivon is more efficacious than Pristine
($P = 0.008$)

Fontelis versus Merivon

Phil Brennen, Univ. GA

8 comparisons; 5 states

Brown rot incidence

(Fontelis = 22.3; Merivon = 10.8)

Merivon is more efficacious than Fontelis
($P = 0.008$)

Pristine versus Fontelis

Phil Brennen, Univ. GA

18 comparisons; 5 states

Brown rot incidence

(Pristine = 30.8; Fontelis = 33.6)

Fontelis is as efficacious as Pristine
($P = 0.19$)

Pristine versus Inspire Super

Phil Brennen, Univ. GA

9 comparisons; 4 states

Brown rot incidence

(Pristine = 17.2; Inspire Super = 29.1)

Pristine is more efficacious than Inspire Super
($P = 0.007$)

THE HOW ...

2. A fungicide spray at 1-5% bloom and again at 25-50% bloom may reduce blossom blight when the bloom period is extended and weather conditions are wet. Demethylation inhibiting (DMI) fungicides [(Elite, Orius, Tebuzol); Indar, Quash, Rally, and (Bumper, Orbit, PropiMax)] are effective against blossom blight but are at **moderate to high risk for resistance** development if used regularly. Resistance to anyone of the DMI fungicides may result in cross-resistance to the others. **It is recommended that DMI fungicides be saved for preharvest sprays and that they not be used in bloom and cover sprays.** Recommended fungicides for blossom blight include:

chlorothalonil [**M5**] (Bravo Weather Stik, 3.5 pt/acre, or Equus 720 3.5 pt/acre, or Echo 720 3.5 pt/acre), ***

OR

cyprodinil [**9**] (Vangard 75WG, 5.0 oz/acre), **OR** ****
pyrimethanil [**9**] (Scala SC, 18 fl oz)

OR

iprodione [**2**] (Rovral 4 F 1.0 pt/acre). Rovral is **NOT** labeled for use after petal fall, ****

OR

captan [**M4**] + thiophanate-methyl [**I1**] (Captan 50WP, 4.0 lb/acre, 80WP 2.5 lb/acre, Captec 4L, 2.0 qt/acre + Topsin M 70WSP, 1.25 lb/acre, or T-Methyl 70WSP 1.25 lb/acre, or Thiophanate Methyl 85WDG 1.0 lb/acre). Fungicide containing thiophanate-methyl should be used only once. ****

Bloom Sprays



Shuck Split – Shuck Fall

Peach scab can be adequately controlled only with the proper use of a fungicide, although scab control may be aided by factors such as adequate pruning and selecting orchard sites that allow for rapid drying of the foliage.

Controls**Effectiveness**

Recommended fungicides include:

captan [**M4**] (Captan 50WP, 5.0 lb/acre, 80WP 3.2 lb/acre, Captec 4L 2.5 qt/acre) *****

In orchards where scab has been a problem or orchards not previously sprayed for scab, tank-mixing thiophanate methyl [**I**] (Topsin M 70WP, 1.25 lb/acre, Thiophante Methyl 85WDG 1.0 lb/acre) with captan (Captan 50WP 4.0 lb/acre **OR** Captec 4L, 2.0 qt/acre)

in the season, thiophante -methyl formulations should **NOT** be used later in the season for fruit brown rot control especially if it had also been used in bloom because of potential for resistance problems,

OR

chlorothalonil [**M5**] (Bravo Weather Stik 4.0 pt/acre, Equus 720 SST 4.0 pt/acre, or Echo 720 4.0 pt/acre). Do NOT use chlorothalonil after shuck split, ****

OR

Sulfur [**M2**] ---many wettable powder and flowable formulations are available. Regardless of the formulation, do not use less than 10 pounds of actual sulfur per acre. If frequent periods of rainfall occur, apply sulfur at 5- to 7-day intervals. These close spray intervals are especially important during the 4 week period after shuck split when risk of scab infection is greatest. ***



THE HOW ...

Number of sprays needed is based on weather and disease pressure. Recommended fungicides with preharvest intervals (PHI) and restricted entry intervals (REI):

21 days preharvest --

Captan [**M4**] (Captan 50WP 5.0 lb/acre, Captec 4L 2.5 qt/acre, Captan 80WDG 3.25 lb/acre) ---
0 day PHI and 24 h REI ***

OR

azoxystrobin [**11**] (Abound 2.08F, 10.0 fl oz/acre) ****

Plus

thiophanate methyl [**I**] (Topsin M 70WSP 1.0 lb/acre, Thiophanate Methyl 85WDG 0.75 lb/acre) ---
1 day PHI and 48 h REI.

14 to 10 days preharvest --

pyraclostrobin [**11**] + boscalid [**7**] (Pristine 38WG 12 oz/acre) --- 0 day PHI and 12 h REI, *****

OR

pyraclostrobin [**11**] + fluxapyroxad [**7**] (Merivon 500SC 6.0 fl oz) --- 0 day PHI and 12 hr REI *****

OR

penthiopyrad [**7**] (Fontelis 1.67F 20 fl oz) --- 0 days PHI and 12 hr REI ****

PREHARVEST



2 ½ - 3 week before ripe

THE HOW ...

7-1 day preharvest –

difenoconazole [3] + cyprodinil [9] *****

(Inspire Super 2.82EW, 20 fl oz/acre)

--- 0 days PHI and 12 hr REI

OR

fenbuconazole [3] (Indar 75WSP, 2.0 oz/acre) *****

--- 0 day PHI and 12 h REI,

OR

flutriafol [3] (Topguard 14 fl oz/acre) *****

--- 7 days PHI and 12 hr REI

OR

propiconazole [3] (Orbit 3.6EC, PropiMax 3.6EC, *****

Bumper 41.8EC, 4.0 fl oz/acre)

--- 0 day PHI and 12 h REI,

OR

tebuconazole[3] (Elite 45DF, Orius 45DF, *****

Tebuzol 45DF, 4.0 to 8.0 oz/acre)

--- 0 days PHI and 12 h REI.

PREHARVEST



1 – 7 days prior to ripe

The How -- Things That Can Affect Efficacy

- **Time of fungicide application.** For optimal brown rot and scab control, fungicide must be present prior to occurrence of conditions for infection - that is before rainfall.
- **Application method.** For optimal results, must “hit the target”. Sprayer must work properly, use correct rate of fungicide and proper amount of water per acre, conditions when fungicide is applied (wind, rain).
- **Disease pressure.** This involves two main components – inoculum concentration and environmental conditions for infection and disease development.

THE HOW ...

Spray-Mix Coverage – Is Your Sprayer Ready?

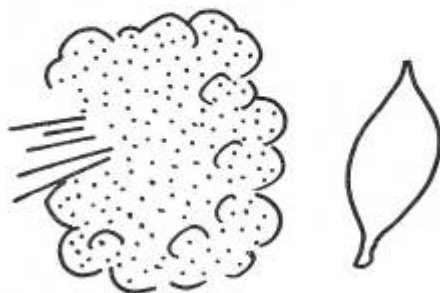
HIGH - PRESSURE SPRAYER



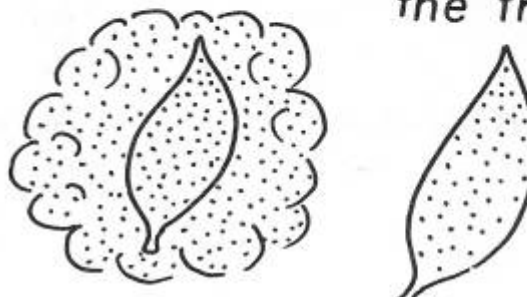
Fungicide is mixed with water and applied by hand in high-pressure stream



AIR - BLAST SPRAYER



Fungicide is mixed with water, injected into high velocity air stream which carries spray into the tree.

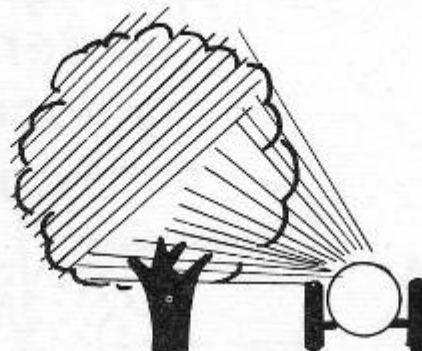


THE HOW ...

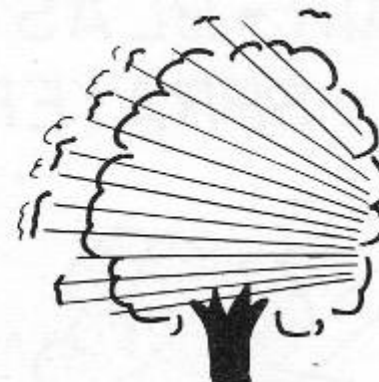
Basis of Air-Blast Spraying



All standing
air



....is displaced
by spray-laden
air



.... the entire
tree is filled
with spray
material

What is done prior to pit-hardening greatly impacts diseases at harvest



Bud-break

TO

Just Prior to Pit-Hardening



OR



General Strategy for Control of Peach Diseases

FOR SUCCESSFUL DISEASE CONTROL

**Cannot wait until the disease is observed to begin
applying controls!!!**

THUS – To achieve successful disease control, ACTION must be taken at some earlier time before the disease is observed.

This time is influenced by the ENVIRONMENT
the PATHOGEN, and
the HOST.

AND

Correct use of the appropriate control(s).