

**Almond disease
management in the
San Joaquin Valley:
Spring- and Summer-
time diseases**

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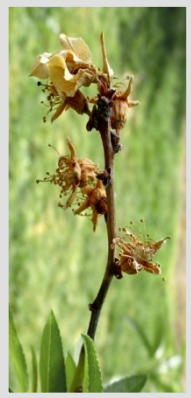
Overview of presentation

- Overview of leaf and blossom diseases of recent economic importance
- Currently registered and new fungicides for almond
- Comparative efficacy of registered and new fungicides
- Management of spring- and summer-time diseases
- Management of resistance

Common foliar and fruit diseases of almond in California



Brown rot blossom blight



Green fruit rot/Jacket rot



Shot hole



Anthracnose



Scab



Alternaria leaf spot



Rust



Hull rot



Shifts in Almond Horticulture

- Low density
- High volume, short irrigation
- Low/Moderate fertilization

- High density plantings
- Low volume, long irrigation
- High fertilization

*Less
conducive
environments,
susceptible
host*

More....

Chemical disease control in almond production

- There is an increasing arsenal of fungicides being introduced.
- Many of the new developments are pre-mixtures.
- Using the proper material is becoming more difficult and requires an increasing knowledge on the modes of action (fungicide classes), spectrum of activity, efficacy, and best usage strategies.
- **Goal: Use each class only once per season or rotate between pre-mixtures containing different classes.**

Fungicides for Managing Almond Diseases

Single-fungicides - Inorganics and Conventional Synthetics

Inorganics

Copper,
Sulfur

M1

1960s

Dithiocarbamates

Ziram,
(Maneb)

M2

1940s

Phthalimides

Captan

M3

1950s

Isophthalonitriles

Bravo, Echo,
Equus

M4

1960s

Guanidines

Syllit

M6

1960s

Benzimidazoles

Topsin-M,
T-Methyl

1

1970s

Sterol inhibitors (DMIs)

Rally, Laredo, Orbit,
Indar, Quash, Inspire

3

1970s – 1980s

SDHIs

Endura,
Luna Privilege,
Xemium?

7

1960s

Anilinopyrimidines

Vanguard,
Scala

9

1990s

Dicarboximides

Rovral,
Iprodione,
Nevado

2

1980s

Qols

Abound,
Gem

11

1990s

Hydroxyanilides

Elevate

17

1990s

Polyoxins

Ph-D

19

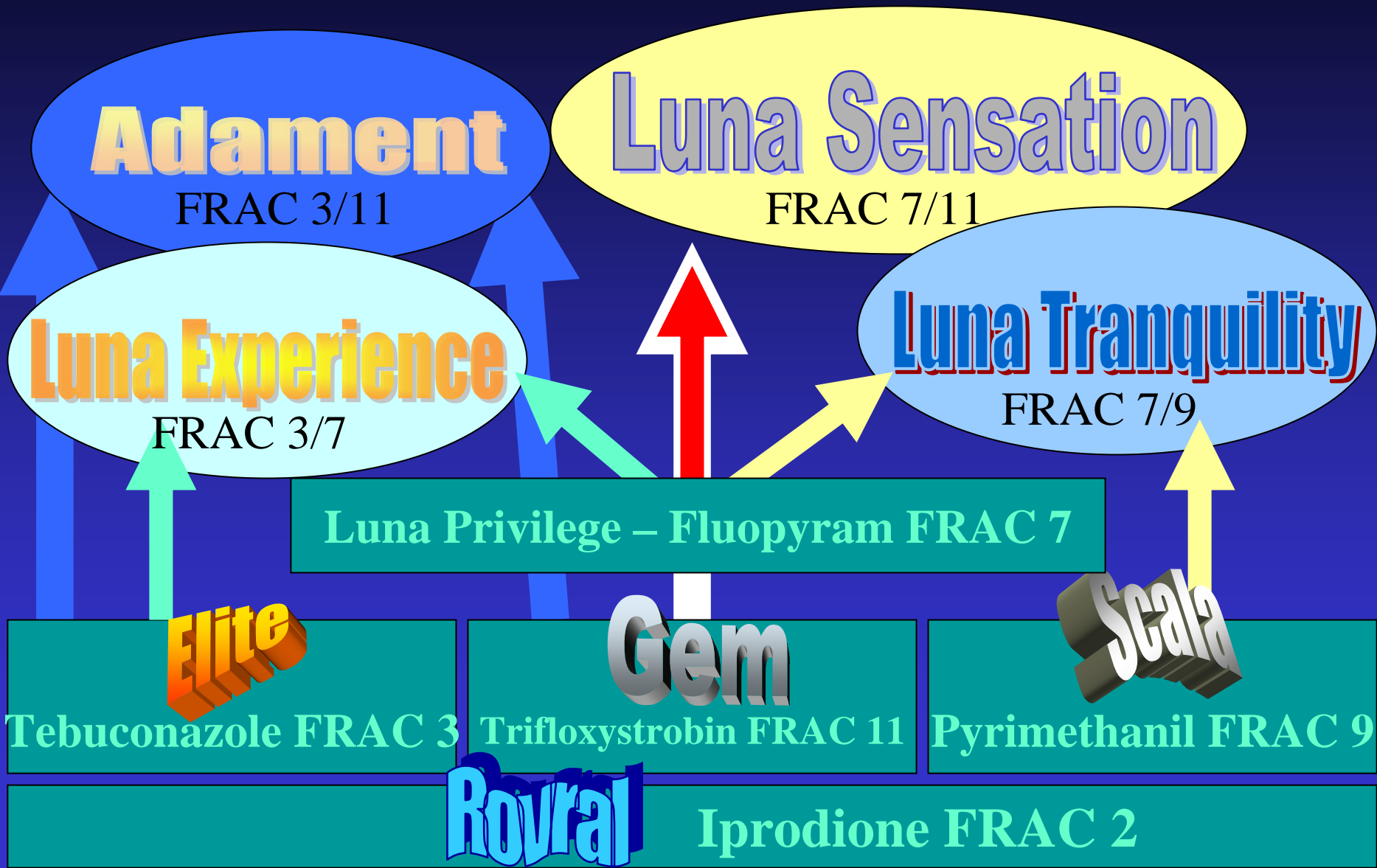
1960s

New in 2010 and beyond:

Ph-D, Inspire, Quash, SDHIs sold only in combination.

○ Multi-site mode of action
 ○ Single-site mode of action
 ○ Reduced risk fungicides

New Bayer Fungicides



New Syngenta Fungicides

Inspire XT

FRAC 3/3

Difenoconazole
– Inspire
FRAC 3

Propiconazole
– Tilt
FRAC 3

Cyprodinil
- Vanguard
FRAC 9

Azoxystrobin –
Abound
FRAC 11

Quadris Top

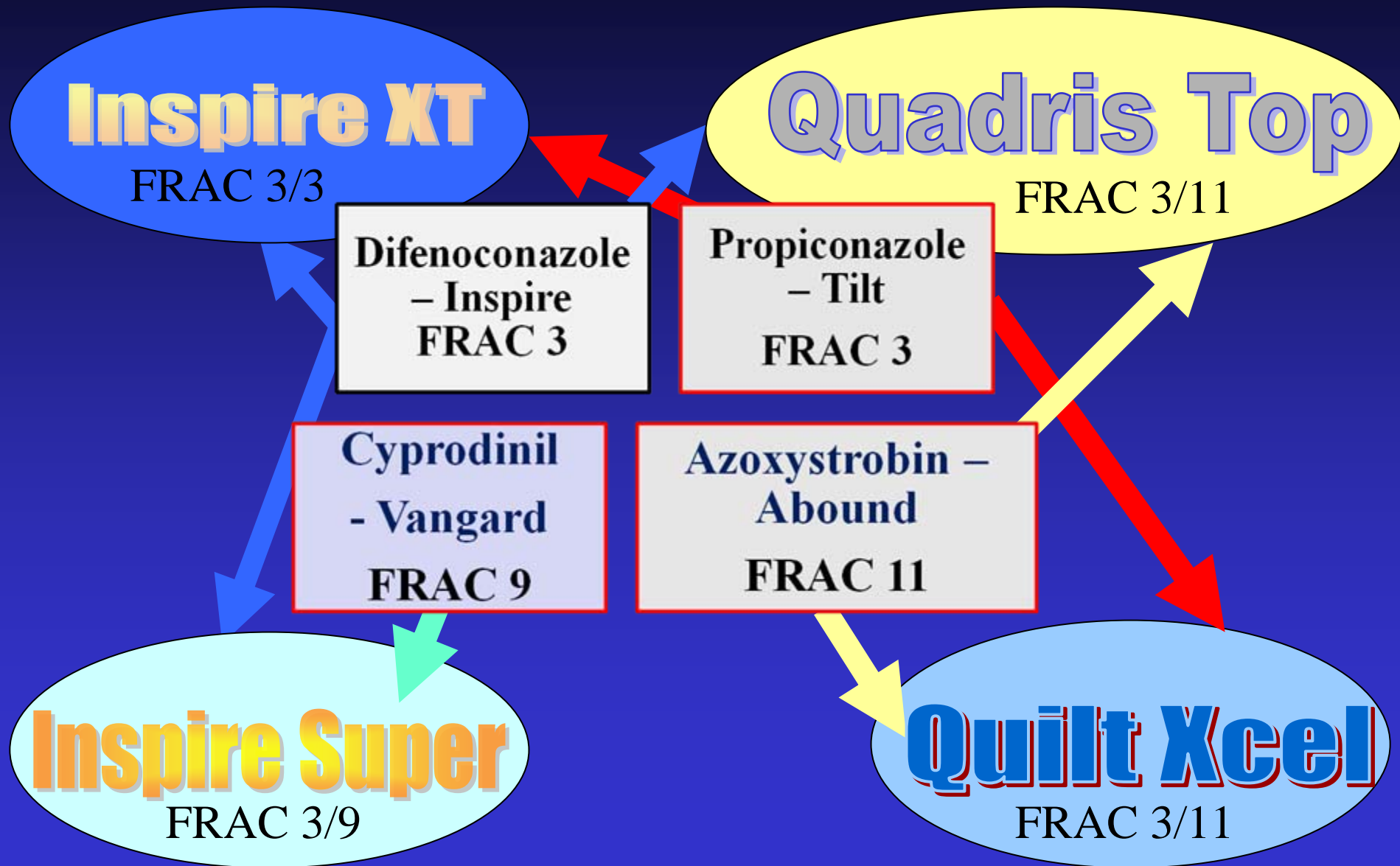
FRAC 3/11

Inspire Super

FRAC 3/9

Quilt Xcel

FRAC 3/11



New BASF Fungicides

Cabrio -
Pyraclostrobin
FRAC 11

Xemium -
Fluxapyroxad
FRAC 7

BAS703

FRAC 7/11

Endura -
Boscalid
FRAC 7

Pristine

FRAC 7/11

New Valent Fungicides

Quash

Metconazole

FRAC 3

New Arysta Fungicides

Elevate

Fenhexamid

FRAC 17

Ph-D

Polyoxin-D

FRAC 19

Fungicides for Managing Almond Diseases

Conventional Synthetic Fungicides – Pre-mixtures

Pristine

7+11

2000s

Luna Sensation
BAS703?

7+11

2012s

Inspire XT

3+3

2012s

Inspire Super

3+9

2011s

Adament

3+11

2007

Quilt Xcel

3+11

2011s

Quadris Top

3+11

2011s

New

3

DMIs

7

SDHIs

9

Anilinopyrimidines (APs)

11

QoIs

Natural
Products

Regalia,
Actinovate,
Cerebrocide

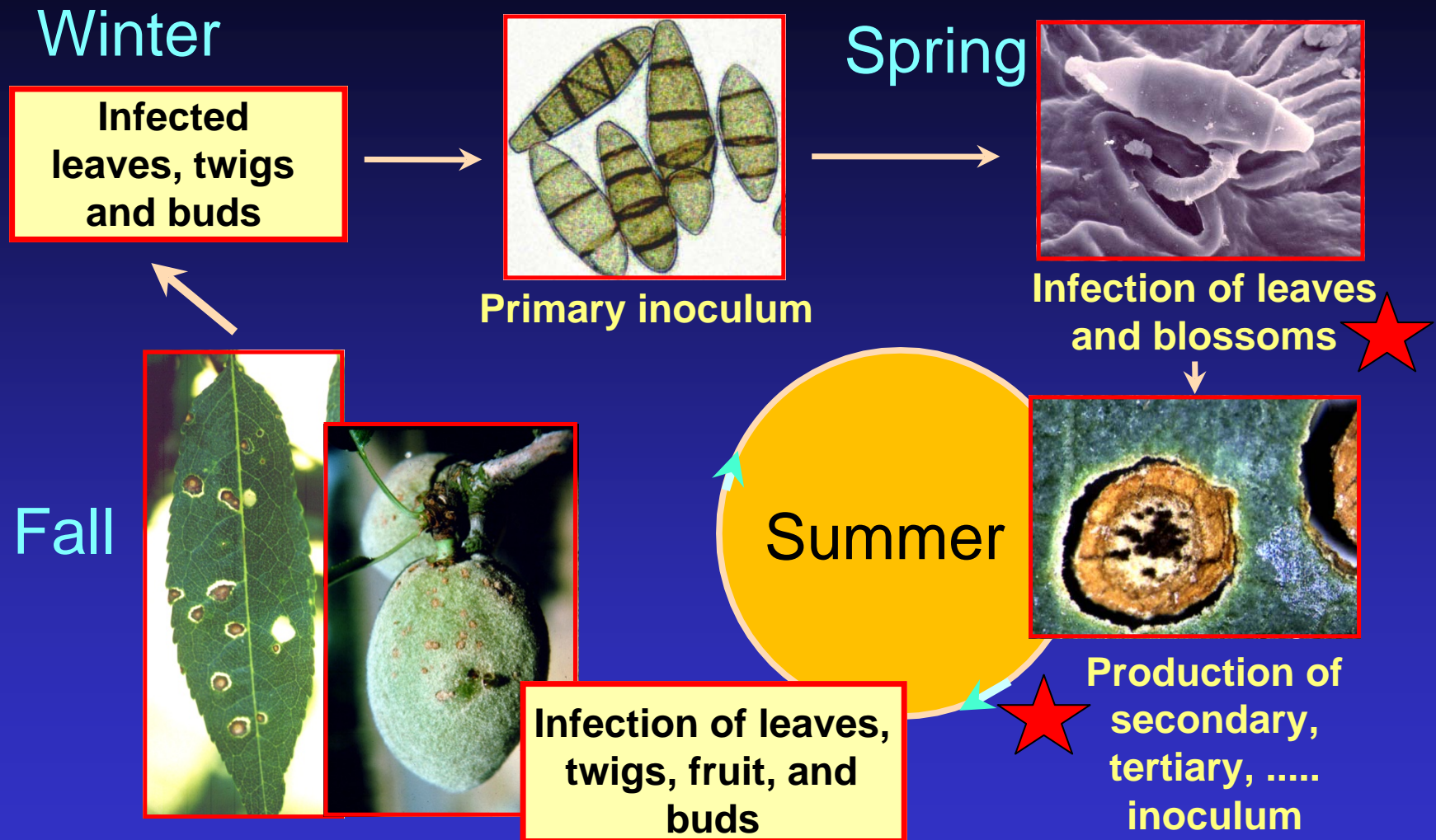
2000s

Natural products from plant extracts that potentially will be OMRI approved were evaluated for organic farming of almonds.

Management of springtime foliar diseases of almond

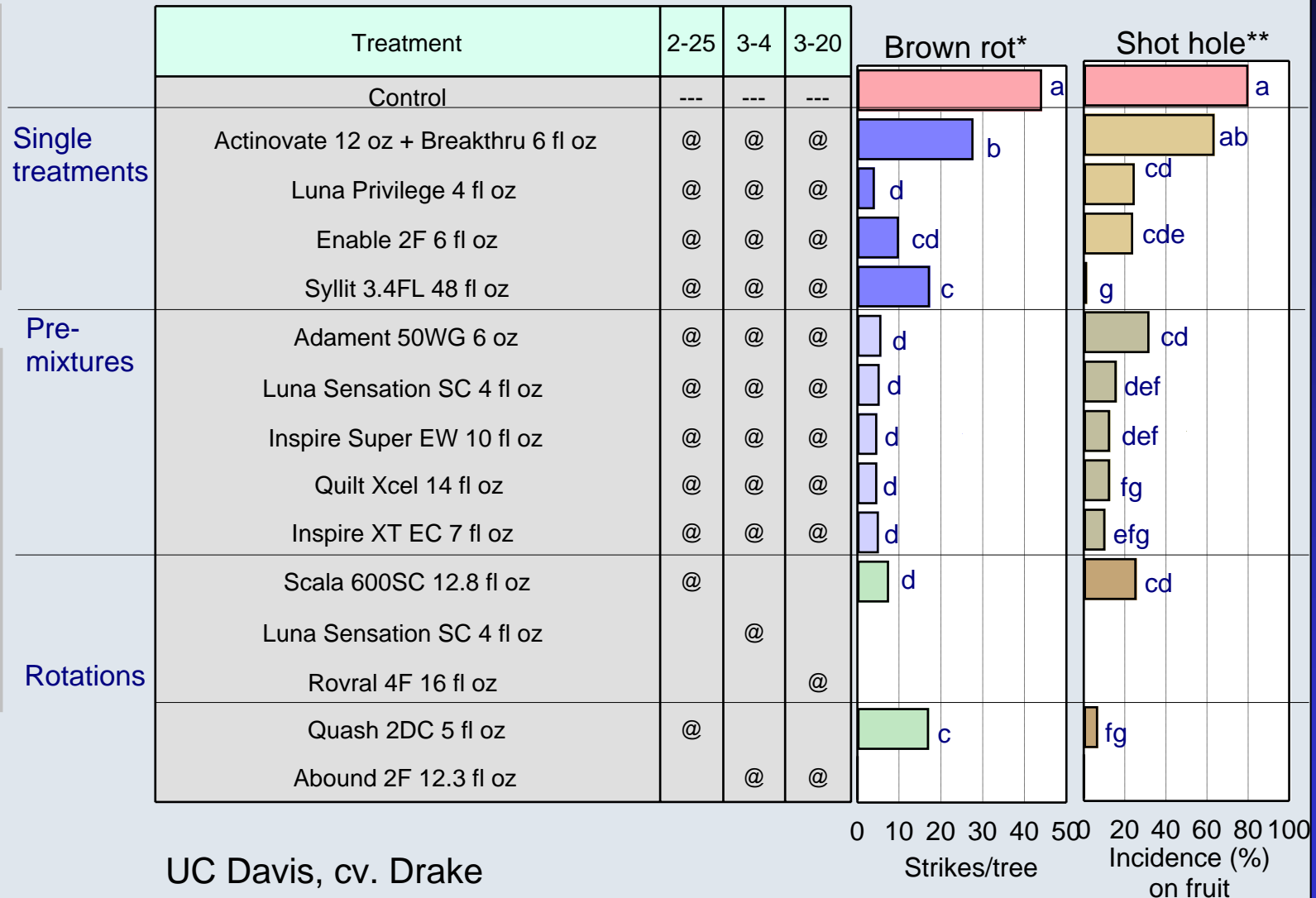
Brown Rot Blossom Blight, Jacket Rot, Shot hole

Shot hole of almond - Disease cycle in California



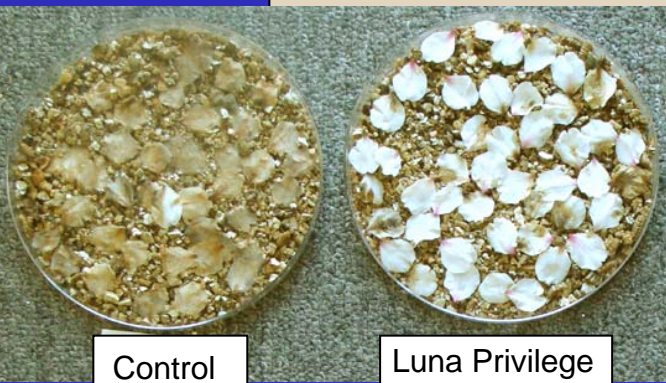
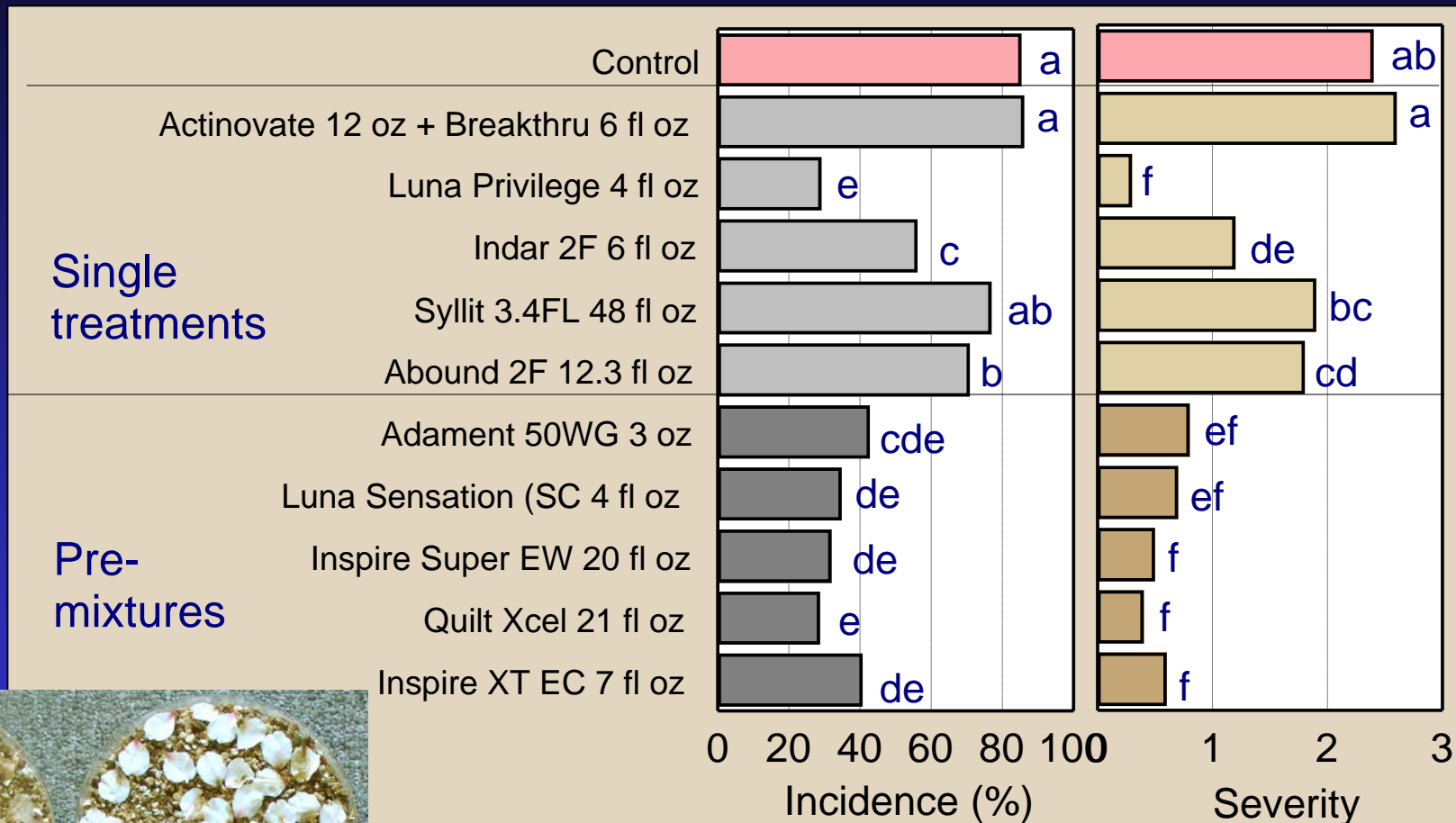
If inoculum is present at critical levels from disease in the previous fall or from disease in the spring and if climatic conditions favor disease progress, fungicides will need to be applied. ★ = fungicide timing for optimal management

Brown rot and shot hole trial, Solano Co.



UC Davis, cv. Drake

Management of Botrytis Blossom Blight (Jacket Rot/Green Fruit Rot)



Data from 2009 – Drake almond (Solano Co.)

Management of Brown Rot Blossom Blight and Shot Hole

Most effective new fungicides:

- **Brown rot:** Tilt, Quash, Elite, Indar, Scala, Vanguard
 - Pre-mixtures: Adament, Luna Sensation, as well as Inspire Super, Inspire XT, and Quilt Xcel
- **Shot hole:** Pristine, Quadris Top, Quilt Xcel, Syllit, (Abound, Gem, Rovral, Luna Sensation), Bravo, Rovral
- **Jacket Rot:** Scala, Vanguard, Pristine, Inspire Super, Luna Sensation, BAS703, Bravo, Rovral
- **Natural products/biocontrols:** Actinovate, Regalia, and Cerebrocide showed some activity, but were not as effective as most fungicides. Actinovate was the most consistent



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Fungicide treatment timings for almond

Disease	Dormant	Bloom			Spring		Summer	
		Pink Bud	Full Bloom	Petal Fall	2W	5W	May	June
Anthracnose	-	++	+++	+++	+++	+++	+++	++
Brown Rot	-	++	+++	+	-	-	-	-
Green Fruit Rot	-	-	+++	-	-	-	-	-
Leaf Blight	-	-	+++	++	+	-	-	-
Scab	+	-	-	+	+++	+++	++	+/-
Shot Hole	+	+	++	+++	+++	++	-	-
Rust	-	-	-	-	-	+++	+++	+
Alternaria	-	-	-	-	-	++	+++	+
Hull Rot	-	-	-	-	-	-	-	July

+++ = most effective, ++ = moderately effective, + = least effective, and - = ineffective.

Scab timings should follow sporulation of twig infections and conducive environments

Relative efficacy of Bayer fungicides for management of spring-time foliar diseases of almond

Fungicide	Class	Mode of action	BB blight	Jacket rot	Anthrax -nose	Shot hole
Adament	SBI/Qol	Multiple	++++	+++	++++	++
Luna Sensation	Qol/SDHI	Multiple	++++	++++	++++	+++
Gem	Qol	Single	+++	-	++++	+++
Rovral	Dicarboximide	Multiple	+++	+++	-	+++
Scala	Anilinopyrimidine	Single	++++	++++	?	++

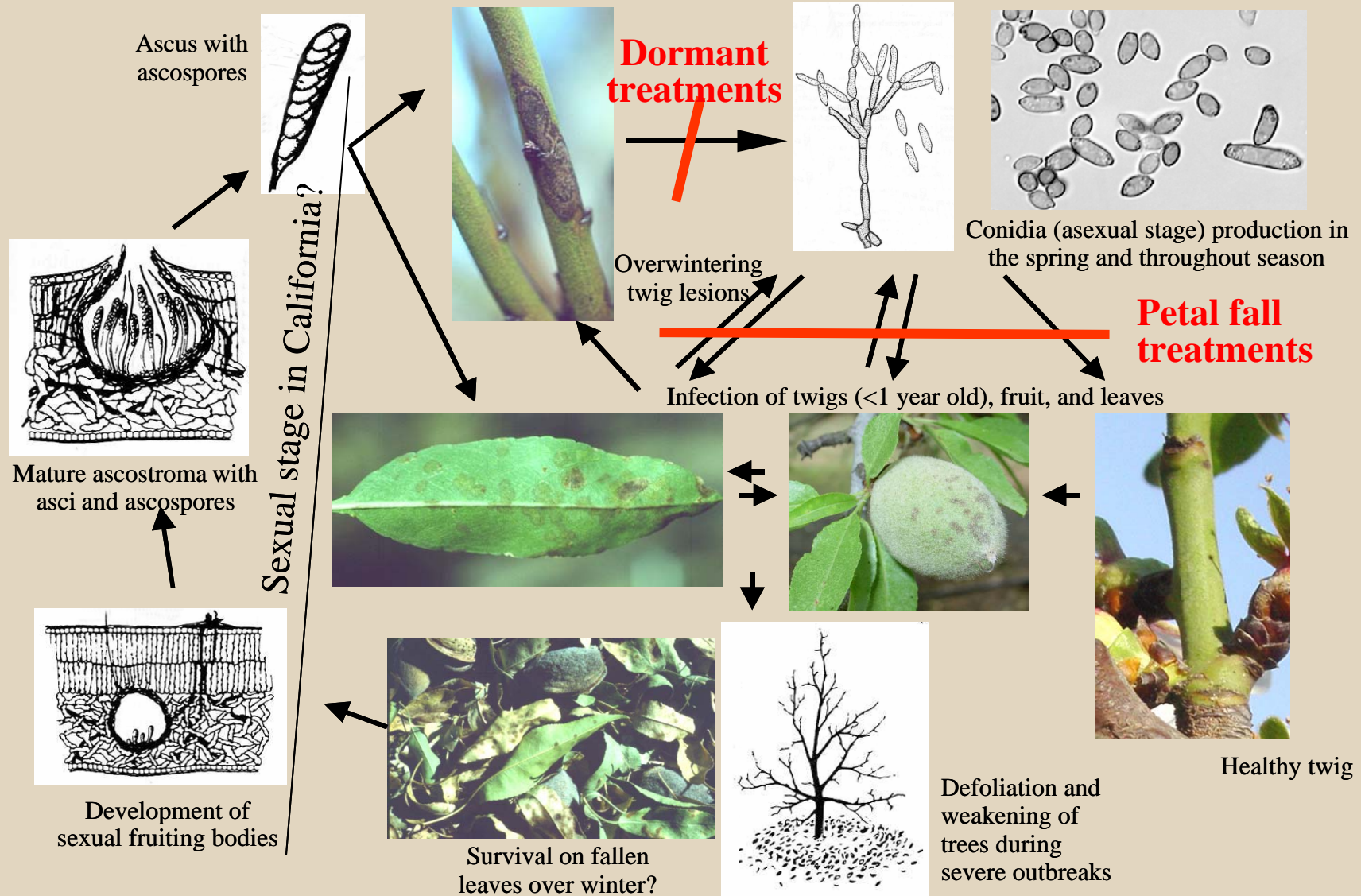
- Highly effective fungicides are available for managing important diseases of almond.
- Pre-mixtures generally improve performance. They have an increased spectrum of activity because the individual ingredients complement each other. The efficacy, however, is rate-dependent.

Management of summertime foliar diseases of almond

*Scab, Alternaria Leaf Spot, Rust
and Hull Rot of Almond*

Management of Scab

Disease cycle of *Venturia carpophila* (*Cladosporium carpophilum*)



Management of Scab

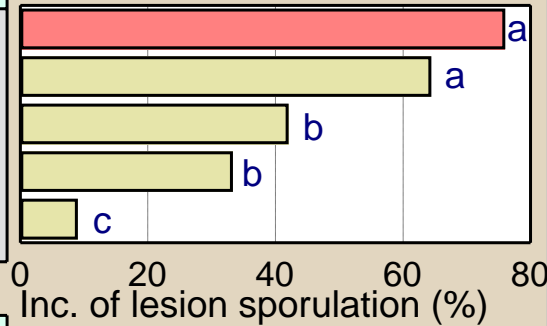
- Dormant treatments
- Petal fall treatments



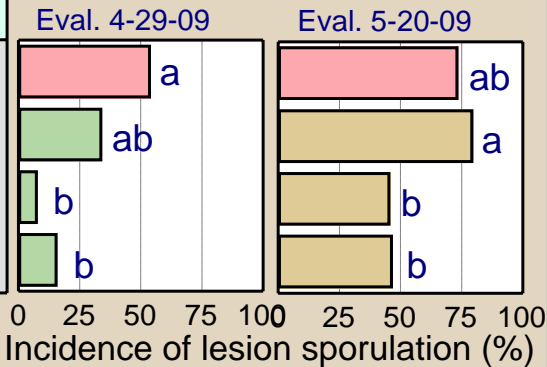
Management of Scab:

Dormant applications to reduce inoculum in the spring

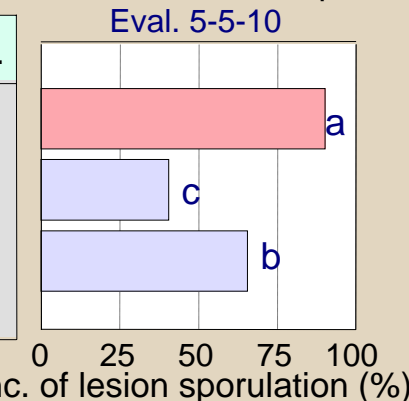
2008 Treatments	Jan.
Control	---
Oil 4 gal	@
Kocide 2000 6 lb	@
Liquid lime sulfur 16 gal	@
Kocide 2000 6 lb + Oil 4 gal	@



2009 Treatments	Jan.
Control	---
Oil 4 gal	@
Kocide 2000 6 lb	@
Kocide 2000 6 lb + Oil 4 gal	@



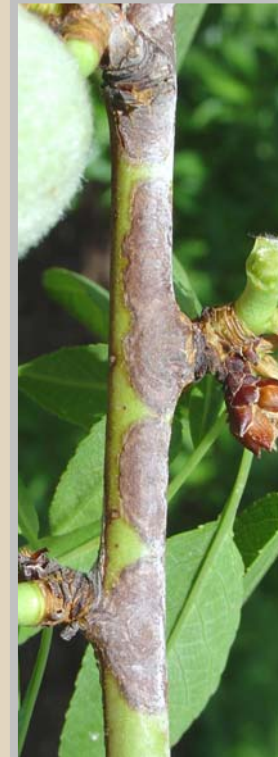
2010 Treatments	Jan.
Control	---
Kocide 3000 5 lb - Oil 4 gal	@
Kocide 3000 5 lb - Cohere	@



cv. Carmel, Butte Co.



Control



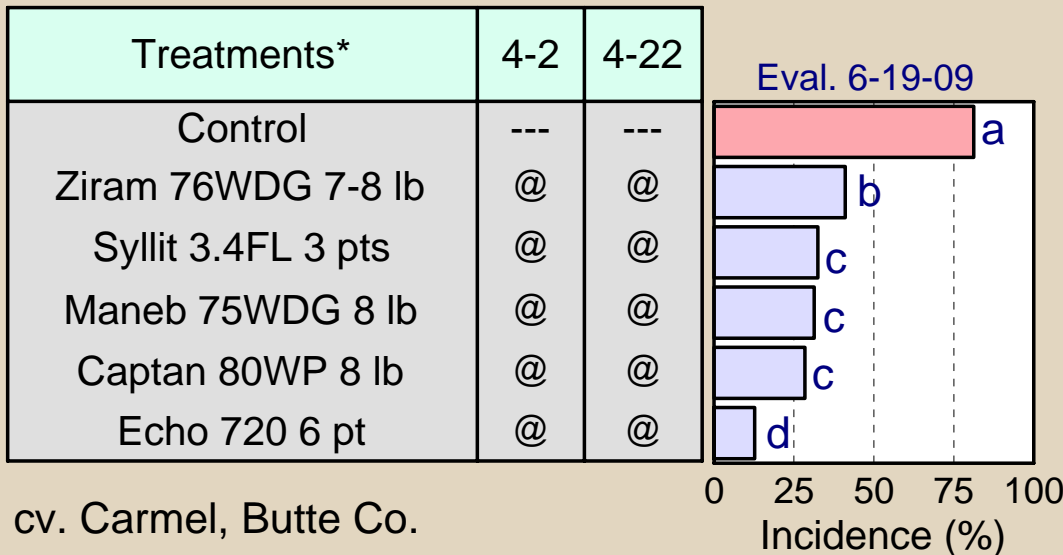
Copper-oil

Delayed dormant treatments delay the onset and amount of sporulation on overwintering twig lesions but do not prevent the disease. Integrated petal fall treatments are still needed.

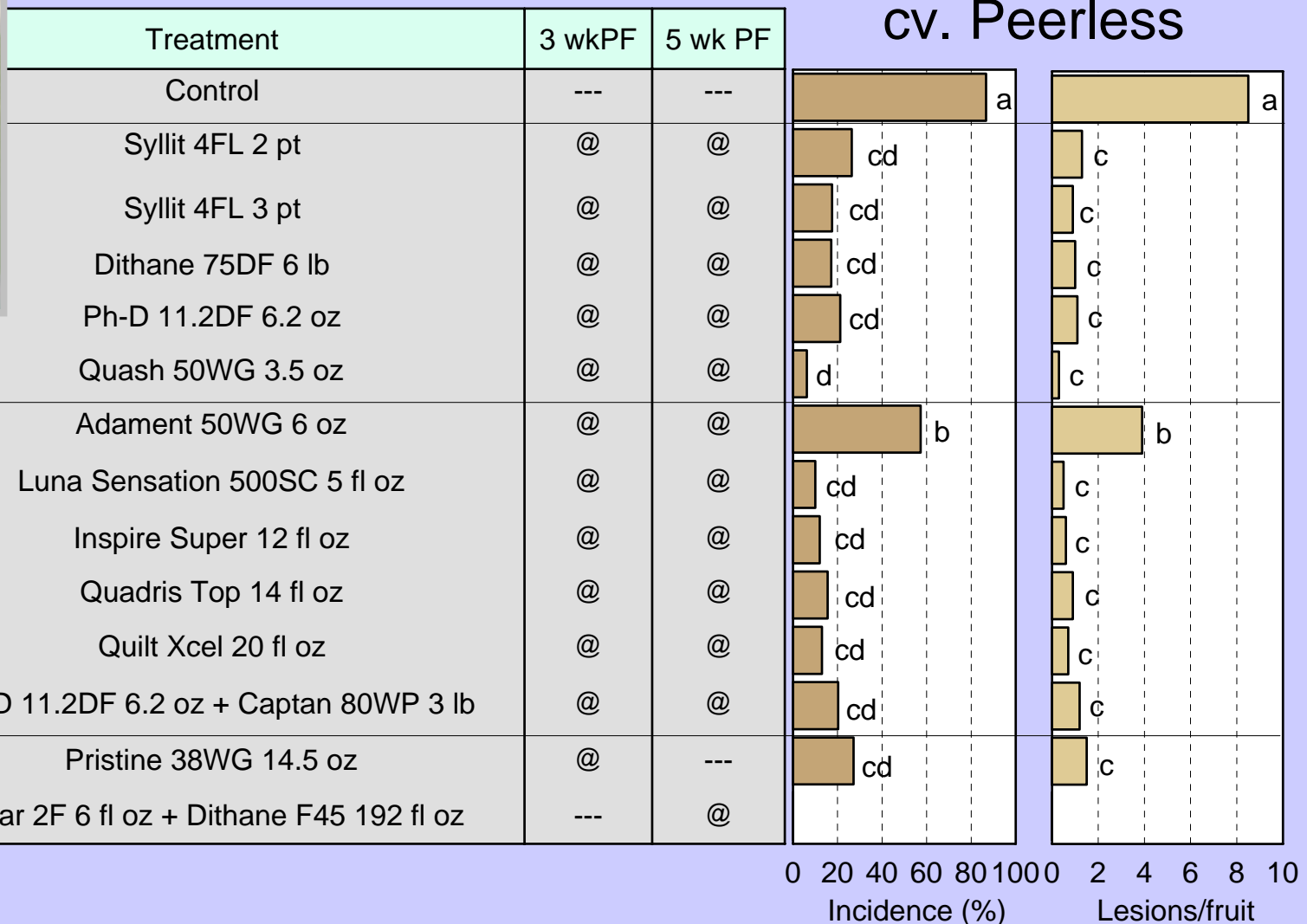
Management of Scab: In-season applications timed after twig lesion sporulation



- Highly effective after-petal-fall applications: chlorothalonil (e.g., Echo, Bravo, Equus), Maneb (or in the future mancozeb), Captan, Ziram
- A shorter PHI for chlorothalonil has been requested and IR-4 studies were approved.
- New effective single-site fungicides for almond scab : Inspire, Quash, Ph-D (polyoxin-D), and Syllit (dodine),
- Pre-mixtures: Inspire Super, Quilt Xcel, and Luna Sensation.



Efficacy of fungicide programs for management of scab of cv. Peerless almonds Butte Co. 2010



Management of Scab

- **Dormant treatments** - In problem orchards, plan a delayed dormant treatment with LLS or copper-oil.
- **Petal fall treatments** – Bravo/Echo, Captan, Maneb, DMIs (*Inspire, Quash, Indar*, and pre-mixtures (e.g., Qol+ SDHI = *Luna Sensation*).
- **Late-spring treatments** – Sulfur, Captan

Fungicide resistance in *Cladosporium carpophilum* –

- Widespread against benzimidazoles, Qols
- High risk for DMIs and SDHIs
- Do not apply single-site mode of action fungicides once disease is developing.
- Plan for rotation programs and integrated strategies



Management of Scab: Cultural Practices

- **Planting: Varietal Susceptibility**

- Most Susceptible: Carmel, Merced, NePlus Ultra, Peerless, Price, Ruby, Sonora, Winters.
- Less Susceptible: Butte, Fritz, Mission, Monterey, Wood Colony, Thompson.
- Least Susceptible: Nonpareil

Practice	Goal
Planting Design	Allow air circulation
Tree Pruning	Increase air movement and reduce RH
Irrigation Management	Reduce orchard RH
Clean Cultivation	Reduce orchard RH
Foliar fertilizers? (Monosodium phosphate + urea?)	Increase tree health
Avoid heavy late-summer/fall fertilization with N	Reduce production of highly susceptible host tissues

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Fungicide application timing for almond scab

	Bloom			Spring		Summer	
	Pink bud	Full bloom	Petal fall	Two weeks	Five weeks	May	June
Dormant	-	-	+	+++	++++	+	+/-

Management programs should be based on disease history of the orchard. Spring spray timings are based on sporulation of twig infections and environmental conditions.

Suggested management programs

	Petal Fall		Early Spring	
Dormant	2-wk after	5-wk after	mid-April	early May
M1, M2	Chlorothalonil-M5	Ziram-M3	3, 7/11	S-M2
M1, M2	Maneb-M5	Chlorothalonil-M5	3, 7/11	S-M2
M1, M2	Chlorothalonil-M5	Captan-M4	3, 7/11	S-M2

Resistance against QoI fungicides (FRAC Group 11) is widespread in populations of *C. carpophilum*.

Alternaria leaf spot caused by the *A. alternata* complex*



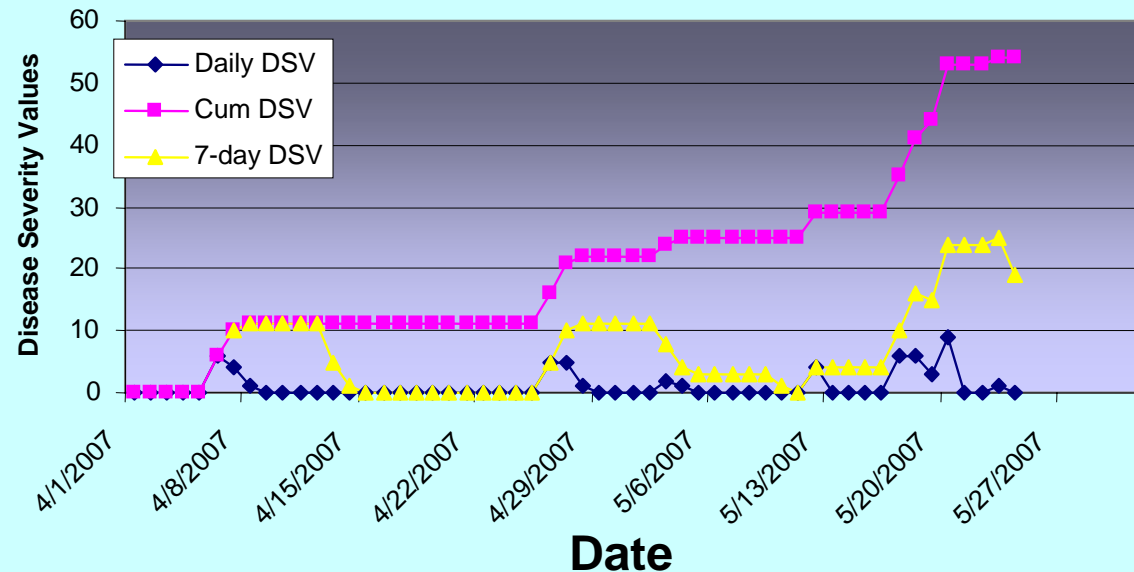
* *Alternaria alternata*,
A. arborescens,
A. tenuissima

The modified DSV model for forecasting Alternaria leaf spot of almond

Mean temperature (C) during wetness	Leaf wetness duration (hours)				
15-17	0-6	7-15	16-20	21	---
17.1-20	0-3	4-8	9-15	16-22	23+
20.1-25	0-2	3-5	6-12	13-20	21+
25.1-29	0-3	4-8	9-15	16-20	23+
DSV	0	1	2	3	4

Disease severity values (DSV) as a function of leaf wetness duration and average air temperature during the wetness period.

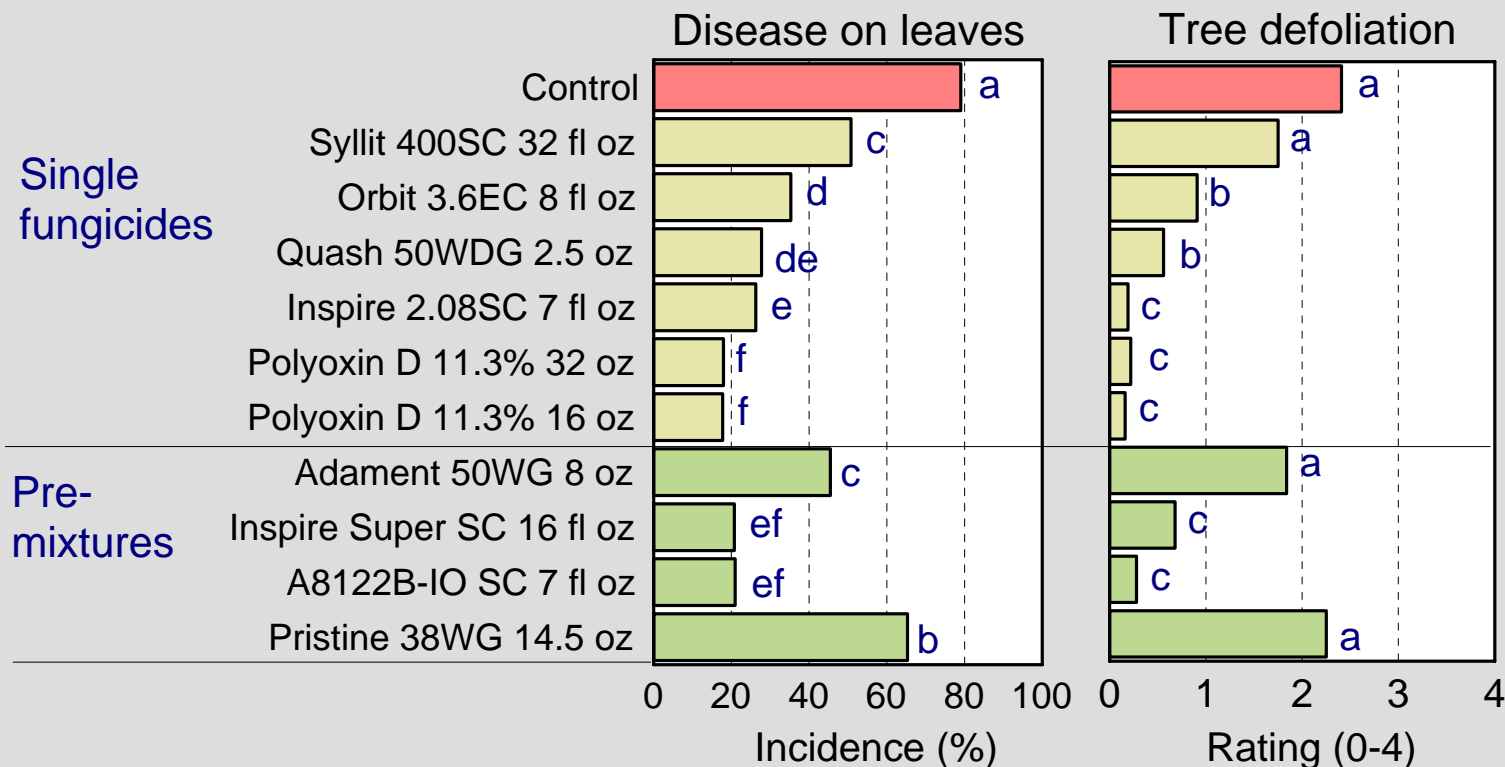
DSV Model 2007 Kern Co.



Fungicide efficacy trial, Glenn Co. 2008



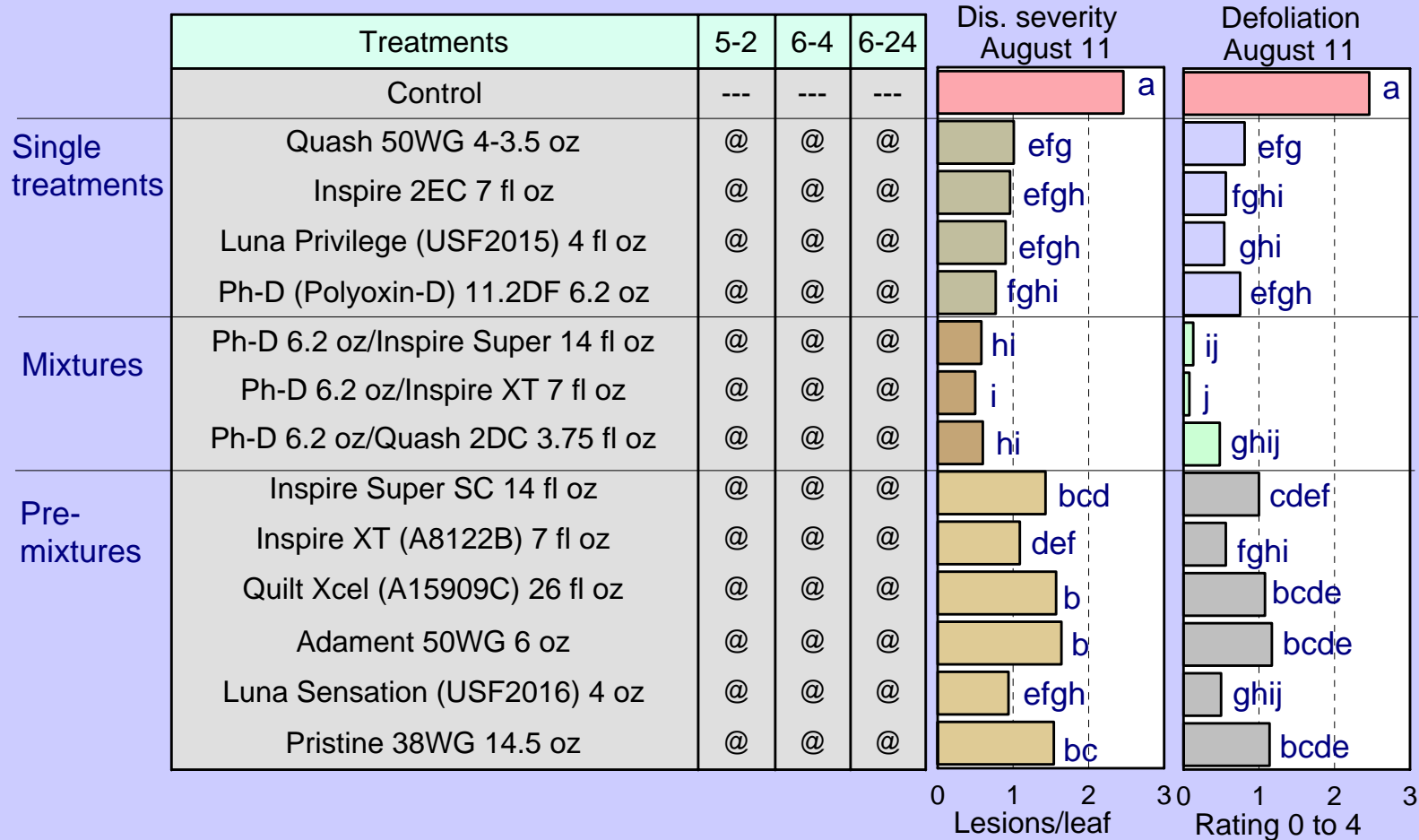
Cv. Carmel – 3 applications



Treatments were applied on 5-13, 6-6, and 6-23-08 using an air-blast sprayer at a rate of 100 gal/A. Evaluations were done on 8-12-08.

High incidence of QoI and carboxamide resistance in this orchard

Management of Alternaria Leaf Spot - 2009



cvs. Carmel and Monterey - Kern Co. 2009

Applications: 5-12, 6-4, 6-24-10.

Incidence of QoI resistance 97%, incidence of carboxamide resistance 60%

Fungicide efficacy trial – *Alternaria* leaf spot

Tree defoliation evaluated in August



Control



Polyoxin-D + Inspire Super

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ALMOND—TREATMENT TIMING FOR SCAB AND ALTERNARIA

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	Two week	Five week	May	June
Scab	++	-	-	+	+++	+++	+/-	+/-
Alternaria	-	-	-	-	-	+++	+++	+++

Fungicide options available for rotational and mixture programs for management of Scab and Alternaria leaf spot of almond

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	2	3, 7/11 ² 11 ² , 19	3, 7/11 ² 11 ² , 19
Scab ⁴	M2 ³	---	---	1 ² , 7/11 ² 11 ² , M3 M4, M5	1 ² , 7/11 ² 11 ² , M3 M4, M5	3, 7/11 ² 11 ² , M2 ³ M3, M4	M2 ³ M4	---

Summary *Management of Alternaria leaf spot*

1. Management programs should start with petal fall applications that include Rovral. The effectiveness of Rovral at this timing will depend on the occurrence of favorable environmental conditions for the disease in early spring.
2. Because field resistance against QoIs and SDHIs is occurring, late-spring/early-summer applications (based on the DSV model) have to be done with other materials at most locations.
3. New materials (Quash, Inspire - both group 3) and Ph-D - group 19) should be strictly used in rotations and mixtures for resistance management.
4. Other components of the integrated approach in disease management are highly critical for management of *Alternaria* leaf spot.

Guidelines for the Integrated Management of Alternaria leaf spot

Practice	Goal
Almond cultivar selection	Plant less susceptible cultivars
Planting design	Allow air circulation
Tree training	Allow air circulation and reduce dew formation
Foliar disease and mite control	Minimize amount of stressed and injured leaf tissue
Irrigation management	Reduce orchard RH
Orchard floor management	Reduce orchard RH and amount of senescing plant tissues colonized by <i>Alternaria</i> spp.
Chemical control	Rotate and mix 2 to 3 applications between mid-April and late-June based on DSV model

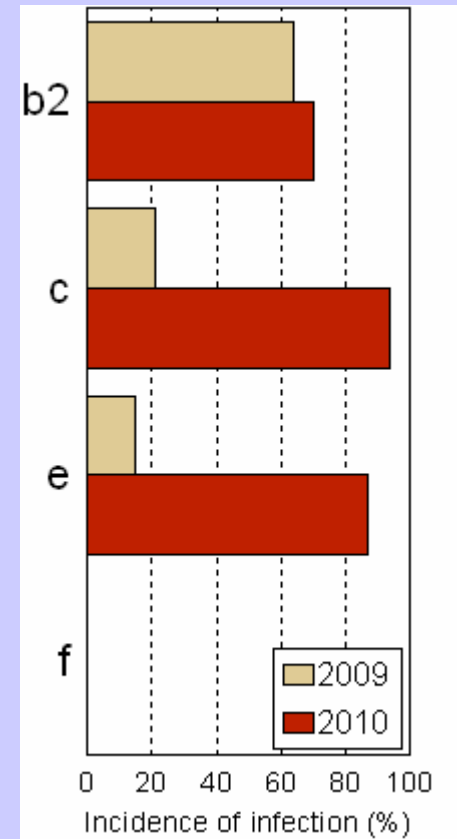
Management of Hull Rot

Susceptibility of almond fruit at different hull split stages to infection of *Rhizopus stolonifer*- Laboratory studies

- Hull is highly susceptible to infection during early to mid-split stages of nut development.
- Most susceptible at hull split stages b2 through e.
- Infection likely due to conducive environments.
- This information is important for the timing of fungicide applications.



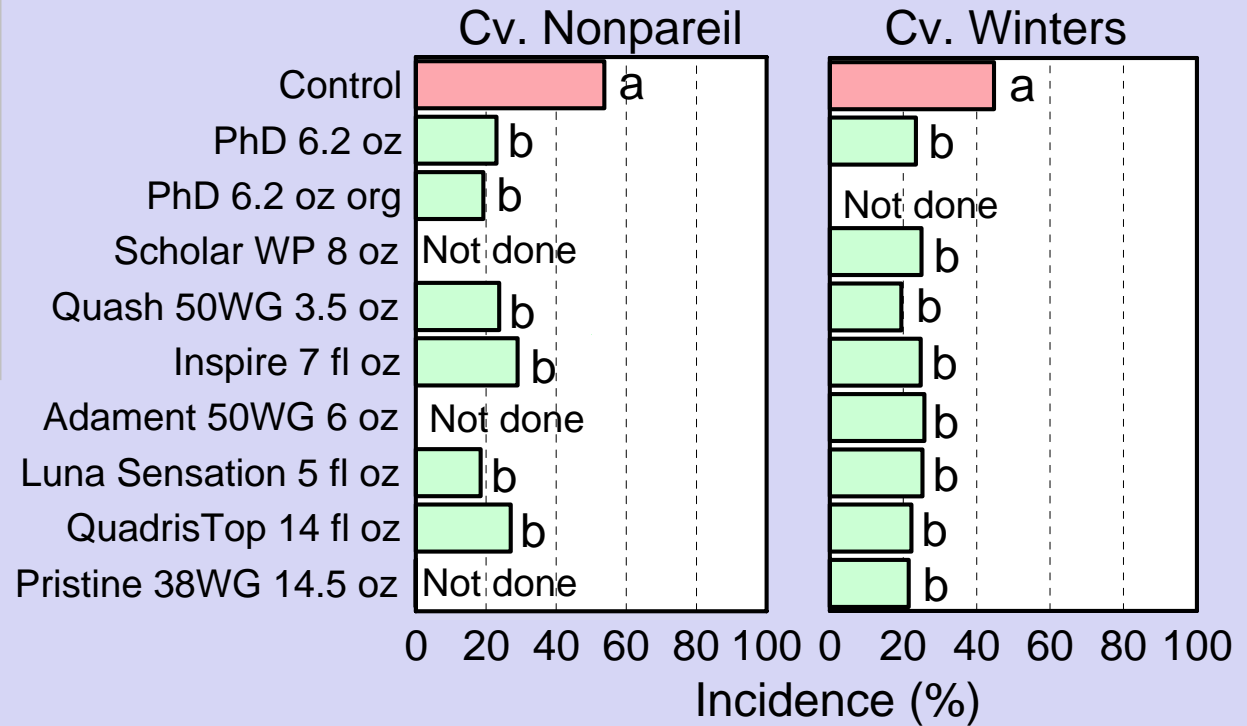
Hull split stage*



Stages b1 and f had low susceptible (F was not done 2010).

* - UC-IPM Manual for Almonds

Management of hull rot caused by *Rhizopus stolonifer* - 2010



Application cv. Nonpareil: 8-13-10, Evaluation on 9-9-10

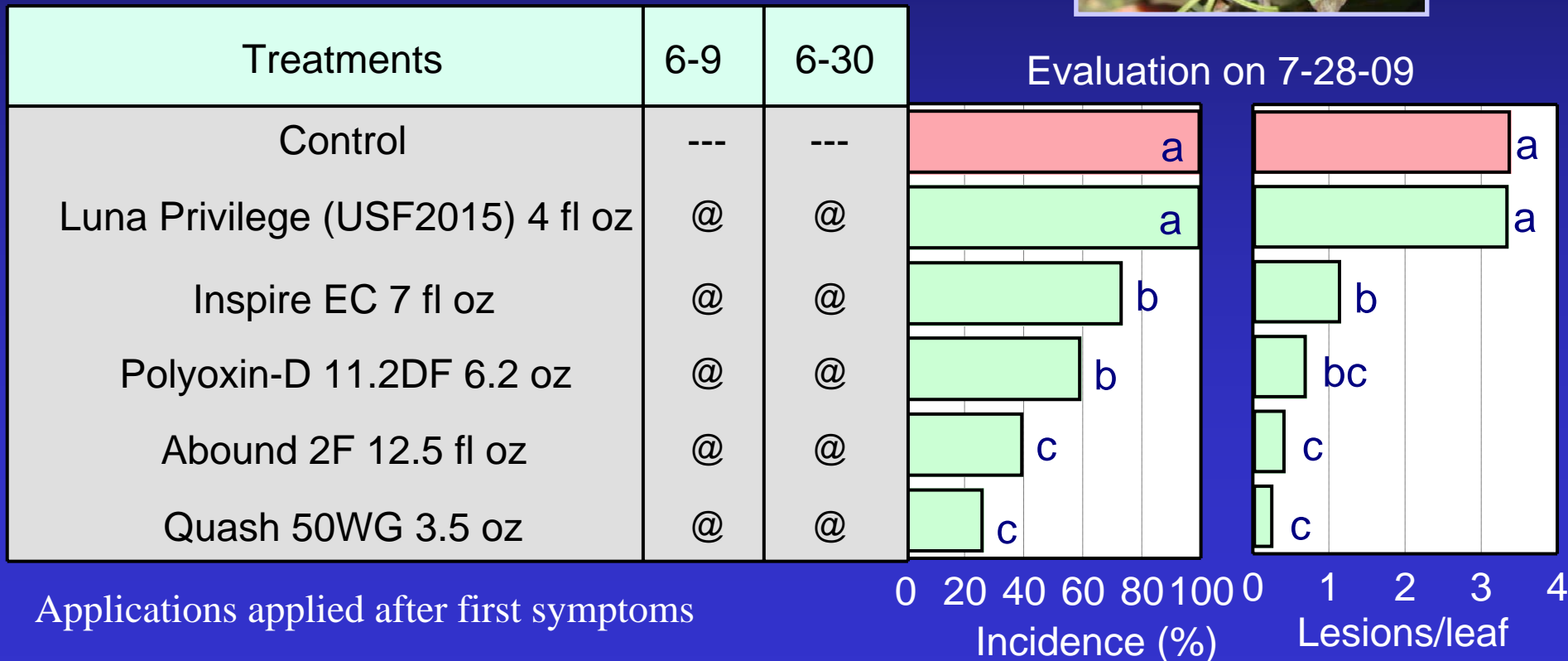
Applications cv. Winters: 8-31, 9-10-10, Evaluation on 10-1-10

Management of Leaf Rust

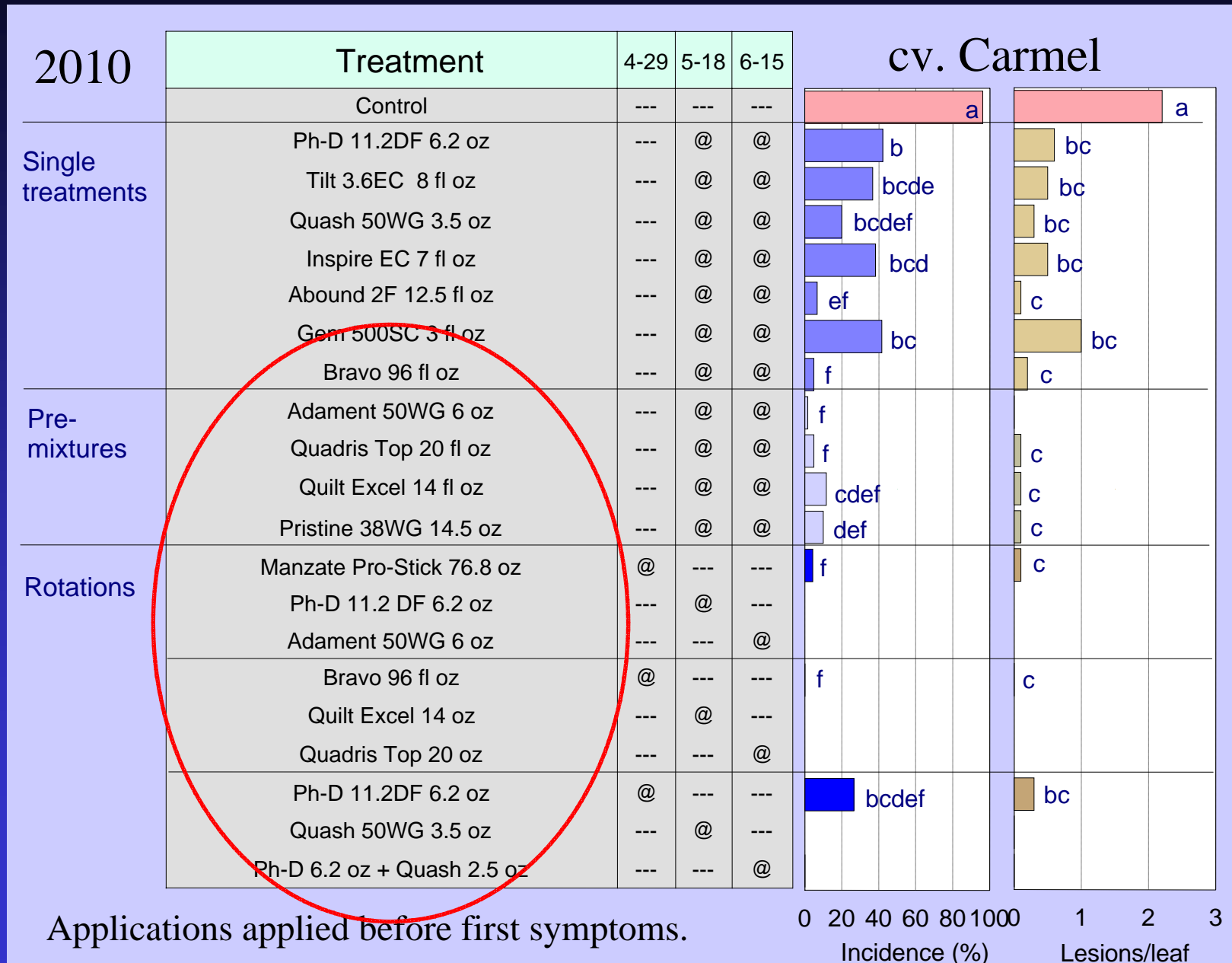
cv. Carmel



Evaluation on 7-28-09



Management of Leaf Rust, con't



Fungicide resistance in Alternaria and Cladosporium spp. on almond

Alternaria spp.

QoIs (strobilurins)

- 2003/04 resistance detected
- 2005 field (practical) resistance in Kern Co.
- 2007 field (practical) resistance in Northern CA

SDHIs (Carboxamides)

- 2007 resistance first detected in Northern and Southern CA
- Pristine not effective in some locations

Cladosporium carpophilum

QoIs (strobilurins)

- 2006 resistance detected
- 2008 practical resistance in many locations in Northern CA

Fungicide resistance management

Fungicide selection

- Limit use of each mode of action (class) to once per season)
- Use pre-mixes, tank mixes, or alternate fungicides with different modes of action (classes of fungicides)
- Be sure to use fungicide pre-mixtures where both components have activity against a particular pathogen.

Anti-resistance strategies

“Minimize disease and pathogen survivors”
Do not compromise control by minimizing
rates or coverage

Anti-resistance strategies for fungicide use on almonds

- Application of “Following the Rules” in Fungicide Stewardship -

- **Rotate or mix fungicides of different mode of actions** –
- **Use labeled rates** – For strobilurins, use upper label rates.
- **Limit total number of applications** – limit any single-site mode of action fungicide class to 1 or 2 per orchard per season (strobilurins perhaps to 1/season for scab and Alternaria).
- **Educate yourself about fungicide activity, mode of action, and class** - as well as resistance management practices.
- **Start a fungicide program with multi-site mode of action materials** (e.g., Captan, Bravo/Echo, Ziram, Rovral, Sulfur)
 - -Reduce pathogen population size that is exposed to subsequent treatments. Probability of selecting for resistance is reduced.