the Southern Region small fruit consortium

SRSFC Sponsored Insect and Disease Identification and Management for Small Fruit

January 6, 2011

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Insect and Disease Identification and Management Agent Training Sponsored by:

the Southern Region small fruit consortium

and

Area Wide Pest Management/ NCSU Program-Methyl Bromide Alternatives

January 6, 2011
Savannah International
Trade and Convention Center
Savannah, GA

In cooperation with

2011 Southeast Regional Fruit and Vegetable Conference

SRSFC Sponsored Insect and Disease Identification and Management for Small Fruit Crops In-service Training for County Extension Agents

Savannah International Convention Center
Savannah, Georgia

January 6, 2011

AGENDA

8:30 – 8:45 a.m.	Welcome and Introduction Dr. Tom Monaco, North Carolina State University
8:45 – 9:45 a.m.	Current Disease Control Issues for Blackberry in the Southeast – Dr. Phil Brannen, University of Georgia
9:45 – 10:45 a.m.	Insect Management in Caneberries – Dr. Doug Pfeiffer, Virginia Polytechnic Institute and State University
10:45 – 11:00 a.m.	Break
11:00 – 12:00 p.m.	Arthropod Identification & Management in Southeastern Small Fruits – Dr. Hannah Burrack, North Carolina State University
12:00 – 1:00 p.m.	Sponsored Lunch
1:00 – 2:00 p.m.	Strawberry Diseases Biology and Integrated Management– Drs. Frank Louws and Mahfuzur Rahman, North Carolina State University
2:00 – 2:45 p.m.	New Fumigant Regulations: Safety, Medical Clearance, Respirator Fitting- Dr. Frank Louws and Mr. Rob Welker, North Carolina State University
2:45 – 3:00 p.m.	Break
3:00 - 3:20 p.m.	Stem Blight and Propagation Issues in Blueberry-Dr.Phil Harmon, University of Florida
3:20 - 3:40 p.m.	Bacterial Leaf Scorch of Blueberry-Dr. Don Hopkins, University of Florida
3:40 - 4:00 p.m.	Mechanical Harvesting of Southern Highbush and Disease Relationships-Dr. Harald Scherm, University of Georgia
4:00 - 4:30 p.m.	Southeastern Blueberry Insect & Mite Pest Management:Time In-Orchard, Scouting & IPM Responses-Dr. Dan Horton, University of Georgia and Danny Stanaland, University of Georgia
4:30 - 5:00 p.m.	Management of Major Blueberry Diseases-Dr.Phil Brannen, University of Georgia

Questions and Answers


the
Southern Region
small fruit consortium

History

- 1999 Meeting
- MOU 2000 NC State, Clemson, Univ of GA
- 2002 Univ of TN
- 2005 VA Tech
- 2008 Univ of Arkansas
- Six Member Institution
- Annual Budget $210,000

Objectives

- Pool expertise
- County Agent Training
- Promote Research
- Education
- Web site

Grant Program

- Goal-provide funding for applied research and extension activities
- Competitive
- Seed Grants-maximum of $5000
- Total amount awarded 2001-2010= $856,847
- Reports posted on SRSFC website
- http://www.smallfruits.org/SRSFCReserchFunding/index.htm

County Extension Agent Training

- Enhance expertise in small fruit production
- Nineteen trainings since 1999
- A total of 463 agents from the member states have attended
- Scholarships awarded to cover cost of training, 4 to 5 per member state
- Events held in the member states

Blueberry Workshop June 2007

Muscadine Workshop 2006

Pruning Workshop 2006 Walterboro, South Carolina

Strawberry Training 2008
Charlotte, North Carolina

Blackberry Training 2009
Lincolnton, North Carolina

SRSFC Web Site

- www.smallfruits.org
- Web Master Brenda Willis UGA
- Hits per day 4,000
- Contents

Other Activities

- Sponsorships of small fruit meetings/conferences
- Travel grants for county agents
- Support of state extension meetings
- Recruiting membership
- Partnering in Specialty Crops Grants
- Grant writing
- Publication spnsorships

January 6 Training

- Reimbursement questions?
- Followup session-Mid May in NC
- SE Regional Fruit and Veg Conference
- Evaluations

January 6 Training

- Organizers-Powell Smith, Allen Straw, Phil Brannen

  Sponsors

  Southern Region Small Fruit Consortium

  Area Wide Pest Management/NCSU Program-Methyl Bromide Alternatives

  Specialty Crops Grant "Advancing Blueberry Production Efficiency by Enabling Mechanical Harvest, Improving Fruit Quality and Safety, and Managing Emerging Diseases"

Current Disease Control Issues for Blackberry in the Southeast

Phillip M. Brannen
Plant Pathology Department
University of Georgia

THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

2010 Southeast Regional Caneberries Integrated Management Guide

Commodity Editor
Phil Brannen (University of Georgia)

Section Editors
Pathology; Guido Schnabel (Clemson University) and Don Ferrin (LSU Ag Center)
Entomology; Hannah Burrack (North Carolina State) and Doug Pfeiffer (Virginia Tech)
Weed Science; Wayne Mitchem and Katie Jennings (North Carolina State University)
Vertebrate Management; David Lockwood (University of Tennessee)
Culture; Gina Fernandez (North Carolina State University)
Pesticide Stewardship and Safety; Bob Bellinger (Clemson University)
and Paul Guillebeau (University of Georgia)

Senior Editors
Phil Brannen (University of Georgia)
Powell Smith (Clemson University)

Contributions were also made by Barbara Smith (USDA/ARS Small Fruit Res. Station, Poplarville, MS), Ed Sikora (Auburn University), Steve Bost (University of Tennessee), Gerard Krewer (University of Georgia), Turner Sutton (North Carolina State University), and Dan Horton (University of Georgia).

www.smallfruits.org

Blackberry Disease Problems (Potential)

- Double blossom (Rosette)
- Botrytis gray mold
- Viruses
  - Dagger nematode
- Orange rust
- Leaf and cane rust
- Phytophthora root rot
- Spur blight
- Crown gall
- Cane blight
- Oak root rot
- Anthracnose
- Orange blotch
- Septoria leaf spot

General Considerations for Disease Management

- Destroy wild brambles within 600 feet of the production area.
- Bramble fields should be located in direct sunlight with good air circulation.
- Purchase certified virus-free plants when available.
- Avoid Phytophthora and other root rots by using raised beds (8-12 inches high). Install drain tile if necessary.

Phytophthora Root Rot

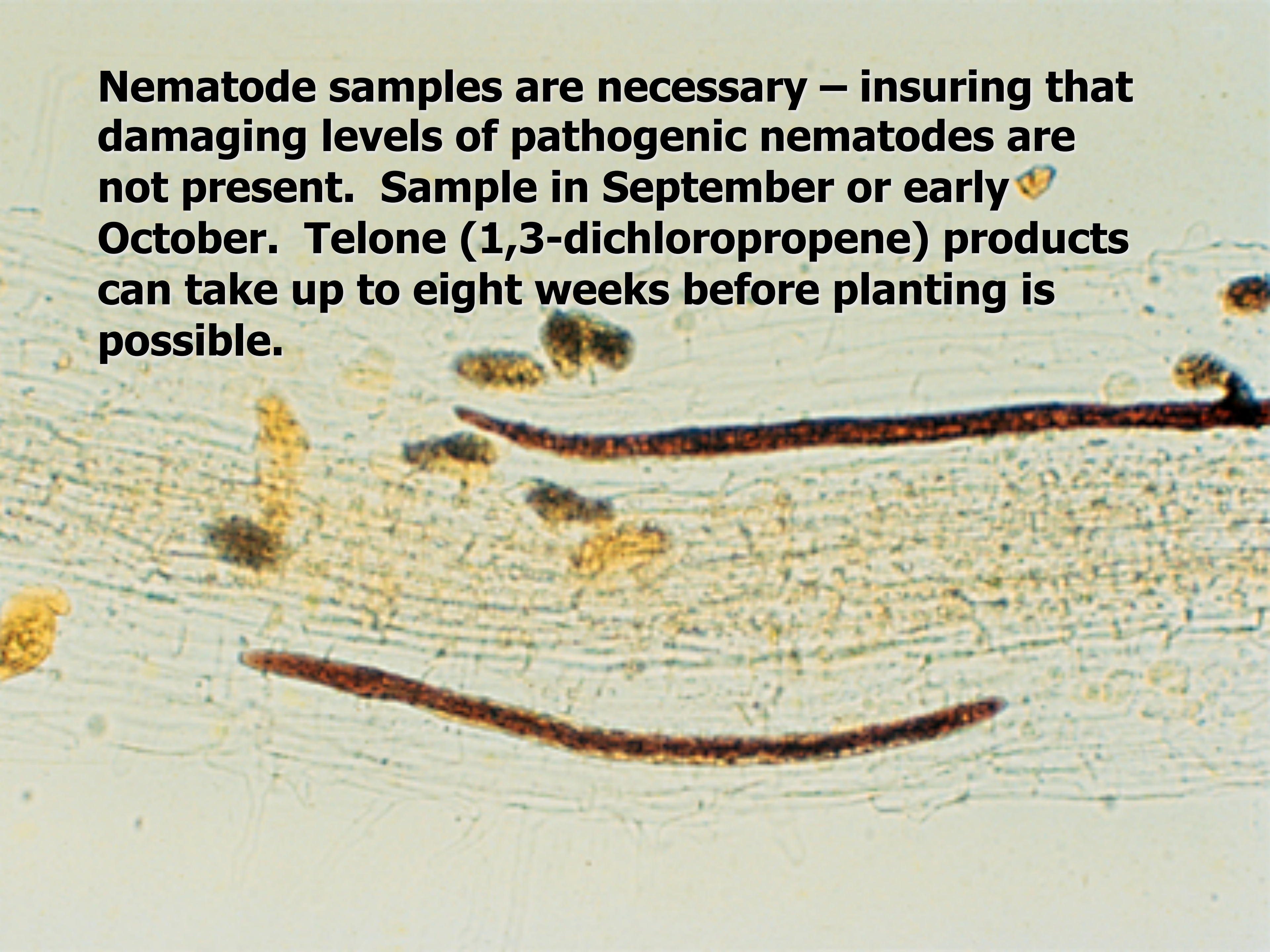
- **Chemical – mefenoxam [Ridomil] {PHI 45 days} and fosetyl-Al [Aliette] {PHI 60 days}**

General Considerations for Disease Management

- 2-4% organic matter is recommended; consider use of manure or green manure crops to increase OM.
- Do not plant immediately following crops of potato, tomato, or eggplant, since Verticillium inoculum may be available for infection. Rotate with non-vert crops for 3-4 years before planting brambles.

Viruses

- Occur on blackberry and raspberry.
- Tomato ringspot, tobacco ringspot, raspberry bushy dwarf, unknowns.
- Currently no chemicals are available for control.
- Use virus-free plant material (availability is the issue).
- Dagger nematode – vector for nepoviruses
  - Telone, metam sodium – preplant only



Nematode samples are necessary – insuring that damaging levels of pathogenic nematodes are not present. Sample in September or early October. Telone (1,3-dichloropropene) products can take up to eight weeks before planting is possible.

Viruses are currently my greatest concern for blackberry production. Tissue culture blackberries are the way to go, and I would not utilize non-tissue cultured plants – period.

Blackberry Yellow Vein Associated Virus (BYVaV)

- New virus
- Latent in some blackberry cultivars
- May be more problematic when mixed with other viruses or "helper" viruses
- Classified as a "crinivirus" (typically transmitted by whiteflies, but transmission has not been demonstrated, but definitely transmitted through cuttings or tissue culture

Crown Gall
(*Agrobacterium tumefaciens*)

- **Blackberry and raspberry problem.**
- **Wound pathogen.**
  - **Gramoxone ???**
- **Biological control is effective (applied at transplanting).**
  - **Isolates K84 and 1026 [Galltrol and NoGall]**

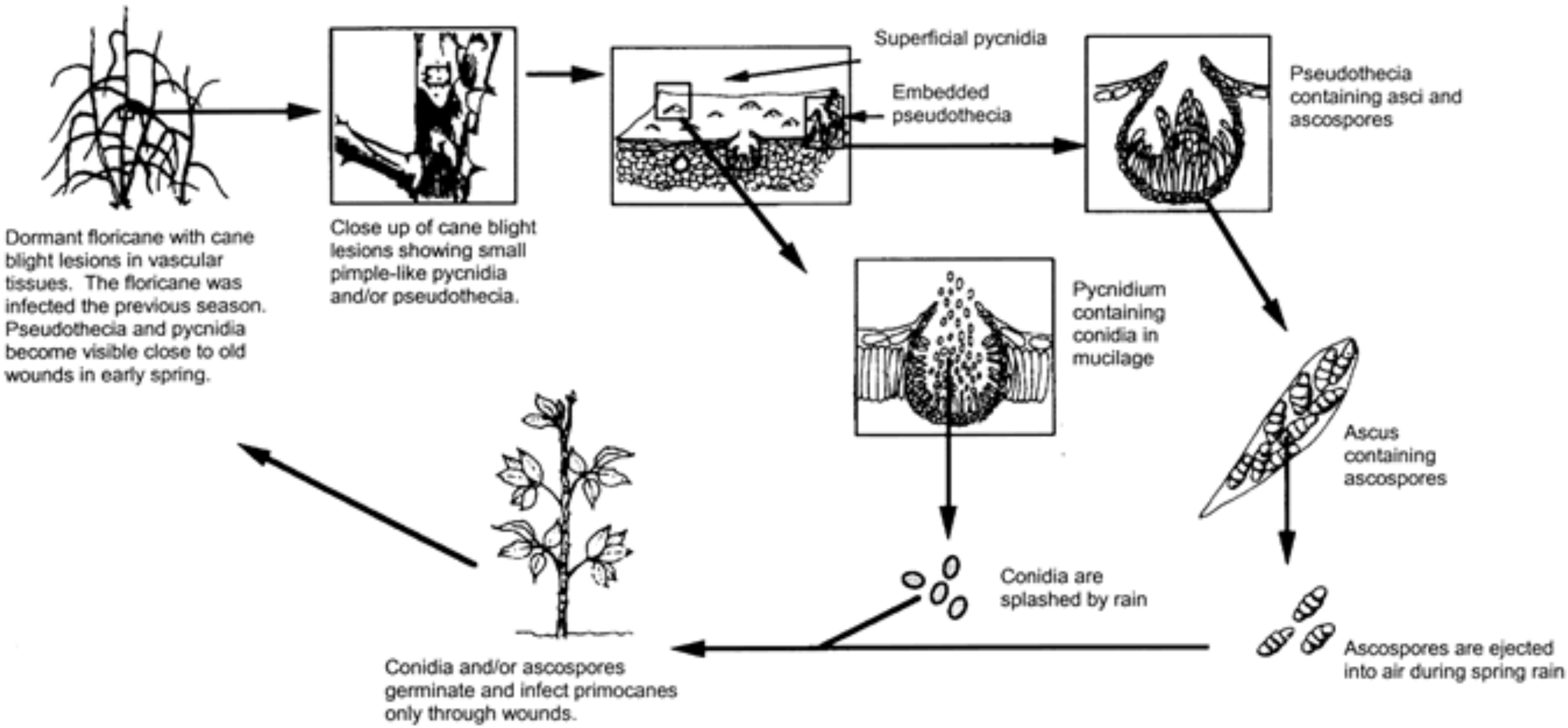

Anthracnose
(*Elsinoe veneta*)

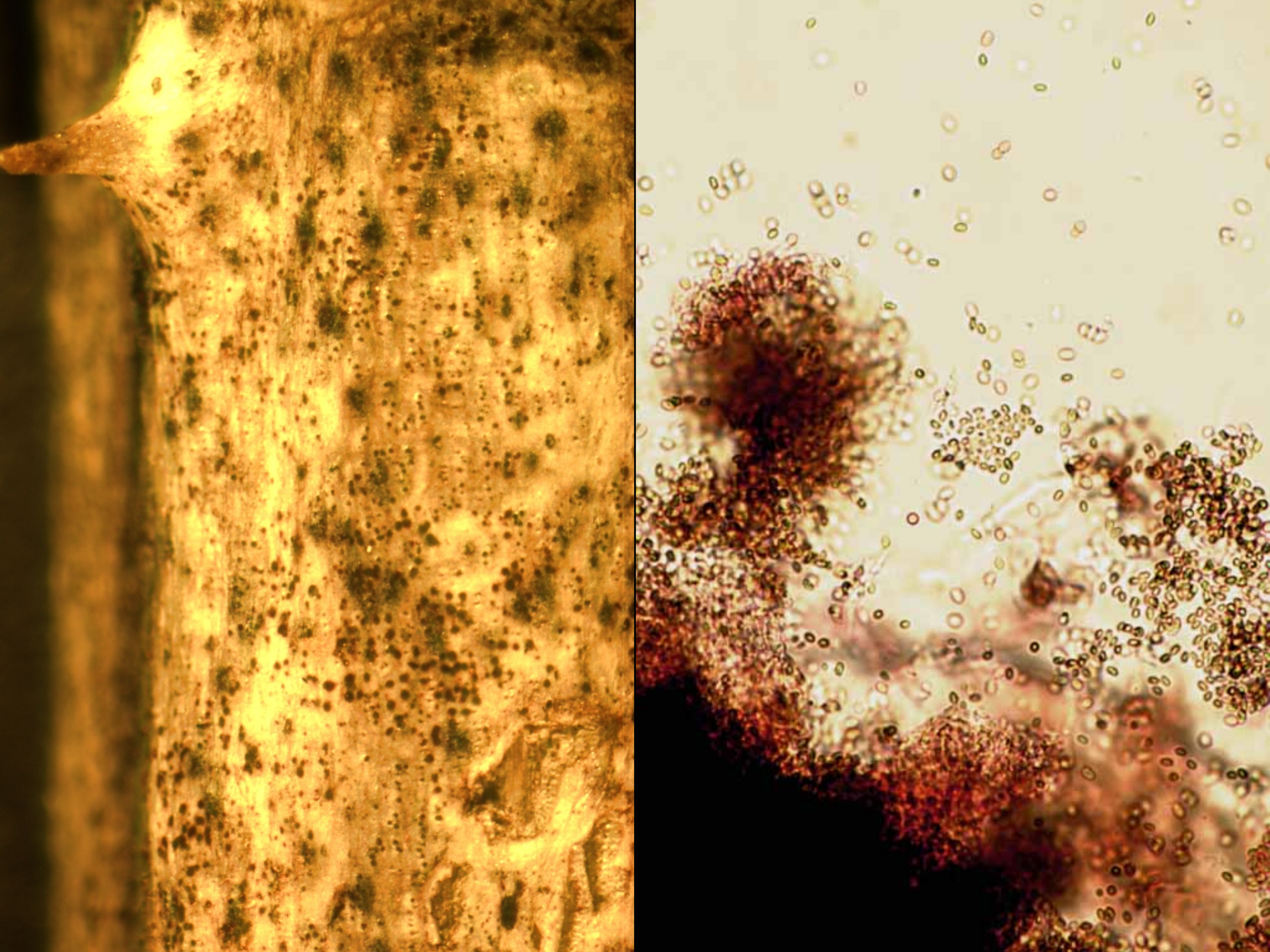
- **Major disease attacking brambles in GA.**
- **The fungus survives the winter on old canes.**
- **Remove old fruiting canes and infected primocanes and destroy (bury or burn) the tissue.**
- **Copper compounds and lime sulfur (delayed dormant only) are registered. Double blossom sprays should be effective if resistance has not occurred.**

Cane Blight

(*Leptosphaeria coniothyrium*)

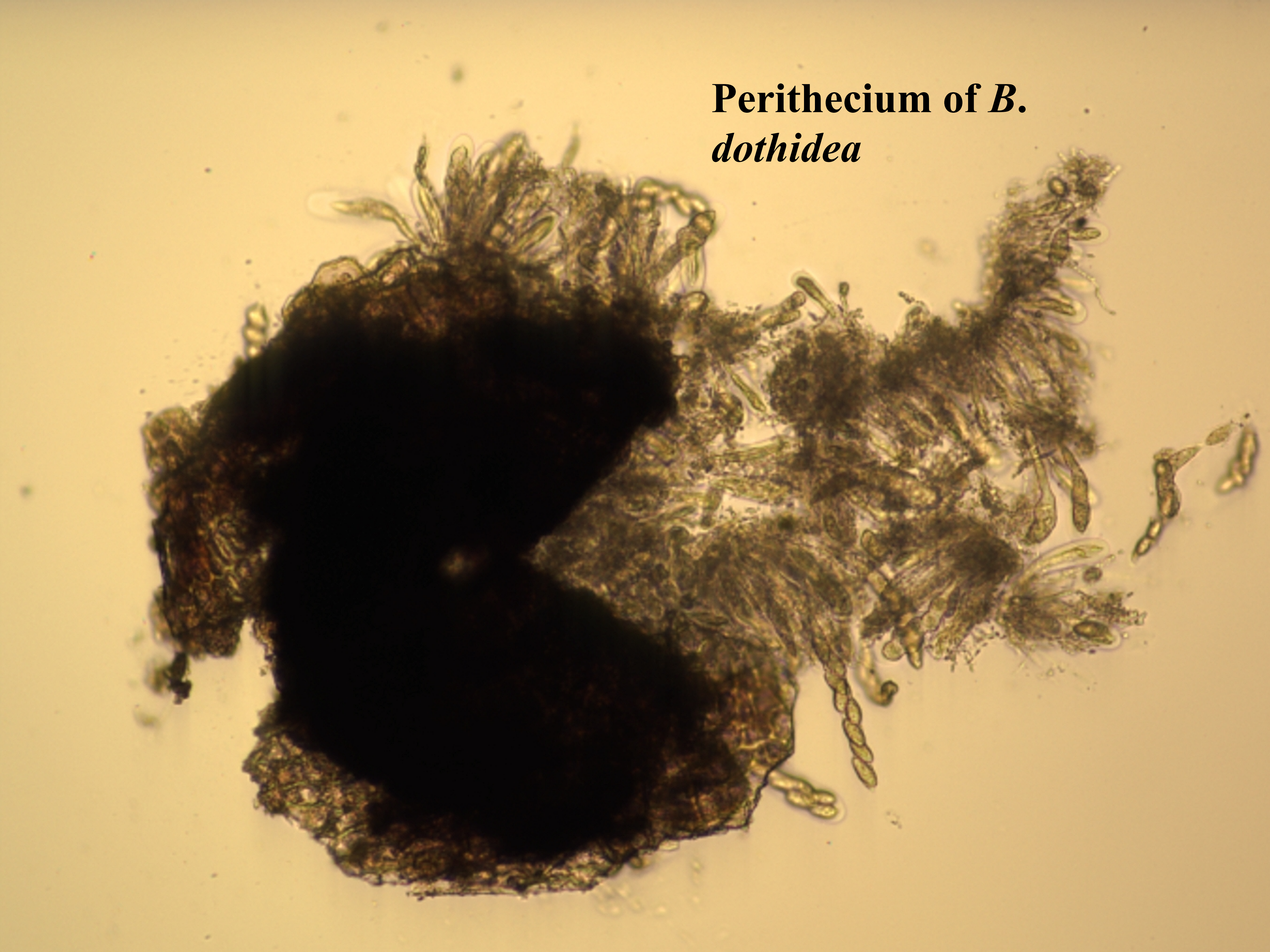
- Major pathogen of blackberries
- Wound pathogen
- Especially aggressive in wet years


Superficial pycnidia
Embedded pseudothecia
Pseudothecia containing asci and ascospores
Dormant floricane with cane blight lesions in vascular tissues. The floricane was infected the previous season. Pseudothecia and pycnidia become visible close to old wounds in early spring.
Close up of cane blight lesions showing small pimple-like pycnidia and/or pseudothecia.
Pycnidium containing conidia in mucilage
Ascus containing ascospores
Conidia are splashed by rain
Ascospores are ejected into air during spring rain
Conidia and/or ascospores germinate and infect primocanes only through wounds.



Botryosphaeria cane
canker of blackberry

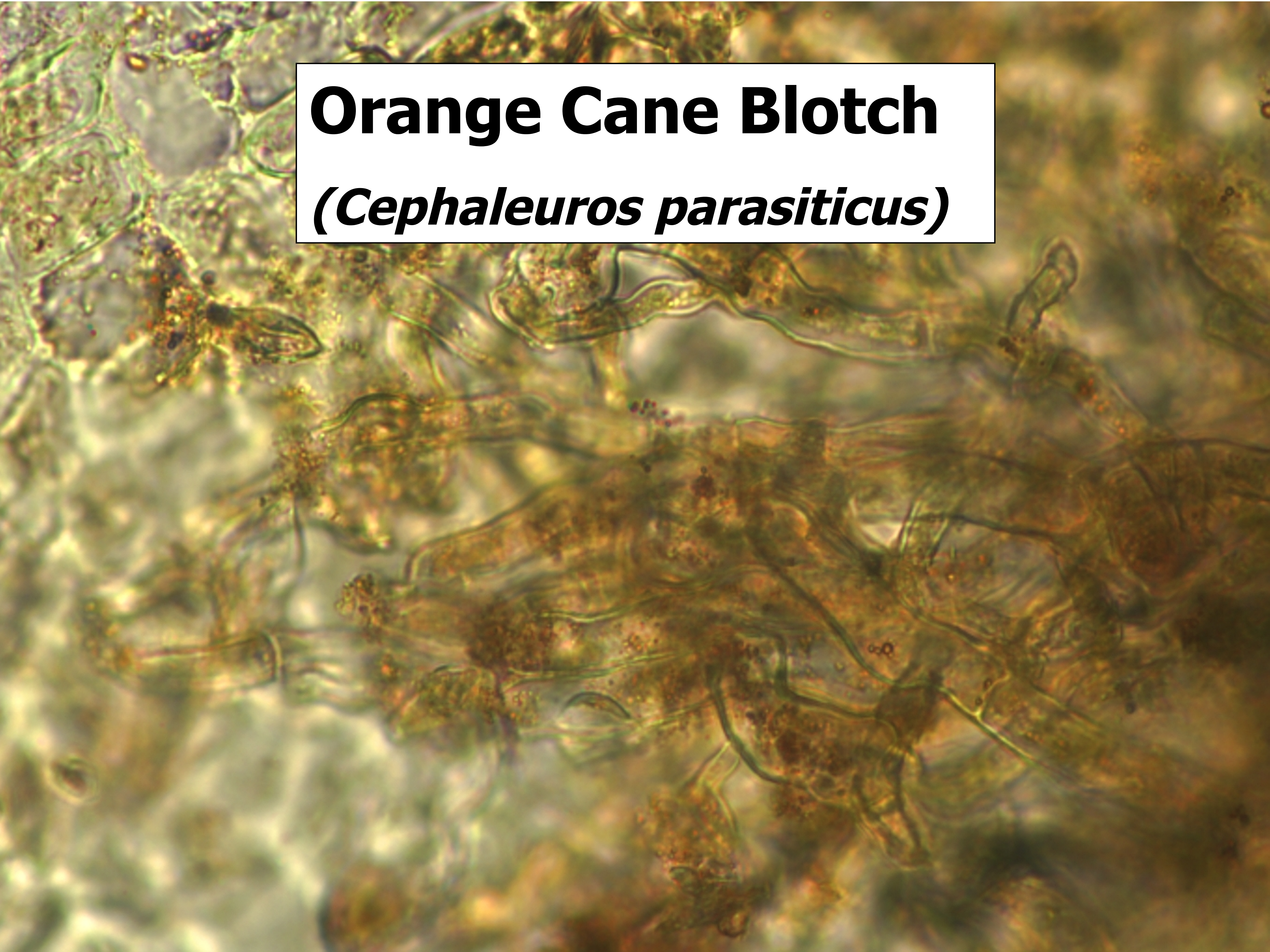

Perithecia on the surface of
blackberry lesion

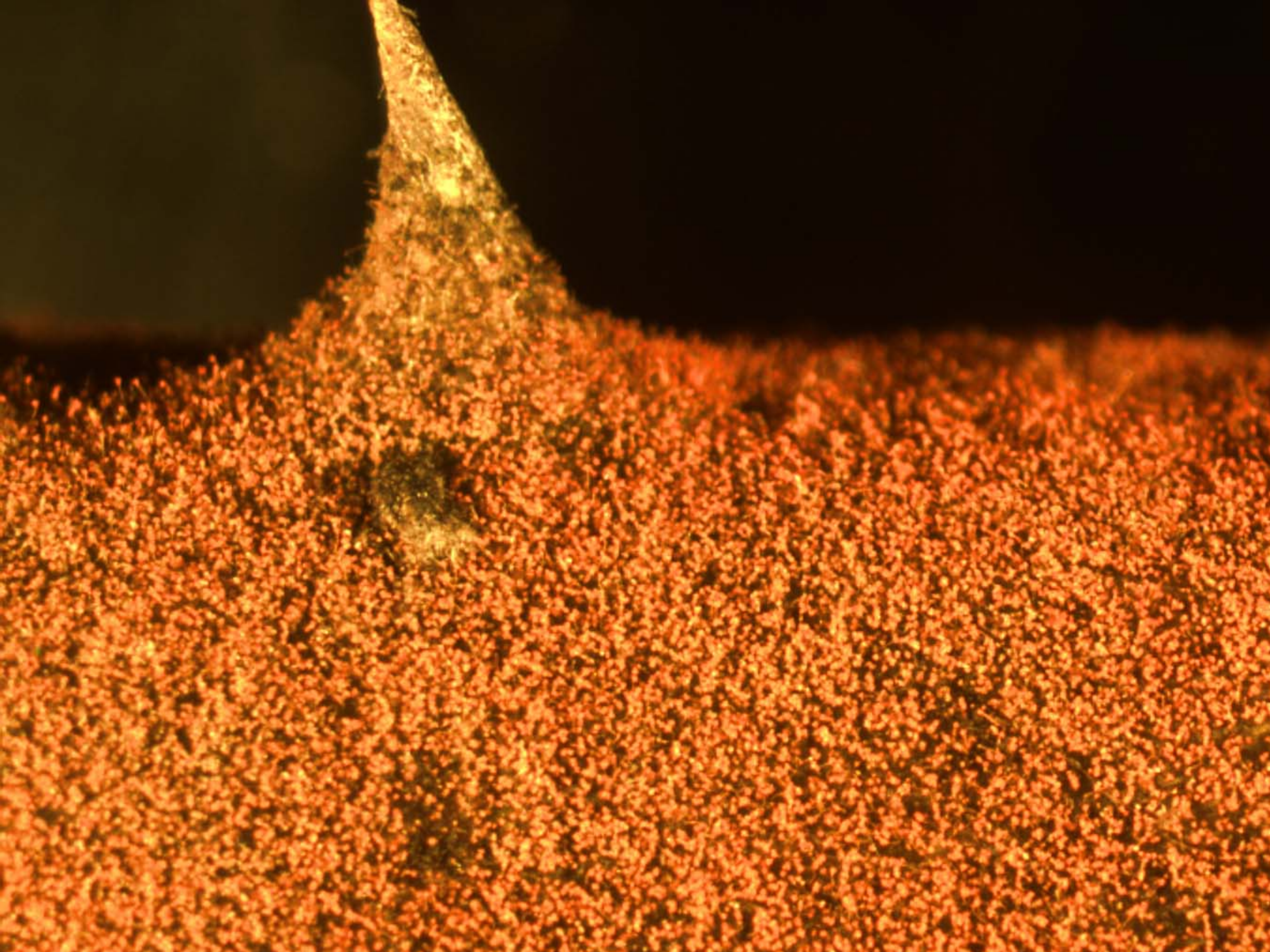

Perithecium of *B. dothidea*


Individual
ascospores in asci


Orange Cane Blotch
DDDI Image (Rome Ethridge)


DDDI Image (Rome Ethridge)


Orange Cane Blotch
(Cephaleuros parasiticus)



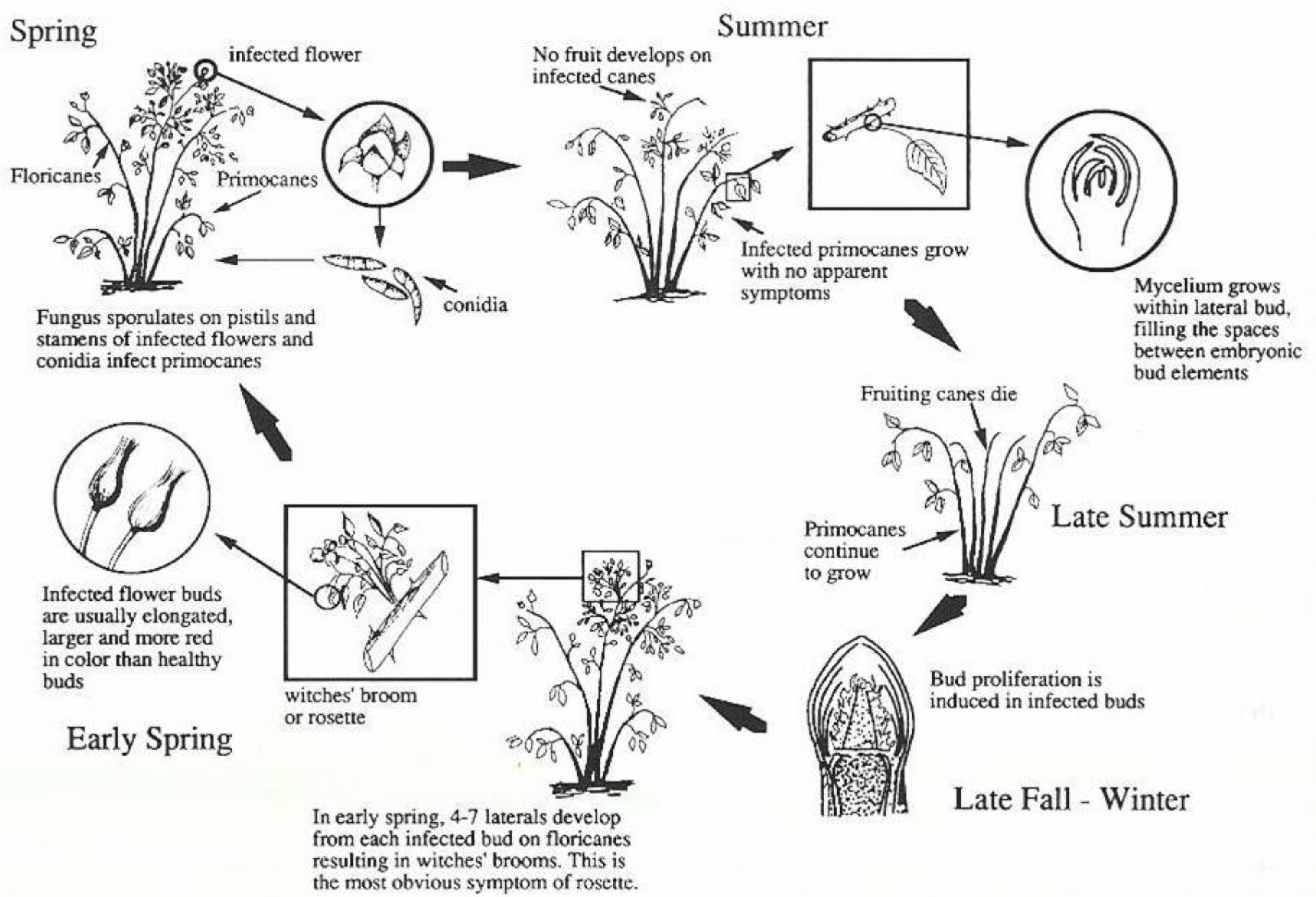


Fig. 10. Disease cycle of rosette, or double blossom. (Drawing by Cindy Gray)

Double Blossom Control Measures

- Plant resistant cultivars (Navaho and Arapaho are examples – thornless).
- Eradicate wild blackberries in the vicinity.
- Prune out rosetted stems (side stems) in the early spring before buds open.
- Apply fungicides.

Fungicides for Double Blossom

- Apply to prevent spread from infected flowers to the primocanes. Most rosette infection occurs during bloom.
- Start the program when the first double blossom is observed. Requires scouting. Continue through entire bloom period.
- Benomyl (Benlate) was the major fungicide utilized for control.
- Control shows up the following spring.

Fungicides for Double Blossom

- **Abound is registered for control of this disease, and it does have good to excellent activity.**
- **Pristine does not have double blossom on the label, but it also has good to excellent activity.**
- **Switch is also effective.**
- **Cabrio and other fungicides may have some impact, but sufficient data is not available for recommendations at this time.**

Fungicides for Control of Rosette

Treatment and rate/A	Rosette incidence (%)	Rosette severity (%)
Untreated	100	52
Benlate 12 fl.oz.	89	22
Pristine 1.45 lb	45	2
Abound 0.9 fl.oz.	34	1
Abound 1.5 fl.oz.	5	0.1

Buckley and Waters; 2002

Resistant Cultivars

Cultivar and breeding selection	Rosette incidence (%)	Rosette severity (%)
Shawnee	100	52
Kiowa	100	19
Chickasaw	99	24
Apache	0	0
Navaho	0	0

Buckley and Waters; 2002

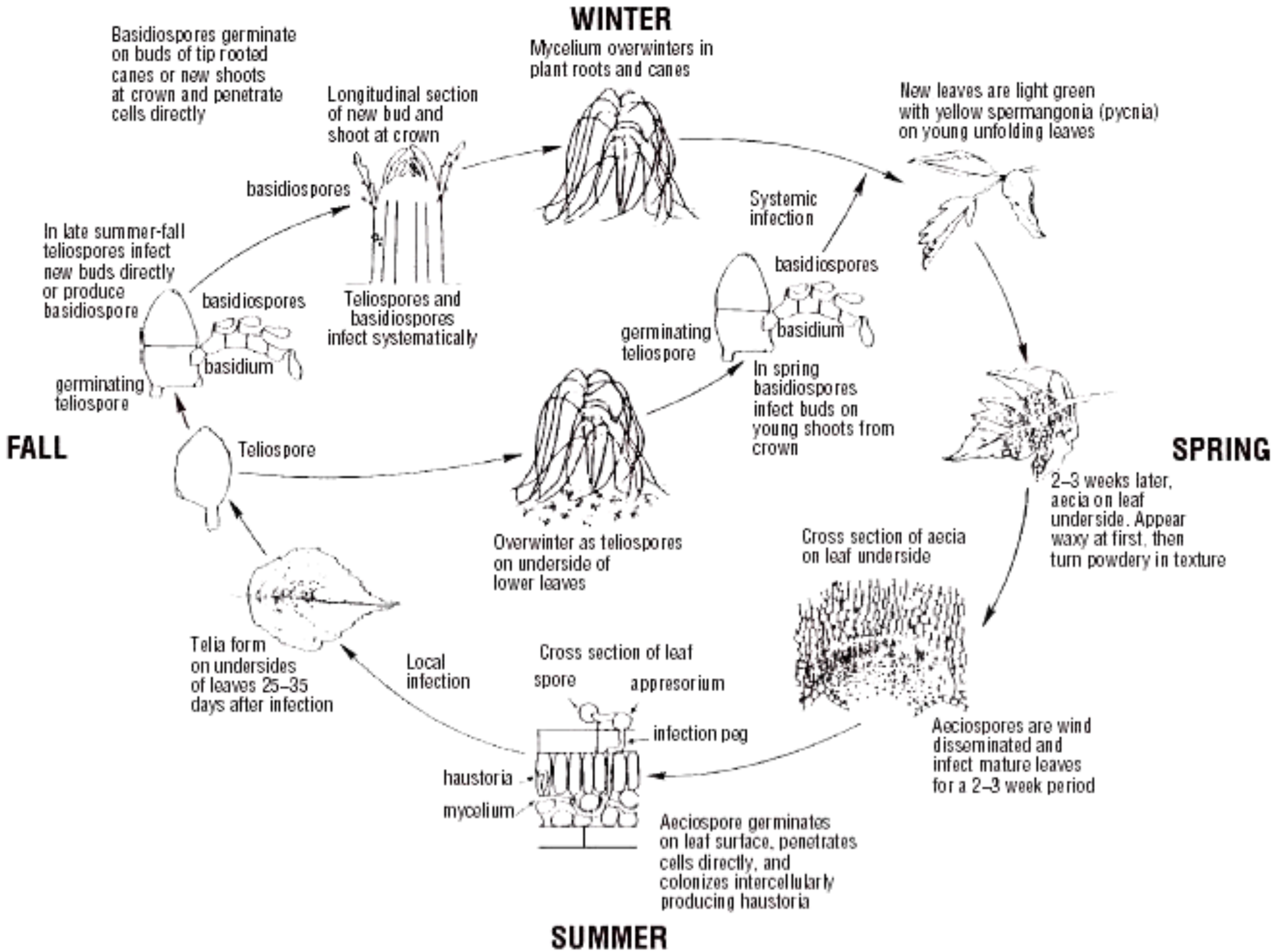
Blackberry Resistance to Double Blossom (Rosette)

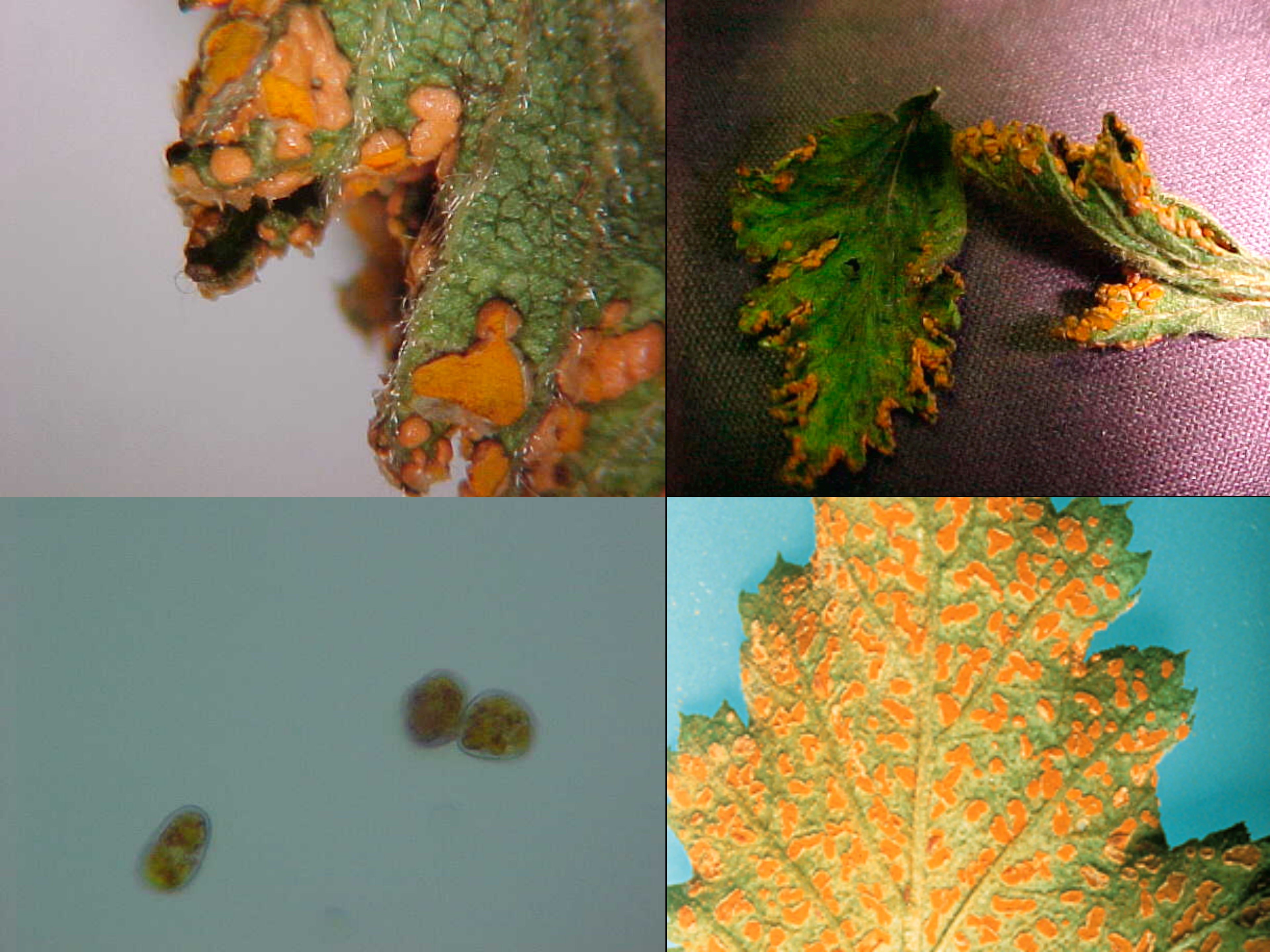
Highly Susceptible	Susceptible	High Resistance
Chickasaw (thorned)	Kiowa (thorned)	Navaho (thornless)
Shawnee (thorned)	Arapaho ??? (thornless)	Apache (thornless)
Black Satin	Rosborough (thorned)	Humble
Choctaw (thorned)	Hull (thornless)	
	Chester (thornless)	
	Loch Ness	

Orange Rust

(*Arthuriomyces peckianus* and *Gymnoconia nitens*)

- **Can be a major problem in blackberry (erect and trailing types).**
- **Navaho, Darrow, Humble and, Purple and Black raspberry are very susceptible.**


WINTER
Mycelium overwinters in plant roots and canes
Basidiospores germinate on buds of tip rooted canes or new shoots at crown and penetrate cells directly
Longitudinal section of new bud and shoot at crown
basidiospores
Teliospores and basidiospores infect systematically
New leaves are light green with yellow spermangonia (pycnia) on young unfolding leaves
Systemic infection
basidiospores
basidium
germinating teliospore
In spring basidiospores infect buds on young shoots from crown
In late summer-fall teliospores infect new buds directly or produce basidiospore
basidiospores
basidium
germinating teliospore
FALL
Teliospore
SPRING
2–3 weeks later, aecia on leaf underside. Appear waxy at first, then turn powdery in texture
Overwinter as teliospores on underside of lower leaves
Cross section of aecia on leaf underside
Aeciospores are wind disseminated and infect mature leaves for a 2–3 week period
Telia form on undersides of leaves 25–35 days after infection
Local infection
Cross section of leaf
spore
appresorium
infection peg
haustoria
mycelium
Aeciospore germinates on leaf surface, penetrates cells directly, and colonizes intercellularly producing haustoria
SUMMER



Leaf and Cane Rust (*Kuehneola uredinis*)

- **Blackberry problem – rust pustules on canes in spring – canes are rendered unproductive.**
- **Shawnee, Choctaw and some older cultivars are susceptible.**

Nova, Pristine and Cabrio

- Applications should be initiated as early as bud break and should continue on a 10-14 day interval, depending on disease pressure and diseases to be controlled.
- Applications may be made up to the day of harvest on most materials.
- Observe resistance management restrictions and total number of applications.

Botrytis Gray Mold
(*Botrytis cinerea*)

- **Blackberry and Raspberry problem**
  - **Blackberry stamen blight causes incomplete/distorted or dried up berries**
  - **Raspberry bloom and fruit rot problem**
- **Cultural – Prune for open growth**

Late-Season/Post-Harvest Rots

Treatments	% Botrytis Fruit Rot (6 DAH)	% Botrytis Fruit Rot (9 DAH)
UTC	64.7 a	100.0 a
Switch	0 b	60.7 d
Pristine	0 b	69.8 c
Elevate	0 b	79.7 bc
Rovral	0 b	81.5 bc
CaptEvate	0 b	89.5 ab

Ross, Krewer, and Brannen; 2006

Preharvest applications are very helpful. Are residues an issue?

Harvest on 1 Sept and 15 Sept

		% Infected Berries*			
		First harvest (14 days in incubation)		Second harvest (8 days in incubation)	
Treatment and Rate (lb ai/A)	Time of Application**	*Botrytis*	*Rhizopus*	*Botrytis*	*Rhizopus*
Elevate 50 WDG 0.50 lb	A, B, C, D, E	5.7 b	18.2 c	13.5 a	17.7 bc
Elevate 50 WDG 0.50 lb	A, C, E				
Captan 50 WP 2 lb	B				
Rovral 50 WG 1 lb	D	3.1 ab	17.2 bc	19.8 ab	22.4 c
Switch 62.5 WG 0.547 lb	A, B, C, D, E	0.0 a	1.0 a	14.1 a	13.0 ab
Switch 62.5 WG 0.547 lb	A, C, E				
Captan 50 WP 2 lb	B				
Rovral 50 WG 1 lb	D	0.0 a	3.1 ab	16.1 ab	10.9 ab
Captan 50 WP 2 lb	A, C, D				
Rovral 50 WG 1 lb	B, E	18.8 c	1.6 a	26.0 bc	10.9 ab
Untreated Check	None	29.2 d	38.5 d	34.9 c	9.9 a

* Means followed by the same letter within a column do not differ significantly, based on Fisher's protected LSD, ($P \leq 0.05$); no letter indicates a non-significant ANOVA.

** Application dates: A = 26 June (5-10% bloom), B = 9 July (50% bloom), C = 19 July (100% bloom), D = 16 August (green-red fruit), E = 1 September (ripe fruit, 0-day phi).

J. DeFrancesco and G. Koskela; 1999

Harvest 30 June

Treatment and rate/A	Time of application [x]	Post harvest rot (%) [z] Botrytis cinerea	All fungi
Elevate 50 WDG 1.5 lb	A, B, C, D, E, G	1.0 a[y]	73.5 b
Elevate 50 WDG 1.0 lb + Captan 80 WDG 2.35 lb	A, B, C, D, E, G	1.0 a	51.5 a
Captevate 68 WDG 3.5 lb	A, B, C, D, E, G	3.5 a	51.0 a
Scala 60 SC 18 fl oz	A, B, C, D, E, F	9.0 b	69.0 b
Untreated Check	None	48.5 c	93.5 c

[z] Fruit rot after five days in incubation.

[y] Means followed by the same letter within a column do not differ significantly, based on Fisher's protected LSD (P≤0.05).

[x] Application dates: A = 3 May (5% bloom), B = 13 May (50% bloom), C = 24 May (10% bloom + 90% small green fruit), D = 2 Jun (green fruit), E = 15 Jun (red and green fruit), F = 29 Jun (ripe fruit), G = 30 Jun (ripe fruit).

J. DeFrancesco and G. Koskela; 2004

Septoria Leaf and Cane Spot

J.W. Pscheidt, OSU

Treatment, product rate/A	Time of Application[z]	Incidence [y] (%)	Severity [x]
Tanos, 10 oz	A, B, C	65.0 c[w]	5.0 bc[w]
Tanos, 10 oz + Kocide 3000, 12 oz	A, B, C	60.0 c	3.25 ab
Abound, 10.8 fl oz	A		
Kocide 3000, 12 oz	B		
Pristine, 20.75 oz	C	21.25 ab	1.5 a
Tanos, 10oz	A		
Kocide 3000, 12 oz	B		
Pristine, 20.75 oz	C	8.75 a	1.5 a
Aim 40EW, 6.4 fl oz	A, B		
Pristine, 20.75 oz	C	35.0 b	2.0 a
Untreated check	Not applicable	92.5 d	5.75 c

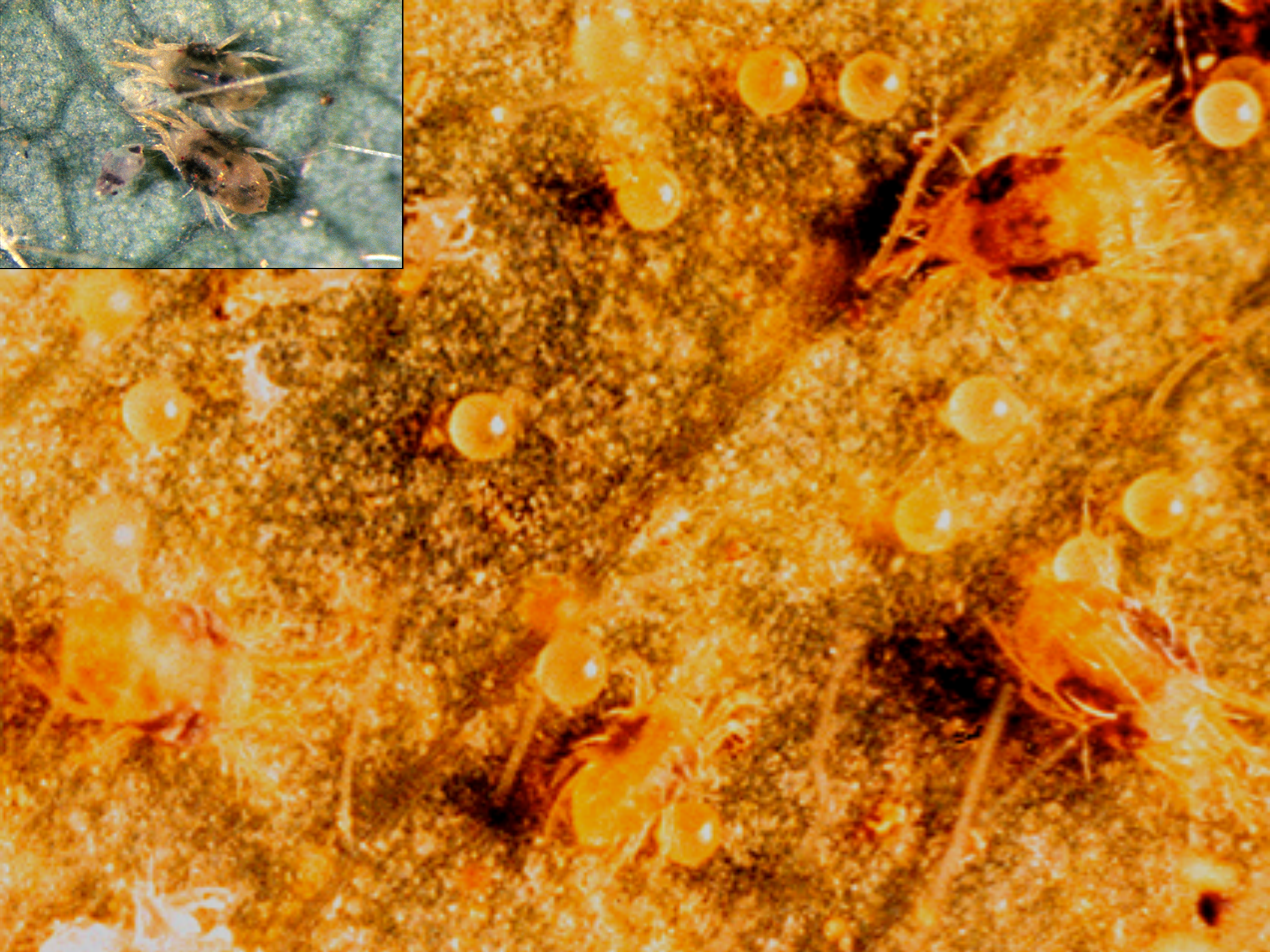
[z] Application dates: A = 19 Apr, B = 30 Apr, C = 17 May

[y] Incidence: percentage of primocanes with leaves showing disease symptoms

[x] Severity rated on a scale of 0-10 where 1= 10% leaf area affected, 10 = 100% leaf area affected

[w] Means within a column followed by the same letter do not differ significantly based on Fisher's protected LSD ($P \leq 0.05$)

J. DeFrancesco and D. Kaufman; 2007



Insect Management in Caneberries

Caneberry Insects

Growth habits of caneberries:

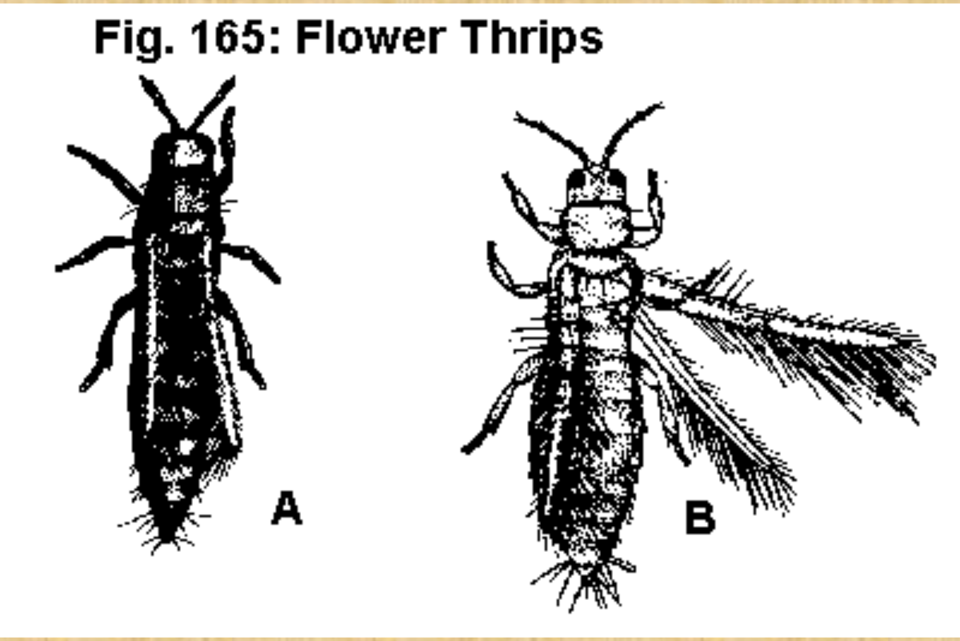
Conventional

- Primocane
- Floricane

Primocane-bearing

Flower/Berry Feeders

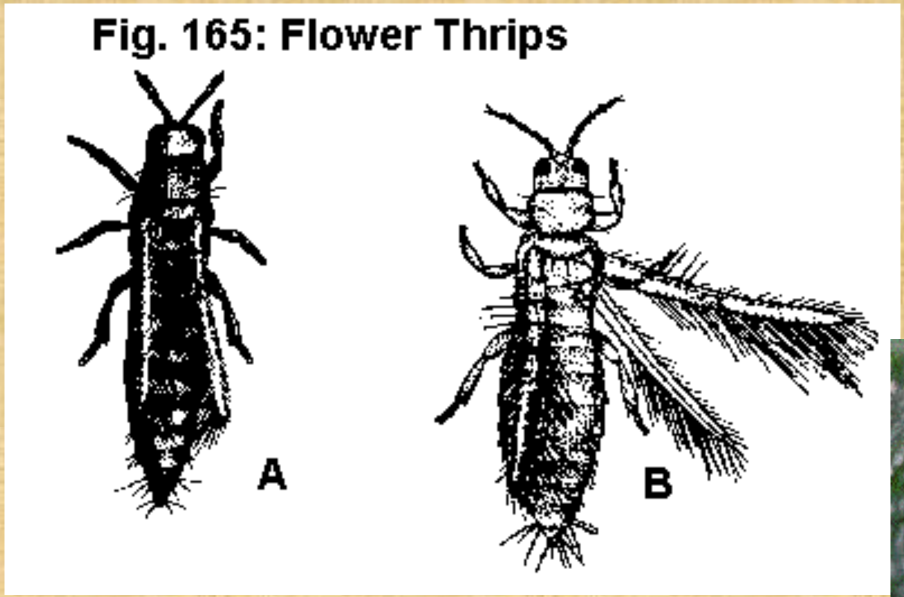
Thrips

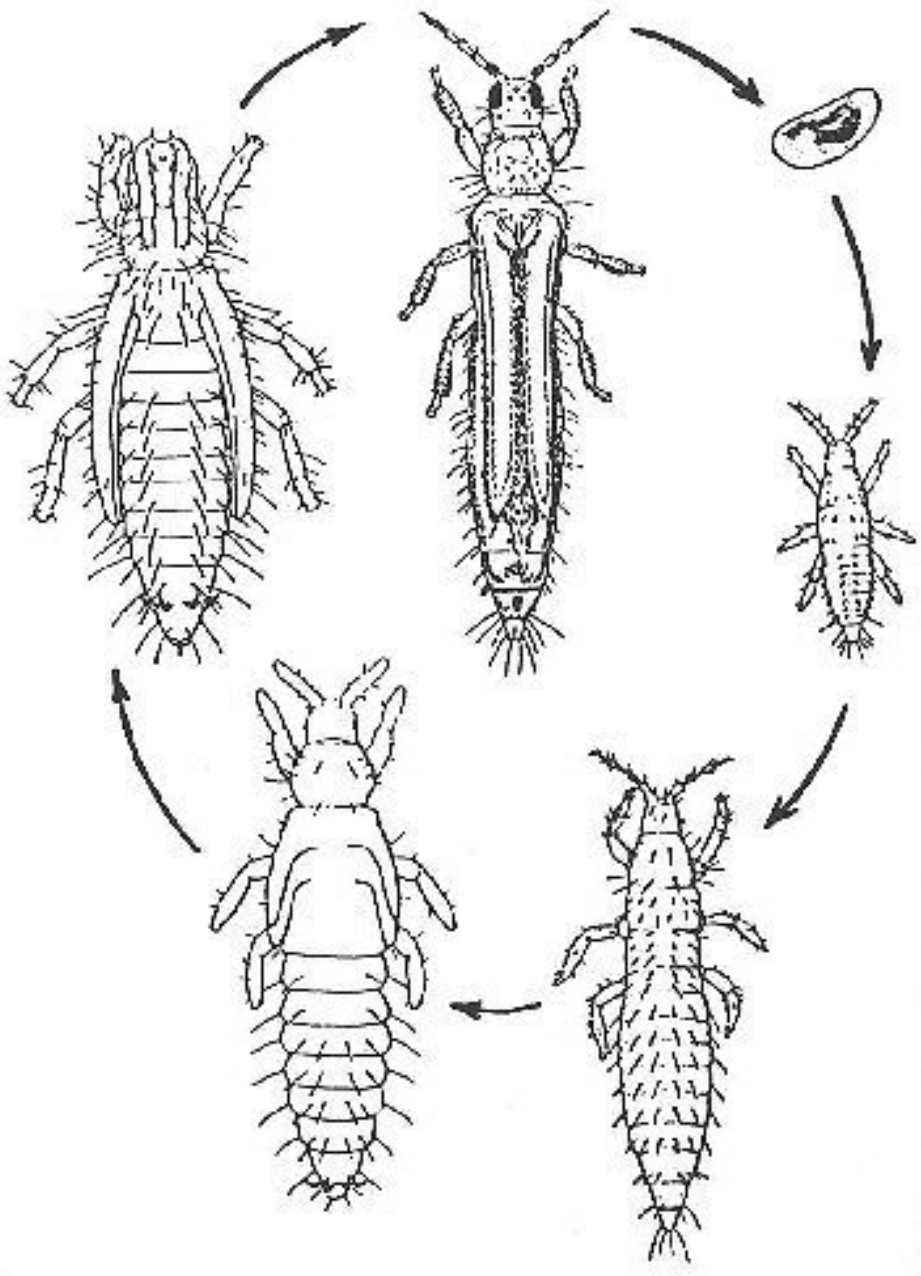


- **B. Pests Causing Direct Injury to Caneberries**

Western Flower Thrips, *Frankliniella occidentalis*

Feeding injury?
Virus transmission?





Thrips Life Cycle

NCSU

Impact of Thrips

- Drupelet effects
- Consumer effects
- Role as virus vectors?

Insecticides for Thrips

• Aza-Direct	12.5-42 fl oz	0 d PHI
• Assail 30SG	4.5-5.3 oz	1 d PHI
• Malathion 8F	2 lb	1 d PHI
• Entrust 80WP	1.25-2 oz	1 d PHI
• Admire Pro	7-14 fl oz	7 d PHI
• Delegate 25WG	3-6 oz	1 d PHI

- Just before blossoms open, and when new canes are 1.5-2 feet long (Admire Pro soil-applied)

- **B. Pests Causing Direct Injury to Caneberries**
  - 1. Japanese beetle, *Popillia japonica* Newman

Japanese Beetle

- Berry feeder
- Timing makes control difficult
- May need to spray late prebloom
- Lower populations in years following drought

Primocane versus floricane: Effects on IPM?

Protracted bloom/fruit period
Later bloom/fruit period

Insecticides for JB

• Sevin 80S	2 lb	7 d PHI
• Sevin XLR	2 qt	
• Aza-Direct	12.5-42 fl oz	0 d PHI
• Assail 30SG	4.5-5.3 oz	1 d PHI
• Actara 25WG	3 oz	3 d PHI
• Surround 95WP	12.5-50 lb	0 d PHI

- Kaolin
- Organic
- Visible residues

Bramble Planting at Kentland Farm

- 11 varieties of raspberries
  - Fall Gold, Heritage, Dinkum, Autumn Bliss, Prelude, Caroline, Himbo Top, Anne, Nova, Autumn Britten and Josephine
- 2 varieties of blackberries
  - Prim Jim and Prim Jan
- All primocane-bearing varieties

Effects of five chemical treatments and an untreated control on numbers of Japanese beetles per 2 m of row in a raspberry planting at Kentland Farm (Montgomery County Virginia) - 2007.

Trt	26 Jun	29 Jun	2 Jul	5 Jul	9 Jul	12 Jul	17 Jul	20 Jul	Year Total
Alverde	0.0b	1.0b	6.6a	16.3a	10.5ab	10.5ab	9.1b	11.6 a	67.3a
Battalion	0.1b	0.1b	6.4a	1.6b	4.3bc	2.5c	7.0b	2.5b	**25.0 b**
Lime-Alum	0.0b	0.1b	0.3b	0.4b	1.6c	0.4c	6.5b	1.3b	**11.8 b**
Aza-Direct	0.6a	2.1b	8.8a	16.9a	9.5ab	8.1b	9.6b	5.9ab	62.8 a
Honey-Milk	0.9a	5.4a	11.9a	21.6a	16.3a	13.8ab	12.9b	7.1a	92.8 a
Control	0.0b	1.8b	5.0ab	12.8a	14.3a	17.0a	23.8a	9.3 a	86.9 a

Means in a column followed by the same letter are not significantly different, α=0.05 (ANOVA and Fisher's protected LSD test were performed on square root transformed means).

Table 2. Differences among eight primocane-bearing raspberry cultivars in numbers of Japanese beetles per 2 m of row at Kentland Farm (Montgomery County Virginia).

Variety	5 Jul	9 Jul	17 Jul	20 Jul	Year Total
Anne	12.0ab	5.8b	10.3ab	4.2b	50.5bc
Autumn Bliss	5.7b	11.8a	13.5a	8.5b	56.3bc
Caroline	9.8ab	7.2b	4.2b	1.5b	40.2c
Dinkum	5.0b	6.7b	7.8b	2.7b	37.2c
Fall Gold	22.8a	13.2a	15.7a	4.0b	80.2b
Heritage	6.8b	4.3b	10.2b	2.3b	38.2c
Himbo Top	3.3b	4.8b	8.8b	5.5b	34.5c
Prelude	27.2a	21.3a	21.3a	21.5a	124.8a

Means in a column followed by the same letter are not significantly different, α=0.05 (ANOVA and Fisher's protected LSD test were performed on square root transformed means).

Average number of Japanese beetles per 1.2m of raspberries following insecticidal treatment - 2009

Trt	8-Jul	15-Jul	22-Jul	5-Aug	Total
Assail	29 a	18 a	48 a	14 a	109 a
MGK	13.5 ab	15 a	16 b	10.5 a	55 b
Control	14.5 ab	10.5 a	13 b	6 a	44 b
Battalion	11.5 ab	3.5 a	14 b	2.5 a	31.5 b
Neemix/ Trilogy	3 b	6.5 a	11 b	9.5 a	30 b
Altacor	3 b	5.5 a	11 b	6.5 a	26 b

Percent living Japanese beetles after 6, 18, 24, and 48 hours - 2009

Treatment	% alive 6 hrs	% alive 18 hrs	% alive 24 hrs	% alive 48 hrs
Control	100 a	100 a	100 a	100 a
Neemix/Trilogy	100 a	100 a	96 a	96 a
Requiem	96 a	96 a	92 a	88 a
Altacor	96 a	88 ab	88 a	80 a
MGK	92 a	88 ab	84 a	76 a
Battalion	84 ab	64 bc	52 b	44 b
Assail	64 b	52 c	36 b	32 b

Percent Defoliation from Japanese Beetle on Raspberry - 2009

Treatment	% damage
Control	10.0 a
MGK	5.3 ab
Requiem	4.7 b
Battalion	3.8 b
Assail	2.2 b
Altacor	2.0 b
Neemix/Trilogy	1.4 b

Table 3. Effects of five chemical treatments and an untreated control on numbers of Japanese beetles per 2 m of row in a blackberry planting at

Kentland Farm (Montgomery County Virginia).

Treatment	29 June	5 July	12 July	Year Total
Agricure	0.0c	7.3ab	7.0ab	44.8ab
Battalion	0.0c	2.3c	2.5b	15.3c
Capture	0.3bc	3.8bc	2.0b	28.0bc
Hot Pepper Wax	2.5ab	8.3ab	12.3a	54.5ab
Proud	3.8a	12.0a	8.5ab	46.8ab
Control	3.0ab	8.3ab	17.3a	59.0a

Means in a column followed by the same letter are not significantly different, $\alpha=0.10$ (ANOVA and Fisher's protected LSD test were performed on square root transformed means)

Tarnished Plant Bug

- Prevent flowering weeds
- But do not mow flowering weeds while bramble fruit or blossoms are present

Tarnished Plant Bug

- Adults overwinter in weedy areas, legumes like alfalfa.
- 3-4 generations per year in mid-Atlantic area

Tarnished Plant Bug

- Kills individual drupelets, small fruit
- Treat when 1 TPB in every two flower clusters
- Prevent flowering weeds
- But do not mow flowering weeds while bramble fruit or blossoms are present

Stink Bugs (Hemiptera: Pentatomidae)

Brown Stink Bug

- *Euschistus servus* (Say)

Dusky Stink Bug

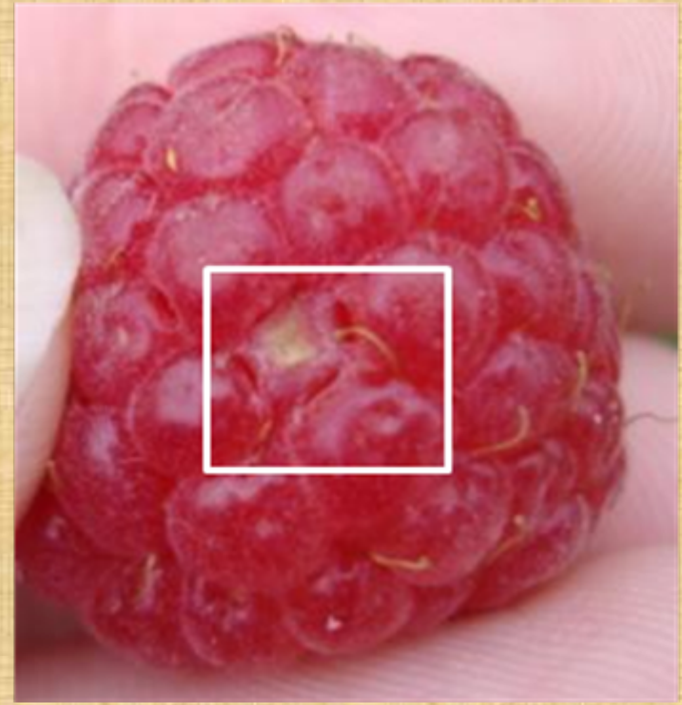
- *Euschistus tristigmus* (Say)
- In most respects, similar to brown
- Secondary in importance

Green Stink Bug

- *Acrosternum hilare* (Say)

Stink Bug Injury

- Injury to berries



Insertion of stylets -

TPB and Stink Bugs

- Azinphosmethyl gone
- Sevin XLR 2 qt
- Brigade 10WSB 8-16 oz
- Sniper 2 3.2-6.4 fl oz
- Assail 30SG 4.5-5.3 oz

New kid on the block:
brown marmorated stink bug

Brown marmorated stink bug, *Halyomorpha halys*

- From China
- Introduced to Allentown PA 1996
- Low numbers in Virginia 2004
- In 2010 high impact in VA



Brown marmorated stink bug, *Halyomorpha halys*

- Impact in caneberries?
- Catoctin Mt. meeting
- 50% loss of berries reported by a Virginia grower



Brown marmorated stink bug, Problems with control:

- Efficacy
- Recovery
- Continued immigration
- Induction of secondary pests



Borers

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
  - Rednecked cane borer *Agrilus ruficollis* (F.) (Buprestidae)
  - Raspberry cane borer *Oberea bimaculata* (Olivier) (Cerambycidae)

Wash. St. Univ.

Col. St. Univ.

Raspberry Crown Borer

- **Adult is a moth that mimics yellowjackets**

OSU photo

Raspberry Crown Borer

- **Eggs are laid on the undersides of new leaves, with 2-3 eggs per plant.**
- **Eggs incubate 3-10 weeks, beginning to hatch in late July (about the first week of September and continuing until early November in the northern part of its range (Canada))**

WSU photo

Raspberry Crown Borer

- The young larva spins down to the crown, where it overwinters in a hibernaculum.
- In the spring it tunnels into the cambium. Cracks develop at this site, from which reddish brown frass is produced in April.

WSU photo

Raspberry Crown Borer

- In the second summer, the larva ascends into a cane, girdling it a few inches above the soil surface, and causing it to wilt and break.
- One year life cycle in Arkansas. Two-year life cycle in northern part of range (BC, WA, MI.)

WSU photo

Raspberry Crown Borer

- Chemical control: Azinphosmethyl was lost under FQPA (NRDC Consent Decree).
- Sevin XLR (2 qt/A) or malathion 25WP (2 lb/A) may be applied as a foliar spray
- Brigade 10WSB (16 oz) or Sniper 2 (6.4 fl oz) (both bifenthrin) applied in 50 gal/A (Arkansas data; don't need 200 gal/A)
- Cultural control: infested canes and crowns should be removed and destroyed.
- Eliminating nearby wild brambles also reduces infestations.

Rednecked Cane Borer

- A buprestid beetle, dark gray with coppery pronotum
- Adults are about 6-7 mm (1/4 inch) long

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
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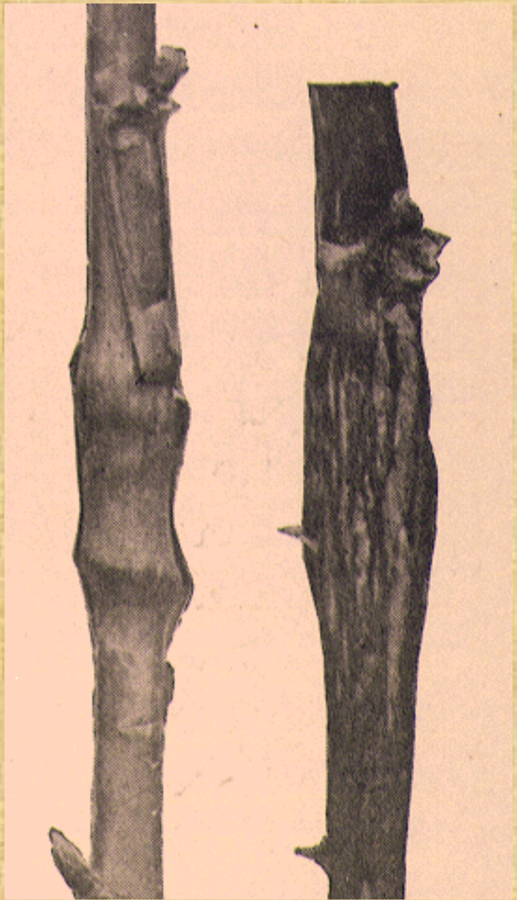

Rednecked Cane Borer

- Adults are present from May to August, or late April to early June, depending on the region.
- Females lay white spherical eggs on the trunk.
- Larvae exit the egg directly into the plant, never becoming exposed, and so are impervious to sprays.

Rednecked Cane Borer

- Young larvae are restricted to the cambium, circling the cane 3-4 times in a close spiral, girdling the primocane, and producing gall-like swellings.

UGA photos

Rednecked Cane Borer

- Larvae reach a length of 12 mm, and have a pair of horn-like projections on the posterior end. The larvae are white and legless, with a flattened head (the family is often called flatheadeded borers).
- Larvae winter in the cane, and in March create a pupal chamber. The pupa is formed in late April. The pupal period lasts 20-40 days.

Rednecked Cane Borer

- When the adult leaves the pupal skin, it remains in the tunnel for about 10 days before chewing a D-shaped emergence hole.
- Adults feed on foliage for several days before beginning oviposition.

Rednecked Cane Borer

- Chemical control: After leaf fall, if more than 10% of the primocanes are infested, or if the number of primocanes expected to be pruned off is exceeded, a spray in justified.
- Examine primocanes for adults twice weekly, beginning at the beginning of bloom. Damage is minimized when malathion, Brigade are applied twice at intervals of 7-12 days from the time the first beetles appear (early to mid May).
- Wild host removal helpful in itself, also makes chemical control more effective.

Rednecked Cane Borer

- Cultural control: Remove galled canes in dormant season or early spring.
- This is most effective if nearby wild hosts are eliminated, and also more effective in open settings (wild brambles in nearby woods provide a source of wild beetles).

Raspberry Cane Borer

- Adult is a longhorned beetle, black with orange pronotum, ½ inch long

- **B. Pests Causing Indirect Injury to Caneberries**
  - Raspberry crown borer *Pennisetia marginata* (Harris) (Sesiidae)
  - Rednecked cane borer *Agrilus ruficollis* (F.) (Buprestidae)
  - Raspberry cane borer *Oberea bimaculata* (Olivier) (Cerambycidae)

Raspberry Cane Borer

- Adults appear in June, and are present until late August. After ovipositing, the female girdles 6 mm above and 6 mm below the egg puncture.
- Shoot tips wilt in early summer.



Raspberry Cane Borer

- Chemical control: Just before blossoms open, malathion 8F (1 pt/A) may be applied;
- M-Pede - 2 % solution

- Cultural control: Wilting canes or those with girdling should be destroyed. If pruning occurs within a few days of the onset of wilting, only a small amount of additional shoot need be removed.

Insecticides for aphids

• Malathion 8F	2 pt
• Asana XL	4.8-9.6 fl oz
• Sevin XLR	2 qt
• M-Pede	2% soln
• Assail 30SG	2.5-5.3 oz
• Actara 25WG	2-3 oz
• Admire Pro	7-14 fl oz (soil applied)

Organic tools

- M-Pede
- Azadirachtin products
- Stylet oil
- Dipel
- Entrust
- Surround

Questions?

Arthropod identification & management in southeastern small fruits

Hannah J. Burrack

Dept. of Entomology

North Carolina State University

NC STATE UNIVERSITY

The Basics: Integrated Pest Management

- IPM hierarchically utilizes the tools at hand to manage crop pests
  - Using the least disruptive tools first and only using pesticides when other options have failed to reduce economically threatening damage

The Basics: Integrated Pest Management

Minimize

Monitor

Manage

The Basics: Integrated Pest Management

Crop & variety selection, Site selection, Rotation, planting date, Nutrition, Preventative pesticides, etc. → **Minimize**

Monitor ← Correctly identify damage and responsible pests, Track injury and pests over time, Use appropriate tools

Based on thresholds: → **Manage**

Cultural, Biological, Chemical

The Basics: Integrated Pest Management

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Based on thresholds: → **Manage**

Cultural, Biological, Chemical

The Basics: Arthropod Biology

- How do arthropods damage plants?

The Basics: Arthropod Biology

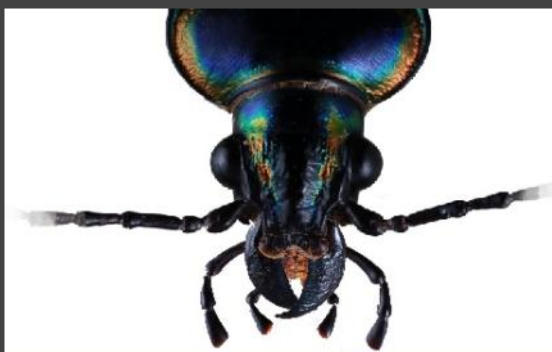
- How do arthropods damage plants?

The Basics: Arthropod Biology

- How do arthropods damage plants?
  - CHEWING
  - SUCKING
  - CONTAMINATION
  - RASPING
  - EGG LAYING
  - VECTORING PLANT DISEASES
- Depending on developmental strategy (hemi- or holometabolis), life stages may differ in feeding behavior & damage potential

The Basics: Arthropod Biology

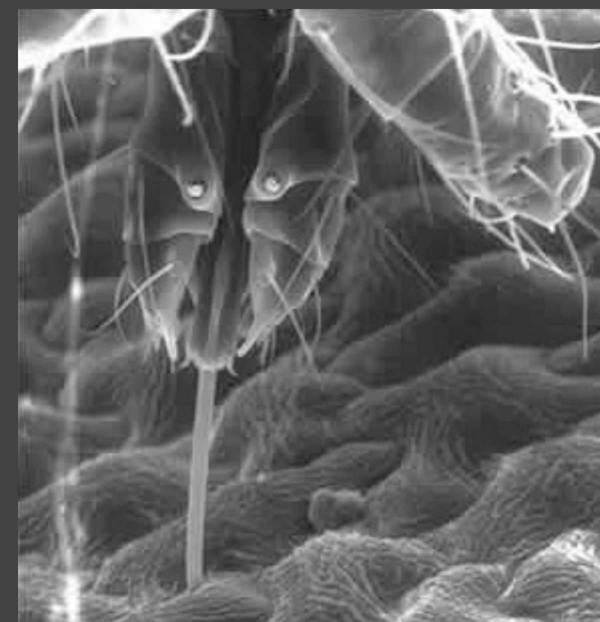
- Insect mouthparts



Beetles, caterpillars, grasshoppers & others have chewing mouthparts

Butterflies and moths have sucking mouthparts but are rarely pests

Flies have lapping, sucking mouthparts but are rarely pests. Their offspring (maggots) may have chewing mouthparts and can be pests.



Spider mites, aphids, leafhoppers, plant bugs, stink bugs, and others have piercing, sucking mouthparts

Photos: J. Meyer, ENT 425

Photo: Washington State Univ.

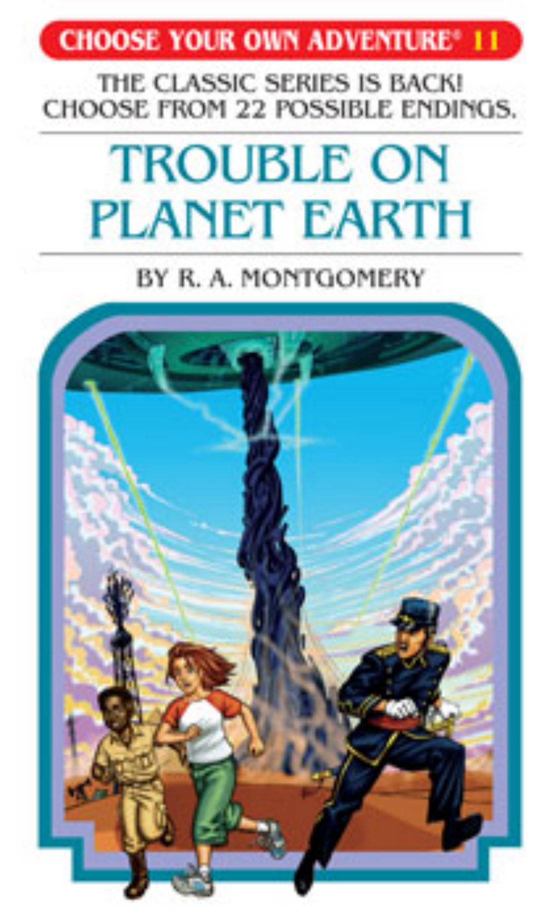
The Basics: Injury Identification

- Determine the type of injury present (chewing, sucking, rasping, vector-borne disease, honeydew)
- Determine age of injury
  - Some injury can be present long after the insect responsible has left (leaf mines, chewing damage, disease)
  - Old injury cannot be cured, management is only justified to prevent additional economic loss

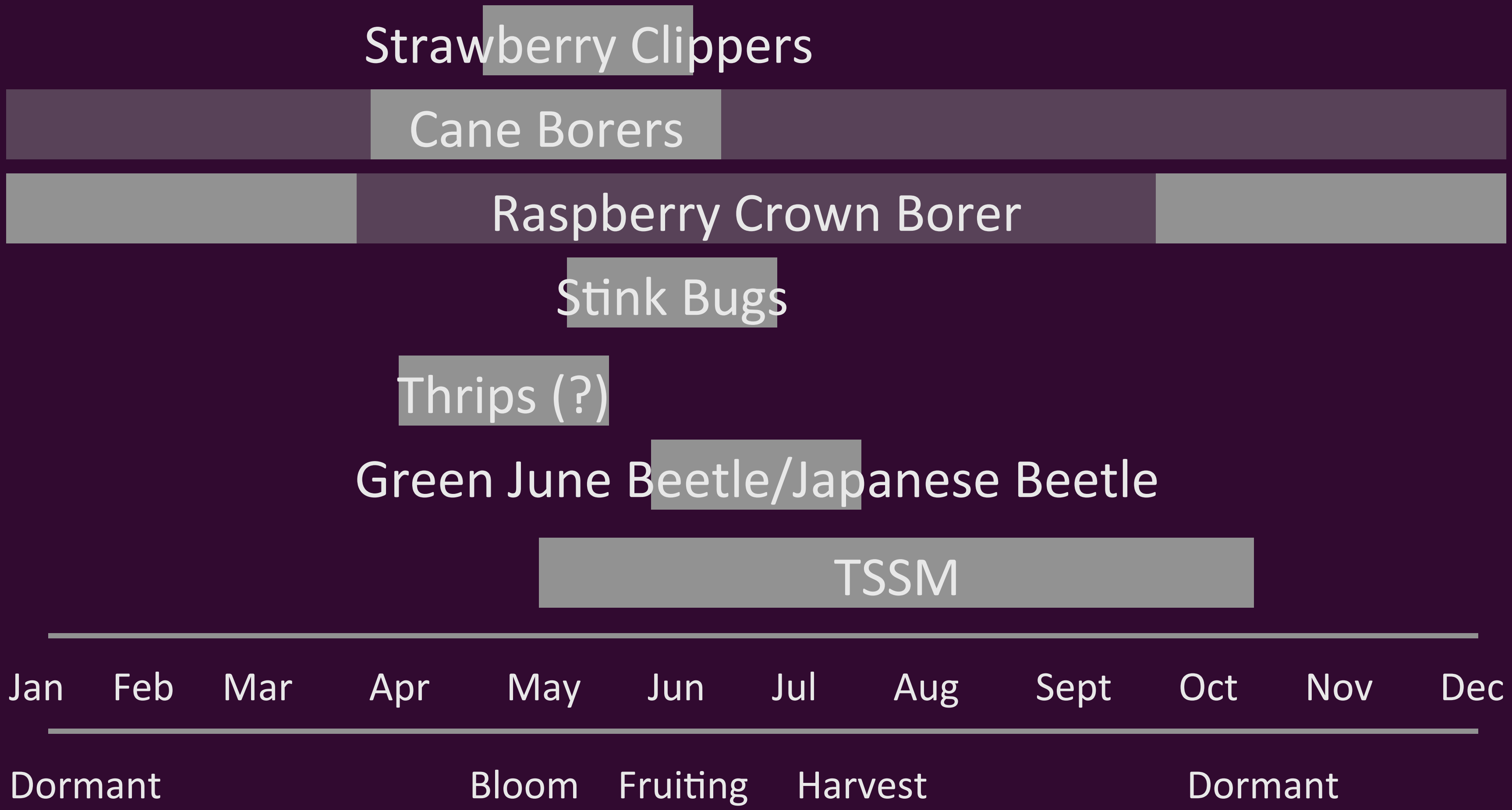
The Basics: Injury Identification

- For new injury, assess whether arthropods present could have caused the injury
  - Assess via direct observation, sweep netting, traps, etc.
  - Management is effective only if the potential culprits are still present in the crop

Key Arthropod Pests of Small Fruits: Choose Your Own Adventure



Caneberries: Key Pests



Strawberries: Key Pests

Aphids

TSSM

Strawberry Clipper

Corn Earworms

Lygus Bugs

Sap Beetles

Thrips

Aphids

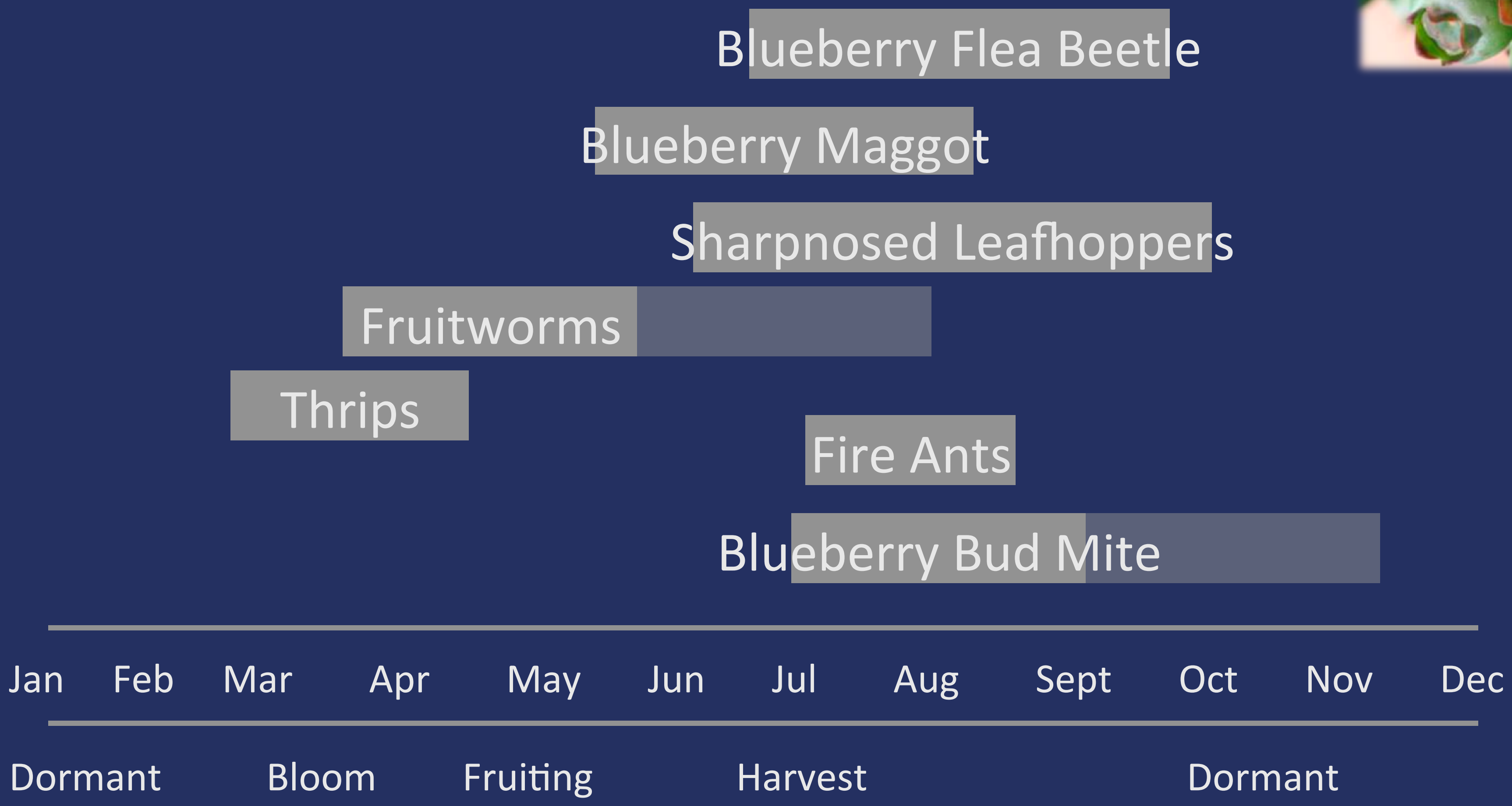
TSSM

Cutworms

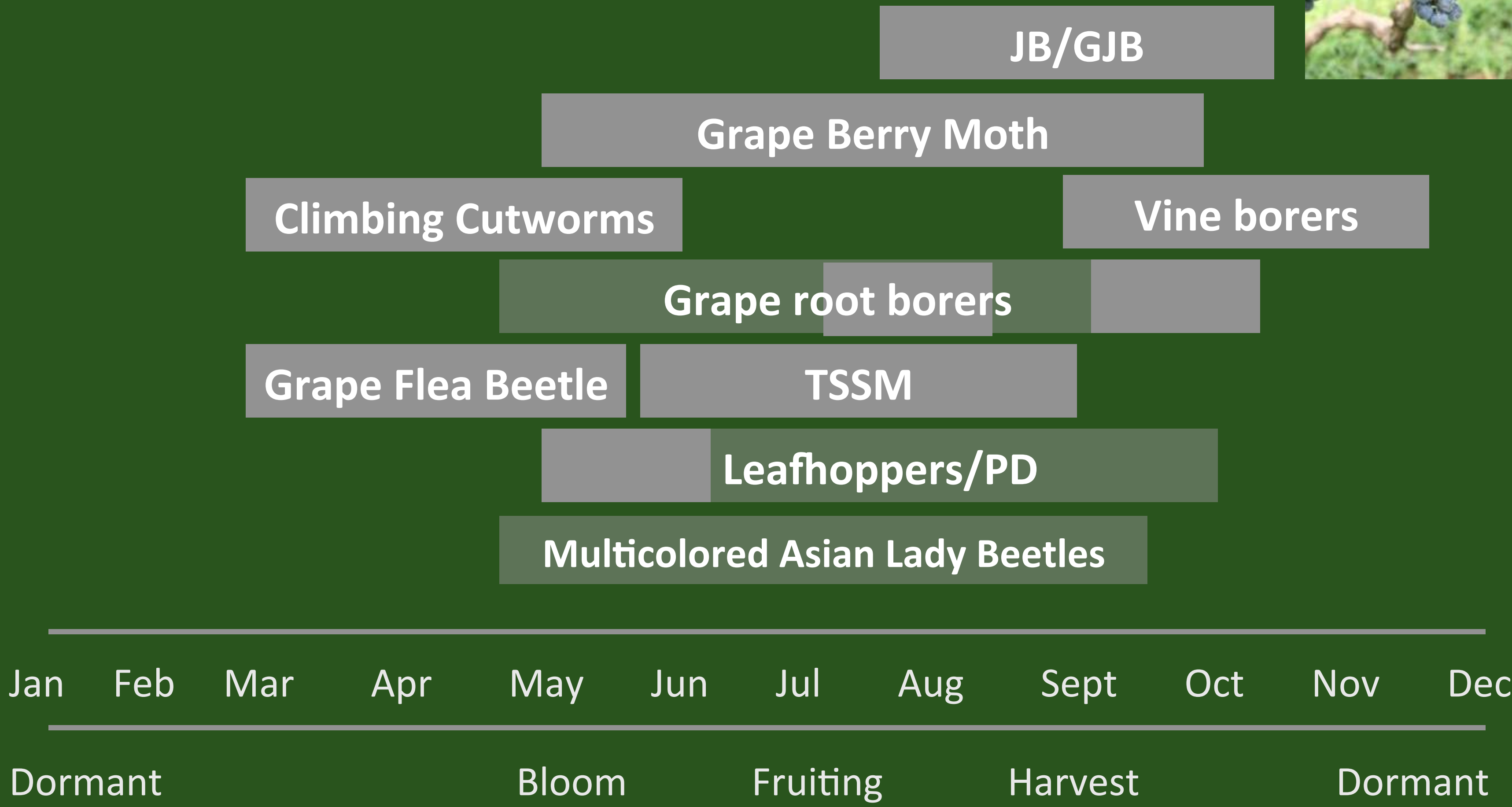
Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec

Dormant Bloom & Fruiting Harvest Transplant

Blueberries: Key Pests



Grapes: Key Pests



Invasives: Key Potential Pests

Blueberries: Blueberry Flea Beetle

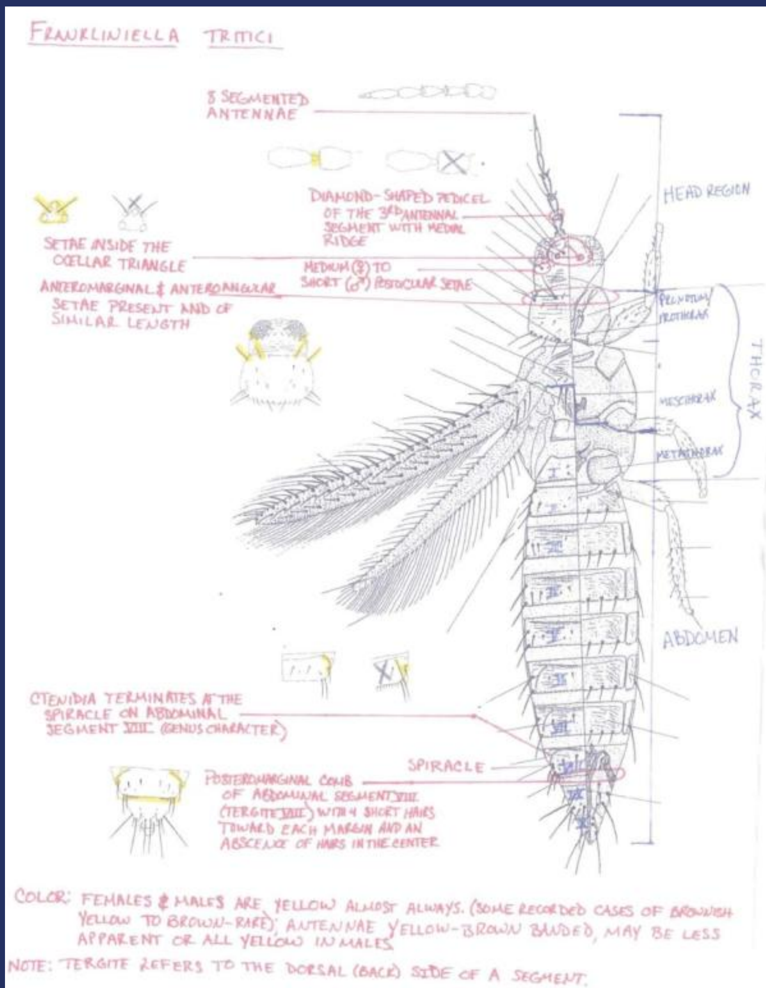
Adult Blueberry Flea Beetle (*Altica sylvia*)
Larvae & adults feed on foliage

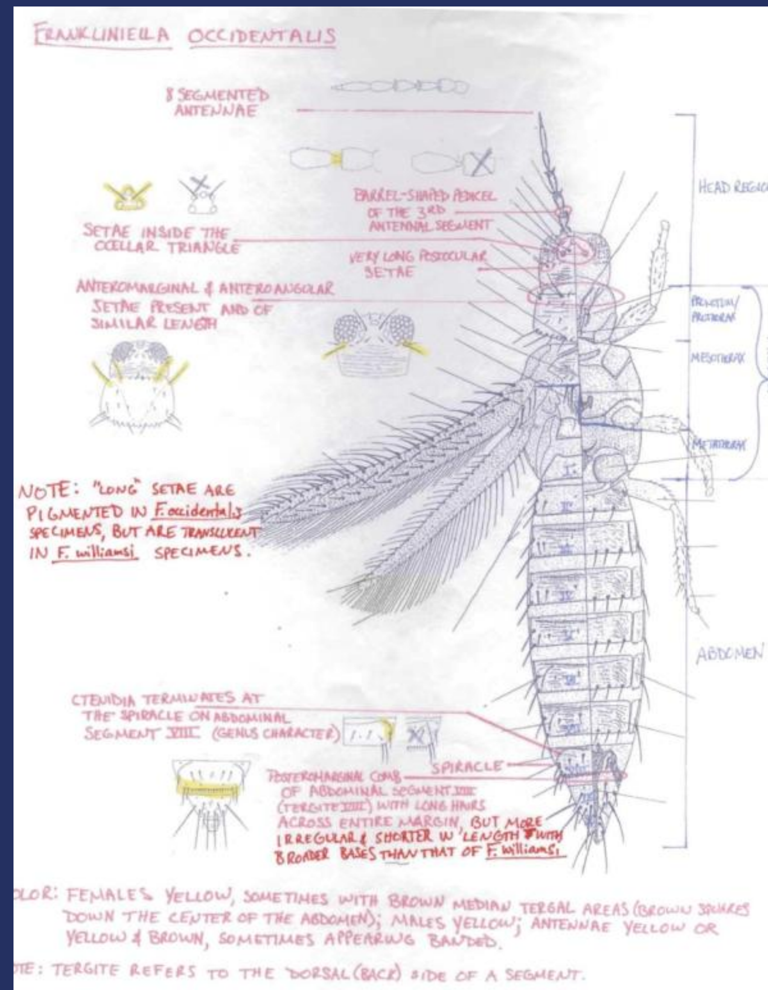
Blueberry Flea Beetle injury (similar to Japanese beetle feeding)

Blueberries: Thrips

- Eastern flower thrips are the most common species in NC & SC blueberries, but western flower thrips are more damaging

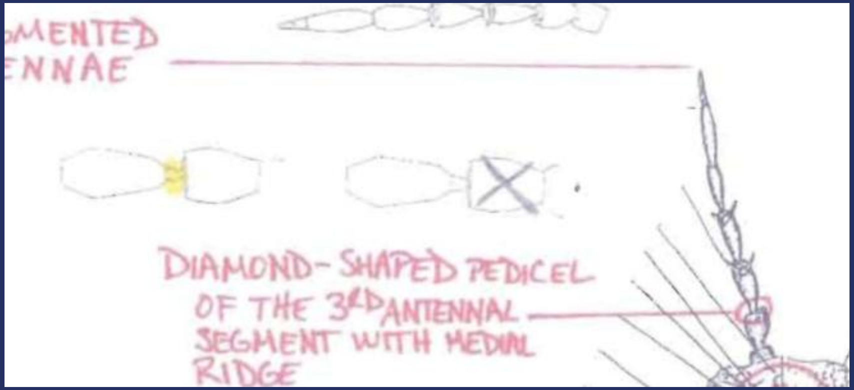
Blueberries: Thrips

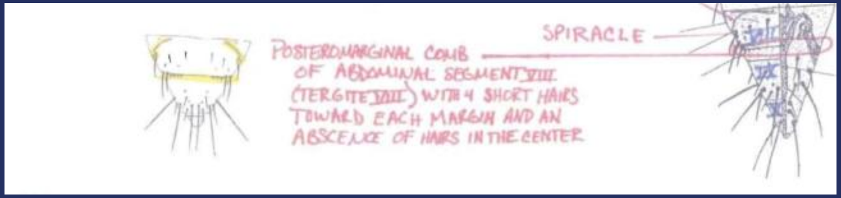




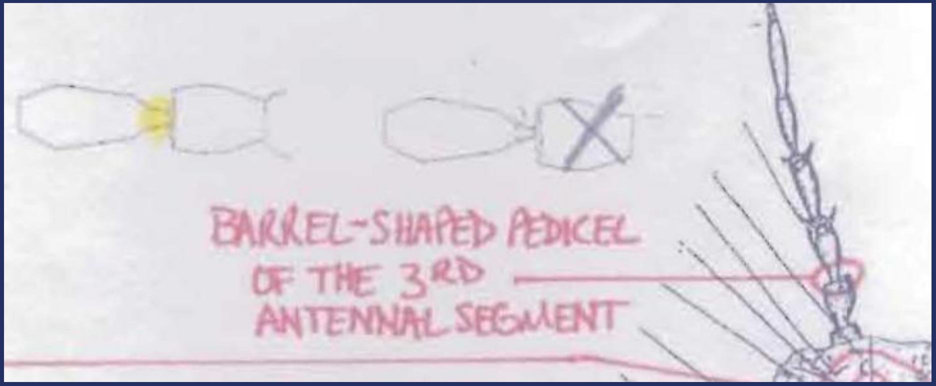
Blueberries: Thrips

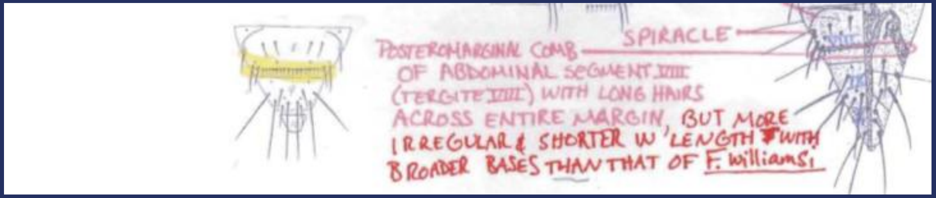
Frankliniella tritici





Frankliniella occidentalis





Blueberries: Thrips

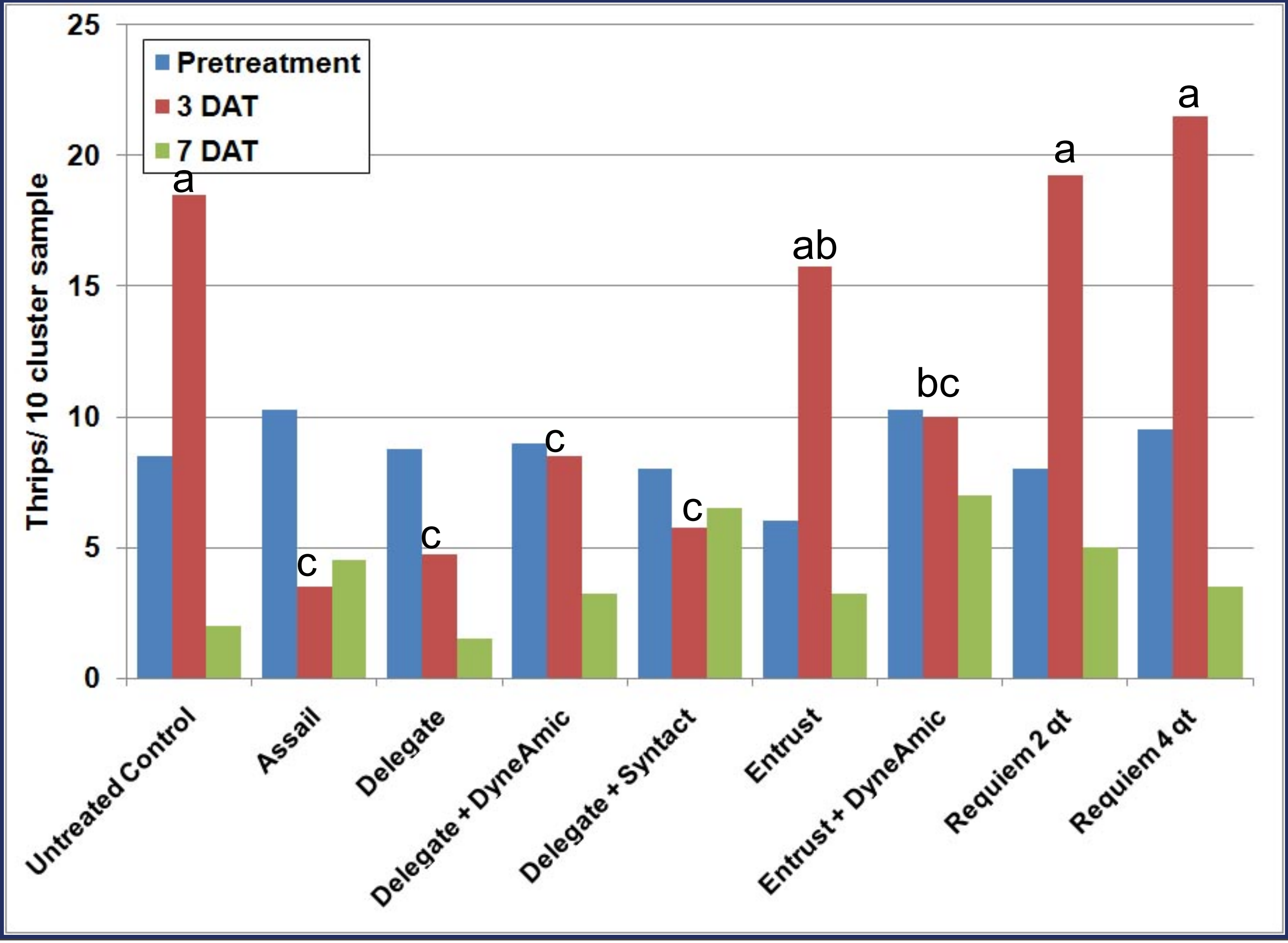
- Thrips threshold = 2+ per flower (10+ per typical cluster)
- Thrips are more important in rabbit eye blueberries – rarely in NC SHB
  - Spring thrips populations depend on:
    - Winter temperatures, spring precipitation
  - Bloom timing

Blueberries: Thrips

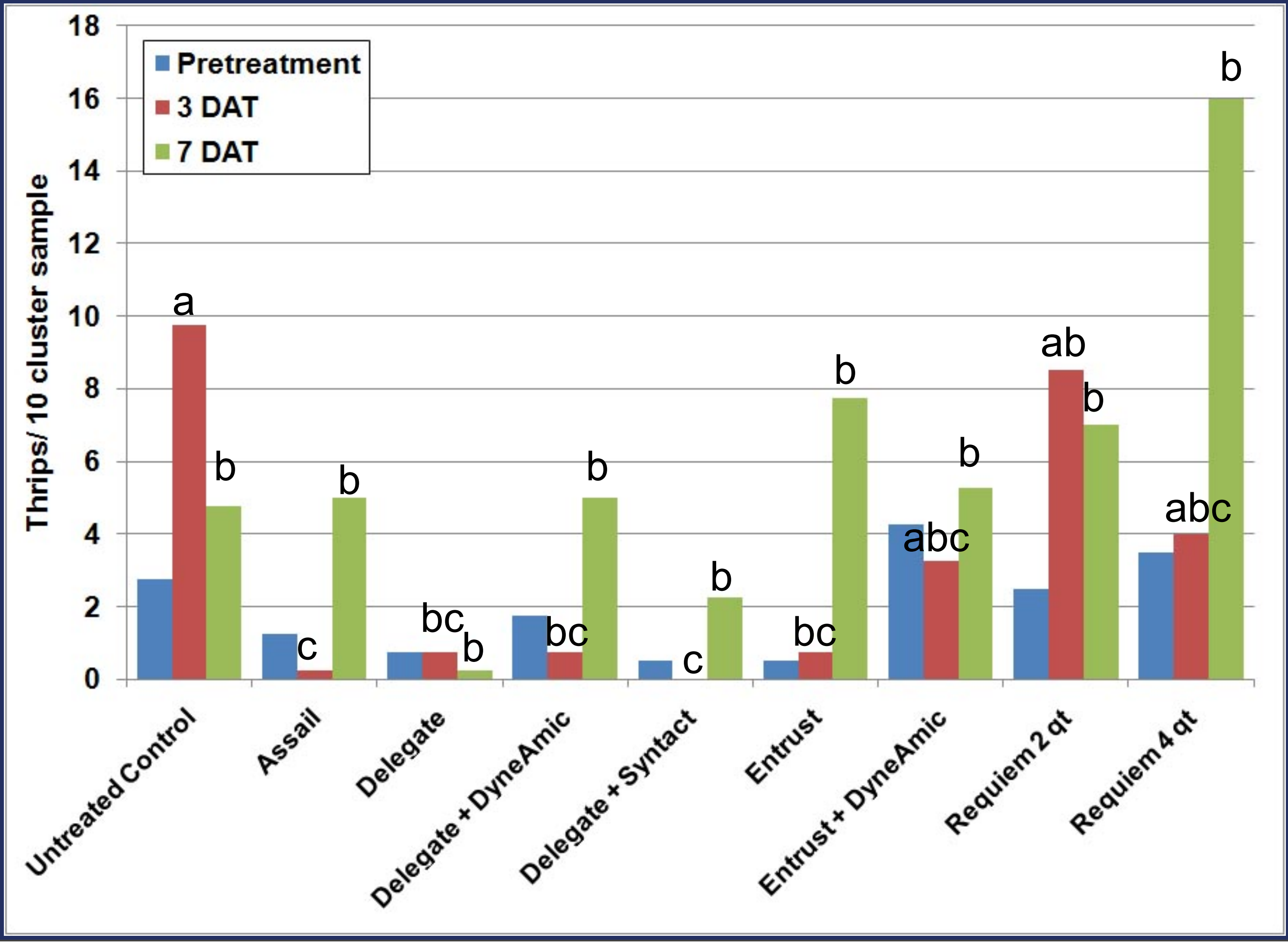
- Thrips sampling:
  - Method 1: plastic bag
  - Method 2: alcohol vial
  - Method 3: beat cup

All 3 methods are accurate, but use the same method for the entire season!

Blueberries: Adult Thrips



Blueberries: Larval Thrips



Blueberries: Fruitworms

- Two species in the southeast
- Cranberry fruitworm (*Acrobasis vaccinii*) & Cherry fruitworm (*Grapholita packardi*)

Blueberries: Fruitworms

Eggs laid in calyx cup on young fruit

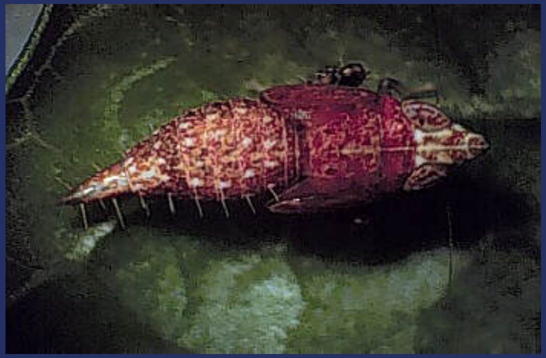

Figure 13. Webbing (arrow) and premature ripening of fruit caused by feeding larvae.

Larvae overwinter in hibernaculae in soil (CBFW) or in pruning stubs/dead leaves (CFW)

Pupation occurs in spring, and adults emerge around bloom

Blueberries: Sharpnosed Leafhoppers

- *Scaphytopius magdalensis*
- Vector Blueberry Stunt
- Management critical in May, July, late September



Blueberries: Sharpnosed Leafhoppers

- Monitor with AM traps (Trece, Inc. unbaited)
  - Also used for blueberry maggot

Blueberries: Blueberry Maggot

- Univoltine, *Vaccinium* specialist
- Subject to quarantine by Canada and western United States

Blueberries: Blueberry Maggot

- Hang traps in May, bait with ammonium bicarbonate
- Check at least weekly
- 2-4 traps/acre
- Threshold depends on fate of fruit

Blueberries: Blueberry Maggot

Calendar method

Chemical treatment (any registered/recommended insecticide for *R. mendax*) begins at 1st trap capture **in the area** and continues every 7-10 days through the end of harvest

IPM method

Chemical treatment begins at first trap capture **at the farm** and is repeated 7-10 days later. Treatment continues only if additional flies are caught.

Blueberries: Blueberry Maggot

Blueberries: Blueberry Maggot

Site	Size (acres)	County	Number of traps	Weeks observed	Total *R. mendax* captured
1	270	Bladen	20	12	0
2	300	Bladen	26	13	1
3	40	Bladen	5	13	0
4	73	Bladen	9	13	0
5	153	Bladen	13	13	1
6	55	Bladen	7	13	0
7	27	Bladen	5	11	0
8	80	Bladen	9	12	0
9	165	Bladen	13	13	0
10	80	Pender	9	12	0
11	30	Pender	5	10	0
12	220	Pender	16	13	1
13	65	Pender*	9	11	0
14	1	New Hanover*	3	13	0
Total	1559		149		3
15 (validation site)	5	Rockingham*	4	8	165

Blueberries: Stink Bugs

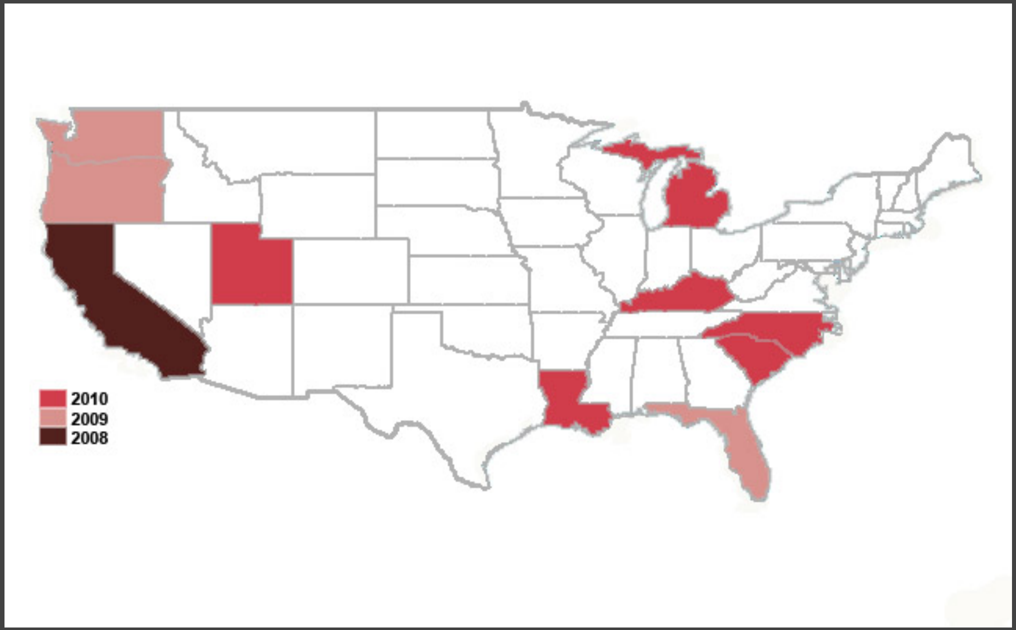
- Numerous stink bugs present during bloom and fruit development (*Banasa dimidiata*)
- **No known damage due to SB or LFB**
  - Translation: Do not treat!

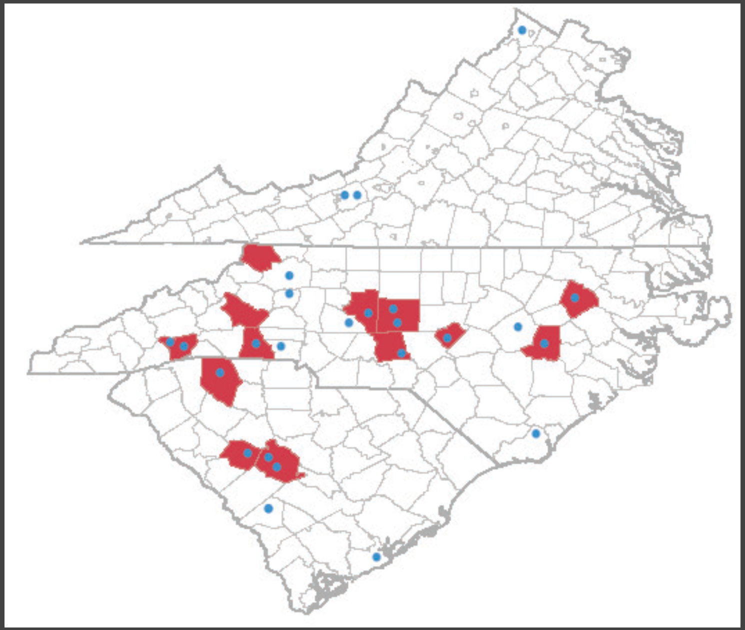

Blueberries: Scarab Beetles

- Isolated & mysterious flower, foliar, and fruit feeding
- Eventually attributed to *Anomala undulata*

Invasives: Spotted Wing Drosophila

- Current Range
  - NC, SC, and VA monitoring supported by Southern Region Small Fruit Consortium





Invasives: Spotted Wing Drosophila

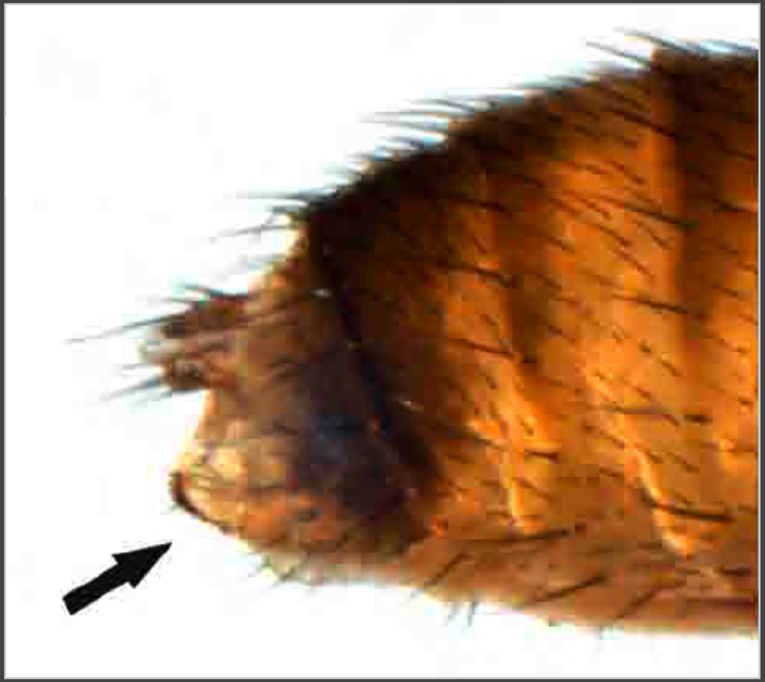
- Host range

  Strawberry, Raspberry, Blackberry, Blueberry, Grape, Peach, Nectarine, Pear, Plum, Apple, Fig, Persimmon, possibly other soft skinned fruit




Invasives: Spotted Wing Drosophila

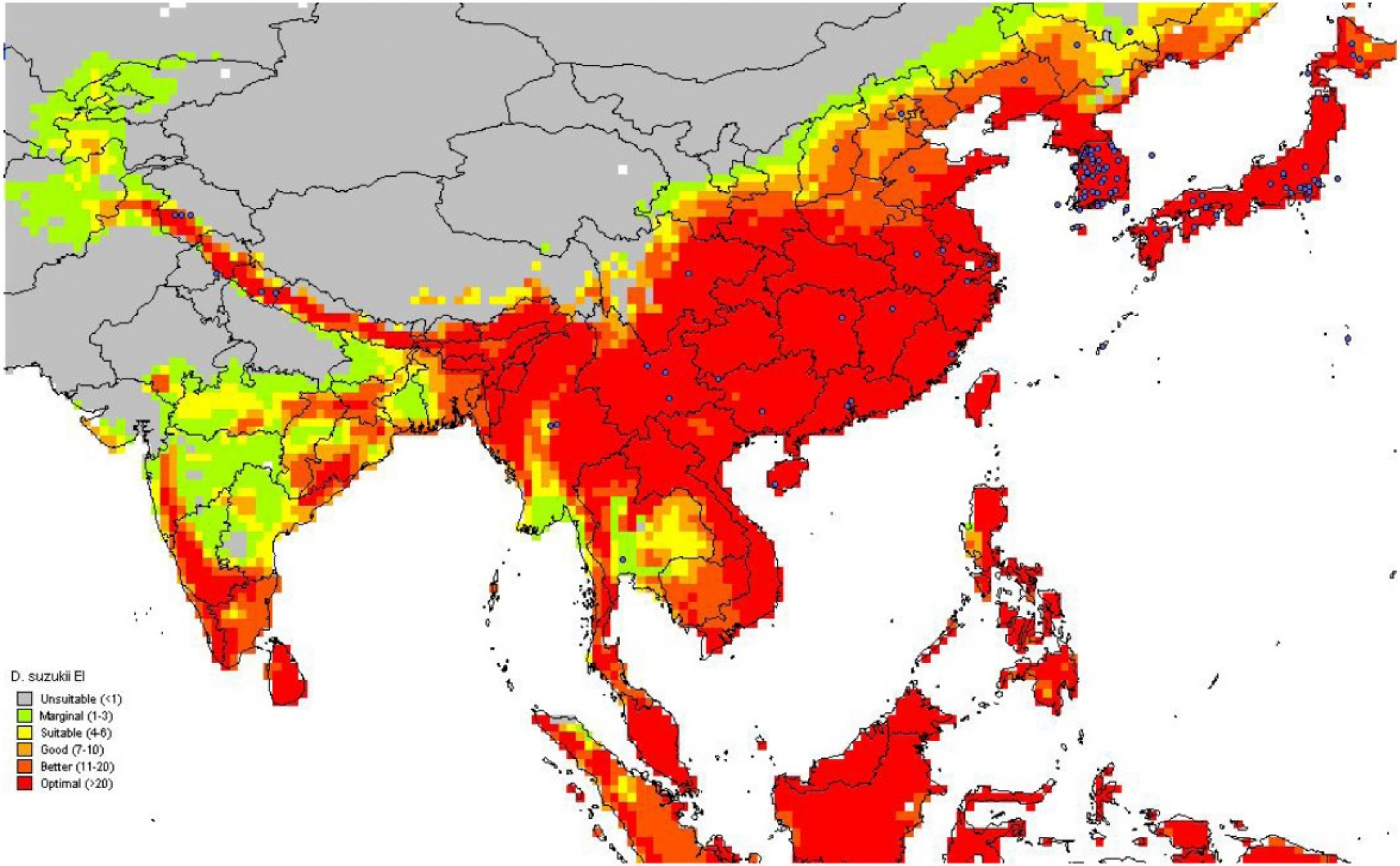
Invasives: Spotted Wing Drosophila



Other *Drosophila* spp.

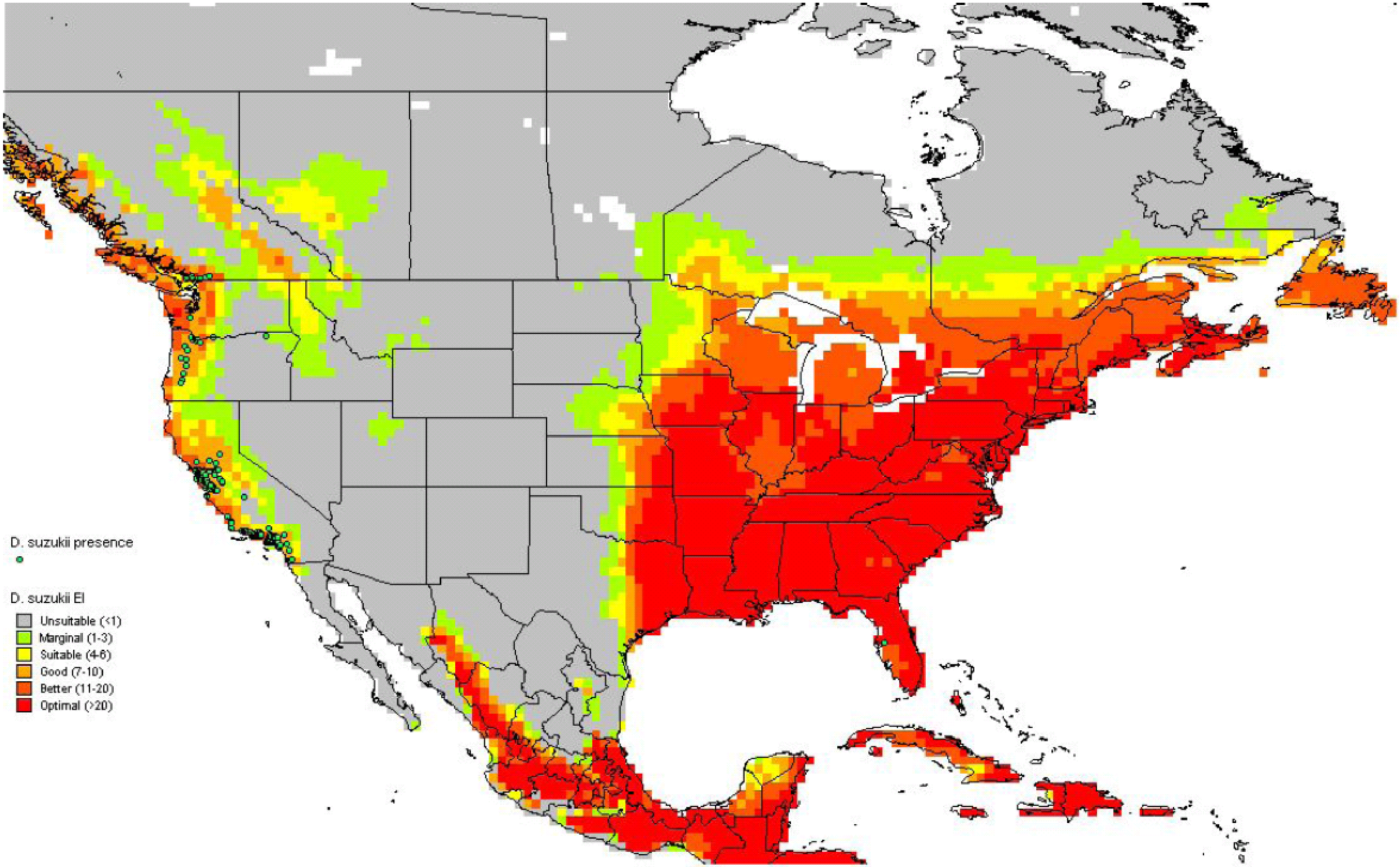
Drosophila suzukii

CLIMAX ecological modeling by Martin Damus, Canadian Food Inspection Agency



Known and predicted native range, based on temperature thresholds

CLIMAX ecological modeling by Martin Damus, Canadian Food Inspection Agency



Potential range, based on temperature thresholds

Invasives: Spotted Wing Drosophila

Adult Monitoring Methods	Larval Monitoring Methods
Apple cider vinegar baited trap	Sugar test
Yeast & sugar baited trap	Salt test
Sweep net	Floatation test
Bug Vac	

Invasives: Spotted Wing Drosophila

Site	Mean ± SE D. suzukii adults: Apple Cider Vinegar Lure	Yeast & Sugar Lure
Davidson County, NC	6.00 ± 0.89 a	0.33 ± 0.21 b
Edgecombe County, NC	1.13 ± 0.36 a	0.27 ± 0.15 a
Henderson County, NC Site 2	9.08 ± 1.40 a	2.46 ± 0.58 b
Lee County, NC	2.00 ± 1.30 a	0.55 ± 0.38 a
Montgomery County, NC	1.00 ± 0.35 a	0.50 ± 0.29 a
Randolph County, NC Site 1	5.22 ± 3.67 a	0.78 ± 0.46 a
Lexington County, SC	1.77 ± 0.78 a	0.33 ± 0.33 a

Invasives: Spotted Wing Drosophila

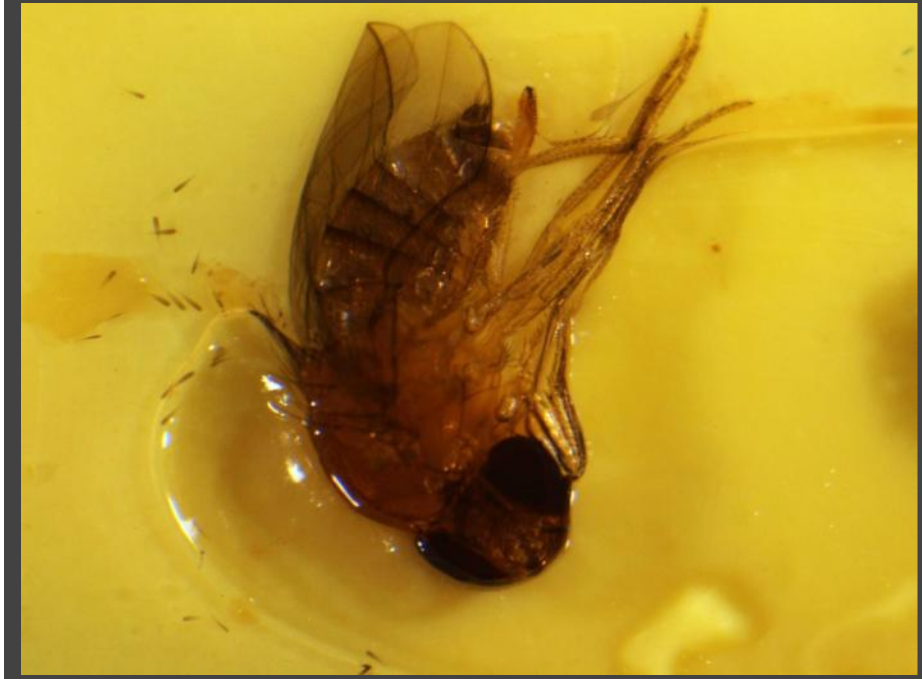
- Male flies are easy to see, females are more difficult
- Check with extension personnel if female SWD are suspected

Invasives: Spotted Wing Drosophila

- Male flies are (relatively) easy to see, females are more difficult

Invasives: Spotted Wing Drosophila

- Male flies are (relatively) easy to see, females are more difficult



Invasives: Spotted Wing Drosophila

Invasives: Spotted Wing Drosophila

- Sanitation is **crucial**

Invasives: Spotted Wing Drosophila

- Sanitation is **crucial**
  - Remove all susceptible fruit
  - Dispose of culls off site or otherwise destroy
    - Composting or burying will not necessarily kill SWD larvae

Invasives: Spotted Wing Drosophila

- If flies are captured & susceptible fruit are present, treatment is recommended.
- Current recommendations:
  - Weekly treatments
  - Rotate MOAs at least every other week
  - *May* be able to reduce treatments if populations decrease

Invasives: Light Brown Apple Moth

- Current range
  - Found only central California
  - Monitored by state departments of agriculture

Invasives: Light Brown Apple Moth

Epiphyas postvittana

Identification Guide: http://cemonterey.ucdavis.edu/files/43053.ppt

Invasives: Brown Marmorated Stink Bug

- Currently found in NJ, PA, VA, MA, MD, DE, NC


Photo: Debby Wechsler

Invasives: Brown Marmorated Stink Bug

- Wide reproductive host range
- Tree fruit widely attacked
- Possible caneberry damage observed in 2010

Invasives: Brown Marmorated Stink Bug

- Identification

Strawberries: Cutworms/ Armyworms

- Armyworms can monitored with sweep nets or via plant observation
  - Most common in warm falls
  - Grass/corn/rice strain different from broadleaf strain
- Cutworm adults can be monitoring with pheromone lures (Great Lakes IPM & others)
- Cutworms will migrate into plug beds and newly transplanted berries
- If adult moths are caught in traps, monitor plants and treat at first feeding holes (small, webless holes at crown)

Strawberries: Black Cutworm (*Agrotis ipsilon*)

- Traps: Bucket traps or sticky traps

Strawberries: Black Cutworm (*Agrotis ipsilon*)

- Management options
  - Bt, spinosad, malathion, carbaryl
  - Some Malathion formulations can be applied through drip (Malathion 8 Flowable is one)
    - Check the label!
  - Carbaryl (Sevin 5% bait) can be applied to plant beds preventatively
    - Varieties vary in phytotox (Early Dawn & Sunrise)
    - Only apply if history of damage or damage observed on transplants/plants

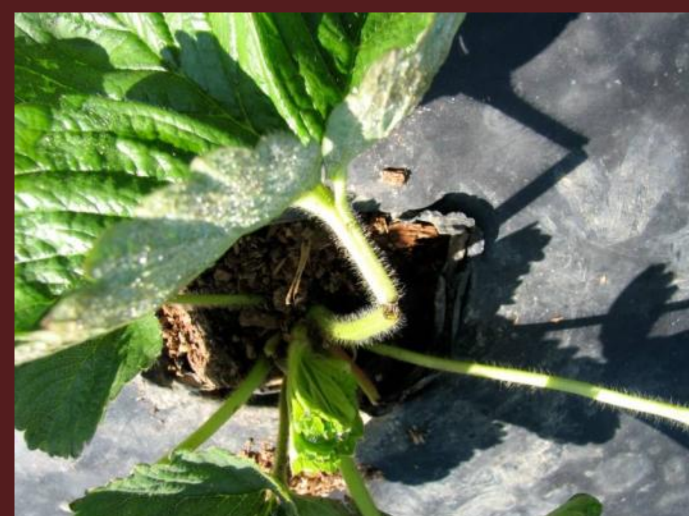
Strawberries: Strawberry Clipper

Anthonomus signatus

Small, weevil with multiple generations

Feeds on strawberry, caneberry, and wild relatives

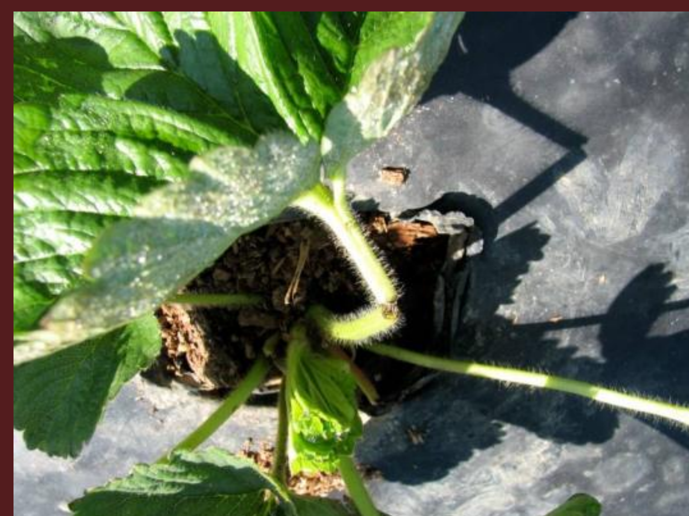
Cutworms, strawberry clipper, or mechanical damage?



Cutworms, strawberry clipper, or mechanical damage?

Clipper: Buds are clipped, damage occurs primarily in spring

Cutworm: Base of leaves, crown are cut. Preceded by leaf feeding. Occurs primarily in fall.



Mechanical damage? Leaves cut in middle/ end of stem. Occurs in fall, winter, early spring.

Strawberries: Strawberry Clipper

- Sample = 2 ft lengths, 5-10 locations per field
- Threshold = 0.6 clipped buds/ft
- Some varieties compensate for bud loss, so this threshold is conservative
- Some thresholds incorporate clipped bud age
- **Use caution when treating blooms**

Strawberries: Spider Mites

Twospotted spider mites (*Tetranychus urticae*) are the most common economically important pest of strawberries in the southeast

Adult Male and Eggs

Adult Female

Diapausing Adult Female

Strawberries: Spider Mites

- TSSM are also economically significant pests of caneberries & grapes

http://cru.cahe.wsu.edu/CEPublications/eb1959e/eb1959e.pdf

http://whatcom.wsu.edu/ag/comhort/nooksack/ipmweb/Insec_4_Sheet.html

Strawberries: Other Mites

- Cyclamen mites(*Phytonemus pallidus*) and Carmine mites (*Tetranychus cinnabarinus*) may also occur in NC
  - Distribution in SE not clear

Strawberries: Spider Mite Monitoring

- Monitoring
  - Sample 10 mid tier leaflets/acre for fields < 10 acres, 5 leaflets/acre for fields > 10 acres
  - Observe with 10x hand lens or use mite brush/microscope
- Thresholds
  - CA research
    - 5 mites/leaflet, early season
    - 10 mites/leaflet, fruiting
  - FL research
    - 2 mites/leaflet

Strawberries: Corn Earworms

- If you have had CEW problems in the past, you can trap using pheromone lures or a blacklight
- Bt is effective against this occasional pest

Trap instructions at:
http://www.ca.uky.edu/entomology/entfacts/ef010.asp

Strawberries: Lygus Bug Biology

- Are Lygus bugs important pests of strawberries in the southeast?

Strawberries: Poor pollination, Lygus bug, or other damage?

Strawberries: Poor pollination, Lygus bug, or other damage?

Poor pollination: Different sized seeds, no brown or hollow seeds

Lygus bug: Uniform seed size, evident throughout the fruit

Dried calyx disorder: Unknown (likely abiotic cause) appears on calyx

Strawberries: Lygus Bug Biology

- Lygus are not typically a pest in NC strawberries, but are in FL and CA and could potentially cause problems in warm SE areas
- Growers have been concerned about lygus but damaging populations have not been observed recently

Strawberries: Lygus Bug Biology

- What Lygus are not:

Tarnished Plant Bug
(*Lygus lineolaris*)

Big Eyed Bug (*Geocoris* spp.)

False Chinch Bug
(*Nysius raphanus*)

Strawberries: Lygus Bug Biology

- Threshold 1 Lygus/20 plants
- Sampling: Using a beat sheet, sample 20 ft sections at a time
- Also observe nearby weeds
- Lygus are more prevalent in summer, so summer plantings/day neutrals are more likely to experience damage

Strawberries: Lygus Bug Biology

- Lygus are very difficult to control, and few registered materials are effective, so before treating, be certain that Lygus are present in damaging numbers

- Weed control is important to minimize Lygus populations

Strawberries: Sap Beetle

- Sap beetles feed on over ripe fruit and are attracted to the alcohols produced by the microbes feeding on this fruit
- Can be problematic in peach, plum, and apple production as well
- At least 3 species of ripe fruit feeding beetles are pests of SE strawberries
  - Strawberry sap beetle (*Stelidota geminata* (Say)), Picnic beetles (*Clishchrochilus quadrisignatus* or *C. fasciatus*)

Strawberries: Sap Beetle

- Sap beetles are late season pests in the southeast but may become problematic if summer berry production (using day neutral varieties) is adopted

Strawberries: Sap Beetle

- There are no thresholds developed for sap beetles in strawberries
- Observe ripe fruit when picking for surface damage and tunneling
- If harvest is anticipated to run long, or if beetle damage is suspected, bait buckets placed at the edge of fields will attract the small adult beetles
  - Buckets can be baited with over ripe fruit or bread dough
  - Dispose of baits off site

Strawberries: Sap Beetle

- Cultural control is the only recommended form of SB management
  - There are registered chemicals, but because SBs occur during harvest, pesticide applications should be kept to a minimum
- Bait buckets can trap out adult beetles
  - Check at least weekly and dispose of off site
- Frequent, thorough harvest eliminate attractive over ripe fruit
  - Dispose of culls offsite
  - Watch U-Pickers

Strawberries: Aphids

- Multiple species of aphids may feed on strawberries in the Southeast

Aphis gossypii

Chaetosiphon fragaefolii

Myzus persicae

Photos: UC IPM Program

Strawberries: Aphids

GPA: Cornicles long, light, if dark, only at tips

Melon aphid: Cornicles short and dark

Strawberry aphid, knobbed hairs

Aphis gossypii

Chaetosiphon fragaefolii

Myzus persicae

Photos: UC IPM Program

Strawberries: Aphids

- Multiple species of aphids may feed on strawberries in the Southeast
- Aphids reproduce rapidly (females do not need to mate or lay eggs, male aphids are rare)
- All strawberry feeding species are polyphagous
  - Aphids prefer new growth, and will move on as plants age

Strawberries: Aphids

- Fairly high levels of aphids can be tolerated, and in typical SE conditions, aphids should not reach damaging numbers
- Treatment threshold: 10 aphids/leaflet
- Sampling method:
  - At each plant sampled for TSSM, collect one newly expanded leaf
  - Count aphids with a hand lens
  - If aphids are present, monitor weekly

Strawberries: Aphids

- Exceptions:
  - Nursery production
    - Aphids transmit viruses in strawberries and not tolerable in nurseries
      - Strawberry crinkle virus
      - Strawberry mottle virus
      - Strawberry mild yellow edge virus
      - Strawberry vein banding virus
    - Treatment should be initiated at the first sign of aphids
  - Perennial production
    - Virus transmission can also occur in perennial production

Strawberries: Aphids

- Aphids are attracted to high nitrogen levels in plants - avoid over fertilization
- Row covers and tunnels may increase aphid populations
  - If applied before aphids are present, row covers can protect against aphid infestation
- Numerous, naturally occurring, wasp parasitiods attack aphids in the Southeast
  - Do not include parasitized aphids in count
  - If a large proportion of the aphid population is parasitized, consider delaying treatment

Strawberries: Aphids

- Numerous, naturally occurring, wasp parasitiods attack aphids in the Southeast
  - Do not include parasitized aphids in count
  - If a large proportion of the aphid population is parasitized, consider delaying treatment

Strawberries: Thrips

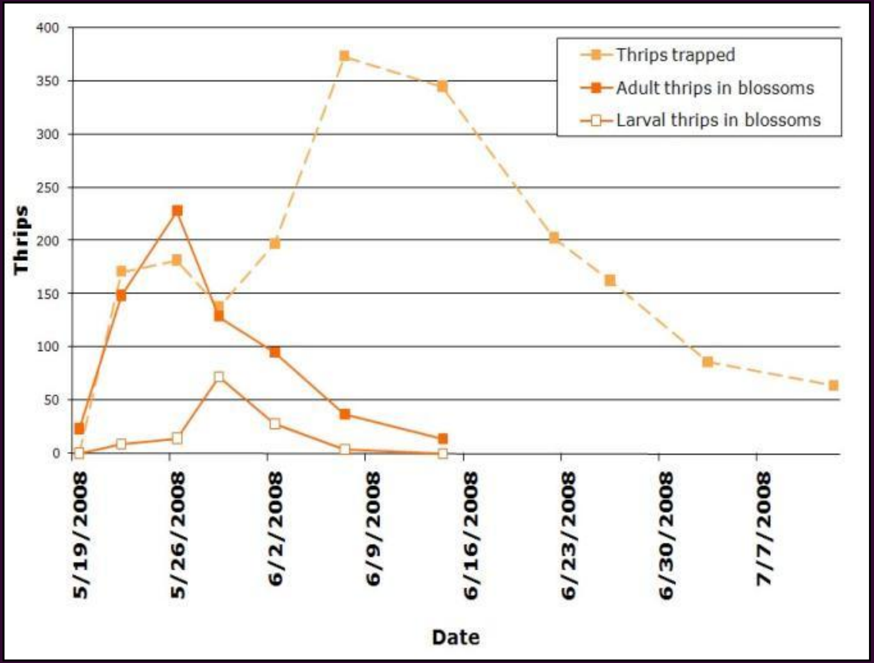
- Thrips feeding causes bronzing near the stem on fruit
- Thrips do not cause catfacing
- Threshold = 10/flower
- If bronzing is not observed, do not treat for thrips

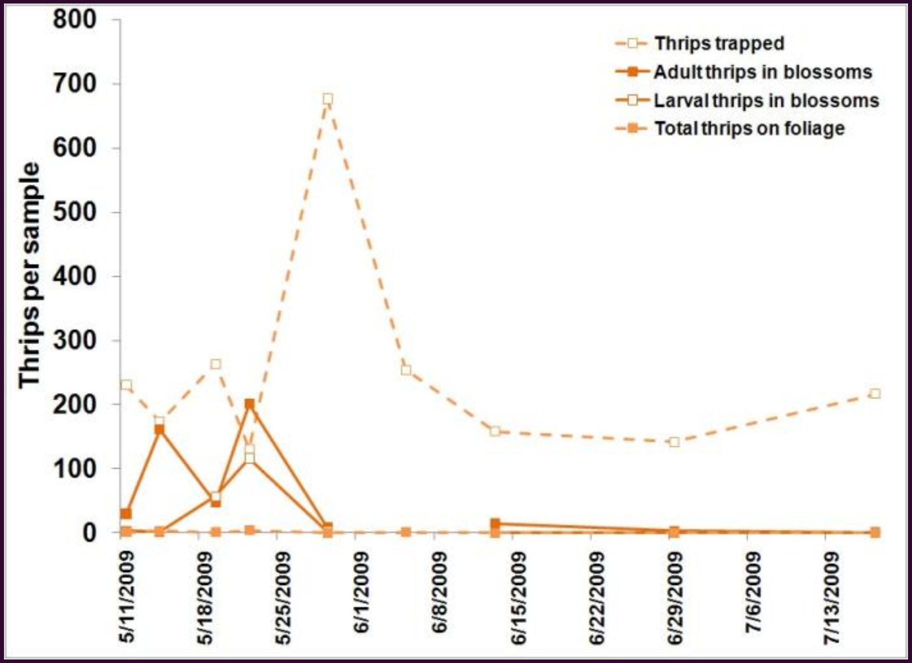
Caneberries: Thrips

- Why are we studying thrips?
  - Grower concern about fruit injury/ pollination
  - Contamination pest
- Objectives
  - Diversity and seasonal biology of thrips
  - Pest status of thrips
  - Management strategies

Caneberries: Thrips

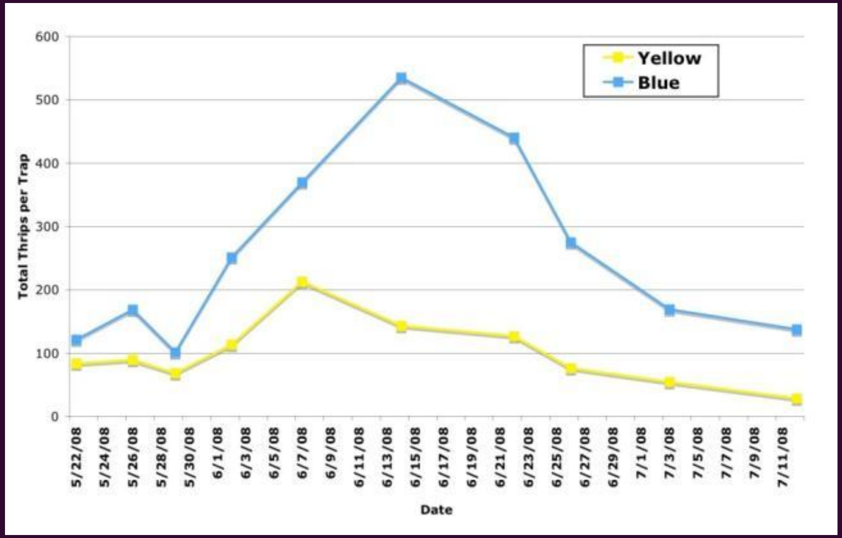
- Present on in both flowers and foliage
- Plant samples peak during bloom, while trap capture continue to increase

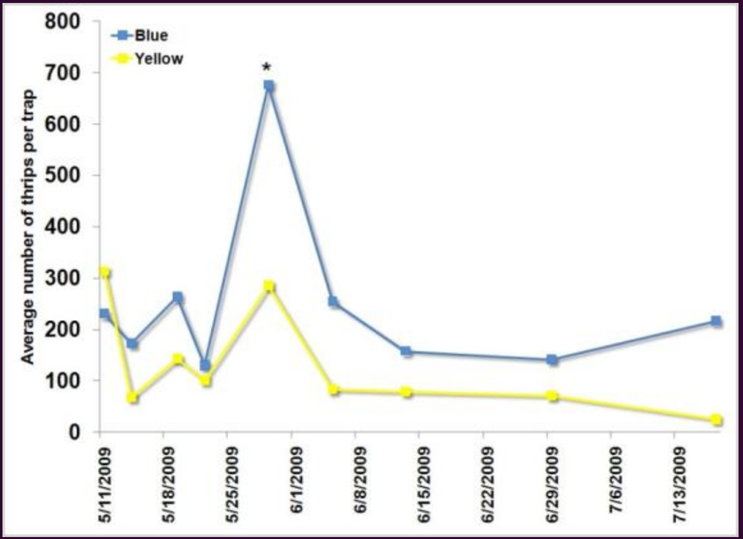




Caneberries: Thrips

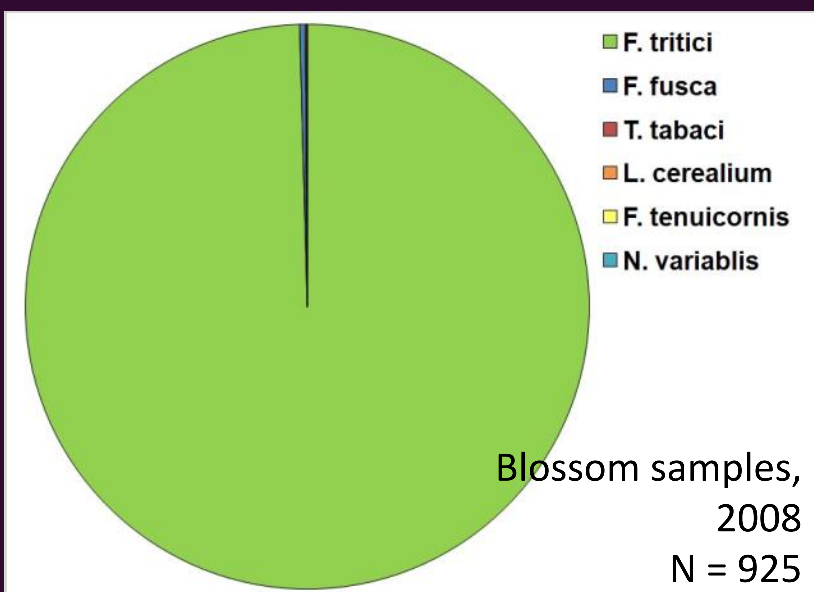
- Monitoring tools



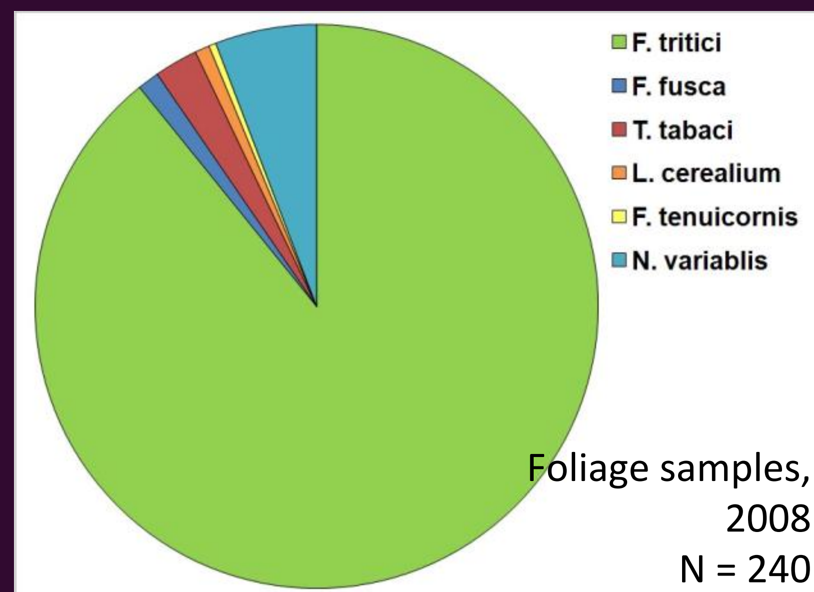


Caneberries: Thrips

- Blossom samples have higher thrips density
- Foliage samples have greater thrips diversity



Blossom samples, 2008
N = 925



Foliage samples, 2008
N = 240

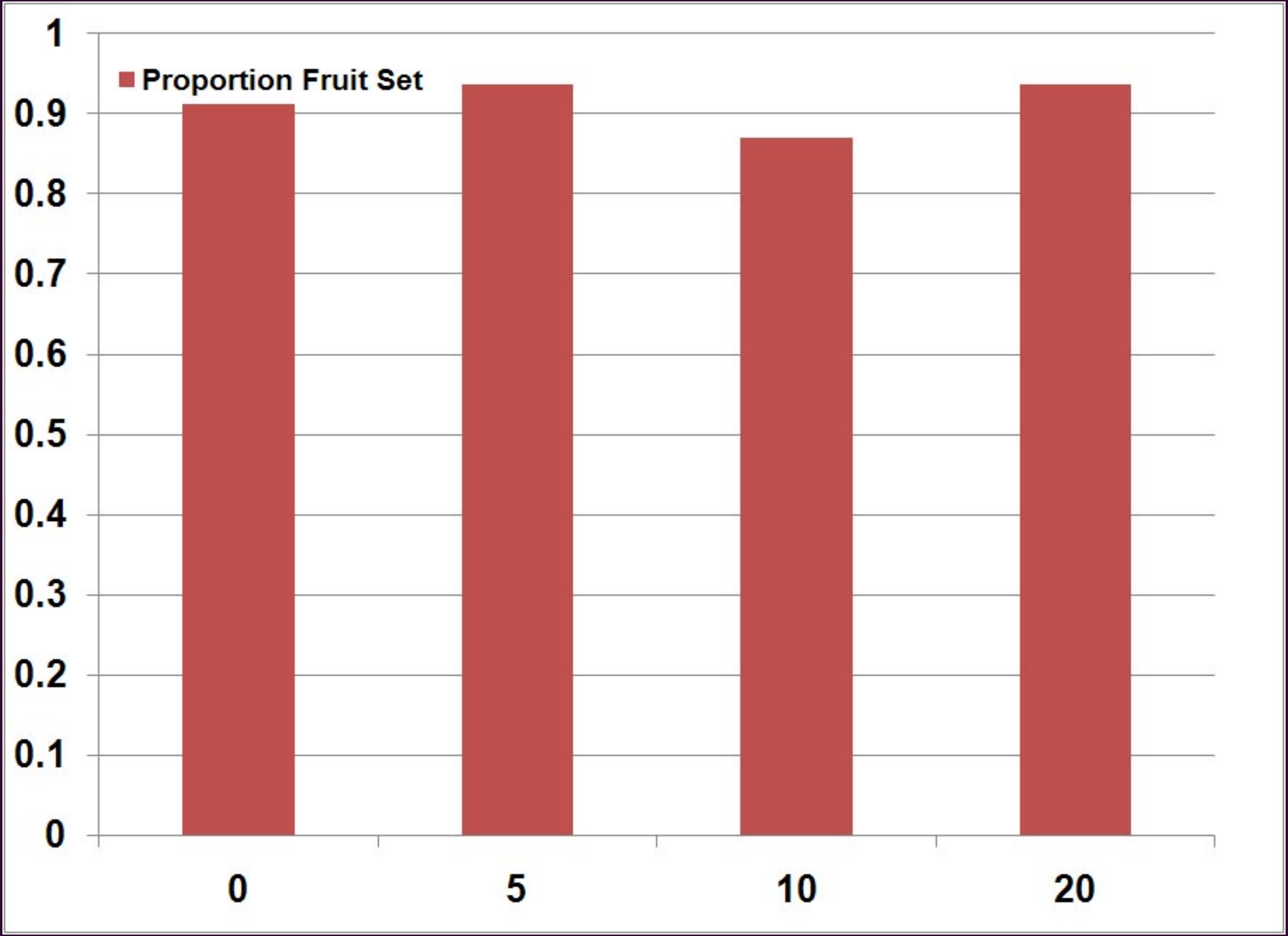
Caneberries: Thrips

- Small scale caging trial
- Kinston, NC
- 5 mature buds or flowers caged, all Apache
- Infested with ***F. occidentalis*** for 7 days, cages removed (7 cages/density, 4 blocks)
- Fruit set, size, shape, druplets, white druplets rated

- Trial Limitations: did not assess thrips survivorship, WFT used, caging effects?

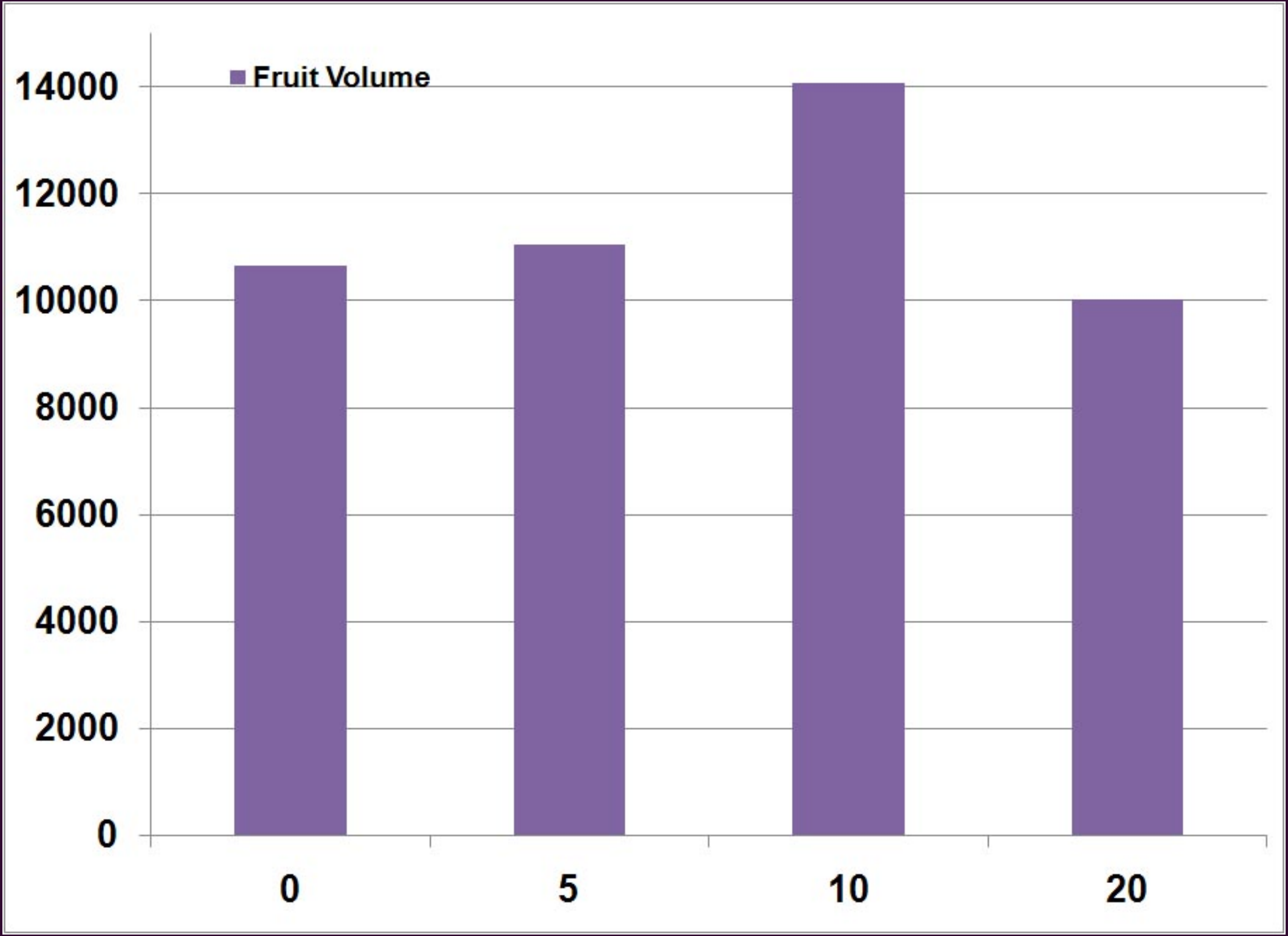
Caneberries: Thrips

- No differences in fruit set



Caneberries: Thrips

- No differences in fruit size and druplet number



Caneberries: Thrips

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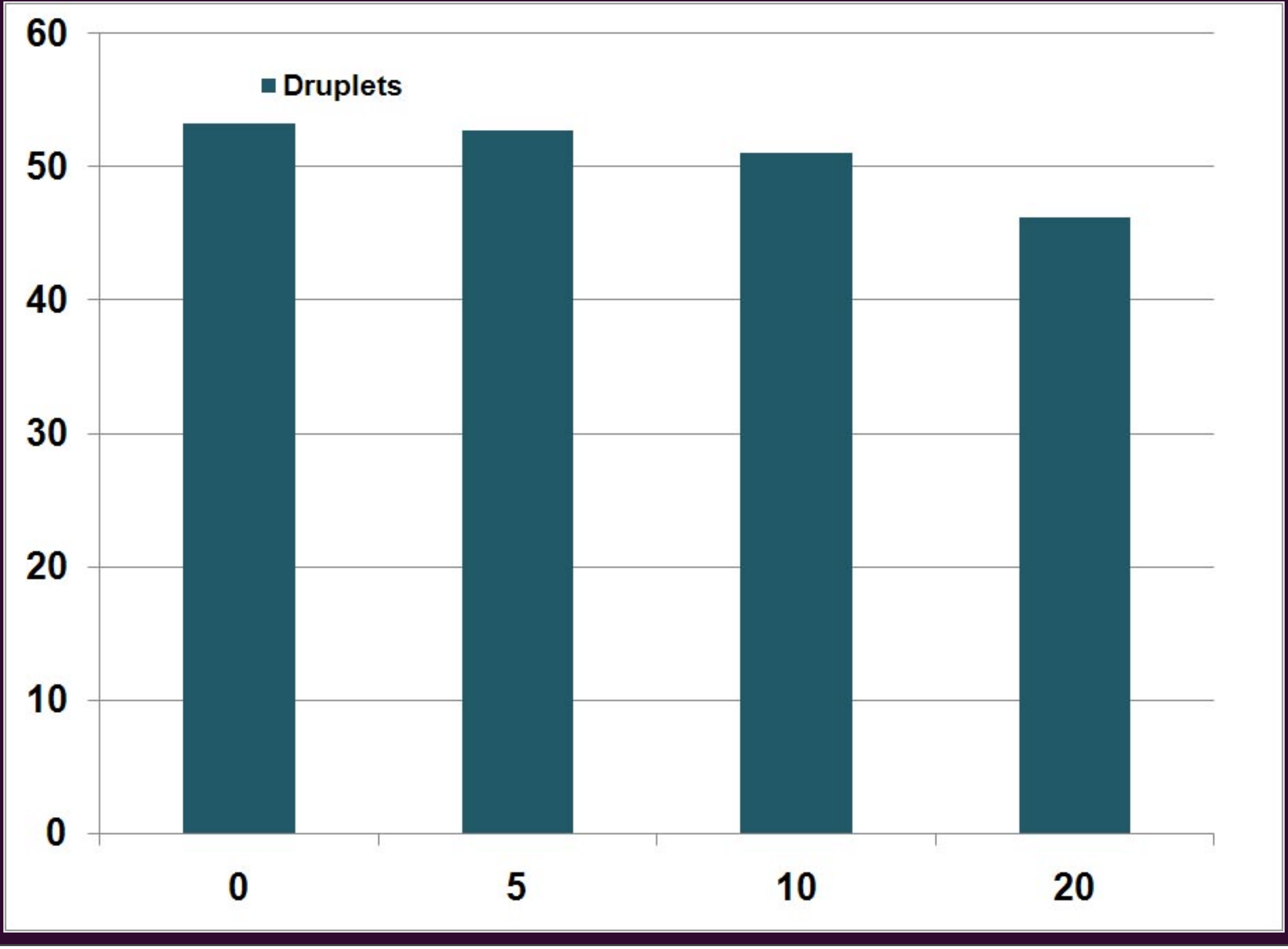


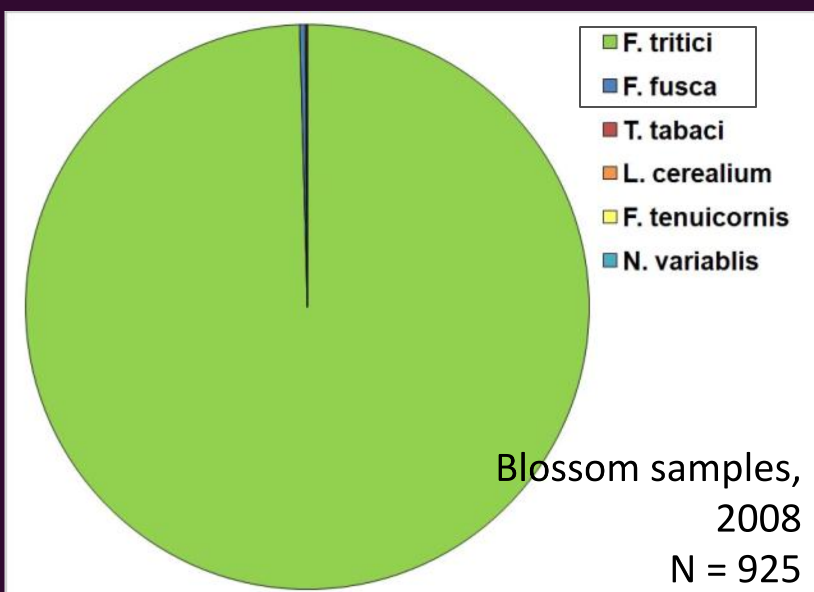
Caneberries: Thrips

- Should we be treating for thrips in caneberries?

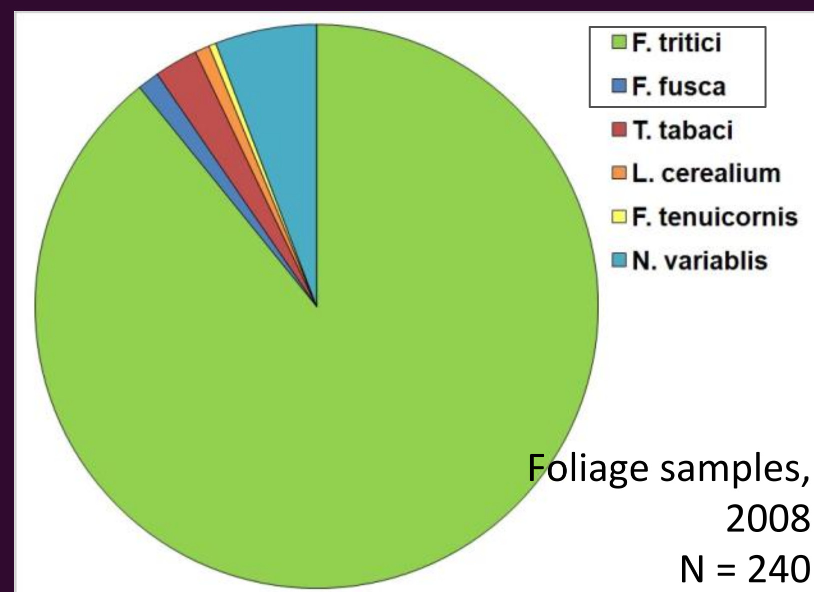
Not necessarily

Caneberries: Thrips

- Focus shifting to potential virus vectors
- Moving beyond thrips to include leafhoppers, whiteflies, and aphids



Blossom samples, 2008
N = 925



Foliage samples, 2008
N = 240

Caneberries: Thrips

- Focus shifting to potential virus vectors
- Moving beyond thrips to include leafhoppers, whiteflies, and aphids

Caneberries: Stink Bugs

- Several species of stink bugs may be present in SE blackberries
  - Brown SB
  - Green SB
  - Brown marmorated?
- Direct feeding damage & contamination

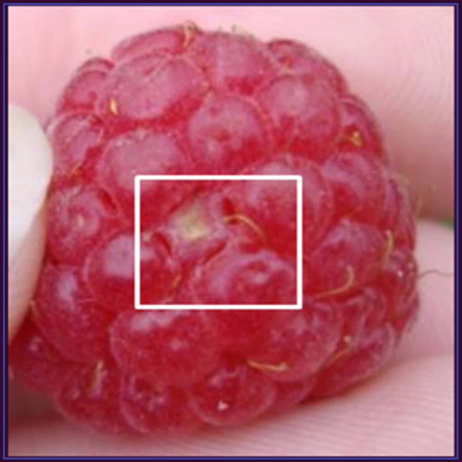
Caneberries: Stink Bugs

- Brown, green, and other stink bugs can be present
  - *Acrosternum hilare* (green)
  - *Euschistus servus* (brown)
  - *Nezara viridula* (SGSB)
- Fruit damage unclear, contamination

Caneberries: Stink Bugs

- No threshold or scouting procedures
- Only broad spectrum insecticide registered/ recommended

Caneberries: Stink Bugs



Images from Laura Maxey & Doug Pfeiffer, Department of Entomology, Virginia Polytechnic University

Caneberries: Stink Bugs

Images from Laura Maxey & Doug Pfeiffer, Department of Entomology, Virginia Polytechnic University

Caneberries: Cane Borers

Red necked cane borer

Raspberry cane borer

Caneberries: Cane Borers

Red necked cane borer

- Adults feed and mate on leaves and lay eggs only in primocanes (May-June)
- Larva girdles cane
- Girdling produces gall in July-August
- Larvae overwinters in pith
- Gall predisposes canes to winter injury

Raspberry cane borer

- Adults appear in June, eggs hatch in July, larvae overwinter in cane
- Girdling 1/2 apart, 4-6 inches below growth point
- Tips wilt
- As the larvae moves down the cane, the entire cane can die

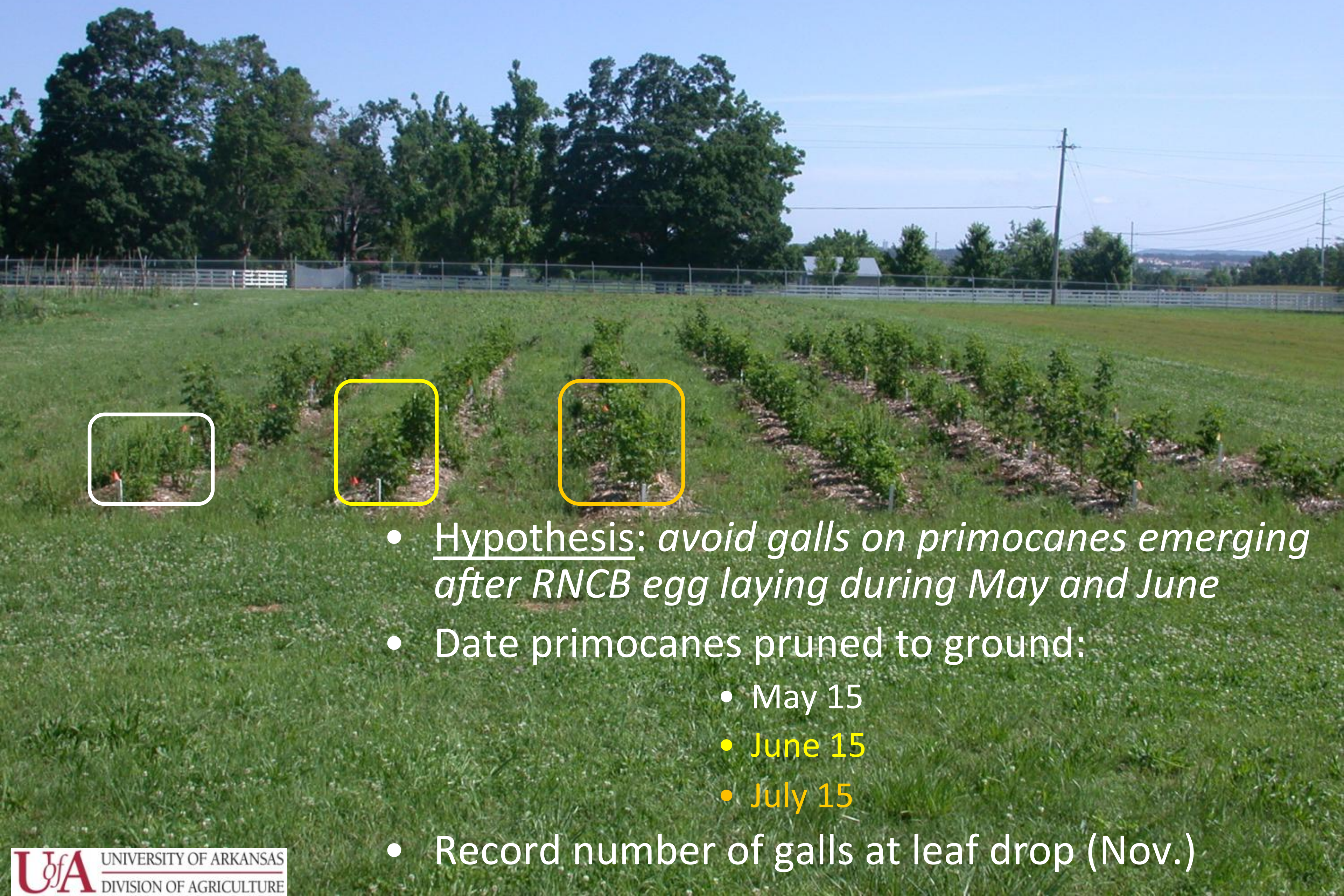
Rednecked Cane Borer (RNCB)

- Adults feed and mate on leaves and lay eggs only in primocanes (May-June)
- Larva girdles cane
- Girdling produces gall in July-August
- Larvae overwinters in pith
- Gall predisposes canes to winter injury

RNCB Management

- When **not** to treat for cane borers
  - **During winter, if < 5% galled canes**
    - Prune off galled commercial canes and nearby wild canes at ground and burn canes to kill RNCB larvae
  - **Mid June**, at end of RNCB egg laying period
    - Cut off blackberry primocanes at the soil surface (Walton 1951)
      - Reduced galling by > 83 percent

Methods: cultural control confirmed



- <u>Hypothesis</u>: *avoid galls on primocanes emerging after RNCB egg laying during May and June*
- Date primocanes pruned to ground:
  - May 15
  - June 15
  - July 15
- Record number of galls at leaf drop (Nov.)

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RNCB Galling Differs By Cane Removal Date for Primocane-bearing Blackberries

Cane removal date	No. RNCB galls/plot	Yield
May 15	3.1a	Fruit
June 15	1.4b	Fruit
July 15	0.6c	No fruit
Prob. F > P	< 0.0001	

Source: Johnson and Rom, unpublished data

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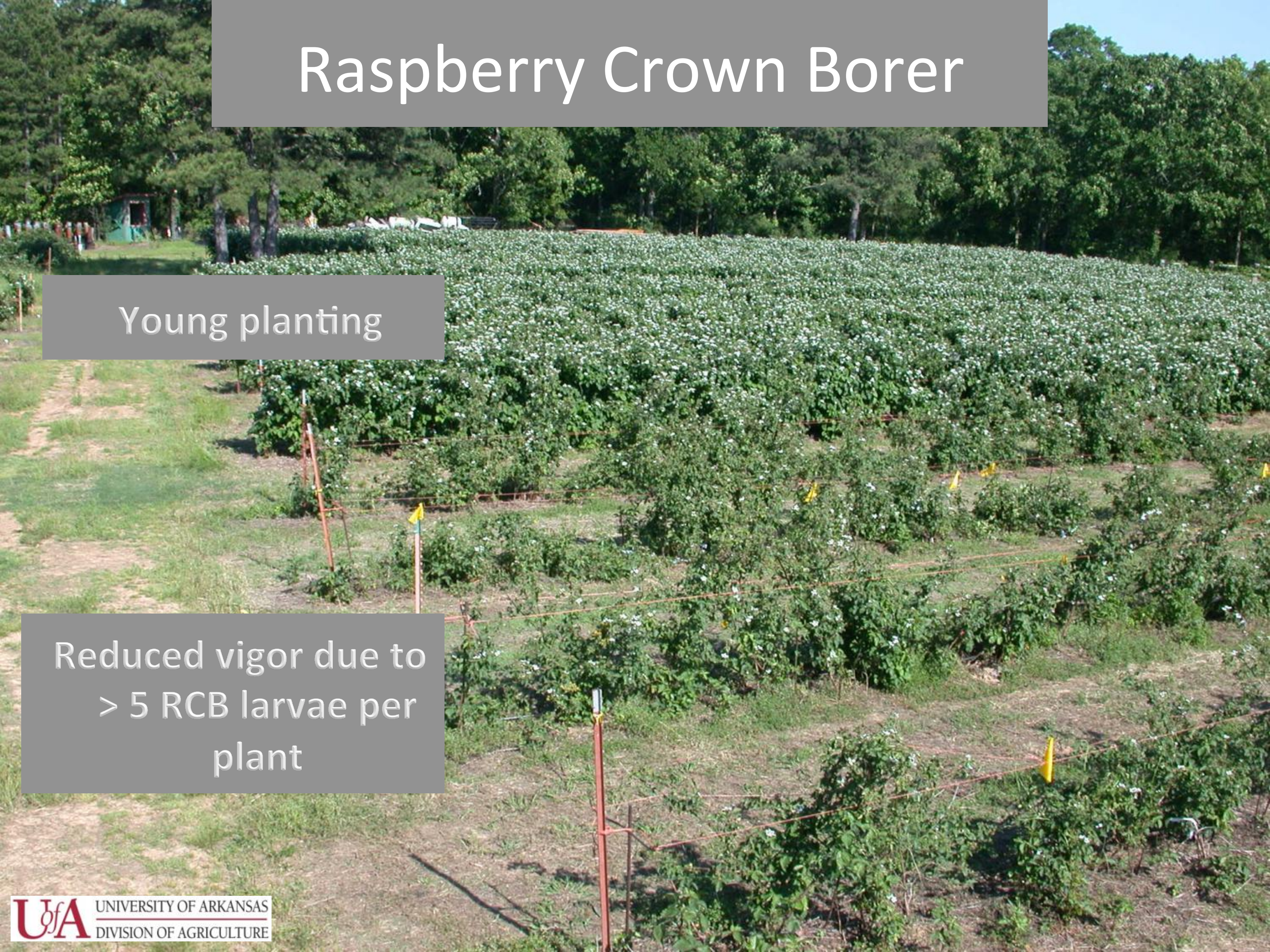
Raspberry Crown Borer
Young planting
Reduced vigor due to > 5 RCB larvae per plant
UNIVERSITY OF ARKANSAS
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Raspberry Crown Borer

Eggs on underside of leaves

Larva overwinters in cane below soil (WSU photo)

Pupal skin emerges in Sept. - Oct.

Adults mate

Laying egg

Raspberry crown borer

- When to treat for RCB
  - Late fall & early spring
    - Scout for RBC damage in July and adult moths in September (on primocanes)
- What are we treating in fall & early spring?

Caneberries: Japanese Beetle

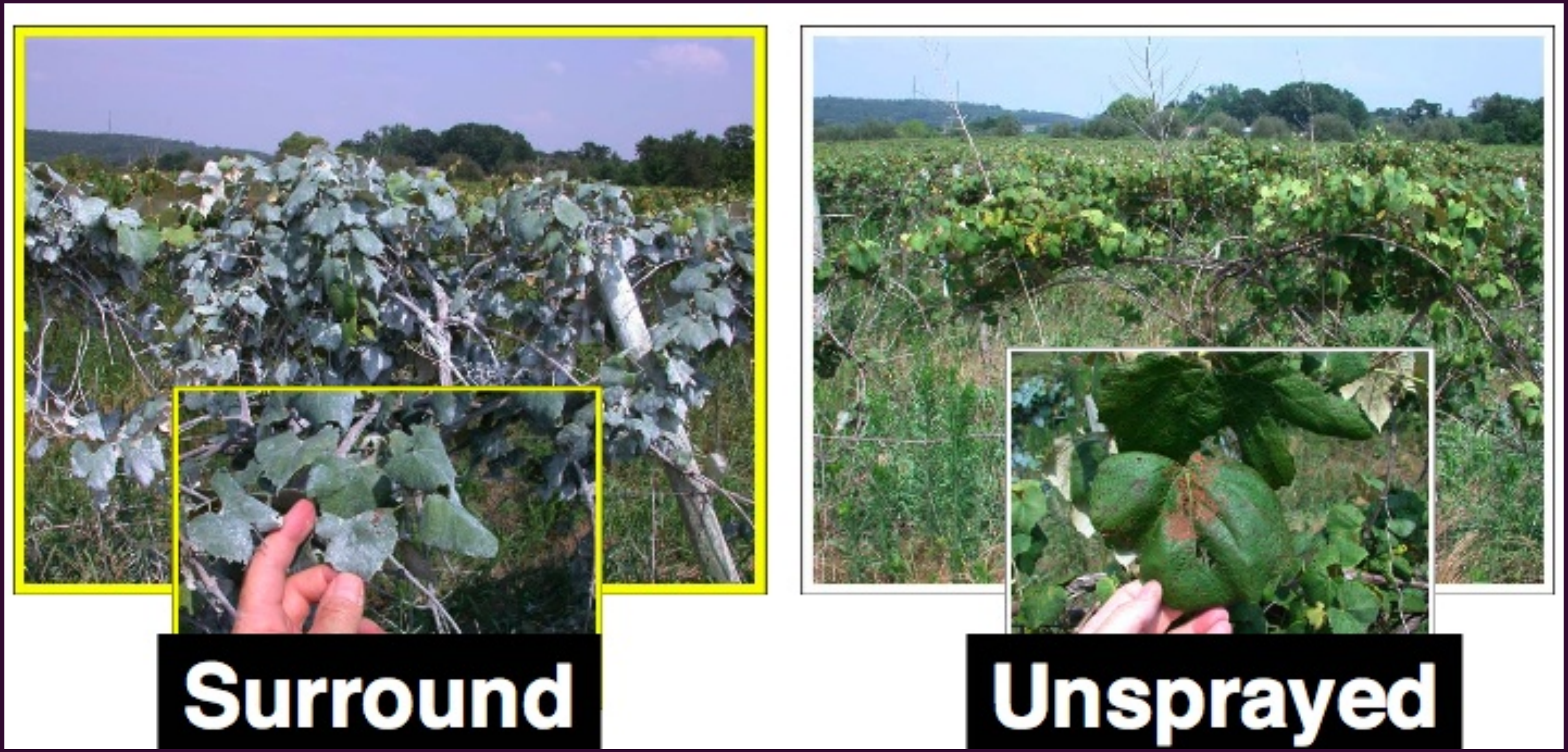
Japanese beetles feed on both foliage and fruit.

Injured plants are more attractive.

Beetles feed from top of plant down (keep in mind while scouting).

Conventional materials provide good control, but can flare other pests (mites).

Caneberries: Japanese Beetle

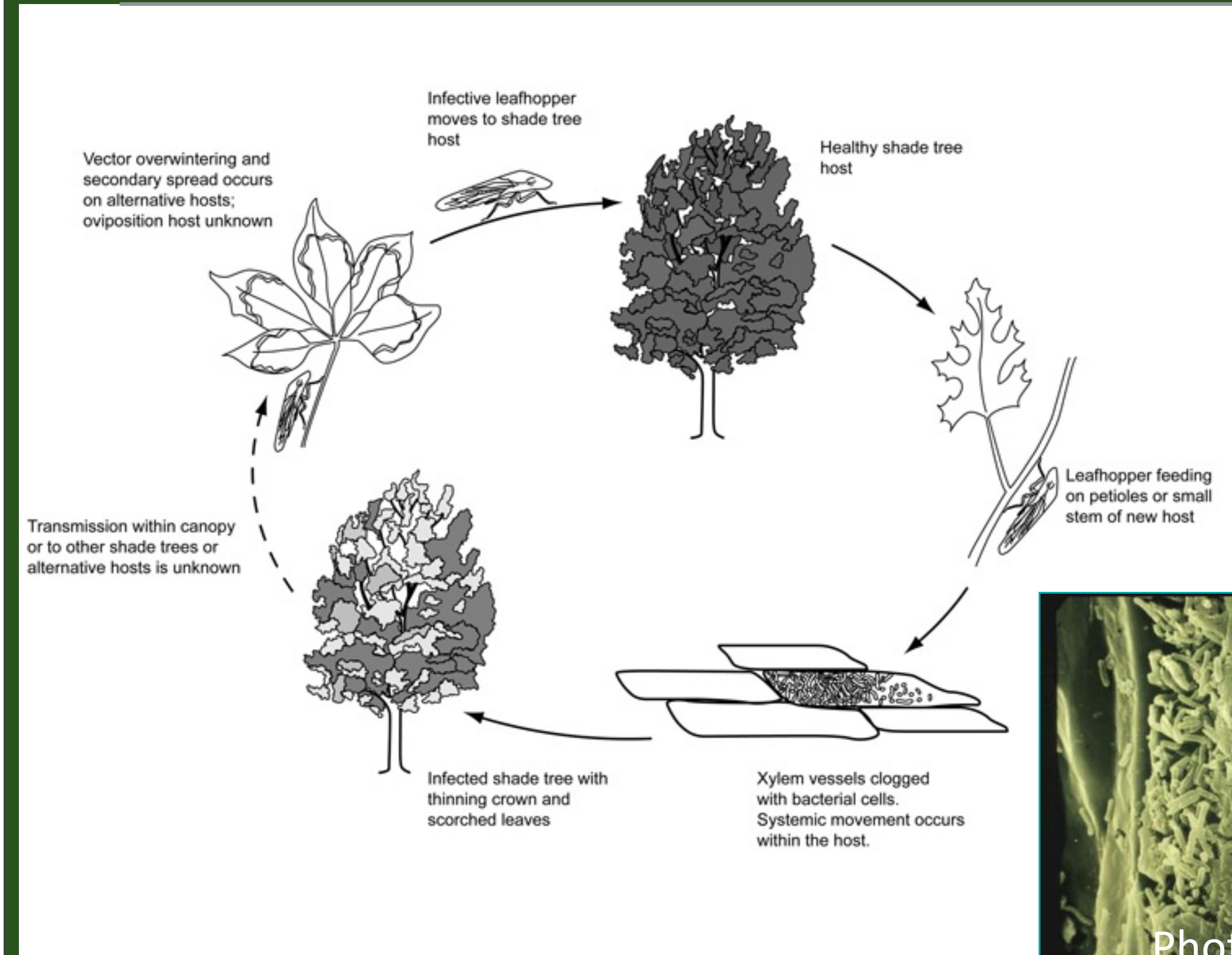


Images from Donn Johnson, grapes

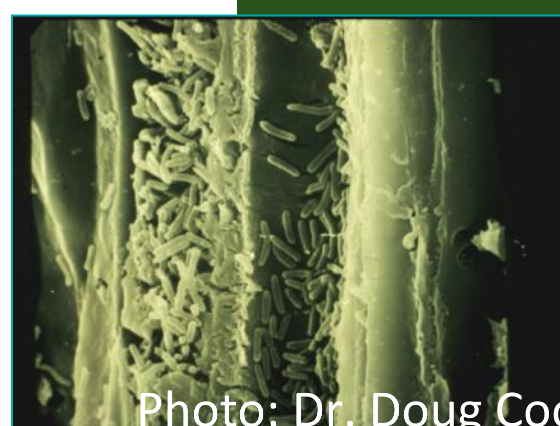
Grapes: Leaphoppers & Pierce' s Disease

- Leafhoppers are pests in their own right (California production/some New York Production)
- Leafhoppers vector *Xyella fastidiosa* (Pierce' s disease) in the eastern US and southern California

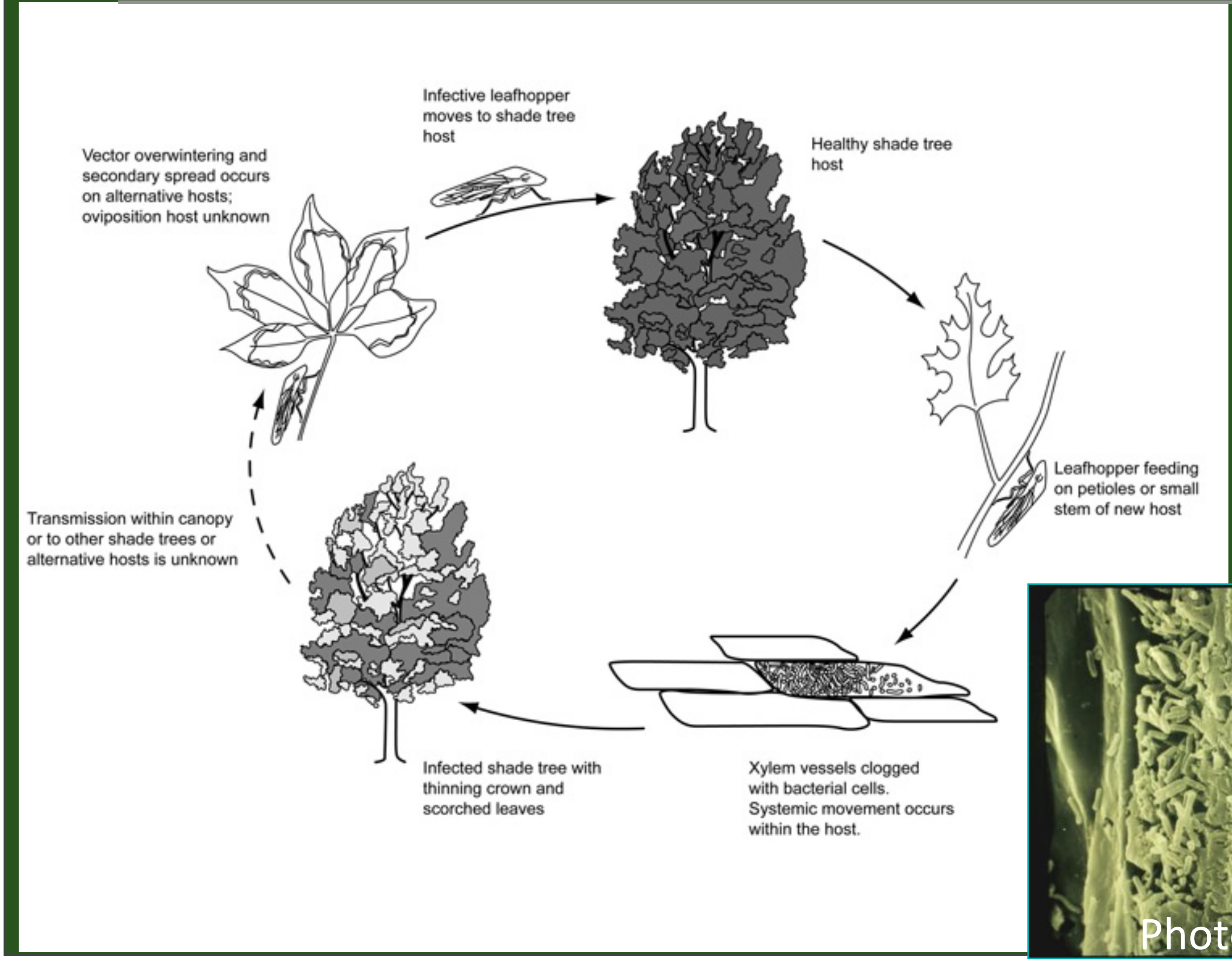
Grapes: Leaphoppers & Pierce's Disease



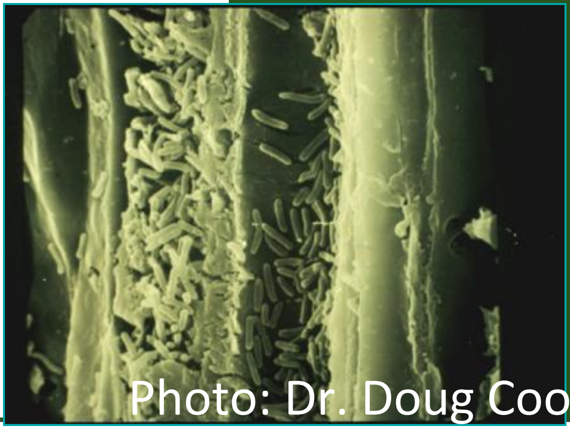
- Xylem feeding Cicadellid leafhoppers aquire the bacterium
- *X. fastidiosa* adheres to the foregut of the insect & multiplies



Grapes: Leaphoppers & Pierce’s Disease



- Insect is no longer infectious after molting (forgut is cuticular)
- No latent period for infection



Grapes: Pierce's Disease

- The glassy-winged sharpshooter is not the most common vector in NC

Homalodisca vitripennis

Graphocephala versuta

Agalliota constricta

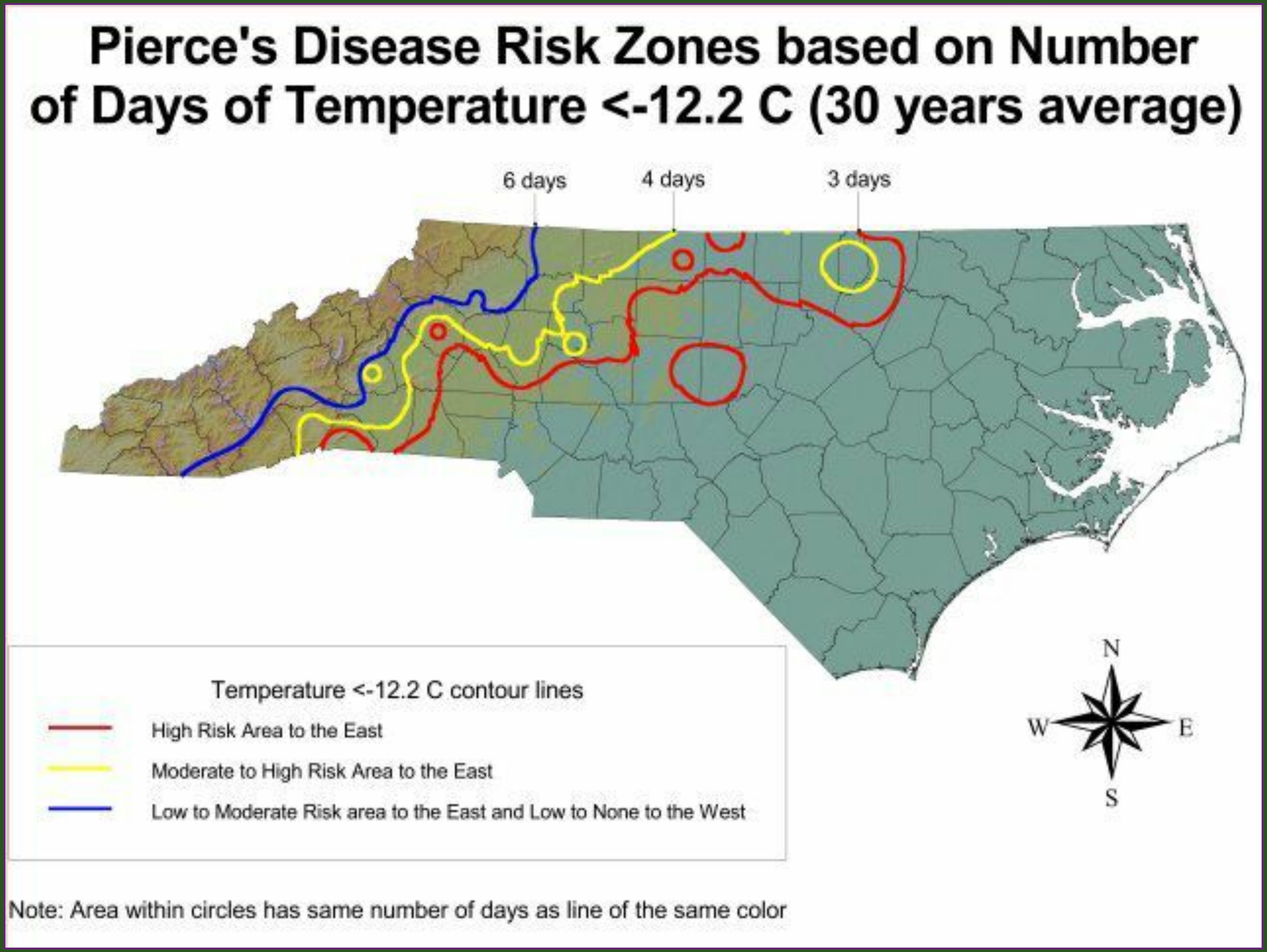
Grapes: Pierce’s Disease

- Symptoms

Grapes: Pierce's Disease

- Symptoms

Grapes: Pierce's Disease



Grapes: Pierce's Disease

California

Few, inefficient native vectors

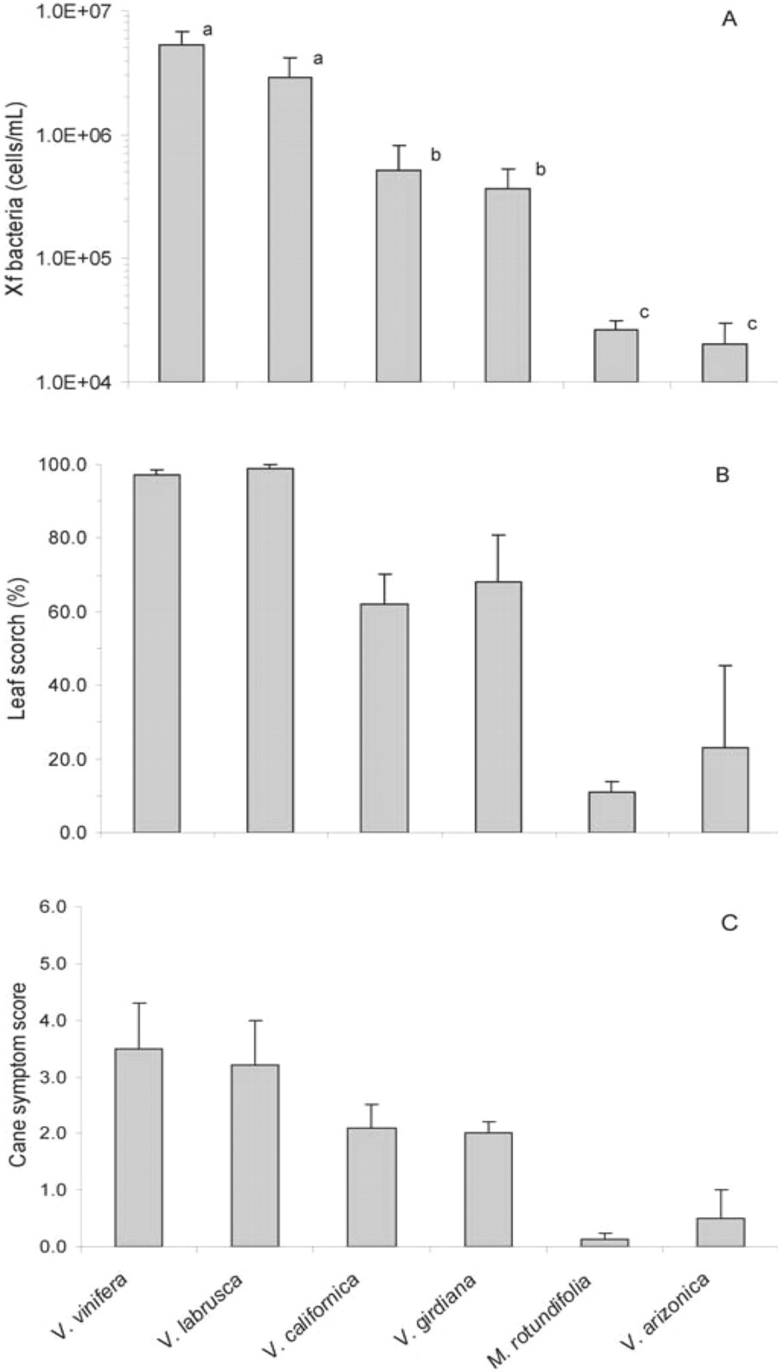
Large scale *V. vinifera* production

Invasive, efficient vector

North Carolina

Many native vectors

Little *V. vinifera* production, most production is in tolerant muscadine grapest



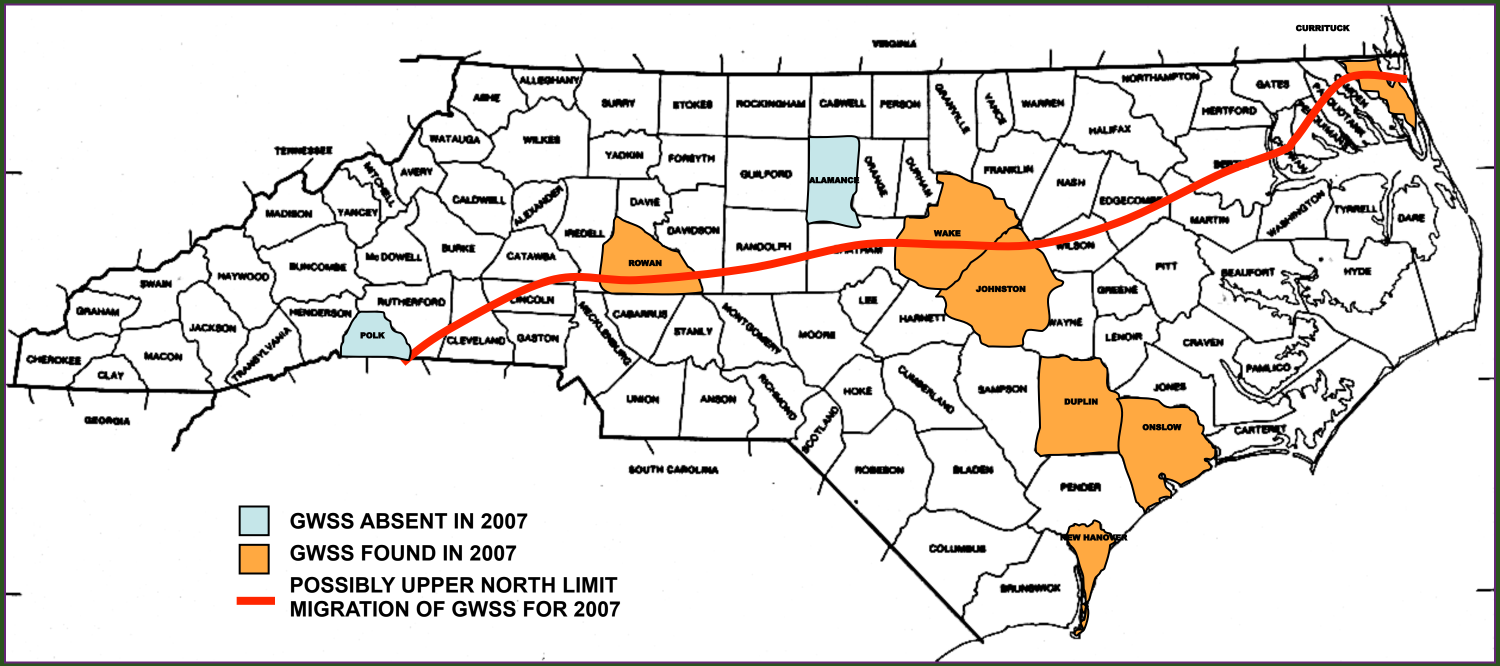
Grapes: Pierce's Disease

- Muscadine grapes are more naturally resistant to PD

Ruel & Walker 2006

Grapes: Pierce's Disease

- The glassy-winged sharpshooter is not the most common vector in NC



Grapes: Other Leafhoppers

- Damage:
  - Stippling
  - Leaf drop
  - Sooty mold

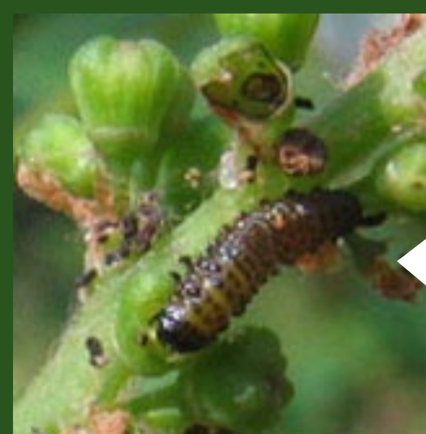
Grapes: Other Leafhoppers

Grapes: Grape Flea Beetle

Summer adults & larvae feed on leaves

Adults over winter and lay eggs in spring near bud & under loose bark

Pupate in soil



Larvae feed on developing buds or leaves

Grapes: Grape Flea Beetle

Management is primarily chemical via broad spectrum insecticides. Damage threshold = 4% or greater of buds damaged

Grapes: Grape Root Borer

- Larvae are damaging life stage (1-2 year life cycle)
- Greater densities in low, wet areas
- Sampling tools
  - Visual observation of weaken vines + larvae
  - Cast skins (look during spring/early summer)


Grapes: Grape Root Borer

- Sampling tools
  - Adult moth trapping
    - Traps are generally species specific with the exception of the Squash vine borer (*Melittia satyriniformis)*

Grapes: Grape Root Borer

- Treatment thresholds
  - University of Kentucky = 5% of vines with cast skins
  - University of Georgia = 29 cast skins/acre

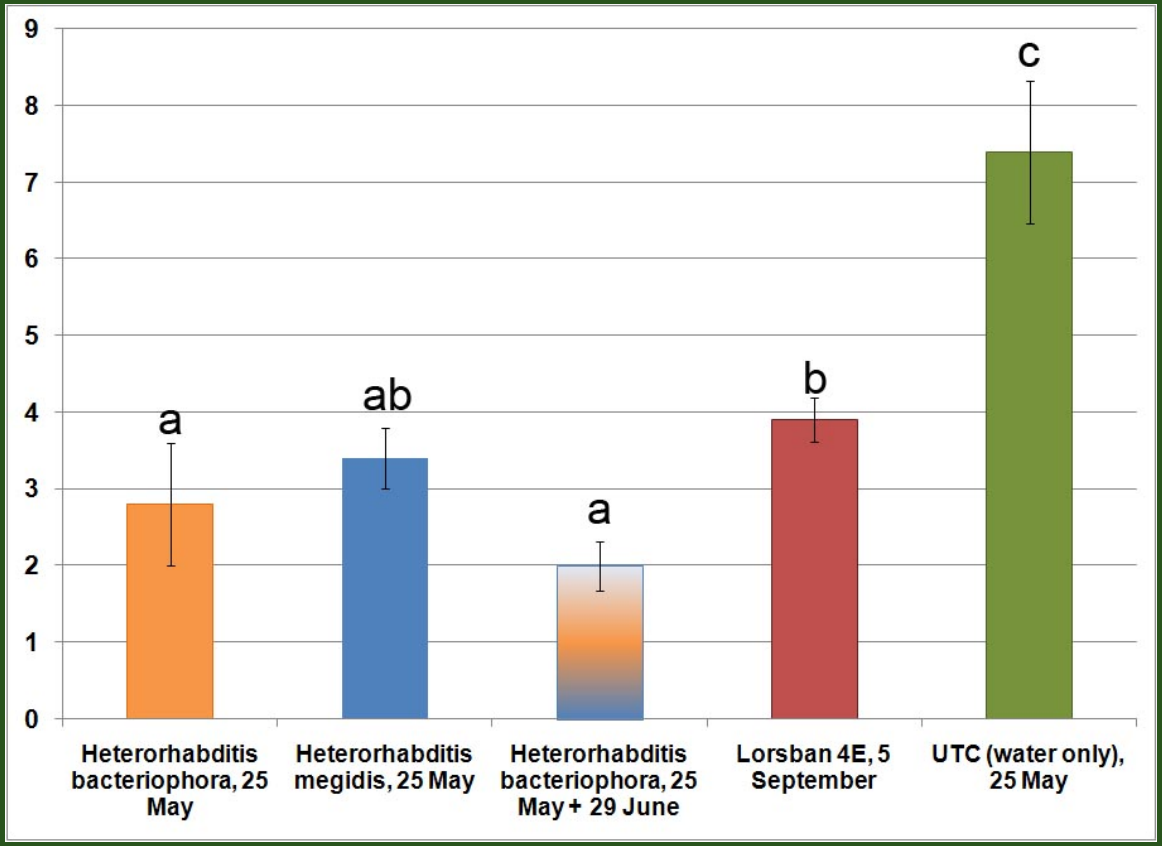
Grapes: Grape Root Borer

- Management methods
  - Timing is important!
  - Lorsban (chlorpyrofos) is only registered insecticide
  - Biological control
    - Biocontrol methods still being tested

Grapes: Grape Root Borer

- Management methods
  - Lorsban
    - Cannot contact leaves/fruit
  - Soil mounding
    - Mound soil (July or August)
    - Mounds need to be knocked by after October
  - Entomopathogenic nematodes
    - Nematodes found several weeks after treatment
    - Nematodes require water to move - irrigation is important

Grapes: Grape Root Borer



FYI: *H. bacteriophora*, 10 million @ $55

Research from Florida A&T, Hix (2008)

Grapes: Grape Berry Moth

Grape berry moth (*Paralobesia vitana*) damage is relatively uncommon in NC.
(Michigan State University photos)

Grapes: Grape Berry Moth

- GBM populations can be monitoring via pheromone baited traps
- Management stratgies:
  - Chemical control
  - Mating disruption

What are the pros and cons of these?

Grapes: Thrips

Western flower thrips (*Frankliniella occidentalis,* top) and Eastern flower thrips (*Franklinieálla tritici*, bottom) are the most likely species present in grape blooms.

Not an issue in muscadines

(UC IPM and U Fl photos)

Grapes: Thrips

Economically significant thrips damage results from early season feeding on developing fruit.

In what production system would thrips damage be of greatest concern?

Grapes: Grape Phylloxera

Daktulosphaira vitifoliae

Family: Phylloxeridae

Typically subterranean, occasionally foliar

Grapes: Grape Phylloxera

North American root stocks are resistant

Foliar forms treated chemically

Grapes: Mulitcolored Asian Ladybeetle

- Nuisance pest and potential wine contaminant
  - 0.87/kg grapes for Concord juice
  - 0.19/kg for winegrapes
- Can feed on overripe or damaged fruit in high numbers
- Can infest clusters, particularly later in the fall

Grapes: Mealybugs

Grape (*Pseudococcus maritimus*, left), obscure (*Pseudococcus viburni*, middle), and long tailed (*Pseudococcus longispinus*, right) mealybugs are all known to occur in NC. Grape and obscure mealy bugs can be separated via the "poke" method.

All of these can transmit Grape Leafroll Disease

Grapes: Mealybugs





Grapes: Mealybugs

- Managing ants can decrease mealybugs
- Other controls are chemical, most successful control from systemic treatments

Grapes: Japanese Beetles

- Larvae develop in soil
- Annual life cycle
- Highly polyphagous

NC STATE UNIVERSITY

Strawberry Diseases Biology and Integrated Management

Frank J. Louws and Mahfuzur Rahman
Department of Plant Pathology
North Carolina State University

Savannah International Convention Center
Savannah, Georgia
January 6, 2011

Fruit

Gray Mold
Anthracnose Ripe fruit rot
Gnomonia fruit rot
Leather fruit rot
Tan brown spot
Miscellaneous fruit rots

Leaf Diseases

Angular leaf spot
Common leaf spot (Mycosphaerella)
Phomopsis leaf blight
Gnomonia leaf blotch
Powdery mildew
Leaf scorch
Phytoplasmas

Minor Diseases
Major Diseases

Crown and Root Diseases

Anthracnose crown rot
Phytophthora crown rot
Black root rot
Red Stele
Southern stem blight
Armillaria root rot
Fusarium wilt
Botrytis crown rot
Nematodes (root knot, Pratylenchus, Sting)

STEPS IN DIAGNOSIS

NARROW IT DOWN

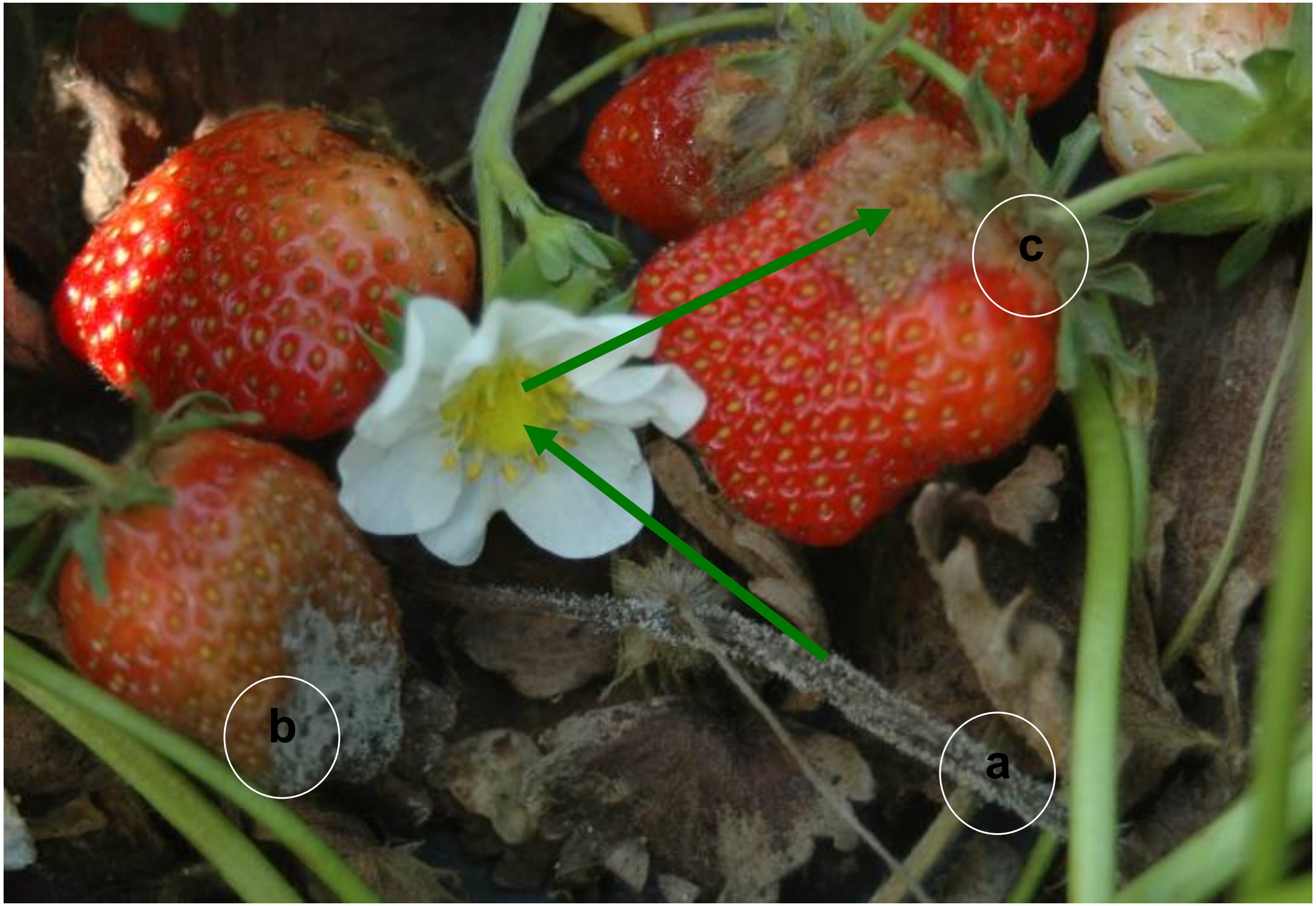
LIVING FACTOR
BIOTIC

- PATHOGEN
  - FUNGAL
  - BACTERIA
  - VIRUS
  - NEMATODE
- INSECT
- WEED
- OTHER PEST

NON-LIVING FACTOR
ABIOTIC

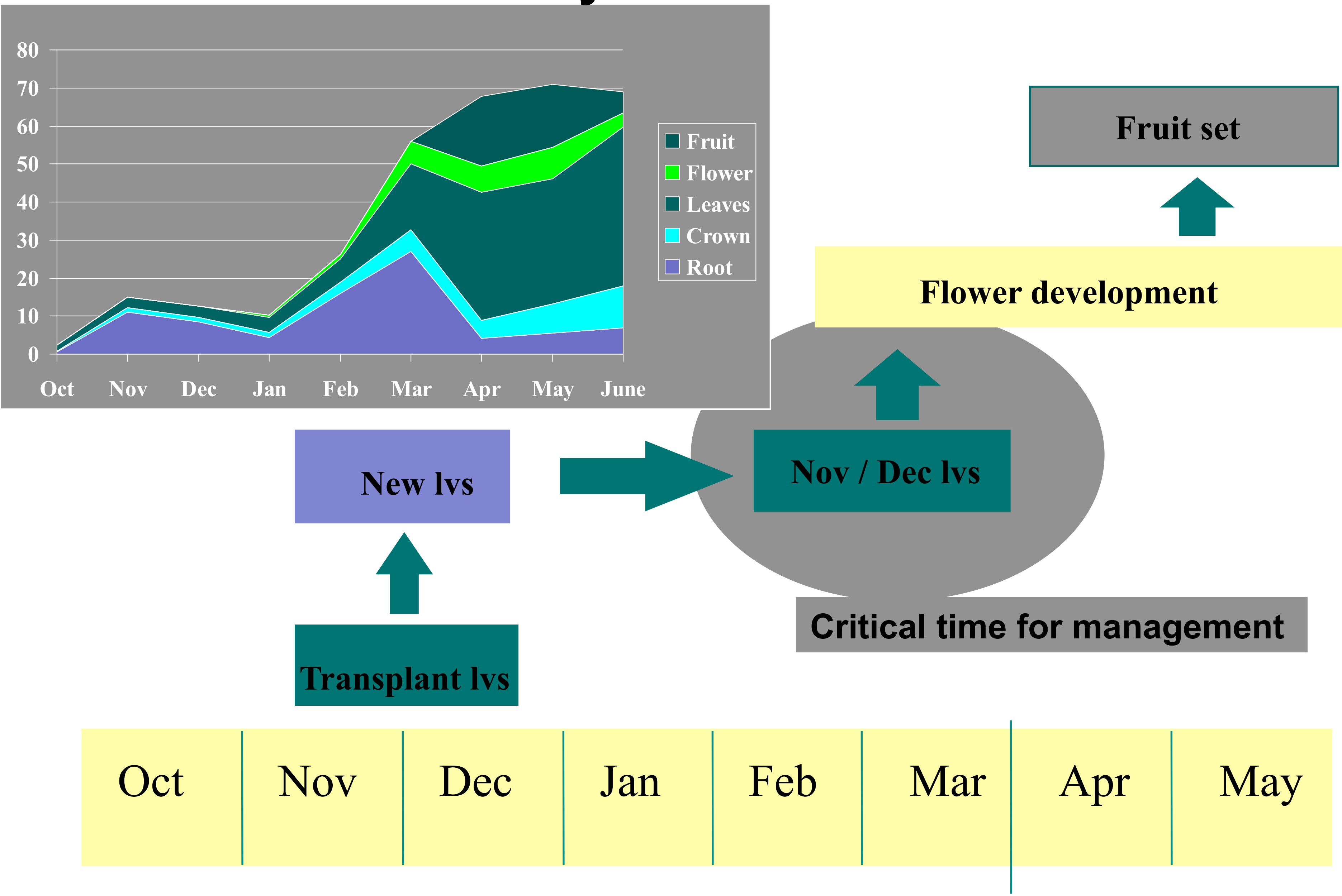
- MECHANICAL
- PHYSICAL
- CHEMICAL
  - SOIL pH
  - SALTS

Botrytis Biology: Gray mold of strawberry



Gray mold on different parts of strawberry; a) Sporulation on dead petiole and leaf; b) fruit infection from colonized dead tissue; c) lesion appearance from internal infection that has occurred through the flower parts such as the stigma.

Infection Cycle of *B. cinerea*



Source of inoculum


IPM-based Management for Gray Mold:

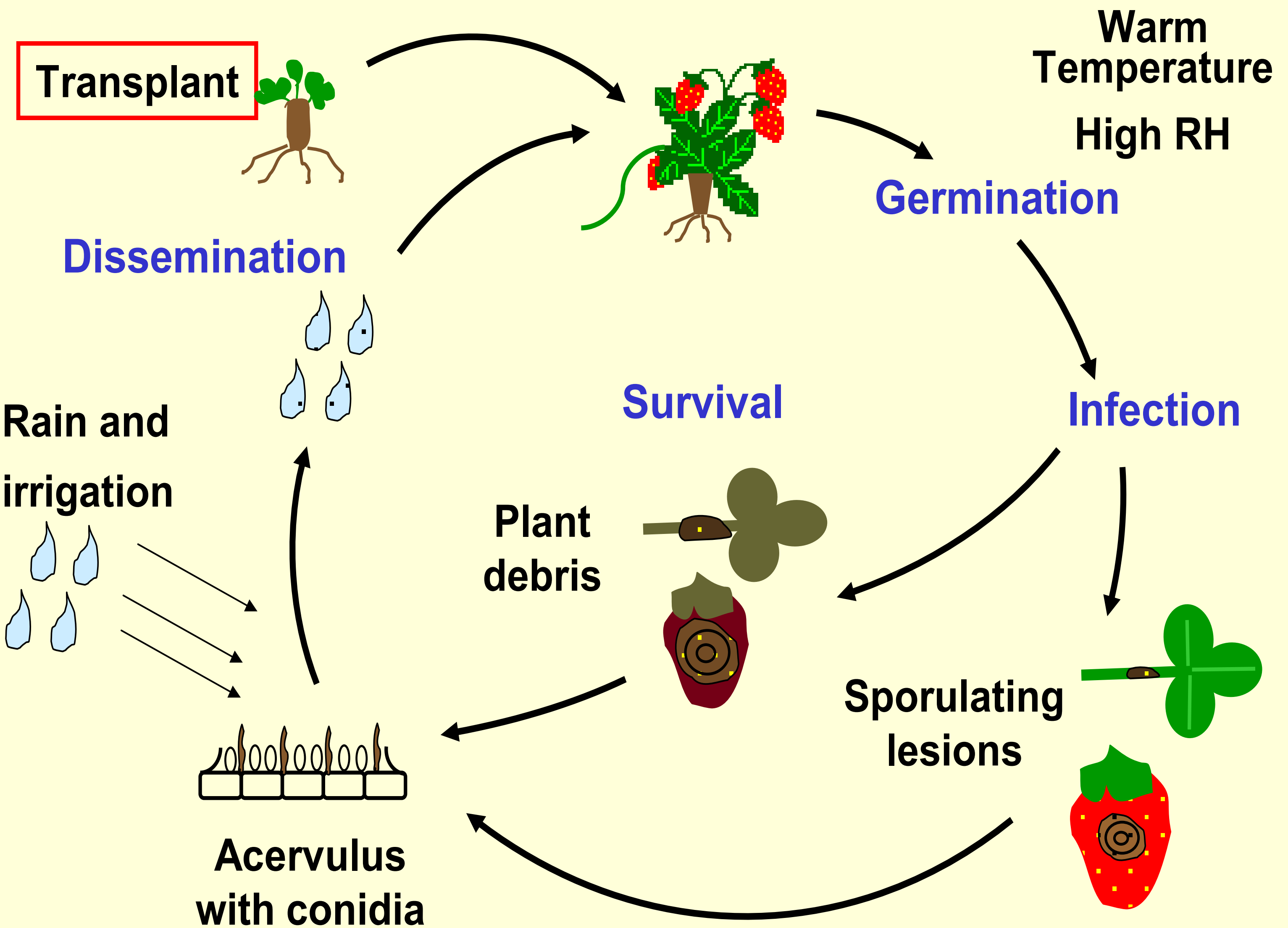
- manage optimum fertility
- optimum plant spacing
- remove dead and dying leaves before first bloom (not economical if fungicides will be used; never conduct if anthracnose is present)
- initiate fungicide sprays at first bloom
- Implement a fungicide program to reduce risk of disease and that seeks to prevent selection of Botrytis populations that are resistant to the new fungicides.

Strawberry Anthracnose: Biology

The Anthracnose Pathogens

Species	**Associated Disease Phase**	**Economic Importance in NC**
Colletotrichum acutatum	Fruit rot	High
Colletotrichum gloeosporioides	Crown rot	Low to moderate
Colletotrichum fragariae	Crown rot	Not found since 1986

Disease cycle of *C. acutatum* on strawberry



L. Leandro

Anthracnose

Ripe fruit rot/black spot:
Colletotrichum acutatum

Symptoms appear as whitish, water soaked lesions (3mm) eventually become sunken and black

Crown rot: ***C. gloeosporioides***

Symptoms: Above ground-Plant collapse/ wilting and death; Crown-firm, reddish brown/marbled appearance

All parts of strawberry are susceptible to *C. acutatum*

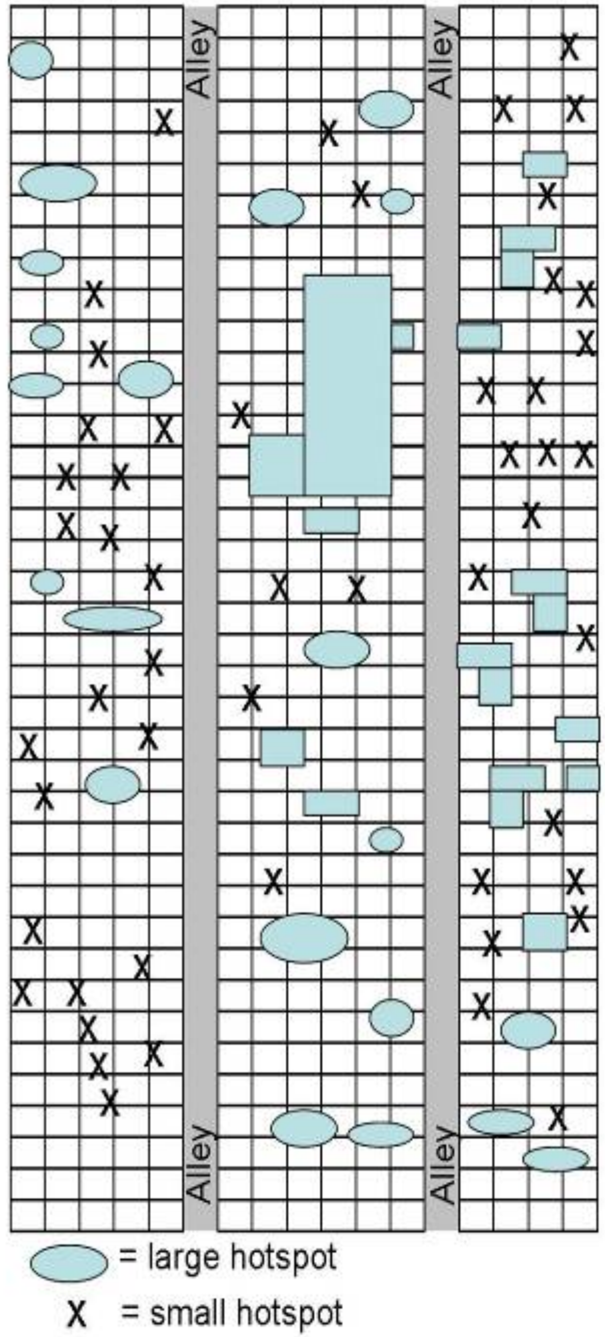
Anthracnose petiole rot, flower blight & green fruit rot

Symptoms on foliage

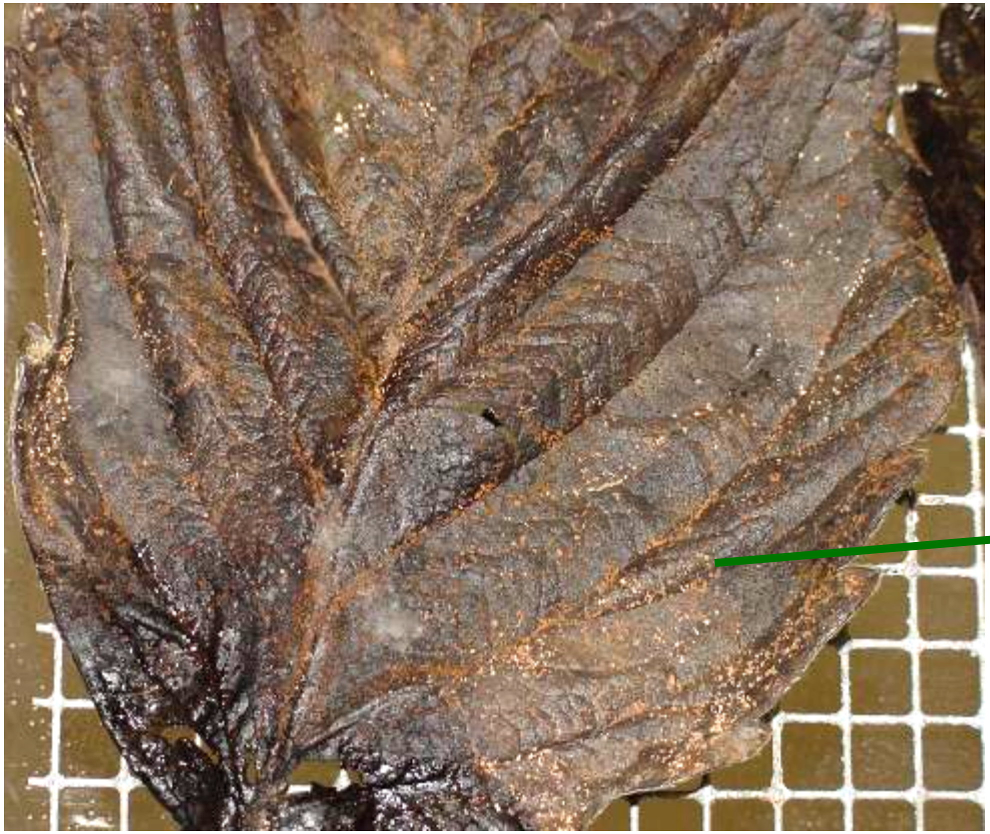
- Quiescently infected tips normally express symptoms during plug production under mist.
- Plants are not establishing in the field uniformly
- Black irregular lesions on leaf
- Black lesion on runner and petiole

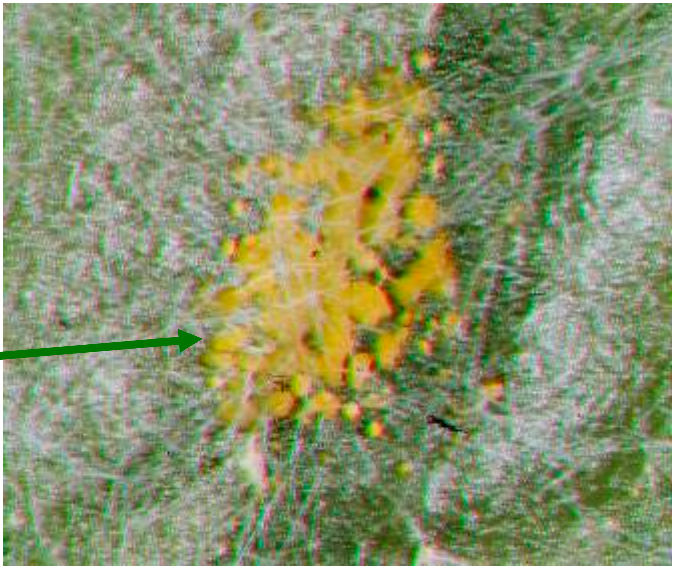
Problems in plug production and transplants (plant source)

Figure 3: Rough outline of hotspots within 60,000 plants.



(Gramoxone) Paraquat-killed leaves allow the pathogen to grow out.





The pathogen reproduces on green leaves without showing symptoms.

Biology: Anthracnose of strawberry

- Infested plants are the main source of disease.
- NC observations suggest over-summering of the disease does not occur if all infected plants are destroyed after final harvest.
- Infested tips leads to widespread problems in plug houses
- Quiescent infections may be present and spring epidemics occur under favorable conditions
- *C. gloeosporioides* can originate from wild hosts

Non cultivated wild host

Climbed on pine tree

Virginia Creeper leaf, *C. gloeosporioides*-
incidence very high
PCR tested
Strawberry inoculated in green house

Symptom reproduction in greenhouse

Symptom in Growth Chamber (34^0 C)

Isolate collected from Virginia Creeper (CH)

Crown also showed typical discoloration

Isolate collected from strawberry crown

Isolate collected from Virginia Creeper

Biology: Anthracnose of strawberry

- Infested plants are the main source of disease.
- NC observations suggest over-summering of the disease does not occur if all infected plants are destroyed after final harvest.
- Infested tips leads to widespread problems in plug houses
- Quiescent infections may be present and spring epidemics occur under favorable conditions
- *C. gloeosporioides* can originate from wild hosts

IPM-based Management for Anthracnose ripe fruit rot:

- buy disease-free plants (Tissue cultured, certified or grown under similar stringent conditions)
- immediately rogue out infected plants if small number
- destroy or bury all infected plants/fruit
- initiate QoI fungicides [Cabrio/Pristine] combined with or rotated with Captan sprays (NOTE: Failure using Quadris has occurred in recent years)
- specific recommendation programs with available fungicides for proactive management and re-active management of anthracnose ripe fruit rot.

Integrated Management Programs

- Know the Biology
- Use all available tools
- Screen products for efficacy
- Integrate products into program for anthracnose, Botrytis, and resistance management

•Make IPM recommendations to growers

Fungicides: New chemistry, Efficacy and Scheduling

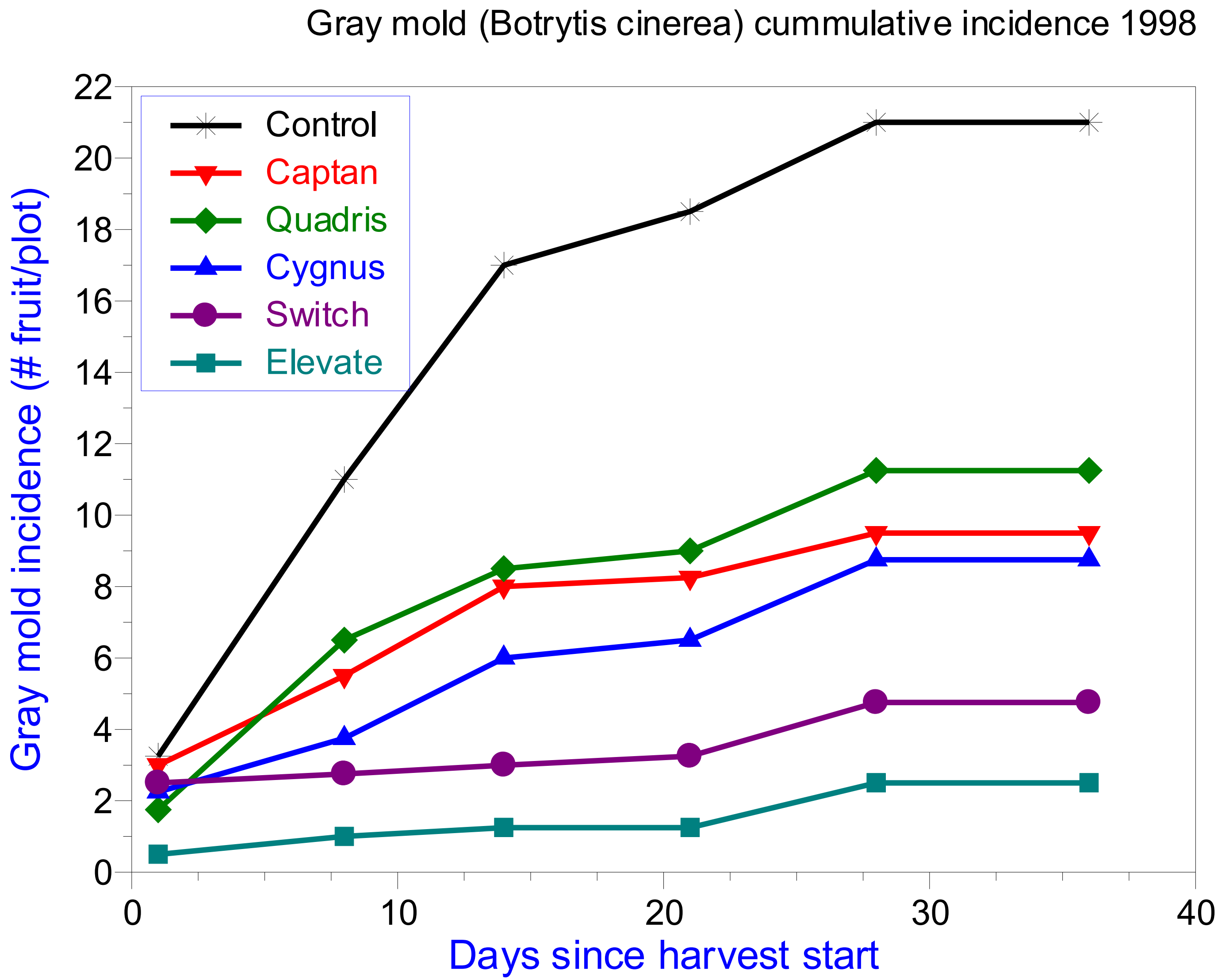
Captan
Topsin-M
Thiram
(Benlate)
Copper
Rovral

Elevate
Switch
Quadris
Cabrio
Pristine
Scala

Ridomil
Aliette
ProPhyt

Nova
Procur
Sulfur
Quintec

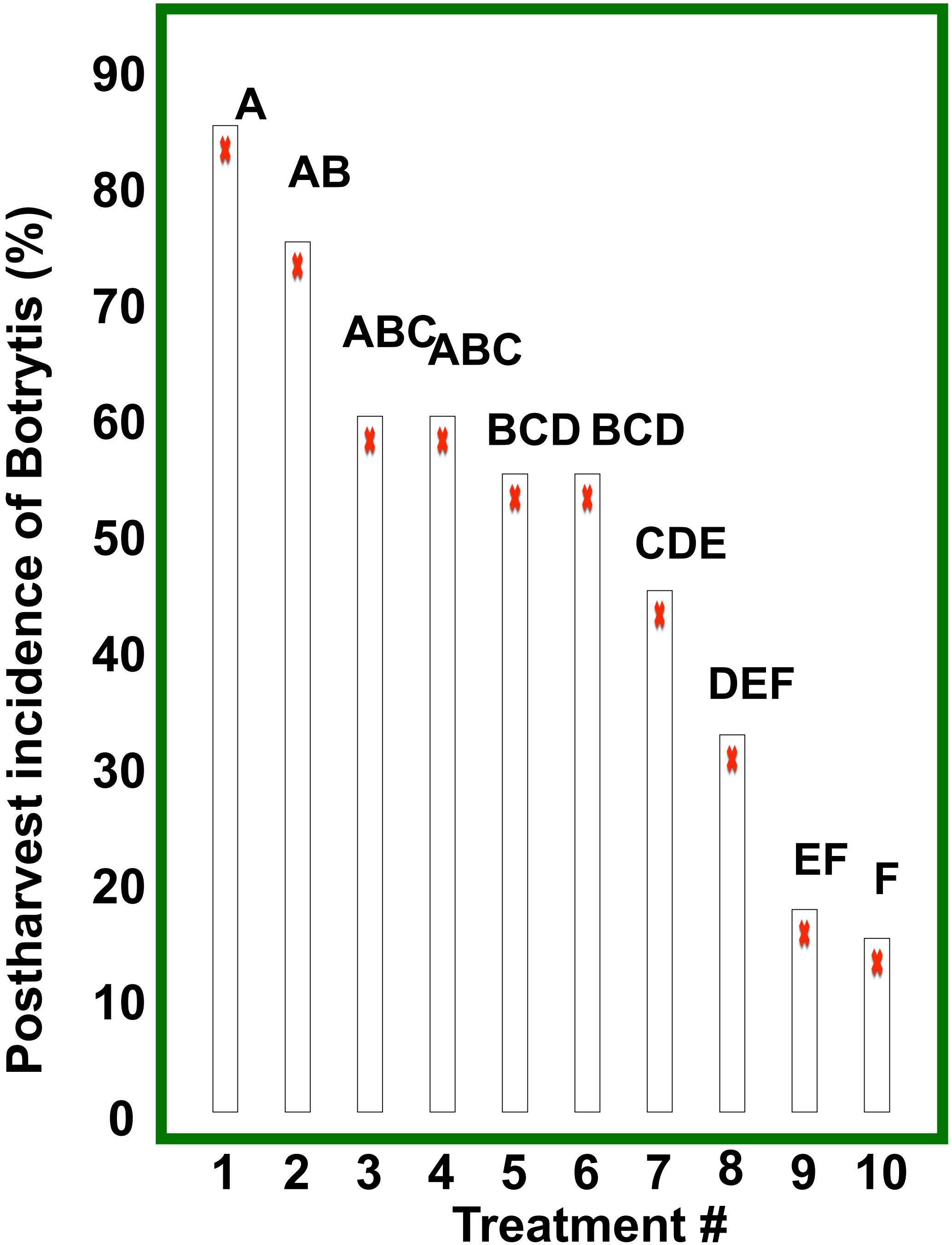
Fungicide Evaluations


Gray mold (Botrytis cinerea) cummulative incidence 1998
Gray mold incidence (# fruit/plot)
Days since harvest start
Control
Captan
Quadris
Cygnus
Switch
Elevate
0
2
4
6
8
10
12
14
16
18
20
22
0
10
20
30
40

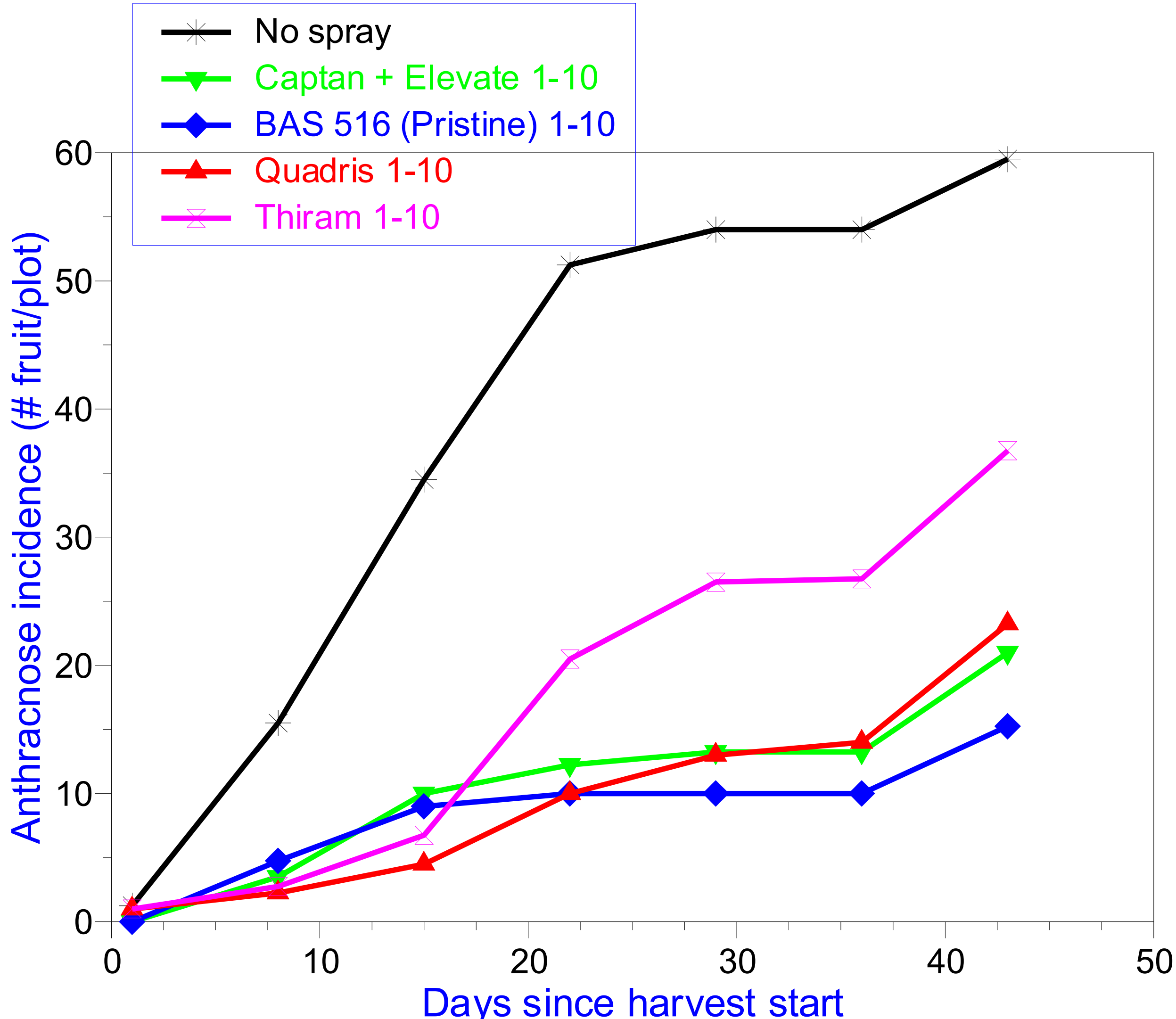
YIELDS FIRST 5 HARVESTS 2009

TRT #	Treatment	Fruit with Botrytis (g/plot)		Total Wt (g/plot)	MKTBLE Wt (g/plot)	%MKTBLE (g/plot)		% Gray Mold Wt (g/plot)	
4	Captan/P/Sw1-9	221.58	A	13198.20	12223.55	92.66	B	1.69	A
12	Capt/TM Fall and 1-9	237.83	A	13438.40	12280.35	91.49	B	1.73	A
2	Switch 1-9	225.73	A	12774.08	11600.35	90.95	B	1.75	A
3	**Captan/P/Sw1-4**	**226.88**	**A**	**12855.03**	**11312.15**	**88.14**	**B**	**1.75**	**A**
5	Captan/P/Capt1-9	242.33	A	12390.38	11370.61	91.80	B	1.95	A
1	Control	524.75	B	12494.58	11084.95	88.68	B	4.22	B
7	Alexin	773.05	C	12874.93	10528.25	81.96	A	5.94	C
		0.05		NS	NS	0.05		0.05	

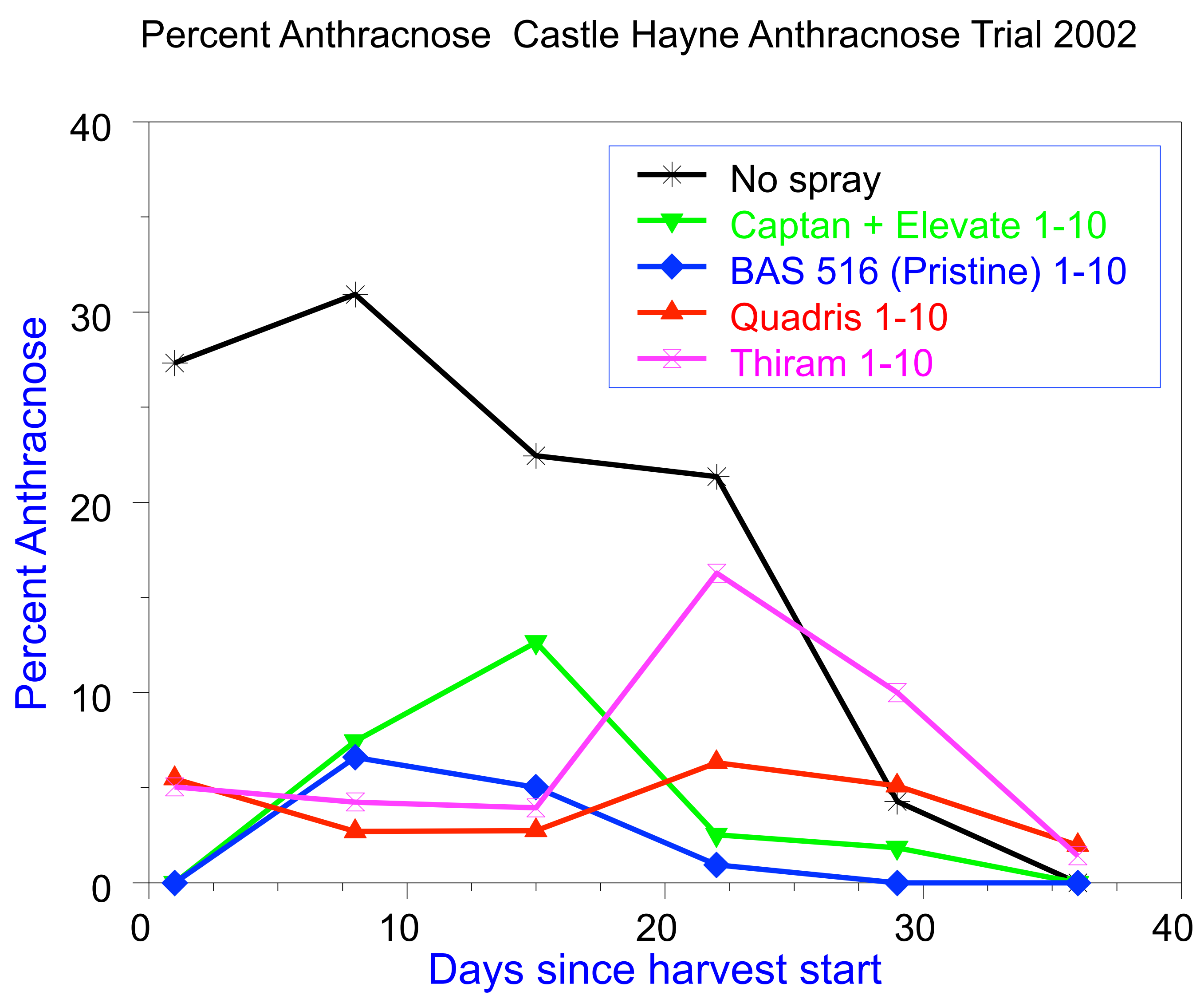
Importance of Post-harvest decay



1. No spray
2. Thiram 65WS 3.0 lb
3. Switch 62.5 WG 11 oz /
   Elevate 50 WG 1.5 lb
4. Elevate 50 WG 1.0 lb +
   Captan 50 WP 3.75
5. Elevate 50 WG 1.5 lb
6. Sanitation
7. Captan 50WP 4.0 lb +
   Topsin M 70W 1.1 lb /
   Elevate 50 WG 1.5 lb /
   Switch 62.5 WG 11 oz
8. Switch 62.5 WG 11 oz
9. Captan 50WP 4.0 lb +
   Topsin M 70W 1.1 lb /
   Pristine 1.45 lb /
   Switch 62.5 WG 11 oz
10. Pristine 1.45 lb



Anthracnose Incidence Castle Hayne Trial 2002



Percent Anthracnose Castle Hayne Anthracnose Trial 2002
Percent Anthracnose
0
10
20
30
40
0
10
20
30
40
Days since harvest start
No spray
Captan + Elevate 1-10
BAS 516 (Pristine) 1-10
Quadris 1-10
Thiram 1-10

Anthracnose Incidence 2002

Treatment and rate/A	Timing*	Anthracnose (%)**	Total yield (lb/plot)	Marketable fruit (%)
Sanitation ……………………………...………..	-	19.3 f	12.4	50.7 a
No spray ………………………………..........	-	17.5 ef	13.1	54.6 ab
Captan 50WP 4.0 lb + Quadris 2.08SC 9.0 fl oz …..	6-9	11.9 de	14.1	70.8 cd
Captan 50WP 4.0 lb + Quadris 2.08SC 9.0 fl oz Switch 62.5 WG 0.88 lb ………………….........	1,2 3,4	9.9 cd	14.2	64.0 bc
Thiram 65 WSB, 3.0 lb ……………………….....	1-10	9.0 bcd	15.9	68.9 cd
Switch 62.5WG 0.88 lb Quadris 2.08SC 9.0 fl oz ………………………..	1,3 2,4	8.1 abcd	14.5	63.7 bc
Quadris 2.08SC 9.0 fl oz ……….…….....................	1-10	5.4 abc	13.6	75.8 de
Elevate 50 WG 1.5 lb + Captan 50WP 5.63 lb ….....	1-10	4.6 abc	15.8	74.8 de
Switch 62.5WG 0.88 lb Elevate 50 WG 1.5 lb Captan 50WP 4.0 lb + Quadris 2.08SC 9.0 fl oz .	1,3 2,4 6-9	4.2 ab	18.2	81.3 e
BAS 516 UDF 38% 1.45 lb ……….…...................	1-10	3.0 a	15.4	83.0 e
LSD (*P*=0.05) ……………………………………...		5.5	NS	9.6

* Applications 1-10 correspond to weekly applications between 14 Mar and 16 May. Alternatively, fungicides were limited to 4 appl applied early season only (appl 1-4) or beginning at first appearance of anthracnose fruit rot (appl 6-9; no application in week 5).

** Values followed by the same letter within a column are not significantly different.

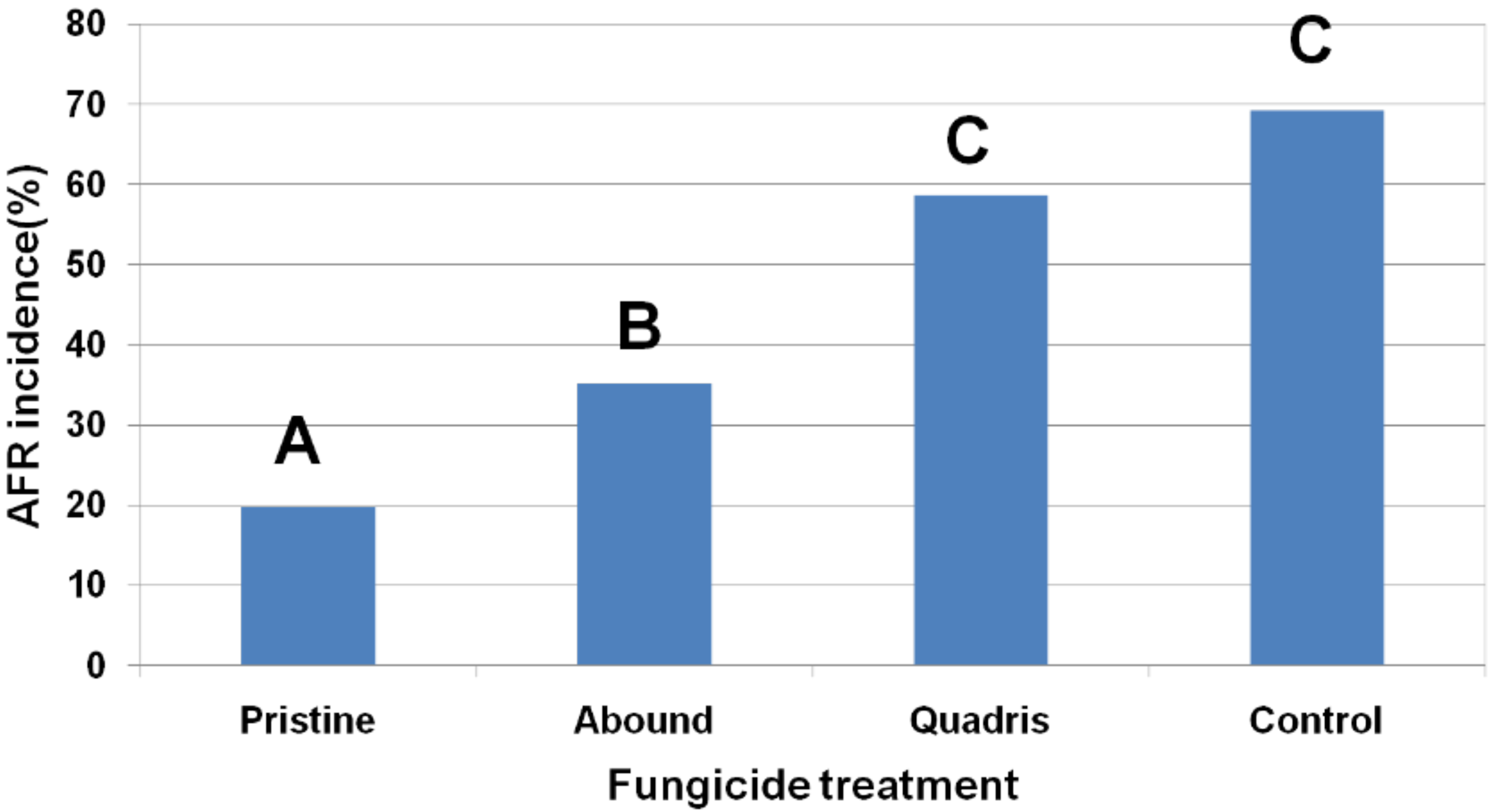
Efficacy of fungicides and biologicals against AFR, 2009

Treatments and rates (units product/A)	Schedule	Anthracnose Incidence (%)[w]	Marketable Yield (g/plant)
Not-treated……………………………………	---	67.85 ab	142.91
Captan 50 WP 4.0 lb + Topsin M 70 W 1.0 lb Pristine WG 1.45 lb……………………………..	spray #1,4,7,8 spray #2,3,5,6	*25.66 d*	*333.23*
Captan 50 WP 4.0 lb + Topsin M 70 W 1.0 lb Abound 12 fl oz ………………………………..	spray #1,4,7,8 spray #2,3,5,6	62.35 bc	250.69
KPP-105WP 2.0Kg……………………………..	spray #1-8	68.73 a	188.43
KPP105WP 4.0Kg……………………………...	spray #1-8	61.92 bc	197.10
Captan 50 WP 4.0 lb +Topsin M 70W 1.1 lb BU EXP 1216S4 3 lb CaptEvate 68WDG 4.5 lb BU EXP 1216S4 3 lb …….............................	Spray#1 Spray#2,4 Spray#3,5,7 Spray#6,8	60.72 c	280.21

[w]Means within a column followed by the same letter are not significantly different according to Fisher's protected LSD test ($P \leq 0.05$). Average from all harvests.

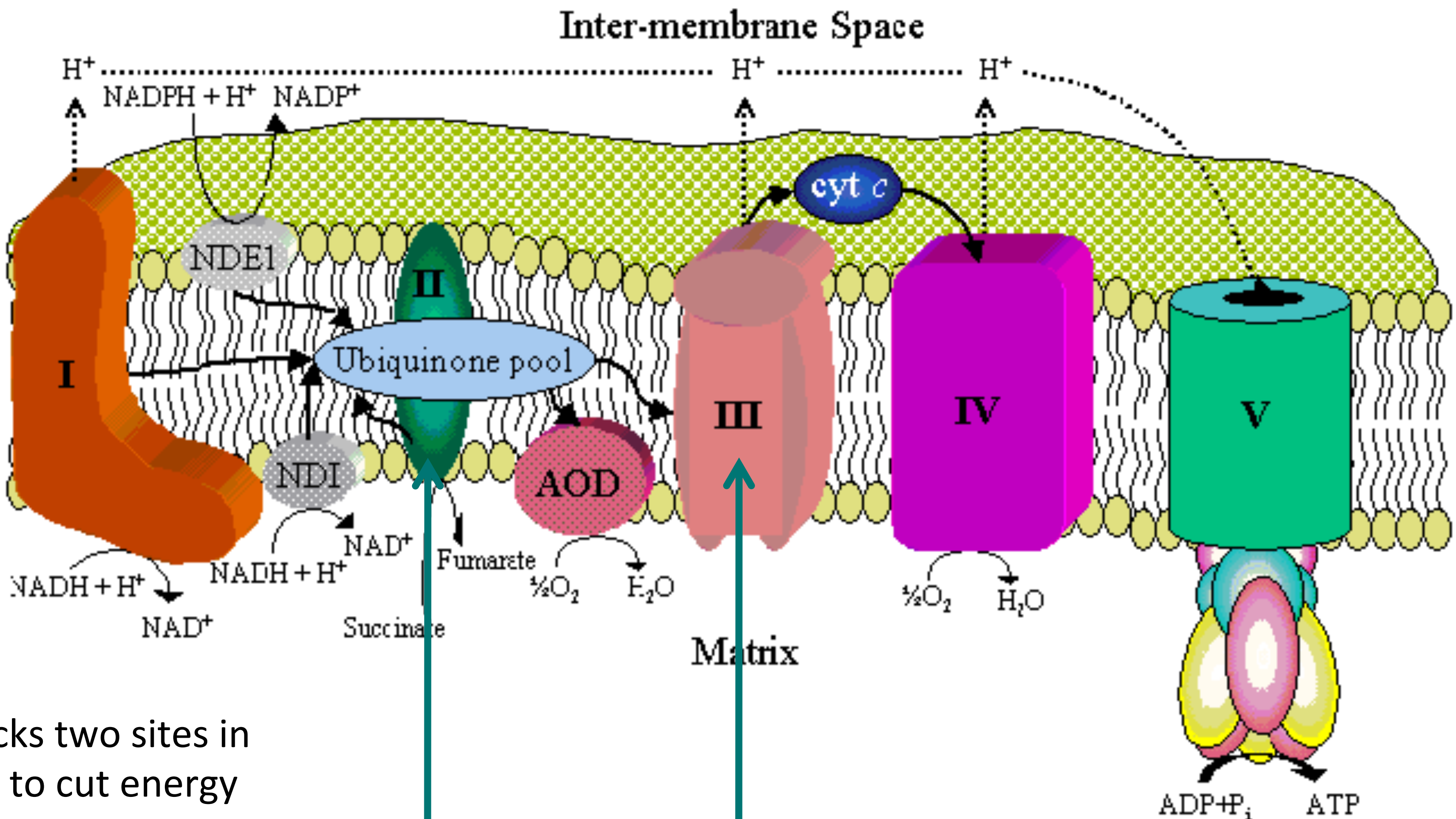
Abound did not work either in 2007-2008 or 2008-2009 while Captan, pristine based schedule was effective

Chemical control of AFR, 2010



Only from 6th harvest, fungicides were applied 24 h prior to inoculation

How premix a.i. products work?



Blocks two sites in ETC to cut energy production

Boscalid

Pyraclostrobin

SCHEDULE 1: For cases when there is no risk of anthracnose and growers need to focus on gray mold control.

For growers who adopt a conservative (low risk) fungicide program, apply sprays every 7-10 days according to the following suggested schedule:

Application # 1: at 10 % bloom apply captan + Topsin-M OR Switch

Application #2 : Elevate OR Pristine OR Switch

Application #3: same as #1 if there is a "full bloom" situation

Application #4 and "weekly": Rotate two or more of the following: captan, Elevate, Switch OR Pristine.

SCHEDULE 2: For cases where some insurance is desired against anthracnose but the focus remains on gray mold control.

Application # 1: at 10 % bloom apply captan + Topsin-M

Application #2 : Captan + Elevate (CaptEvate)
OR Pristine
(We have identified failure with Quadris for 'acutatum')
Application #3: same as #1 if there is a "full bloom" situation

Application #4 and "weekly": Rotate two or more of the following: Captan, Captan + Elevate, OR Pristine

HOBO leaf wetness smart sensor

Prediction based spray schedule

Treatments	# of sprays applied	AFR incidence (%)[ab]	Marketable yield (lb/plant)[b]
Non treated control	-	8.45 a	0.73 b
Regular Schedule Captan 50WP 4.0 lb + Topsin M 70W 1.0 lb Pristine WG 1.45 lb CaptEvate 68WDG 4.5 lb Pristine WG 1.45 lb ………………………	 1 2, 4 3, 5, 7 6, 8	3.22 b	0.87 a
Prediction based schedule Captan 50WP 4.0 lb Captan 50WP 4.0 lb Pristine WG 1.45 lb	 1 2 3	4.43 b	0.75 ab

[a]Disease incidence was calculated from all harvested fruits over 8 weeks

[b]Means in a column followed by the same letter are not significantly different by Fisher's protected LSD test ($\alpha \leq 0.05$).

Regional Recommendations:

Southeast Regional Strawberry Integrated Management Guide

http://www.smallfruits.org/SmallFruitsRegGuide/Guides/2010/2010StrawberryIMGFinal_Nov12.pdf

RELATIVE EFFECTIVENESS OF VARIOUS CHEMICALS FOR STRAWBERRY DISEASE CONTROL

F. J. LOUWS, Plant Pathology Extension

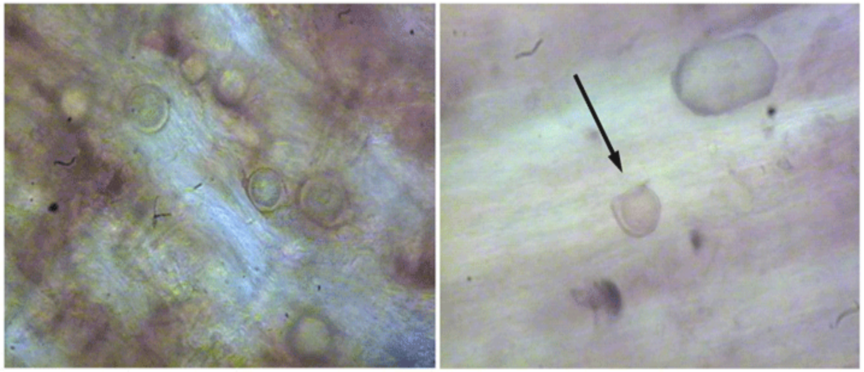
(— = ineffective; +++ = very effective; ? = efficacy unknown)

TABLE 7-16. RELATIVE EFFECTIVENESS OF VARIOUS CHEMICALS FOR STRAWBERRY DISEASE CONTROL

	Relative Control Rating											
Pesticide	Anthracnose (crown rot)	Anthracnose (fruit rot)	Gray Mold	Powdery Mildew	Common Leaf Spot	leaf blight and fruit rot	Leather Rot	Mucor Fruit Rot	Rhizopus Rot	Angular Leaf Spot	Phytophthora Crown Rot	Red Stele Root Rot
Strobilurins:												
azoxystrobin (Abound)	+++	+++	+	+	+	—	—	—	—	—	—	—
pyraclostrobin (Cabrio)	+++	+++	+	+	+	—	—	—	—	—	—	—
pyraclostrobin + boscalid (Pristine)	+++	+++	+++	+	+	—	—	?	?	—	—	—
captan (Captan)	++	++	++	—	+++	+	+	+	+	—	—	—
copper	—	—	—	—	+[P]	—	+[P]	—	—	+[P]	—	—
cyprodinil + fludioxinil (Switch)	+	+	+++	?	+?	+?	—	?	?	?	—	—
fenhexamide (Elevate)	—	—	+++	—	—	—	—	—	—	—	—	—
fenhexamide + captan (CaptEvate)	+	+	+++	—	++	+	+	+	+	—	—	—
fosetyl-Al (Aliette)	—	—	—	—	—	—	++	—	—	—	++	++
iprodione (Rovral)	—	—	+++[R]	—	++	—	—	X	—	—	—	—
mefenoxam (Ridomil)	—	—	—	—	—	—	+++[R]	—	—	—	+++	+++
myclobutanil (Nova)	—	—	—	+++[R]	++[R]	++[R]	—	—	—	—	—	—
phosphites (Phostrol and others)	—	—	—	—	—	—	++	—	—	—	++	++
pyrimethanil (Scala)	—	—	++	—	—	—	—	—	—	—	—	—
sulfur	—	—	—	++[P]	—	—	—	—	—	—	—	—
thiophanate-methyl (Topsin M)	+[R]	—	++[R]	+[R]	++	++	—	X	—	—	—	—
thiram (Thiram)	++	++	++	—	+	+	+	+	+	—	—	—
triflumizole (Procure)	—	—	?	+++[R]	?	?	—	—	—	—	—	—

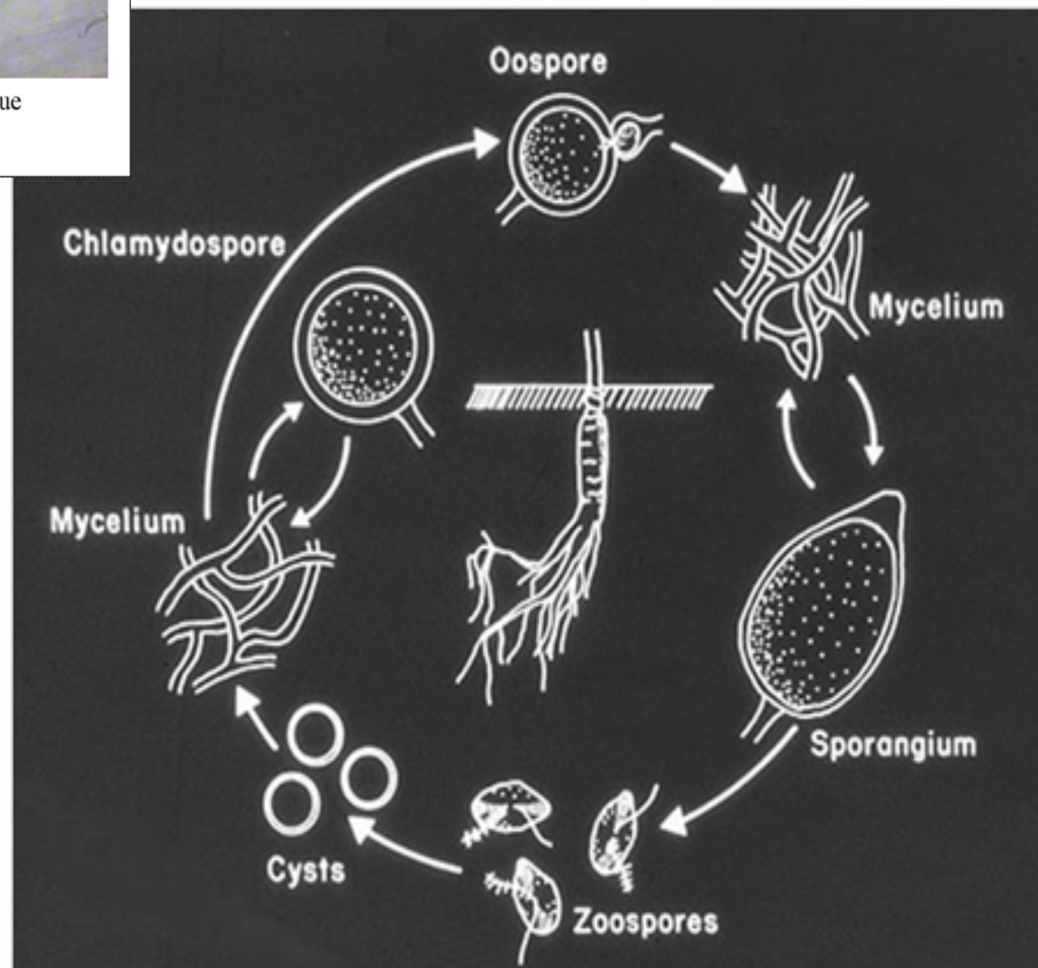
[R] = not effective if pathogen is resistant to the fungicide
[P] = phytotoxicity could occur
X = chemical use increases problem


Phytophthora crown and root rot



Oospores of *P. cactorum* can be seen in infected strawberry root tissue

(Photo courtesy of F.J. Louws, NC State University)



Disease Cycle of *P. cactorum*

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2010 Southeast Regional Strawberry Integrated Management Guide

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Recommendations are based on information from the manufacturer's label and performance data from research and Extension field tests.

Because environmental conditions and grower application methods vary widely, suggested use does not imply that performance of the pesticide will always conform to the safety and pest control standards indicated by experimental data.

Site Selection

- Good soil drainage is critical!
- Areas of standing water will increase the possibility of Phytophthora crown and root rot.

Strawberry Integrated Management Guide (continued)

Pre-planting: Disease Control

Pest/Problem	Management Options	Effectiveness (+) or Importance (*)	Comments
Anthracnose Angular leaf spot Phytophthora crown rot Viruses		***** +++++	Use of certified plants or plants produced in a similarly stringent program is the most important method to prevent these diseases.
Nematodes	Sample soil	***	Sample [illegible] for nematode analysis through local state services to determine which fumigant may be re[illegible]
	Crop rotation and cover crop selection	***	Selected su[illegible]ver crops and rotating fields to other crops for 2-3 years can suppress nematode po[illegible]
Weeds Root and crown rot disorders (Black root rot; Phytophthora crown rot)	Pre-plant fumigation and laying down plastic mulch	+++++	See fumigation [illegible] Consult with custom applicators and/or Extension agents for product and rate [illegible]ons.

Pre-plant fumigation and laying down plastic mulch

Use of certified plants or plants produced in a similarly stringent program is the most important method to prevent these diseases.

Relative Efficacy of Currently Registered Alternative Fumigants or Fumigant Combinations for Managing Soilborne Nematodes, Diseases, And Weeds					
Product	**Rate per Broadcast Acre**	**Nematodes**	**Disease**	**Nutsedge**	**Weeds: Annual**
Methyl bromide[1] (MB)	400 lb	+++++	+++++	+++++	+++++
Telone C35[3] (1,3-D + chloropicrin)	35 gal	+++++	+++++	+	+++
Telone C35 + VIF[3]	See comments below	+++++	+++++	+++	+++
Metam sodium[2] (MS)[3]	75 gal	++	+++	?	++++
Chloropicrin[3]	150 lb	+	+++++	—	—
Pic-Chlor 60[3] (chloropicrin + 1,3-D)	150 lb	+++++	+++++	+	+++
Chloropicrin + MS[3]	150 lb + 75 gal	++	+++++	?	++++
Midas 50:50 (iodomethane + chloropicrin)[3, 4]	160 lb	+++++	+++++	+++++	+++++

[1]Because of methyl bromide's high cost and diminishing supply, this fumigant is mostly available from distributors as a 50:50 formulation with chloropicrin. Reduced rates of MB are recommended for use with virtually impermeable film (VIF).

[2]Metam sodium can be Vapam, Sectagon or other registered formulations.

[3]Each of these fumigant alternatives has performed well in trials and can provide higher returns per acre than MB. Some fumigants may need to be complemented with herbicides or hand weeding depending on weed pressure. Refer to the "Herbicide Recommendation" section of this guide for directions pertaining to herbicide applications. Reduced rates can be used with virtually impermeable film (VIF).

[4]Virtually impermeable film (VIF) must be used for the Midas 50:50 rate of 160 lb/treated acre. Various formulations of Midas are available.

There are now several registered fumigants which provide good disease management, to include control of *Phytophthora* spp. in the planting bed.

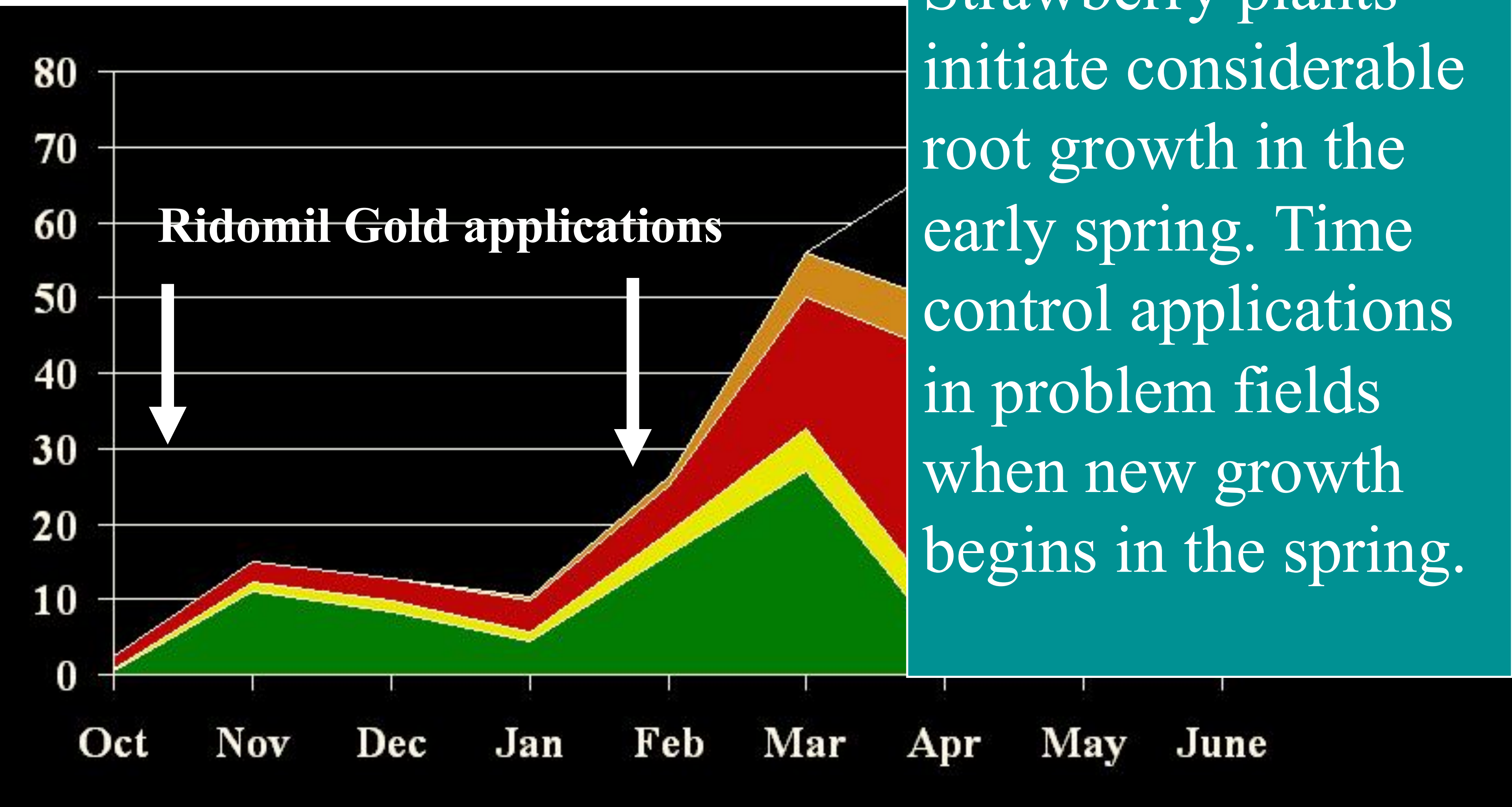
Several products are registered for plant dips to kill pathogens or to protect plants just prior to field setting, but only a limited amount of research has been done with plant dips. In general, these treatments are not recommended except under specific circumstances, for example, if a disease has been diagnosed to be on the transplants.

Phosphites—Dip plants in 2.5 lb/100 gal (Aliette), 2 pints/100 gal (ProPhyt), or 2.5 pints/100 gal (Phostrol) for 15 to 30 minutes, and then plant within 24 hours after treatment. This treatment should help to suppress *Pythium* and *Phytophthora* problems.

Phytophthora Fungicidal Tools

Fungicide	Application Rate	REI	PHI	Comments
Ridomil Gold SL	1 pt/acre	12 hrs	0 days	3 applications are allowed.
Phosphites (phosphonates) i.e. Aliette, ProPhyt, etc.	Various rates; see label	12 hrs	0 days	Red Stele and Leather Rot are on the label. Do not tank mix with copper compounds of foliar fertilizers.

Management through root-development phenology-based recommendations



Strawberry plants initiate considerable root growth in the early spring. Time control applications in problem fields when new growth begins in the spring.

What about resistance development?

- Mefenoxam resistance has been reported for *P. cactorum* (crown rot) in South Carolina (Jeffers et al., 2004).
- Continued and exclusive use of mefenoxam may easily select for resistant *P. cactorum* isolates in individual field sites, resulting in control failure.

The phosphite-based chemicals (ProPhyt, Aliette, etc.) are not as effective as Ridomil Gold. Consider phosphites if the pathogen is known to be resistant to mefenoxam or if strawberry plants have poor root systems but sufficient foliage for chemical uptake.

Table 1. Effects of treatments with Aliette or Ridomil on productivity of two strawberry cultivars in non-infested soil and soil infested with *Phytophthora cactorum*[a]

Strawberry cultivar	Soil treatment[b]	Chemical treatment program[c]	Marketable yield (total grams per plant)
Diamante	Infestation w/ *P. cactorum*	Aliette plant dip and spray	1031
		Water control plant dip and spray	572
		Ridomil soil drench	1163
		Water control soil drench	659
	Non-infested control	Aliette plant dip and spray	1113
		Water control plant dip and spray	1097
		Ridomil soil drench	1172
		Water control soil drench	1128
Aromas	Infestation w/ *P. cactorum*	Aliette plant dip and spray	1388
		Water control plant dip and spray	938
		Ridomil soil drench	1400
		Water control soil drench	891
	Non-infested control	Aliette plant dip and spray	1481
		Water control plant dip and spray	1250
		Ridomil soil drench	1463
		Water control soil drench	1384
Least significant difference:			**386**

Aliette = dip and five applications
Ridomil = 3 applications

Strawberry disease diagnosis

Cut the crown longitudinally

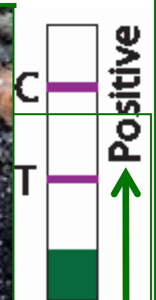
No discolorati-on inside crown

Abiotic causes are most likely

* High salt
* Boron toxicity
*Improper planting depth

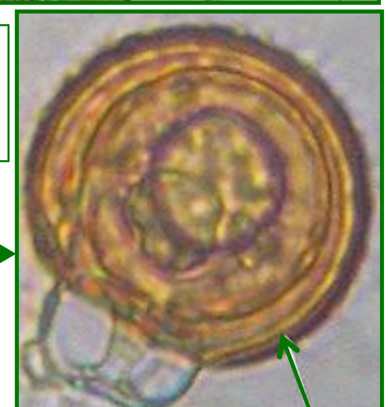
Marbled reddish brown-most likely glo crown rot

Dull brown color-most likely Phytophthora

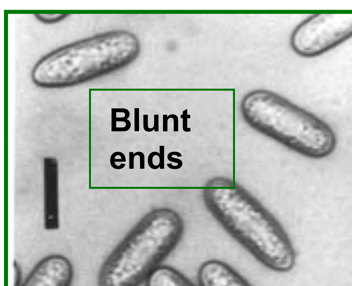


Presumptive quick test with Agdia immunoStrip

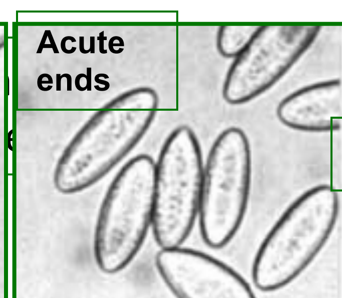
Incubate the crown in a plastic container on 3 layers of moist paper towels



Oospore (*P. cactorum/fragariae*)



C. gloeosporioides



C. acutatum (rare)

If no conclusion is drawn, proceed with DNA based method

ANGULAR LEAFSPOT

Xanthomonas fragariae

- **has a narrow host range restricted to strawberry**
- **Distribution: now world-wide probably on infected plants**

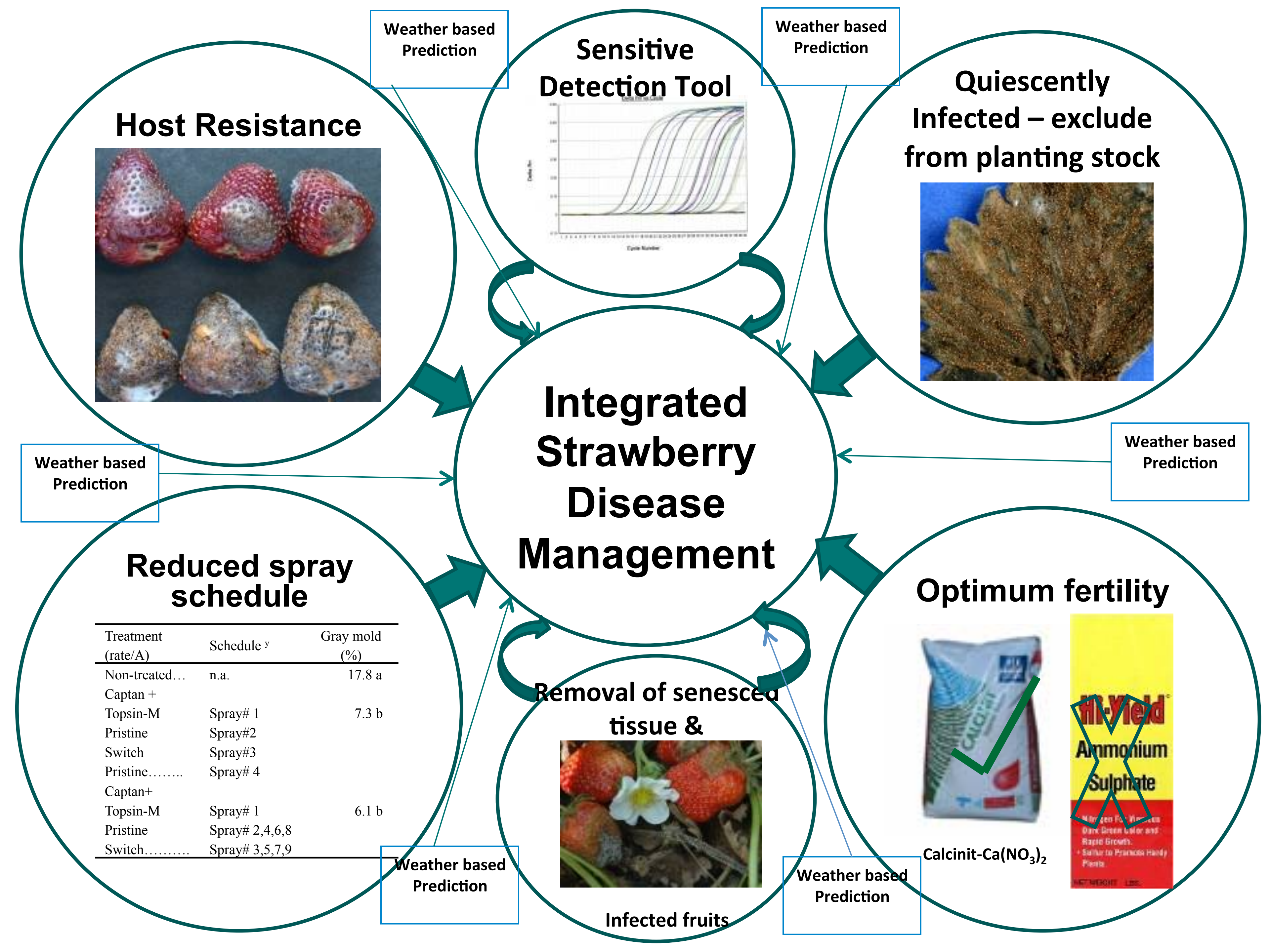

Angular Leaf Spot Disease Management Requires

1. SITE SELECTION AND PREPARATION: NA

2. USE DISEASE FREE PLANTS: Use healthy plants, although symptoms may not be apparent at the time of field setting.

3. MONITOR AND MANAGE: Limit overhead watering and frost protection events; Use row-covers in frost protection.

4. CHEMICAL CONTROL: No products have shown effective control or benefits. Copper may be useful to limit the occurrence of calyx infections. Use 3 applications during cool wet weather and as fruit is forming.


Integrated Strawberry Disease Management
Host Resistance
Sensitive Detection Tool
Quiescently Infected – exclude from planting stock
Optimum fertility
Calcinit-Ca(NO3)2
Hi-Yield
Ammonium Sulphate
Removal of senesced tissue &
Infected fruits
Reduced spray schedule
Treatment (rate/A) | Schedule y | Gray mold (%)
Non-treated… | n.a. | 17.8 a
Captan + Topsin-M | Spray# 1 | 7.3 b
Pristine | Spray#2
Switch | Spray#3
Pristine…….. | Spray# 4
Captan+ Topsin-M | Spray# 1 | 6.1 b
Pristine | Spray# 2,4,6,8
Switch………. | Spray# 3,5,7,9
Weather based Prediction
Weather based Prediction
Weather based Prediction
Weather based Prediction
Weather based Prediction
Weather based Prediction
Cycle Number

Stem blight and propagation issues in blueberry

Agent Training
Jan 2010—Savannah GA

Phil Harmon
Assistant Prof. and Extension Specialist
Plant Pathology Dept., UF Gainesville

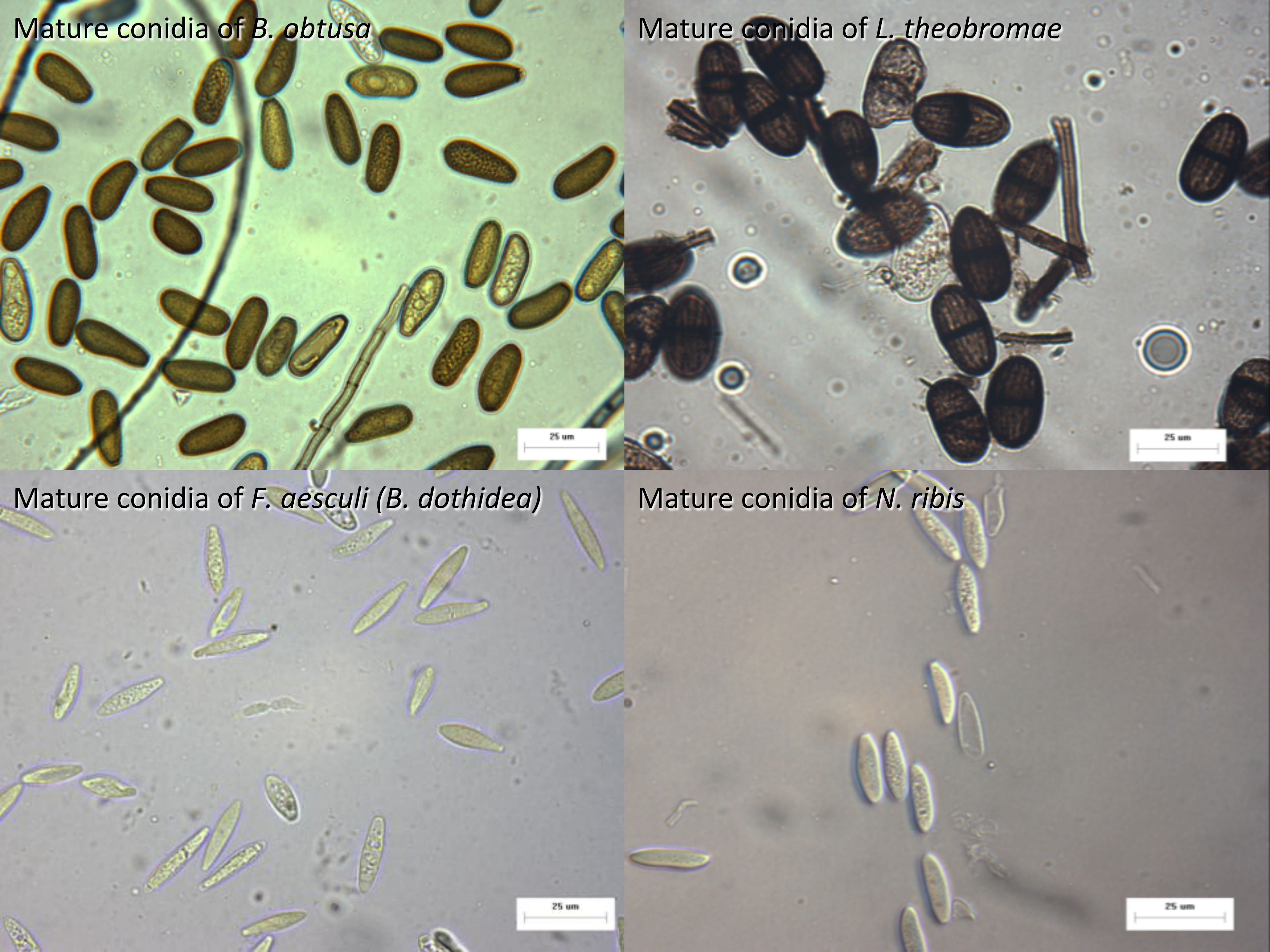
UNIVERSITY OF
FLORIDA
IFAS EXTENSION

Two Symptoms

- Flagging symptom reduces yield and plant vigor
  - Requires hand-pruning to remove diseased wood
- Crown infection reduces vigor and kills plants just as they start to become productive
  - Requires replant
  - Lost establishment investment
  - Lost yield profit


Discoloration under the bark at the crown of plants with dieback
stem blight

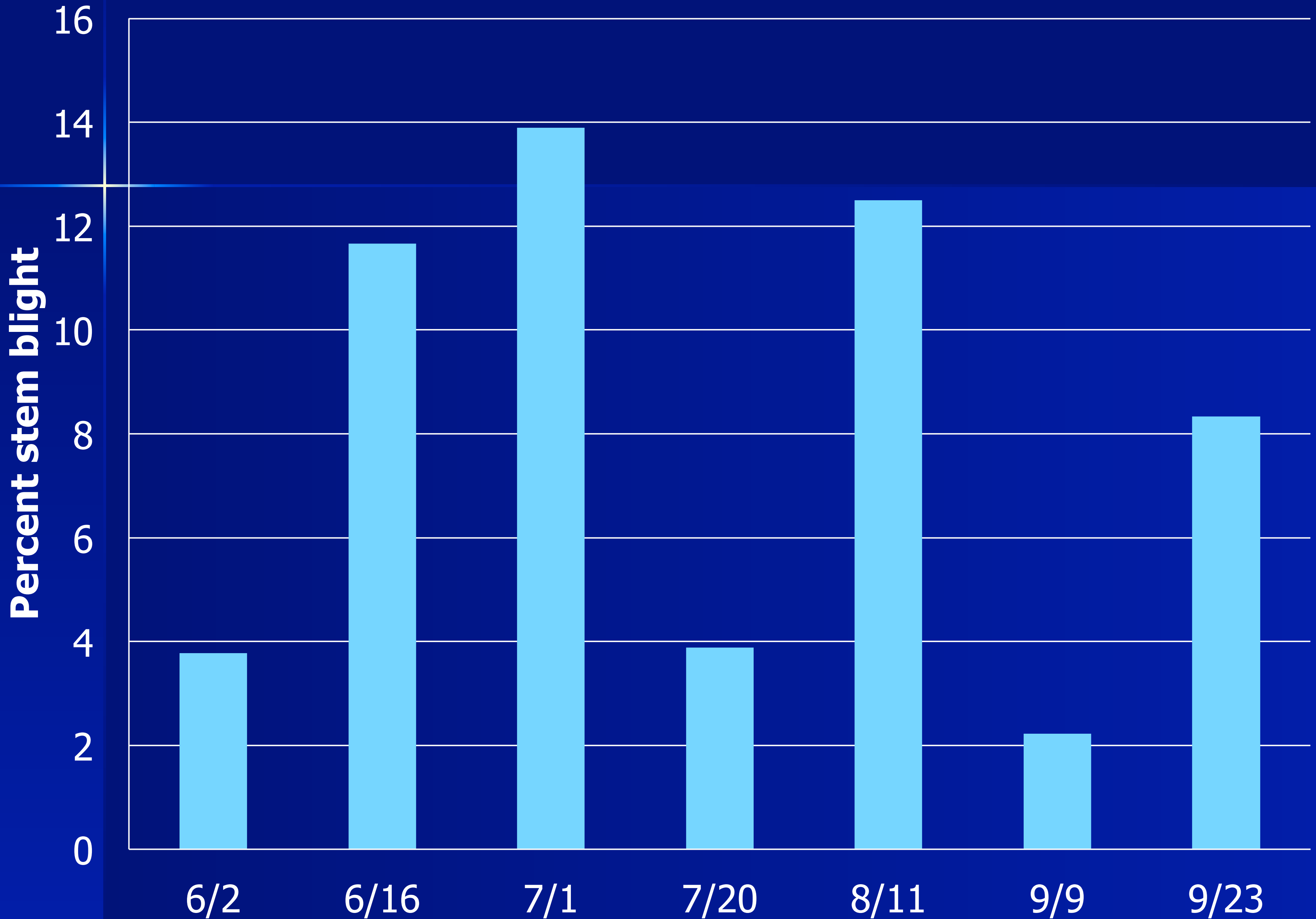
Botryosphaeria fungi


Mature conidia of *B. obtusa*
25 um
Mature conidia of *L. theobromae*
25 um
Mature conidia of *F. aesculi (B. dothidea)*
25 um
Mature conidia of *N. ribis*
25 um


Star SW cuttings taken from field

10 to15% of 'Snowchaser' cuttings developed stem blight

Snowchaser cuttings from Windsor, FL. 2009



Latent infection or external contaminant?

Leaves and stems washed for 2hrs.
Lisate was filtered onto sterile filter paper and placed onto PDA with rif and amp.

Leaves and stems were surface sterilized with bleach and then plated

Number of Bot. colonies recovered from lisate

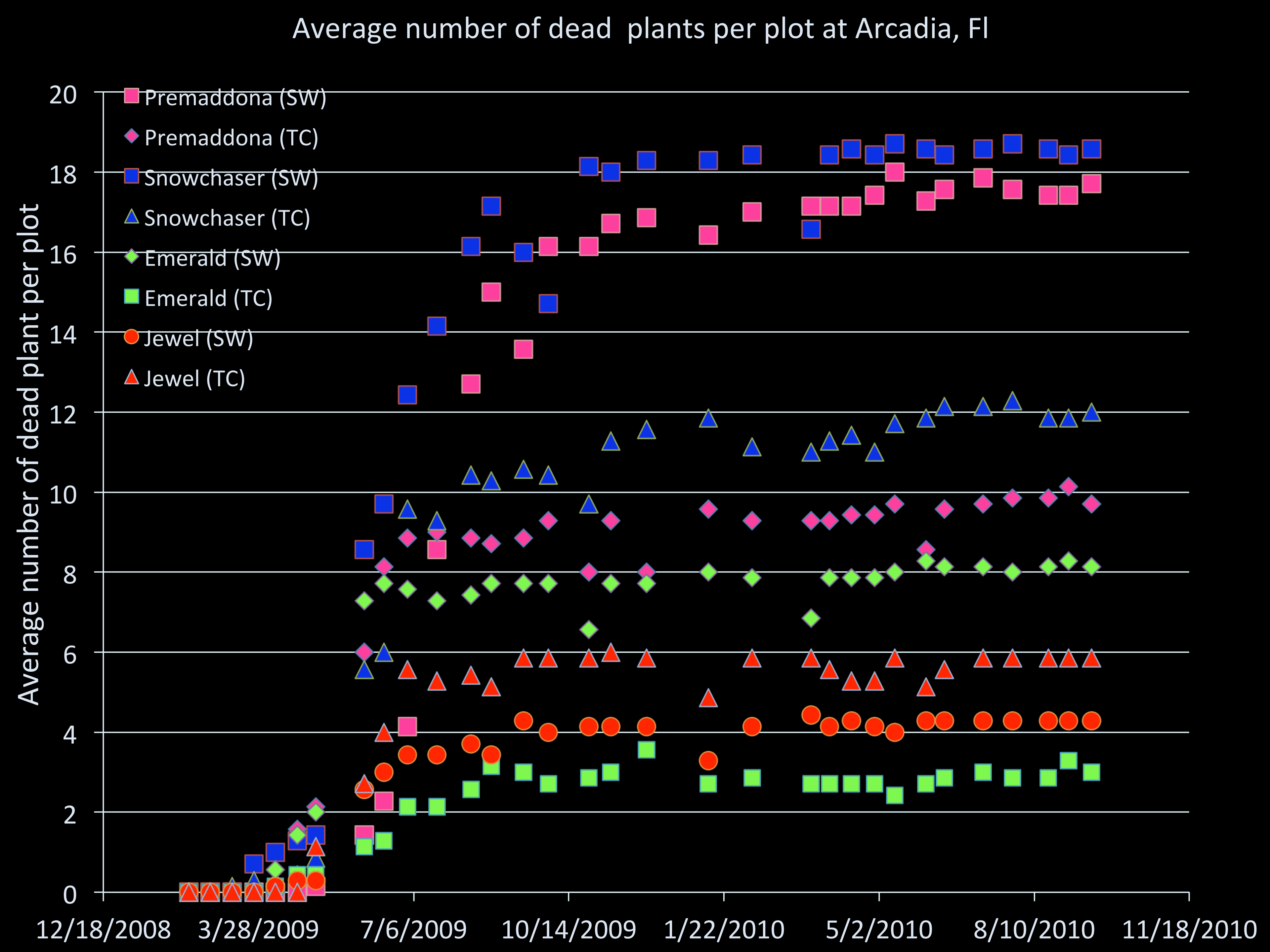
Date	No. Colonies	*B. obtusa*	*L. theobromae*	*N. ribis*	Unknown
5/20/10	0	-	-	-	-
6/30/10	0	-	-	-	-
7/28/10	1	-	1	-	-
8/28/10	1	-	-	1	-
9/28/10	6	-	2	2	2

Number of Bot. colonies recovered from surface sterilized swc

Date	No. Colonies	*B. obtusa*	*L. theobromae*	*N. ribis*	Unknown
5/20/10	1	1	-	-	0
6/30/10	6	-	1	3	2
7/28/10	7	-	-	4	3
8/28/10	7	-	-	6	1
9/28/10	10	-	-	9	1

Propagation methods 2009-10

	Total	Stem blight	Percent
Alachua Co.			
SW	22	14	63%
TC	17	4	2%
Total	39	18	45%
DeSoto Co.			
SW	242	234	96%
TC	43	35	81%
Total	285	269	94%
Polk Co.			
SW	49	35	71%
TC	6	1	2%
Total	55	36	65%



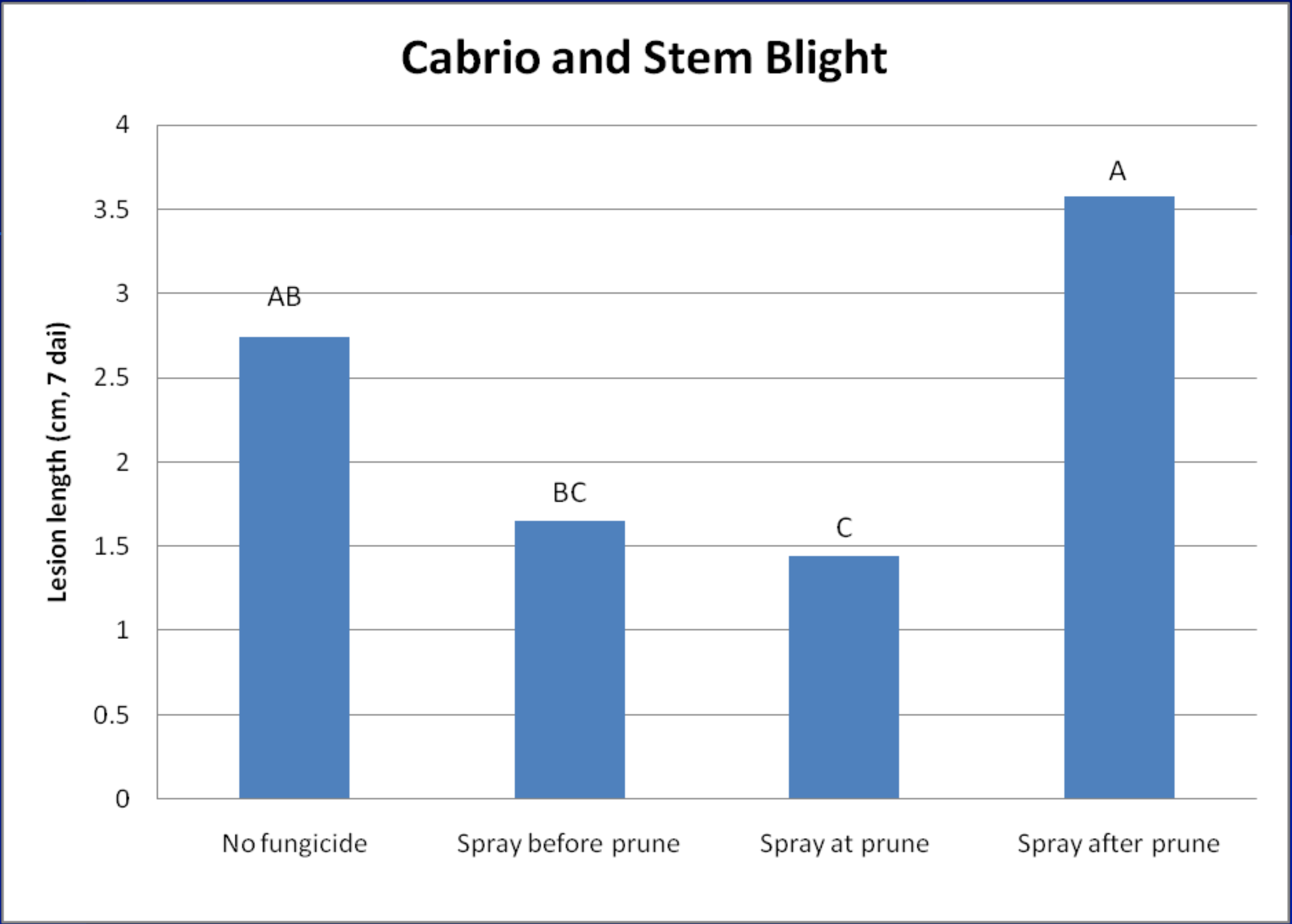
Average number of dead plants per plot at Arcadia, Fl
Premaddona (SW)
Premaddona (TC)
Snowchaser (SW)
Snowchaser (TC)
Emerald (SW)
Emerald (TC)
Jewel (SW)
Jewel (TC)
Average number of dead plant per plot
20
18
16
14
12
10
8
6
4
2
0
12/18/2008
3/28/2009
7/6/2009
10/14/2009
1/22/2010
5/2/2010
8/10/2010
11/18/2010

Management strategies (general)

- Choose clean plant material for propagation.
- Prune out blight and remove diseased plant material from the field—remove plants with severe dieback. They cannot be cured.
- Manage irrigation carefully to prevent water stress.
- Do not allow young plants to overproduce berries in the first few years.
- Fungicides used to manage fruit rots, leaf spots, and other foliar diseases may help with this disease by reducing stress, especially in nursery situations.
- Use less-susceptible cultivars
- Fungicide use at pruning?

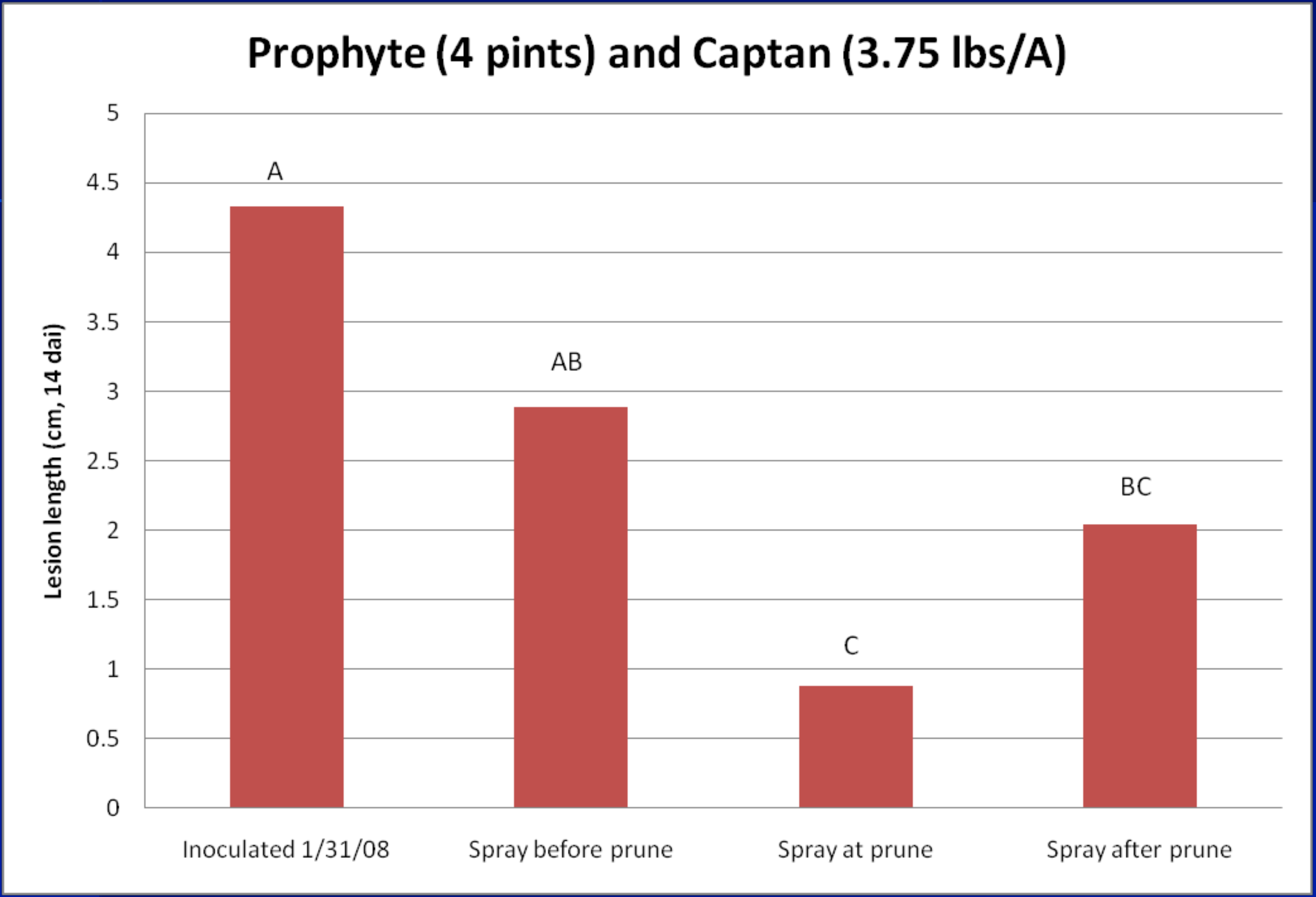
Management strategies

- More on fungicides
  - Applications in fall 2006 did not prevent plants from dying through Fall 2007.
  - Pruning out disease in the plots did not reduce the number of plants that died
  - Increased fall fertility did not affect rate of plant death
- Marginal reduction in disease observed when applications made same day as pruning



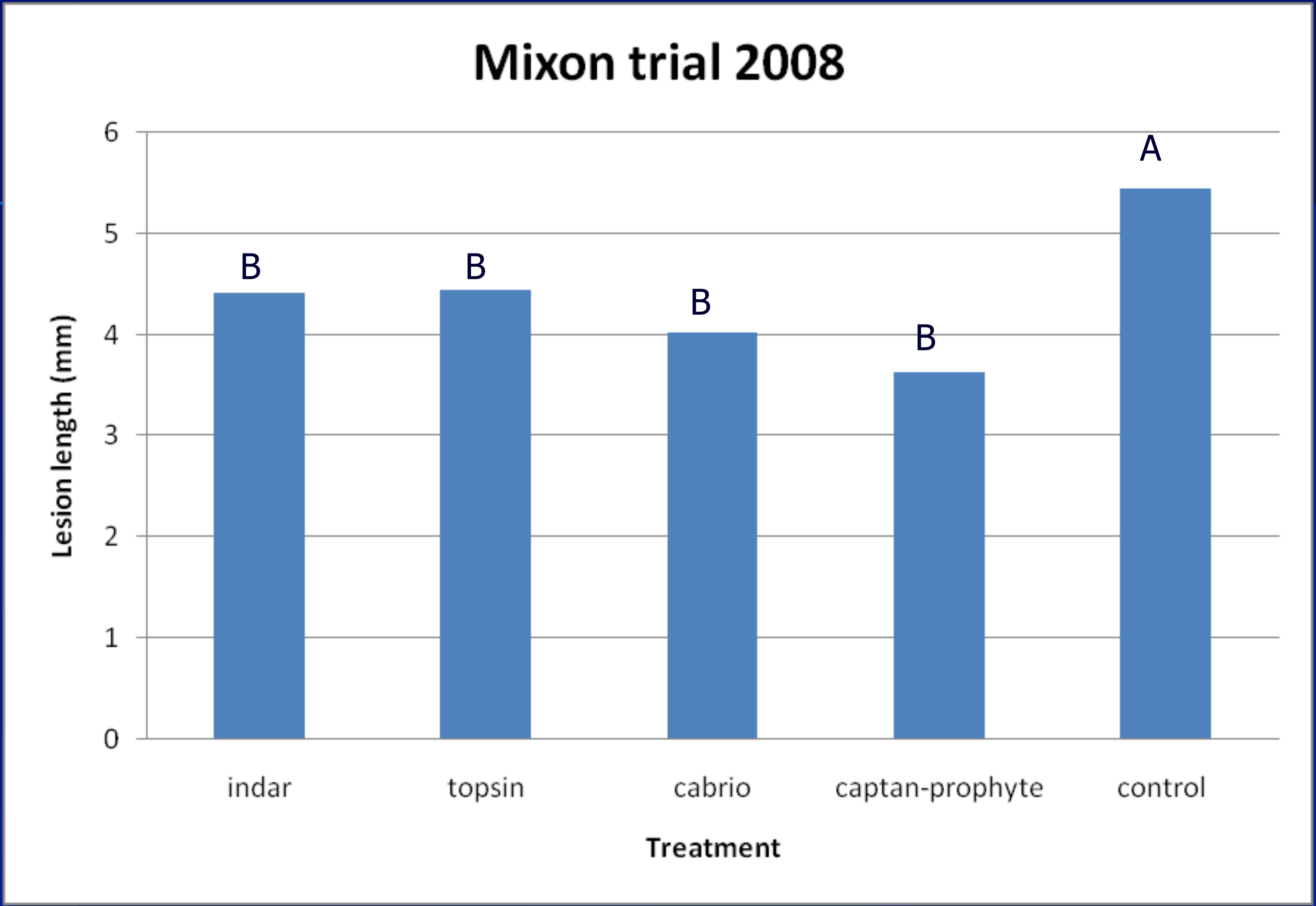
Cabrio and Stem Blight
Lesion length (cm, 7 dai)
4
3.5
3
2.5
2
1.5
1
0.5
0
AB
BC
C
A
No fungicide
Spray before prune
Spray at prune
Spray after prune

GH trial



Prophyte (4 pints) and Captan (3.75 lbs/A)
Lesion length (cm, 14 dai)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
A
AB
C
BC
Inoculated 1/31/08
Spray before prune
Spray at prune
Spray after prune

GH trial



Mixon trial 2008
Lesion length (mm)
0
1
2
3
4
5
6
B
B
B
B
A
indar
topsin
cabrio
captan-prophyte
control
Treatment

Field trial

Thanks. Questions?

Phil Harmon
pfharmon@ufl.edu


Bacterial Leaf Scorch of Blueberry
Don Hopkins
Mid Florida REC
University of Florida

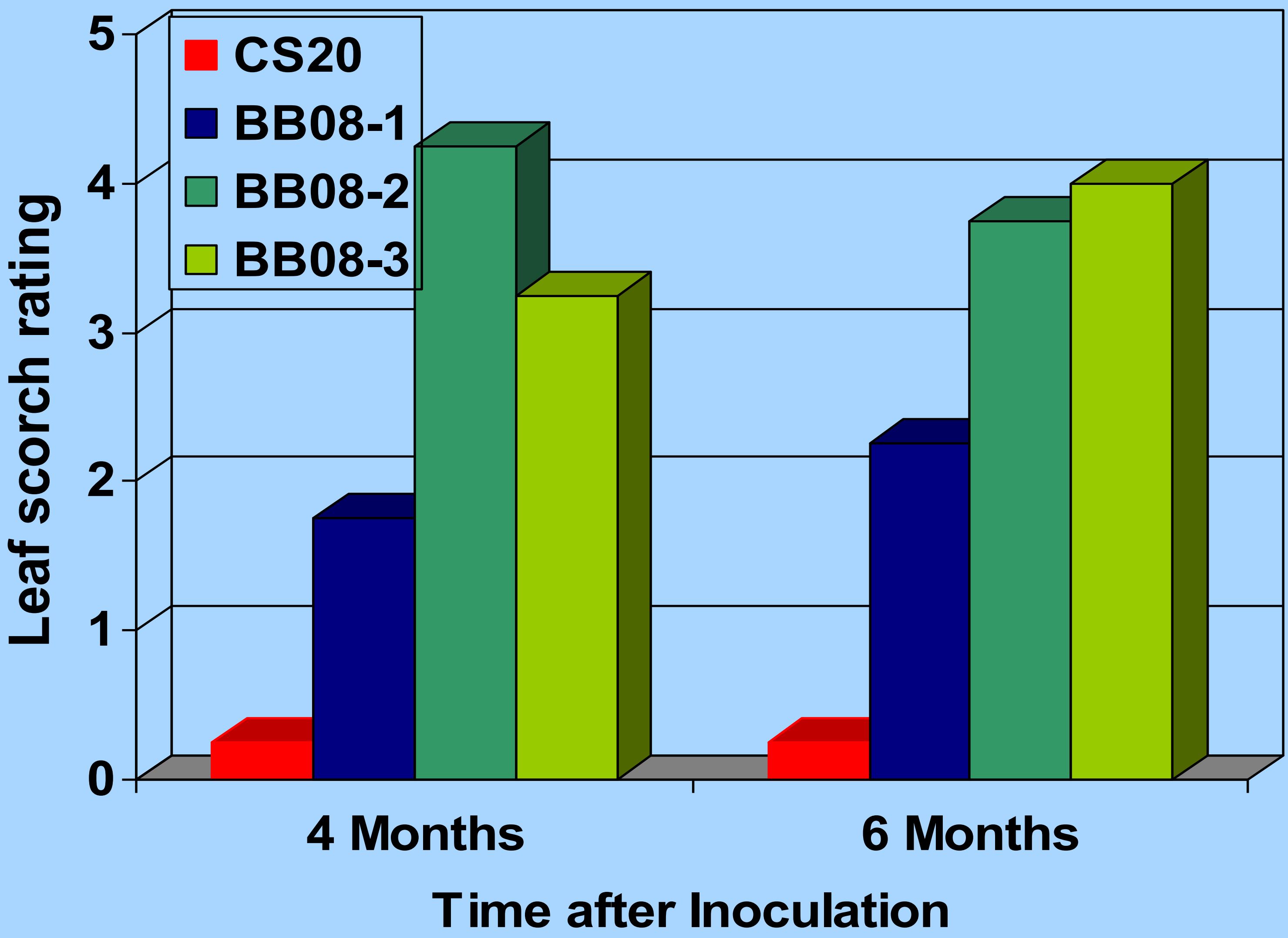
Blueberry Leaf Scorch Symptoms

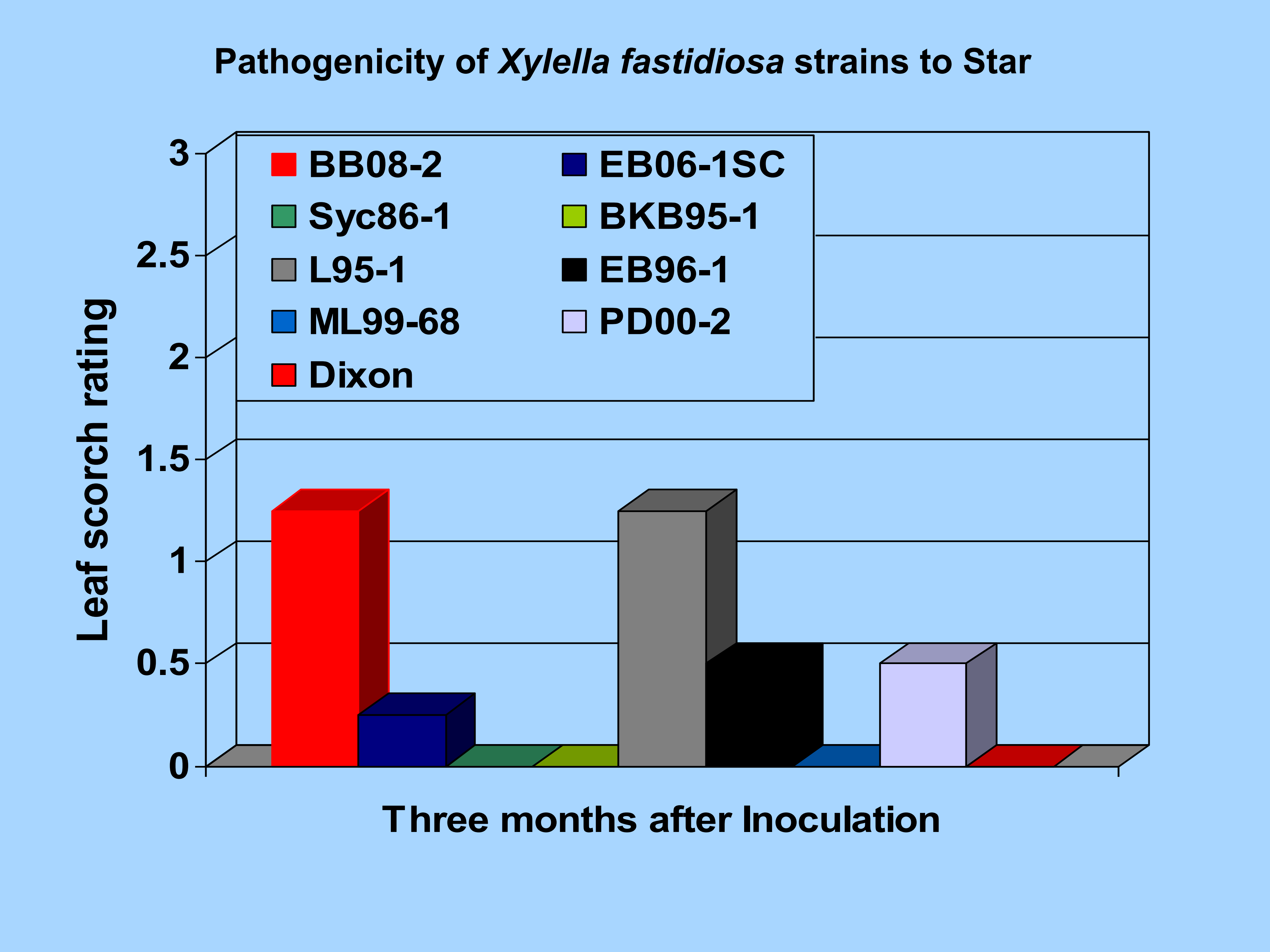
- First symptom is marginal leaf scorch, which may be bordered by a darker band.
- Leaf drop occurs and young stems take on a yellow appearance.
- Eventually plants die.

Leaf scorch Symptoms

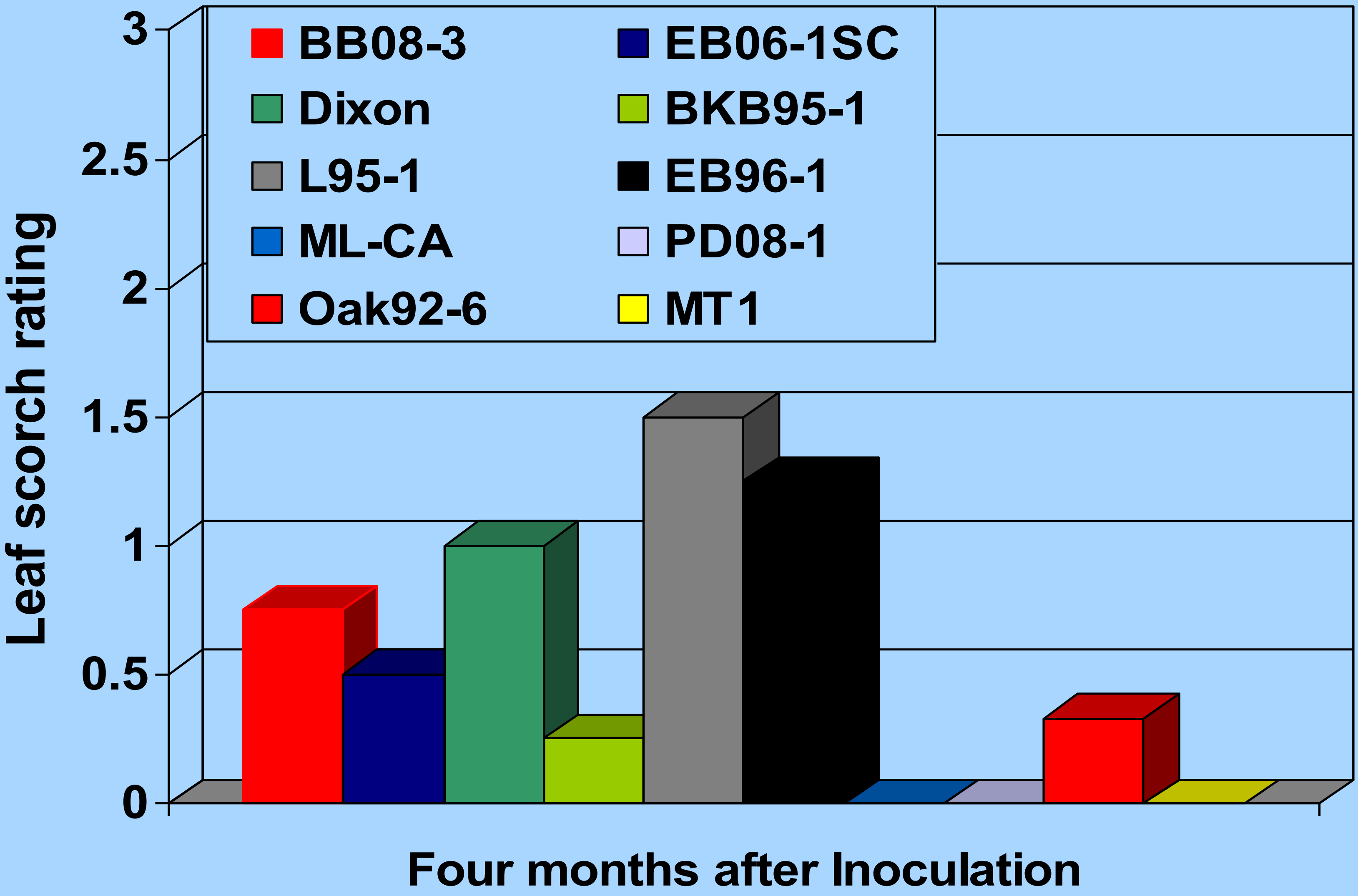

Yellow stem symptoms

Pathogenicity of *Xylella fastidiosa* strains to Star




Pathogenicity of *Xylella fastidiosa* strains to Star
BB08-2
EB06-1SC
Syc86-1
BKB95-1
L95-1
EB96-1
ML99-68
PD00-2
Dixon
Leaf scorch rating
3
2.5
2
1.5
1
0.5
0
Three months after Inoculation

Pathogenicity of *Xylella fastidiosa* strains to V1 (2010 test



Pathogenicity of *Xylella fastidiosa* *to Blueberry*

- Strains from blueberry vary in virulence.
- On Star, the strains BB08-2 and L95-1 from lupine produced symptoms.
- On V1, strains BB08-3, Dixon (almond), L95-1 (lupine), EB96-1 (elderberry), and EB06-1SC (elderberry) produced symptoms.

Resistance to Blueberry Leaf Scorch

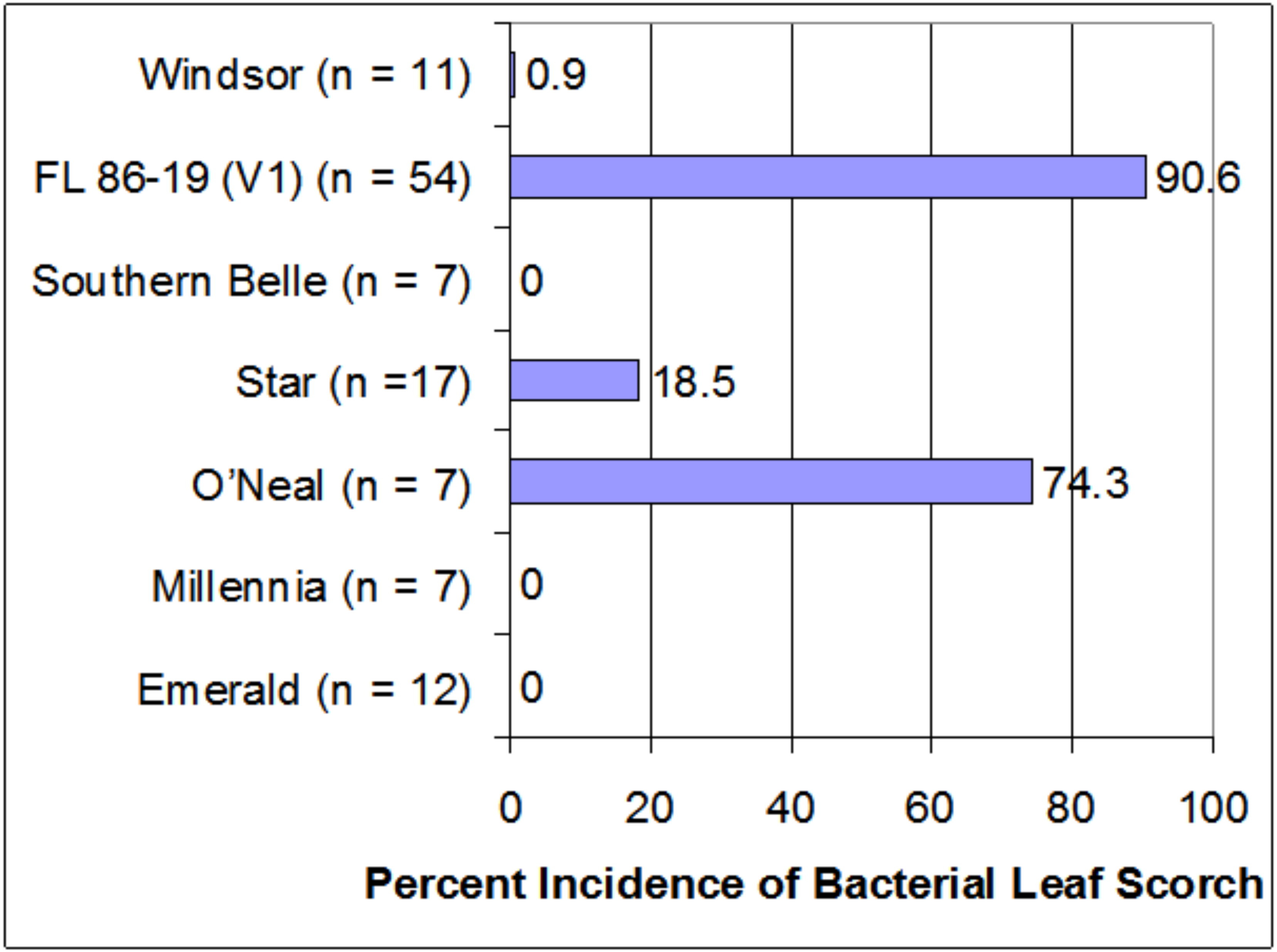
- Cultivars vary in field susceptibility (Brannen, Harmon, and Scherm).
- Most susceptible appeared to be FL86-19 (V1), Star, Jewel, and Countrywide.
- Very little leaf scorch was observed in some cultivars, such as Emerald, Millennia, and Southern Belle.
- Can we screen for resistance in the greenhouse to obtain rapid evaluations of blueberry lines?

Incidence (mean and range of the percentage of symptomatic plants) of bacterial leaf scorch in southern highbush blueberry cultivars in Georgia, based on a disease survey conducted in 2008.

Cultivar	Disease incidence (%) in young plantings (1st through 3rd leaf)	n[z]	Disease incidence (%) in older plantings (4th leaf and older)	n[z]	Combined disease incidence (%)	n[z]
Bluecrisp	NA	NA	9.6 (0-37.5)	4	9.6 (0-37.5)	4
Emerald	0	20	0.03 (0-0.3)	10	0.01 (0-0.3)	35
Jewel	0	2	0	1	0	3
Millennia	NA	NA	0.1 (0-0.5)	5	0.1 (0-0.5)	5
O'Neal	0.6 (0-1.25)	2	23.1 (0-74.3)	8	18.6 (0-74.3)	10
Rebel	1.8 (0-7.5)	5	15.6 (8.75-22.5)	2	5.7 (0-22.5)	7
Southern Belle	NA	NA	0	4	0	4
Star	2.0 (0-23.75)	31	15.6 (0-62.5)	23	7.8 (0-62.5)	54
FL 86-19 (V1)	10.7 (0-58.8)	12	49.0 (0.8-100)	10	28.2 (0-100)	22
V5	0	1	0	2	0	3
Windsor	0	1	0.3 (0-0.9)	5	0.2 (0-0.9)	6

[z]n = number of fields.

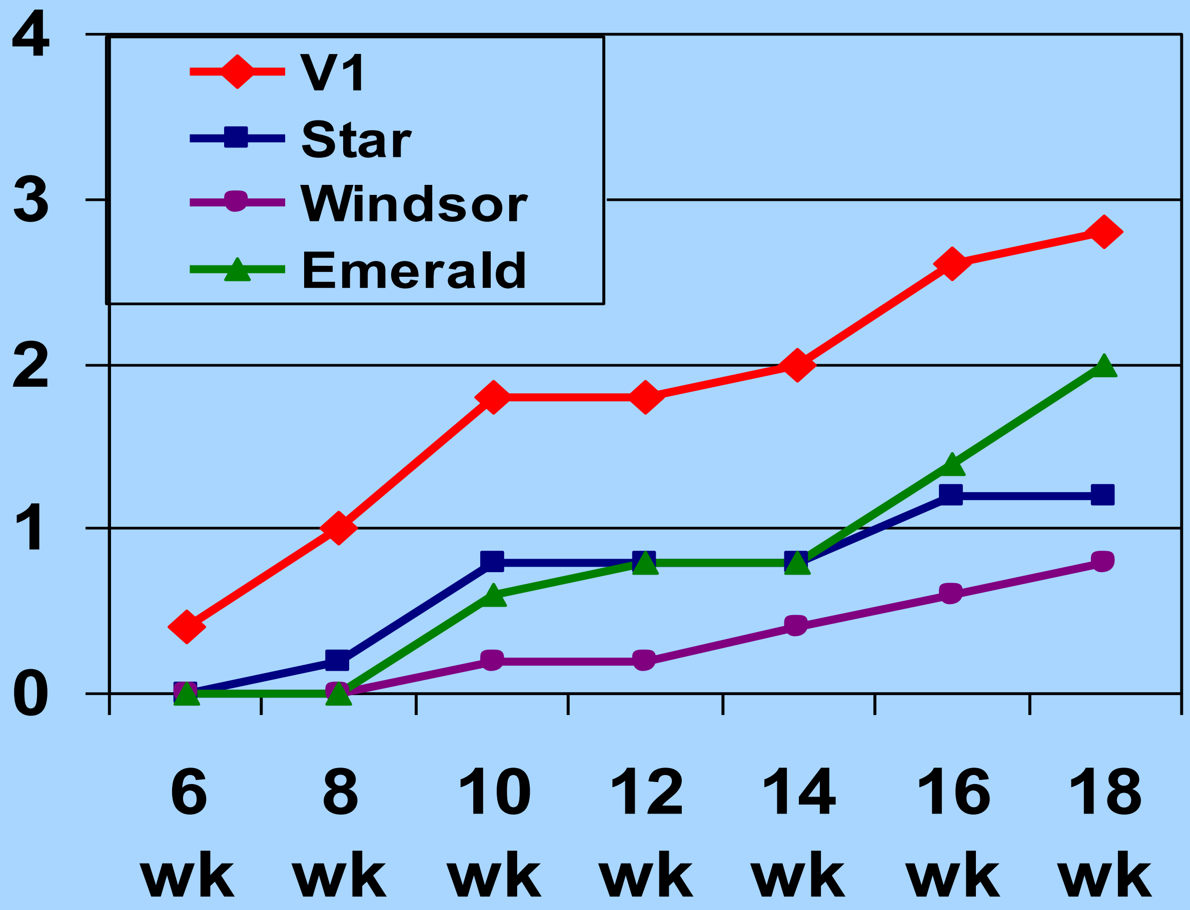
Brannen et al., 2008



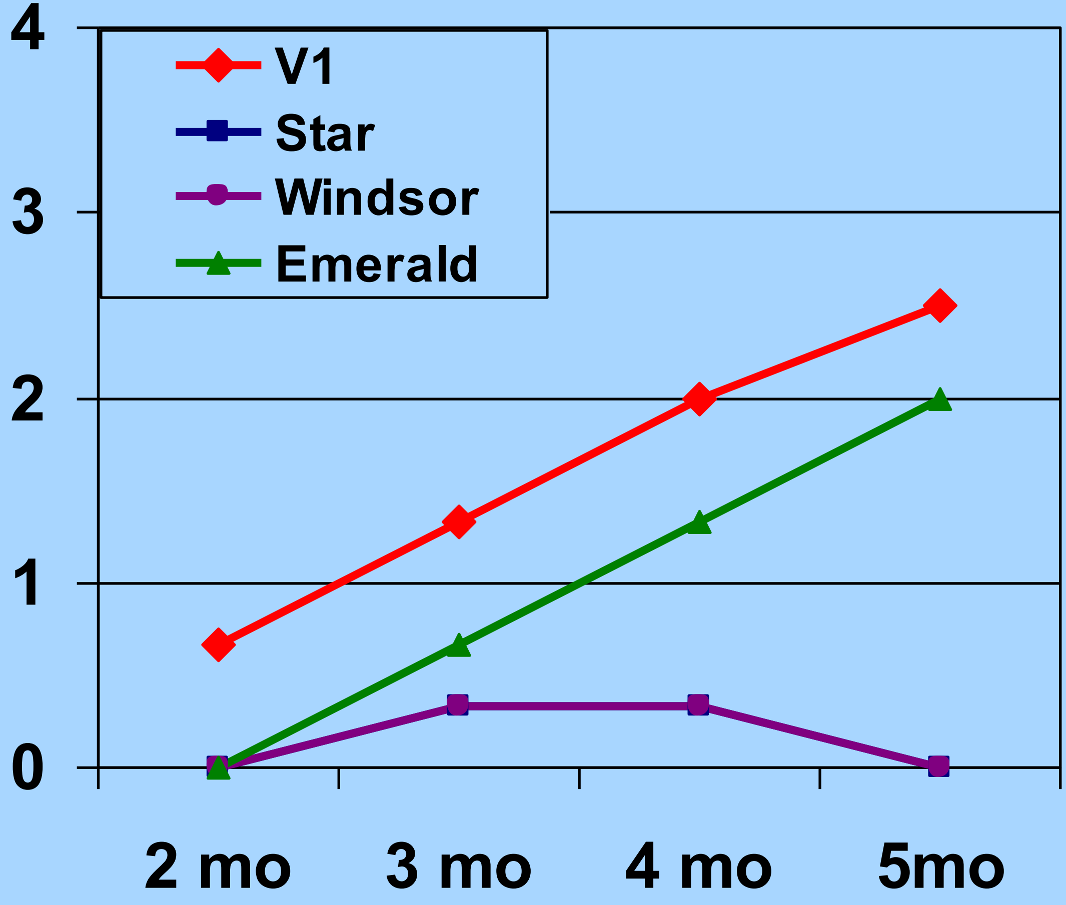
Incidence (percentage of symptomatic plants) of bacterial leaf scorch by cultivar at one 7th leaf producer site in Colquitt County. The number of rows surveyed (*n*) is shown in parentheses next to the cultivar name.

P. Brannen, UGA

Blueberry leaf scorch symptom Development with 10-fold dilution of 0.25 OD BB08-2 Inoculum (2009)



Blueberry leaf scorch symptom development with 0.25 OD BB08-3 inoculum (2010 test)




STAR
1.3 OD
STAR
10' Dil

V1
0.25 OD
V1
10' Dil

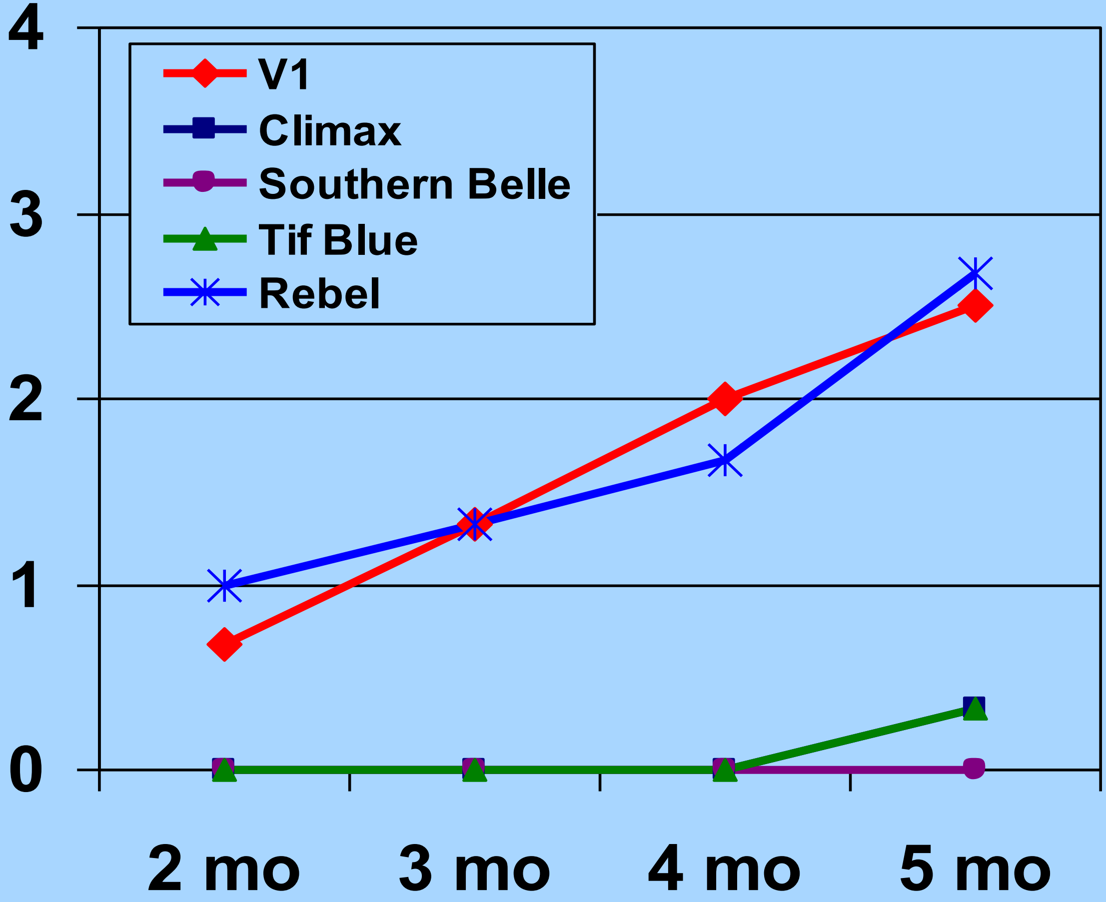

WINDSOR
0.25 OD
WINDSOR
10' Dil.


Emerald
1.3 OD
Emerald
10' Dil.


VI
10' Dil
Emerald
10' Dil.
WINDSOR
10' Dil.
STAR
10' Dil


FL
86-19
[V1]
Emerald
Millennium
Windsor

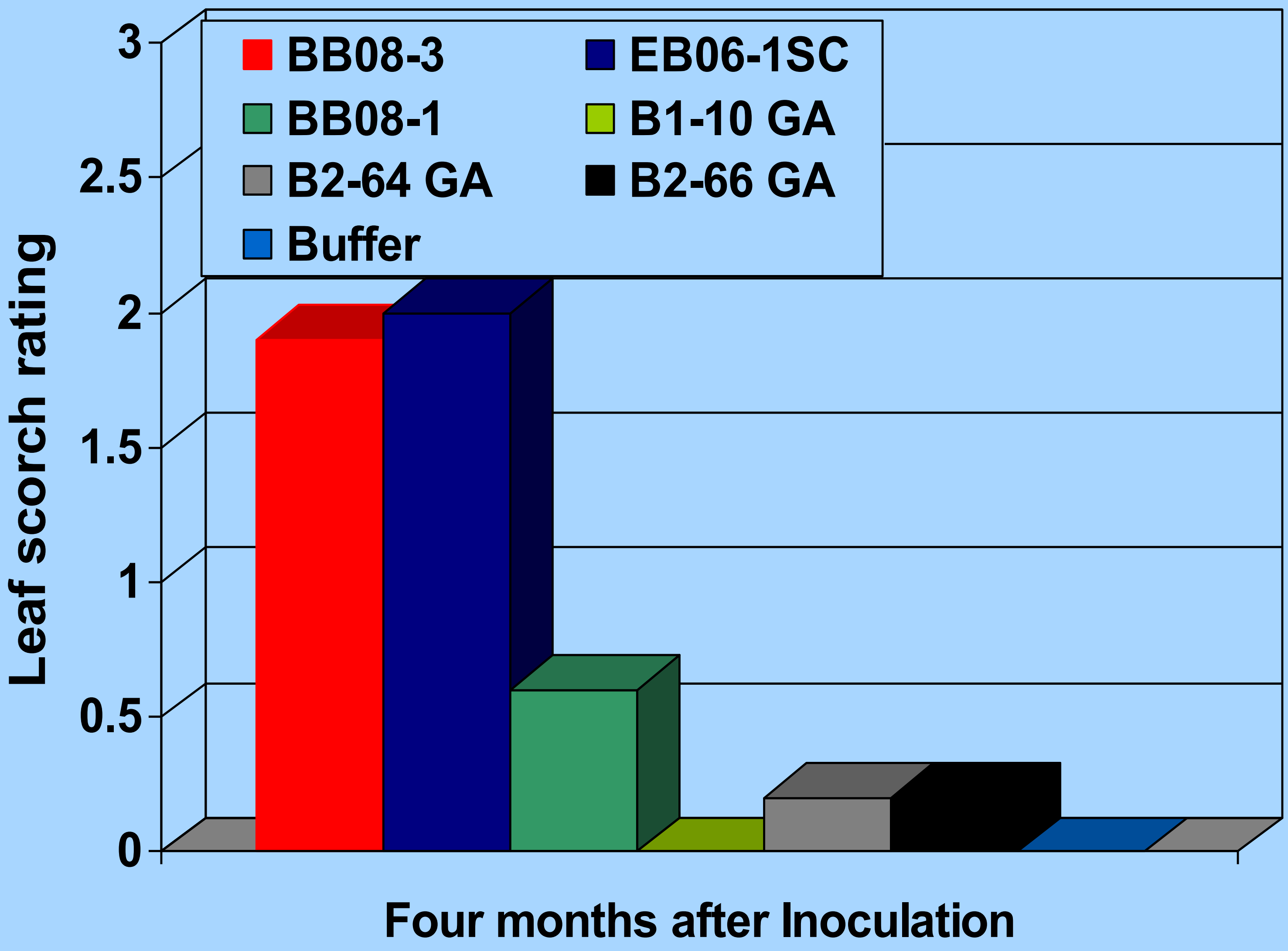
Blueberry leaf scorch symptom development with 0.25 OD BB08-3 inoculum (2010 test)



Comparison of Field Resistance to Blueberry Leaf Scorch and Greenhouse Resistance

Cultivar	Field	Greenhouse
V1	Susceptible	Susceptible
Star	Susceptible	Moderate Res.
Windsor	Resistant	Resistant
Emerald	Resistant	Susceptible
Rebel	Susceptible	Susceptible
Southern Belle	Resistant	Resistant
Climax	?	Resistant
Tif Blue	?	Resistant

Pathogenicity of *Xylella fastidiosa* strains to Emerald, 2010 test




EMERALD BLUEBERRIES
Inoculated 6-24 or 6-30-10
Picture Date 11-2-10
B1-10 GA


BB08-1 FL


SCP


BB08-3 FL


EB06-1 SC

B2-64 GA

B2-66 GA

Greenhouse Screening for Resistance to Leaf Scorch

- Resistance to blueberry leaf scorch in greenhouse screening agreed with observed field resistance for most cultivars.
- Emerald was more susceptible to *Xylella fastidiosa* in the greenhouse than in the field.
- Star appeared to be more resistant in greenhouse tests than has been observed in the field.
- Differences between greenhouse and field observations could be due to host specificity of strains, agressiveness of strains, or loss of virulence in some strains during culture.

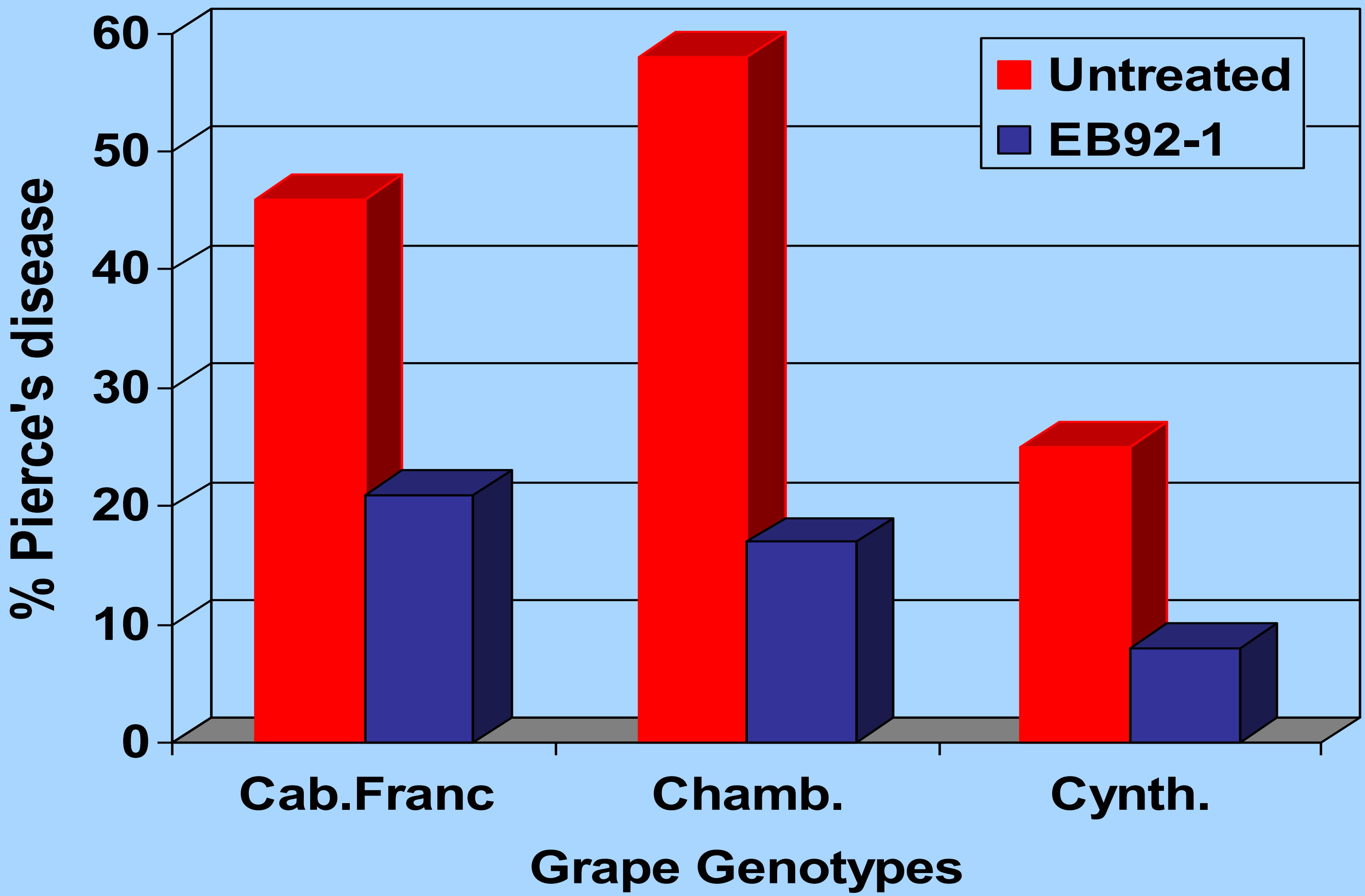
Cross-Protection for Biological Control of Pierce's Disease of Grape

Cross protection is the phenomenon in which plant tissues infected with one strain of a pathogen are protected from infection by other more severe strains of the same pathogen.

Field injections

Current tests on new grape plantings of various grape genotypes

Thirteenth Season in the UF vineyard for Cabernet Sauvignon treated with Biocontrol strain EB92-1



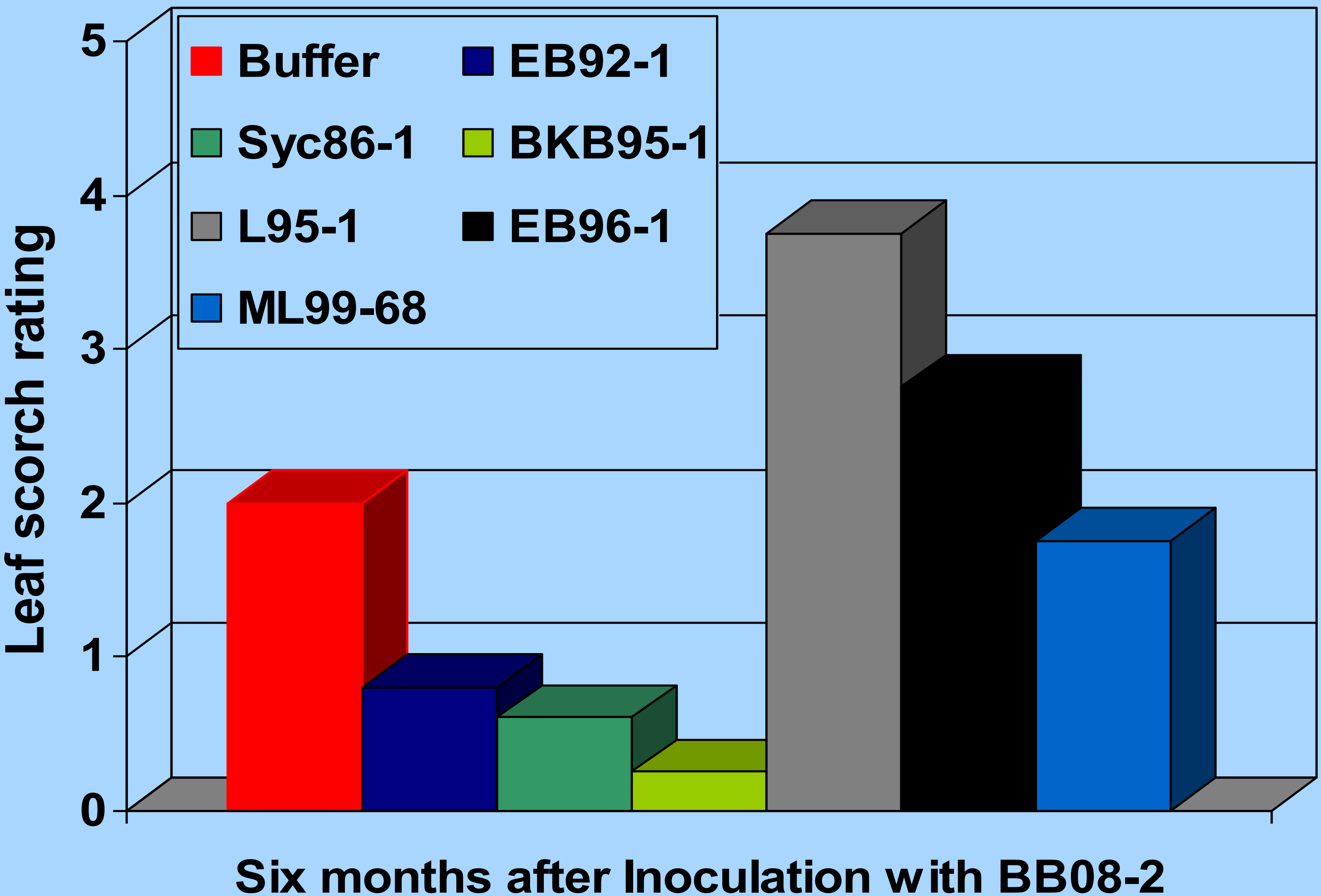
• Effect of strain EB92-1 is on PD in various genotypes, *V. vinifera* (Cabernet Franc), *V. aestivalis* (Cynthiana), and French/American hybrid (Chambourcin) in the vineyard in Central Florida.

Evaluation of Benign Strains of *X. fastidiosa* for the Biological Control of Blueberry Leaf Scorch by Cross-Protection

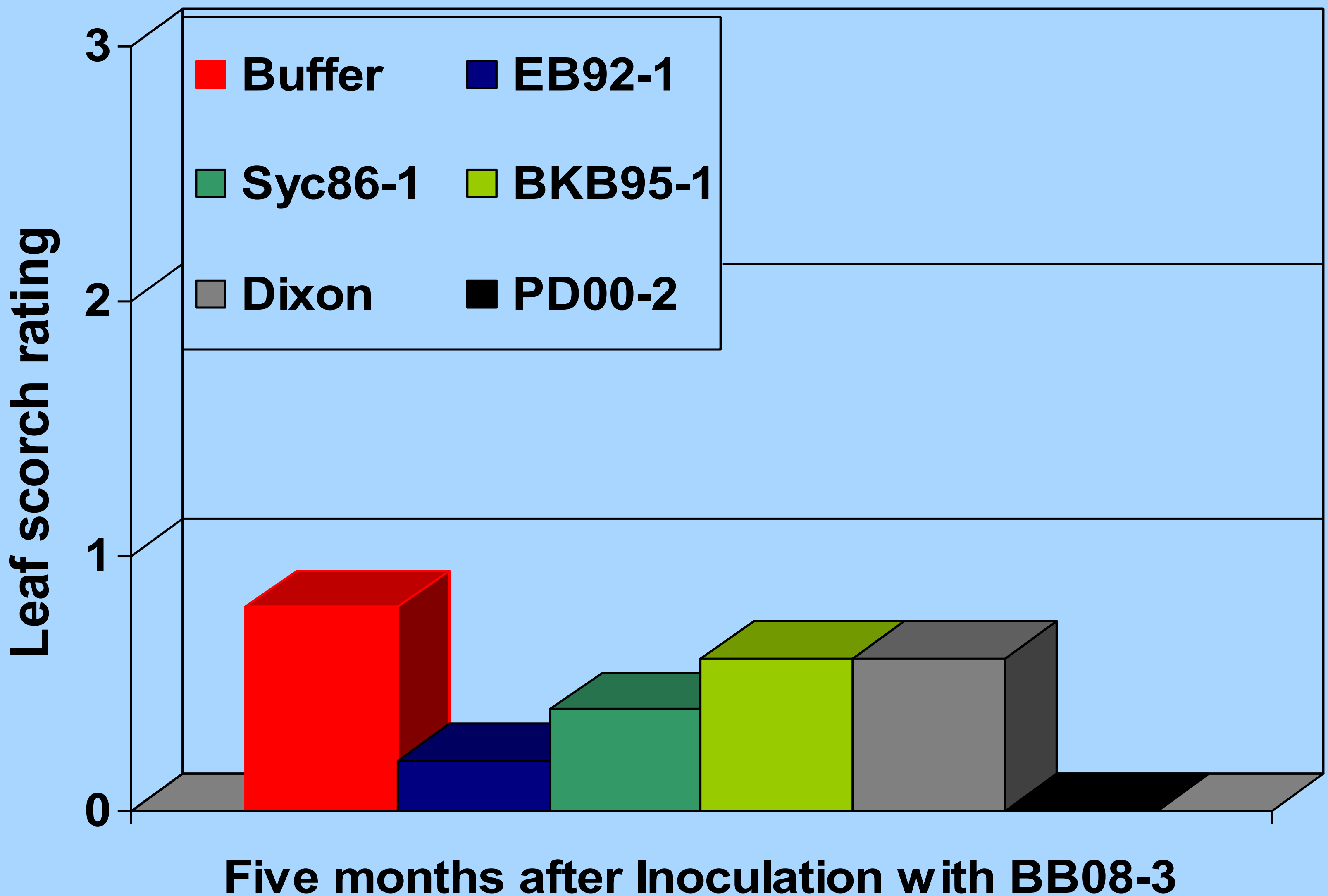
- **Various strains of *X. fastidiosa* are being evaluated in the greenhouse for biological control of blueberry leaf scorch in 'Star' and 'V1', including strains from elderberry, blackberry, sycamore, and mulberry.**
- **'Star' and 'V1' blueberry plants inoculated with these strains were challenged 3-4 weeks later with the blueberry leaf scorch strain BB08-2 in 2009 or BB08-3 in 2010 to evaluate biological control of the disease.**
- **Disease incidence and severity are rated once a month.**

Don Hopkins, UF

Biological Control of Blueberry Leaf Scorch in Star



Biological Control of Blueberry Leaf Scorch in V1 (2010 test



Biocontrol of Blueberry Leaf Scorch

- In greenhouse tests, *X. fastidiosa* strains EB92-1 and Syc86-1 reduced leaf scorch in both Star and V1. BKB95-1 provided biocontrol in Star and PD00-2 was effective in V1.
- Strain PD00-2 is not a candidate for biocontrol of blueberry leaf scorch, because it is pathogenic to grapevine.
- Further greenhouse and field tests are warranted for EB92-1, Syc86-1, and possibly BKB95-1.

Summary

- In addition to *X. fastidiosa* strains from blueberry, strains from lupine, almond, and elderberry were pathogenic to blueberry.
- Resistance to blueberry leaf scorch in greenhouse screening agreed with observed field resistance for most cultivars. The development of a quick screening test for resistance to leaf scorch is possible.
- Differences in virulence or host specificity were observed in *X. fastidiosa* strains used in greenhouse tests.
- Greenhouse tests for the biological control of leaf scorch were positive. Field tests are needed.

Thank You for Your Attention!

Research was supported byUSDA-NIFA award no. 2008-51180-19579 (Specialty Crop Research Initiative)

<u>Thanks to colleagues:</u>

Phil Brannen
Phil Harmon
Harald Scherm

Mechanical Harvesting of Southern Highbush Blueberries and Disease Relationships

- Part of comprehensive 4-year research/ extension project to take southern highbush production to next level
- Main themes:
  1) Overcome genetic, horticultural, and engineering barriers that stand in the way of mechanical harvesting for fresh market
  2) Improve overall fruit quality and microbial safety
  3) Address emerging systemic diseases that threaten the industry

THE UNIVERSITY OF GEORGIA

NC STATE UNIVERSITY

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P. Lyrene


D. Hopkins


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Questions to be addressed as part of mechanical harvest component

- Compare standard cultivars to the new crispy-flesh cultivars such as **Sweetcrisp**, **Farthing**, and **Meadowlark:**
- Do the plants survive and produce well?
- Do they mechanical-harvest well?
- Can they be manipulated with fruit abscission chemicals to improve harvest?
- How much delay in harvest occurs with machine-harvest?
- How much ground loss occurs?
- Does the fruit hold up well in storage? What are the impacts on microbial contaminants and postharvest disease?
- Do consumers like the crispy flesh fruit?
- Will switching to partial mechanical harvest improve profit margin?

Potential disease/ pathogen issues associated with machine-harvest

- Bush damage, especially at base of plant, due to harvester's catch pans
  - Entry points for stem blight and canker pathogens
- Fruit bruising due to direct contact with harvester's beater rods or as result of fruit falling in harvester
  - Increased susceptibility to postharvest decay
  - Potential attachment sites for microbial contaminants of food safety concern

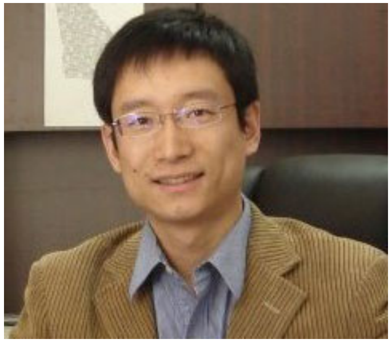
Minimizing crown injury

- Proper pruning, cultivar selection (narrow crown)
- Careful harvester operation
- Idling disk catch pans ("centipede scales")?


BEI International

Quantifying fruit bruising: Blueberry harvest impact sensor

BIRD (Blueberry Impact Recording Device)

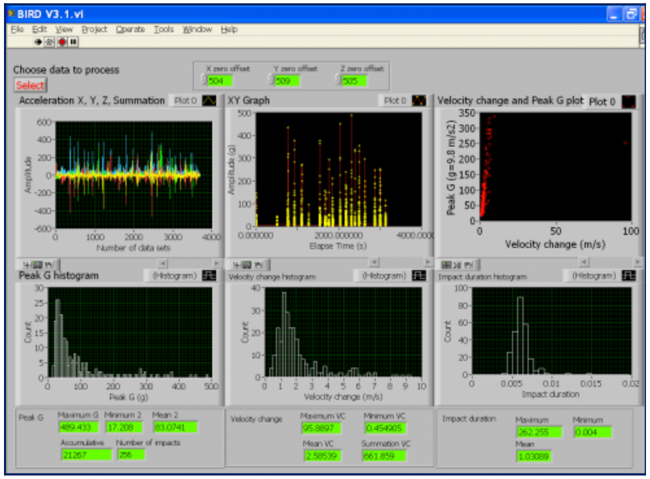


Changying Li Pengcheng Yu

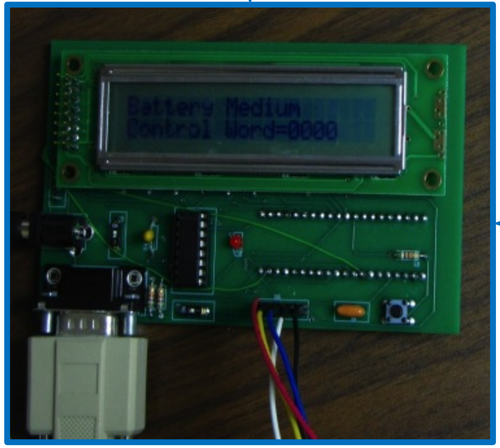
BIRD (Blueberry Impact Recording Device)

BIRD sensor node

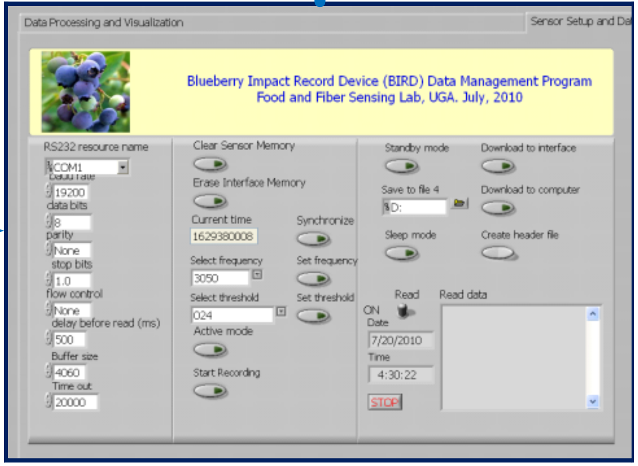
PC-BIRD software: data analysis



Downloading/recharging interface

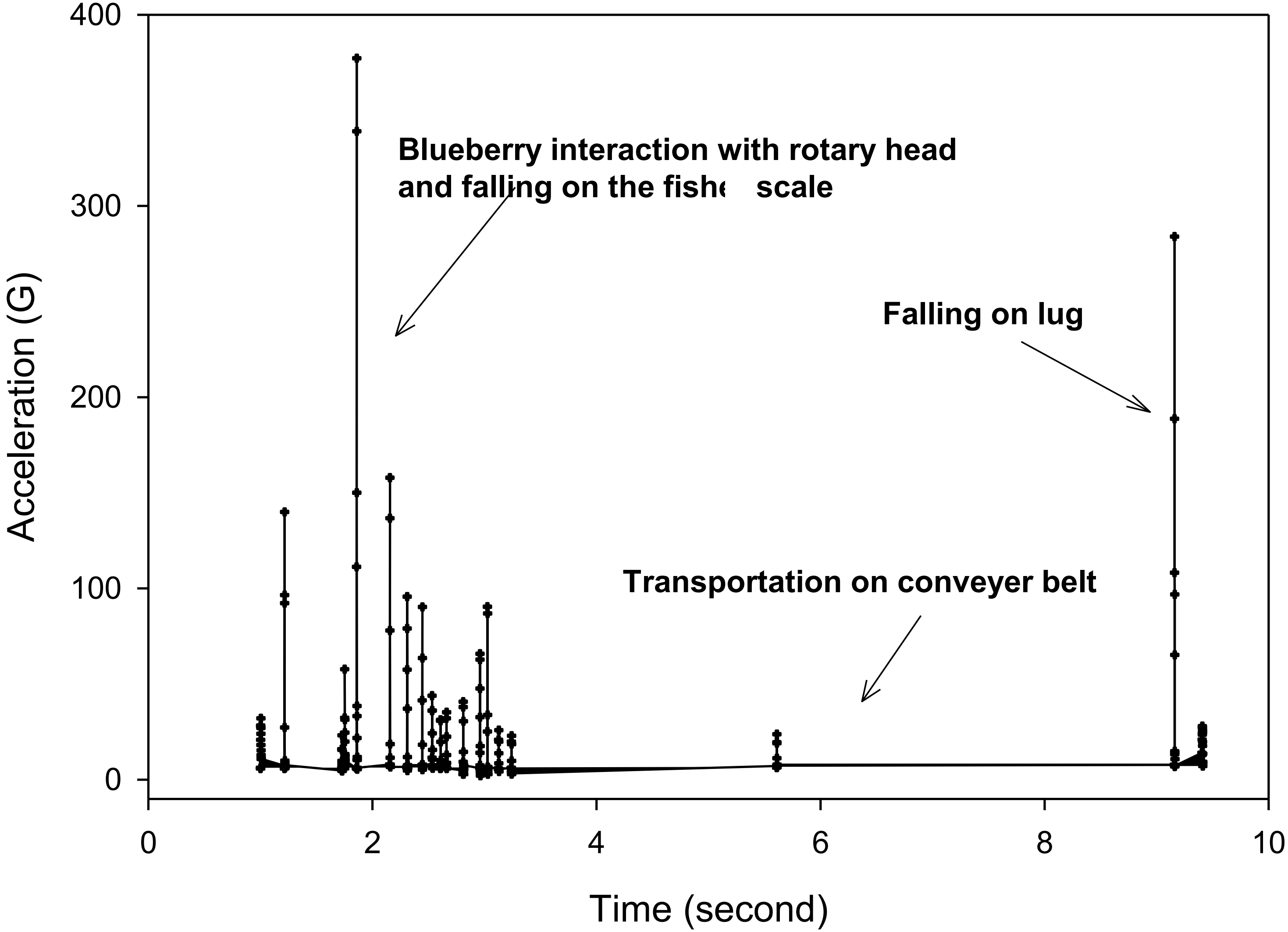


PC-BIRD software: data acquisition



C. Li

BIRD (Blueberry Impact Recording Device) during mechanical harvest with Korvan 8000



Fruit firmness and machine-harvesting

- Berry firmness is key
- Current SHB cultivars such as Star, Emerald, Scintilla, Primadonna
  - Lower firmness than rabbiteyes
- Novel crisp-textured SHB cultivars
  - New focus of UF, NC, and UGA breeding programs
  - Firmer berries than conventional cultivars
  - E.g. Sweetcrisp, Farthing, Meadowlark

Lucky Mehra

Machine-harvesting of new SHB cultivars may be feasible with reduced bruising and postharvest decay

Crispy berries, machine-harvest, and postharvest disease development

- Compare conventional and crisp-textured SHB genotypes after hand- or mechanical-harvest in relation to:
    1. microbial contamination on fruit at harvest
    2. subsequent postharvest decay development

- Identify fungal organisms associated with postharvest decay

Cultivars and harvesting (Waldo, FL)

- "Conventional" type
  - Star, Scintilla (2009/2010)
  - FL 05-486, Primadonna (2009)
  - FL 01-248 (2010)
- "Crispy" type
  - Sweetcrisp, Farthing (2009/2010)
  - FL 98-325, FL 05-290 (2009)
  - Meadowlark (2010)

OR

4 replicate row sections

Cold storage for 0, 7, 14, and 21 days

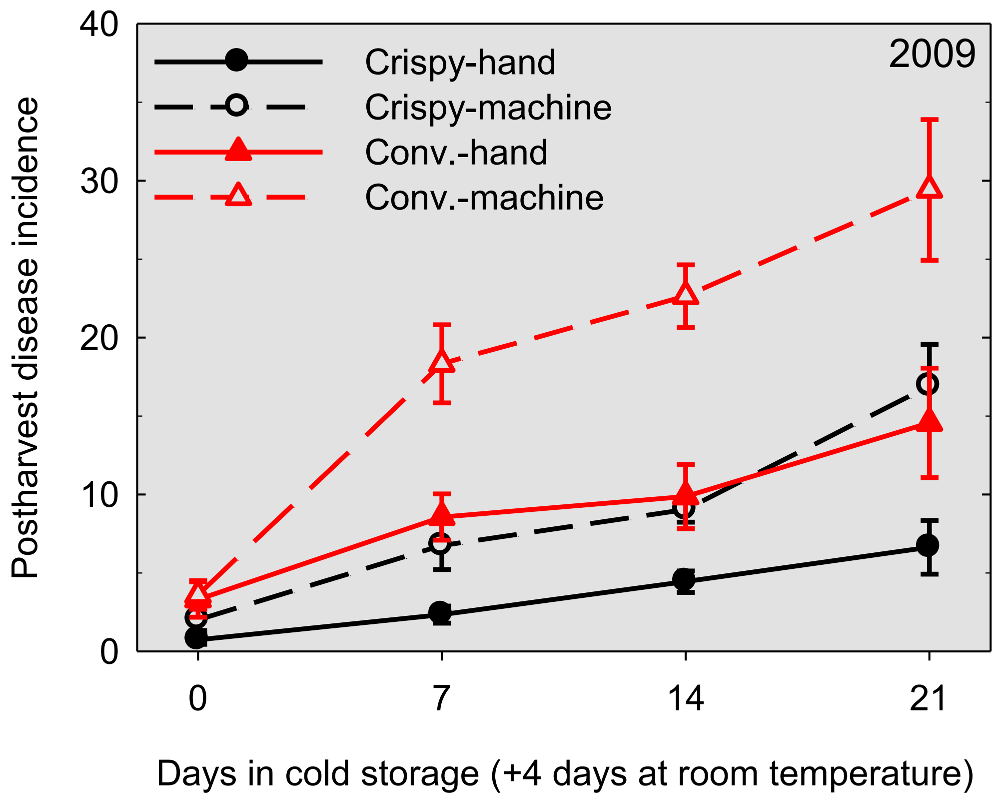
Microbial fruit surface contaminants

- Overall contaminant counts (**aerobic bacteria, yeast, mold**) below commonly used thresholds for processed blueberries
- No effect of harvest method or flesh type
- No ***E. coli*** detected in either year
- **Coliforms** detected in:
  - One rep of hand-harvested Primadonna in 2009 (avg. 7 CFU/g)
  - Machine-harvested reps of Farthing and Sweetcrisp in 2010 (avg. 1 and 20 CFU/g, respectively)

Natural disease development in cold storage

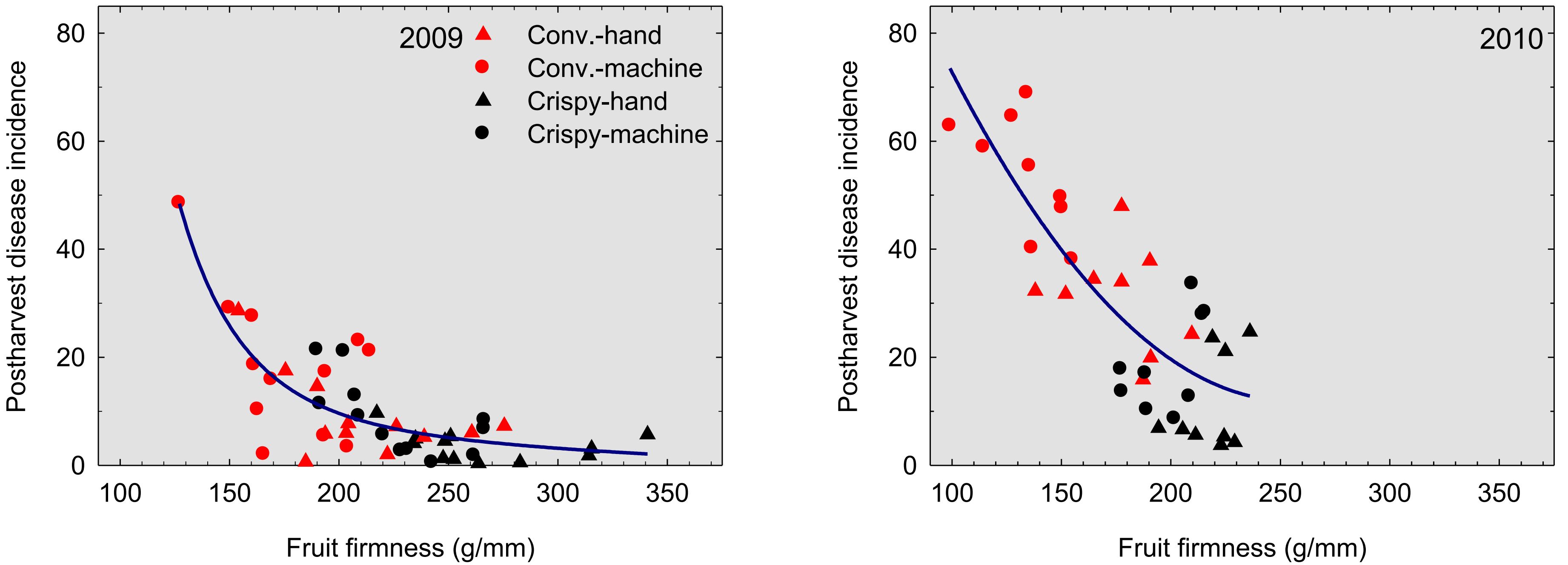
- 6 cultivars
  - Conventional: **Star**, **Scintilla**, **FL 05-486** (2009) or **FL 01-248** (2010)
  - Crispy: **Sweetcrisp**, **Farthing**, **FL 98-325** (2009) or **Meadowlark** (2010)
- 1 clamshell/treatment, 4 reps
- Cold storage and decay assessment
  - Stored at 2°C for 0, 7, 14, and 21 days
  - Moved to 25°C for 4 days prior to assessment (high disease pressure)

Natural disease development in cold storage



Source	2009				2010			
	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
Flesh type (F)	1	6	62.75	0.0002	1	6	274.5	<0.0001
Harvest (H)	1	6	139.53	<0.0001	1	6	157.8	<0.0001
F × H	1	6	2.55	0.162	1	6	18.4	0.005
Time (T)[b]	3	164	53.30	<0.0001	2	120	10.4	<0.0001
T × F	3	164	1.53	0.209	2	120	2.83	0.063
T × H	3	164	4.08	0.008	2	120	0.270	0.761
T × F × H	3	164	0.610	0.609	2	120	0.030	0.967

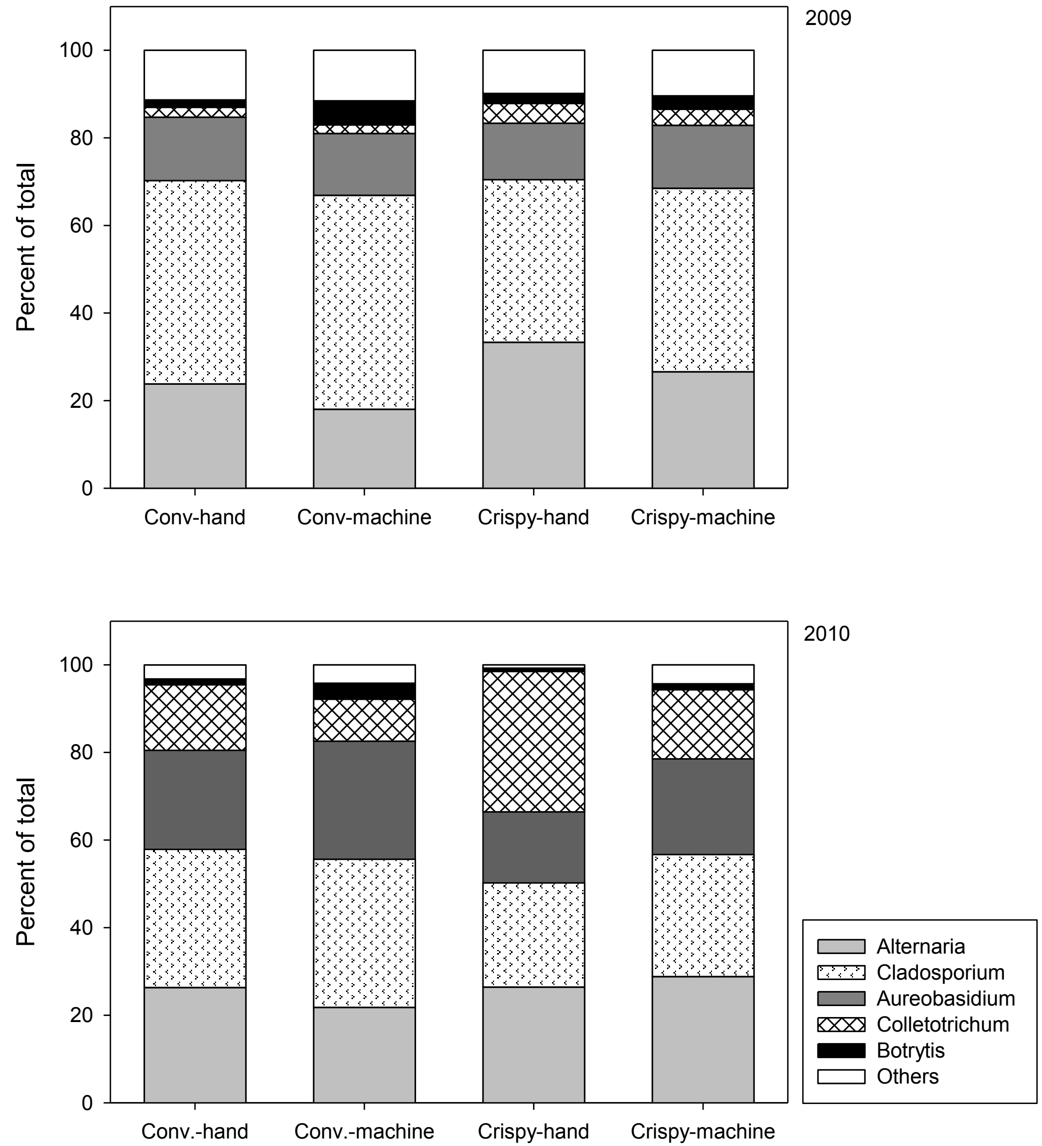
Disease incidence in relation to firmness



- Inverse relationship
- In 2009, >220 g/mm associated with low disease
- In 2010, firmness reached desired levels only in few cases

Contribution by different fungal genera

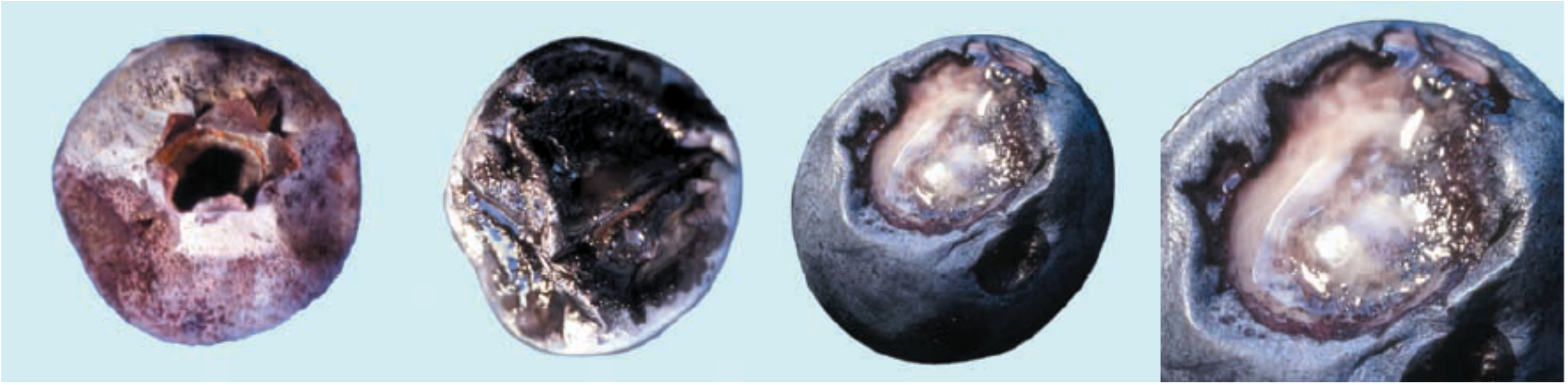
- *Alternaria* spp., *Cladosporium* spp., and *Aureobasidium pullulans* most common
- Higher proportion of *Colletotrichum* in 2010
- Complex of fungi similar for all treatments



Data from all 6 cultivars over 4 assessment dates

Cladosporium spp. and Aureobasidium pullulans

- *Cladosporium* infection limited to velvety mycelial tuft visible at stem scar or cracks near scar
- *A. pullulans*: wet and slimy appearance of berries

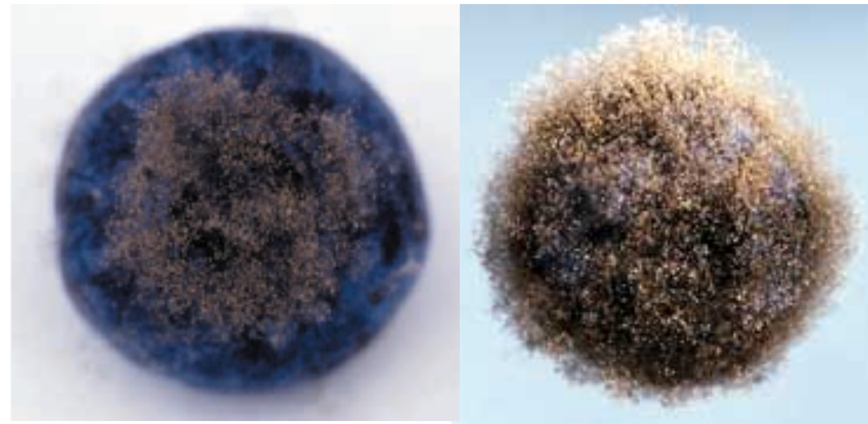


Images courtesy Wharton & Schilder

MSU

Alternaria, Botrytis and *Colletotrichum spp.*

Alternaria spp.



Botrytis spp.

Colletotrichum spp.

MSU

Conclusions

- No significant effect of flesh type and harvest method on microbial contaminants
- Natural decay incidence: Lower for hand-harvested fruit; for crispy flesh type
- Machine-harvested crispy flesh equal to or lower than hand-harvested conventional flesh
- Fruit firmness good predictor of post-harvest decay; >220 g/mm desirable
- *Cladosporium, Alternaria,* and *Aureobasidium* most common
- Artificial inoculation: Lower decay incidence for crispy flesh

Machine-harvested crispy SHB acceptable in terms of postharvest disease and quality

Overall Bottom Line from Mechanical Harvesting Experiments so far

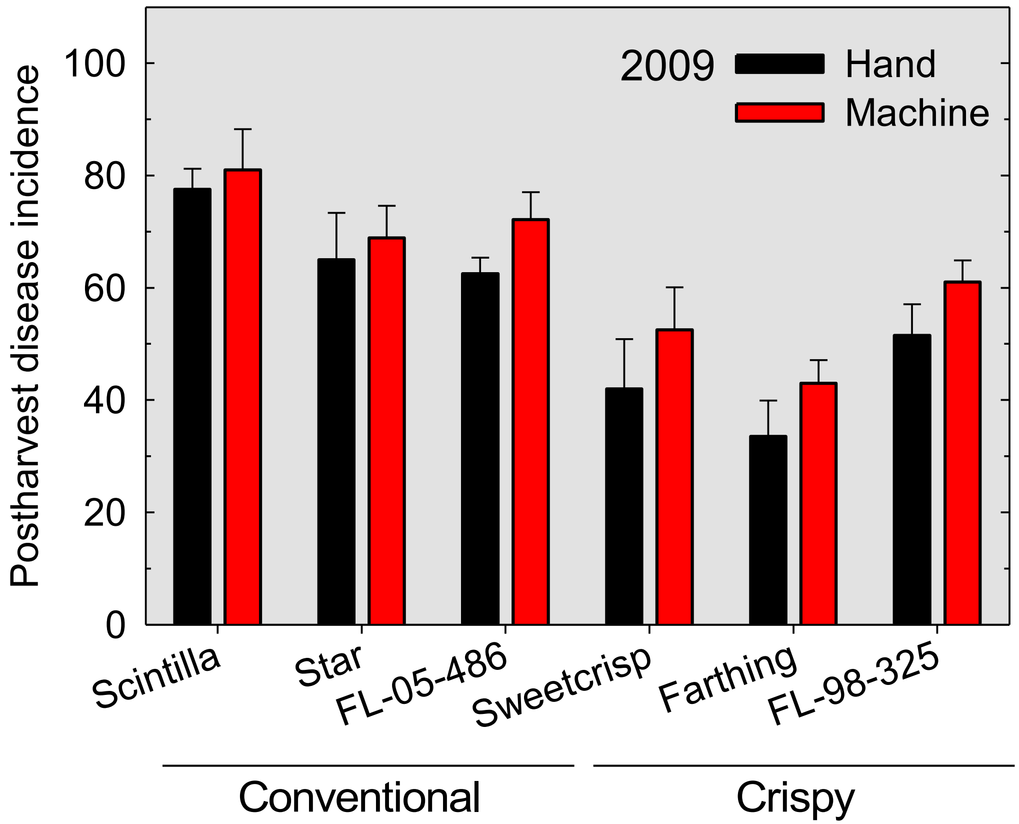
- For most quality and postharvest attributes, hand-harvested conventional and machine-harvested crispy equivalent
- 2010 not quite as successful
  - Missed optimal harvest window
  - Too many greens (too early)
  - Too soft (hot temperatures)
- Field losses (ground drops) still problematic, but can be addressed with pruning, cultural practices, and breeding
- Economics: cautiously optimistic

Disease Development After Artificial Inoculation

- <u>6 cultivars</u>
  - Conventional: **Star**, **Scintilla, FL 05-486** (2009) or **FL 01-248** (2010)
  - Crispy: **Sweetcrisp**, **Farthing**, **FL 98-325** (2009) or **Meadowlark** (2010)
- <u>Inoculation and incubation</u>
  - 4 reps, 50 fruit per replicate
  - Inoculated with *A. alternata*, *B. cinerea*, or *C. gloeosporioides* on stem scar
  - Incubation: 1 day at room temperature + 7 days in cold room (7°C) + 60–72 h at room temperature

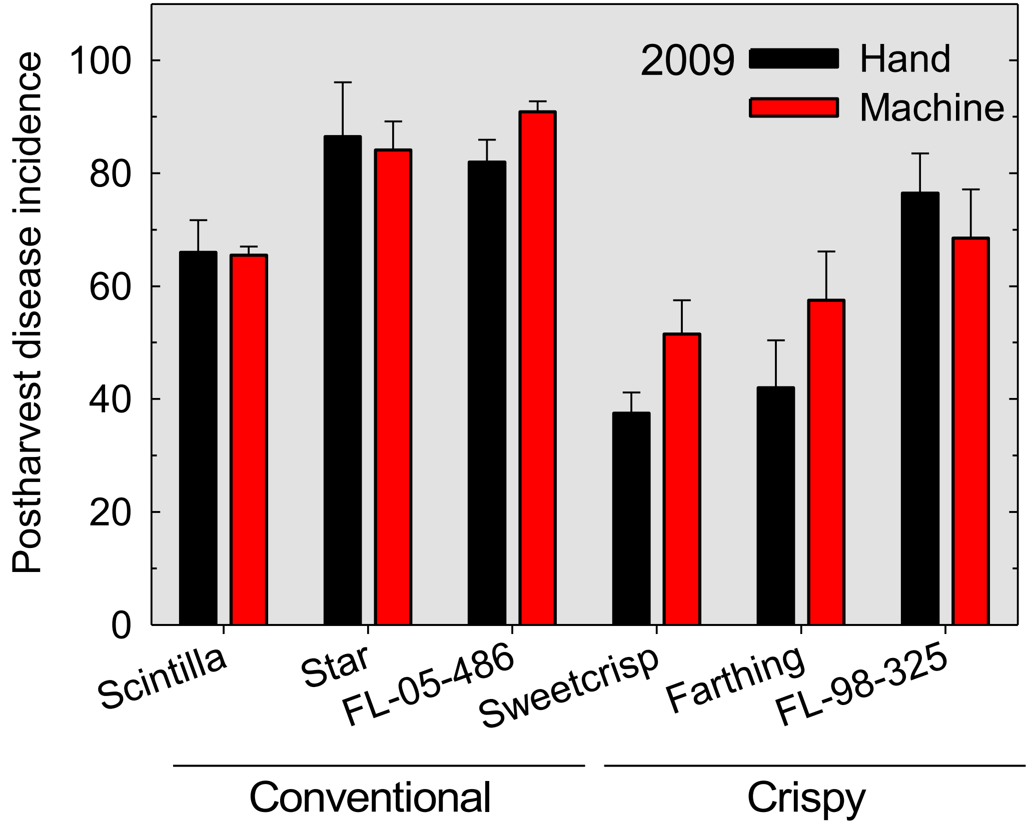
Inoculated fruit in Petri dishes

Botrytis Inoculation



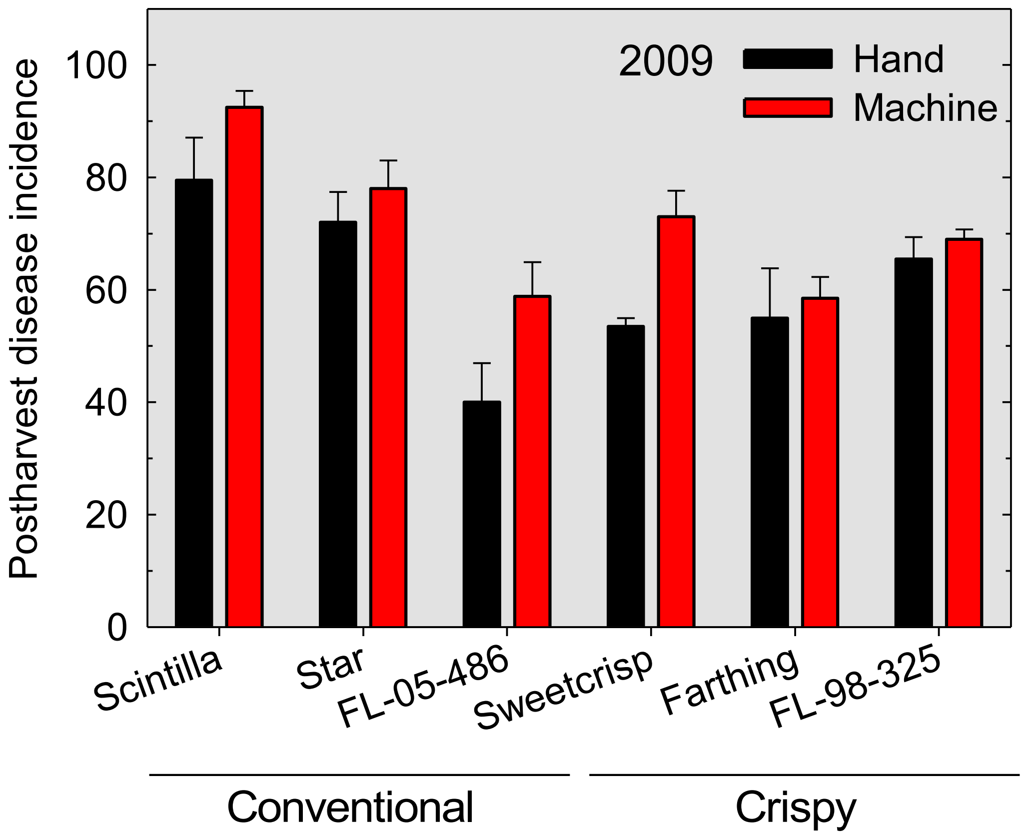
Source	2009				2010			
	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
B. cinerea								
Flesh type (F)	1	6	116.6	<0.0001	1	6	84.9	<0.0001
Harvest (H)	1	38	3.84	0.057	1	38	0.050	0.832
F × H	1	38	0.120	0.728	1	38	1.24	0.273

Colletotrichum Inoculation



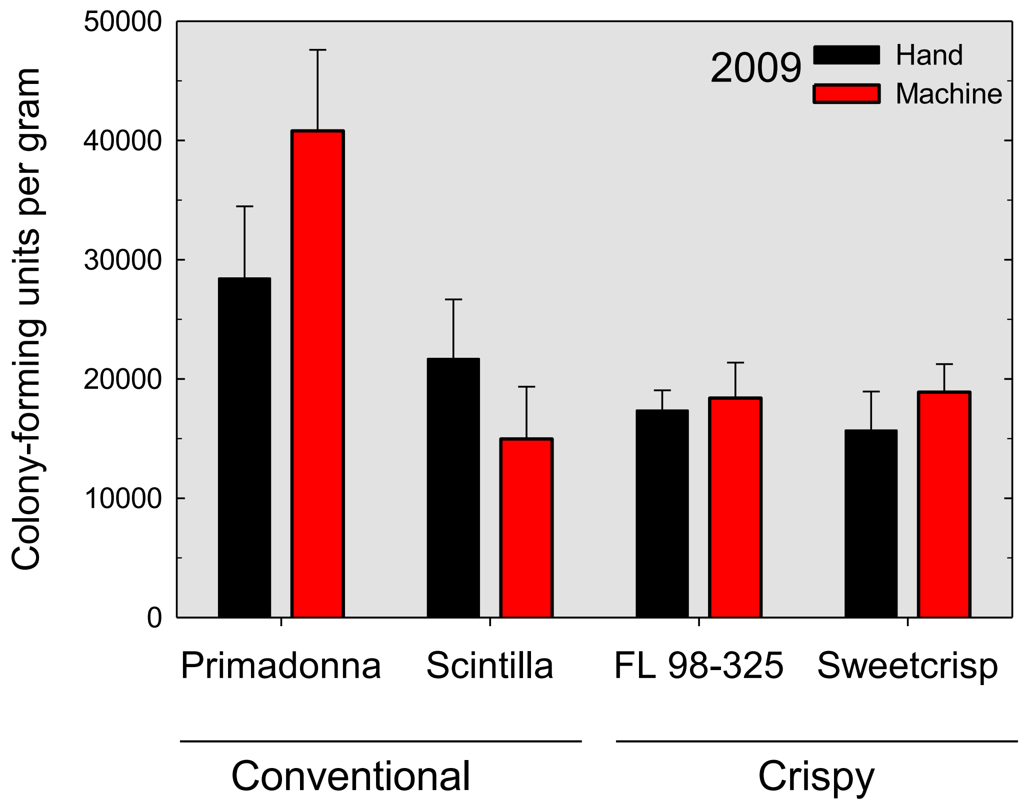
Source	2009				2010			
	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
C. gloeosporioides								
Flesh type (F)	1	6	22.4	0.003	1	6	6.56	0.045
Harvest (H)	1	38	0.470	0.496	1	38	0.180	0.671
F × H	1	38	0.300	0.588	1	38	0.110	0.738

Alternaria Inoculation



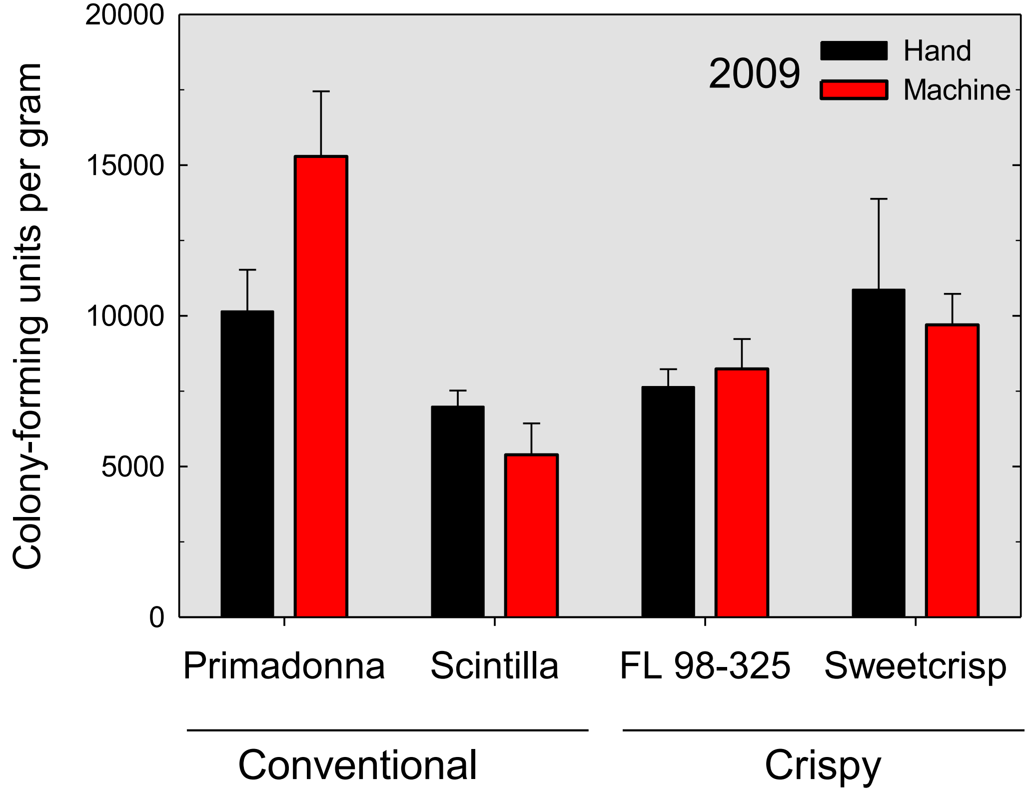
Source	2009				2010			
	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
A. alternata								
Flesh type (F)	1	6	31.4	0.001	1	6	267.9	<0.0001
Harvest (H)	1	38	5.00	0.031	1	38	1.19	0.281
F × H	1	38	0.350	0.557	1	38	1.35	0.253

bacteria



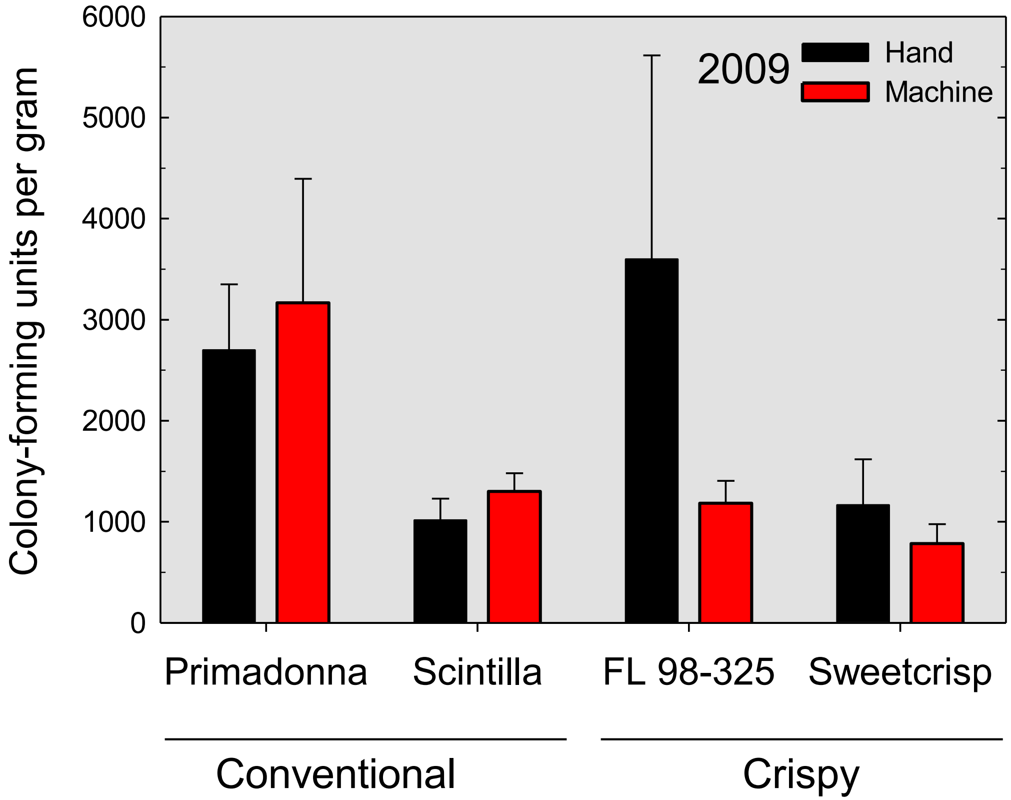
Source	2009				2010			
	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
Aerobic bacteria								
Flesh type (F)	1	6	4.59	0.076	1	6.16	2.51	0.163
Harvest (H)	1	22	0.090	0.768	1	21.5	0.450	0.510
F × H	1	22	0.160	0.688	1	21.5	0.290	0.597

Surface contaminants: Total yeast count



	2009				2010			
Source	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
Total yeast								
Flesh type (F)	1	6	0.030	0.859	1	6	0.130	0.728
Harvest (H)	1	22	0.050	0.822	1	22	4.27	0.051
F × H	1	22	0.010	0.936	1	22	0.000	0.971

count



	2009				2010			
Source	ndf	ddf	*F*	*P*	ndf	ddf	*F*	*P*
Total mold								
Flesh type (F)	1	6	1.21	0.313	1	6	0.040	0.846
Harvest (H)	1	22	0.640	0.431	1	22	2.26	0.147
F × H	1	22	2.46	0.131	1	22	0.570	0.456

Southeastern Blueberry Insect & Mite Pest Management: Time In-Orchard, Scouting & IPM Responses

Dan Horton, UGA, Entomology, Athens &
Danny Stanaland, UGA Cooperative Extension Service, Area Blueberry Agent

Blueberry "Entomologists"

Phillip Marucci, Rutgers

Herbert Neunzig, NCSU

Jim Cane, USDA

Jerry Payne, USDA

Blair Sampson, USDA

Oscar Liburd, UFL

Hannah Burrack, NCSU

Danny Stanaland, UGA

Importance of Blueberry Insects in the Various Growing Areas

Payne, Horton & Amis. 1988. *In:* Harris & Rogers, The entomology of indigenous & naturalized systems in agriculture, Westview Press.

	N.J.	Mich.	Me.	N.C.	Mass.	Canada	Ga.	Wash.
Blueberry Maggot	1	1	1	2	2	1	4/2	5
Cranberry Fruitworm	2	1	4	1	2	4	2/3	5
Plum Curculio	3	3	4	1	3	4	4/4	5
Scales	3	3	4	3	3	4	3/3	3
Blueberry Bud Mite	3	4	4	2	3	4	4/3	5
Blueberry Flea Beetle	4	4	2	4	3	2	4/2	5
Termites	4	4	4	3	4	4	3/3	5
Blueberry Tip/Gall	3-4	4	3	5	5	3	5/1-2	5
Midge								
Flower Thrips							3/1-2	

1 Needs treatment virtually every year
2 Almost always present but needs treatment only occasionally
3 Rarely present in pest proportions
4 Never present in pest proportions
5 Not found on blueberries



Blueberry Insect & Mite Scouting

Pest Calendars Allow IPM Practitioners to Bear Down When Pests are Typically Present at Damaging Levels

Need to Understand Pest Biology/Life Cycle, Signs & Symptoms

Pay Close Attention to Weather & Crop Developmental Stages

Develop Field History, Maps & Records of IPM Responses and their Outcomes

Blueberry Gall Midge - Key Rabbiteye Pest

Dasineura oxycoccana (Johnson) (Diptera: Cecidomyiidae)

Steck, Lyrene & Payne, 1995

male

female

Blueberry Gall Midge

Tiny, < 3 mm fly
Long, slender legs
Globular antennae
Wings with very little venation

Lays eggs in flower & vegetative buds as bud scale separate, late Stage 2

Blueberry Gall Midge - Quite Susceptible in Stages 2, 3

Substantial flower bud injury since the mid 1990s in the SE USA & in Europe,
Responsible for up to 80% flower bud loss (Gainesville, FL 2004),
Aborts Vegetative Buds post bloom

Midge injury is easily underestimated; midge-aborted flower buds are readily mistaken for cold injury or poor pollination

Time Window in SE GA: February to March for Rabbiteye
January into February for Southern Highbush

Blueberry Gall Midge Lifecycle

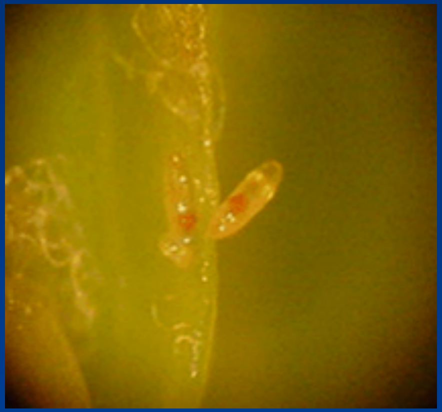
Adult 2-3 days

Egg 1-2 days

Larva 9-12 days

Puparia 8-10 days

Blueberry Gall Midge
% Dissected Buds with Eggs &/or Larvae (Gulfport, MS)



15 Jan– 0% flower buds
1 Feb- 07% flower buds
15 Feb- 20% flower buds
01 Mar- 27% flower buds
15 Mar- 60% flower buds
1 Apr- 123% flower buds
15 Apr- 193% flower buds
1 May- 206% vegetative buds
15 May- 183% vegetative buds

UGA Monitoring: **Collection & Observation of Flower Buds-**

Collect flower buds 2- to 3-Xs/week, placing them in zip-lock bags to monitor for larval infestation.

Bagging flower buds is the simplest midge monitoring technique, but monitoring damage commits to decisive action once a control threshold is reached

Midge Control

Midge insecticides are protectants, they do not clean up existing larval infestations, thorough coverage is a must

Flower Bud Stage-2 to Bloom/Fertilization is the Window of Vulnerability, Must protect Stage-2 up to Bloom when Weather is Mild

Spray to Protect Buds you think can be carried to harvest; Petal-Fall Apps Protects the Late Blooms

Diazinon IRAC #1B	++++	4-h/7-d	Material of choice for early gall midge, helpful suppression of thrips, do not apply within 5-d of bloom
Malathion IRAC #1B	+	12-h/1-d	May be applied as-needed early evening up to 1-d pre-bloom, do not apply while bees are foraging
SpinTor or Entrust IRAC # 5	+++	4-h/3-d	Material of choice for gall midge &/or thrips, apply as-need just before bloom, toxic to bees for at least 4-h, must dry thoroughly to be non-toxic
Delegate IRAC # 5	+++	4-h/3-d	Effective for gall midge & thrips, a long residual material, serious resistance risk, best saved for years with breakout thrips #s, do not apply within 5-d of bloom, toxic to bees & long lasting
Assail IRAC # 4A	++	12-h/1-d	Good resistance management tool, a change of pace (MOA/IRAC #)

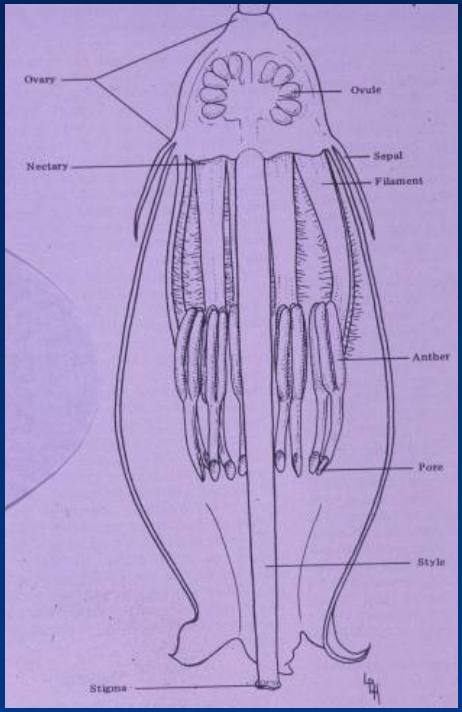
Flower Thrips Injury-Stages 4, 5, 6 & 7

Adults & nymphs have rasping and sucking mouthparts

Feed on style, filaments, anthers & developing fruit

Protected by feeding within blooms

Injury Symptoms:
distorted berries
flower and fruit abortion
puncture wounds on ovary



Rabbiteye Flowers' Closed Corollas Make it Easy for Flower Thrips to Hide and Difficult to Get Insecticide to the Thrips

Thrips Control is Confounded by the Crop's Tenuous Pollination

Flower Thrips Complex

Funderburk et al. 2000

Frankliniella bispinosa
FL flower thrips
F. occidentalis
Western flower thrips
F. tritici
Flower thrips

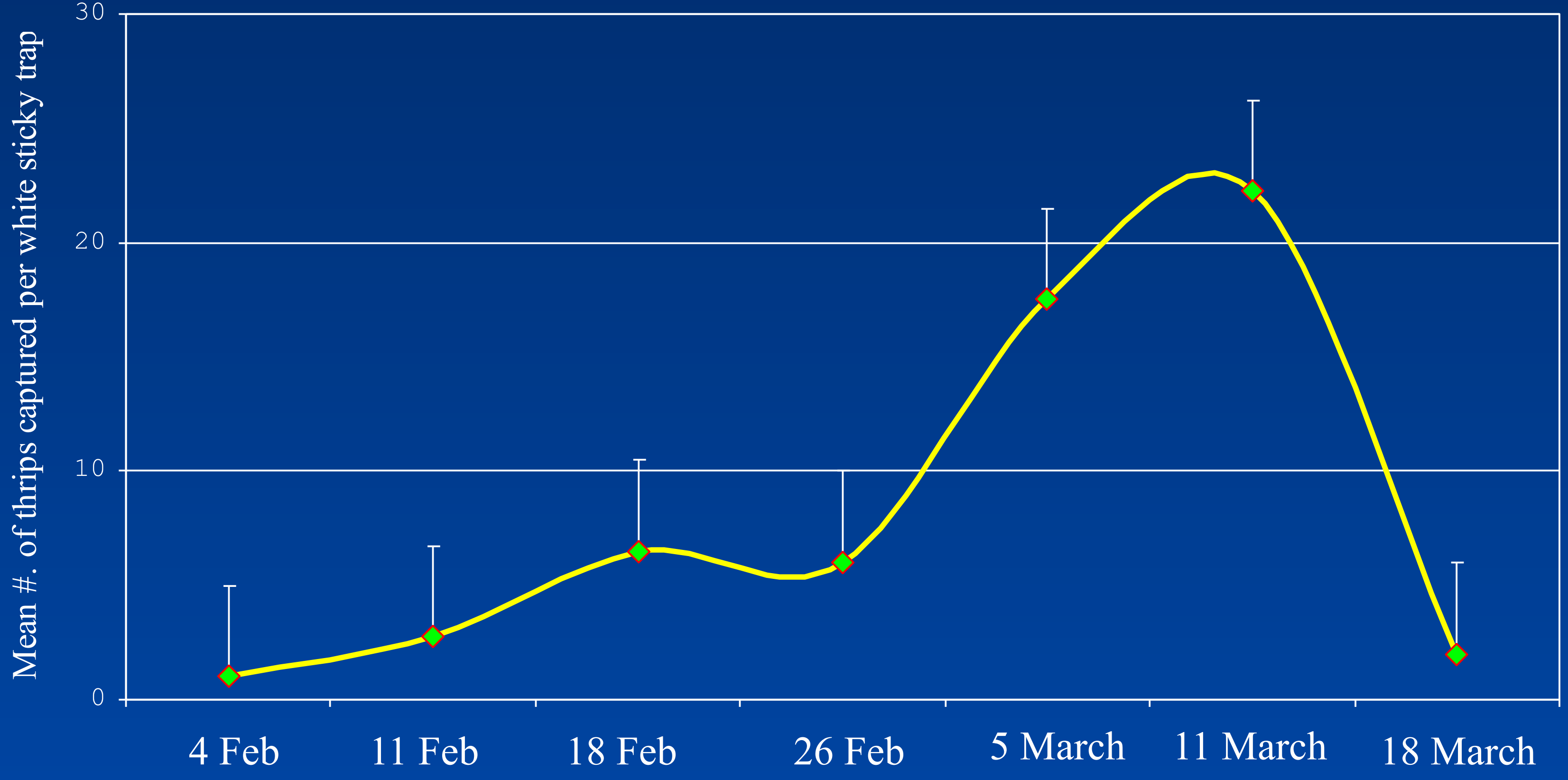
Egg, 2 active, feeding Nymphal stages, non-feeding Pre-Pupa, Pupa & winged Adults

Life cycle may be completed in 21 days or less

Females injury blueberries with their serrated ovipositor, males & females feed

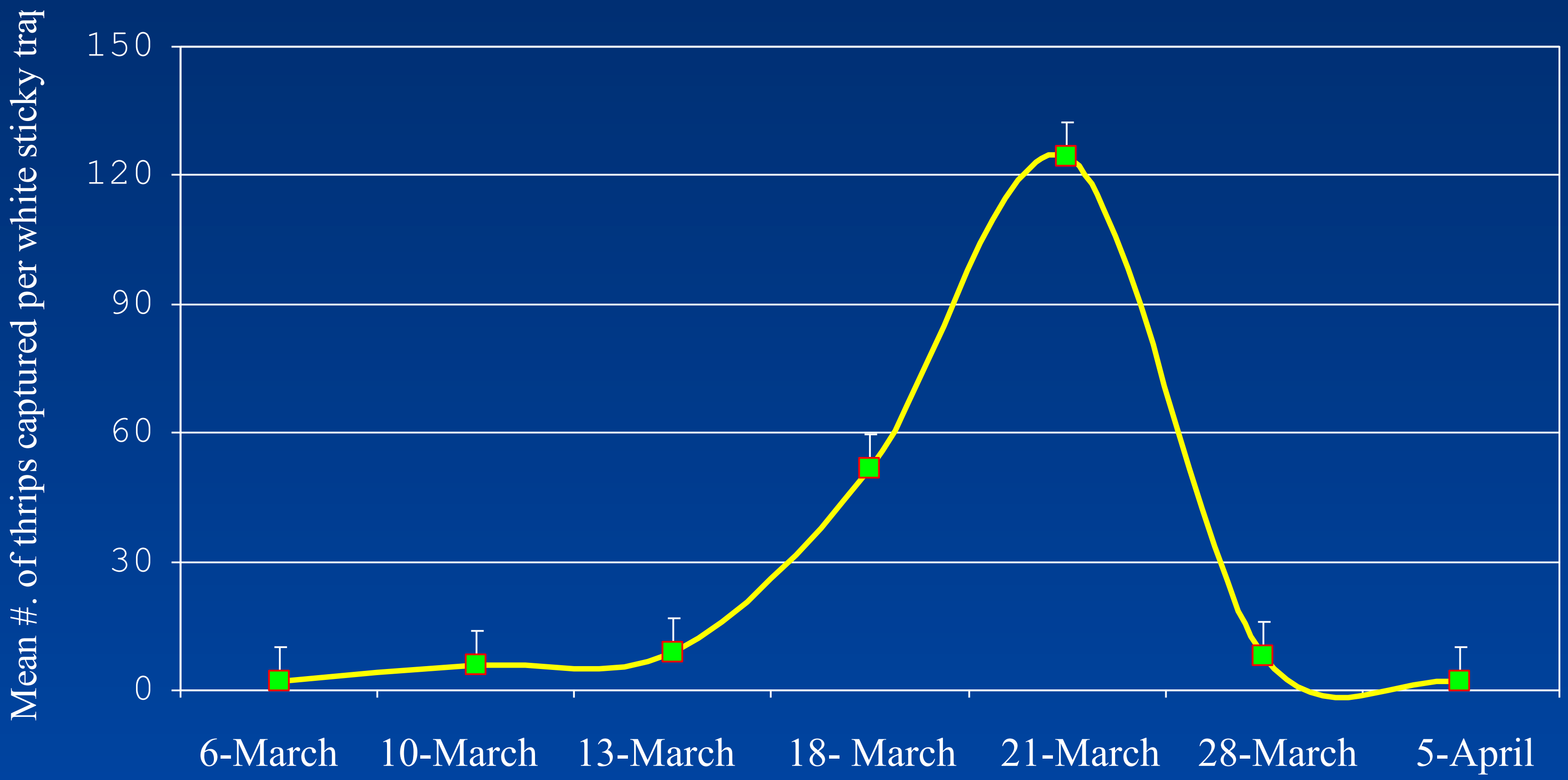
Captures of flower thrips on white sticky boards in southern highbush blueberries

Inverness, Florida (2003)



Captures of flower thrips on white sticky boards in rabbiteye blueberries,

Windsor, Florida (2003)

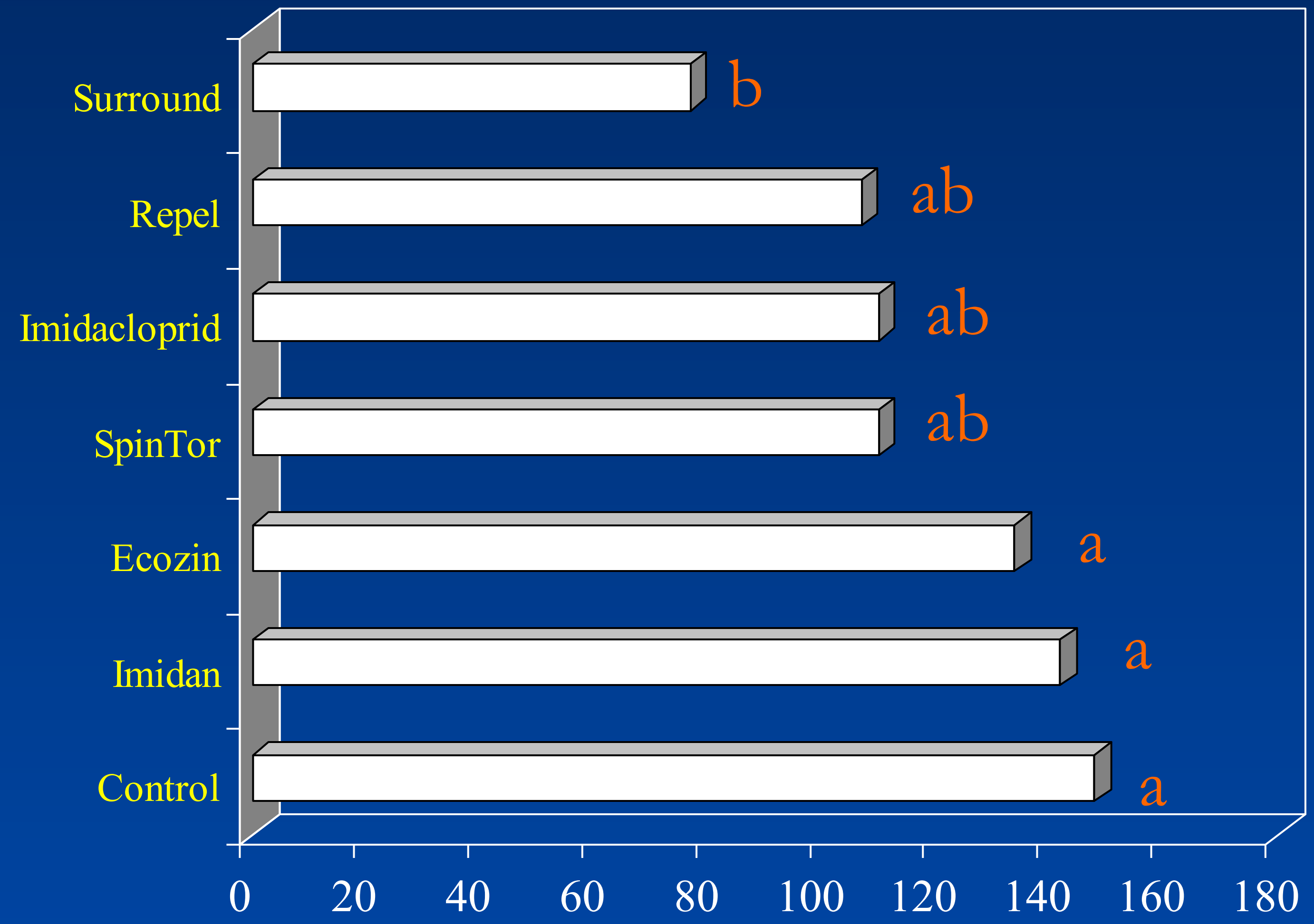


UFL Techniques for monitoring flower thrips in blueberry plantings (2003)

Technique	Mean ± SEM # Flower thrips	
	Rabbiteye	Southern Highbush
White Sticky Board	168.8 a	271.5 a
Alcohol Dip	101.0 b	50.0 b
Floral Tap	57.5 c	30.0 b
Floral Dissection	100.0 b	11.8 b

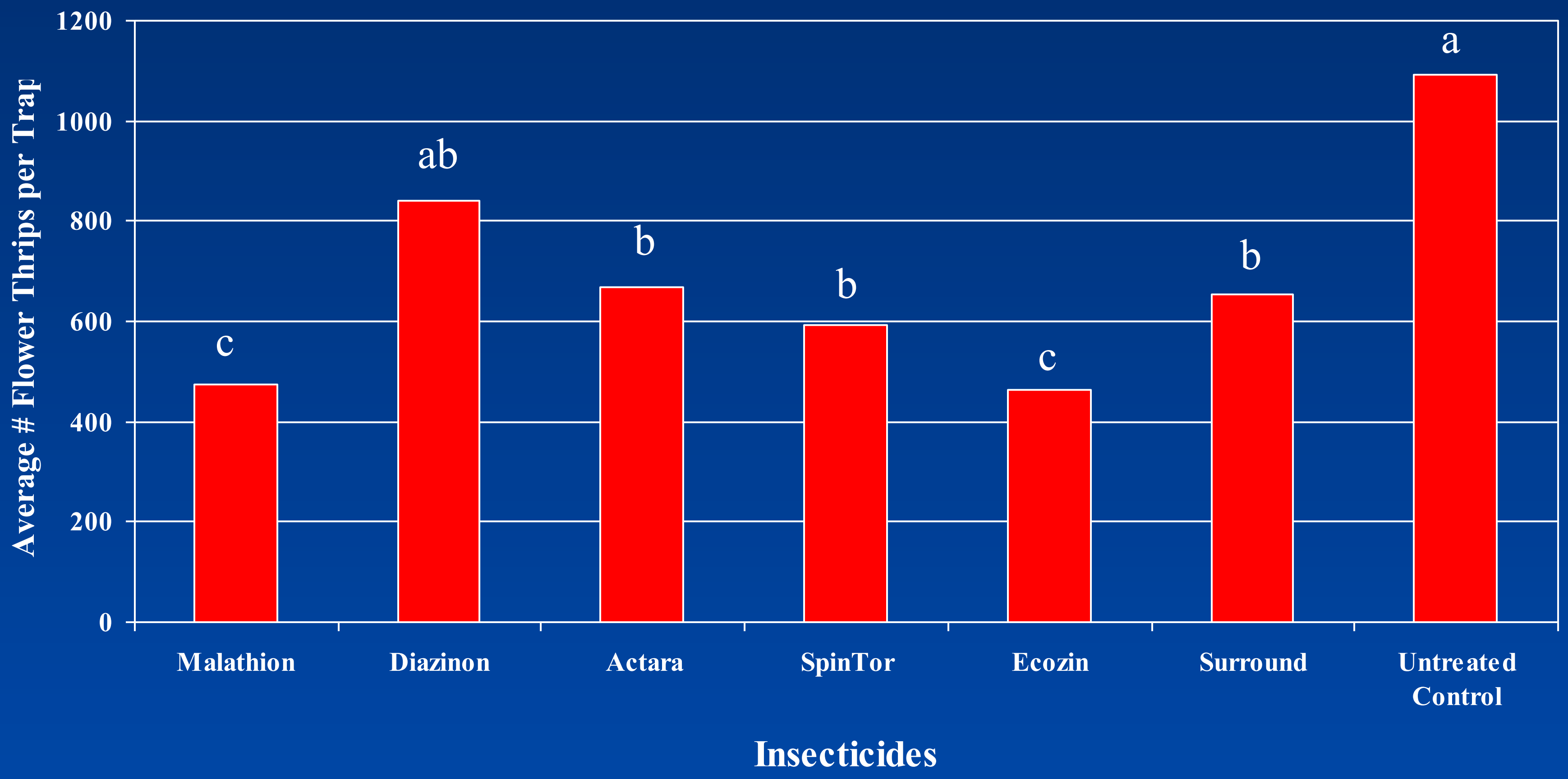
Means within columns followed by same letter are not significantly different $P = 0.05$ LSD test.

Effect of Selected Insecticides on Populations of Florida Flower Thrips (2003)



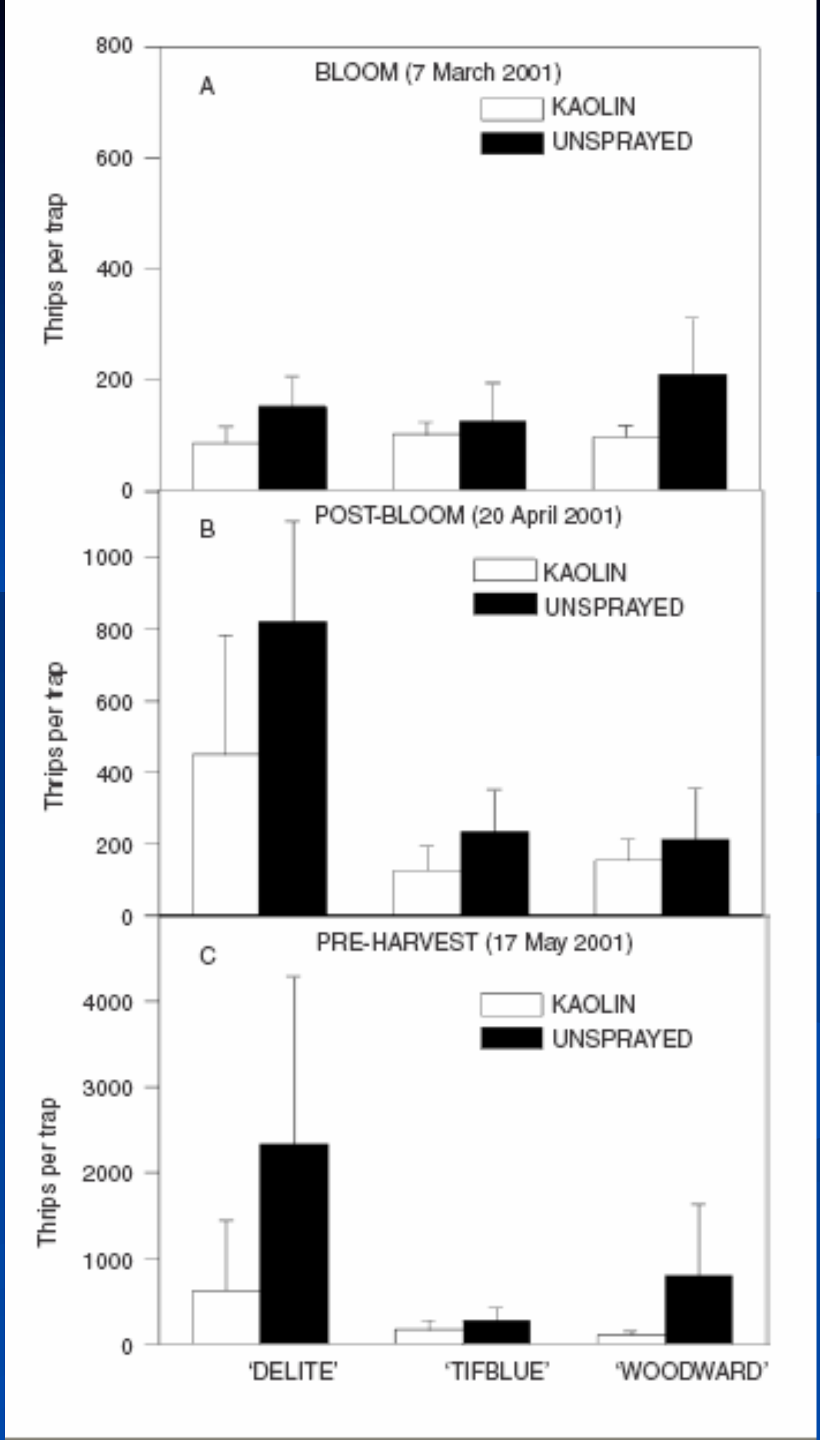
Effect of selected insecticides on populations of flower thrips in rabbiteye blueberries

Georgia (2003)



Impact of Surround (kaolin) on fruit set, development & size of ‘Cooper’ southern highbush blueberries. ***(Bars represent mean ± 1 SD)***

Spiers 1978






Flower Thrips Can be Very Injurious in Dry Springs

Blueberries are Pollination Sensitive

Flower Thrips are Primarily a Rabbiteye Pest

(floral morphology & timing)

Sample 2- to 3Xs/week beginning with Stage 3,

Place bloom clusters in sealed bags to drive thrips from blooms

< 2/bloom OK, > 2/bloom becoming problematic,

> 6/bloom quite injurious

diazinon early, followed by malathion or SpinTor,

Pro-Gibb has a role to set the last part of the crop

Floral Visitors of Rabbiteye Blueberries

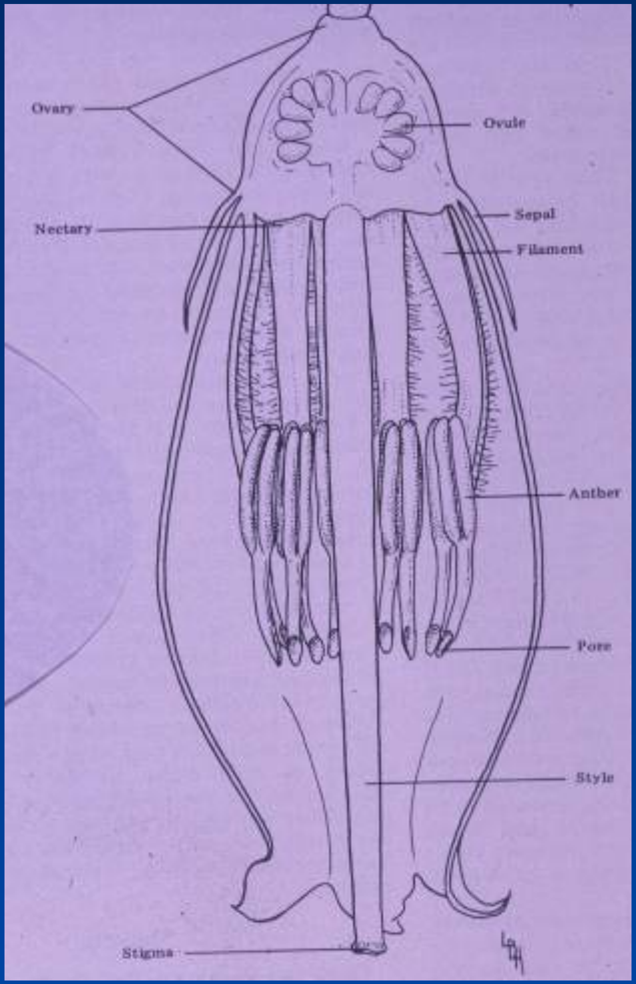
SE blueberry bee

Bumble bees

Honey bees

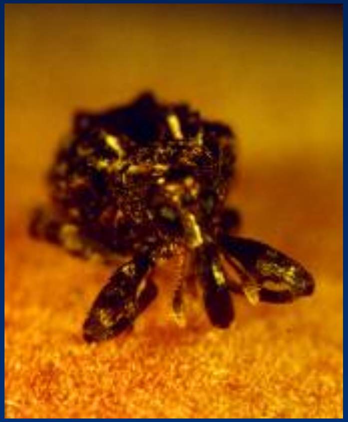
Carpenter bees

Rabbiteye Blueberry’s Floral Design Accounts for its Sensitivity to any Challenges to Floral Visitors




Post-Bloom Insects





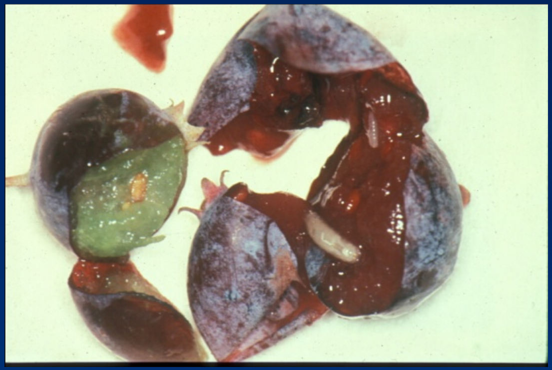

Plum Curculio

PC is Presently a Non-Pest of Blueberries in GA

PC is a Key Pest in NC

PC is a key, quarantine pest barring importation into CA

50-Years Without a Single Rejection of GA Peaches for PC-Infested Fruit Suggests Insecticidal Exclusion of PC is Realistic



Blueberry Maggot
Key Pest, though still an Only an Occasional Occurrence in the SE USA,
Quarantine Pest
Typically Site-specific, more problematic in NC than GA,
Trapping works, typically seen as Fruit Color Develops (Rabbiteyes late May-July)

Yellow Necked Caterpillars produce localized defoliation, typically late July to August, intuitively a potential cause of yield loss in young rabbiteye orchard & certainly in young southern highbush plantings

Blueberry Leaf Beetles or Flea Beetles are Post-Harvest Defoliators, as with yellow necked caterpillars importance of defoliation is linked to orchard age & species (rabbiteye vs. southern high bush), orchard pay-back linked to early yields = filling the canopy

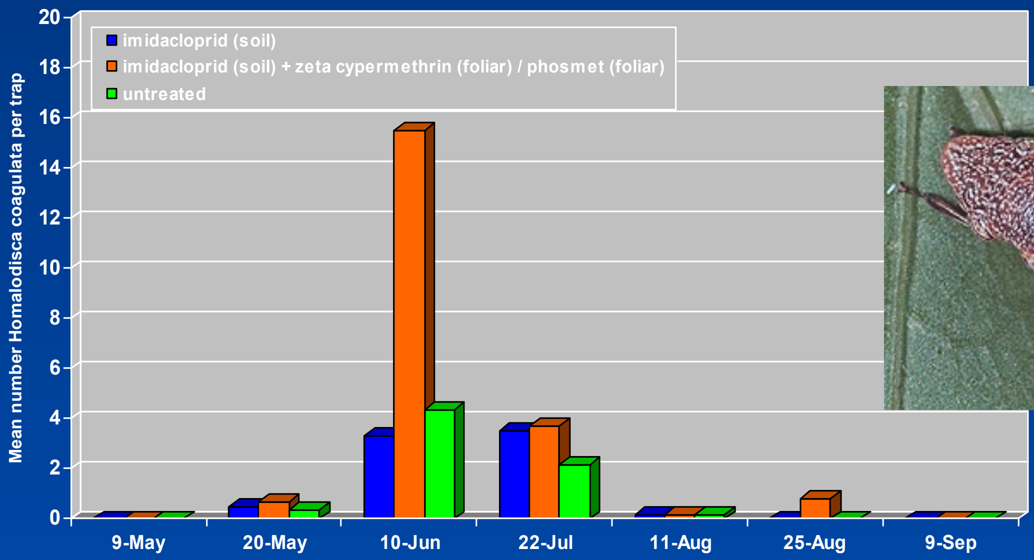
Blueberry Bud Mite is a propagation-linked pest Post-harvest Hedging reduces carry over; 2 high volume oils or endosulfans post-harvest at the onset of growth provides suppression

Managing Scale

One 2% Dormant Oil Application each winter or 2 as-needed provides reliable control of armored scale

Occasional Soft Scale Infestations may be controlled via oil, imidacloprid or OPs to crawlers

2008 Glassy Winged Sharp Shooter-
Pierce County



Pesticides a Grouped by their Toxic Mode-of-Action

http://www.irac-online.org/eClassification/

Customize Links | Free Hotmail | RealPlayer | Windows Marketplace | Windows Media | Windows

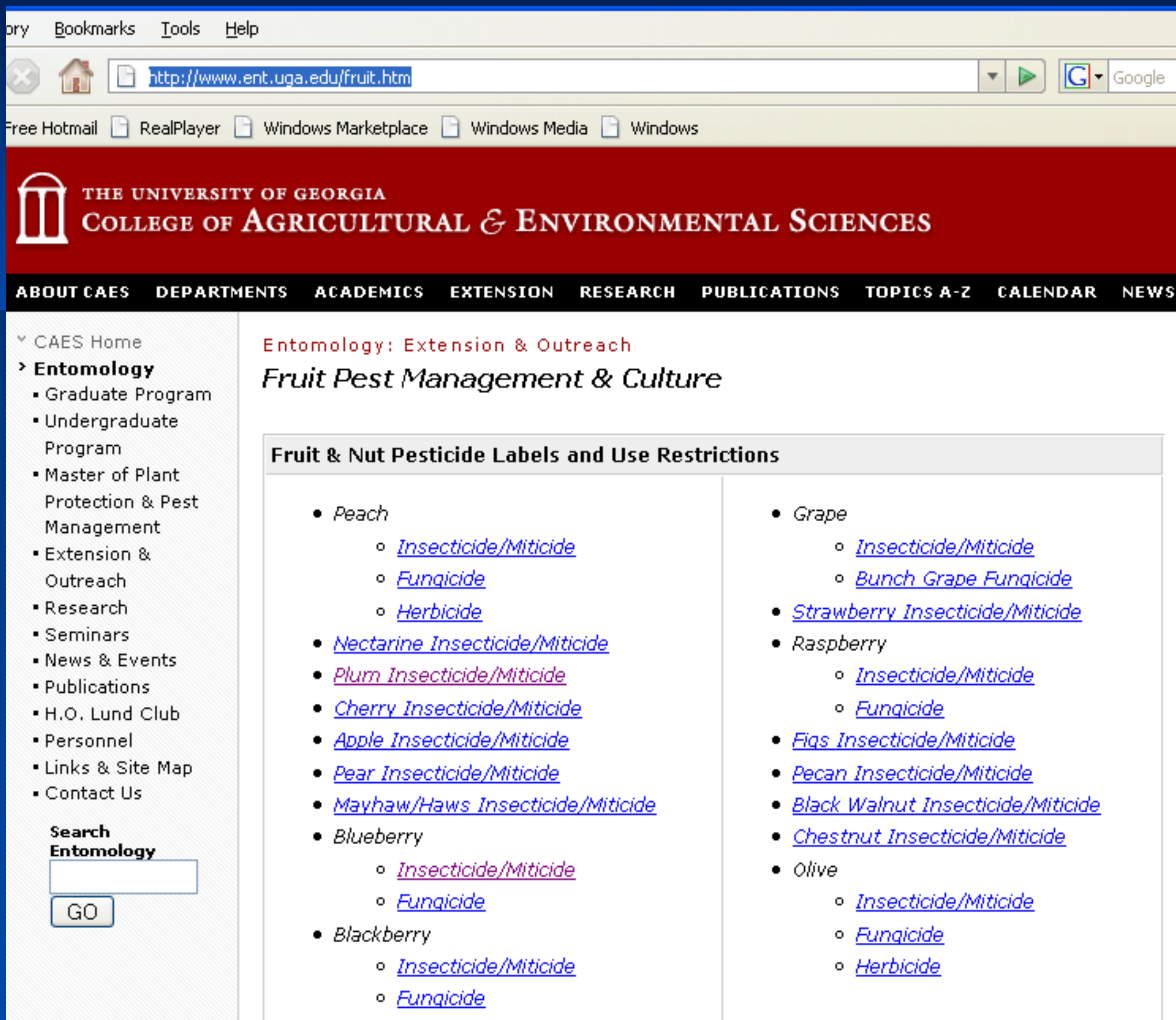
IRAC
Insecticide Resistance Action Committee

eClassification

Select a group to open... | Select a chemical class to open... | Select an active ingredient to open...

- 1 - Acetylcholine esterase inhibitor
- 2 - GABA-gated chloride channel antagonists
- 3 - Sodium channel modulators
- 4 - Nicotinic Acetylcholine receptor agonists
- 5 - Nicotinic Acetylcholine receptor allosteric activators
- 6 - Chloride channel activators
- 7 - Juvenile hormone mimics
- 8 - Miscellaneous nonspecific (multi-site) inhibitors
- 9 - Selective homopteran feeding blockers
- 10 - Compounds of unknown or non-specific mode of action (mite growth inhibitors)
- 11 - Microbial disruptors of insect midgut membranes (includes transgenic crops expressing B.t. toxins)
- 12 - Inhibitors of mitochondrial ATP synthase
- 13 - Uncouplers of oxidative phosphorylation via disruption of proton gradient
- 14 - Nicotinic acetylcholine receptor channel blockers
- 15 - Inhibitors of chitin biosynthesis, type 0, Lepidopteran
- 16 - Inhibitors of chitin biosynthesis, type 1, Homopteran
- 17 - Moulting disruptor, Dipteran
- 18 - Ecdysone agonists / moulting disruptors
- 19 - Octopaminergic receptor agonists
- 20 - Mitochondrial complex III electron transport inhibitors (Coupling site II)
- 21 - Mitochondrial complex I electron transport inhibitors
- 22 - Voltage-dependent sodium channel blockers
- 23 - Inhibitors of acetyl CoA carboxylase - Lipid synthesis, growth regulation
- 24 - Mitochondrial complex IV electron transport inhibitors
- 25 - Vacant

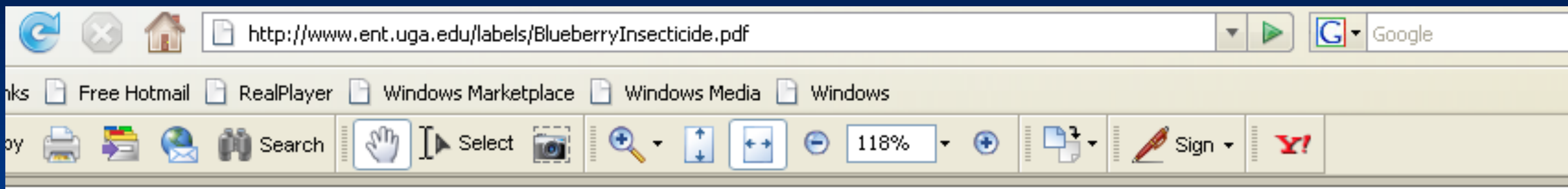
Blueberry Pesticides [http://www.ent.uga.edu/fruit.htm]



x

Blueberry Insecticides/Miticides

[http://www.ent.uga.edu/labels/BlueberryInsecticide.pdf]



7/18/2008

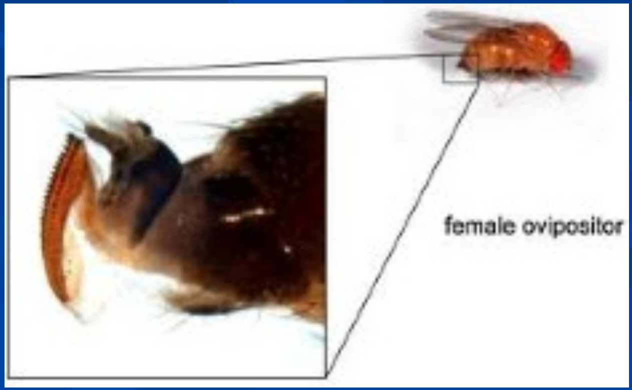
Georgia Blueberry Insecticide/Miticide Labels & Use Restrictions

Dan Horton and Terry All, University of Georgia, Department of Entomology, Athens, GA 30602
http://www.ent.uga.edu/fruit.htm

Based on labels as seen on CDMS (http://www.cdms.net/LabelsMsds/LMDefault.aspx?t=) and Greenbook (http://www.greenbook.net/) websites (last referenced 7/18/2008). UGA provides this compilation to minimize the risk of off-label pesticide use. Always refer to the actual product label, which is the definitive guide for safe, legal pesticide use.

Active ingredient	IRAC group #	Trade name	Manufacturer	Re-Entry Interval (REI) / Pre-Harvest Interval (PHI)
acetamiprid	4A	Assail 30SG	Cerexagri-Nisso	12 hrs/24 hrs
		Assail 70WP	Cerexagri-Nisso	
azadirachtin	18B	Aza-Direct **Organic**	Gowan	4 hrs/day of harvest
		Neemix 4.5 **Organic**	Certis USA	12 hrs/day of harvest
azinphos methyl	1B	Guthion Solupak 50%	Bayer CropScience	7 days/7 days **AL, AR, FL, GA, NC**
Bacillus thuringiensis subsp. *aizawai*	11B1	XenTari **Organic**	Valent	4 hrs/day of harvest
Bacillus thuringiensis subsp. *kurstaki*	11B2	Crymax	Certis USA	4 hrs/day of harvest
		Deliver **Organic**	Certis USA	
		Dipel ES	Valent	
		Javelin WG **Organic**	Certis USA	
botanical oil		Allityn Insect Repellent (garlic oil) **Organic / repellent only**	Helena	4 hrs/12 hrs
		Ecotrol EC	EcoSMART	0 days/day of harvest

Exotic Pests Which May Prove Important in Blueberries



References

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Management of Major Blueberry Diseases

P. M. Brannen
Plant Pathology Dept.
Univ. of Georgia
Athens, GA

Treatment and rate/A	Plant health rating results*
Untreated control	1.8 a**
MBC-33 350 lb	2.2 b
Telone C-35 50 gal	2.3 b
ProPhyt 6 pt	1.7 a

* Rating scale: 0 = dead plant, 1 = partial death of the plant with extreme stunting, 2 = extreme leaf discoloration (reddening and yellowing) and plant stunting, 3 = moderate reddening of leaves and plant stunting, 4 = limited symptoms and very minor leaf discoloration, 5 = healthy plant.

**Analysis of covariance-adjusted means and standard errors of four replicate plots. Means within columns followed by the same letters are not significantly different by *t*-test comparisons ($\alpha = 0.05$).

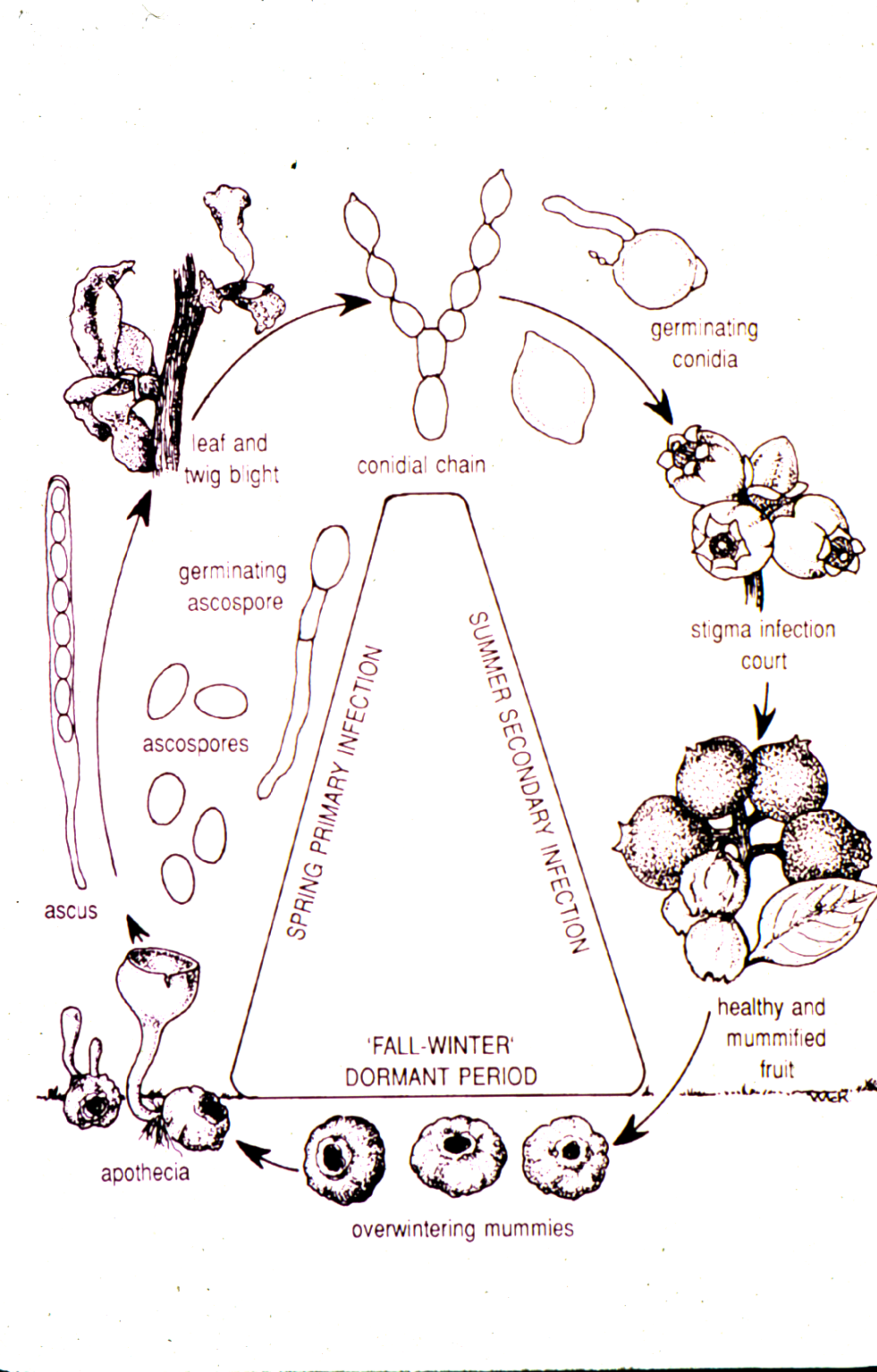
[a] Ring nematode counts per 100 cc soil collected on 27 Jun 2008 (Alma, GA). [b] Subjective vigor rating recorded on 24 Sep 2008 (0 = dead . . . 5 = extremely healthy). [c] Ring nematode counts per 100 cc soil collected on 1 Aug 2008 (Homerville, GA). [d] Means followed by the same letters are not significantly different according to Fisher's protected LSD test.	**Trial Location**		
	Alapaha, GA		Homerville, GA
Treatments	Nematode Counts[a]	Vigor Rating[b]	Nematode Counts[c]
(1) Untreated control (bare ground)	26.8 ab[d]	2.2 b	558.0 a
(2) Untreated control (plastic only)	41.0 a	2.9 a	622.5 a
(3) PicChlor 60 (60% chloropicrin and 40% Telone) @ 21 gallon/acre broadcast rate	3.0 c	3.3 a	37.5 b
(4) Telone II @ 7 gallons/acre broadcast rate	10.0 bc	3.1 a	441.0 a
(5) Methyl bromide 50:50 (50% MeBr and 50% chloropicrin) @ 350 lb/acre broadcast rate	0.0 c	3.4 a	1.0 b
LSD (α = 0.05)	18.3	0.6	250.4

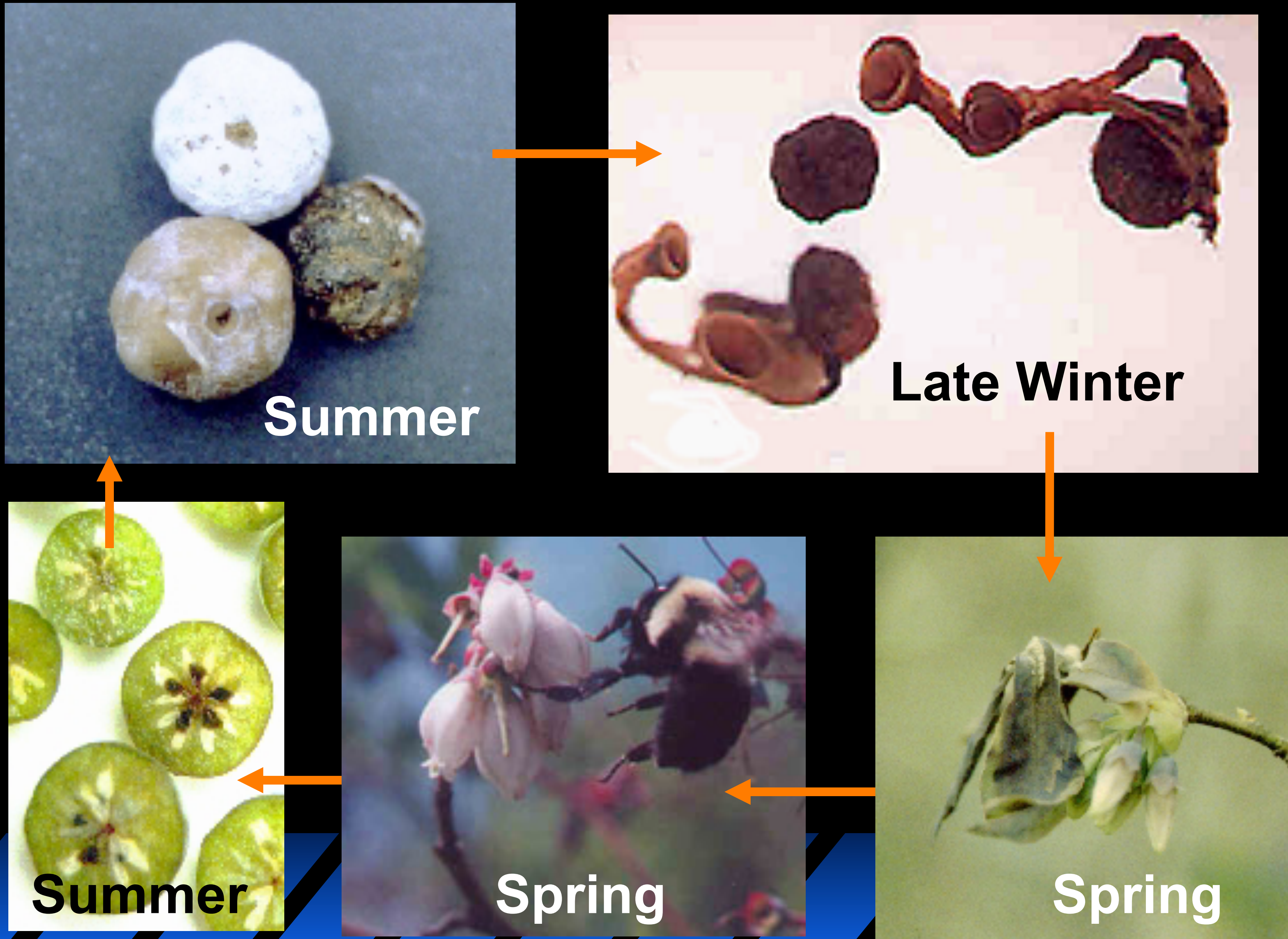
Where does lime sulfur fit or does it fit?

- Bottom line – we do not know for sure.
- Lime sulfur will need to be applied in the dormant or late dormant stage in GA (probably a December – late January application, depending on blueberry variety and species); high temperatures (above 75 F) will increase burn to buds, leaves, blooms, etc.
- It is a "clean up" material, and it is generally thought to reduce inoculum – killing overwintering fungi.
- Limited data is available, and it would be premature to recommend the use. However, if used, it may possibly help to prevent some dieback diseases (not mummy berry as some labels indicate).

Mummy Berry

- GA blueberries are primarily rabbiteye cultivars, *Vaccinium ashei* (>90% of acreage).
- Mummy berry disease
  - Causal agent: *Monilinia vaccinii-corymbosi*
  - Losses: yield reduction, cost of control, and lower quality grades post-harvest


leaf and
twig blight
conidial chain
germinating
conidia
stigma infection
court
healthy and
mummified
fruit
overwintering mummies
apothecia
ascus
germinating
ascospore
ascospores
SPRING PRIMARY INFECTION
SUMMER SECONDARY INFECTION
'FALL-WINTER'
DORMANT PERIOD


Summer
Late Winter
Spring
Spring
Summer

Indar, Orbit, or Tilt

and

Pristine

Berries* *Bushberries Blueberry, Currants, Elderberry, Gooseberry, Huckleberry, *Caneberries Bingleberry, Blackberry, Boysenberry, Dewberry, Loganberry, Lowberry, Marionberry, Olallieberry, Red and Black Raspberry, Youngberry	Mummyberry Disease (*Monilinia vaccinicorymbosi*)	6	Make first application of Orbit beginning at green tip and repeat in 7-10 days. If conditions are favorable for disease development, additional applications may need to be made at pink bud and repeating every 7-10 days through petal fall.
	Leaf Spot and Stem Canker (*Septoria albopuncatata*) Rust (*Pucciniastrum vaccinii*)	6	Apply when conditions favor disease development. Repeat applications on a 4 week spray interval.
	Leaf and Cane Spot (*Septoria rubi*)	6	Apply as a delayed dormant spray after training in the spring. Repeat this applica tion in the late spring, again at bud break, and again once flowering has begun.
Juneberry Lingonberry Salal	Powdery Mildew (*Microsphaera vaccinii*)	6	Apply Orbit at 5-10% bloom. Repeat this application at full bloom and on a 14 day interval while conditions are favorable for disease development.
And cultivars and/or hybrids of these	Leaf Spot (*Septoria* spp.)	6	Make first application any time prior to bloom and again after petal fall. If needed, repeat application just after harvest.

Application: Orbit is most effective when applied and allowed to dry before a rainfall. For best results, sufficient water volume should be used to provide thorough coverage. Orbit may be applied by either ground (a minimum of 5 gal./A) or aerial application (a minimum of 15 gal./A).

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.

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


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, but this is not necessary for infection. Cool, wet conditions are all that is required. <u>The blighted blooms will cause twig blight.</u>

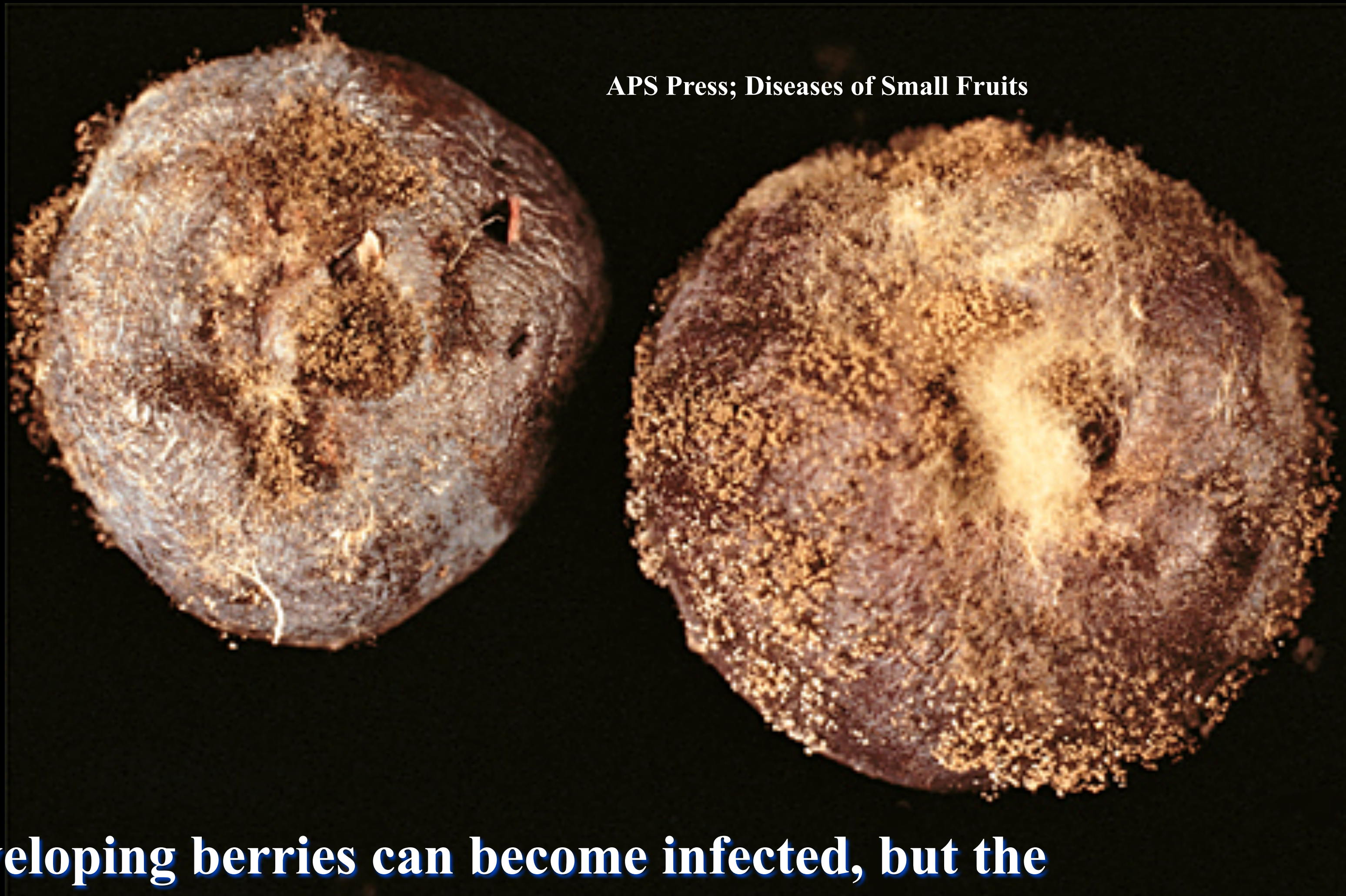
Botrytis Blight and Fruit Rot
(*Botrytis cinerea*)

- 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).

Overwintering Botrytis Sclerotia


APS Press; Diseases of Small Fruits


Young leaves are infected through contact with blossoms.
APS Press; Diseases of Small Fruits

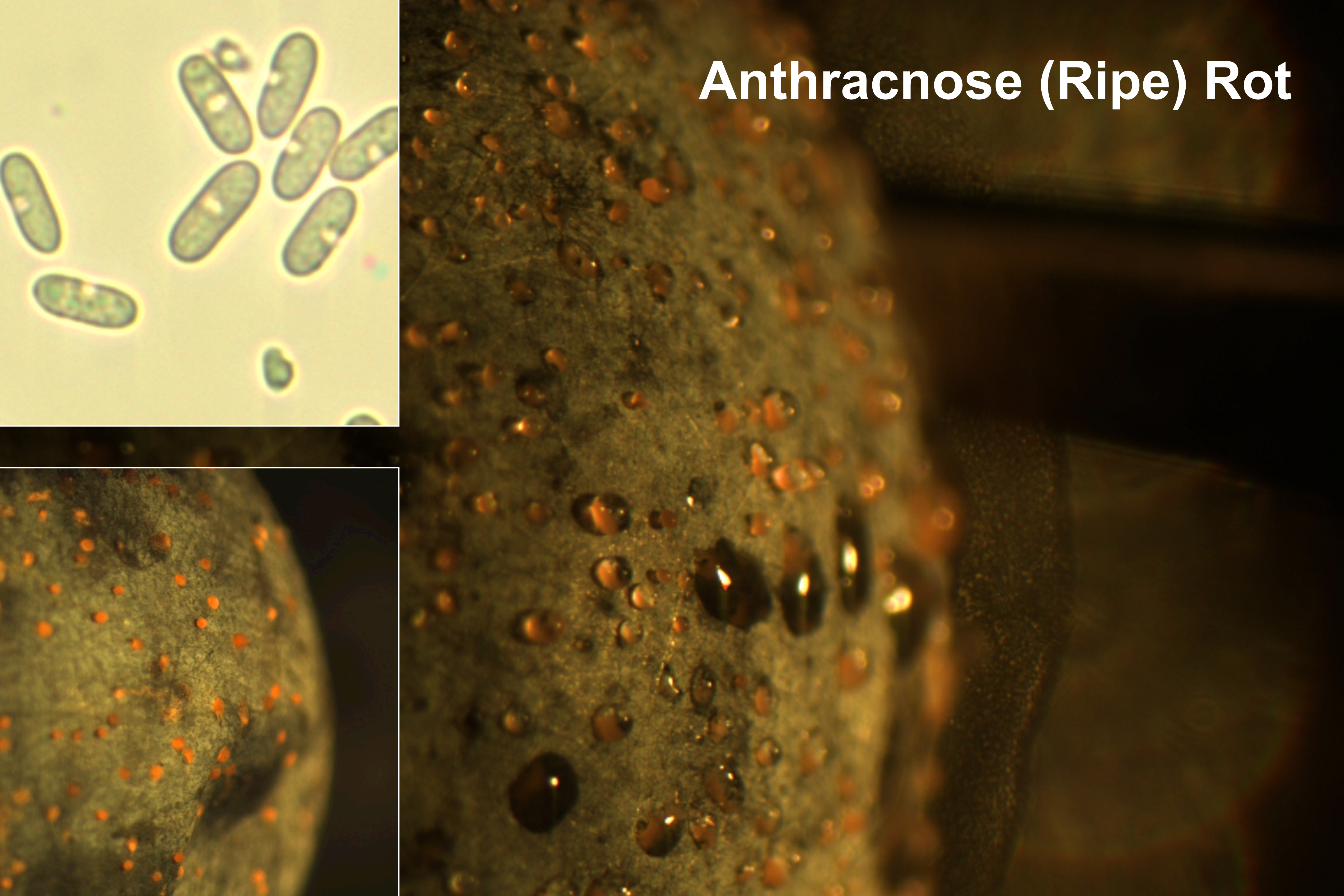


Developing berries can become infected, but the symptoms do not show up till after harvest.

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

Primary Blueberry Rots

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


Anthracnose (Ripe) Rot


Alternaria Fruit Rot
APS Press; Diseases of Small Fruits

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

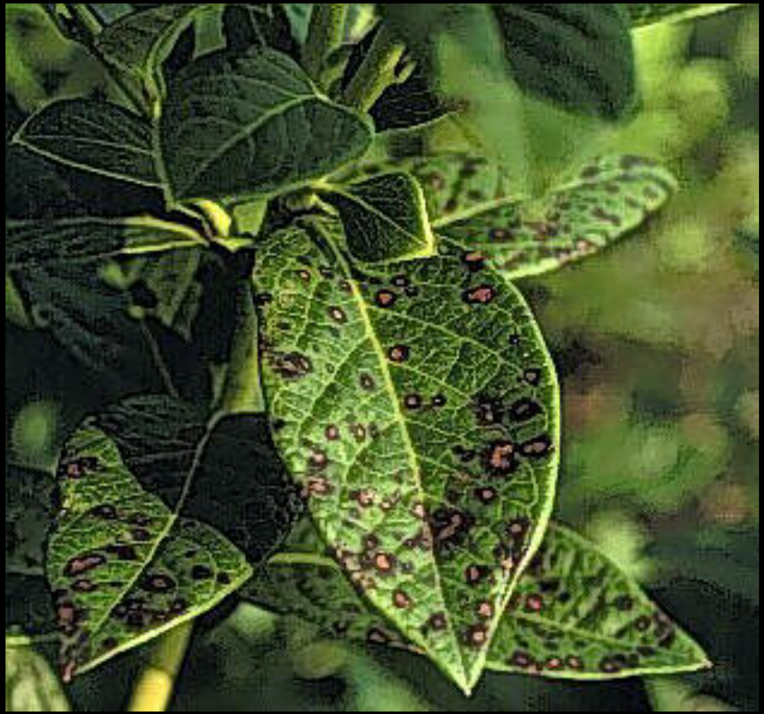
- Fungicide sprays (Switch™, Abound™, Cabrio™, Pristine ™, and Captan) and rapid cooling immediately following harvest provide for control.
- Infection can take place at any time on the fruit, but critical times appear to be bloom, post-bloom and preharvest.

Primary Blueberry Leaf Spots in Georgia

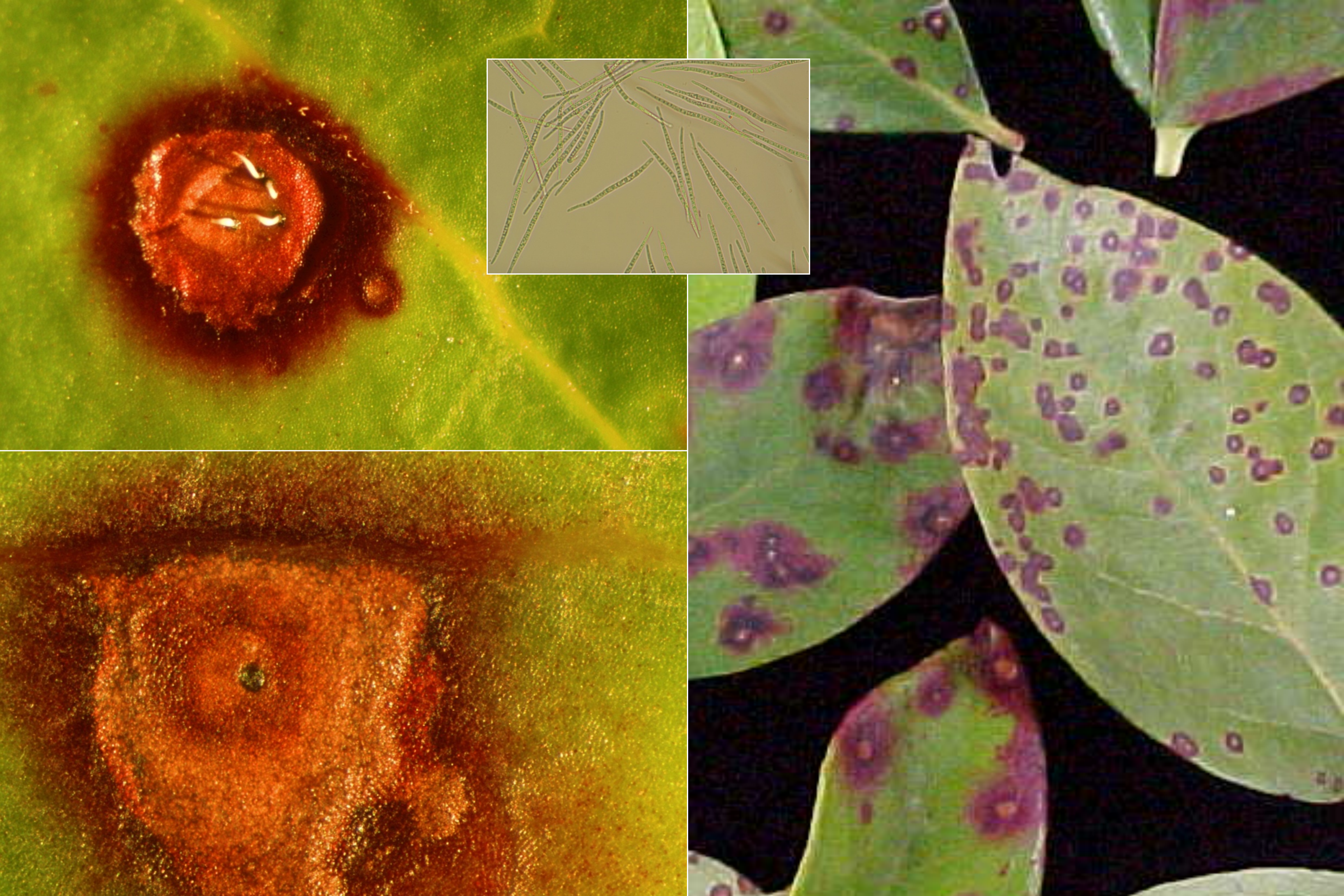
- Septoria Leaf Spot (*Septoria albopunctata*)
- Anthracnose Leaf Spot (*Gloeosporium minus*)
- Leaf rust (*Pucciniastrum vaccinii*)
- Pestalotia (*Pestalotia* sp.)
- Phyllosticta (*Phyllosticta* sp.)
- Powdery Mildew (*Microsphaera vaccinii*)
- Non-pathogenic or Physiological Leaf Spots

Septoria Leaf Spot

- Generally most severe on older leaves which are close to the ground.
- Very serious damage in rooting beds.
- Small spots; white to tan center and purple border.



J. R. Meyer and W. O. Cline; Blueberry Pest Management, a Seasonal Overview; 1997



Anthracnose Leaf Spot

- Caused by *Gloeosporium minus*.
- Causes large, irregular-shaped, brown lesions with a red border.
- Lesions often start at the edge of the leaf.

J. R. Meyer and W. O. Cline; Blueberry Pest Management, a Seasonal Overview; 1997

Anthracnose Leaf Spot

Bill Cline; North Carolina State

Bill Cline; North Carolina State

APS Press; Diseases of Small Fruits

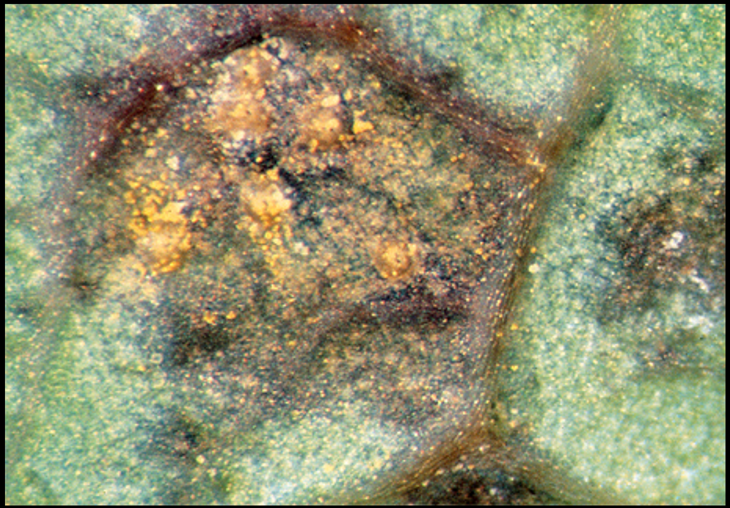
Anthracnose Leaf Spot
(Second Type)

- Different organism(s); *Colletotrichum gloeosporioides* and *C. acutatum*.
- Also causes anthracnose ripe rot of fruit.
- Reported as a serious problem in Georgia during warm, wet conditions.
- Lesions are brown.

APS Press; Diseases of Small Fruits

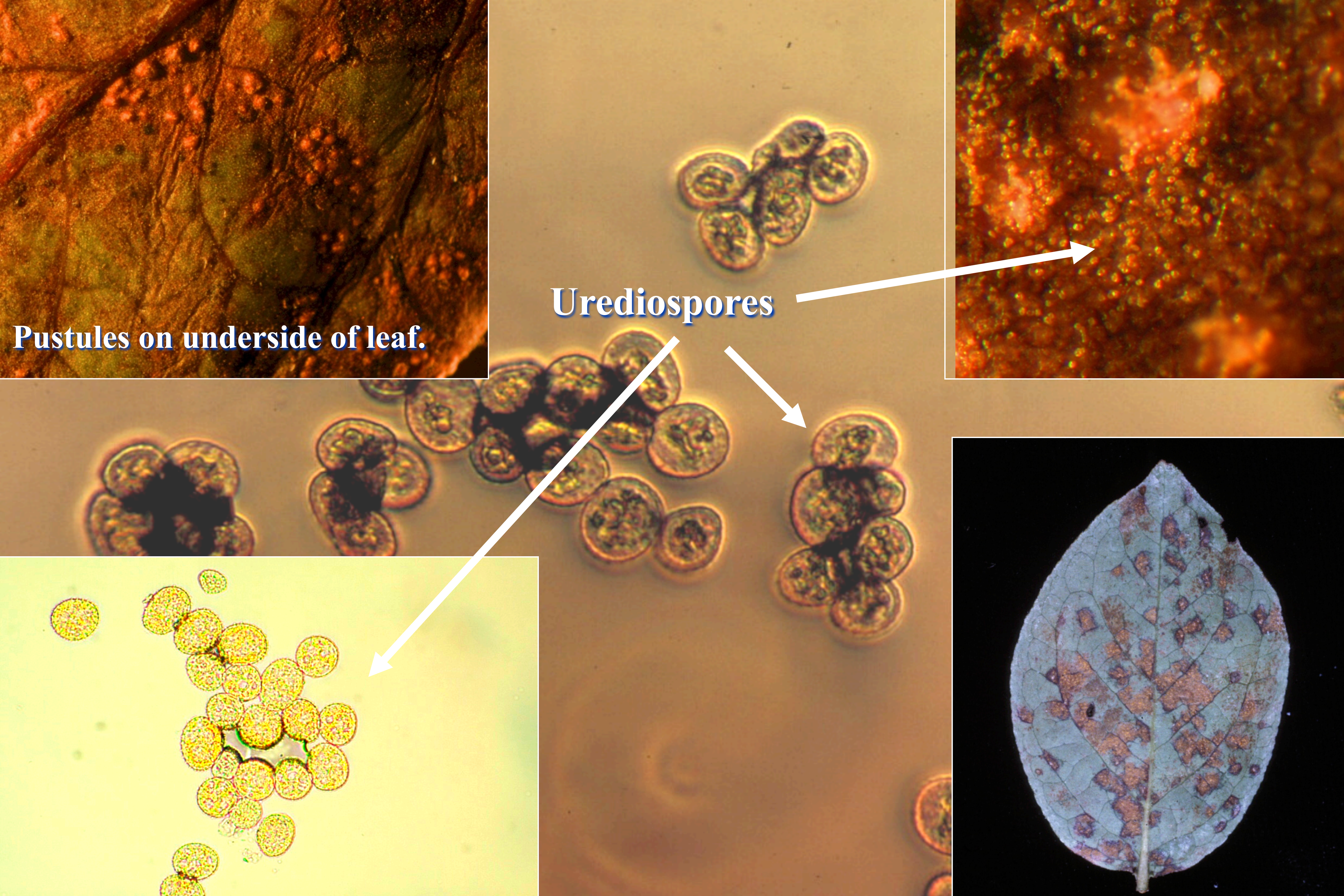
Leaf Rust

- Oblong to angular leaf spots first develop on the upper leaf surface.
- Pale green to yellow and then maroon to brown in color.
- Lower leaf may develop salmon-to-orange pustules.

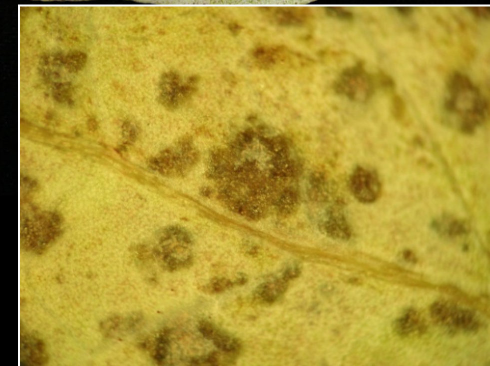


Leaf Rust

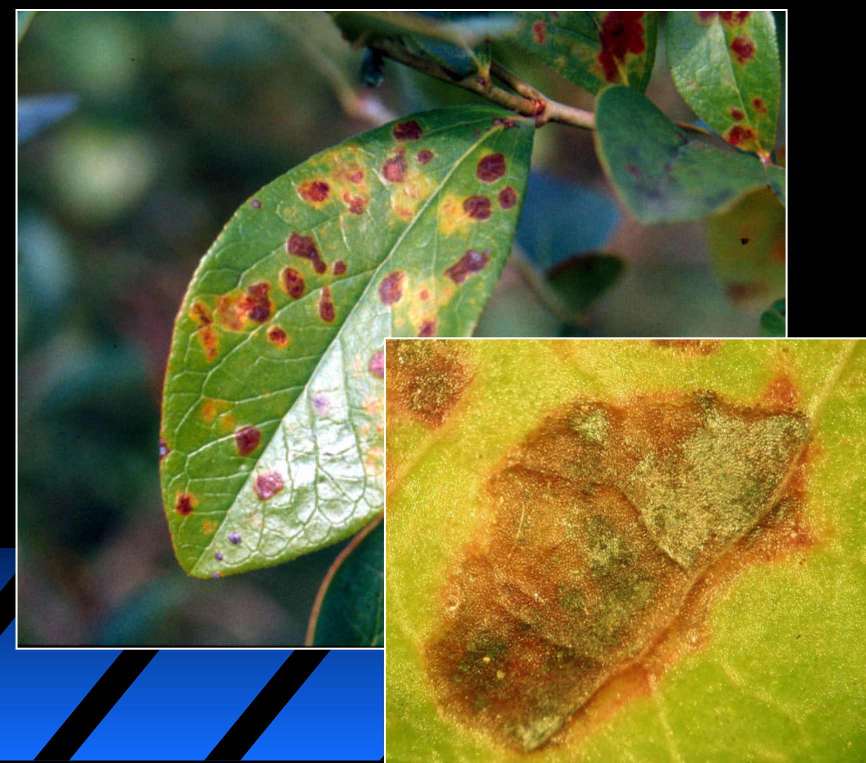
APS Press; Diseases of Small Fruits


Pustules on underside of leaf.
Urediospores

Non-Pathogenic Leaf Spots



- Most common of all in 2002! Very common in 2003 as well
- Found on most rabbiteye samples
- Symptoms:
  - Leaf flecking
  - Water-soaking
  - Edema-like blotches
- Mechanical, hypersensitive response, insect and/or physiological damage?



Cultivar	2002 Leaf Spot Susceptibility Rating		
	Septoria	Anthracnose	Rust
Brightwell	++++	++	++
Climax	++	++	+++
Powderblue	+++	++	+++
Premiere	+++	++	----
Tifblue	+++	++	----
O' Neal	----	+++	----
Star	+++++	+++	----

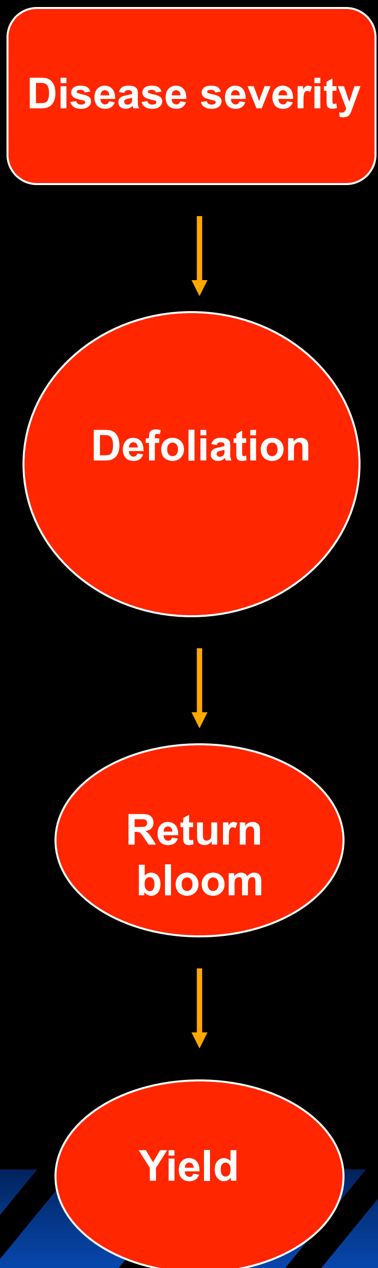
Cultivar	2003 Leaf Spot Susceptibility Rating		
	Septoria	Anthracnose	Rust
Brightwell	++++	+++	+
Climax	++	+++	+++
Powderblue	+++	+++	++
Premiere	+++	+++	+
Tifblue	+++	++	----
Blue Crisp	+++	++	+++
Star	+++++	+++	++

Leaf Spot Field Trial Yield Results

Treatment and Rate/Acre	Yield Increase (% over UTC)	Yield Increase (% over UTC)
Untreated Control (UTC)	0	0
Benlate 50WP 1.0 lb + Captan 75DF 3.0 lb	37	26
Indar 75WP 2.0 oz	44	34
Indar 75WP 2.0 oz + 0.125% B-1956	48	32

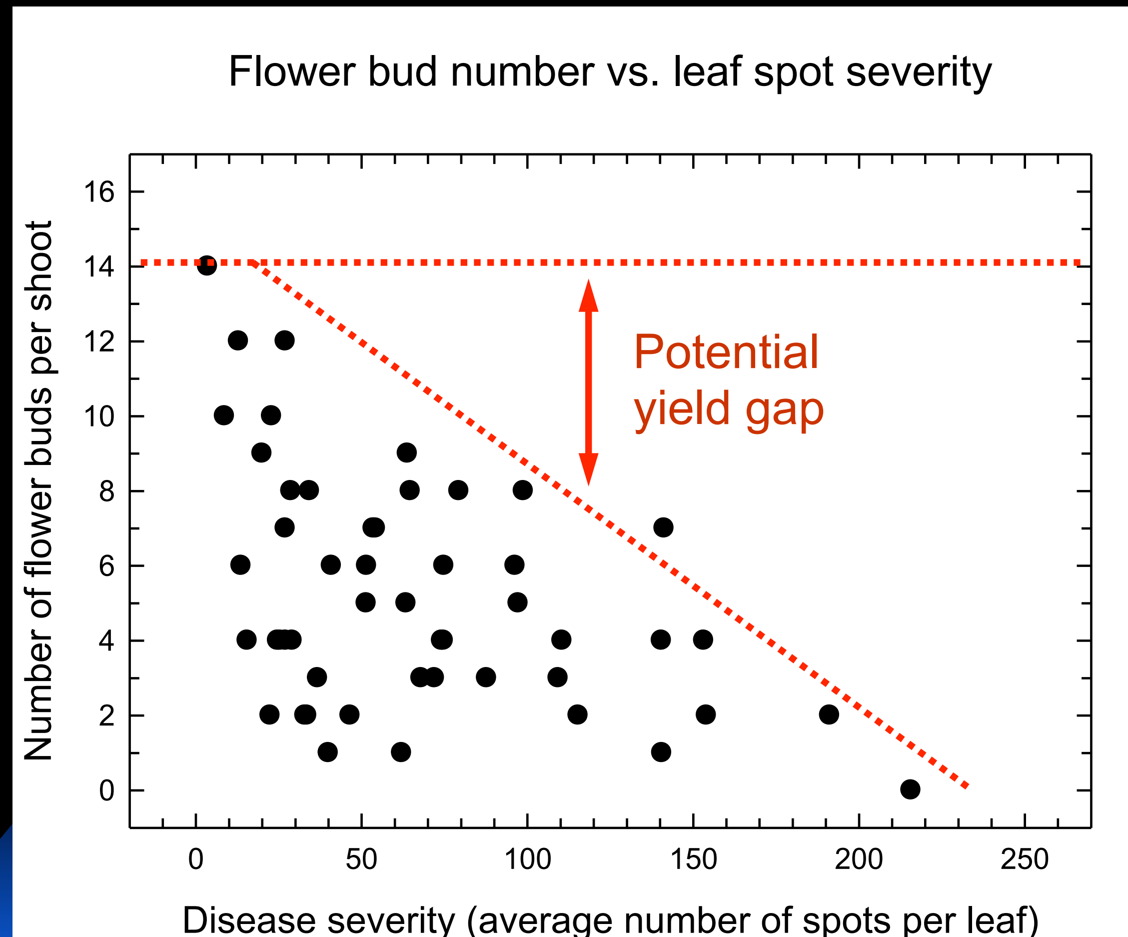
P=0.05

Bill Cline; North Carolina State



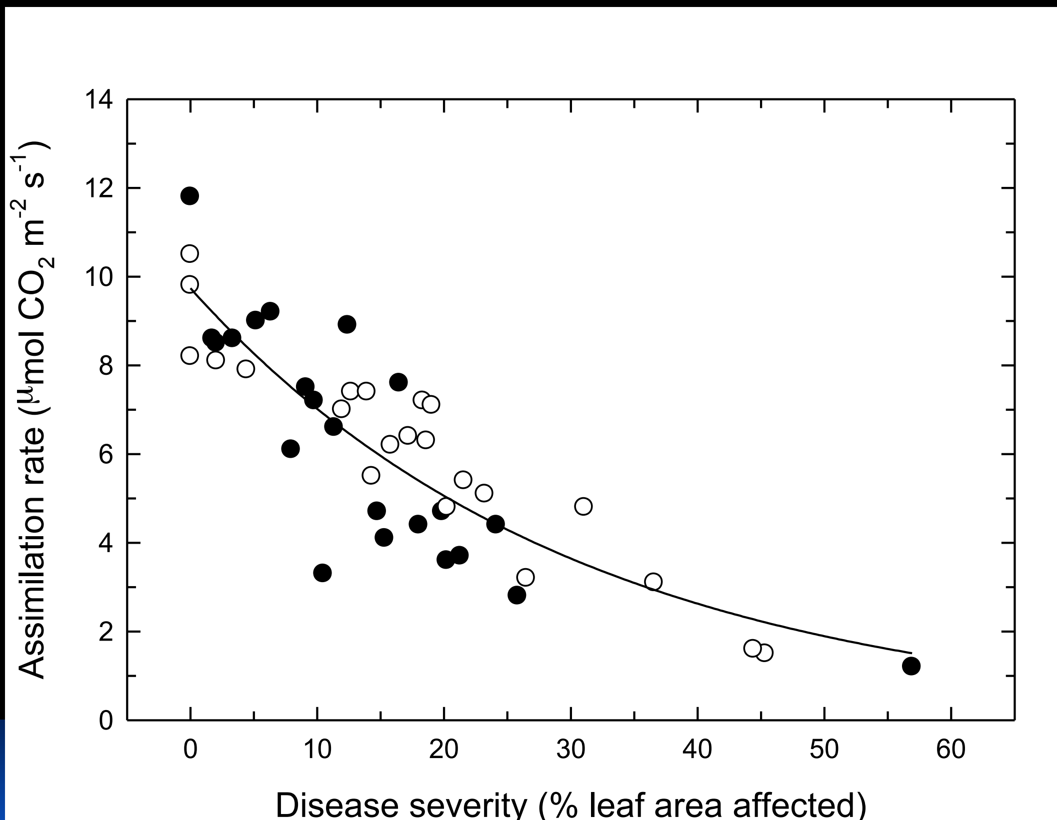
What are the effects of leaf spot severity on subsequent flower bud set and yield?

Peter Ojiambo



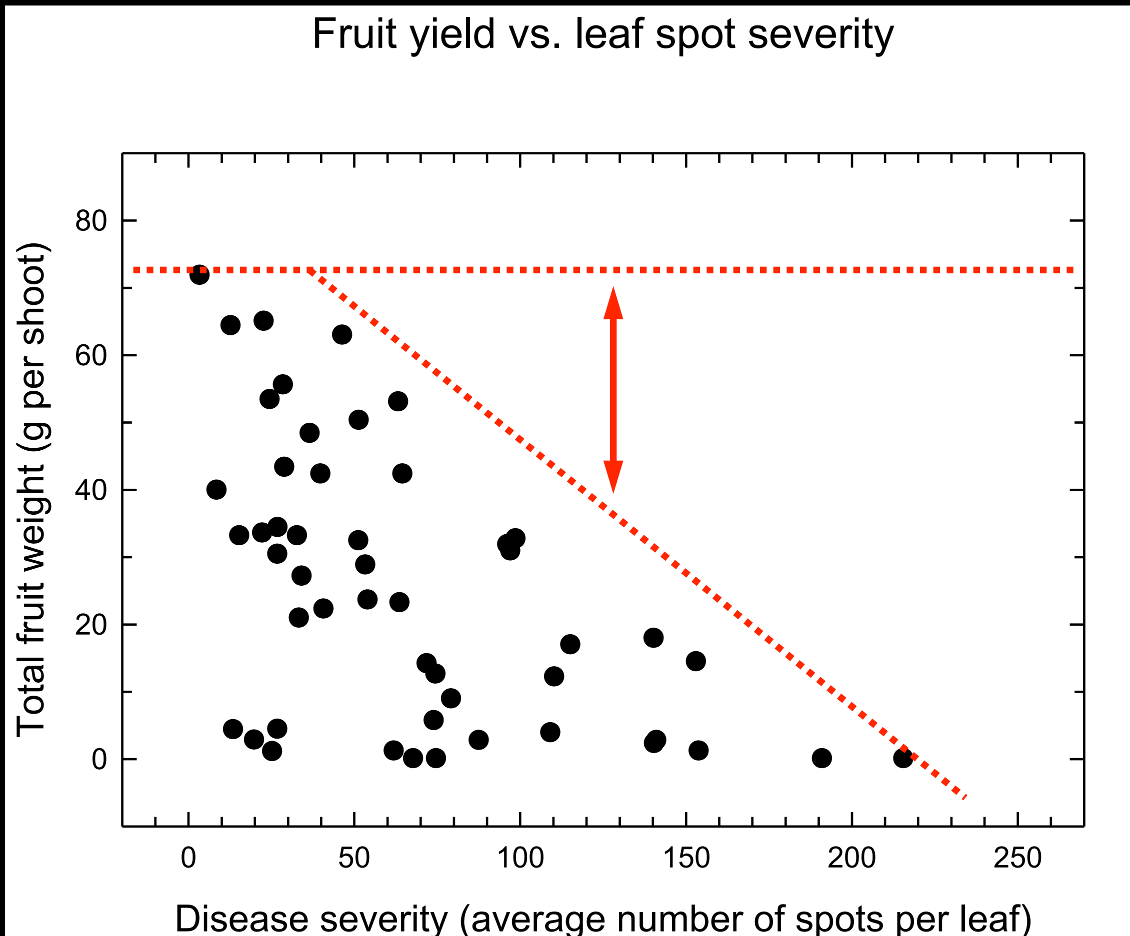
Premier, UGA, 2001

Negative physiological effects due to leaf spots may occur well before leaves defoliate.



Bluecrisp, Homerville, 2002

Inga Roloff

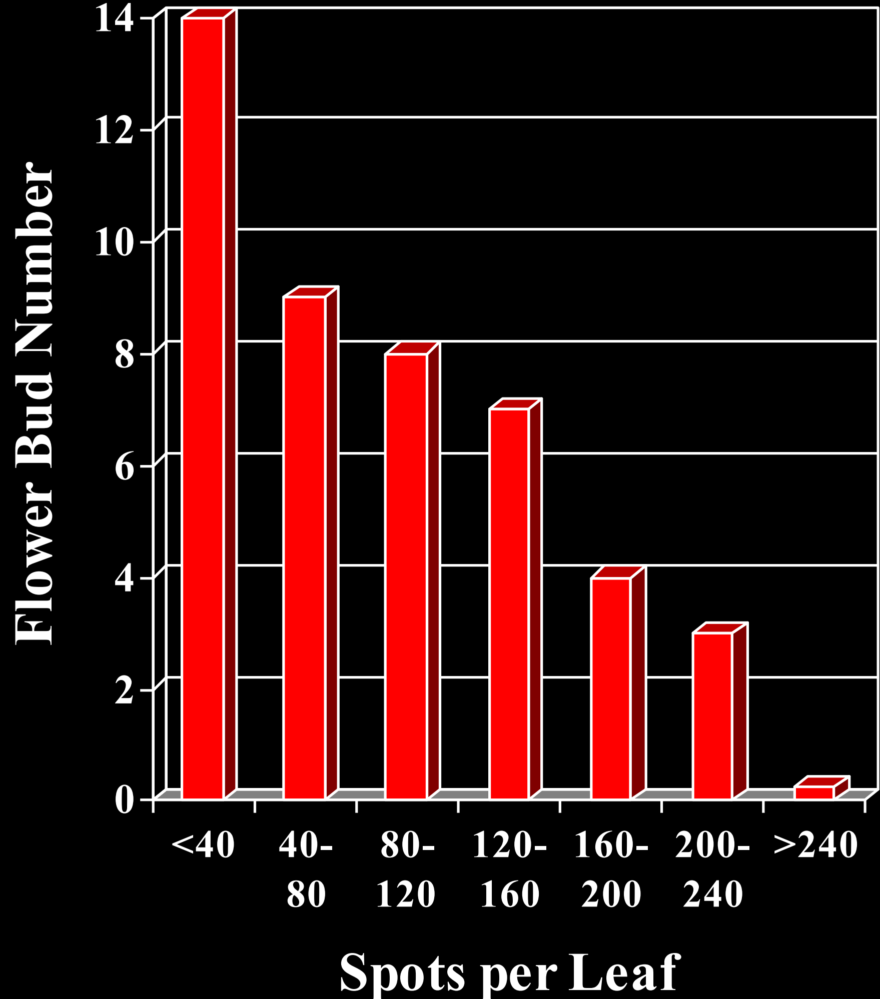


Premier, UGA, 2001

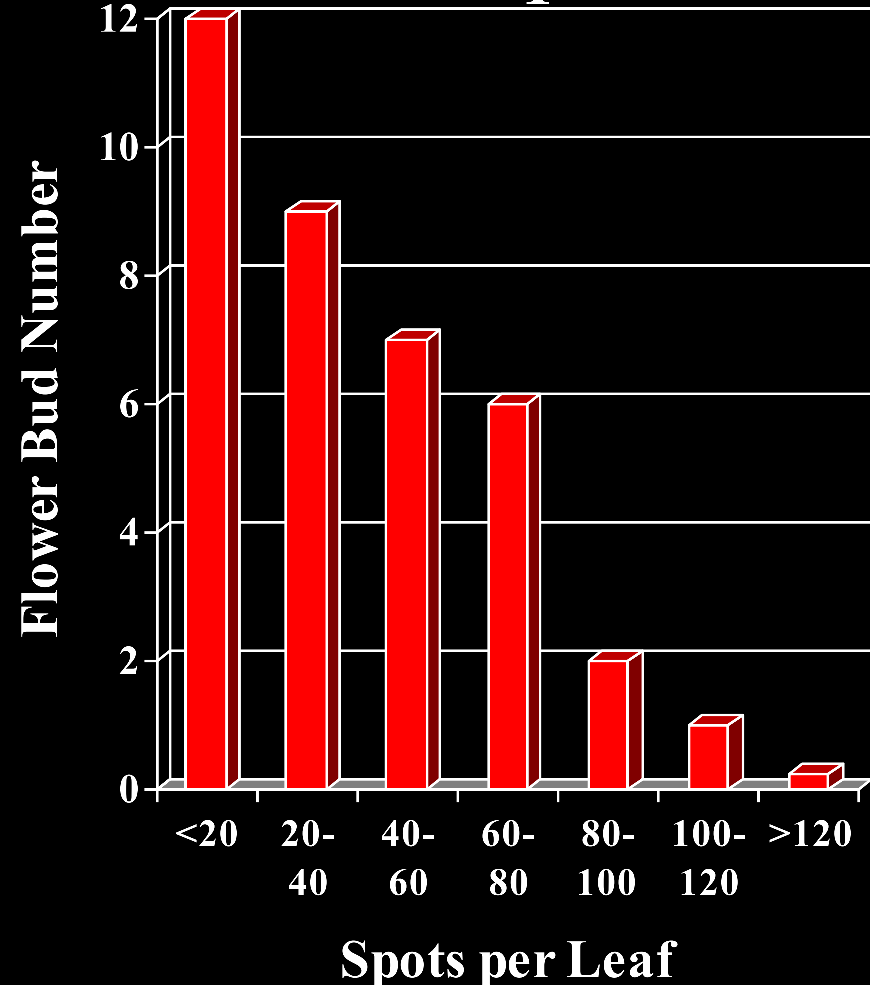
Summary

- Leaf spots reduce photosynthesis and induce premature defoliation.
- Both reduce flower bud set in the fall and yield the next spring.
- Leaf spot control needed for optimal yields on susceptible cultivars.
- Need to develop leaf spot thresholds for treatment.

Premiere Data



Bluecrisp Data



Southern Highbush Blueberry Defoliation Trial Results

Defoliation Date	1998 Yield (Fruit Fresh Wt. [g/cm shoot]) 'Misty'	1998 Yield (Fruit Fresh Wt. [g/cm shoot]) 'Sharpblue'	1999 Yield (Fruit Fresh Wt. [g/cm shoot]) 'Misty'	1999 Yield (Fruit Fresh Wt. [g/cm shoot]) 'Sharpblue'
September	0.26 b	0.18 b	0.22 d	0.11 c
October	0.23 b	0.24 b	0.87 c	0.59 b
November	0.75 b	0.67 a	1.70 b	0.81 ab
December	1.45 a	0.95 a	1.89 b	1.09 a
Control (no mechanical defoliation)	1.50 a	0.67 a	2.60 a	0.82 ab

P=0.05

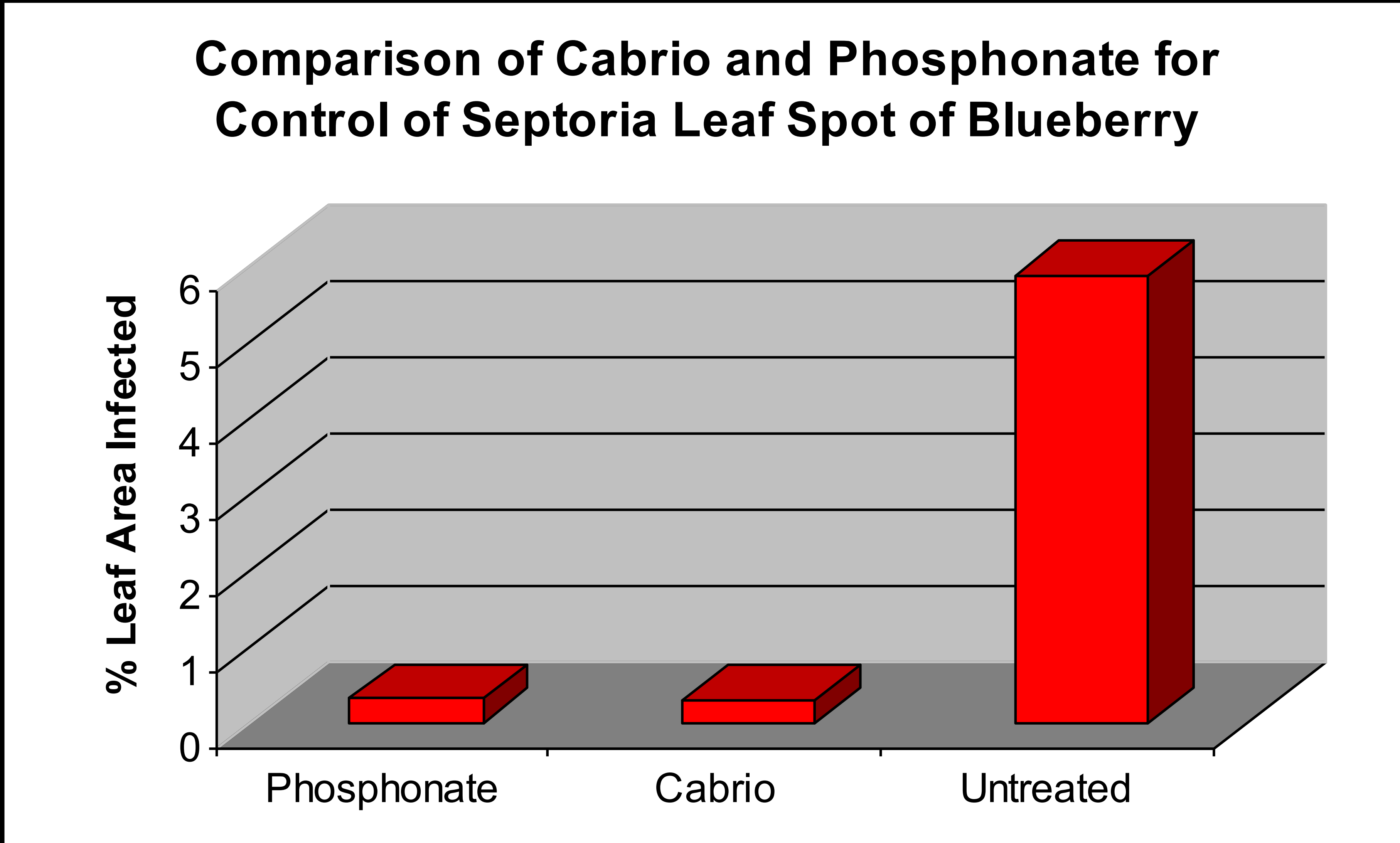
Williamson and Miller; University of Florida

Effect of increasing sequential applications of Abound on severity and incidence of Septoria leaf spot and subsequent defoliation (2003).

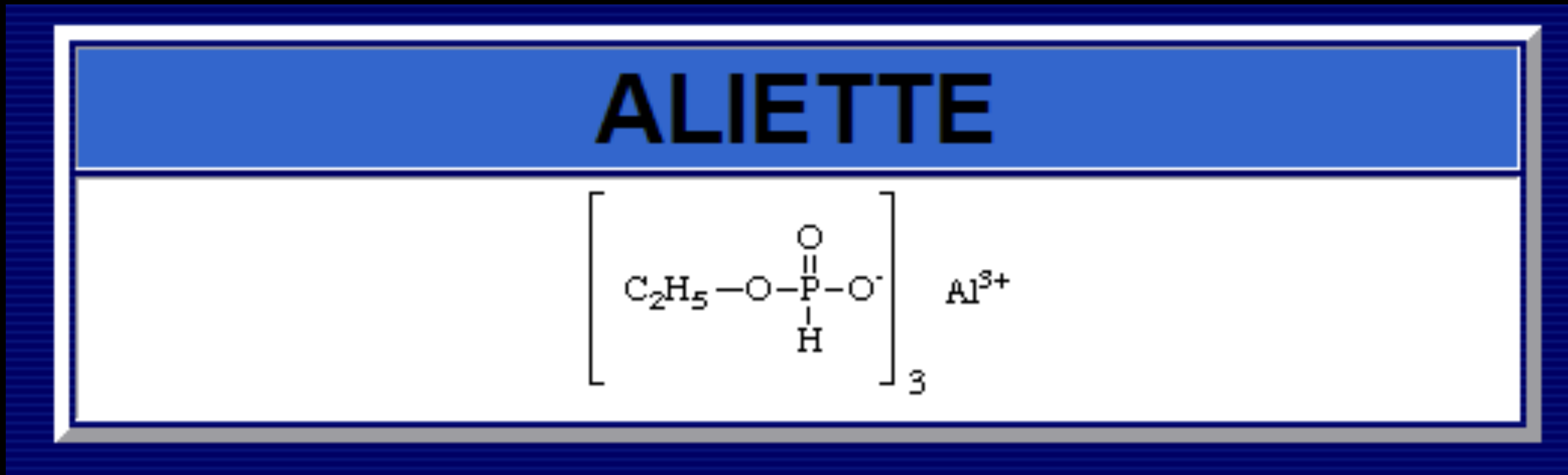
Treatment	Disease Severity* (1 Oct)	Disease Incidence (1 Oct)	Defoliation (18 Nov)
1. Untreated Control	48.6 a	99.6 a	100.0 a
2. Abound (1 app.)	27.2 b	95.6 a	83.3 abc
3. Abound (2 apps.)	11.4 bc	88.0 abc	93.3 ab
4. Abound (3 apps.)	20.2 bc	92.8 ab	79.7 abc
5. Abound (4 apps.)	7.4 bc	82.4 bc	63.9 abc
6. Abound (5 apps.)	5.7 c	76.8 c	59.2 bc
7. Abound (6 apps.)	6.8 c	79.2 c	51.2 c
LSD (*P*=0.05)	20.3	12.7	39.2

*Means followed by the same letters are not significantly different according to Fisher's protected LSD test.

Georgia currently has 24C state labels for use of Bravo Ultrex and Bravo WeatherStik for control of both rust and Septoria leaf spots; these chlorothalonil products make excellent rotation partners for the strobilurin-containing products, Cabrio and Pristine. However, Bravo Ultrex or Bravo WeatherStik can only be used after harvest, as fruit damage occurs with chlorothalonil usage. For labels and recommended rates for Georgia, contact your local county agent (for internet connections, click on these links – BRAVO ULTREX; BRAVO WEATERSTIK).



Septoria disease severity following treatment with Cabrio and phosphonate, as compared to an untreated control.



Aluminum tris (O-ethyl phosphonate)

http://www.agrimor.com/aliette.htm

For some fungi, the mode-of-action for Aliette is thought to be induced systemic resistance. For the oomycetes (not true fungi; algae-like), Aliette may have a direct toxic effect. Aliette contains aluminum tris-O-ethyl phosphonate, of which the phosphonate moiety may be critical to activity.

Some literature indicates that phosphite materials would logically have better efficacy than phosphate materials.

Phosphonates

- Target site is still listed as unknown (FRAC).
- Fosetyl-Al (Aliette) is a primary well-known fungicide in this class, but phosphorous acid is the primary end product which is thought to be active.

2004

Potassium phosphite

Dipotassium phosphonate + Dipotassium phosphate

Fungicide and					
1) Untreated C					
2) Aliette 5 lb	0.0 b	b	11.6 c	2.0 bc	10.4 b
3) ProPhyt 4 pt	0	0.0 b	12.0 c	1.1 c	12.4 bc
4) Biophos 4 pt	0.4 b	0.0 b	22.4 b	3.9 b	22.0 b
5) Cabrio 20EG 14 oz	0.0 b	0.0 b	8.0 c	0.5 c	10.8 c
6) Cabrio 20EG 14 oz alternated with ProPhyt 4 pt (2 applications each)	0.0 b	0.0 b	13.2 c	1.1 c	11.6 bc
7) Manzate 75DF 3 lb	1.2 b	0.0 b	9.2 c	0.1 c	13.0 bc
LSD (*P* = 0.05)	7.8	0.4	8.2	2.2	10.9

Application dates were 12 Jun, 28 Jun, 12 Jul, and 27 Jul.

2005 Leaf Spot Trial Results

Potassium phosphites

		ria leaf spot	Anthracnose		
Fungicide and	y)	Severity (Bacon)	Incidence (Bacon)	Severity (Bacon)	Defoliation (Bacon)
1) Untreated Chec	16.4 a	3.3 a	67.6 a	20.5 a	43.0 a
2) Aliette 5 lb	5.3 b	0.1 b	22.8 b	2.3 b	15.2 b
3) ProPhyt 4 pt	7.7 b	0.2 b	20.0 bc	2.7 b	10.0 b
4) Agri-Fos 5 pt	3.0 b	0.2 b	18.0 bc	1.7 b	12.0 b
5) Cabrio 20EG 14 oz	5.5 b	0.2 b	7.6 d	0.4 b	8.8 b
6) Cabrio 20EG 14 oz alternated with ProPhyt 4 pt (2 applications each)	5.5 b	0.1 b	10.4 cd	1.0 b	4.2 b
7) Procure 480SC 16 fl oz	8.2 b	0.8 b	13.2 bcd	1.0 b	13.8 b
LSD (P = 0.05)	5.9	1.5	9.7	2.7	15.0

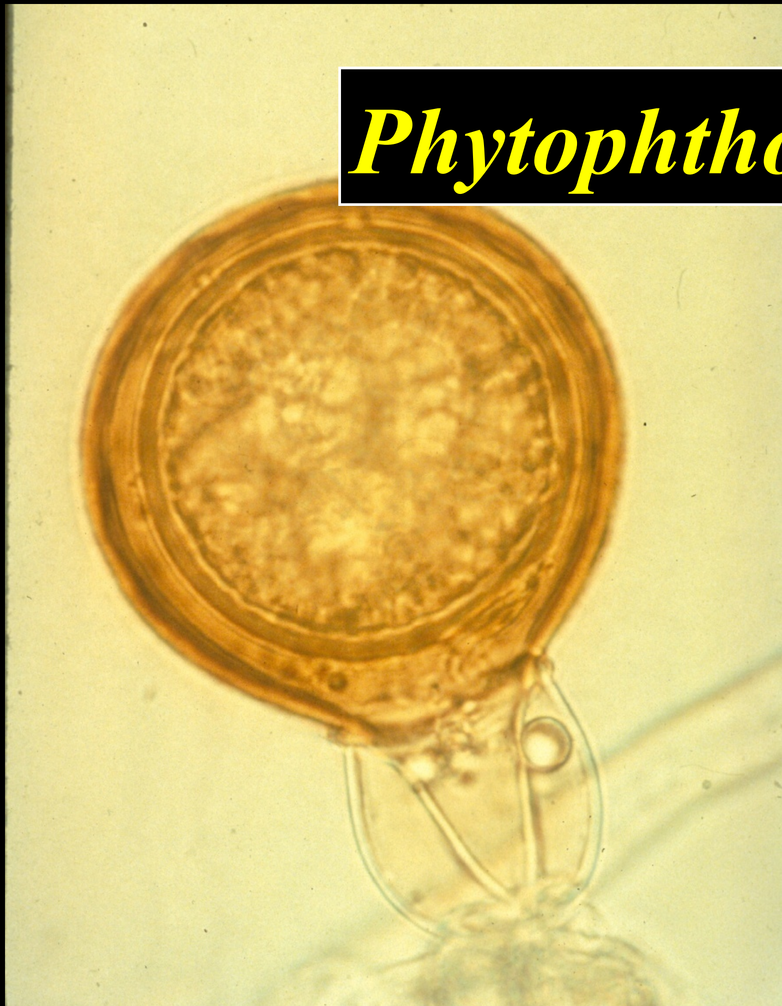
Other Potential Rust Controls

- Various sulfur formulations
- Cupric Hydroxide (post harvest)

Phytophthora Root Rot
(*Phytophthora cinnamomi*)

- Major problem in Southern highbush; can be a problem in rabbiteye as well.
- Drainage is critical.
- Aliette™ (Fosetyl-Al) and Ridomil Gold™ (Metalaxyl/Mefanoxam) are registered for control.
- Neither product is very effective at "cleaning up" infected plants.
- *Pythium* species can also be an issue in wet conditions.

Phytophthora cinnamomi

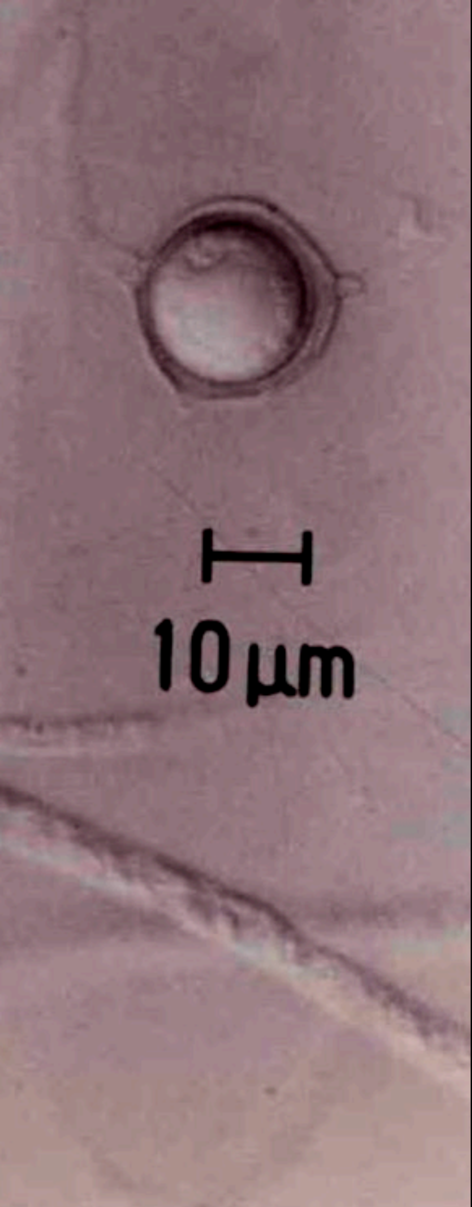


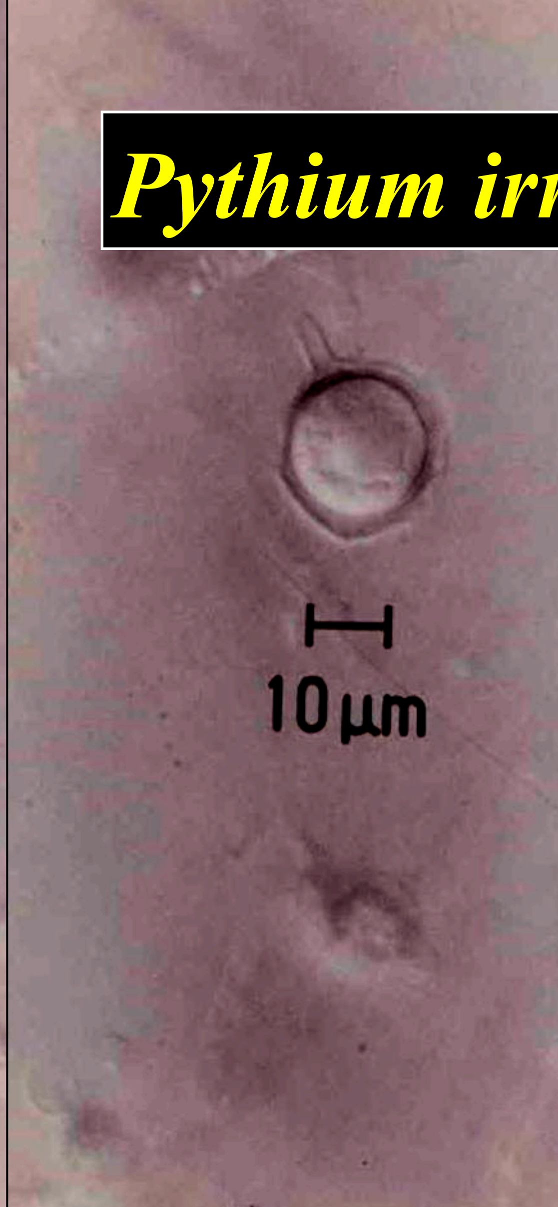
Smooth oogonium of *Phytophthora cinnamomi*

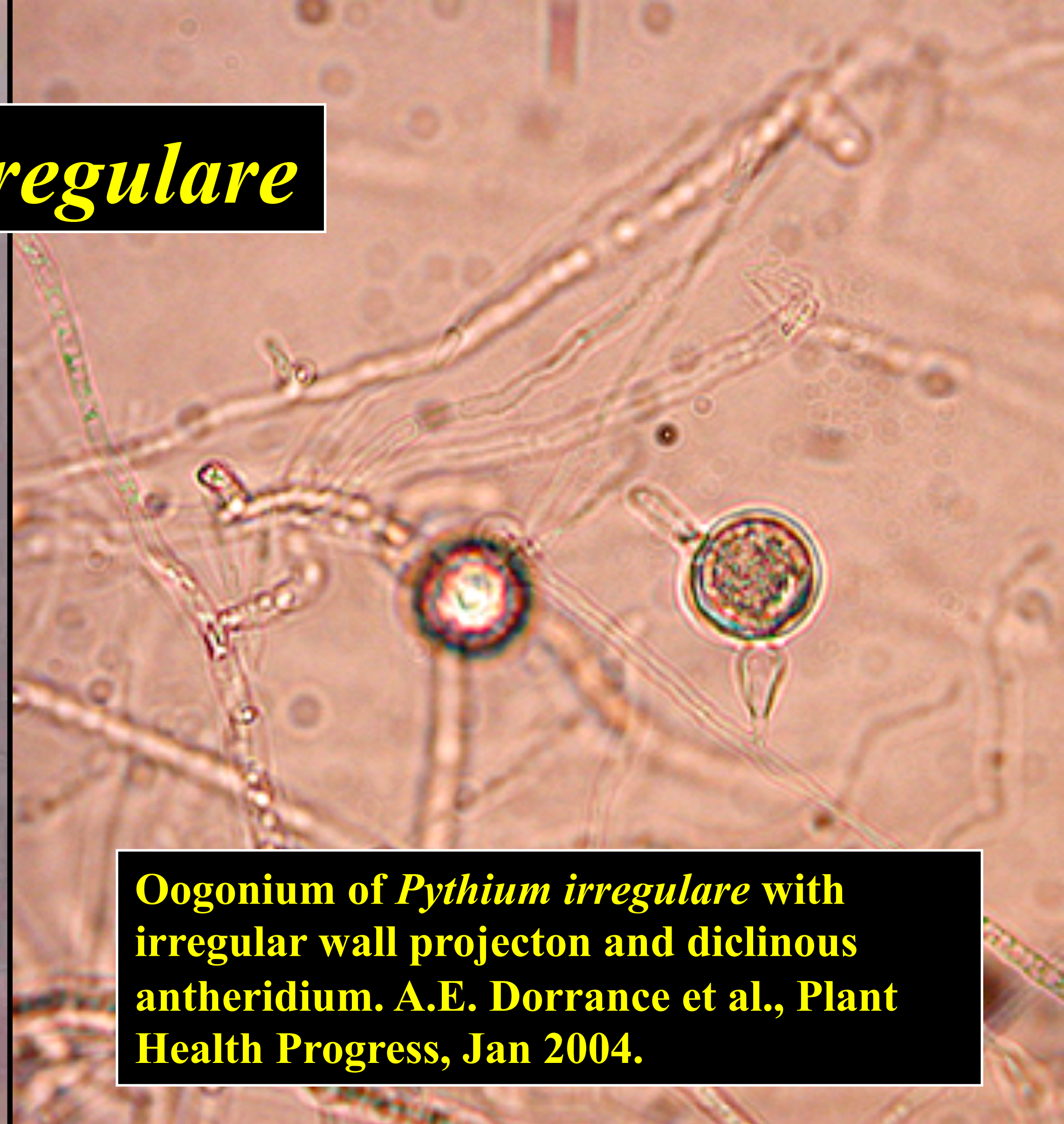
Zentmeyer, G.D. 1980. *Phytophthora cinnamomi* and the Diseases it Causes. APS.

CABI Compendia

Pythium irregulare







Oogonium of *Pythium irregulare* with irregular wall projecton and diclinous antheridium. A.E. Dorrance et al., Plant Health Progress, Jan 2004.


UGA - Ext. Plant Pathology

Phytophthora Root Rot
(*Phytophthora cinnamomi*)

- Major problem in Southern highbush; can be a problem in rabbiteye as well.
- Drainage is critical.
- Aliette™ (Fosetyl-Al) and Ridomil Gold™ (Mefanoxam) are registered for control.
- Neither product is very effective at "cleaning up" infected plants.
- *Pythium* species can also be an issue in wet conditions.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If the phosphonate materials show root-rot control activity which is similar to Aliette, then we may be able to cheaply apply these materials – also obtaining leaf spot control and possibly control of other pathogens.

Experimental Phosphonates

- ProPhyt (potassium phosphite 54.5%; phosphorous acid equivalent 34.3% [4.2 lb/ gallon])
- AgriFos (mono- and di-potassium salts of phosphorous acid [5.17 lb/gallon] equivalent to 3.35 lb phosphorous acid per gallon)

2005 Phytophthora Root Rot Trial

- Randomized complete block design
- Four replications (five plants per plot)
- Transplanted 'Millenium' on 15 Mar 05 in previously planted bark
- ProPhyt and Aliette were applied as foliar applications to runoff, while Ridomil Gold EC was drench applied. Application dates were 11 Apr, 11 May, 20 Jun, and 21 Jul
- Root rot severity was assessed on 7 Sep 05; bud count and plant fresh weight (no leaves) data were assessed on 28 Feb 06.

2005 Root Rot Results

Fungicide and rate/A	Root Rot Severity*	Plant Wt. (g)	Bud Count
1) Untreated Check	2.2 b	236 c	70.3 c
2) Ridomil Gold EC 0.4 gal	3.6 a	912 ab	351.9 b
3) Aliette 5 lb	3.9 a	1104 a	456.9 a
4) ProPhyt 4 pt	3.7 a	860 b	422.3 ab
LSD (P = 0.05)	0.4	210	70.5

*Rating scale (0 = dead plant, 1 = partial death of plant with extreme stunting, 2 = extreme leaf discoloration (reddening and yellowing) and plant stunting, 3 = moderate reddening of leaves and plant stunting, 4 = limited symptoms and very minor plant discoloration, 5 = healthy plant)

Brannen, P.M., and S. NeSmith. 2006. F&N Tests Reports 60:SMF016

2006 Phytophthora Root Rot Trial

- Randomized complete block design
- Four replications (three plants per plot in Alapaha and four plants per plot in Griffin)
- Transplanted 'Southern Bell' during week of 13 Mar 06 in previously planted bark beds and new bark beds (two separate experiments at two locations [Griffin and Alapaha, GA)
- Cabrio, ProPhyt, and AgriFos were applied as foliar applications to runoff, while Ridomil Gold EC was drench applied. Application dates were 10 Apr, 8 May, 4 Sep, and 16 Oct in Alapaha, GA. Application dates were 10 Apr, 8 May, 4 Sep, and 9 Oct in Griffin, GA.
- Root rot severity was assessed on 10 Nov (Griffin) and 14 Nov (Alaphaha); bud count data were assessed on 13 Feb 07 (both Griffin and Alapaha).

2006 Results*	Griffin, GA		Alapaha, GA	
Fungicide and rate/A	Old Bark	New Bark	Old Bark	New Bark
1) Untreated Check	3.1 bc	3.1 a	0.7 d	0.4 c
2) Cabrio 20 EG 14 oz	2.8 c	3.1 a	0.6 d	1.4 bc
3) Ridomil Gold EC 0.4 gal	3.7 ab	3.5 a	1.7 c	2.7 ab
4) ProPhyt 4 pt	4.2 a	3.3 a	2.5 a	3.6 a
5) AgriFos 5 pt	4.3 a	3.3 a	2.3 ab	3.5 a
6) Ridomil/ProPhyt Rotation	3.8 ab	3.3 a	2.0 bc	3.0 a
7) Ridomil/AgriFos Rotation	4.0 a	3.5 a	2.0 bc	3.1 a

*Rating scale (0 = dead plant, 1 = partial death of plant with extreme stunting, 2 = extreme leaf discoloration (reddening and yellowing) and plant stunting, 3 = moderate reddening of leaves and plant stunting, 4 = limited symptoms and very minor plant discoloration, 5 = healthy plant)

2006 Results*	Griffin, GA		Alapaha, GA	
Fungicide and rate/A	Old Bark	New Bark	Old Bark	New Bark
1) Untreated Check	214.6 ab	240.0 a	12.0 cd	12.0 bc
2) Cabrio 20 EG 14 oz	135.6 b	188.5 a	5.5 d	11.0 c
3) Ridomil Gold EC 0.4 gal	223.4 ab	209.9 a	45.8 ab	82.3 abc
4) ProPhyt 4 pt	290.9 a	201.5 a	64.0 a	104.8 a
5) AgriFos 5 pt	310.4 a	244.8 a	36.3 bc	84.3 abc
6) Ridomil/ProPhyt Rotation	256.1 a	203.1 a	53.5 ab	85.5 ab
7) Ridomil/AgriFos Rotation	256.5 a	220.3 a	48.8 ab	85.5 ab

*Average number of flower buds per plant. P = 0.05

Conclusions

In addition to Aluminum tris (O-ethyl phosphonate) (Aliette), other phosponates work equally well for suppression of Phytopthora root rot of blueberry. Phosphonates also provide equivalent control to that of mefenoxam (Ridomil Gold). The cost of phosphonates and ease of application, by comparison to other root rot fungicides, will make them an attractive alternative in blueberry production.


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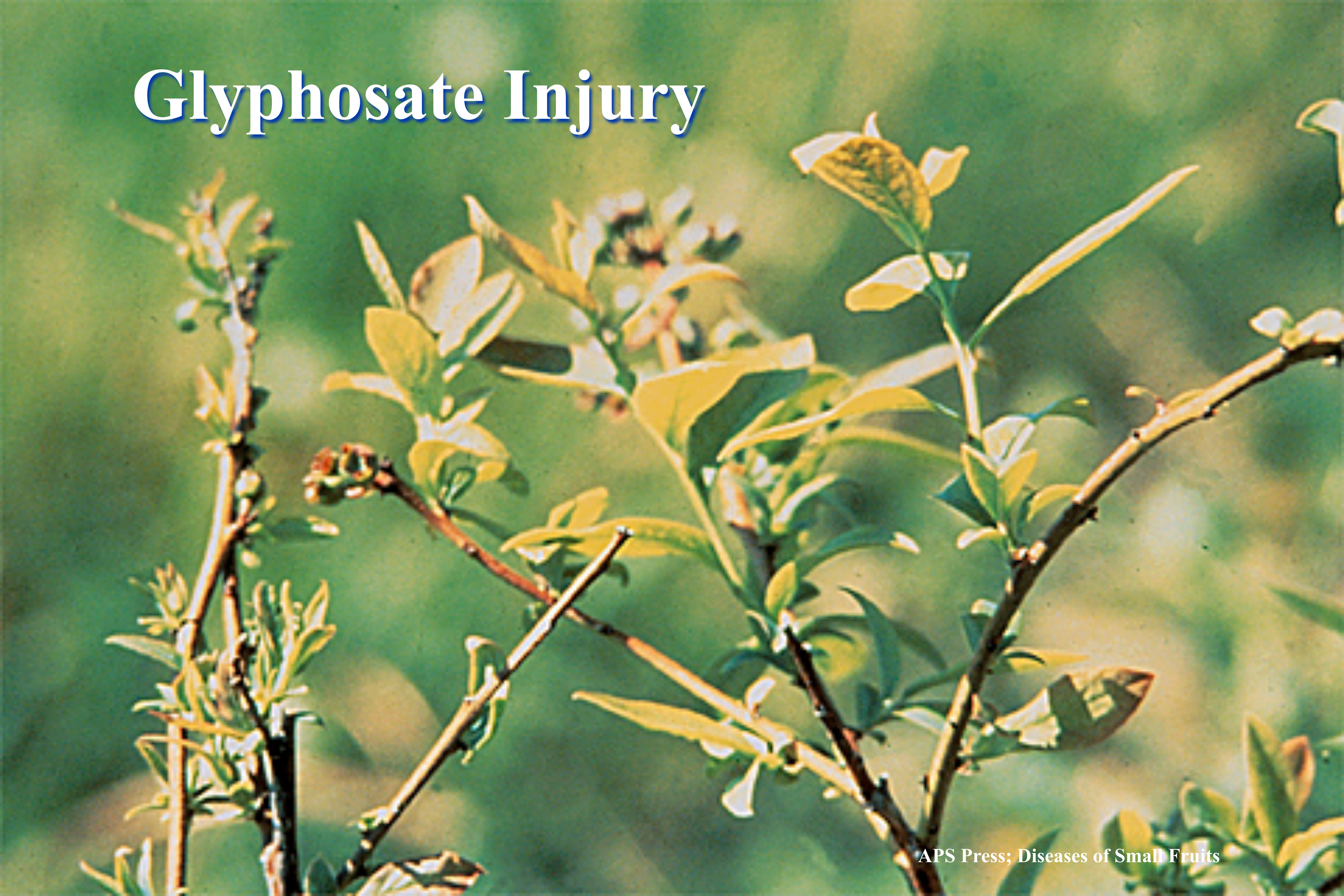
Tissue Analysis Results

	Calcium	Copper	Manganese	Boron
Sample Results	2.8%	0.08 ppm	4309 ppm	227 ppm
Sufficiency Ranges	0.35 -0.80%	6 – 11 ppm	40 – 600 ppm	25 – 75 ppm

Lessons Learned

- Fertility levels are important.
- Tissue and bark analysis will be necessary, especially for high bush blueberry production where bark systems are utilized.
- Water analysis is also important.


Glyphosate Injury
APS Press; Diseases of Small Fruits


Necrotic Ringspot Virus
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