Comment gérons-nous l'anthracnose en Caroline du Nord

How do we manage anthracnose in North Carolina

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CIPM

Anthracnose

Ripe fruit rot/black spot: *Colletotrichum acutatum*

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

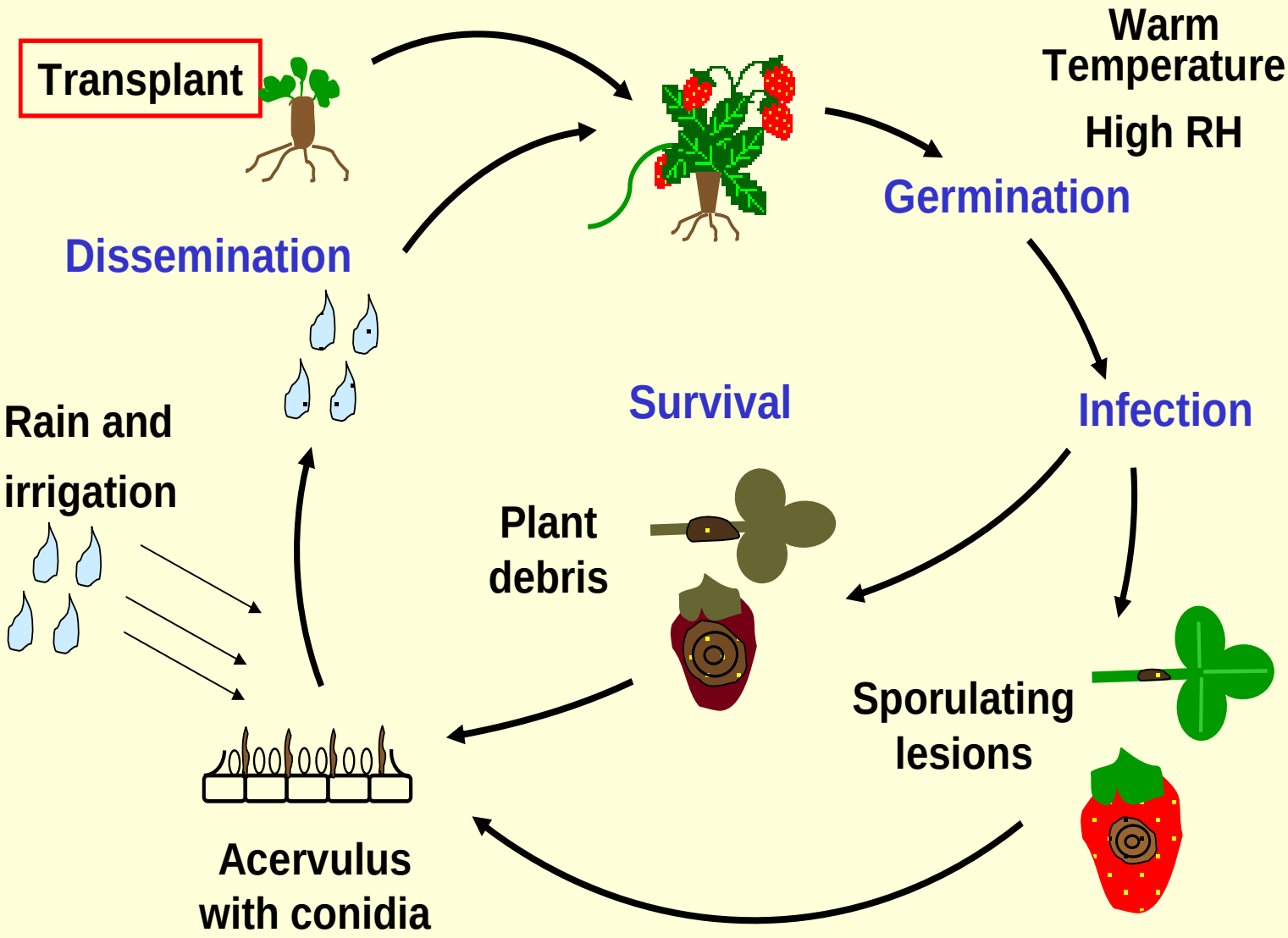
Crown rot: *C. gloeosporioides*

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

The Anthracnose Pathogens

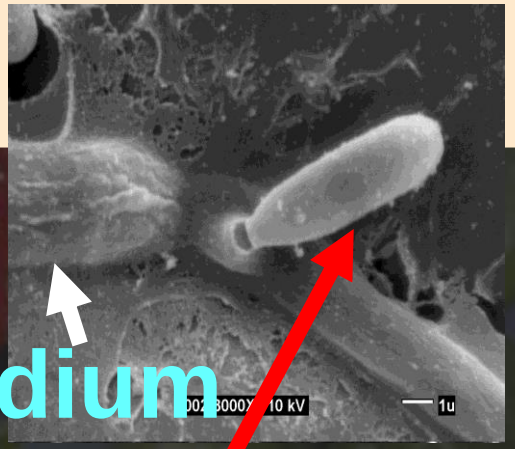
Species	Associated Disease Phase	Economic Importance in NC
Colletotrichum acutatum	Fruit rot	High
Colletotrichum gloeosporioides	Crown rot	Low to moderate

Disease cycle of *C. acutatum* on strawberry



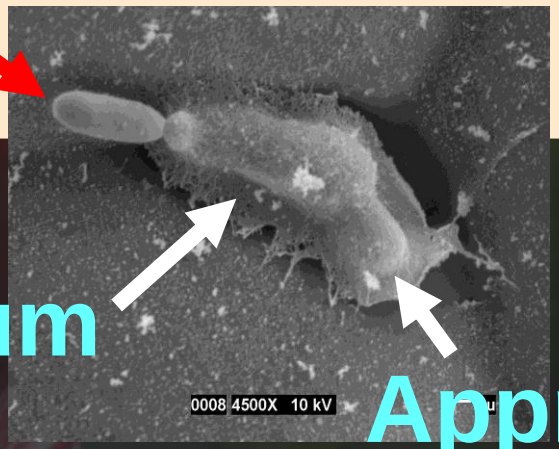
L. Leandro

Germination and Sporulation of *Colletotrichum acutatum* on Symptomless Strawberry Leaves. L. F. S. Leandro, M. L. Gleason, F. W. Nutter, Jr., S. N. Wegulo, and P. M. Dixon. 2001. Phytopathology 91:659-664.



Initial conidium

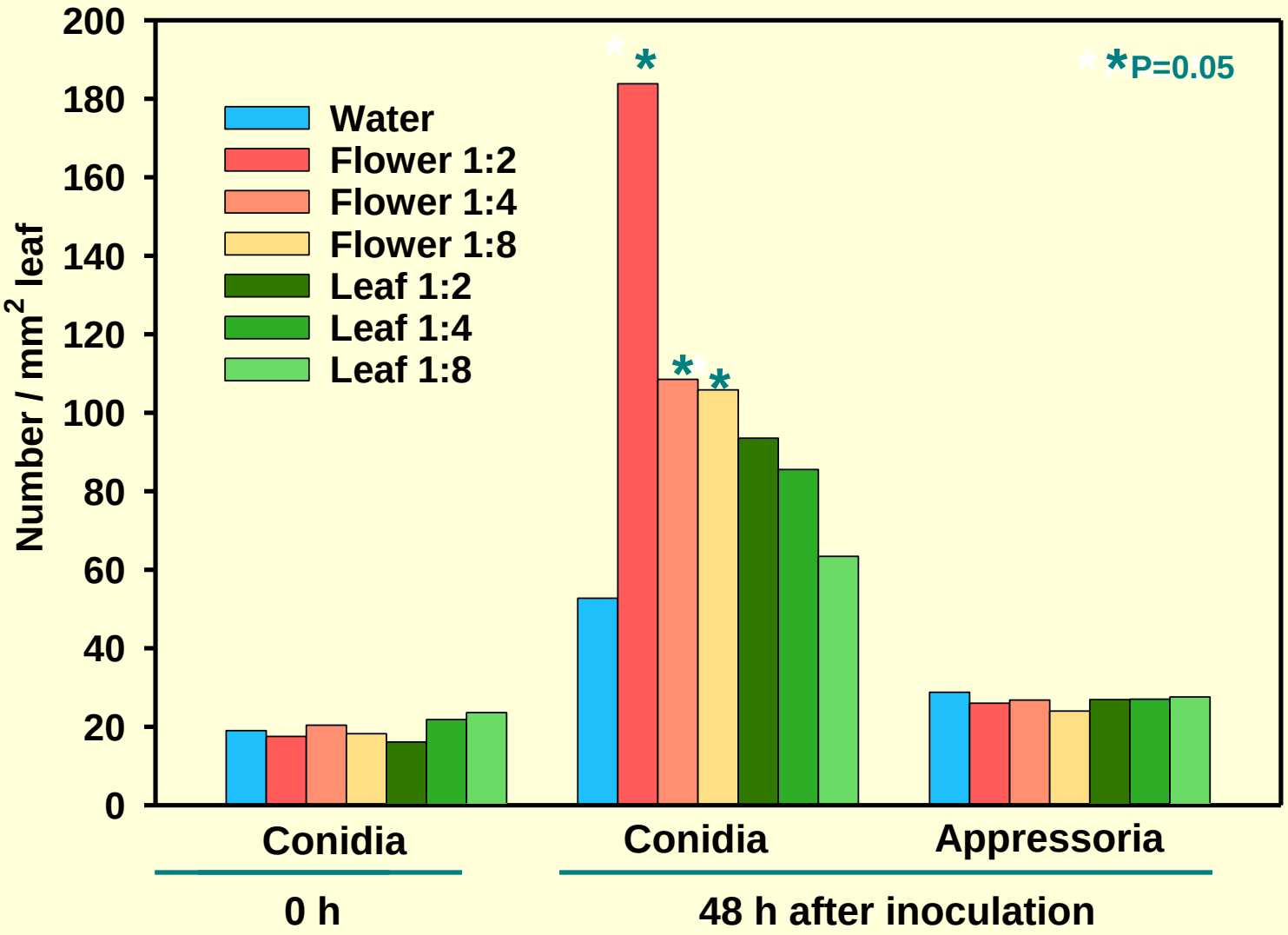
Secondary conidia



Initial conidium

Appressorium

Effects of Strawberry Extracts on *C. acutatum*



Leandro et al. 2002

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

The pathogen reproduces on green leaves without showing symptoms.

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

Anthracnose petiole rot, flower blight & green fruit rot

Problems in plug production and transplants (plant source)

Poor grow-out of infected plants

I. Prevention: (Apparently) Disease Free Plants

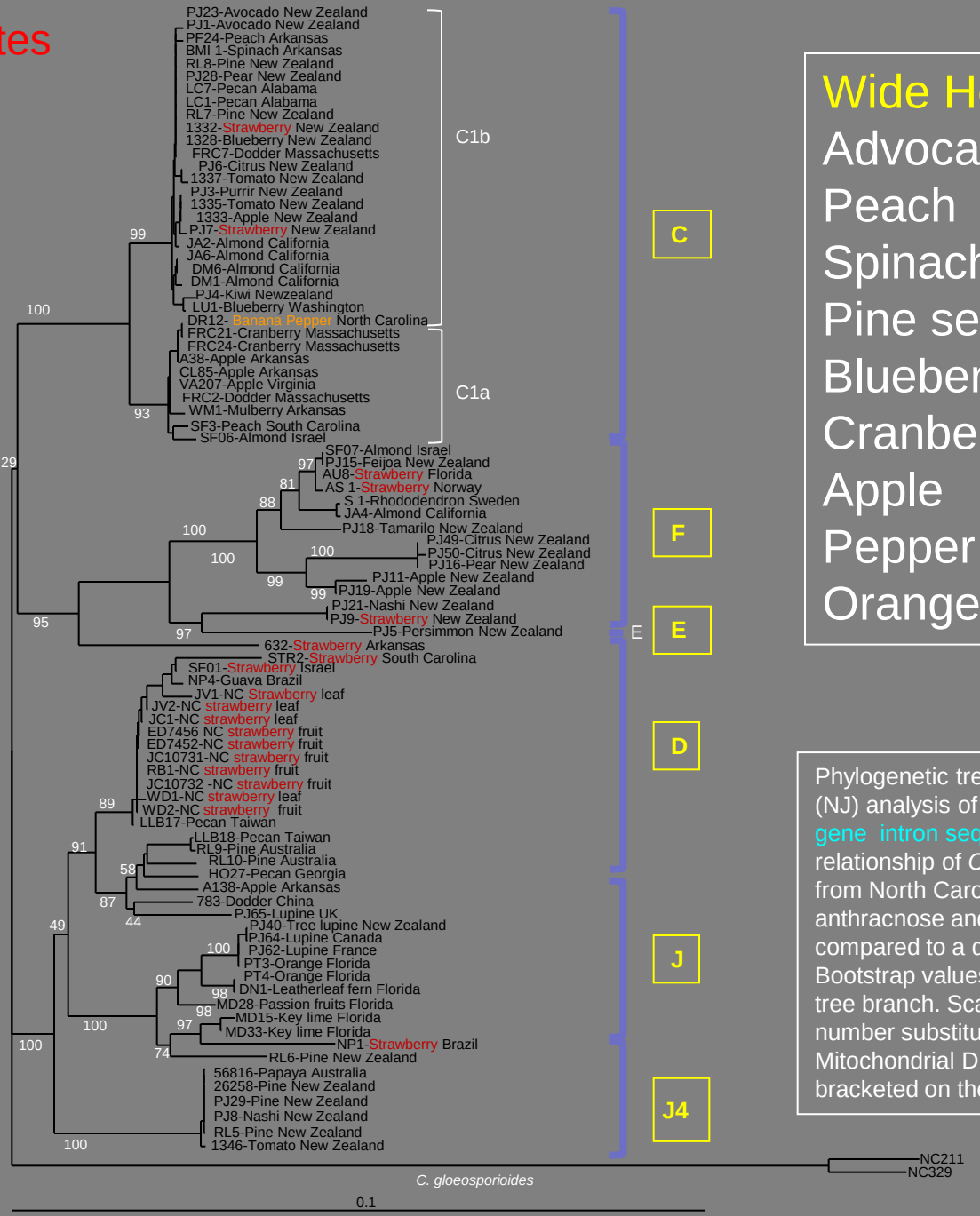
Manage problems
vs.
import problems

Biology: Anthracnose of strawberry

- Infested plants are the main source of disease.
- Observations suggest over-summering/wintering of the pathogen 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 fruit rot epidemics occur under favorable conditions
- *C. gloeosporioides* can originate from wild hosts
- *C. acutatum* has a wide host range but….

Strawberry isolates

NC-pepper

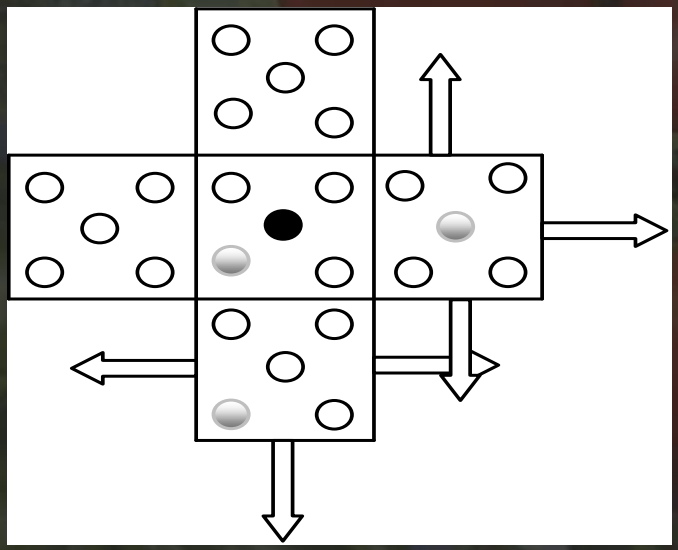


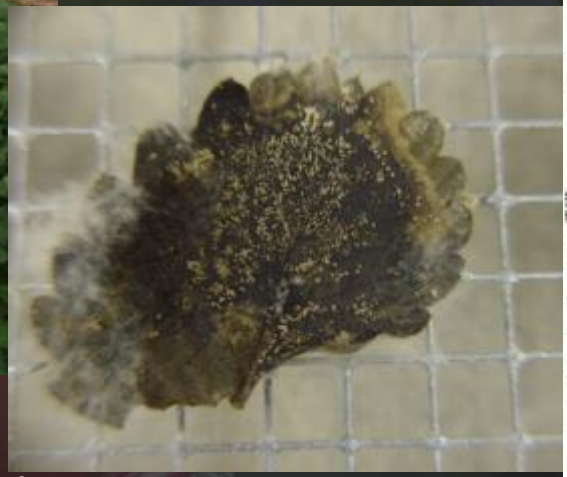
Wide Host Range:

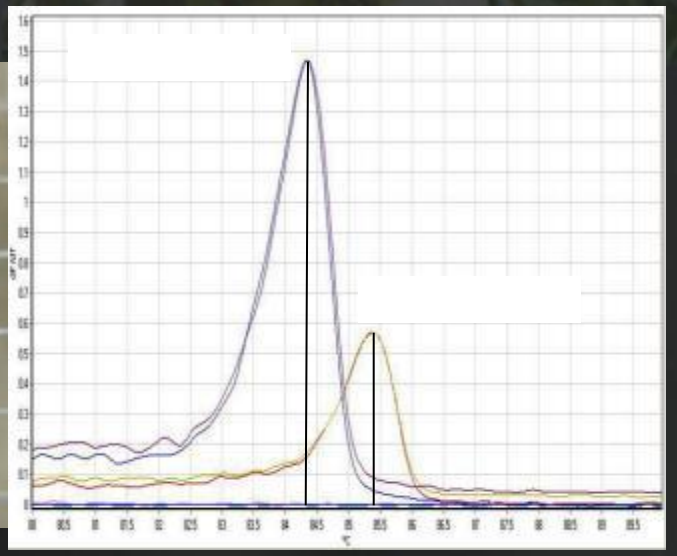
- Advocado
- Peach
- Spinach
- Pine seedlings
- Blueberry
- Cranberry
- Apple
- Pepper
- Orange

Phylogenetic tree based on Neighbor Joining (NJ) analysis of the 1-kb glutamine synthetase gene intron sequences, illustrating the relationship of *C. acutatum* isolates obtained from North Carolina strawberry fruit anthracnose and quiescent leaf infections compared to a diverse world collection. Bootstrap values are labeled on the top of the tree branch. Scale bar represents the average number substitutions per site over time. Mitochondrial DNA haplotypes or groups are bracketed on the right.

II. Detection and Sampling Technologies







Adaptive cluster sampling 2012/2013

Technical/Scientific Limitations:

Will new detection technologies (DNA-based assays) improve detection capabilities? How do you sample large fields of nursery plants?

What is the difference between *Colletotrichum acutatum* and *C. gloeosporioides* in terms of risk. Do they both require zero tolerance in the nursery?

Are all strains of equal risk?

III. Culture Practices

- Scout for problems
- Rogue out infected plants or trays (low level problem)
- Bury or destroy (no herbicide kill)
- N source ($Ca(NO_3)_2$ not ammonium) and optimum levels
- Avoid excess overhead irrigation (Protect against rain?)
- Pick infested fields last (Quarantine)
- Do not work plants when wet
- Do not do hand sanitation in spring
- Remove infected berries

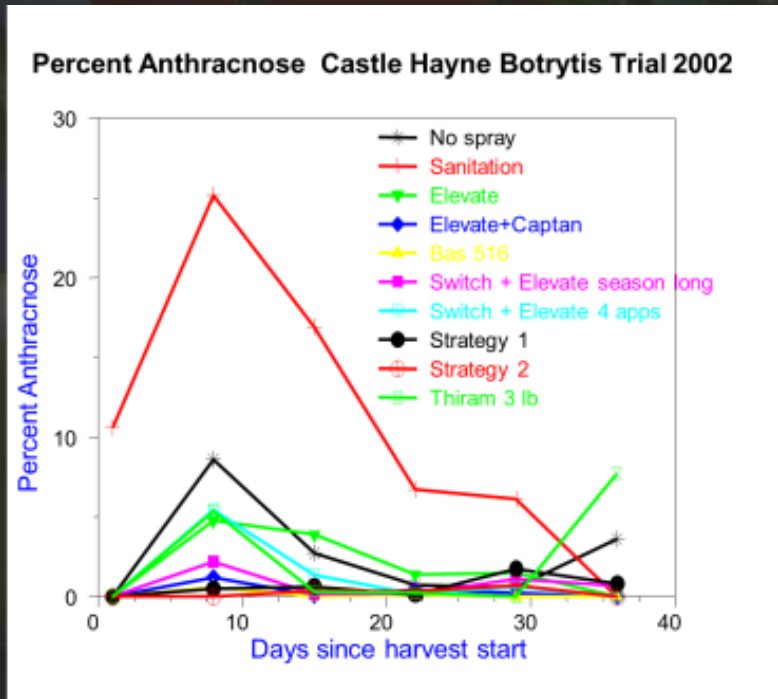


Table 5. Main treatment effects of two studies comparing the effects of N source and level on anthracnose crown rot disease severity ratings (DR)[W] of strawberry plants grown in sand culture in the greenhouse.

Study	N source	DR[X]	N level	DR
N source I	$(NH_4)_2SO_4$	4.3 a[Y]	160 ppm	4.7 a
	$(NH_4)_2HPO_4$	4.3 a	40 ppm	2.7 b
	KNO_3	3.8 a	0 ppm	2.4 b
	NH_4Cl	3.7 ab		
	NH_4NO_3	3.5 ab	**Clone**	
	$NaNO_3$	3.4 ab	MSUS 70	3.9 a
→	$Ca(NO_3)_2$	2.9 bc	MSUS 37	3.7 a
	None	2.4 c	MSUS 98	2.9 b
Study	**N source**	**DR[Z]**	**N level**	**DR**
N source II	$(NH_4)_2SO_4$	4.8 a	120 ppm	3.9 a
	$NaNO_3$	4.2 ab	40 ppm	3.6 a
	$(NH_4)_2HPO_4$	4.1 abc	0 ppm	2.6 b
	NH_4Cl	3.9 abc	**Clone**	
	NH_4NO_3	3.6 bcd	Tangi	5.0 a
	KNO_3	3.1 cd	MSUS 74	4.7 a
→	$Ca(NO_3)_2$	2.8 d	MSUS 70	2.7 b
	None	2.6 d	MSUS 98	2.1 b

[W] Disease severity rated on a scale of 0 = no symptoms to 6 = plant dead 30 days after inoculation with *Colletotrichum fragariae* isolate CF-63.

[X] Disease ratings (DR) in Nitrogen Study I are the average of five plants each of 'MSUS 37,' 'MSUS 70,' and 'MSUS 98' treated with three levels of N (0, 40, and 160 ppm N).

[Y] Mean separation within studies and within columns and factors by Least Significant Difference, $P = 0.05$.

[Z] Disease ratings (DR) in Nitrogen Study II are the average of four plants each of 'Tangi,' 'MSUS37,' 'MSUS70,' and 'MSUS98' treated with three levels of N (0, 40, and 120 ppm N).

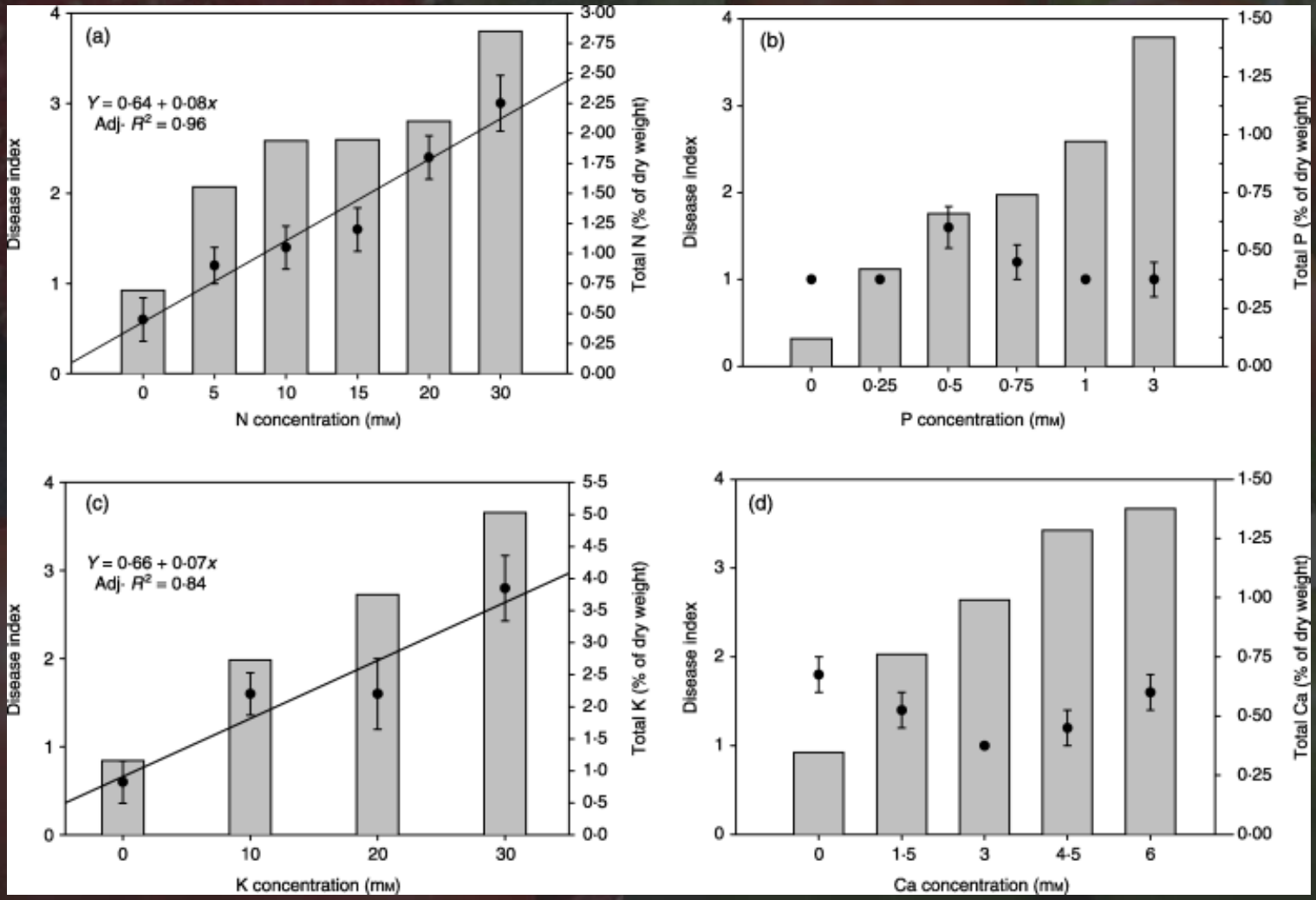
Summary (C. gloeosporioides):

Use Optimum N Rates

Use $Ca(NO_3)_2$ rather than ammonium forms

Smith, B. J. 2009. Nitrogen fertilizer affects the severity of anthracnose crown rot disease of greenhouse grown strawberries. Online. Plant Health Progress doi:10.1094/PHP-2009-0609-01-RS.

Effects of nitrogen, phosphorus, potassium and calcium nutrition on strawberry anthracnose



Plant Pathology
Volume 55, Issue 2, pages 246-249, 17 JAN 2006 DOI: 10.1111/j.1365-3059.2006.01322.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-3059.2006.01322.x/full#f1

IV. Fungicides

Integrated Management Programs

- Screen products for efficacy
- Integrate products into program for anthracnose, Botrytis, and resistance management

- Make IPM recommendations for growers

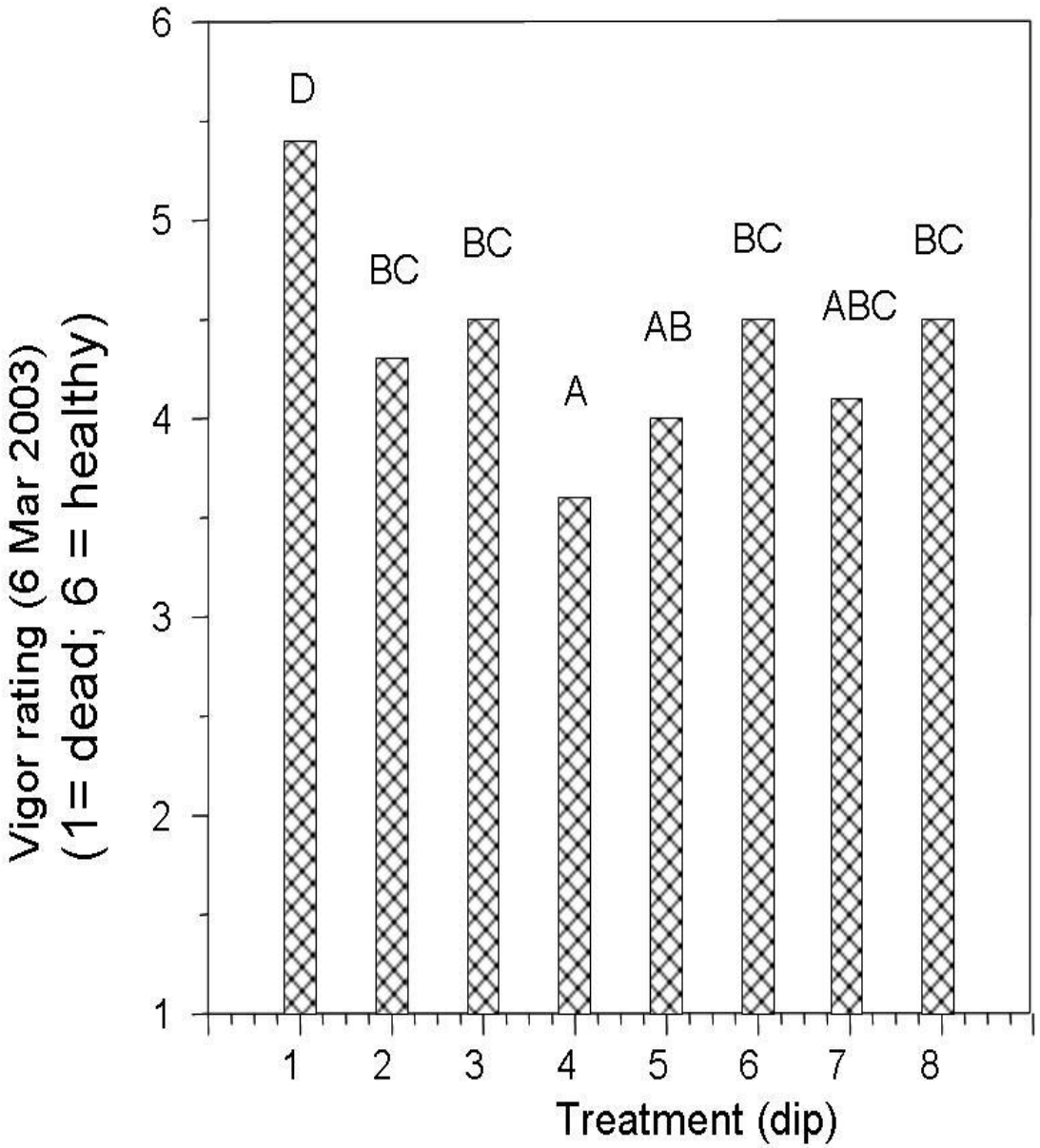
Plug Test - Stunting

Rating: 1 = Dead, ….6 = Not stunted

18.8% Dead Plants, 40-75% Fruit rot

Colletotrichum acutatum

Figure 2: Weighted plant vigor rating in Spring 2003 Castle Hayne



1. Check noninoculated
2. Check inoculated, no treatments
3. Check inoculated + spring program
4. Captan 50WP
5. Captan 50WP+ Bravo 720
6. Rovral 4F
7. Switch 62.5 WG
8. Quadris 2.08 SC

18.8% Dead Plants, 40-75% Fruit rot

Tables from:

Mertely, J. C., Seijo, T. E., and Peres, N. A. 2010. Effect of pre- and post-plant fungicide and fertilizer treatments on infection by *Colletotrichum acutatum*, plant survival, and yield of annual strawberry in Florida. Online. Plant Health Progress doi:10.1094/PHP-2010-0125-01-RS.

Table 2. Effect of pre- and post plant treatments on petiole colonization and isolation frequency from crowns of *Colletotrichum acutatum*, plant mortality, and yield of strawberries in the 2004-2005 season.

Treatment		Product /100 gal	Petiole colonization (%)[v]	Plant mortality (%)[w]	Isolation frequency (%)[x]	Early yield (lb/acre)	Late yield (lb/acre)	Total yield (lb/acre)
Pre-plant	**Wet control** (5-min dip in water)	na[y]	98 ab[z]	25.0 b	33.3 ab	1,000 b	5,400 bc	6,300 bc
	Water (wash, 5-min dip)	na	93 ab	34.2 ab	39.3 ab	600 b	2,900 c	3,500 c
	Water (wash day before, store at 38°F , 5-min dip)	na	93 ab	25.8 b	26.3 b	900 b	5,700 bc	6,600 bc
	Oxidate 27% (5-min dip)	64 fl oz	100 a	44.2 a	48.1ab	500 b	2,800 c	3,300 c
	Abound 2.08F (5-min dip)	6.5 fl oz	90 b	5.8 c	51.7 a	1,700 a	7,500 b	9,200 b
	Switch 62.5WDG (5-min dip)	6.5 oz	35 c	6.7 c	8.9 c	2,300 a	16,200 a	18,500 a
Post-plant	**Dry control** (no wash, no dip)	na	95 ab	39.2 ab	38.6 ab	600 b	3300 c	3,900 c
	Surround WP (no wash, no dip)	25.0 lb	98 ab	37.5 ab	42.5 ab	700 b	4000 c	4,700 c
	Osmocote Plus 15-9-12 (no wash, no dip)	na	100 a	40.8 ab	55.9 a	300 b	3,200 c	3,500 c

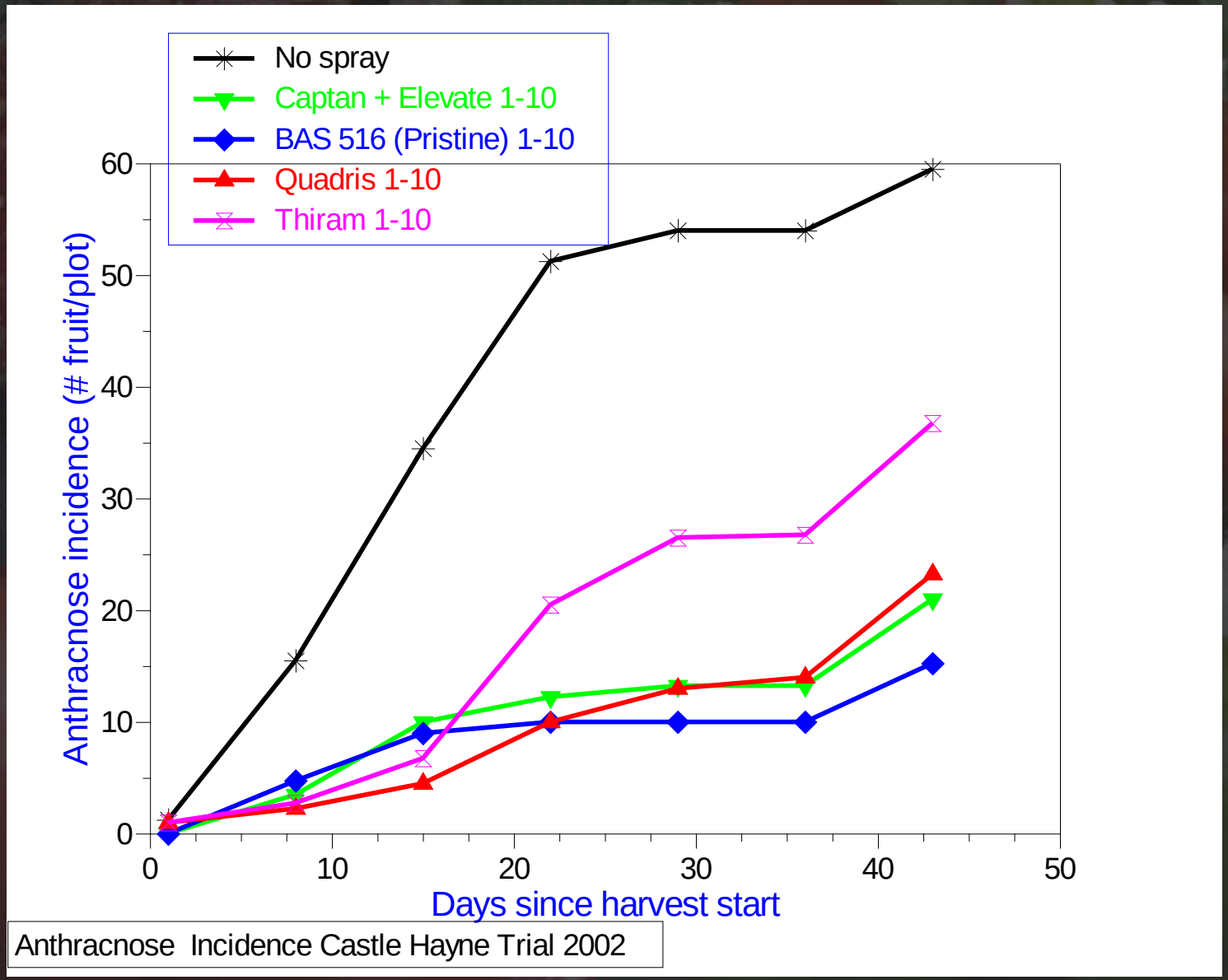
[v] Percent petioles colonized by *C. acutatum* on 28 Oct 2004 (9 days after planting).

[w] Percent dead and dying plants 5 weeks after planting.

[x] Percent living plants from which *C. acutatum* was isolated from the crown 7 weeks after planting.

[y] na = not applicable.

[z] Figures in a column followed by the same letter are not significantly different by Fisher's protected LSD test ($P < 0.05$).



Anthracnose Incidence Castle Hayne Trial 2002

Anthracnose Incidence 2002

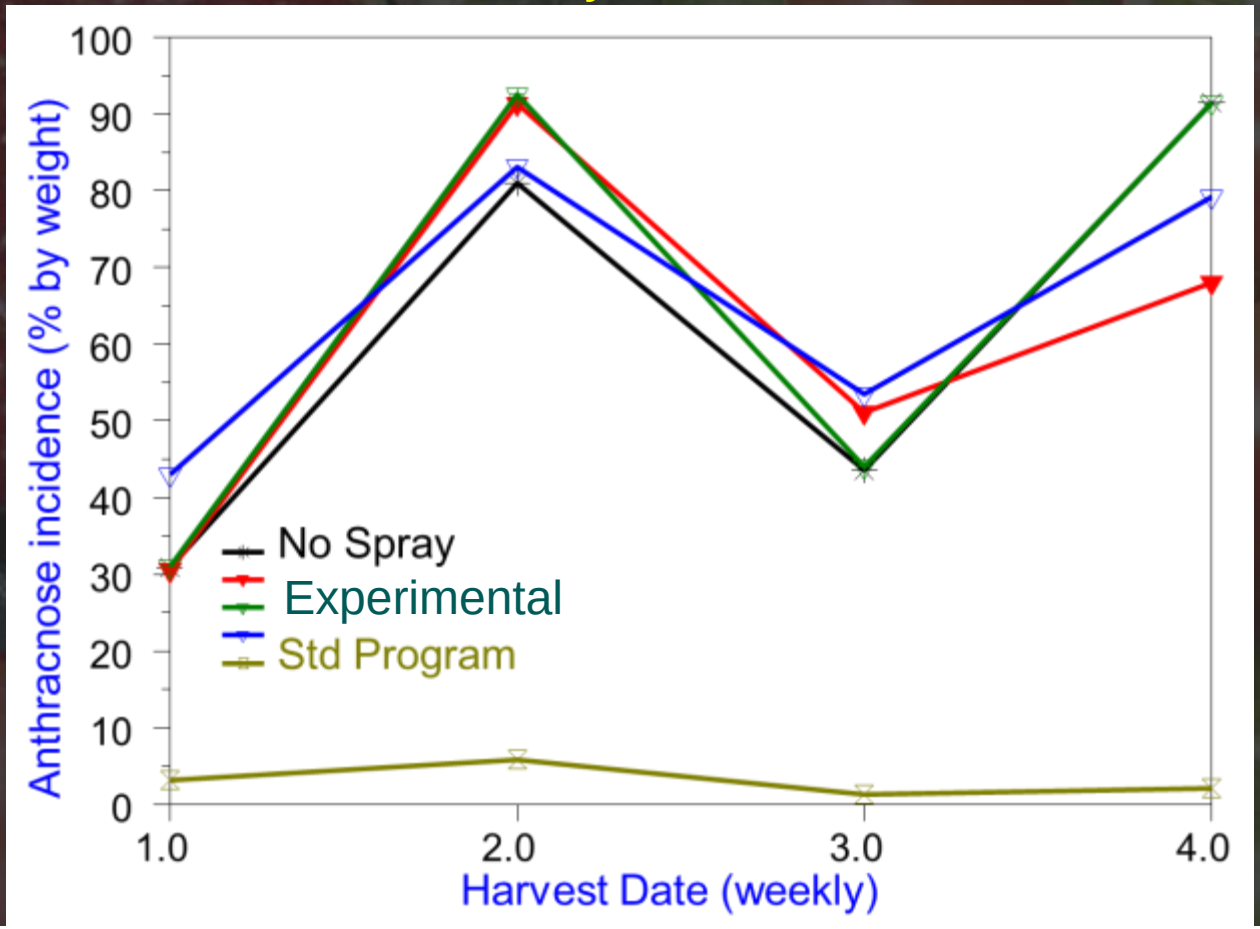
Treatment and rate/A	Timing*	Anthracnose (%)**	Total yield (lb/plot)	Marketable fruit (%)
Sanitation ……...……....	-	19.3 f	12.4	50.7 a
No spray …….....	-	17.5 ef	13.1	54.6 ab
Captan 50WP 4.0 lb + Quadris 2.08SC 9.0 fl oz	6-9	11.9 de	14.1	70.8 cd
Captan 50WP 4.0 lb + Quadris 2.08SC 9.0 fl oz Switch 62.5 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).

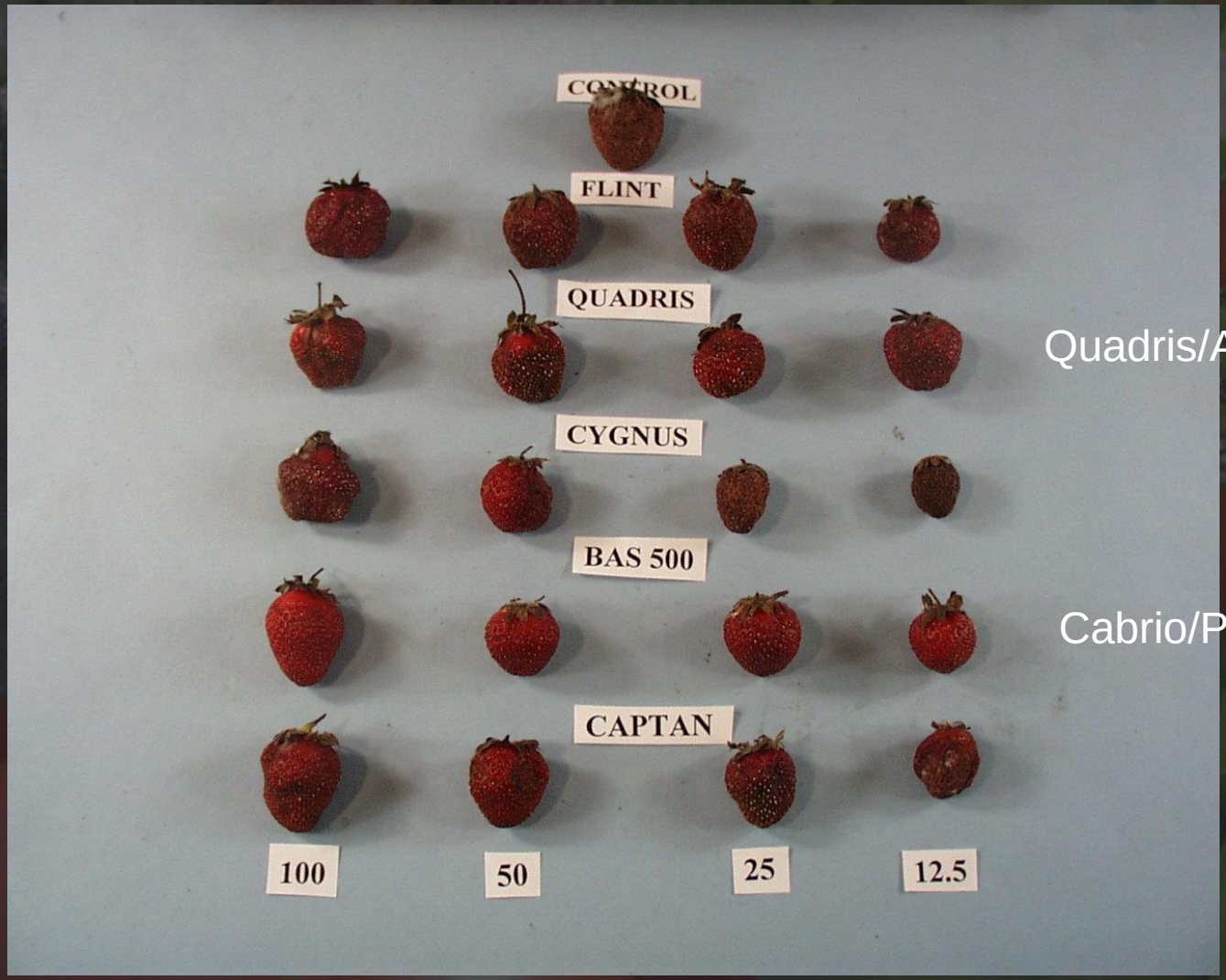
** Values followed by the same letter within a column are not significantly different.

Anthracnose Fruit Rot Incidence by Weight on Each Harvest Date

Castle Hayne NC 2014



10 (Standard)	Captan 50 WP 4.0 lb + Topsin M 70 W 1.0 lb Pristine WG 1.45 lb Captan 50 WP 4.0 lb Switch 62.5WG, 11 ozwt	A B,E C D,F

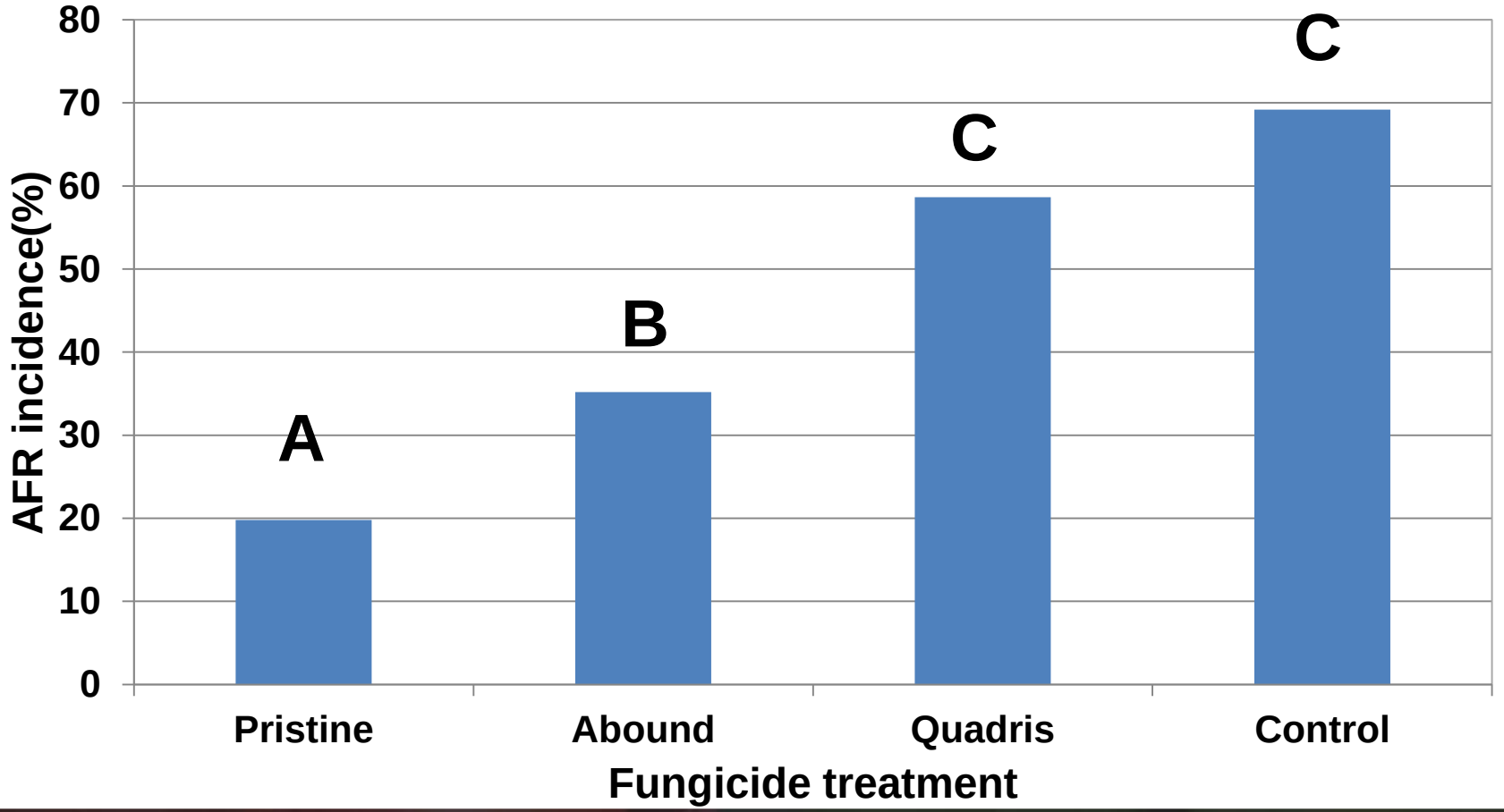


Quadris/Abound

Cabrio/Pristine

Cabrio/Pristine AND Quadris/Abound AND Flint all belong to Group 11 Fungicides

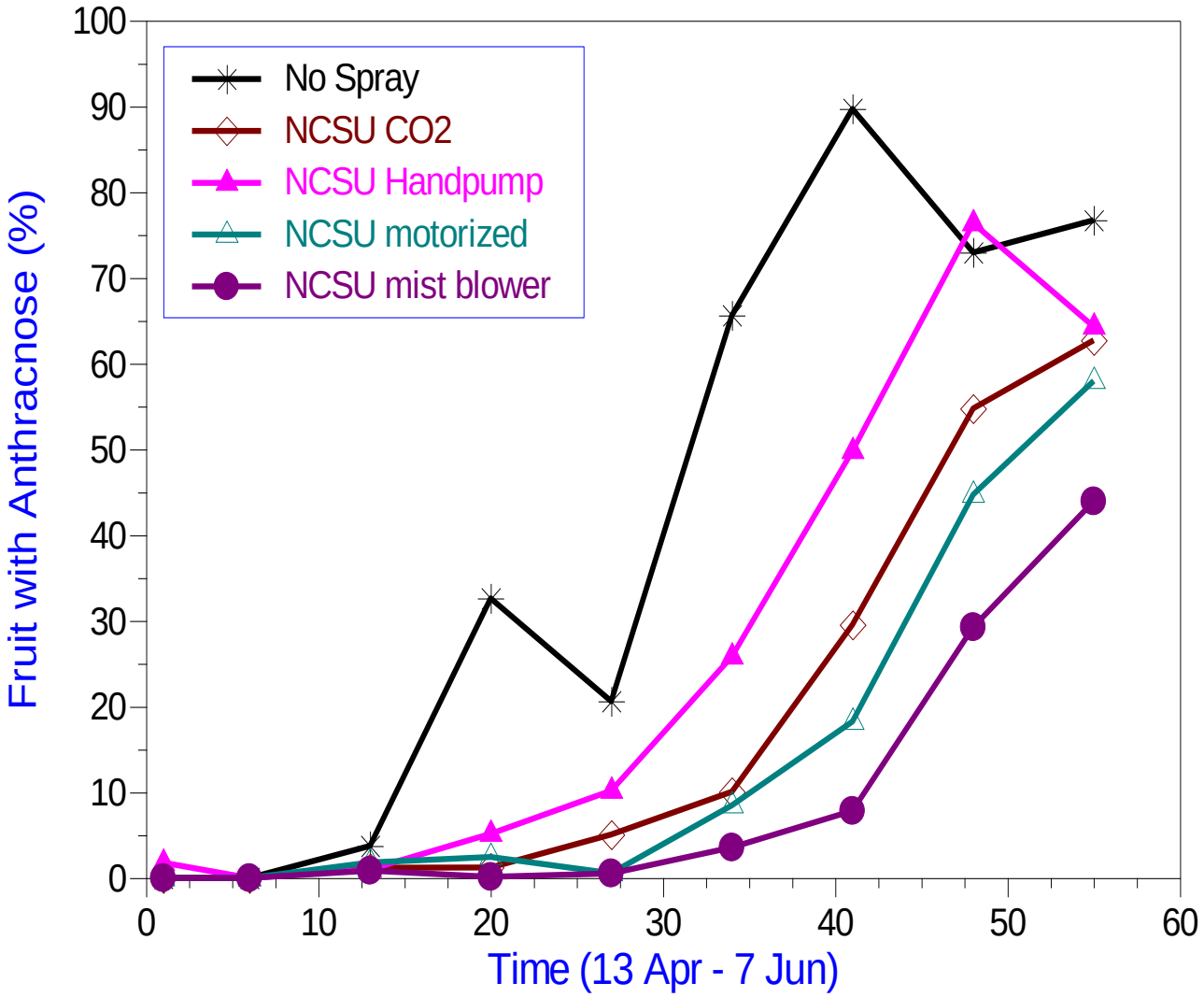
Chemical control of AFR, 2010



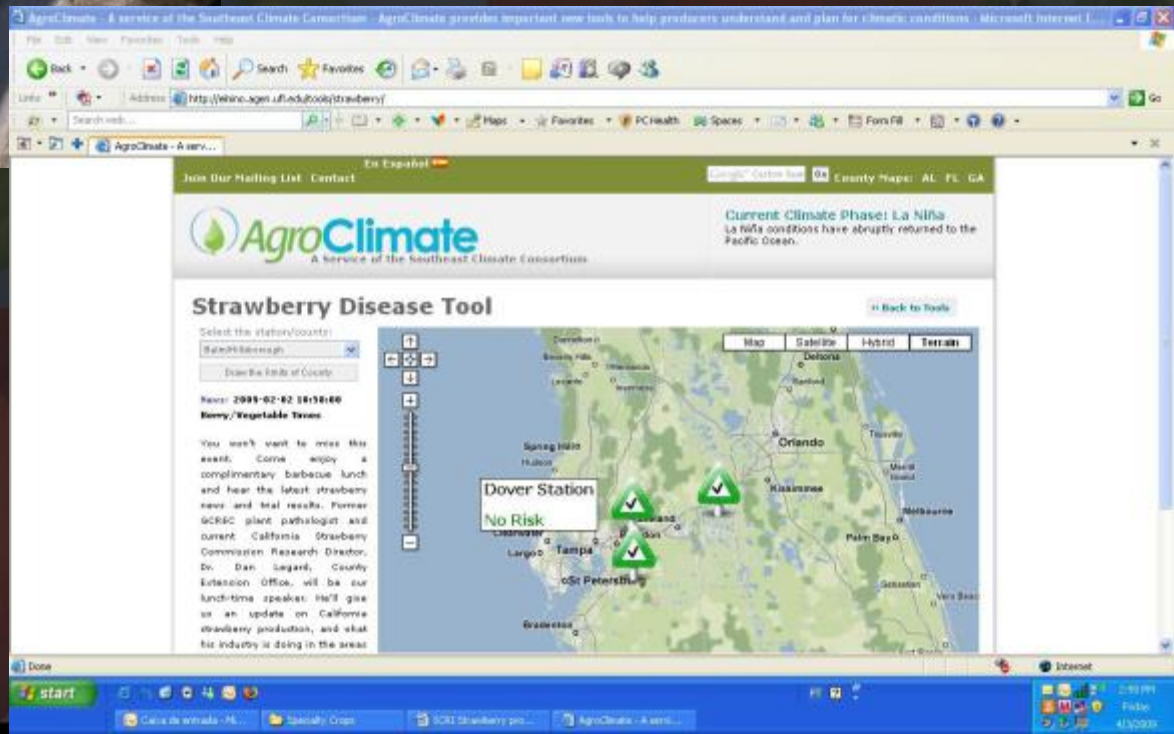
Only from 6th harvest, fungicides were applied 24 h prior to inoculation

2006 spray trial

PROPER COVERAGE AND PENETRATION IS CRITICAL



V. Forecasting



Model Parameters

Anthracnose fruit rot (*Colletotrichum acutatum)*

- affects the foliage, runners, crowns and fruit
- spores typically come in on transplants and are spread by wind-driven rains
- development is favored by temperatures greater than 65°F and wet weather (>12h of Leaf Wetness – LW).

Botrytis fruit rot (*Botrytis cinerea*)

- important pre-harvest and post-harvest disease of strawberry affecting the floral parts, including stamens and petals
- requires free moisture (>6h of LW) and temperatures between 60°F and 72°F to infect and sporulate

Prediction based spray schedule YEAR 1

Treatments	# of sprays applied	AFR incidence (%)[ab]	Marketable yield (lb/plant)[b]
Non treated control	-	8.5 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	3.2 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	4.4 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 ($\alpha \leq 0.05$).

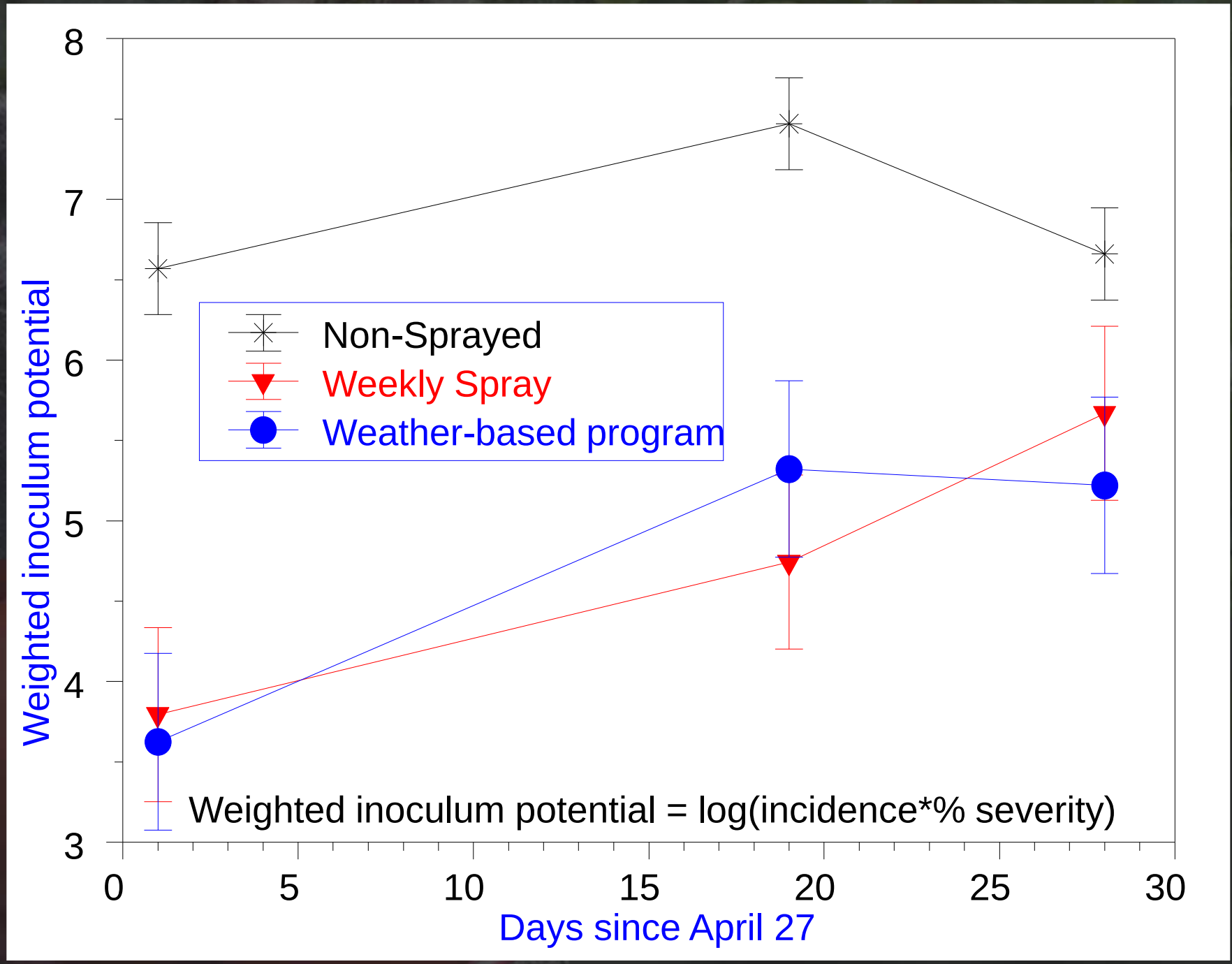
Results: YEAR 2

Treatments	# of sprays applied	AFR incidence (%) [ab]	Marketable yield (lb/Acre) [b]
Non Treated Control	-	22.6 a	11651
Regular Schedule Captan 50WP 4.0 lb+ Topsin M 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	6.425 b	12621
Prediction based schedule Captan 50WP 4.0 lb Pristine WG 1.45 lb Pristine WG 1.45 lb	 1 2 3	11.1 b	16229

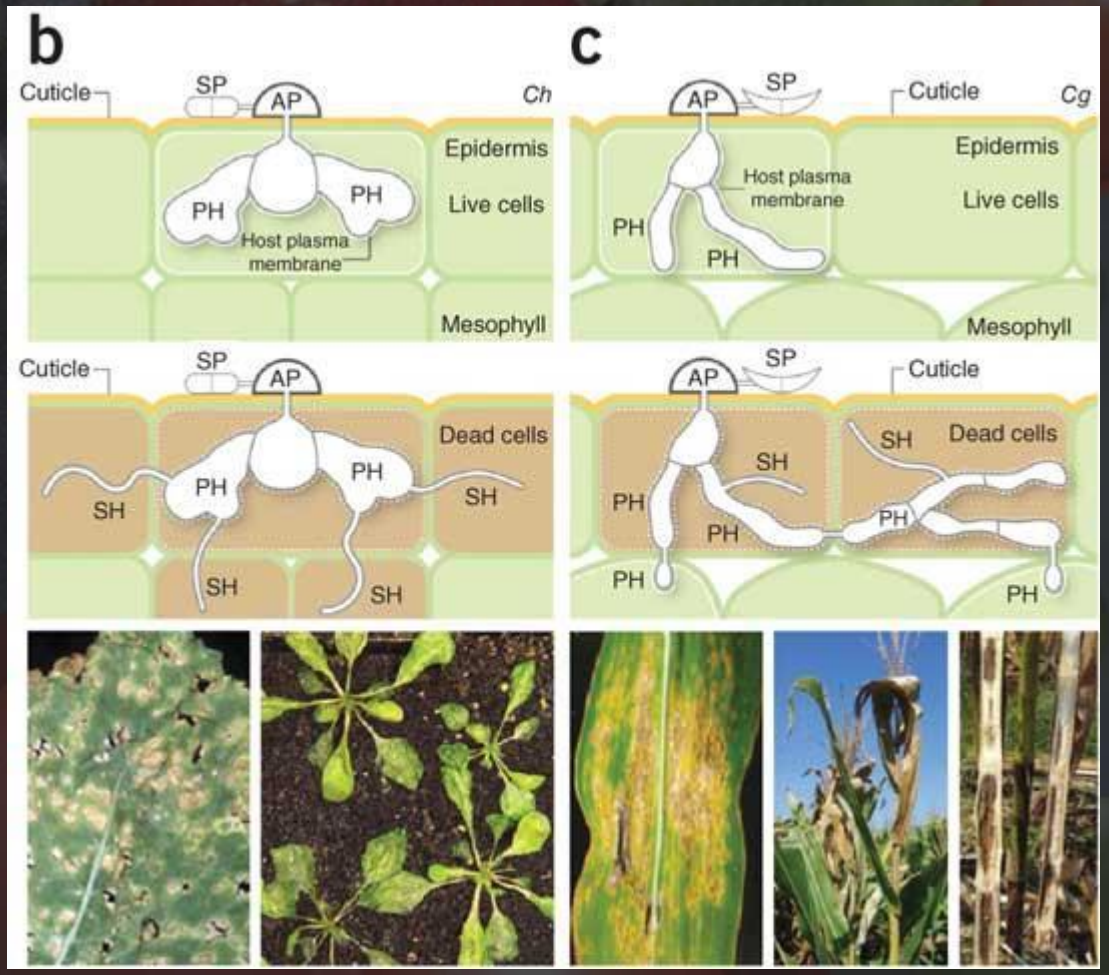
[a]Disease incidence was calculated from all harvested fruits over 6 weeks

*Harvest season was shortened likely due to late planting

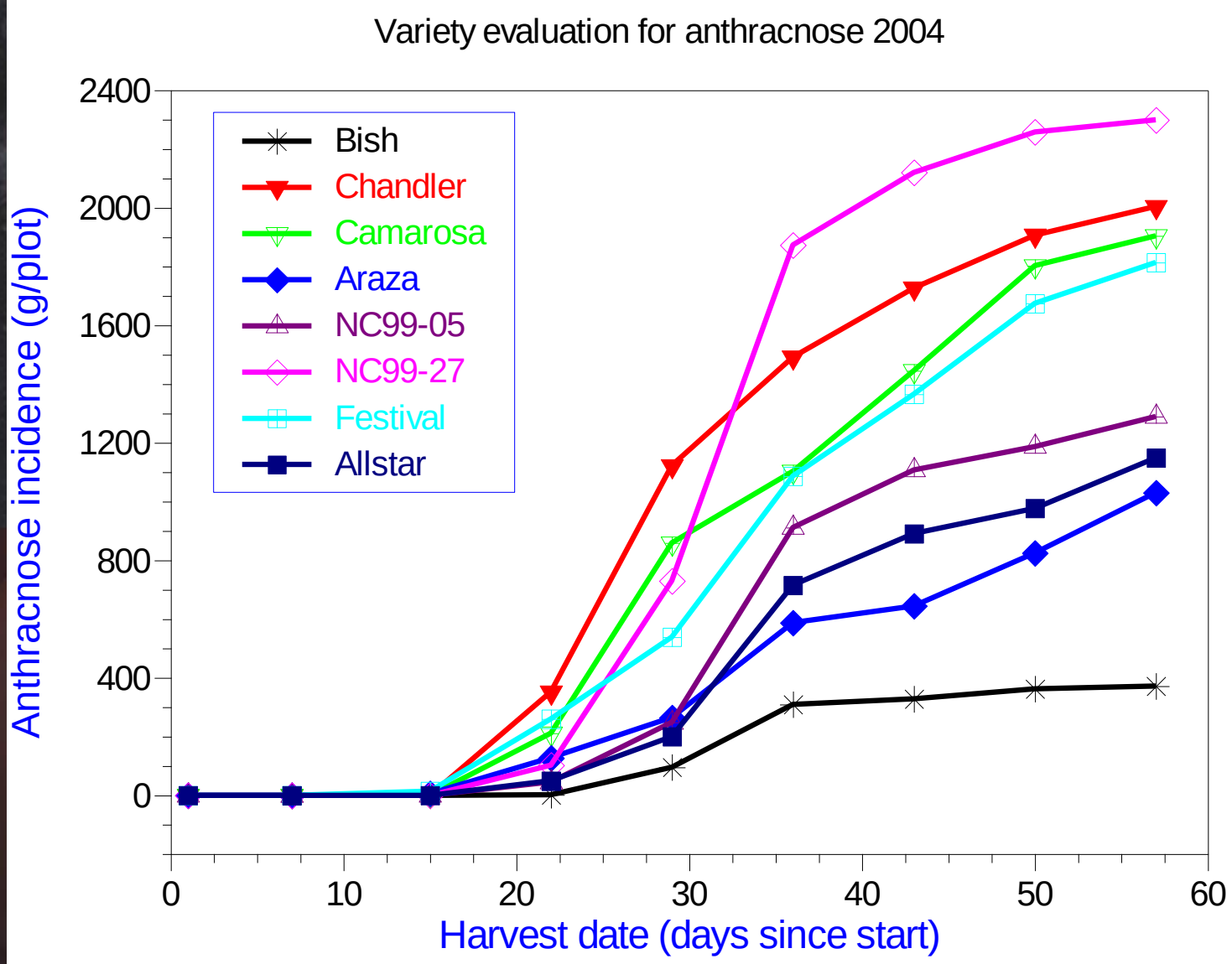
[b]Means in a column followed by the same letter are not significantly different by Fisher's protected LSD test ($\alpha \leq 0.05$).

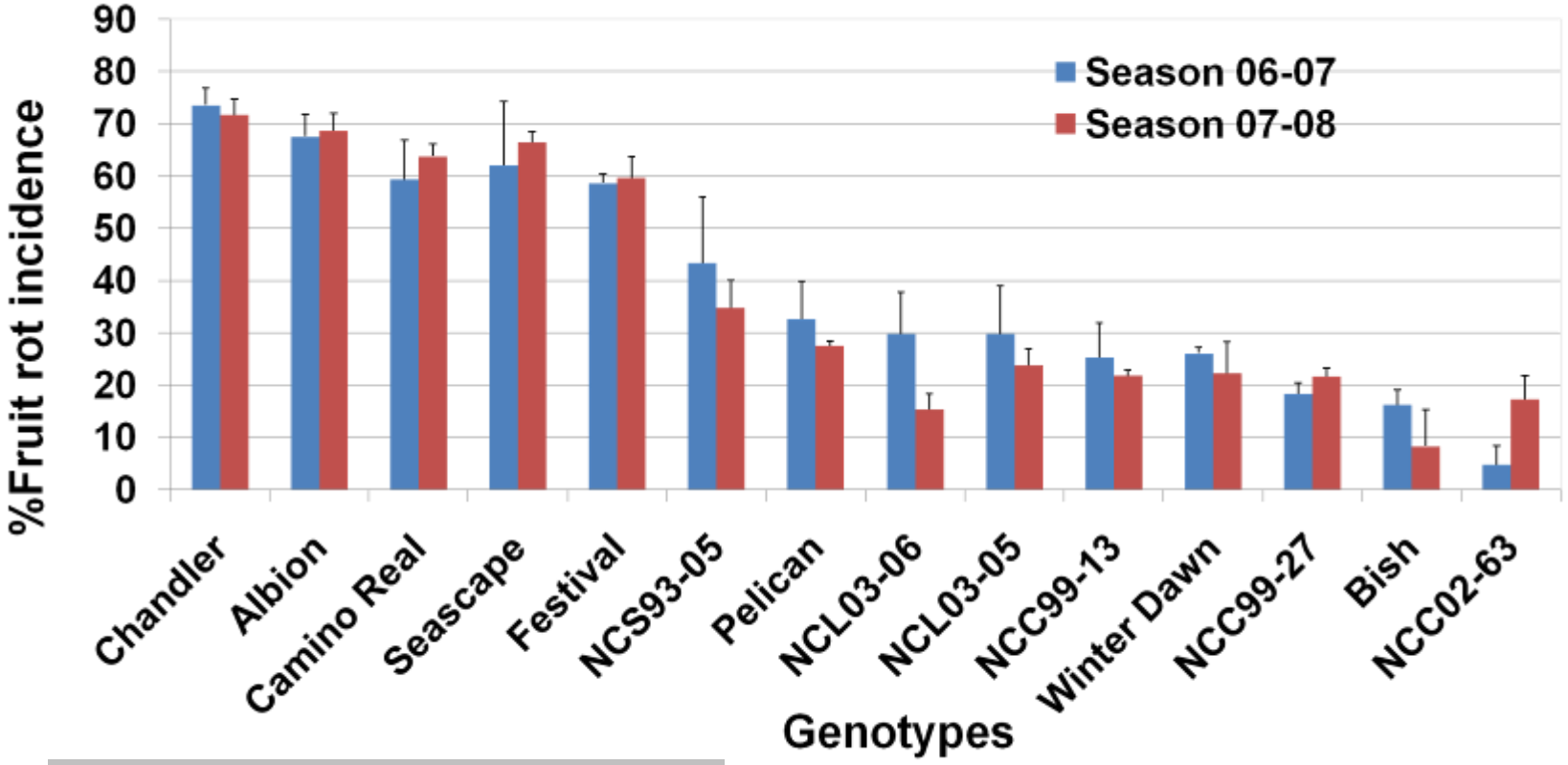

8
7
6
5
4
3
Weighted inoculum potential
Non-Sprayed
Weekly Spray
Weather-based program
Weighted inoculum potential = log(incidence*% severity)
0
5
10
15
20
25
30
Days since April 27

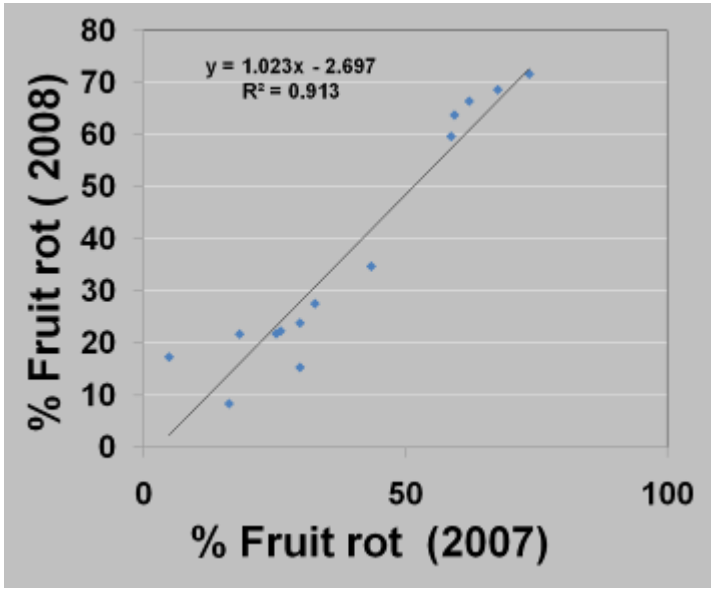
VI. Host Resistance



O'Connell et al. 2012. Lifestyle transitions in plant pathogenic *Colletotrichum* fungi deciphered by genome and transcriptome analyses. Nature Genetics 44:1060-1065


Variety evaluation for anthracnose 2004
Anthracnose incidence (g/plot)
2400
2000
1600
1200
800
400
0
Bish
Chandler
Camarosa
Araza
NC99-05
NC99-27
Festival
Allstar
0
10
20
30
40
50
60
Harvest date (days since start)


%Fruit rot incidence
90
80
70
60
50
40
30
20
10
0
Season 06-07
Season 07-08
Chandler
Albion
Camino Real
Seascape
Festival
NCS93-05
Pelican
NCL03-06
NCL03-05
NCC99-13
Winter Dawn
NCC99-27
Bish
NCC02-63
Genotypes


y = 1.023x - 2.697
R² = 0.913
% Fruit rot (2008)
80
70
60
50
40
30
20
10
0
0
50
100
% Fruit rot (2007)

IPM Of Anthracnose Fruit Rot

I. Prevention: (Apparently)
Disease Free Plants

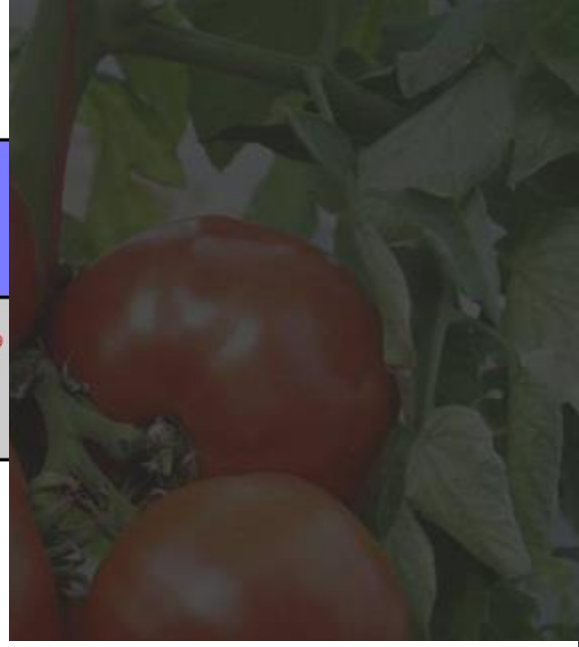
II. Detection and Sampling
Technologies

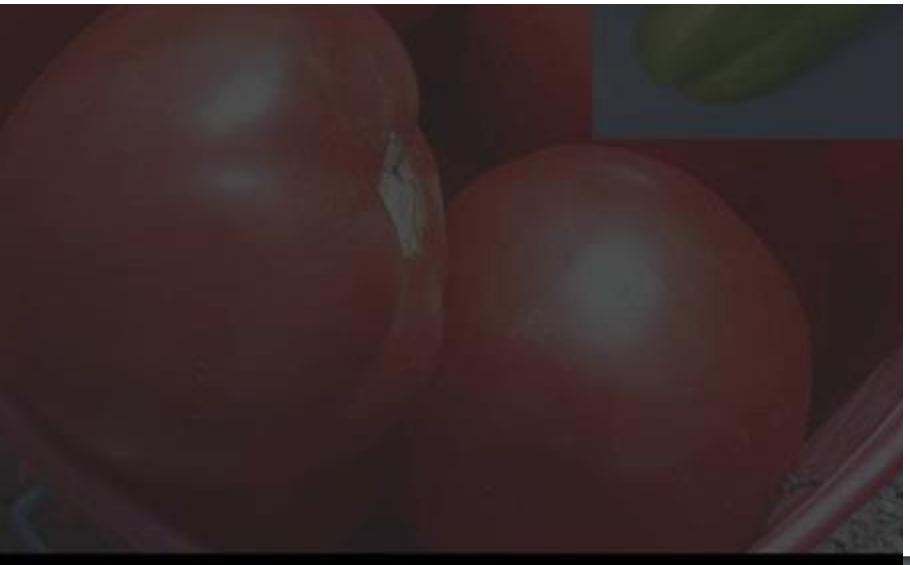
III. Culture Practices

IV. Fungicides

V. Forecasting

VI. Host Resistance





2016 Southeast Regional Strawberry Integrated Pest 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.

This publication is intended for use only as a guide. Specific rates and application methods are on the pesticide label, and these are subject to change at any time. Always refer to and read the pesticide label before making any application! The pesticide label supersedes any information contained in this guide, and it is the legal document referenced for application standards.

Extension Products: (smallfruits.org)

Key Principles to keep in mind (See Handout):

1. Abound/Quadris, Cabrio, and Pristine belong to the same family of chemicals (QoI; Group 11 chemistry).
2. Captan, Thiram, and Switch offer a broad spectrum of disease control. Switch is not strong against AFR in NC research.
3. Elevate may not be used in more than 2 consecutive sprays. It is very effective against Botrytis but no other fungal pathogens. Resistance is known in many fields.
4. High risk fungicides of the same chemical class should not be applied in consecutive applications.

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

Application 1: At FIRST bloom apply Captan, Thiram OR Switch.

Application 2: If risk of resistance is low, apply Elevate OR Fontelis alone; Use CaptEvate, Captan, Thiram or Switch if resistance risk is high.

Application 3: Same as Application 1; use Switch if not used yet (usually occurs during the “full-bloom” stage).

Application 4 and weekly: Rotate two or more of the following: Captan; CaptEvate; Elevate; Switch; Fontelis depending on the resistance profile in the field.

SCHEDULE 2. For cases where anthracnose fruit rot risk is high and gray mold control is also needed:

Application1: At FIRST bloom apply captan or thiram tank mixed with Cabrio.
Application 2: Apply ONE of these alternatives: CaptEvate OR captan.
Application 3: Same as Application 1.
Application 4: and weekly: Rotate two or more of the following: captan; captan+ Cabrio.

Switch is a good rotation partner; Great Botrytis control

Relative Effectiveness of Various Chemicals for Strawberry Disease Control
(— = ineffective; +++ = very effective; ? = efficacy unknown)

Pesticide	Relative Control Rating											
	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)	++	+++	+++[R]	+	+++	+++	—	?	?	—	—	—
Acibenzolar-S-methyl (Actigard)	—	—	—	—	—	—	—	—	—	+	—	—
Azoxystrobin + difenoconazole (Quadris Top)	++	++	+	++	++	?	+	—	—	—	—	—
captan (Captan)	++	++	++	—	++	+	+	+	+	—	—	—
copper	—	—	—	—	+[P]	—	+[P]	—	—	+[P]	—	—
cyprodinil + fludioxinil (Switch)	++	+	+++[R]	?	+?	+?	—	?	?	?	—	—
difenoconazole + cyprodinil (Inspire Super)	++	++	+++[R]	++[R]	++?	?	-	-	-	-	-	-
fenhexamide (Elevate)	—	—	+++[R]	—	—	—	—	—	—	—	—	—
fenhexamide + captan (CaptEvate)	+	++	+++	—	++	+	+	+	+	—	—	—
fosetyl-Al (Aliette)	—	—	—	—	—	—	++	—	—	—	++	++
iprodione (Rovral)	—	—	+++[R]	—	++	—	—	X	—	—	—	—
mefenoxam (Ridomil) or similar products	—	—	—	—	—	—	+++[R]	—	—	—	+++	+++

Relative Efficacy of Fungicides

Fungicide	Botrytis	Anthracnose
Abound (QoI)	+	+
Pristine (QoI)	+++	+++
Captan	++	++
Quadris Top	+	++
Inspire Super	+++	++
CaptEvate	+++	++
Elevate	+++	--
Scala	++	--
Switch	+++	+

www.smallfruits.org Strawberry IPM Guide

MyIPM app and Online Tools

MyIPM

a smart phone app

contains useful strawberry disease information in support of this IPM guide

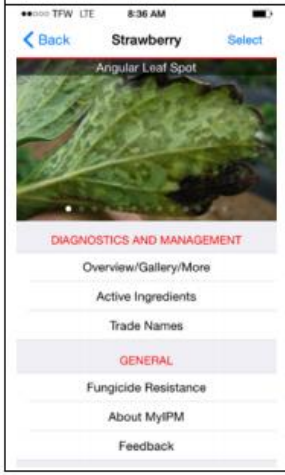
Download for FREE in Apple's App Store or Google's Play Store.

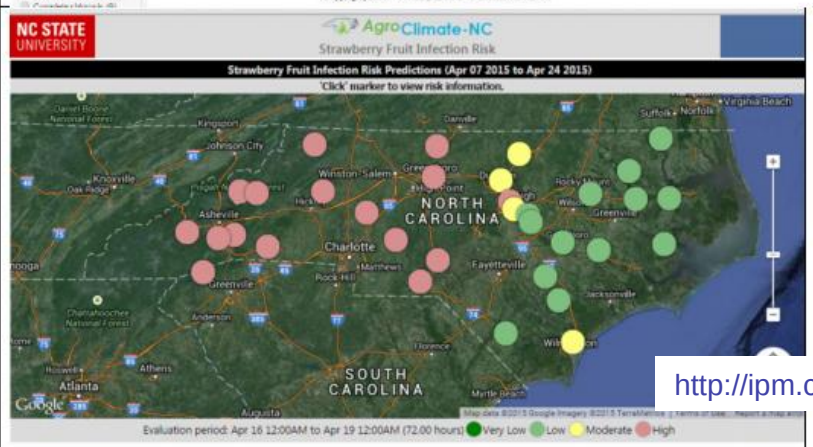
Strawberry Diagnostic Key

includes insects, diseases, nutritional deficiencies and physiological disorders.

Available online at

https://diagnosis.ces.ncsu.edu/strawberry





Strawberry Fruit Infection Risk

weather-based decision support systems to optimize spray timing for Botrytis and Anthracnose fruit rots are available for North Carolina

Visit the Strawberry Advisory System

http://ipm.ces.ncsu.edu/forecast/

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.