Management of Hull Rot in Almond

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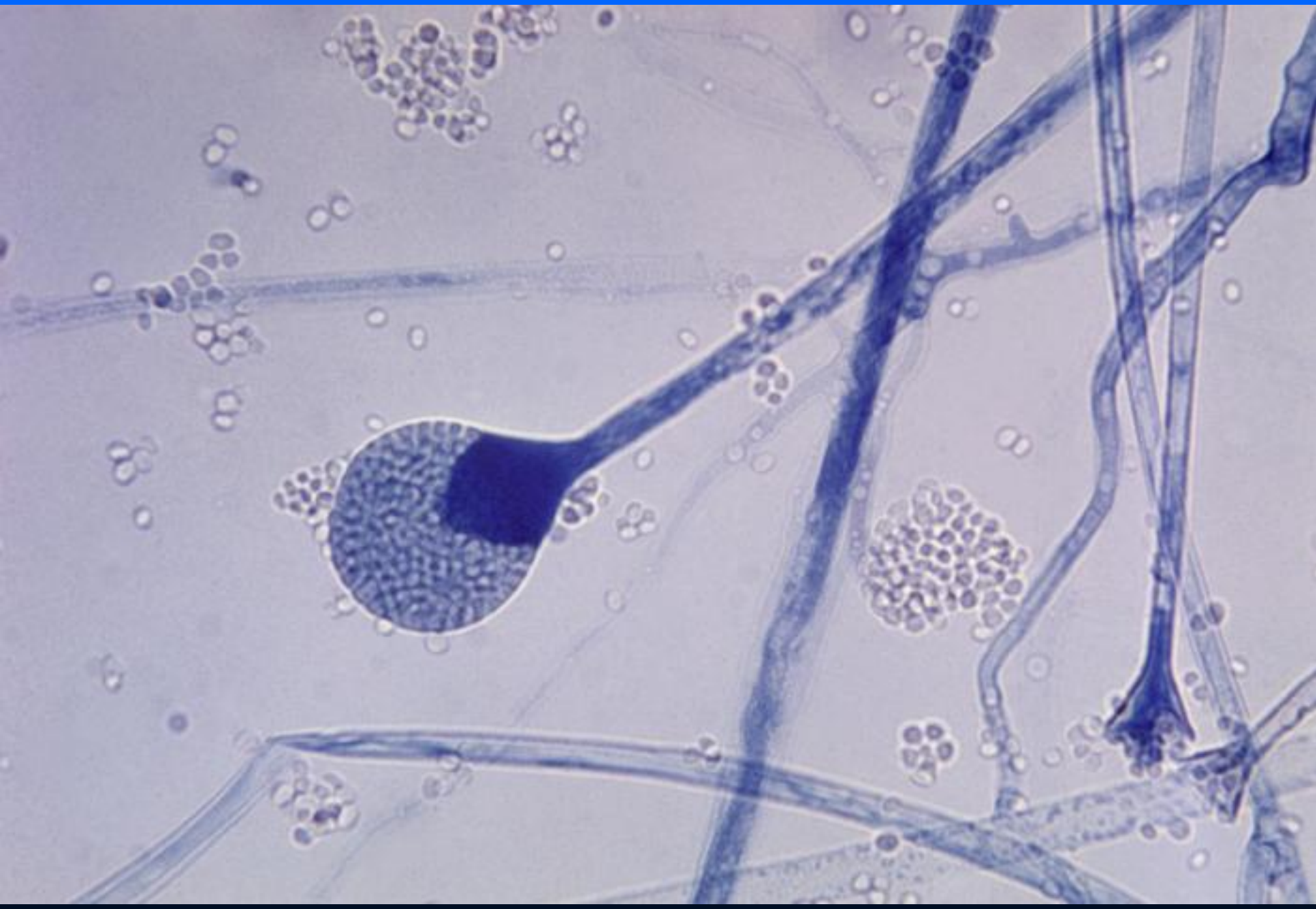
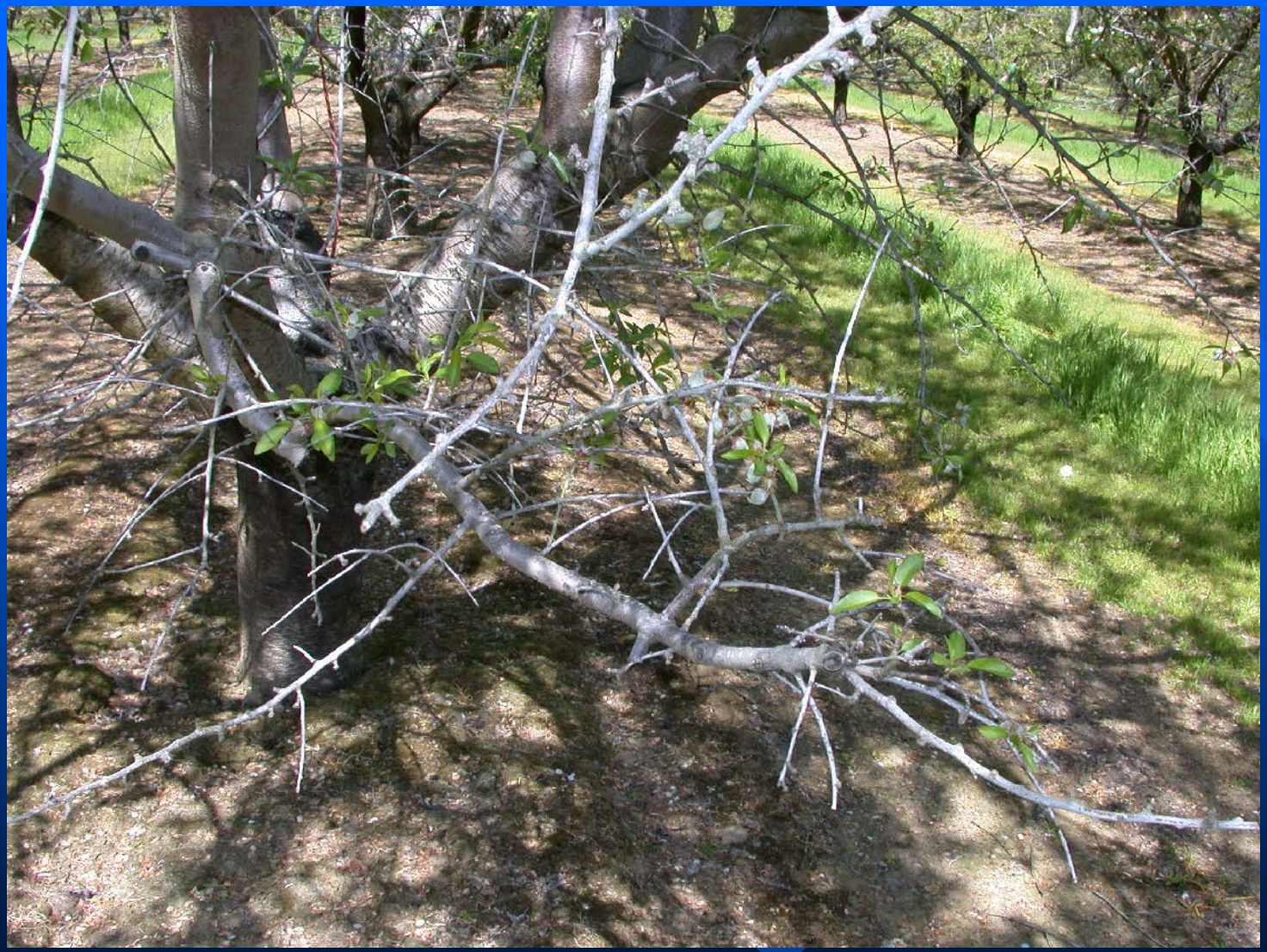
UNIVERSITY OF CALIFORNIA

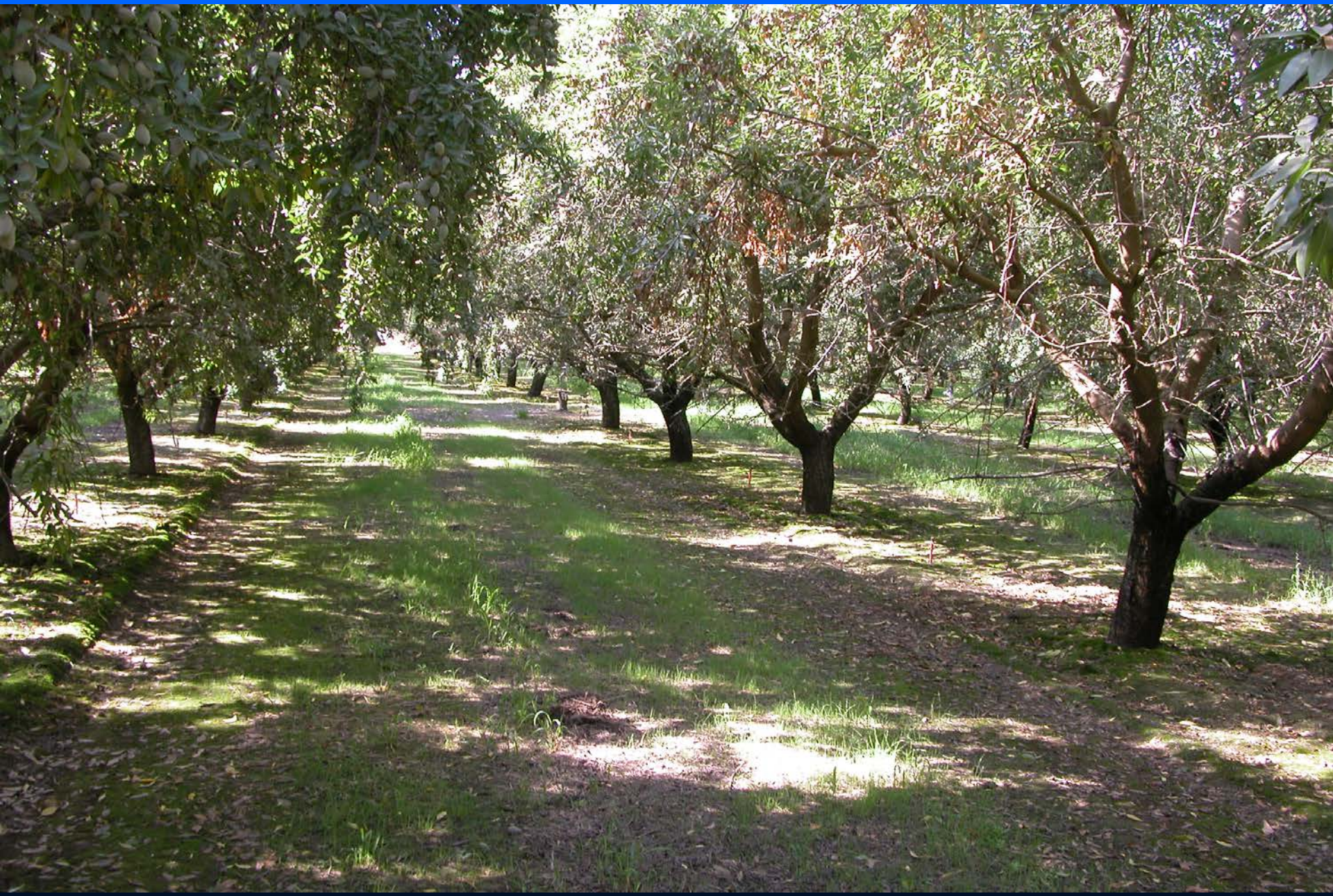
HULL ROT

MONILINIA FRUCTICOLA

RHIZOPUS STOLONIFER







Ten Years Later

HULL ROT

CULTIVAR SUSCEPTIBILITY

	STRIKES/TREE
KAPAREIL	802
NONPAREIL	576
BUTTE	251
WINTERS (13-1)	216

HULL ROT

CULTIVAR SUSCEPTIBILITY

0 STRIKES/TREE

SAVANA
FRITZ
DONNA

CARMEL
MONTEREY

HULL ROT

VIGOROUS, PRODUCTIVE ORCHARDS

AMPLE WATER & NITROGEN

UC CE University of California Agriculture and Natural Resources

HEALTHY FOOD SYSTEMS • HEALTHY ENVIRONMENTS • HEALTHY COMMUNITIES • HEALTHY CALIFORNIANS

HULL ROT

THE GOUT OF ALMOND TREES

TOO MUCH FOOD & DRINK

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HULL ROT

RESPONDS DRAMATICALLY TO CULTURAL CONTROL

HULL ROT MANAGEMENT

NITROGEN

IRRIGATION

FUNGICIDES?

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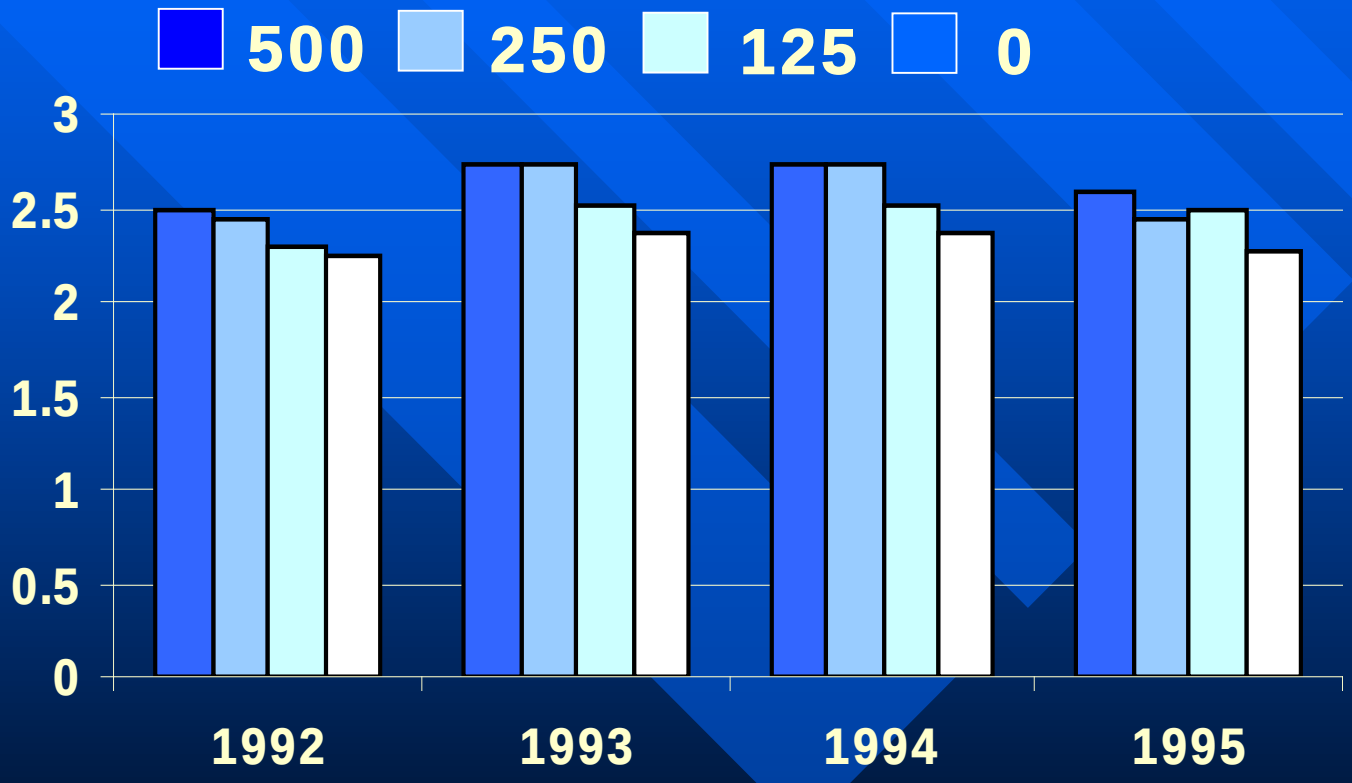
HULL ROT: NITROGEN

COMPARED FOUR RATES (LBS/ACRE)

- 500
- 250
- 125
- 0

HULL ROT: NITROGEN

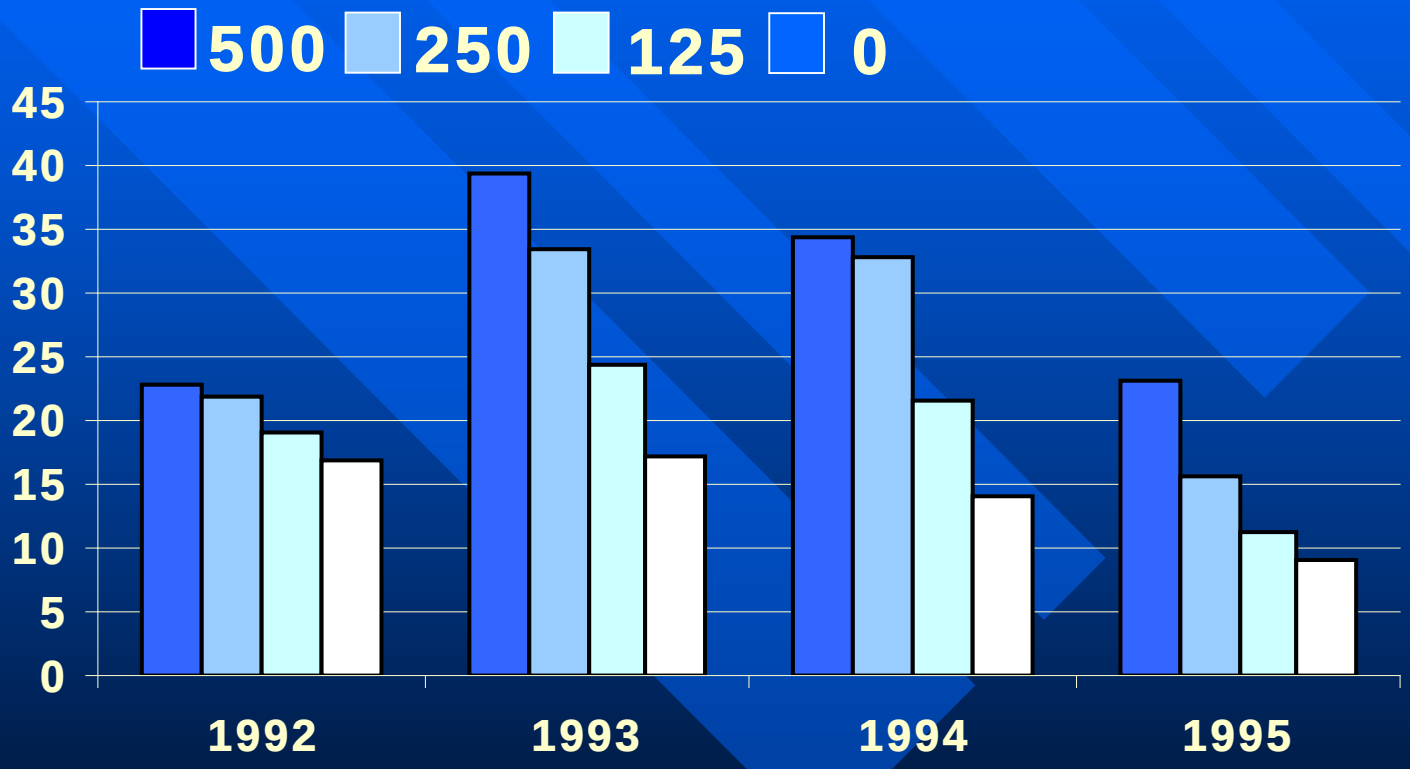
LEAF NITROGEN CONTENT (%)



	1992	1993	1994	1995
LINEAR *P* =	0.003	0.001	0.010	0.020

HULL ROT: NITROGEN

HULL ROT: STRIKES PER TREE

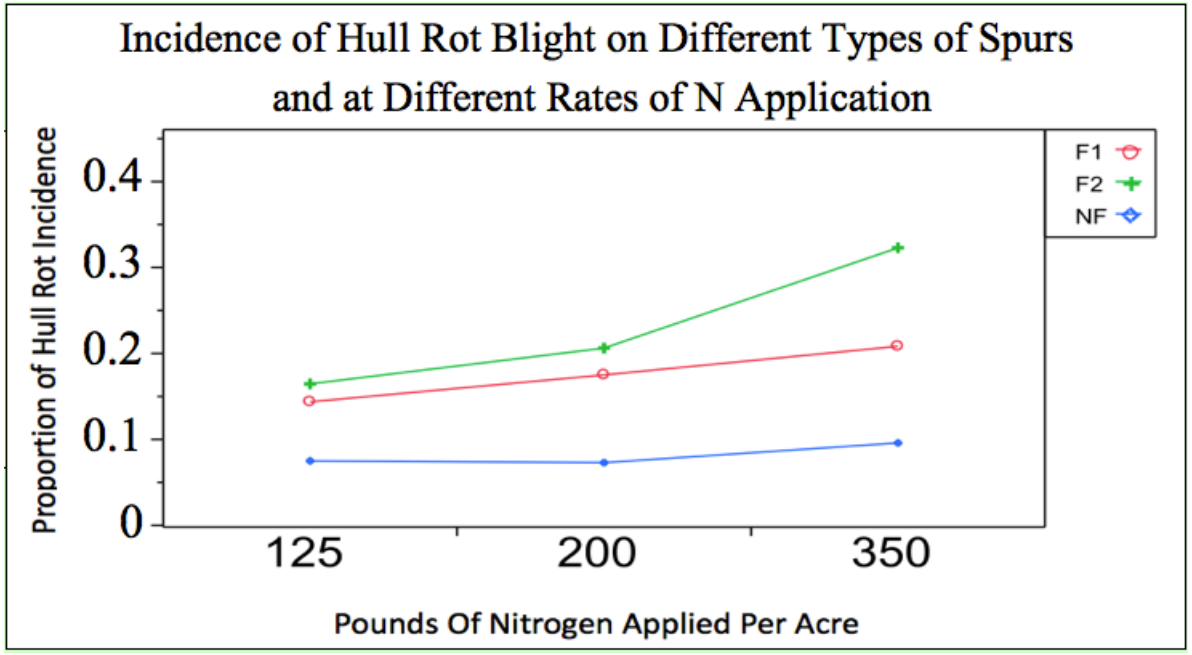


	1992	1993	1994	1995
LINEAR *P* =	0.004	0.001	0.001	0.020

Nitrogen Effect 2011-

by tagged spurs

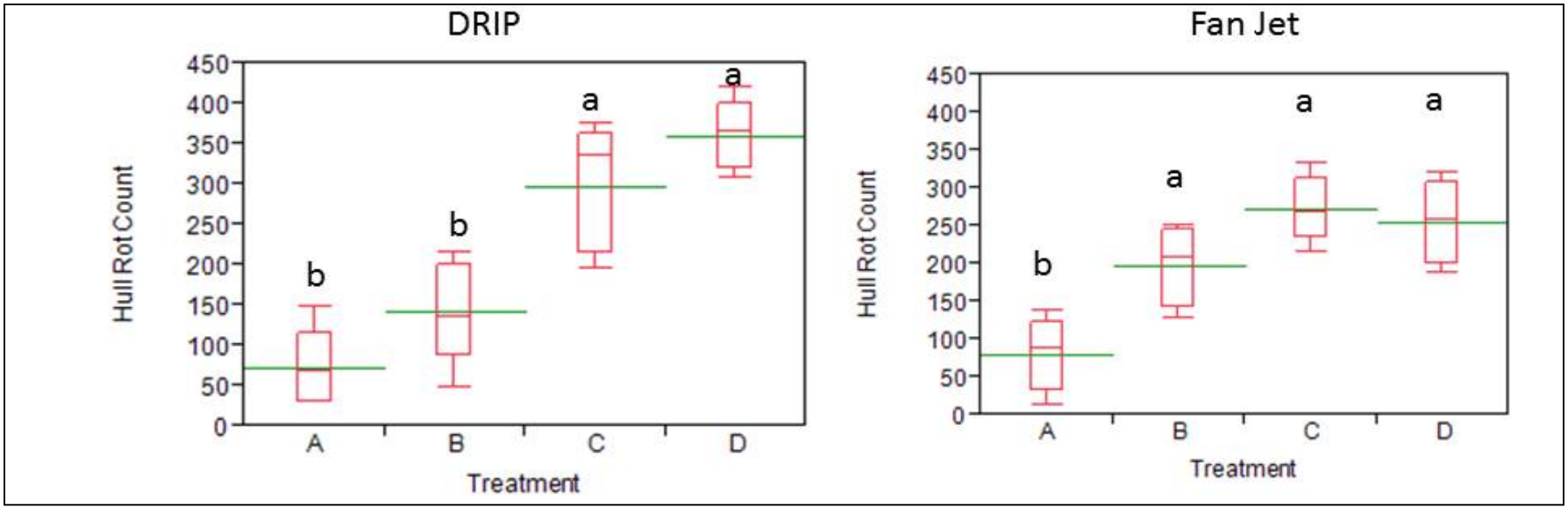
144 trees were selected with different N treatments (125, 200, 350 lbs/acre). In each selected tree a total of 11 non-fruiting spurs (NF), 11 one fruiting spurs (F1), and 11 two fruiting spurs (F2) were labeled for a total of 4,752 labeled spurs. **Hull rot incidence** was determined after harvest as the **proportion of spurs** out of total tagged spurs that were experiencing blight and dieback.



High levels of N have significantly more hull rot incidence than lower levels, mainly due to a higher incident in F2 spurs.

Nitrogen Effect 2011-

by counted shoots



Nitrogen fertilizer effect on hull rot count A=125 lbs N/ac B=200 lbs N/ac, C=275 lbs N/ac, D=350 lbs N/ac.

Blighting was estimated by counting the number of spurs or shoots that had dry leaves. Each treatment comprised 60 trees.

HULL ROT MANAGEMENT

NITROGEN USAGE

- AVOID EXCESSIVE LEVELS
- IDEAL: leaf petiole 2.2-2.5%

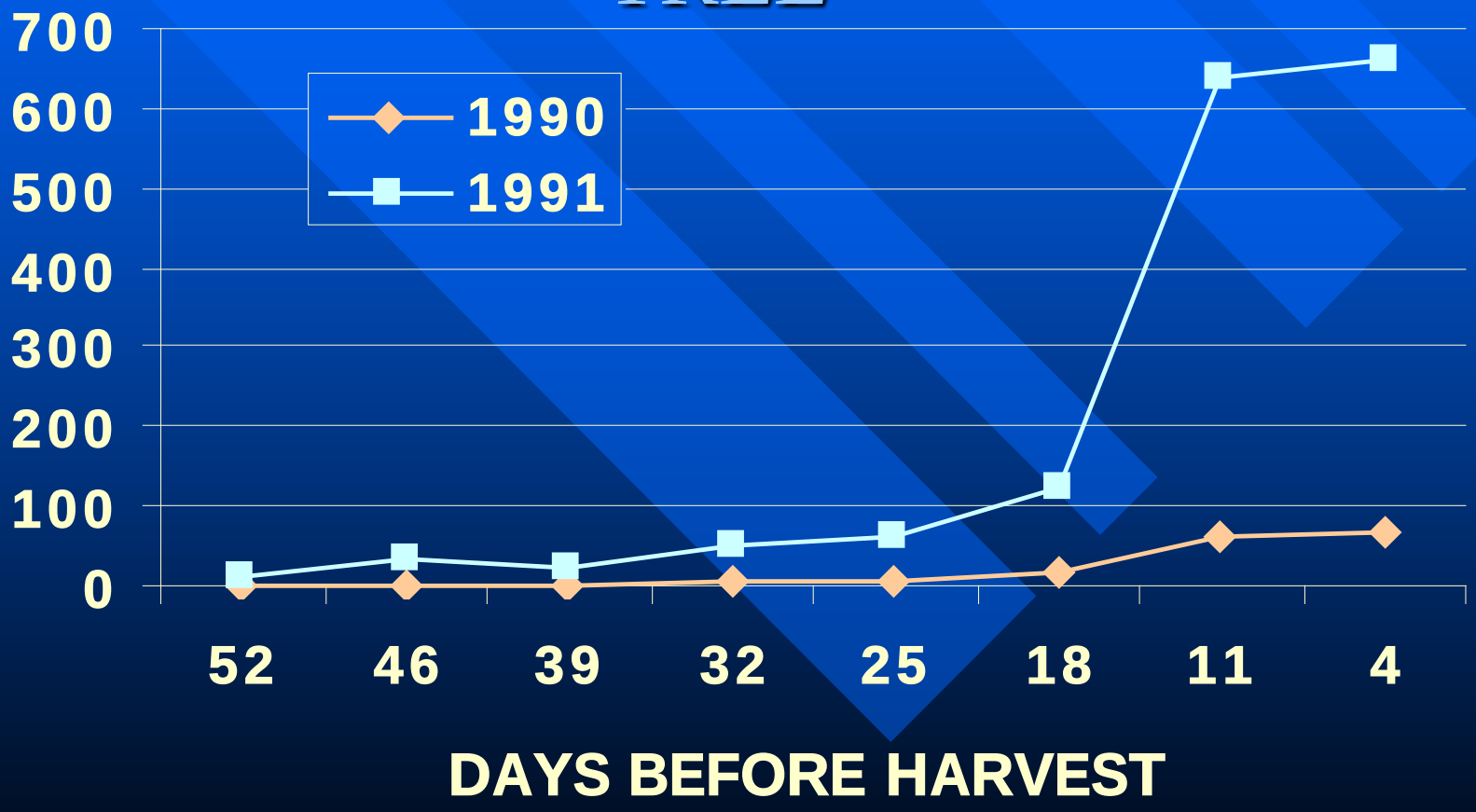
HULL ROT MANAGEMENT

IRRIGATION

- EARLY CUT-OFF
- REGULATED DEFICIT

HULL ROT: IRRIGATION

EARLY CUT-OFF:STRIKES PER TREE



HULL ROT: IRRIGATION

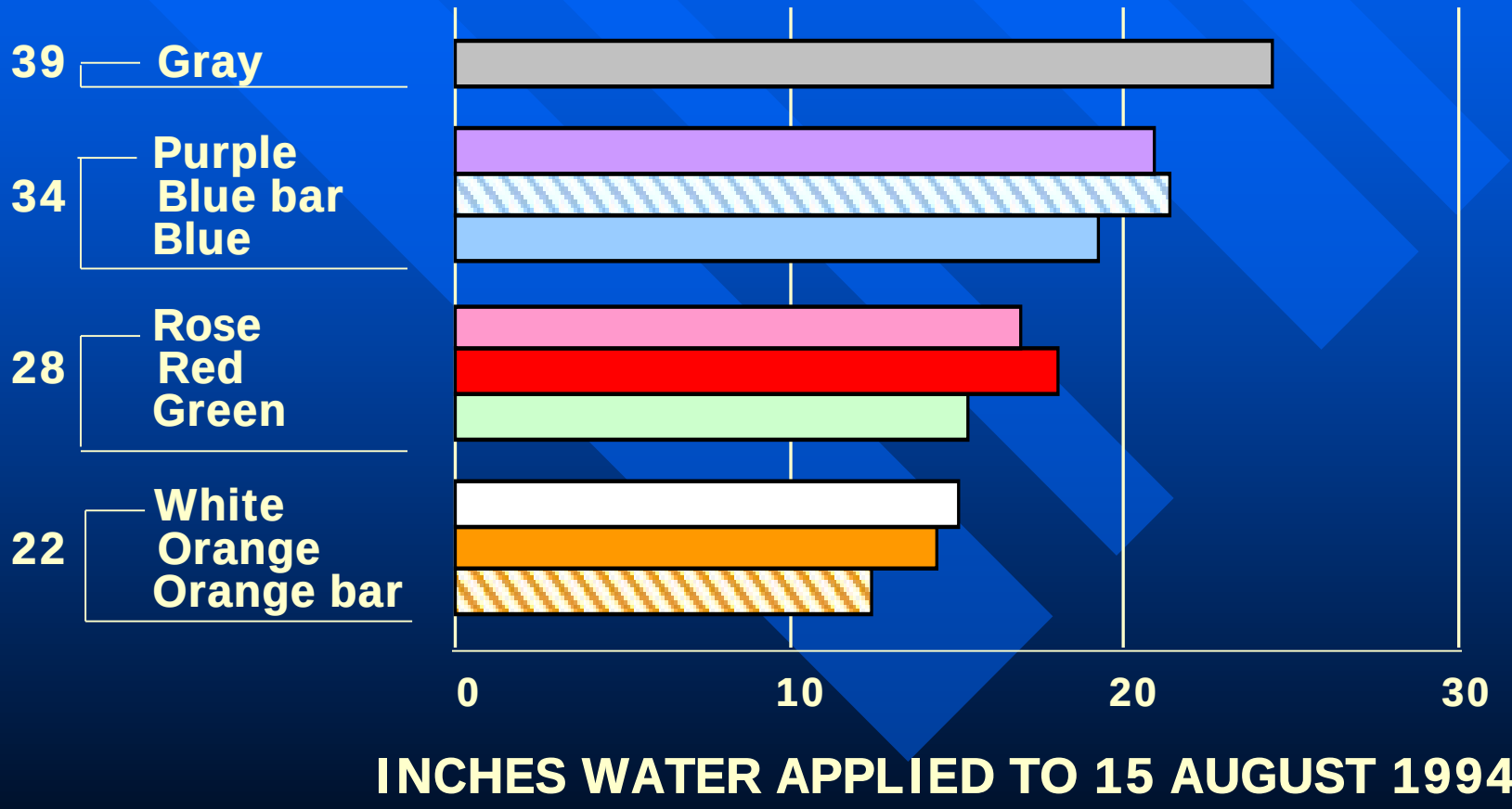
REGULATED DEFICIT

REGULATED DEFICIT IRRIGATION SCHEDULE

	Gray	Purple	Blue bar	Blue	Rose	Red	Green	White	Orange	Org bar
	39-CHK	34-S	34-R	34-R	28-S	28-R	28-R	22-S	22-S	22-S
Mar 1-15	100	85	100	100	70	100	100	55	100	100
16-31										
Apr 1-15										
16-30									50	50
May 1-15							50			
16-31										
Jun 1-15				50		50				
16-30										
Jul 1-15			50							0
16-31			100	100						50
Aug 1-15						100			100	

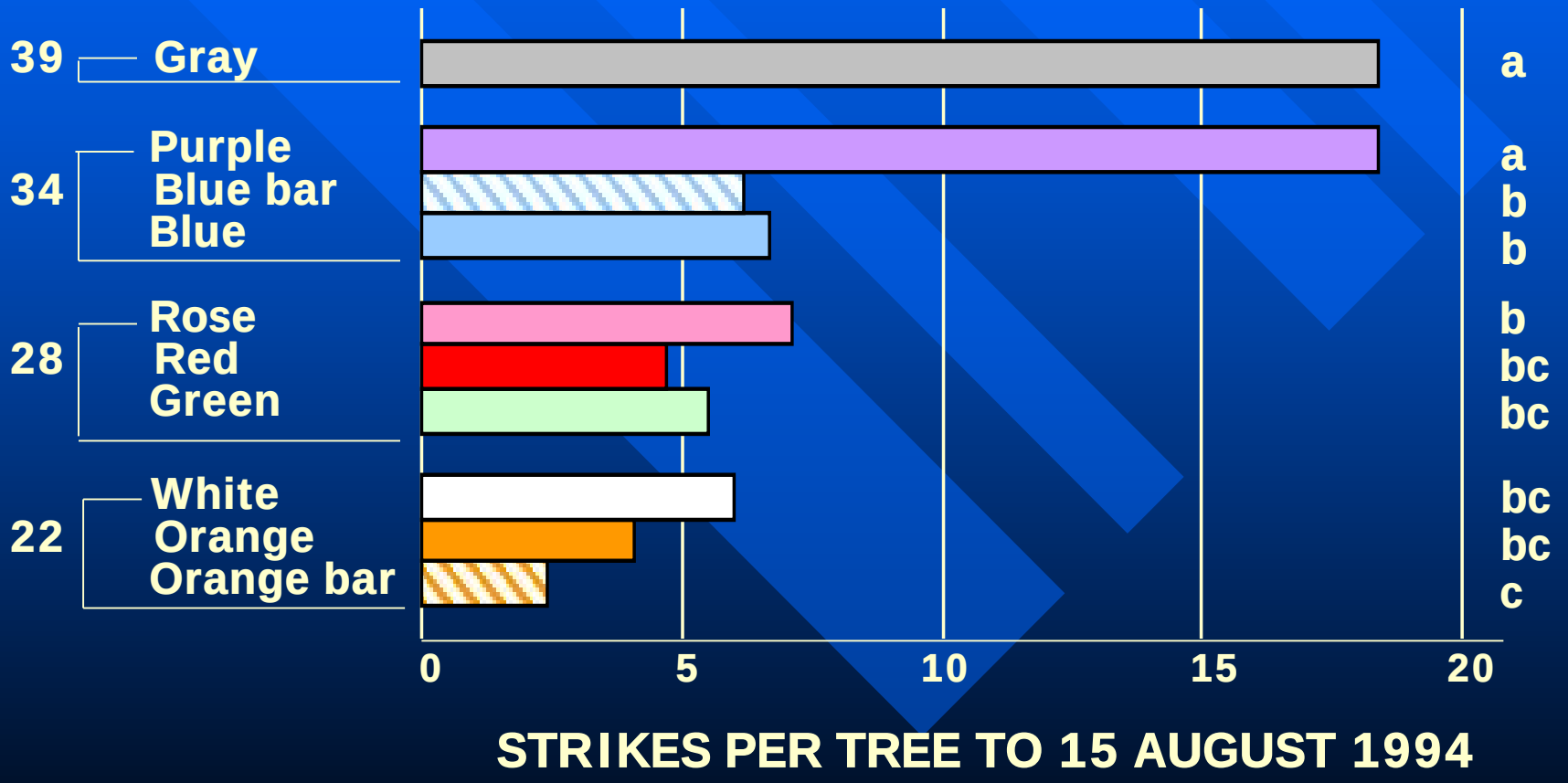
HULL ROT: IRRIGATION

REGULATED DEFICIT - WATER



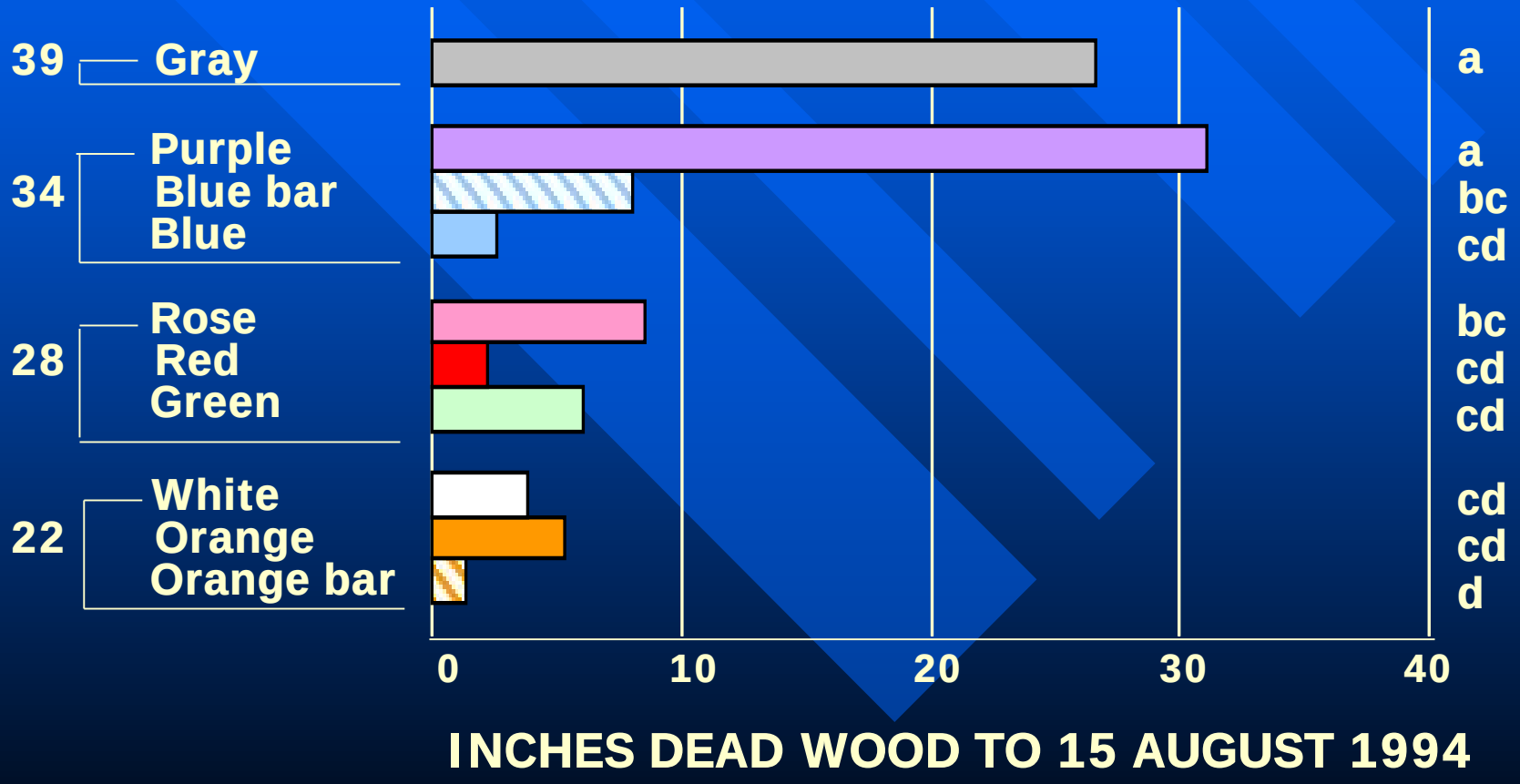
HULL ROT: IRRIGATION

REGULATED DEFICIT - STRIKES



HULL ROT: IRRIGATION

REGULATED DEFICIT - DEAD WOOD



REGULATED DEFICIT IRRIGATION SCHEDULE

	Gray	Purple	Blue bar	Blue	Rose	Red	Green	White	Orange	Org bar
	39-CHK	34-S	34-R	34-R	28-S	28-R	28-R	22-S	22-S	22-S
Mar 1-15	100	85	100	100	70	100	100	55	100	100
16-31										
Apr 1-15										
16-30									50	50
May 1-15							50			
16-31										
Jun 1-15				50		50				
16-30										
Jul 1-15			50							0
16-31			100	100						50
Aug 1-15						100			100	

HULL ROT IRRIGATION

MILD STRESS AT EARLY HULL SPLIT

REDUCES HULL ROT

What is worse?

Pacific Spider Mite?

or

Hull Rot?

- Rhizopus can only infect almond hulls after hull split—not before!!

Deficit Irrigation Management During Hull-Split
OR,
An Almond RDI "Clinical Trial"

Project leader: Ken Shackel, Pomology, UC Davis

Sub-Project Leaders:
Rick Buchner, Joe Connell, John Edstrom, Allan Fulton, Brent Holtz, Bruce Lampinen, Bill Krueger, Wilbur Reil, Larry Schwankl, Mario Viveros

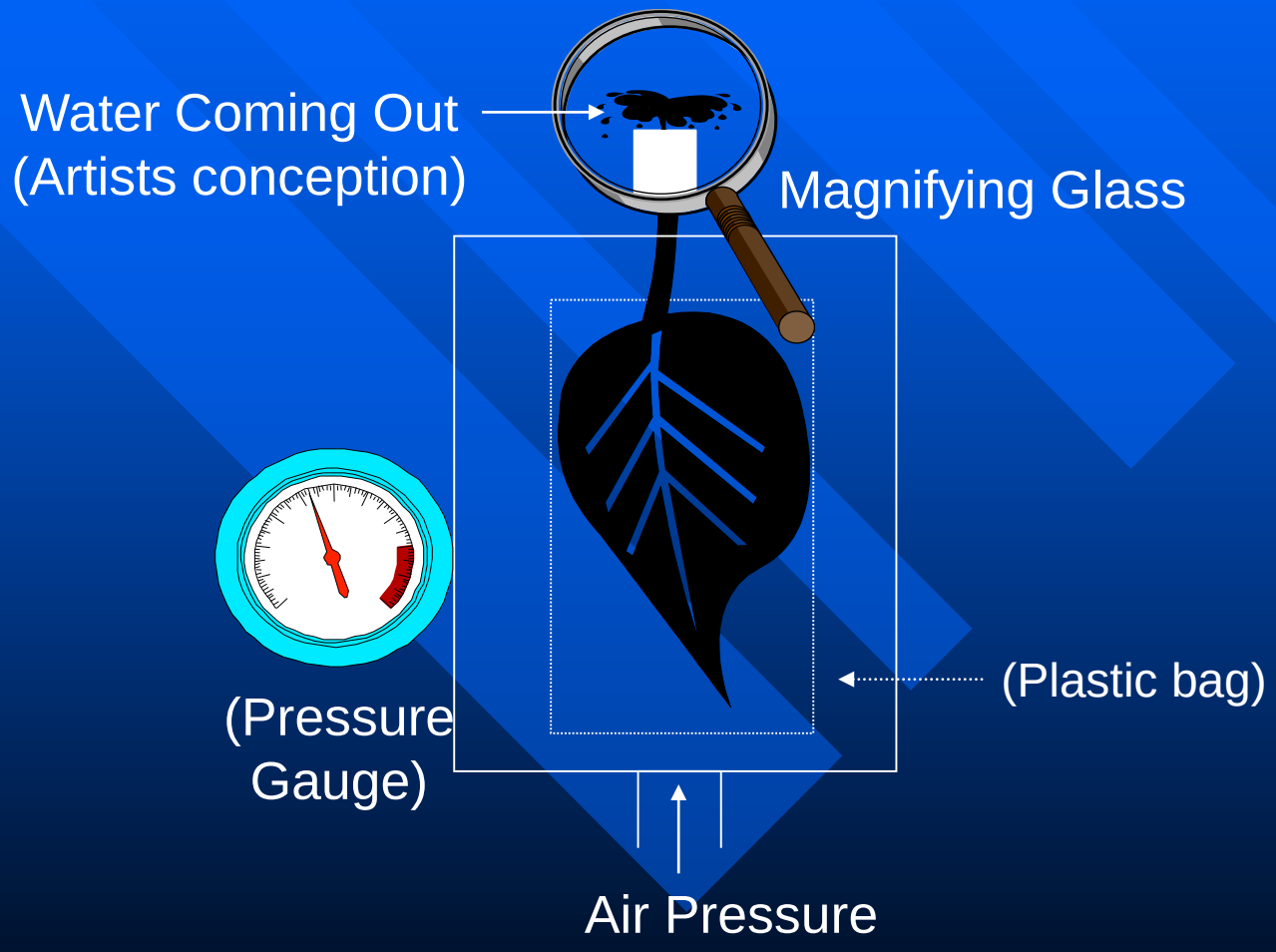
Proposed benefits of RDI for almonds during hull split:

1) Reduce Hull rot
2) Reduce Sticktights (Improve Harvestability)
3) Save Water

Prescription:

1) Measure stress using midday Stem Water Potential (SWP)
2) Prior to hull split: **-7 to -9 bars** SWP (fully irrigated baseline)
3) During hull split: **-14 to -18 bars** SWP (mild to mod. stress)
4) After hull split: **-7 to -9 bars** (as close to harvest as possible)

Pressure chamber method for measuring SWP (schematic)



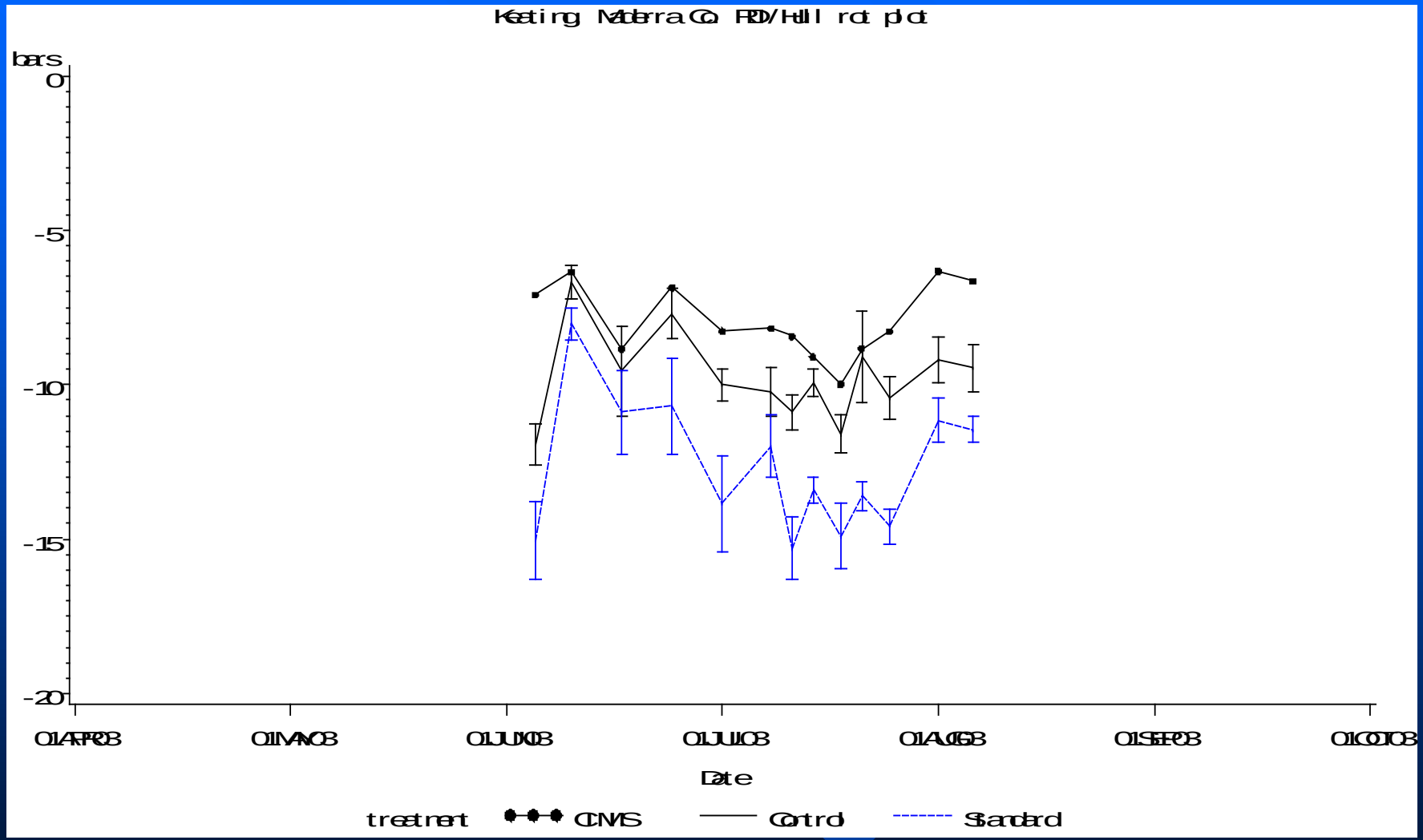
Bagged Leaf

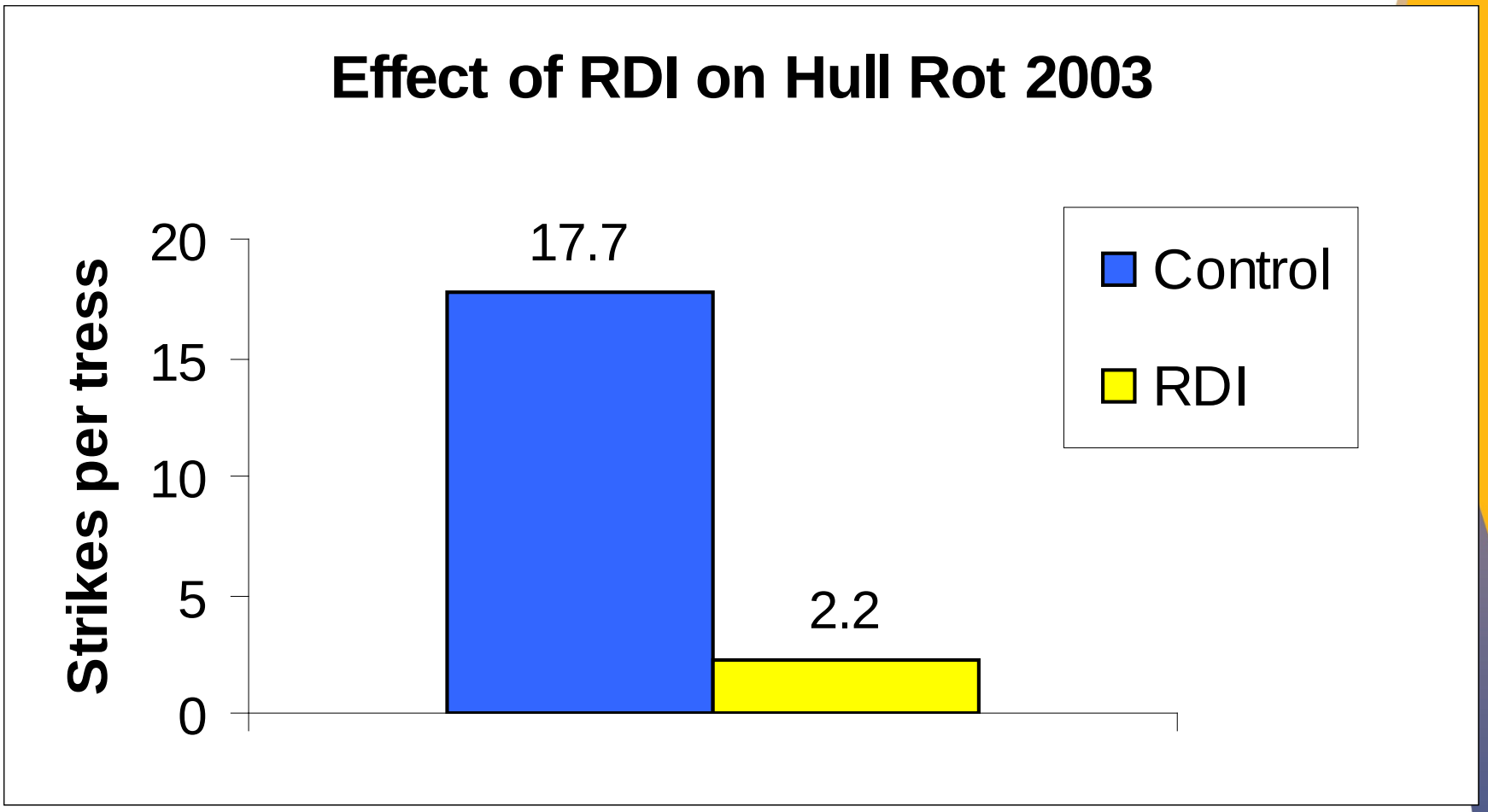
- Leaves are bagged with a small bag that will block out sun light for at least 15 minutes before the measureme nt is taken

MIDDAY STEM WATER POTENTIAL

FULLY IRRIGATED ALMOND TREES

TEMPERATURE (°F)	AIR RELATIVE HUMIDITY (RH, %)						
	10	20	30	40	50	60	70
70	-6.8	-6.5	-6.2	-5.9	-5.6	-5.3	-5.0
75	-7.3	-7.0	-6.6	-6.2	-5.9	-5.5	-5.2
80	-7.9	-7.5	-7.0	-6.6	-6.2	-5.8	-5.4
85	-8.5	-8.1	-7.6	-7.1	-6.6	-6.1	-5.6
90	-9.3	-8.7	-8.2	-7.6	-7.0	-6.4	-5.8
95	-10.2	-9.5	-8.8	-8.2	-7.5	-6.8	-6.1
100	-11.2	-10.4	-9.6	-8.8	-8.0	-7.2	-6.5
105	-12.3	-11.4	-10.5	-9.6	-8.7	-7.8	-6.8
110	-13.6	-12.6	-11.5	-10.4	-9.4	-8.3	-7.3
115	-15.1	-13.9	-12.6	-11.4	-10.2	-9.0	-7.8


Keating Mcberra Co. FRD/Hull rot plot
bars
0
-5
-10
-15
-20
01APR03
01MAY03
01JUN03
01JUL03
01AUG03
01SEP03
01OCT03
Date
treatment
CMS
Control
Standard


Effect of RDI on Hull Rot 2003
Strikes per tress
20
15
10
5
0
17.7
2.2
Control
RDI

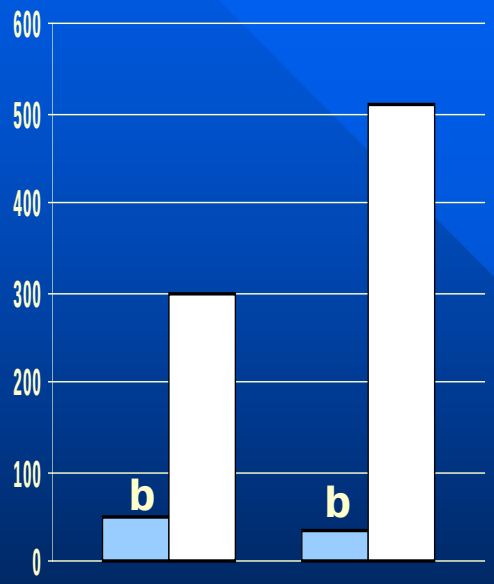
HULL ROT: VALIDATION

WILL DEFICIT IRRIGATION WORK WITH?

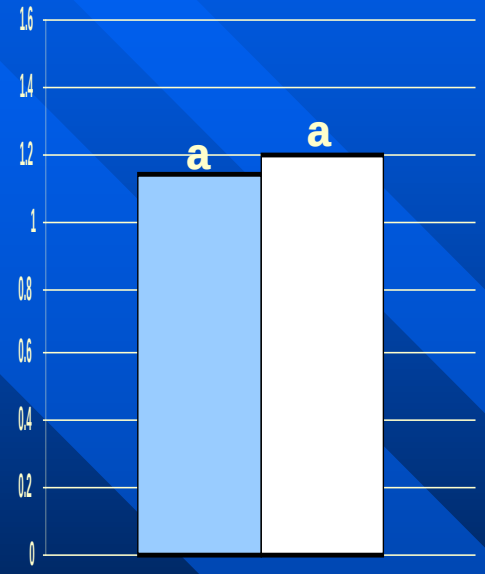
- **MICROSPRINKLER**
- **FLOOD**
- **DOUBLE-LINE DRIP**

HULL ROT: VALIDATION

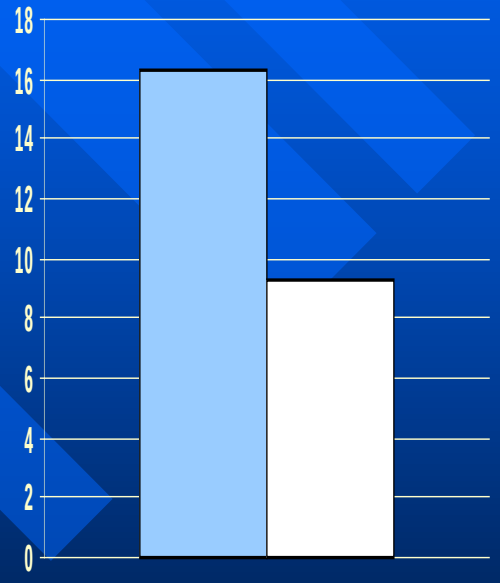
14-DAY (MICRO-SPRINKLERS)



STRIKES DEAD WOOD



KERNEL DRY WT(g)

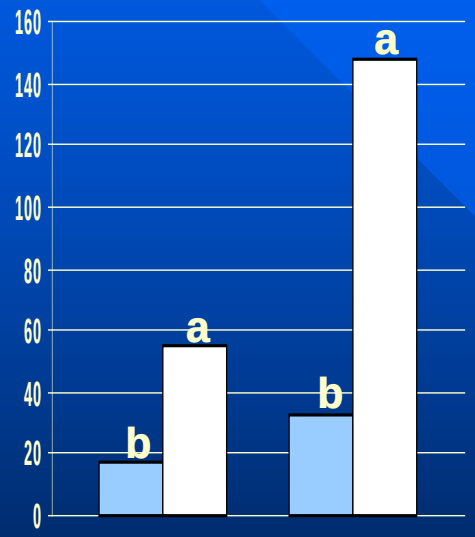


PRE-DAWN LWP

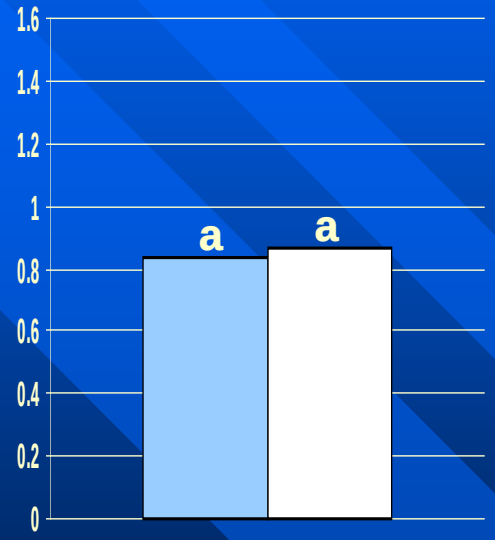
1997 IRRIGATION DEFICIT: FULL NONE

HULL ROT: VALIDATION

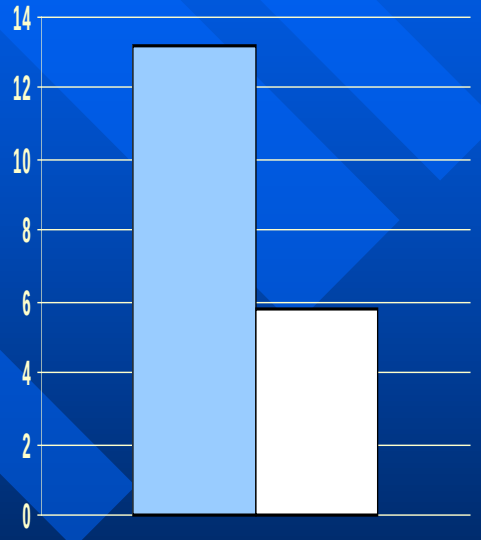
36-DAY (FLOOD)



STRIKES DEAD WOOD



KERNEL DRY WT(g)

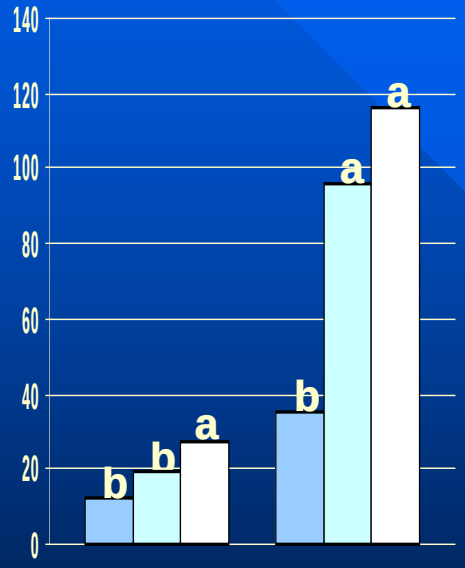


PRE-DAWN LWP

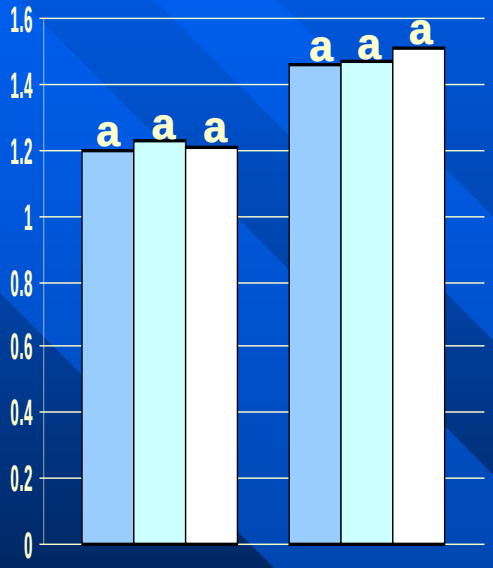
1997 IRRIGATION DEFICIT: FULL NONE

HULL ROT: VALIDATION

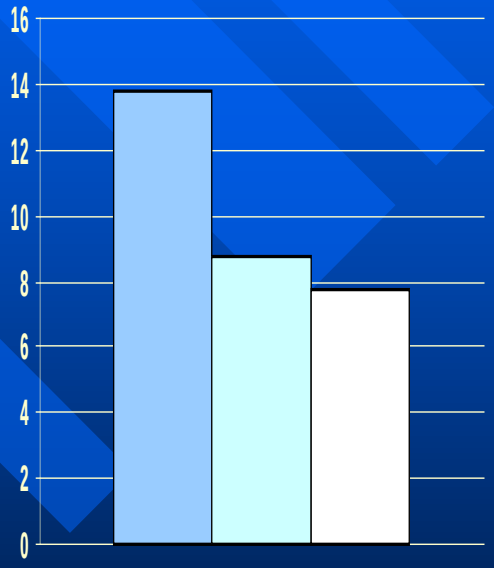
49-DAY (DOUBLE-LINE DRIP)



STRIKES DEAD WOOD



KERNEL DRY WT(g)



PRE-DAWN LWP

IRRIGATION DEFICIT: FULL PARTIAL NONE

HULL ROT: VALIDATION

NOT: PRESCRIPTIONS

ARE: EXAMPLES

THAT HULL ROT CONTROL

CAN BE ACHIEVED IN DIFFERENT SITUATIONS

HULL ROT MANAGEMENT

REDUCE WATER AT EARLY HULL SPLIT

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HULL ROT MANAGEMENT

IRRIGATION

- MAINTAIN ORCHARD AT -7 to -9 BARS
- AT FIRST HULL SPLIT, STOP WATER
- RESUME IRRIGATION AT -14 TO -18 BARS

HULL ROT MANAGEMENT

SLIGHT WATER STRESS AT HULL SPLIT

- REDUCES HULL ROT
- MORE UNIFORM HULL SPLIT
- SHORTENS LENGTH OF HULL SPLIT
- SHORTENS PERIOD OF SUSCEPTIBILTY
- IMPROVES NUT REMOVAL
- CAN REDUCE NAVEL ORANGE WORM

HULL ROT MANAGEMENT

FUNGICIDE APPLICATIONS

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Timing of hull rot treatments

Hull Rot caused mainly by *M. fructicola* 2012 trial

4-4	4-25	6-6	7-13	
---	---	---	---	ab
---	---	---	@	a
@	---	---	---	bc
---	@	---	---	bc
---	---	@	---	c
@	@	@	---	c

Precip. 9.5 mm

0 10 20 30 40
Hull rot counts

Hull Rot caused mainly by *R. stolonifer* 2014 trial

6/10	6/24	7/10	7/23	Hull rot counts
---	---	---	---	a
@	---	---	@	b
---	@	---	@	b
---	---	@	@	b
@	@	@	@	b

0 20 40 60 80 100

Critical timings

Pathogen = *M. fructicola*: Pre-hull split applications (early/mid June)

Pathogen = *R. stolonifer*: Early to late hull split applications but earlier applications at pre-hull split also help to manage the disease.

Both pathogens: Applications in early/mid June and at early hull split.

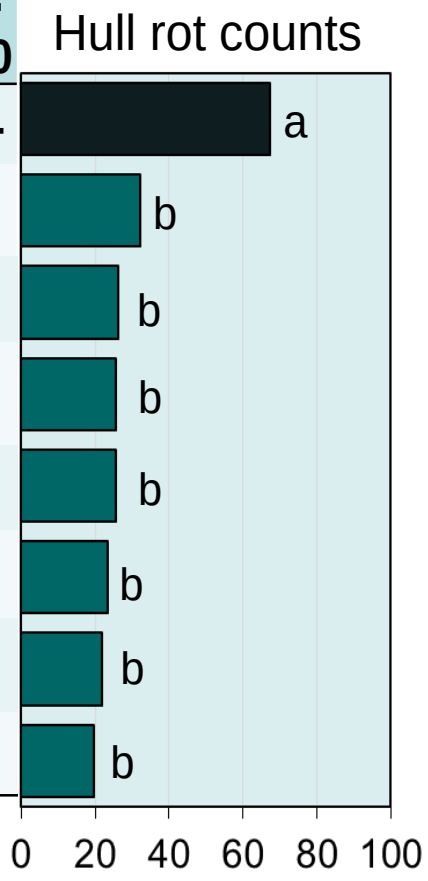
Control of Hull Rot Caused by Both Pathogens

cv. Nonpareil, Stanislaus Co.

Hull rot caused by *M. fructicola* is best managed by late-spring applications. For hull rot caused by both pathogens use late spring and hull split applications.

Effective hull rot treatments against both pathogens

Treatment	Rate (/A) (oz/fl oz)	Applic. 6-5	Applic. 7-10
Control	-----	-----	-----
Quash + S2200	3.36 + 3.36	@	@
Luna Experience	8	@	@
Ph-D + Tebucon*	6.2 + 8 + 8	@	@
Inspire Super*	20 + 16	@	@
Quadris Top*	14 + 16	@	@
Ph-D + Quash*	6.2 + 3 + 8	@	@
Luna Sensation	5	@	@



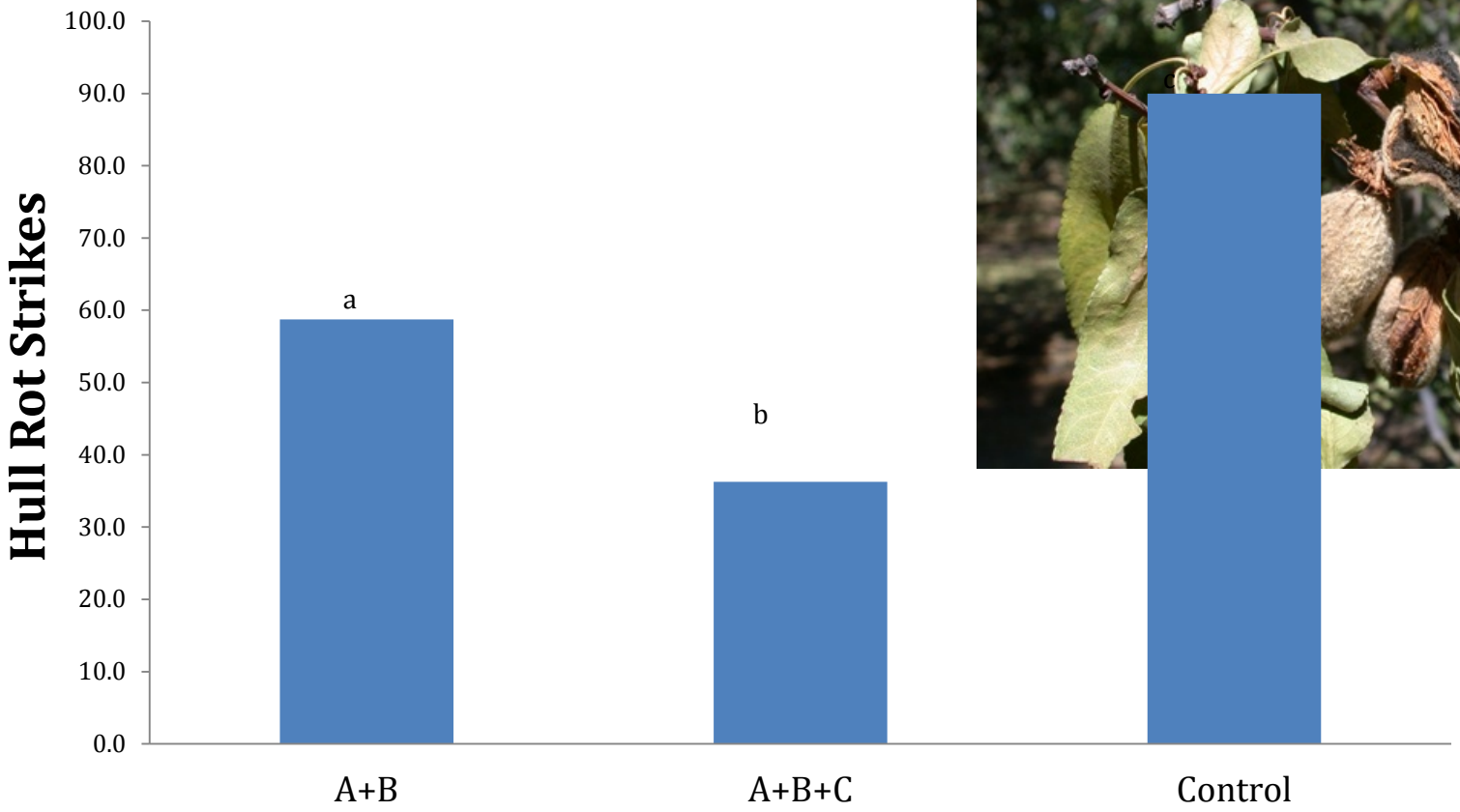
cv. Nonpareil, San Joaquin Co. 2014, Hull rot mainly caused by *R. stolonifer*

* Added DyneAmic or NuFilm-P

Hull Rot Control - Summary

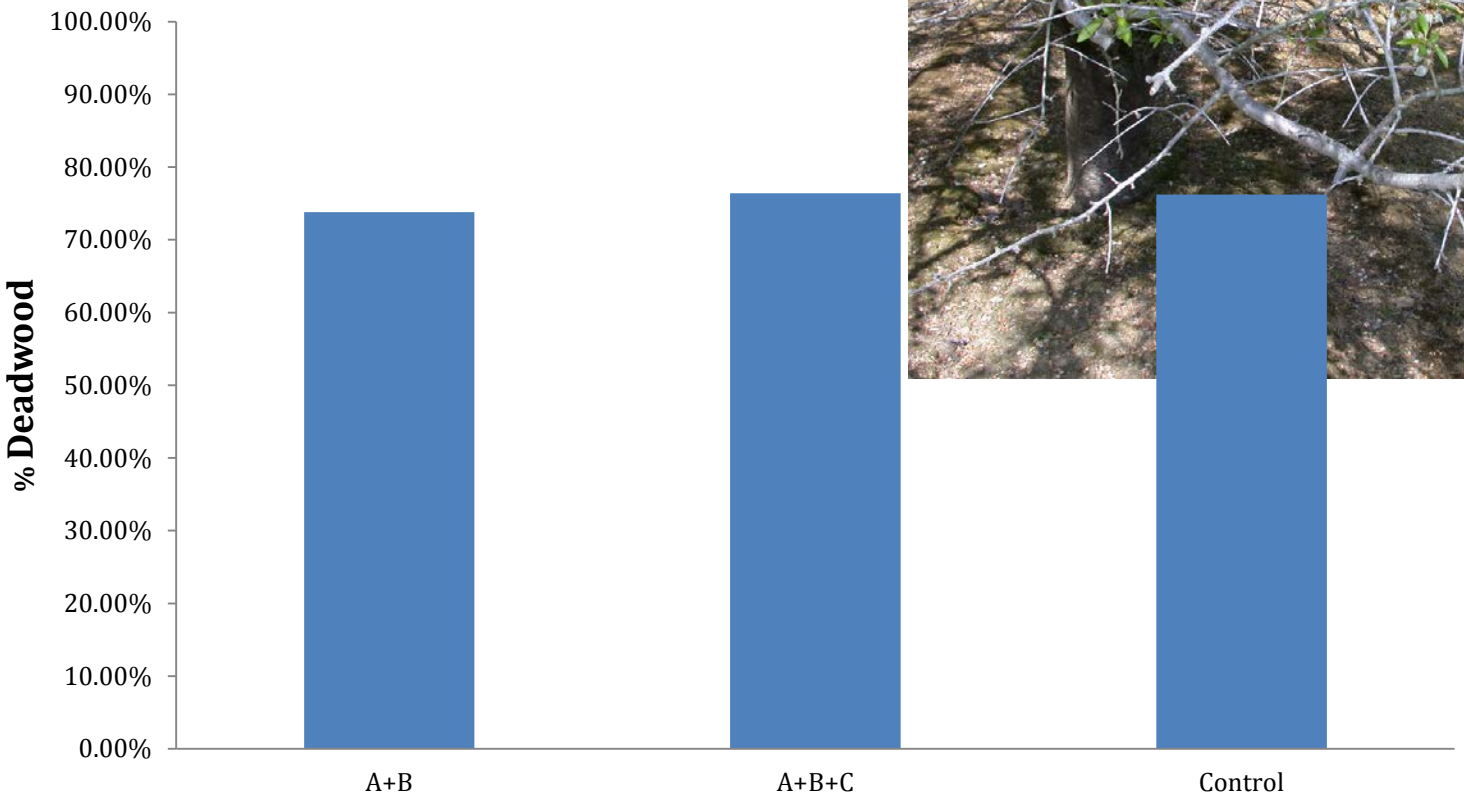
- **Fungicide treatments can be effective in reducing hull rot caused by *R. stolonifer* and by *M. fructicola*.**
  - **For *Rhizopus* hull rot, early hull split applications when susceptibility is high should be done. Fungicides are applied most effectively with NOW applications.**
  - **For *Monilinia* hull rot, applications should be done earlier (late spring).**
- **For the most effective integrated management of hull rot, a) Hull split should be induced simultaneously with proper water management (i.e., reduced irrigation).**
- **b) Proper nitrogen management, possible cut-off dates for Nonpareil – early to mid-May.**

Botran Applications 2002



A= <1% hull split, B=>1% hull split, C=40% hull split, rated 8/26/02

Spring Rating in 2003



A= <1% hull split, B=>1% hull split, C=40% hull split, rated 5/9/2003

HULL ROT MANAGEMENT

NITROGEN

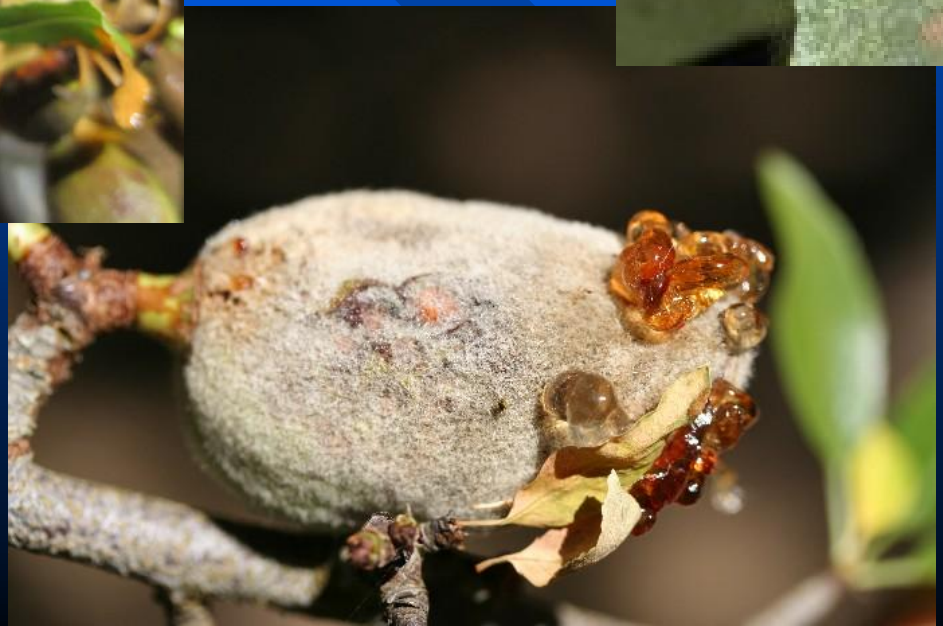
- LEAF N CONTENT MAX OF 2.5%

IRRIGATION

- MILD STRESS AT HULL SPLIT
- EARLY HARVEST

FUNGICIDES AT HULL SPLIT?

Scab
Anthracnose
Alternaria



Almond Scab Disease and Resistance Management

by

Brent A. Holtz, PhD

UC Pomology Farm Advisor

Almond Pest Management Comprehensive Course

Almond Scab
Cladosporium carpophilum

Gray-black, oil-like soft looking spots form on leaves, fruit, and twigs.

Almond Scab
Cladosporium carpophilum

- Young lesions are indistinct small yellow specks, best seen by holding a leaf up to the light.
- Lesions usually are not visible until late spring or early summer.

Almond Scab
Cladosporium carpophilum

- The fungus survives in twig lesions, and spores are spread by wind or rain.
- Scab is favored by prolonged wet spring weather,

Almond Scab
Cladosporium carpophilum

- Severe scab infections can cause early defoliation
- If left uncontrolled for several years, infected trees become weakened.

Timing of Fungicide Treatments for Scab Control

Note: Not all indicated timings may be necessary for disease control.

		Bloom			Spring[1]		Summer	
Disease	**Dormant**	**Pink bud**	**Full bloom**	**Petal fall**	**2 weeks**	**5 weeks**	**May**	**June**
Scab[3]	++	---	---	++	+++	+++	+	---

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

[3] Early treatments (during bloom) have minimal effect on scab; the 5-week treatment usually is most effective. Treatments after 5 weeks are useful in northern areas where late spring and early summer rains occur. Dormant treatment with liquid lime sulfur improves efficacy of spring control programs.

Carmel Variety

Treatment	Rates per acre	Incidence[a]	
6	Bravo (Chlorothalonil)[1] 4 pt, Quadris Top[2] 14 fl oz, Inspire Super[3] 20 fl oz	0.0	a
11	Rovral +oil +Topsin[1], 8 fl oz+1%v/v+10 fl oz, Quadris[2],14 fl oz, Captan[3], 5lbs	0.2	a
18	Microthiol Disperse[1,2,3] 20 lbs	0.4	a
3	Fontelis + Tebucon 45DF[1,2,3], 20 fl oz + 8 oz	0.6	a
17	Merivon SC[1,2,3] 6.5 fl oz	0.6	a
7	Quadris Top[1] 14 fl oz, Bravo (Chlorothalonil)[2] 4 pt, Inspire Super[3] 20 fl oz	0.8	a
12	Rovral +oil+Topsin[1], 11.4floz+1%v/v+14 floz, Quadris[2],14 floz,Captan[3], 5lbs	0.8	a
13	Luna Sensation SC[1,2,3], 6 fl oz	1.6	a
14	Luna Experience[1,2,3], 6 fl oz	1.8	a
15	Luna Experience[1,3], 6 fl oz, Gem+Serenade Optimum[2], 3.0 fl oz + 8 oz	2.8	ab
2	Fotelis + Bumper 3.6EC[1,2,3], 20 fl oz + 8 fl oz	2.8	ab
10	Rovral + oil + Topsin[1,2], 11.4 fl oz+1%v/v + 14 fl oz, Captan[3], 5 lbs	6.8	b
9	Rovral + oil + Topsin[1,2], 8 fl oz+1%v/v + 10 fl oz, Captan[3], 5 lbs	7.0	b
16	Pristine[1,2,3], 14.5 oz	16.6	c
5	Fotelis + Gem 4.05SC[1,2,3], 20 fl oz + 2.9 fl oz	21.0	cd
4	Fotelis + Abound 2.0 8F[1,2,3], 20 fl oz + 12 fl oz	24.2	d
8	Rovral + oil[1,2], 16 fl oz+1%v/v, Captan 80 WG[3], 5 lbs	24.6	de
1	Fontelis 1.67 SC[1,2,3], 20 fl oz	29.4	e
19	Untreated Control	35.0	f
20	Untreated Control	35.4	f

[a]Incidence = number of nuts that have scab lesions on 45 nuts randomly sampled per tree. Three people rated each tree (Cheryl, Scotty, and Stephen). Data was analyzed by ANOVA with means separated by Fisher's Protected LSD ($\alpha = 0.05$) test. Means followed by the same letter are not significantly different. The trial was rated on August 5th and 6th, 2014. All treatments significantly reduced the incidence of almond scab when compared to our two untreated controls.

The following trial applications are outlined above:

[1]First application was performed 2 weeks after petal fall (2WPF) on March 20th.

[2]Second application was performed 4 weeks after petal fall (4WPF) on April 3rd.

[3]Third application was performed was 8 weeks after petal fall (8WPF) on May 1st.

Carmel Variety

Treatment	Rates per acre	Severity[a]	
6	Bravo (Chlorothalonil)[1] 4 pt, Quadris Top[2] 14 fl oz, Inspire Super[3] 20 fl oz	0.0	a
11	Rovral +oil +Topsin[1], 8 floz+1%v/v+10 floz, Quadris[2],14 floz, Captan[3], 5lbs	0.8	a
7	Quadris Top[1] 14 fl oz, Bravo (Chlorothalonil)[2] 4 pt, Inspire Super[3] 20 fl oz	0.8	a
18	Microthiol Disperse[1,2,3] 20 lbs	0.8	a
3	Fontelis + Tebucon 45DF[1,2,3], 20 fl oz + 8 oz	2.0	a
12	Rovral +oil+Topsin[1], 11.4floz+1%v/v+14 floz, Quadris[2],14 floz,Captan[3], 5lbs	2.0	a
14	Luna Experience[1,2,3], 6 fl oz	3.8	a
13	Luna Sensation SC[1,2,3], 6 fl oz	6.2	a
17	Merivon SC[1,2,3] 6.5 fl oz	7.0	a
2	Fotelis + Bumper 3.6EC[1,2,3], 20 fl oz + 8 fl oz	9.4	a
15	Luna Experience[1,3], 6 fl oz, Gem+Serenade Optimum[2], 3.0 fl oz + 8 oz	11.4	a
10	Rovral + oil + Topsin[1,2], 11.4 fl oz+1%v/v + 14 fl oz, Captan[3], 5 lbs	26.2	a
9	Rovral + oil + Topsin[1,2], 8 fl oz+1%v/v + 10 fl oz, Captan[3], 5 lbs	40.6	a
16	Pristine[1,2,3], 14.5 oz	135.0	b
8	Rovral + oil[1,2], 16 fl oz+1%v/v, Captan 80 WG[3], 5 lbs	211.4	c
4	Fotelis + Abound 2.0 8F[1,2,3], 20 fl oz + 12 fl oz	263.8	cd
5	Fotelis + Gem 4.05SC[1,2,3], 20 fl oz + 2.9 fl oz	267.4	cd
1	Fontelis 1.67 SC[1,2,3], 20 fl oz	337.8	d
19	Untreated Control	471.4	e
20	Untreated Control	493.8	e

[a]Severity = total number of scab lesions counted on 45 nuts randomly sampled per tree. Three people rated each tree (Cheryl, Scotty, and Stephen). Data was analyzed by ANOVA with means separated by Fisher's Protected LSD ($\alpha = 0.05$) test. Means followed by the same letter are not significantly different. The trial was rated on August 5th and 6th, 2014. All treatments significantly reduced the severity of almond scab when compared to our two untreated controls.

The following trial applications are outlined above:

[1]First application was performed 2 weeks after petal fall (2WPF) on March 20th.

[2]Second application was performed 4 weeks after petal fall (4WPF) on April 3rd.

[3]Third application was performed was 8 weeks after petal fall (8WPF) on May 1st.

Good Luck!!!

Efficacy Trials of Registered and Developmental Insecticides for Navel Orangeworm

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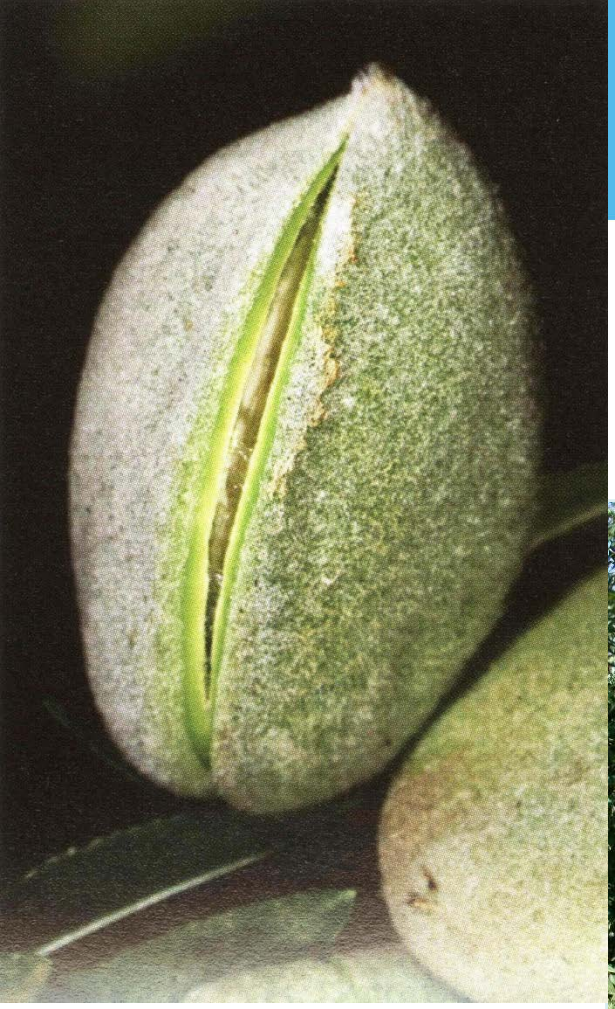
San Joaquin County

UNIVERSITY OF CALIFORNIA

Navel Orangeworm – pest of a variety of nut crops



growing ADVANTAGE™
The Almond Conference

Hull split spray

Navel Orangeworm Efficacy Trial

Nonpareil Variety-August Harvest

2012 Treatments	[a]% NOW	[b]	data transformed[c]
8 Proclaim + Dyne-Amic 4.5 oz + 0.25%v/v	0.4	a	a
11 Hero EW 11.3 floz	0.4	a	a
9 Brigade WSB 18 oz + Hort oil	0.5	a	ab
3 Altacor®+Asana® XL 3.0 oz+ 9.6 floz	0.6	a	ab
4 Altacor® + Bifenthrin 3.0 oz +16.0 oz	0.7	ab	ab
10 Brigade WSB 18 oz + Hort oil+ Vigilant	0.7	ab	abc
12 Athena 19.2 fl oz + Hort oil 1 gal/ac	0.8	abc	abcd
1 Altacor® (Rynaxypyr) 3.5 oz/ac + Hort oil	0.9	abc	abcd
2 Altacor® (Rynaxypyr) 4.0 oz/ac +Hort oil	1.0	abc	abcd
7 Cyazypyr (HGW86) 20.5 floz + Onager	1.2	abc	abcd
6 Cyazypyr (HGW86) 16.9 floz + Zeal	1.5	bcd	bcd
5 Cyazypyr (HGW86) 13.5 floz + Vigilant	1.6	cd	cd
13 Untreated	2.1	d	d

[a]200 nuts were cracked out of each rep, 5 replications, 1000 nuts per treatment. Percent worm damage was determined per 1000 nuts. Data was both transformed (ArcSin(sqrt(x))[c] and not transformed[b] for analysis (one way anova).

Navel Orangeworm Efficacy Trial

Nonpareil Variety-August Harvest

2013 Treatments	% NOW[a]	data transformed[b]	
16 Belt SC 4 floz + Hort oil 1 gal	0.0	0.0	a
11 Proclaim + Dyne-Amic, 4.5 oz + 0.25%	0.0	0.0	a
15 Hero EW 11.3 floz + Hort oil 1 gal	0.0	0.0	a
13 Gladiator 19.0 floz + Hort oil 1 gal	0.0	0.0	a
7 Intrepid 16.0 floz + Vigilant	0.0	0.0	a
12 Athena 19.2 fl oz + Hort oil 1 gal	0.0	0.0	a
10 Intrepid/Delegate Mix 12.0 floz + Vigilant	0.1	0.0141539	ab
8 Asana 12.8 floz + Vigilant	0.1	0.0141539	ab
9 Intrepid/Delegate Mix 10.0 floz + Vigilant	0.1	0.0141539	ab
3 DuPont Exp 35.0 g + Vigilant	0.2	0.0283079	abc
6 Altacor® (Rynaxypyr) 4.0 oz/ac + Vigilant	0.2	0.0283079	abc
5 Cyazypyr (HGW86) 20.5 floz + Vigilant	0.2	0.0283079	abc
14 Brigade WSB 18 oz + Hort oil 1 gal	0.5	0.0425334	abc
2 DuPont Exp 23.3 g + Vigilant	0.5	0.0425334	abc
1 DuPont Exp 11.6 g + Vigilant	0.6	0.0483414	bc
4 DuPont Exp 46.54 g + Vigilant	0.7	0.0625668	c
18 Untreated	1.2	0.109214	d
17 Untreated	1.3	0.110534	d

[a]200 nuts were cracked out of each rep, 5 replications, 1000 nuts per treatment. Percent worm damage was determined per 1000 nuts. Data was transformed (ArcSin(sqrt(x))[b] for analysis (one way anova).

Thank You!