Management of Hull Rot in Almond

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UNIVERSITY OF CALIFORNIA

HULL ROT

MONILINIA FRUCTICOLA

RHIZOPUS STOLONIFER

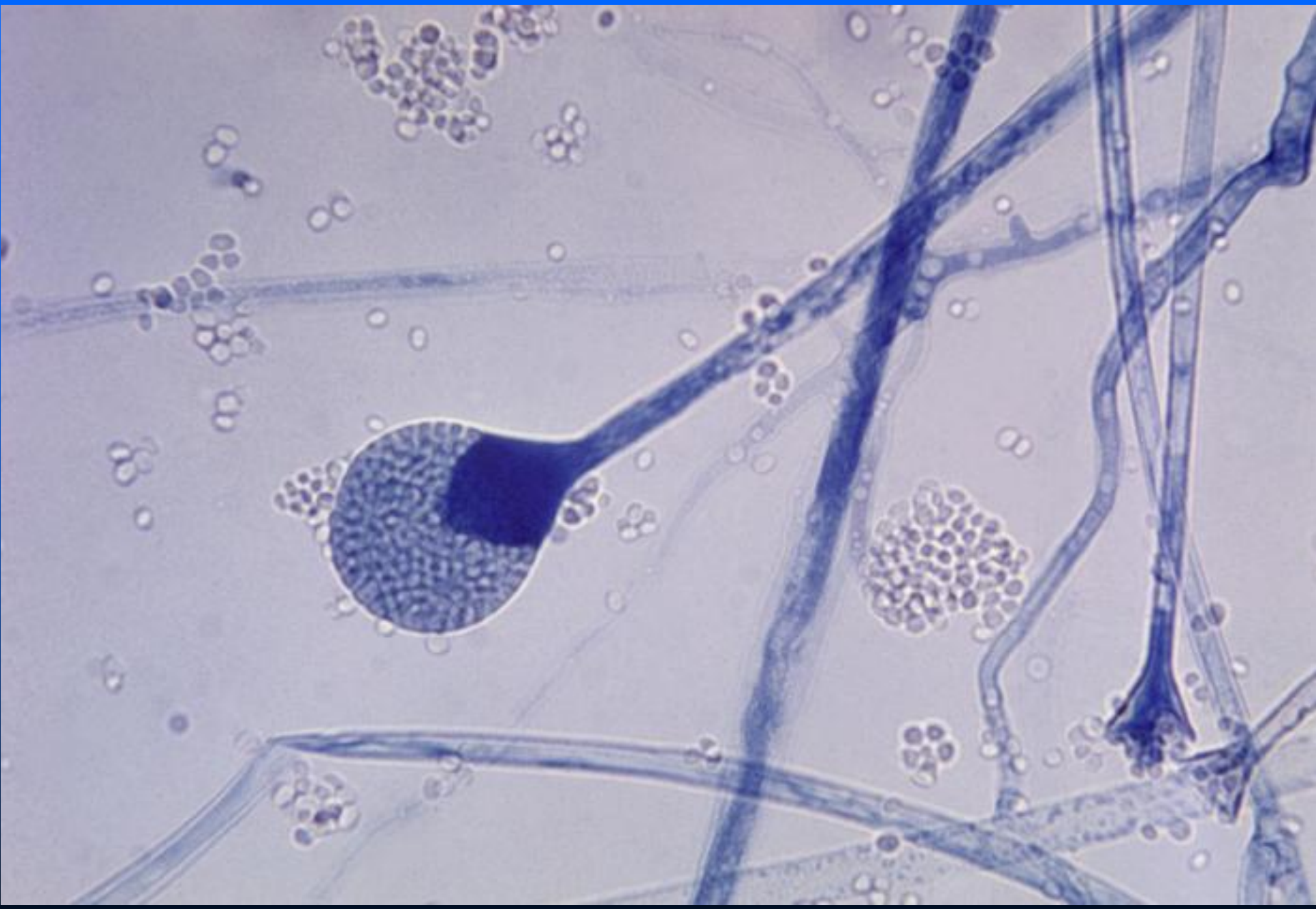
Update on Hull Rot Control

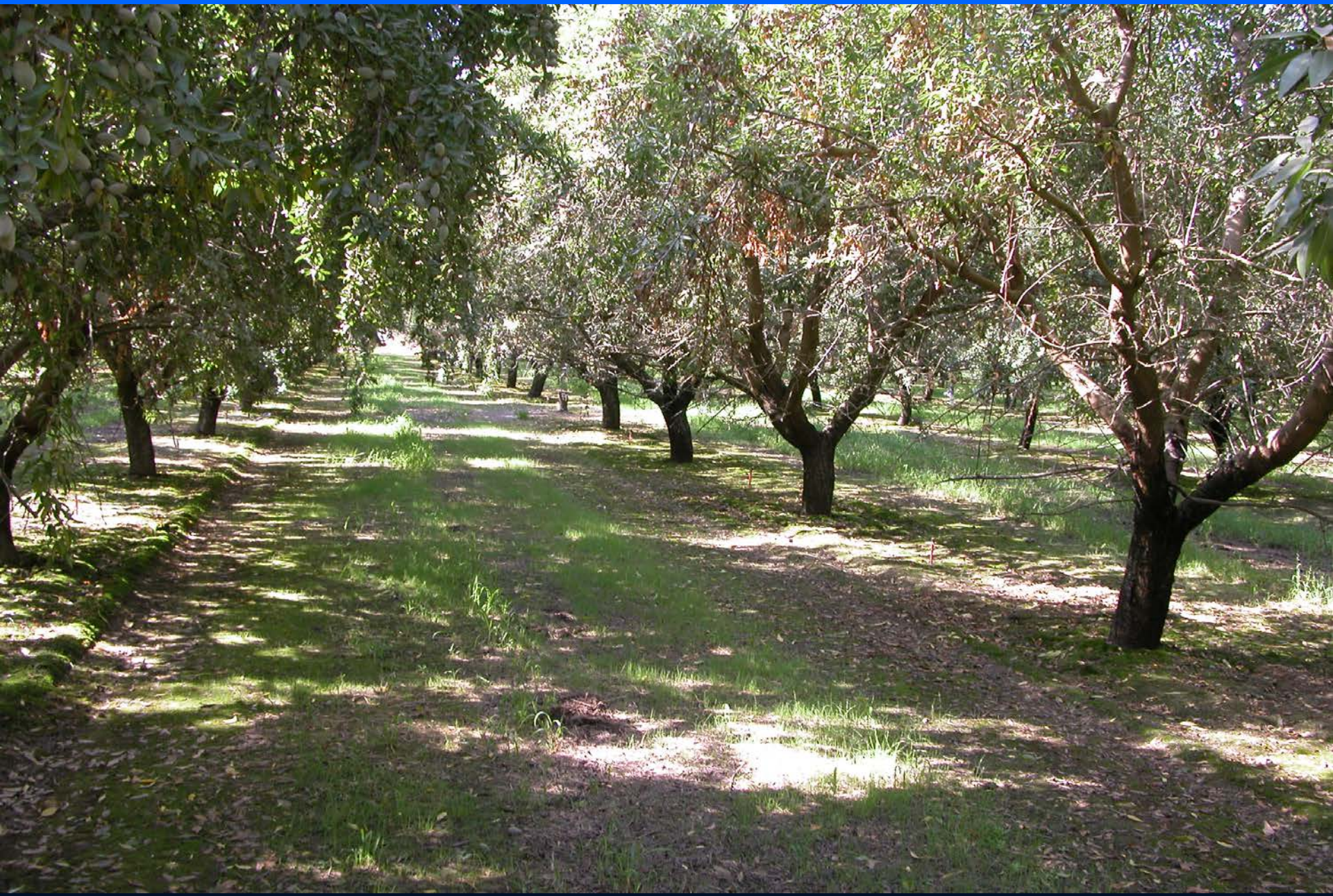
- Caused by *Rhizopus stolonifer* or by *Monilinia fructicola*
- Both pathogens infect fruit and cause dieback

Rhizopus stolonifer

Monilinia fructicola

- Inoculum of *Rhizopus stolonifer* is omnipresent (soil)
- Inoculum of *Monilinia fructicola* originates from other stone fruits (peaches, cherries) or almond. Blossom blight can be caused by *M. laxa* (North) and *M. fructicola* (South regions).





HULL ROT

CULTIVAR SUSCEPTIBILITY

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

HULL ROT

CULTIVAR SUSCEPTIBILITY

100-200 STRIKES/TREE

JOHYN	PRICE
JENETTE	2-19 E
SONORA	25-75

HULL ROT

CULTIVAR SUSCEPTIBILITY

1-100 STRIKES/TREE

CHIPS	2-43 W	MISSION
KAHL	MORLEY	ROSSETA
SANO	ALDRICH	RUBY
YOKUT	JIML	LIVINGSTON
PLATEAU	1-87	PADRE
10102 W	WOOD COLONY	

HULL ROT

CULTIVAR SUSCEPTIBILITY

0 STRIKES/TREE

SAVANA
FRITZ
DONNA

CARMEL
MONTEREY

HULL ROT

VIGOROUS, PRODUCTIVE ORCHARDS

AMPLE WATER & NITROGEN

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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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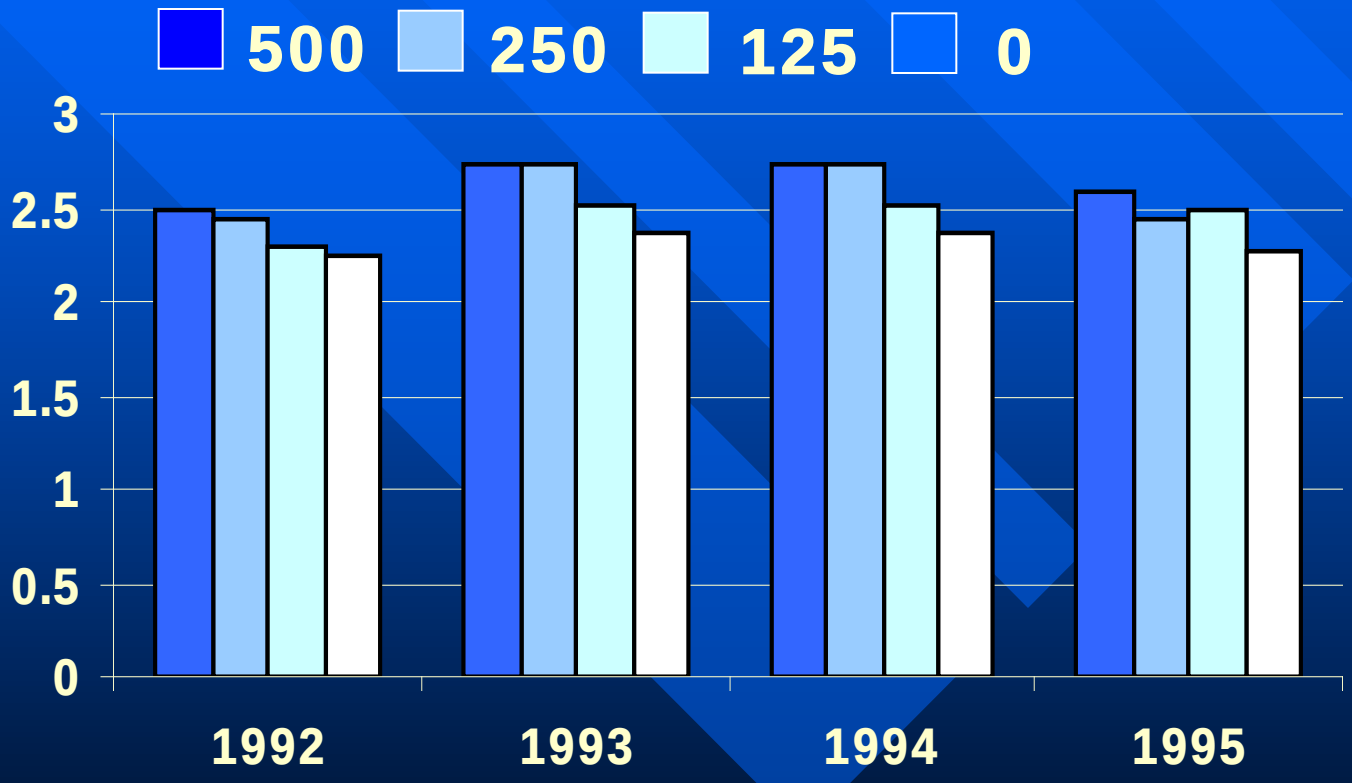
HULL ROT: NITROGEN

COMPARED FOUR RATES (LBS/ACRE)

- 500
- 250
- 125
- 0

HULL ROT: NITROGEN

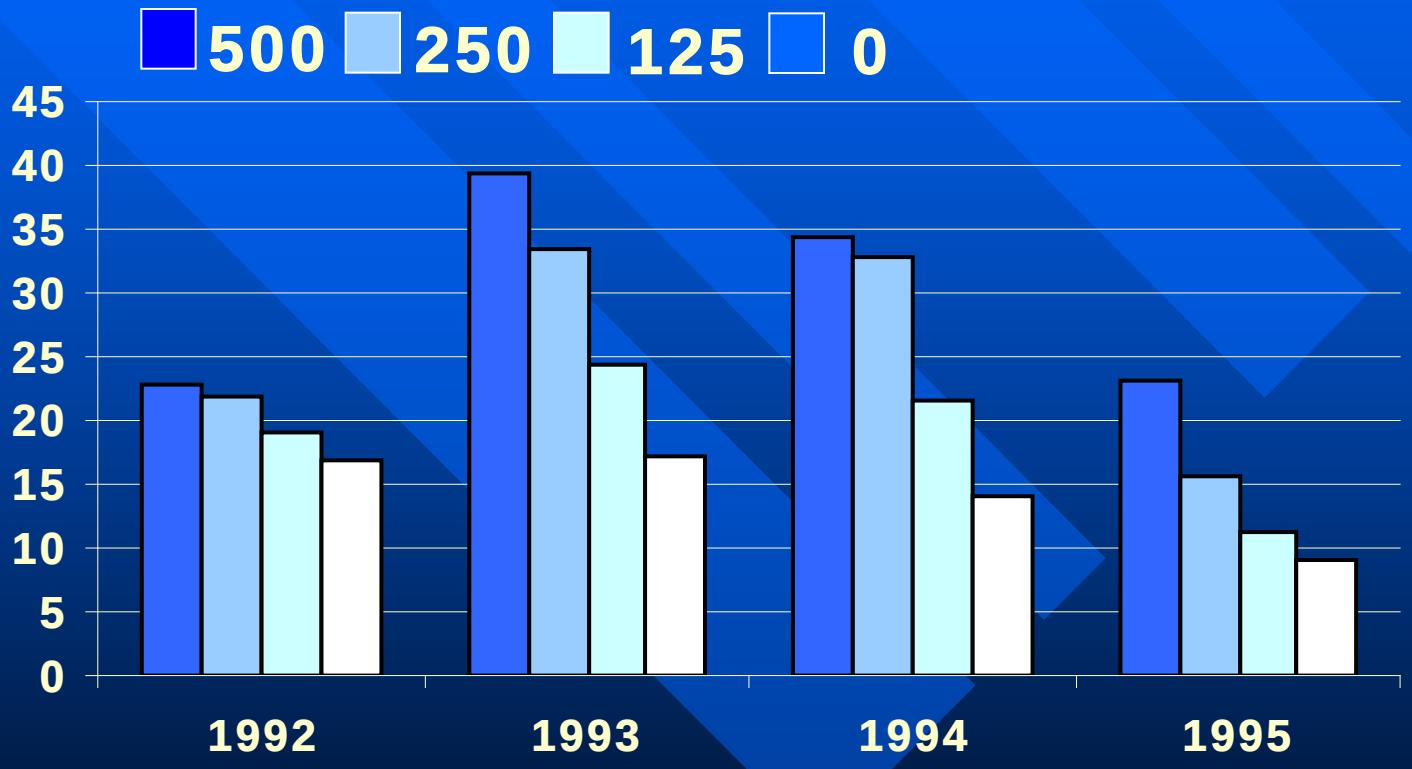
LEAF NITROGEN CONTENT (%)



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

HULL ROT: NITROGEN

HULL ROT: STRIKES PER TREE

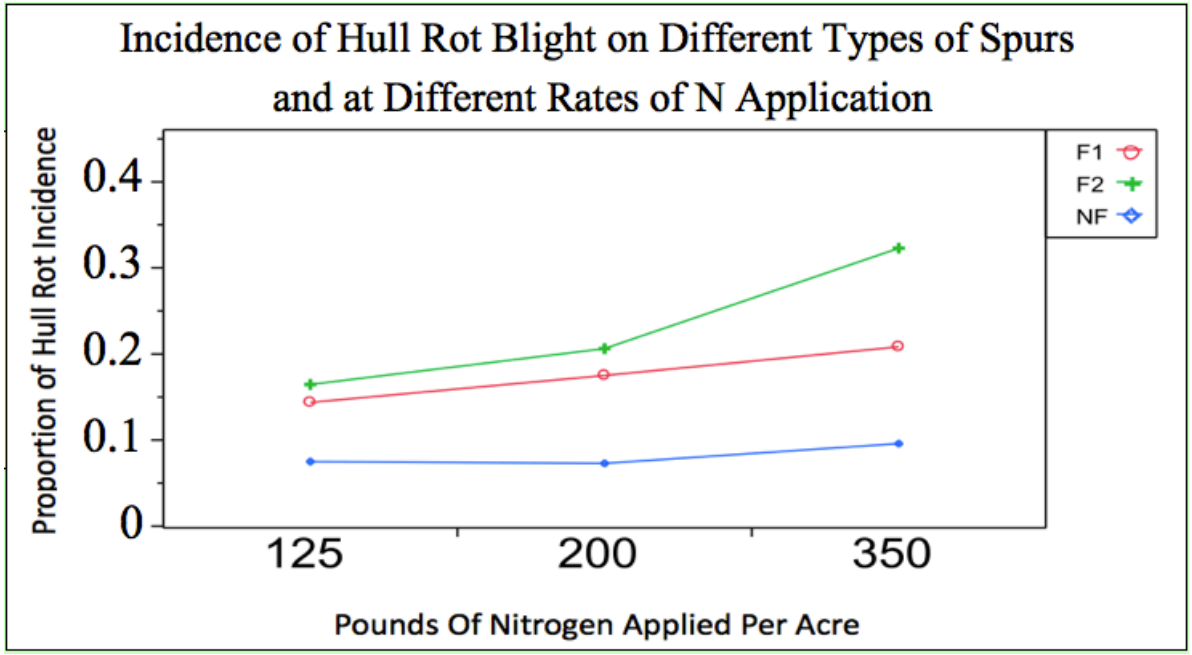


LINEAR *P* = 0.004 0.001 0.001 0.020

Nitrogen Effect 2011-

by tagged spurs

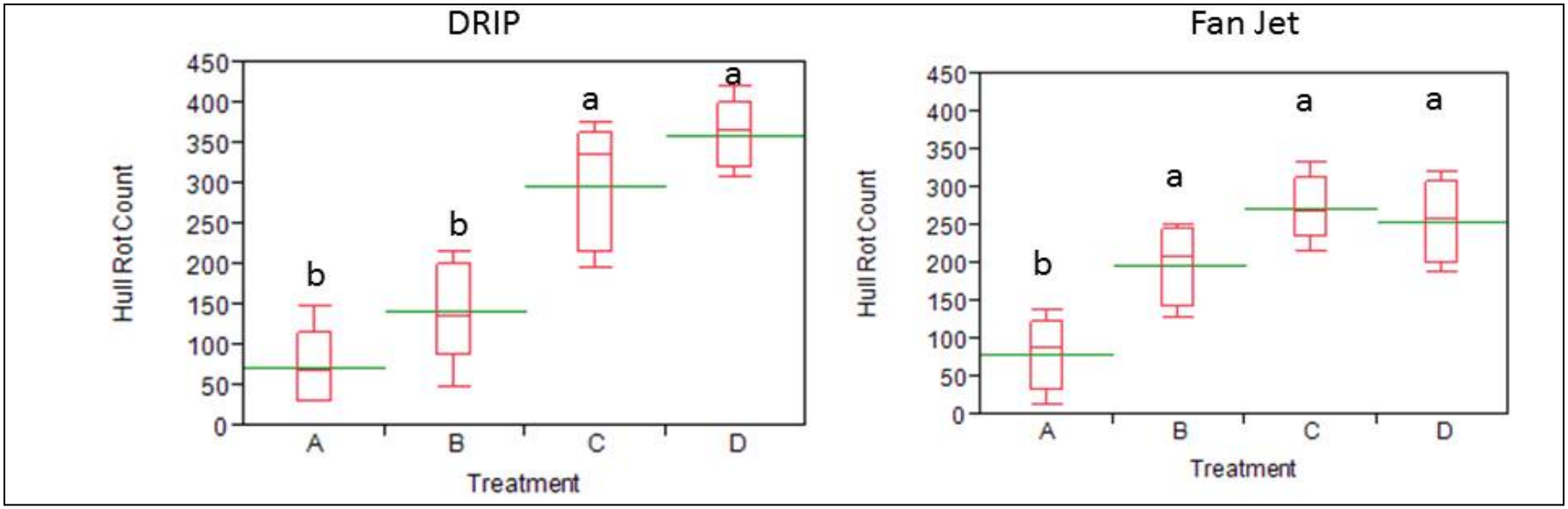
144 trees were selected with different N treatments (125, 200, 350 lbs/acre). In each selected tree a total of 11 non-fruiting spurs (NF), 11 one fruiting spurs (F1), and 11 two fruiting spurs (F2) were labeled for a total of 4,752 labeled spurs. **Hull rot incidence** was determined after harvest as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

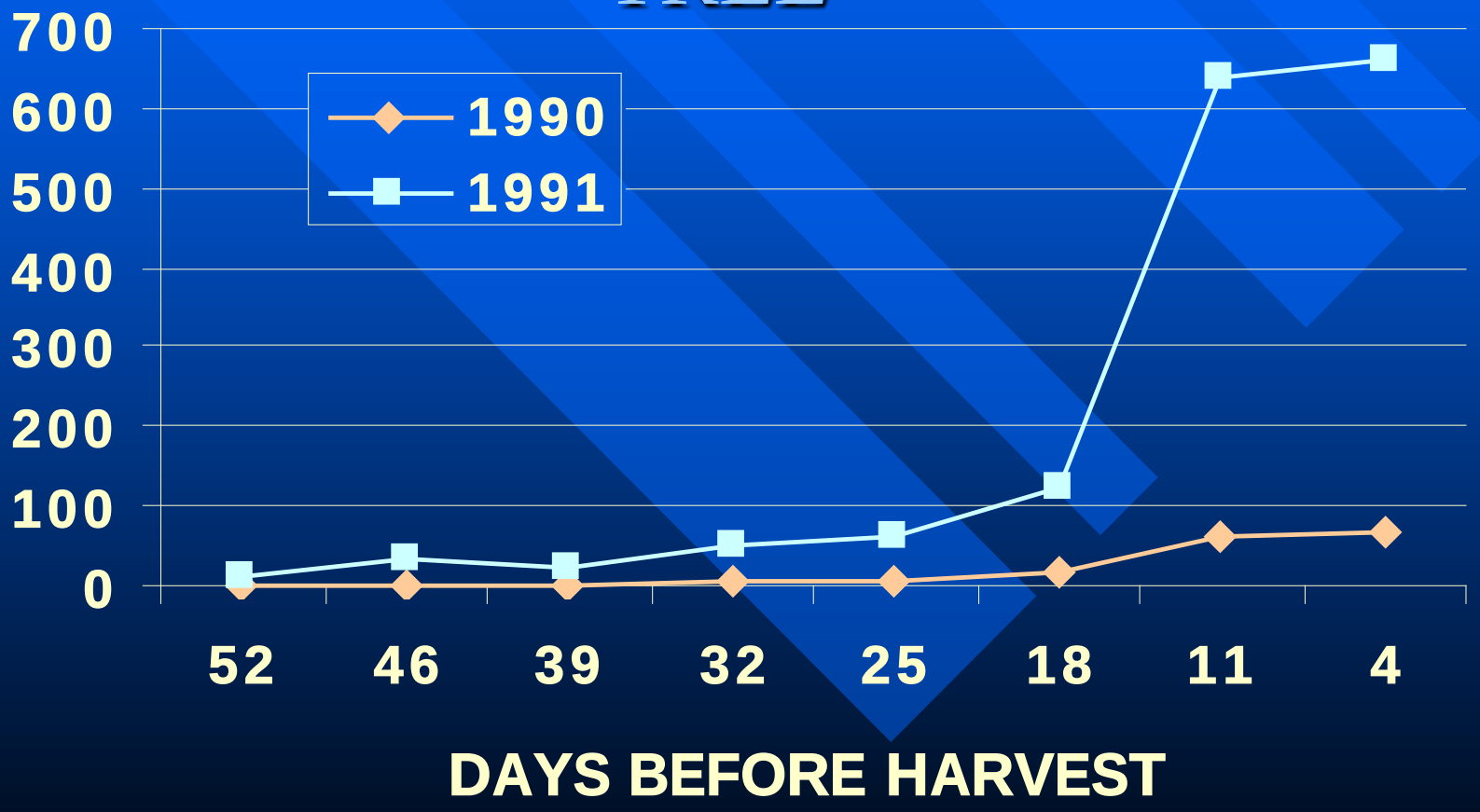
HULL ROT MANAGEMENT

IRRIGATION

- EARLY CUT-OFF
- REGULATED DEFICIT

HULL ROT: IRRIGATION

EARLY CUT-OFF:STRIKES PER TREE



HULL ROT: IRRIGATION

REGULATED DEFICIT

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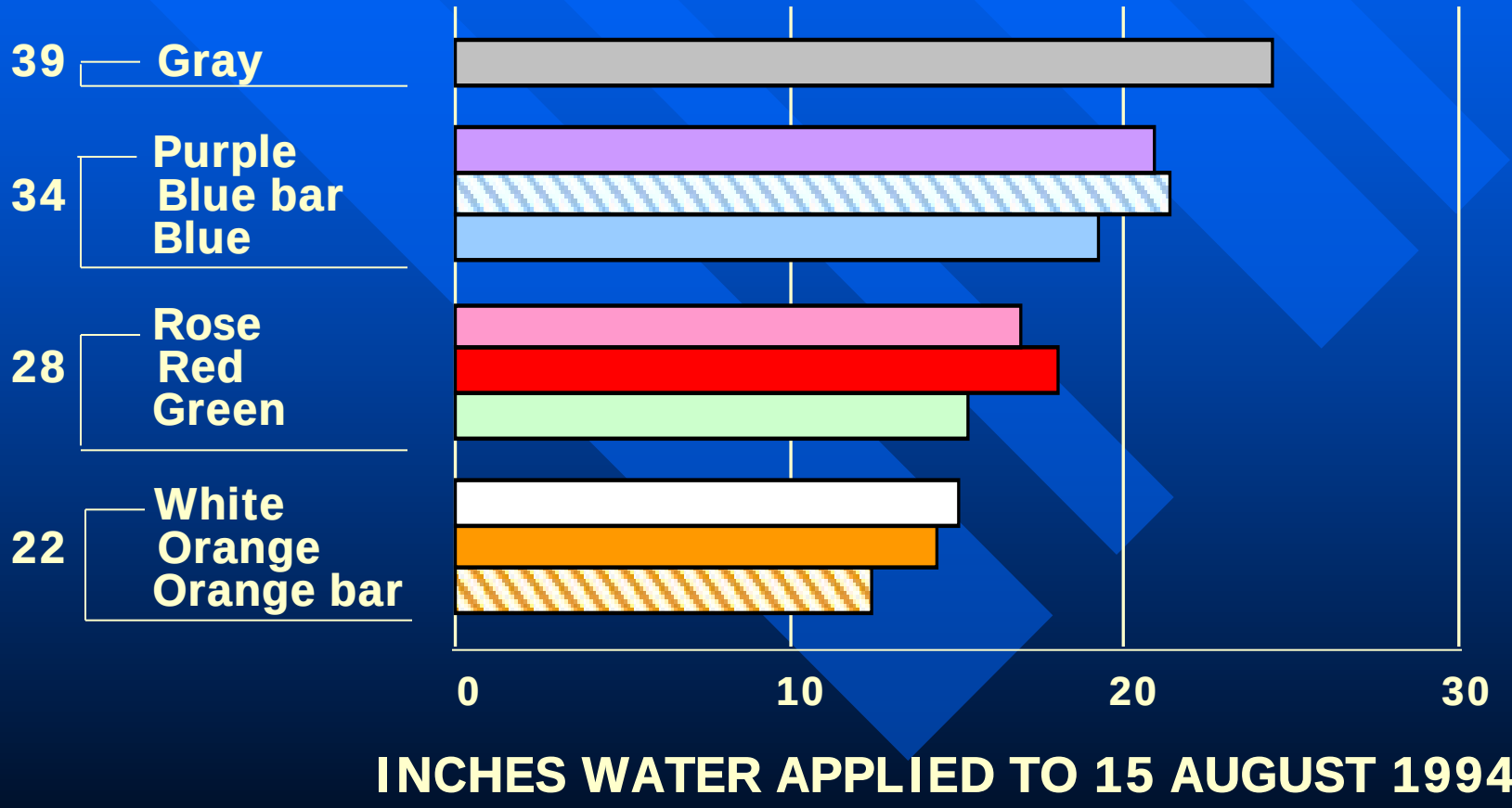
REGULATED DEFICIT IRRIGATION SCHEDULE

	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	

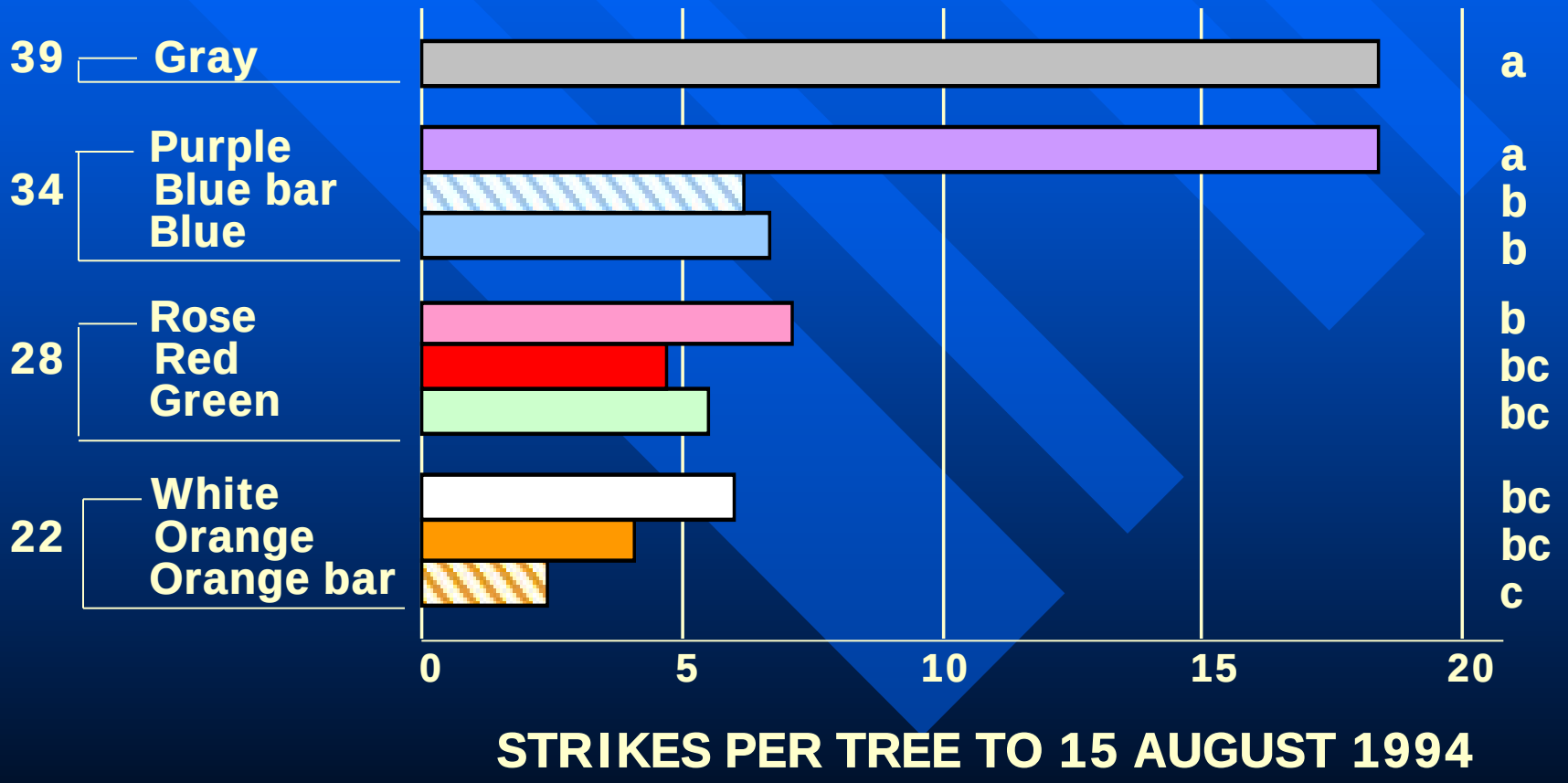
HULL ROT: IRRIGATION

REGULATED DEFICIT - WATER



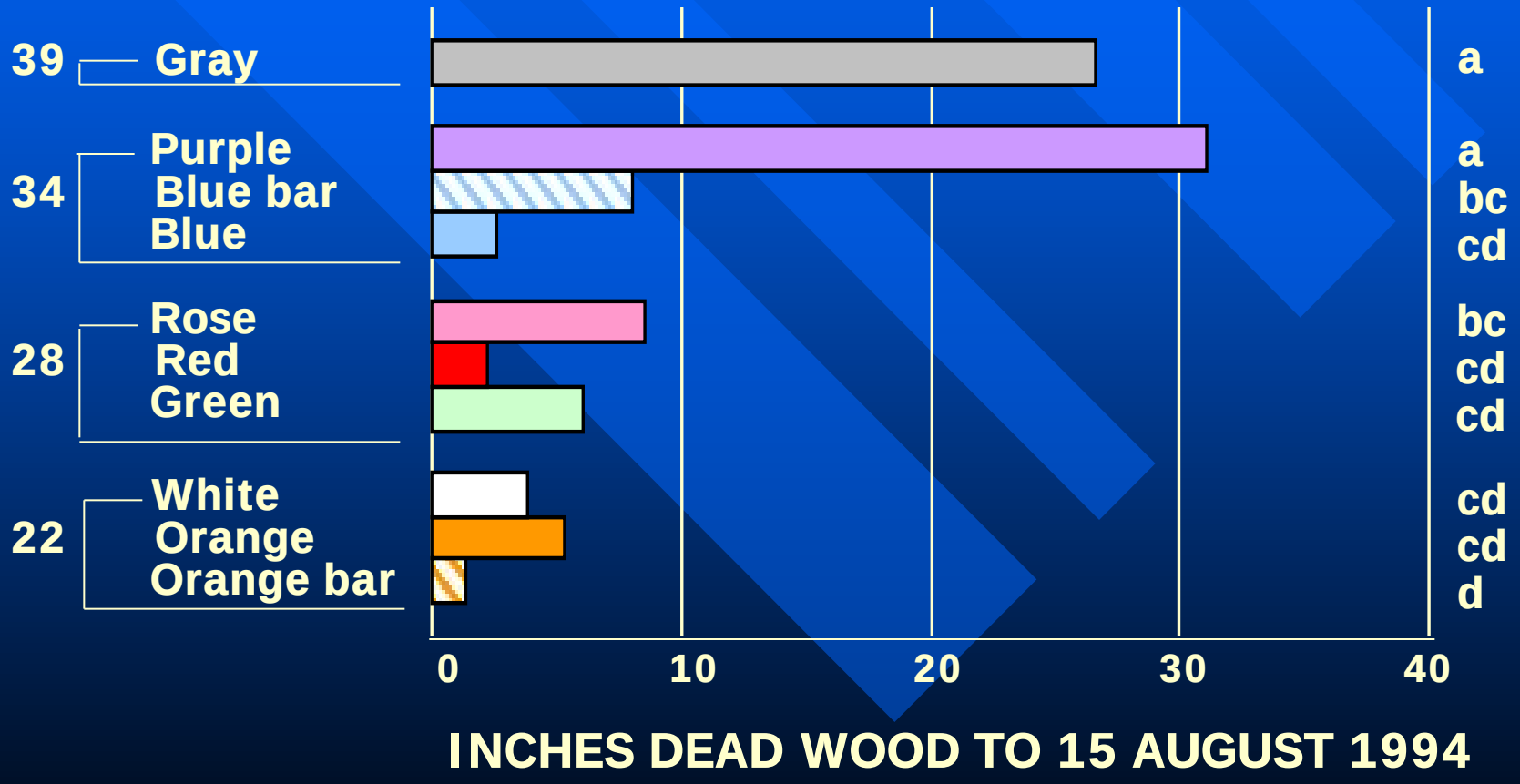
HULL ROT: IRRIGATION

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!!

HULL ROT: VALIDATION

WILL DEFICIT IRRIGATION WORK WITH?

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

HULL ROT: VALIDATION

GOAL

ACHIEVE -14 BARS

PREDAWN LEAF WATER POTENTIAL

BY EARLY HULL SPLIT

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

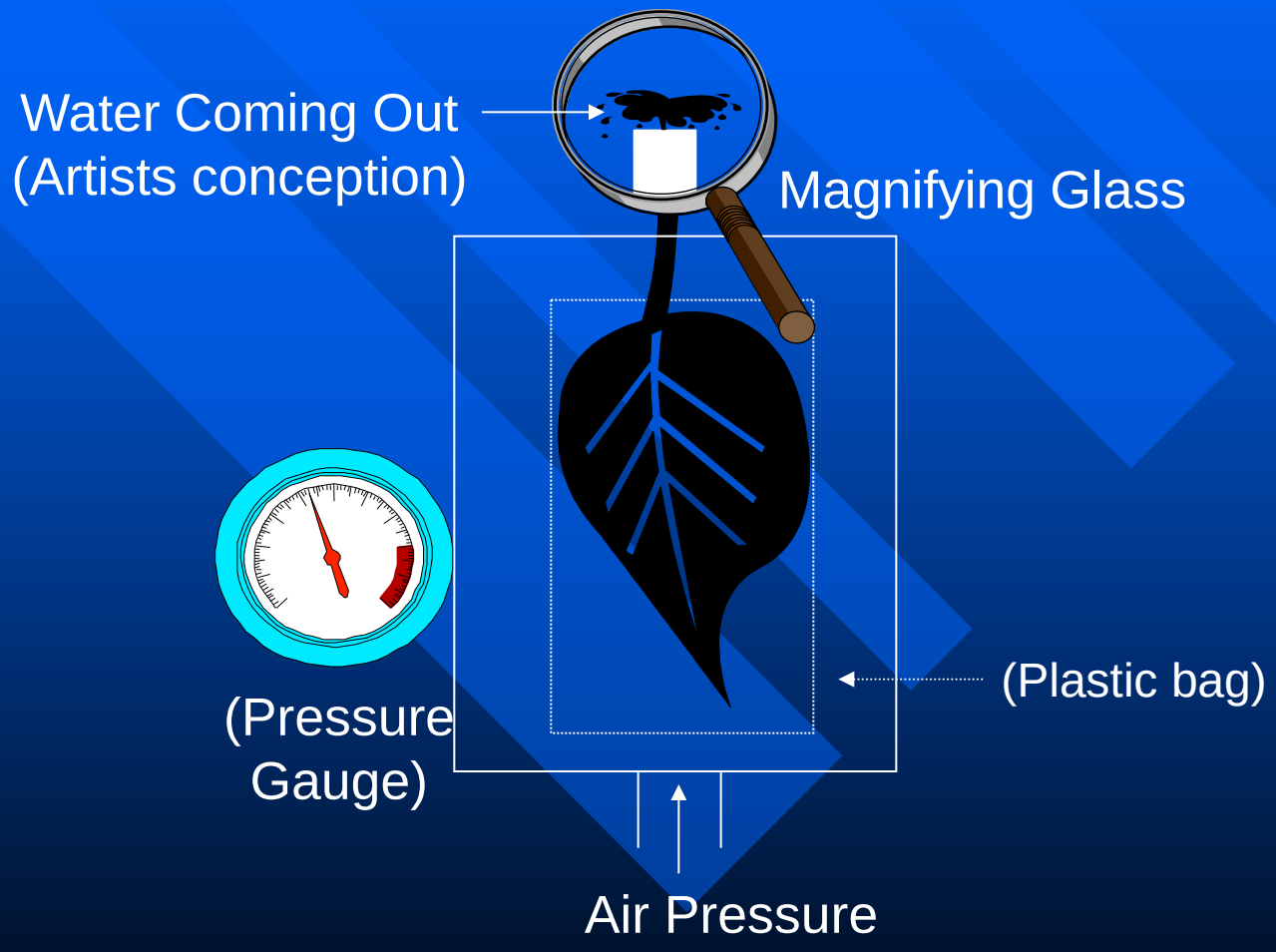
Proposed benefits of RDI for almonds during hull split:

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

HULL ROT MANAGEMENT

MEASUREMENTS

SAMPLING THE ORCHARD

- UNIFORMLY
- MOST REPRESENTATIVE AREA
- AVERAGE OF SEVERAL AREAS

HULL ROT MANAGEMENT

MID-DAY STEM WATER POTENTIAL

WHEN: 1:00 TO 3:00 P.M.

WHERE: LOWER CANOPY NEAR TRUNK

WHAT: HEALTHY, MATURE, SHADED LEAF

NUMBER: ONE TO THREE PER TREE

HULL ROT MANAGEMENT

MID-DAY STEM WATER POTENTIAL

- COVER LEAF WITH OPAQUE PLASTIC BAG
- REMOVE BAG 10-15 MINUTES LATER
- SNAP LEAF FROM TREE, RE-CUT
- IMMEDIATELY INTO PRESSURE BOMB
- OBSERVE FOR DROPLET ON CUT PETIOLE

Hand held pressure bomb

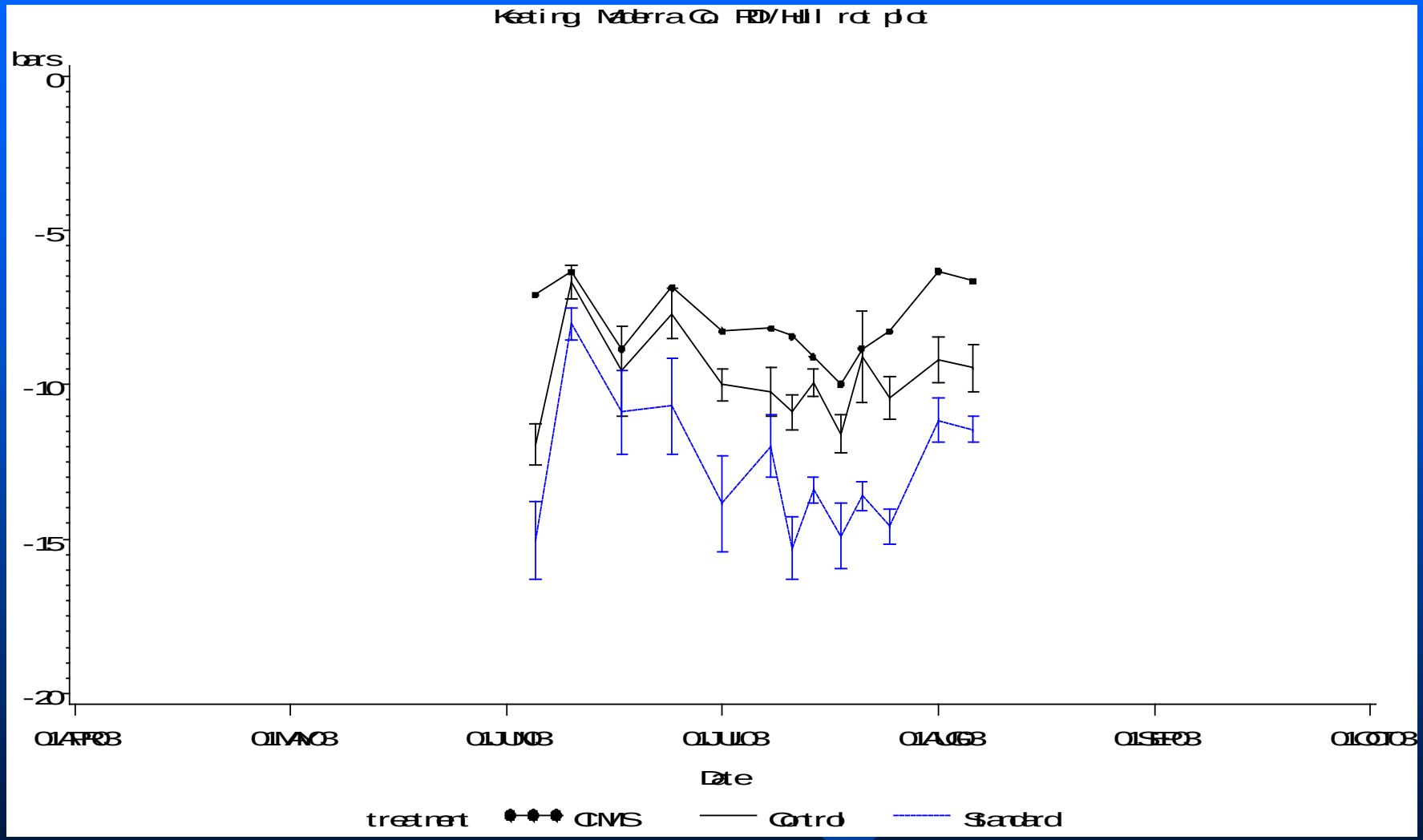
- Leaf is placed in the pressure bomb with the leaf blade protruding out of the chamber

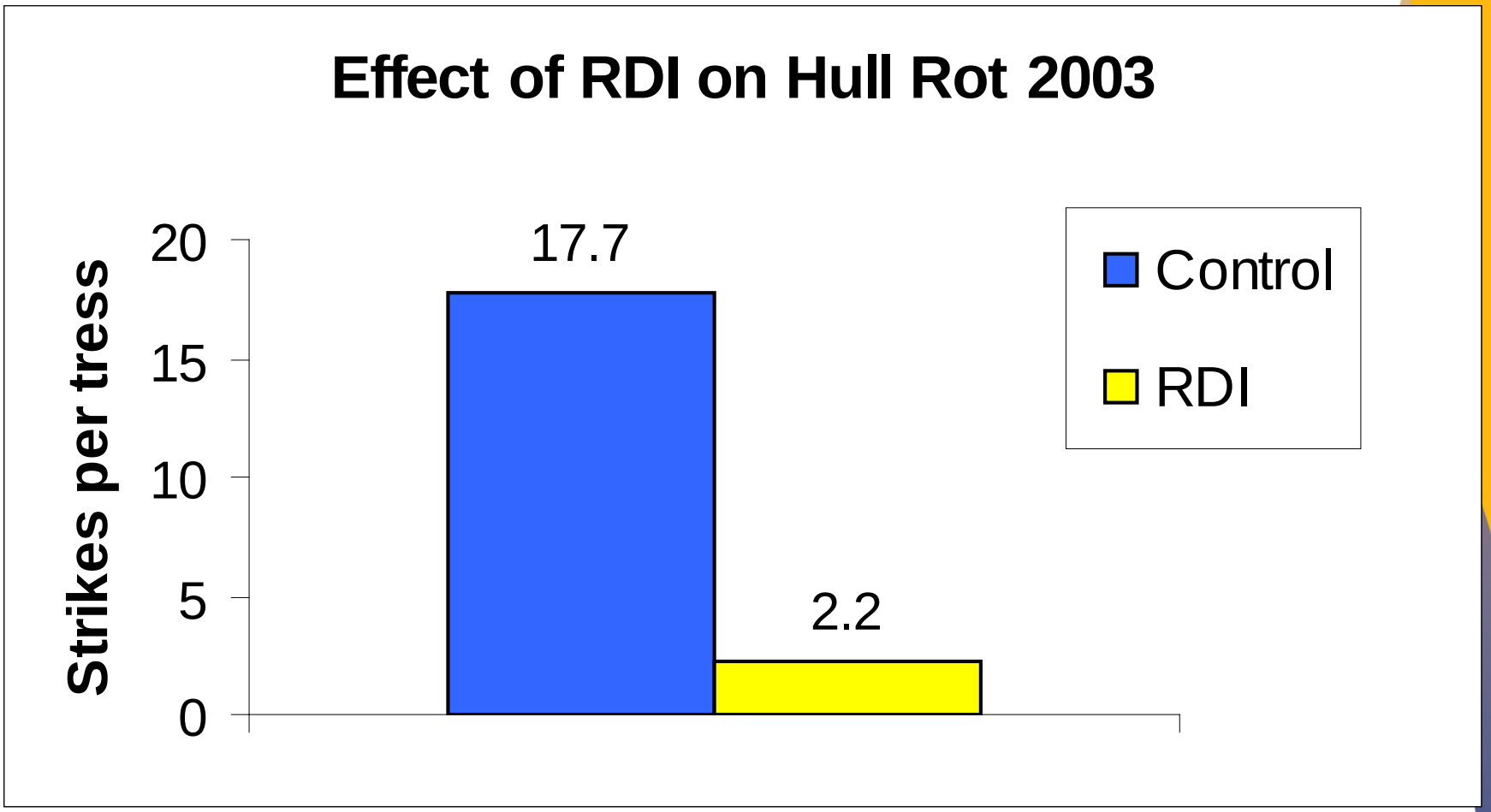
When water potential is reached, water bubbles out the leaf stem

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 Canberra 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

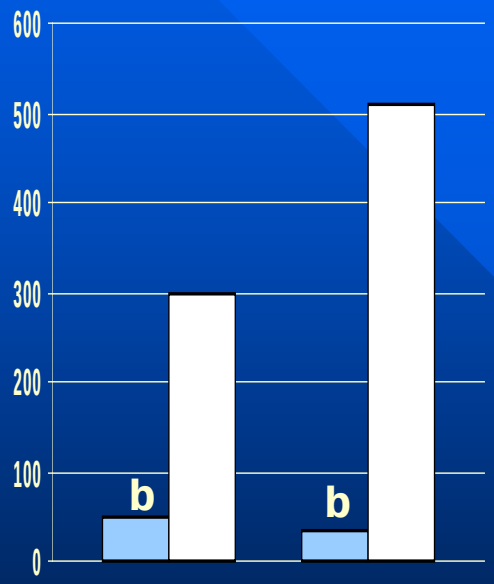
HULL ROT: VALIDATION

WILL IT WORK IN OTHER SITUATIONS?

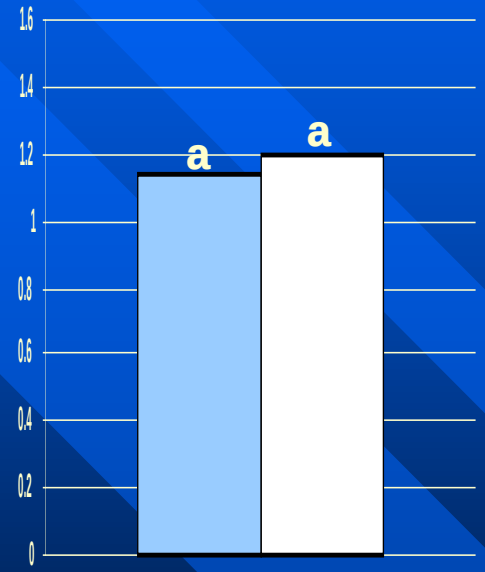
YES

HULL ROT: VALIDATION

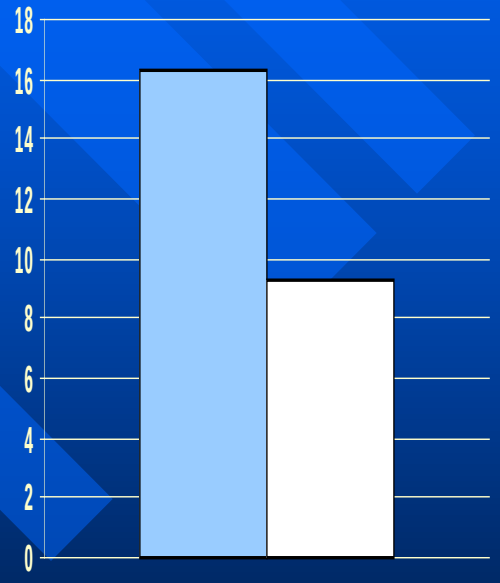
14-DAY (MICRO-SPRINKLERS)



STRIKES DEAD WOOD



KERNEL DRY WT(g)



PRE-DAWN LWP

1997 IRRIGATION DEFICIT: FULL NONE

HULL ROT: VALIDATION

14 DAYS (MICROSPRINKLER)

MEANING:

IT TOOK 14 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS

HULL ROT: VALIDATION

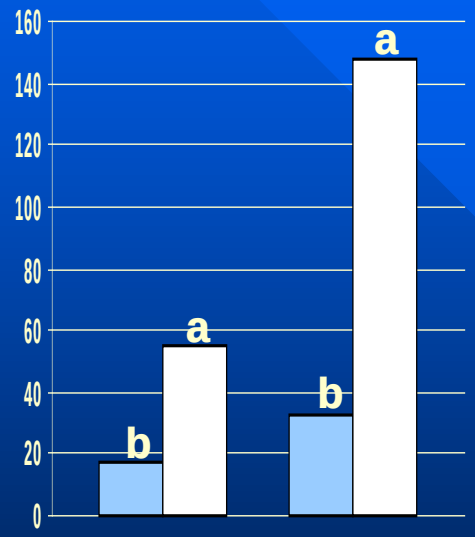
14 DAYS (MICROSPRINKLER)

DOES NOT MEAN:

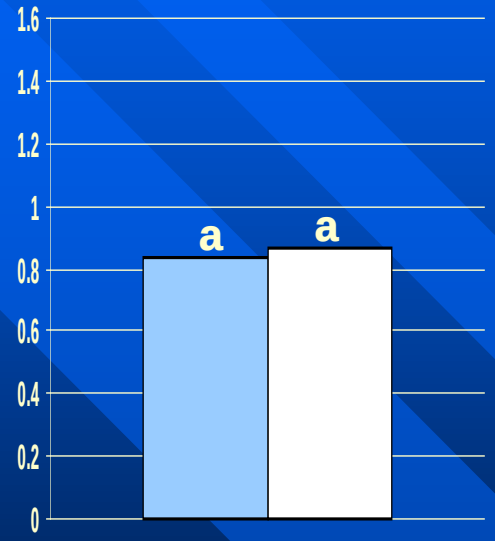
USE A 14-DAY DEFICIT IN ALL MICROSPRINKER ORCHARDS

HULL ROT: VALIDATION

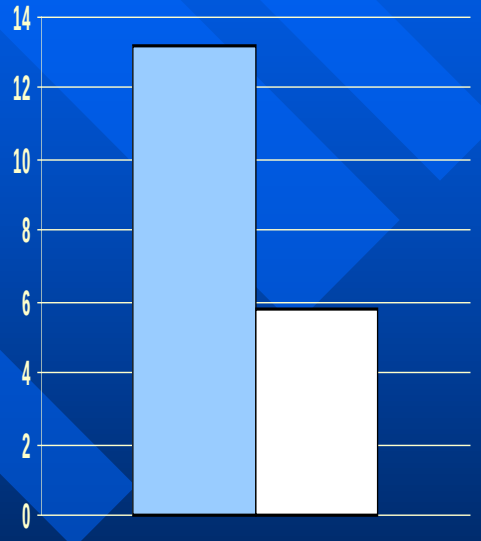
36-DAY (FLOOD)



STRIKES DEAD WOOD



KERNEL DRY WT(g)



PRE-DAWN LWP

1997 IRRIGATION DEFICIT: FULL NONE

HULL ROT: VALIDATION

36 DAYS (FLOOD)

MEANING:

IT TOOK 36 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS

HULL ROT: VALIDATION

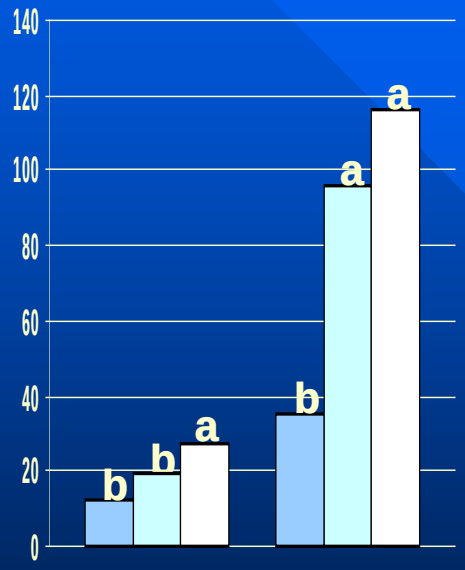
36 DAYS (FLOOD)

DOES NOT MEAN:

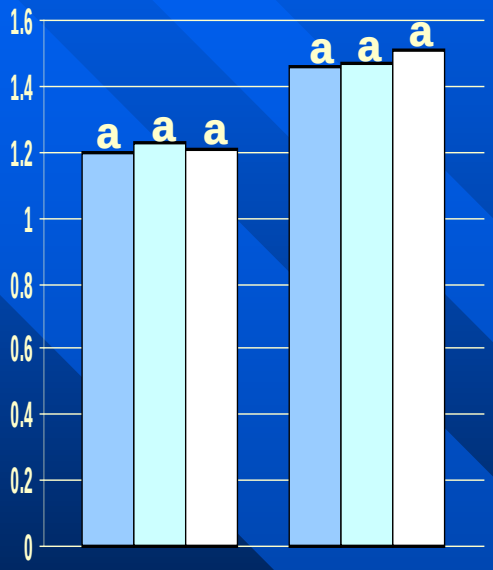
USE A 36-DAY DEFICIT IN FLOOD IRRIGATED ORCHARDS

HULL ROT: VALIDATION

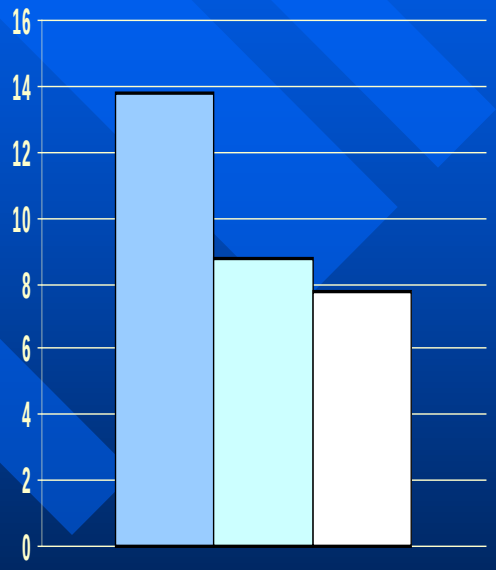
49-DAY (DOUBLE-LINE DRIP)



STRIKES DEAD WOOD



KERNEL DRY WT(g)



PRE-DAWN LWP

IRRIGATION DEFICIT: FULL PARTIAL NONE

HULL ROT: VALIDATION

49 DAYS (DOUBLE LINE DRIP)

MEANING:

IT TOOK 49 DAYS IN THIS ORCHARD TO REACH THE GOAL OF –14 BARS

HULL ROT: VALIDATION

49 DAYS (DOUBLE LINE DRIP)

DOES NOT MEAN:

USE A 49-DAY DEFICIT IN DOUBLE LINE DRIP ORCHARDS

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

REDUCE WATER AT EARLY HULL SPLIT

Intuition

Measurements

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

HULL ROT MANAGEMENT

INTUITION

- KNOW YOUR ORCHARD
- SOIL
- WATER USE
- GROWTH

HULL ROT MANAGEMENT

MEASUREMENTS

- EVAPORATIVE DEMAND
- SOIL MOISTURE
- MID-DAY STEM WATER POTENTIAL

HULL ROT MANAGEMENT

MEASUREMENTS

MID-DAY STEM WATER POTENTIAL

FULLY IRRIGATED : -7 TO -9 BARS

MILDLY STRESSED: -14 TO -18 BARS

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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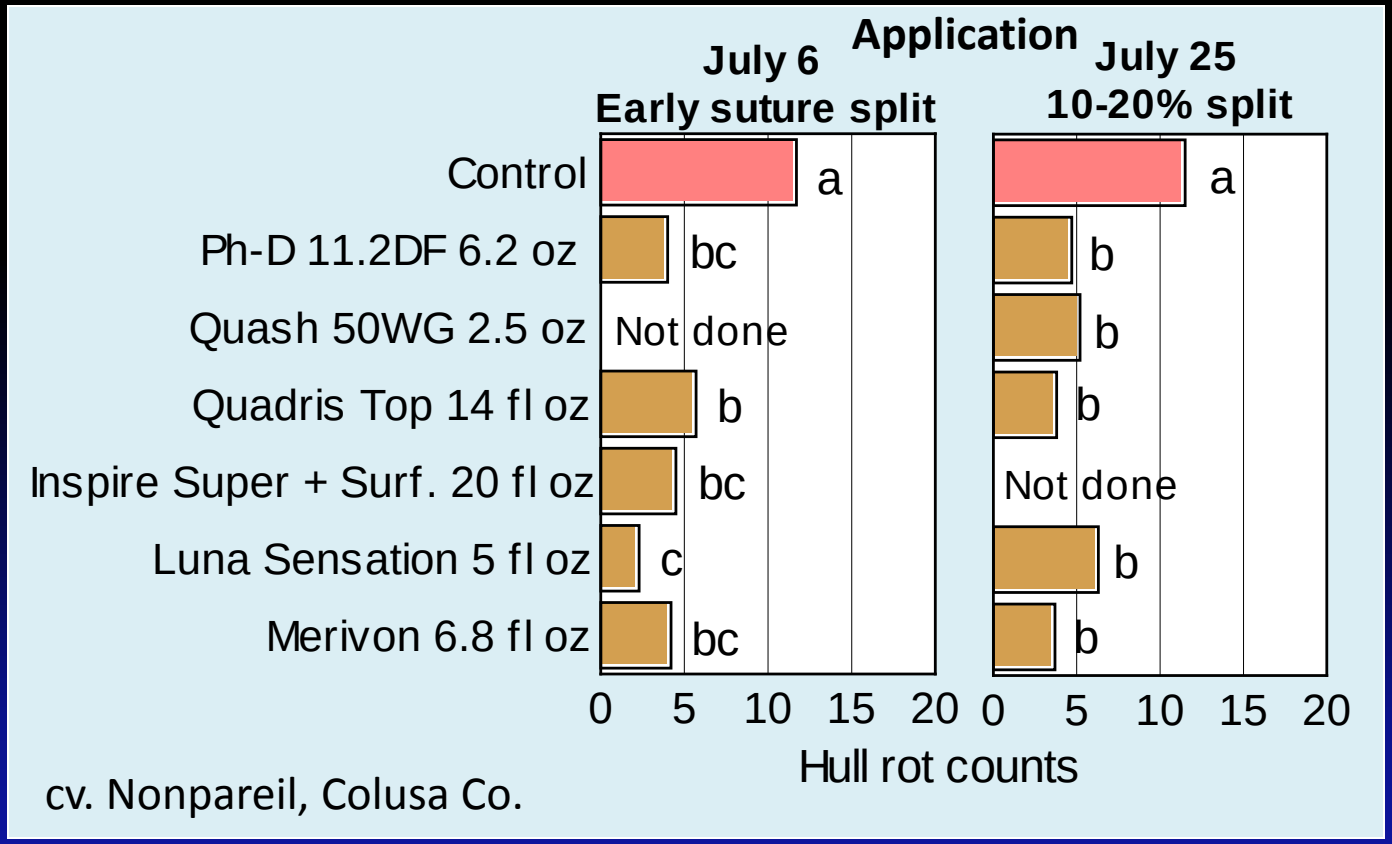
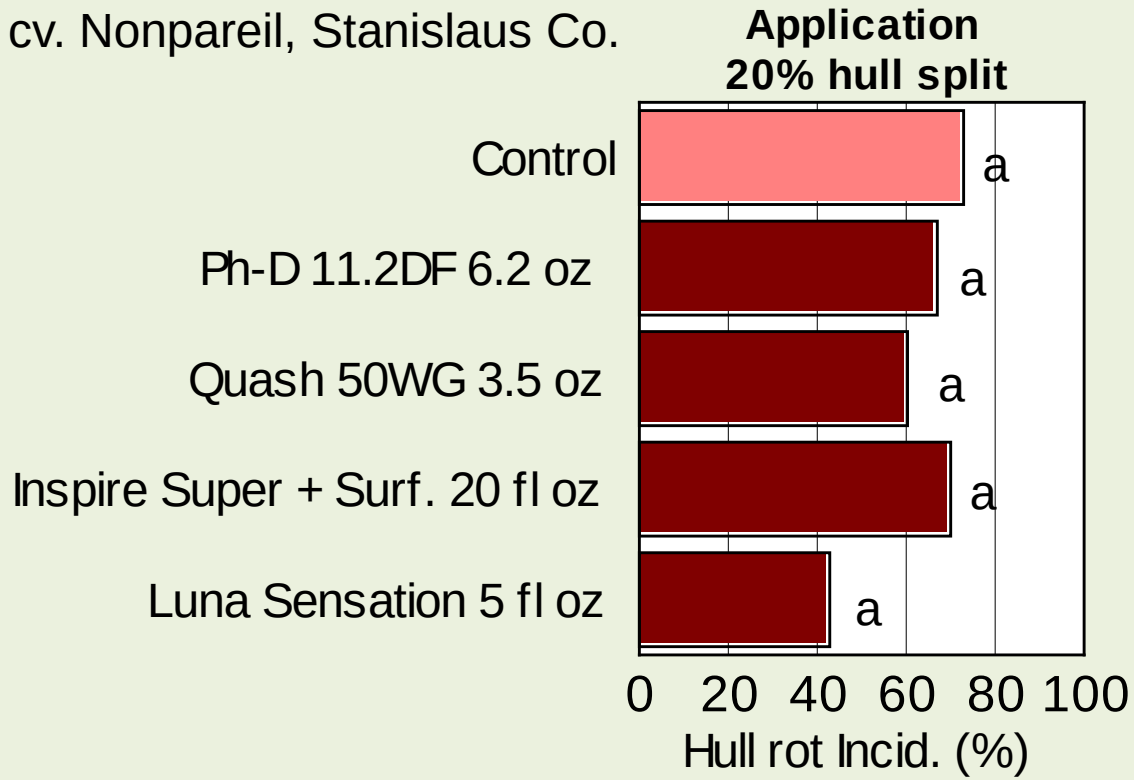
Update on Hull Rot Control

Field trials 2012



Hull rot caused by *R. stolonifer* can be managed with early hull split applications of selected fungicides. Typically, 70% reduction with a single application.

Management of hull rot caused by *Monilinia fructicola* - 2011



Hull rot caused by *M. fructicola* is <u>*not*</u> managed with early hull split applications of selected fungicides.

Update on Hull Rot Control

Field trials 2012

Applications with Luna Experience

4-4	4-25	6-6	7-13
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@	---	---	---
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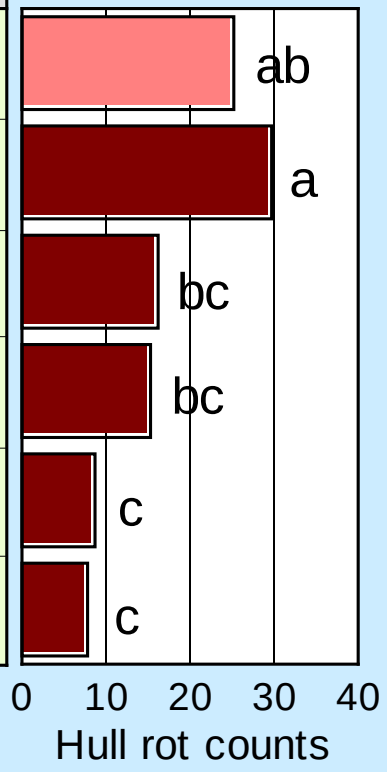
@	@	@	---



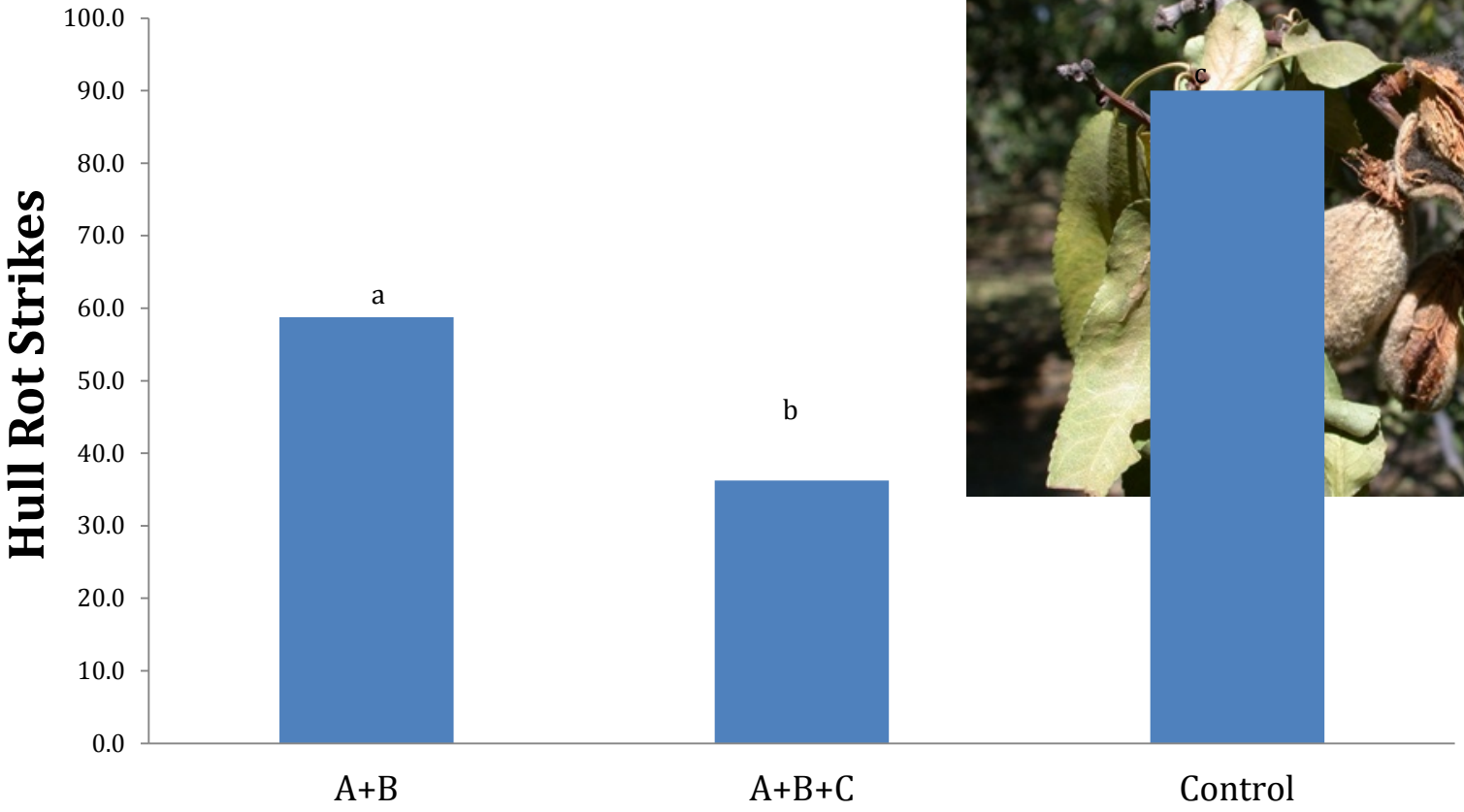
cv. Nonpareil, Stanislaus Co.

Hull rot caused by *M. fructicola* or by both pathogens is managed by late-spring applications. This study will be repeated in 2013 using different fungicides.

Update on Hull Rot Control - Summary

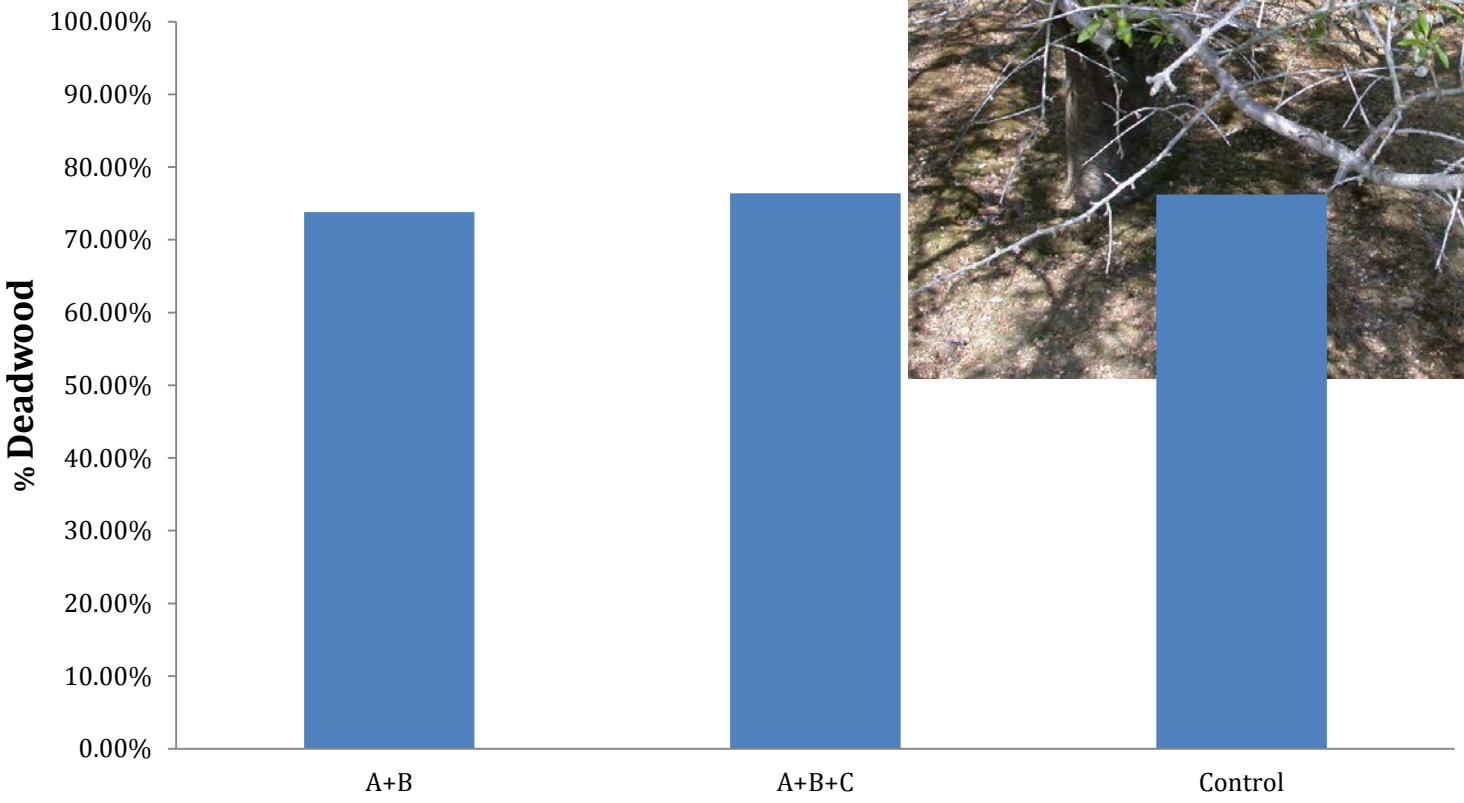
- Knowledge on the management of hull rot is accumulating.
- Fungicide treatments can be effective in reducing hull rot caused by *R. stolonifer* and by *M. fructicola*.
  - For *Rhizopus* hull rot, early hull split applications when susceptibility is high should be done. Fungicides are applied most effectively with NOW applications.
  - For *Monilinia* hull rot, applications should be done earlier (late spring). *This needs further evaluation*.
- For the most effective integrated management of hull rot, hull split should be induced simultaneously with proper water management (i.e., deficit irrigation).

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

Good Luck!!!