Almond Irrigation, Water Stress and Productivity:

Where do Drought & Deficit Irrigation Research Fit In?

Ken Shackel, UCD Plant Sciences
January, 2008

Some drought irrigation history:

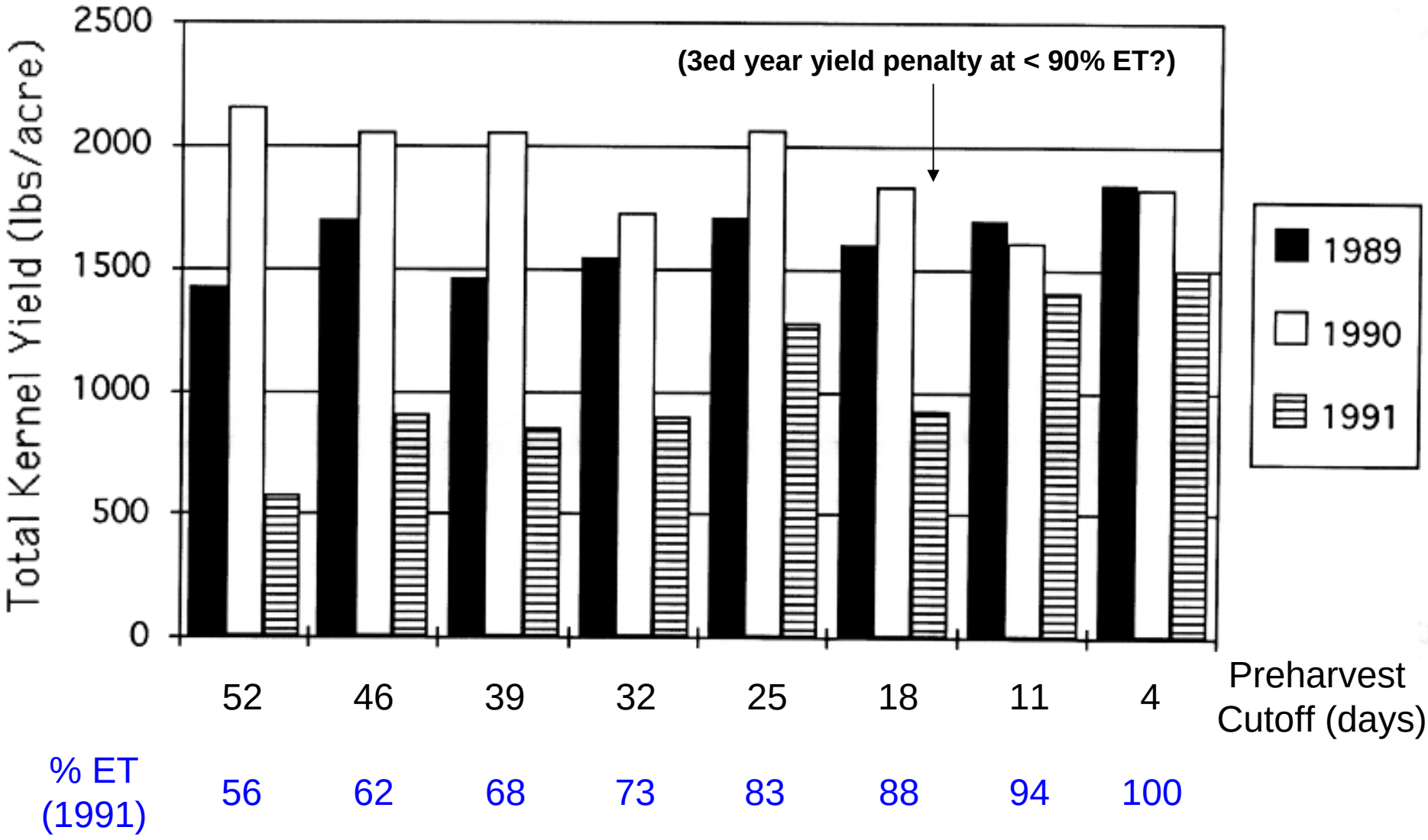
a) 1989 – 1991. Irrigation cutoff & drought recovery trials in Kern Co. on relatively shallow sandy soil (Dave Goldhamer)

b) 1990 – 1995. Irrigaiton cutoff/cutback & drought recovery trials in Manteca on moderate depth sandy loam soil (Terry Prichard)

c) 1993 – 1996. Drought irrigation management trials N. Kern Co. 3' sandy loam (Dave Goldhamer)

Goldhamer study, 1989 - 1991

Full ET: 30" – 40" in-season
Yields: 1,700 #/ac



% ET (1991)	56	62	68	73	83	88	94	100

Goldhamer study, 1989 – 1991

Drought recovery

Drought with a 60% reduction – choices:
a) use it at full ET until it is gone (long cutoff)
b) spread it out for various levels of cutoff

Results: More even spread is best

Prichard study, 1990 - 1993

Full ET: 37" in-season
Yields: 3,360 #/ac

Deficit Treatment	% ET	Yield (% Control)	
		1990-1992	1992
(5) Midseason	50	78	79
(4) Mid and Postharvest	52	85	73
(3) Midseason	66	77	80
(6) Plant-based	66	93	96
(2) Postharvest	72	82	84
(1) Control	100	100	100

No yield loss at 66% ET with season-long plant-based irrigation
(predawn WP < -12 bars)

Irrig Sci (2006) 24: 101–114
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IRRIGATION OF FRUIT TREES AND VINES

David A. Goldhamer · Mario Viveros · Mario Salinas

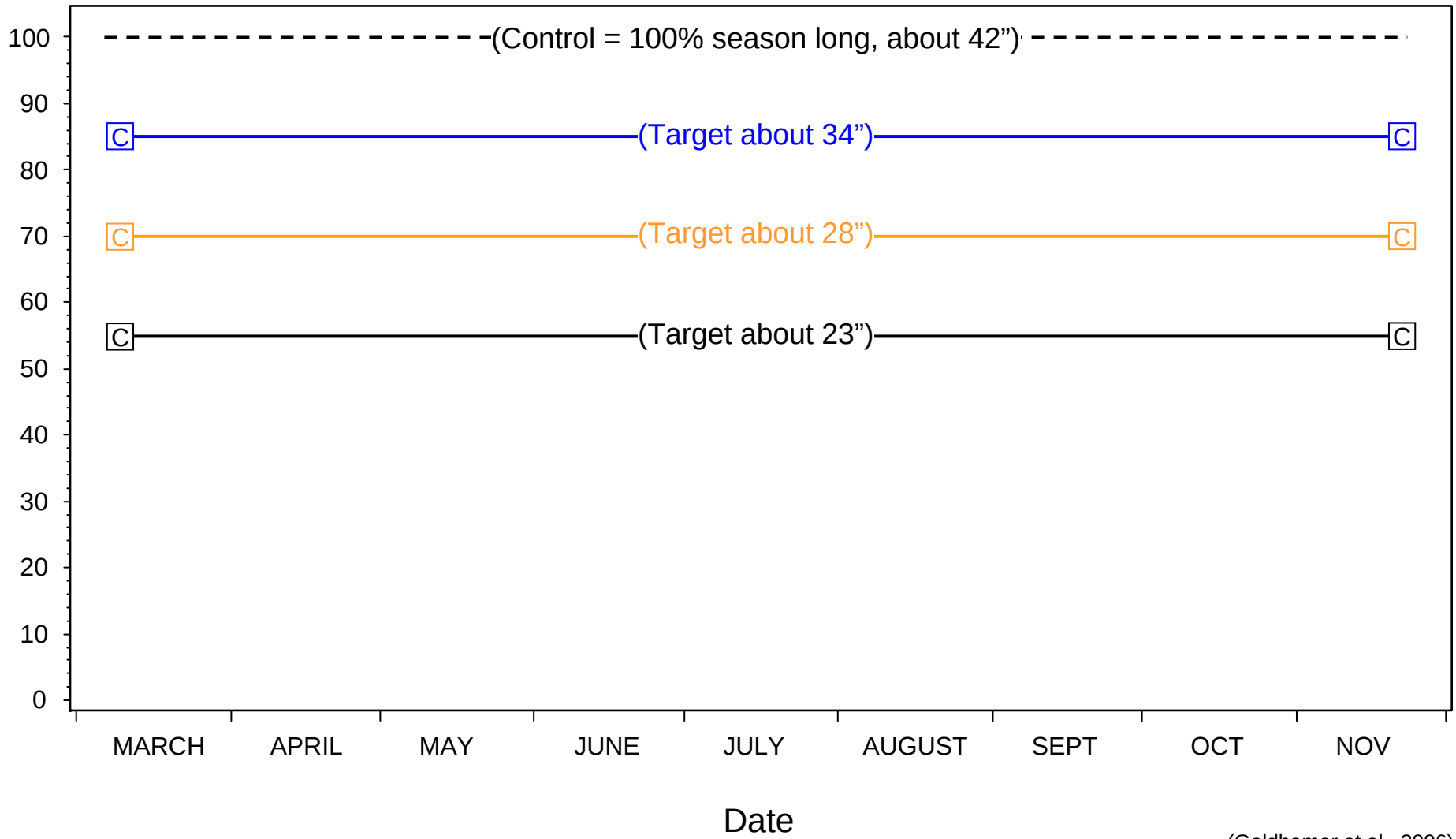
Regulated deficit irrigation in almonds: effects of variations in applied water and stress timing on yield and yield components

Published online: 9 November 2005

- 1993 -1996 study, Southern SJV, 18 year-old orchard
- Control (100% ETc)
- 3 levels of irrigation deficit
- 3 patterns of deficit Ⓐ Ⓑ Ⓒ

“C” Seasonal pattern in water application (% of control)

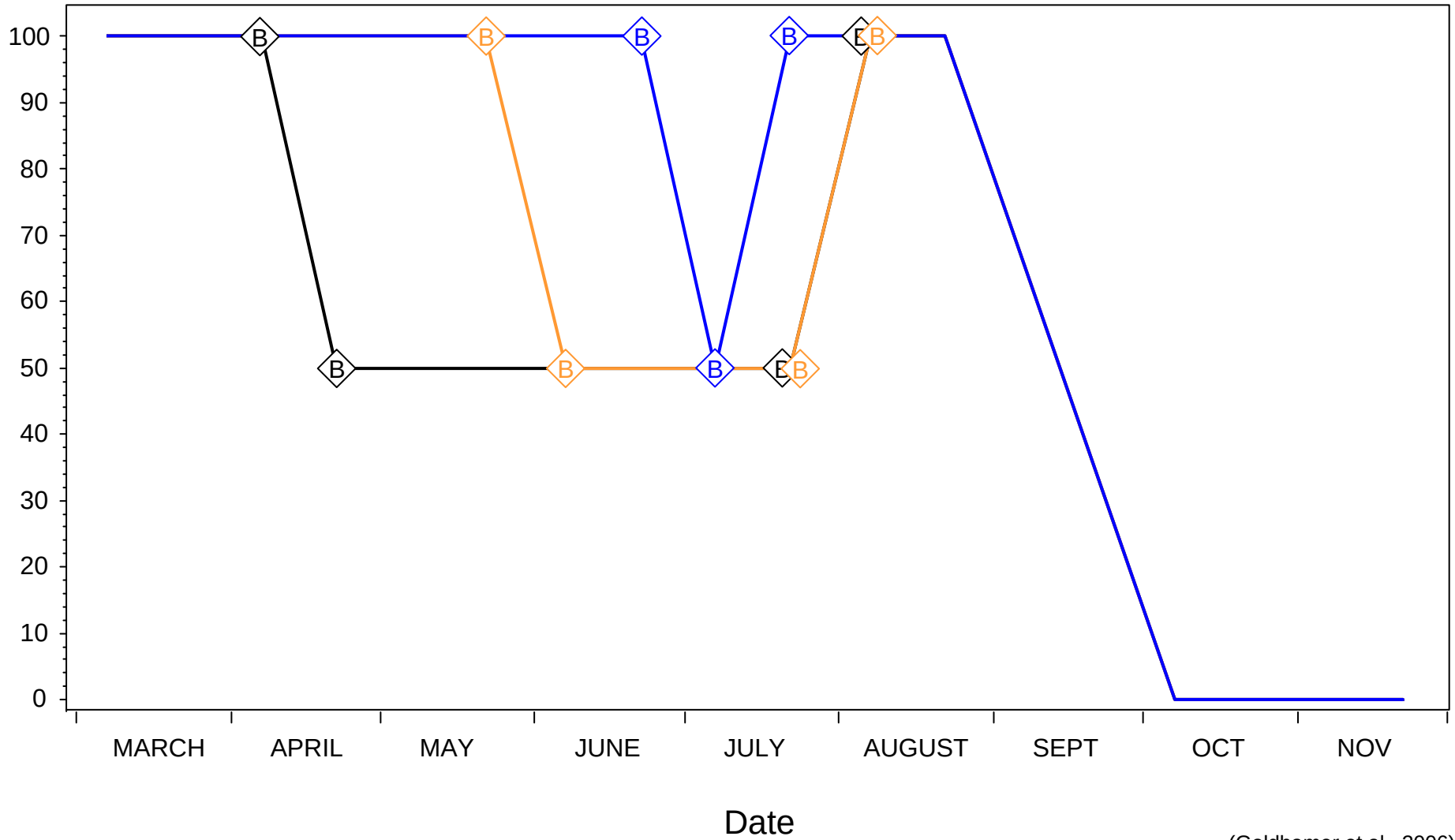
Equal irrigation deficit all season



(Goldhamer et al., 2006)

“B” Seasonal pattern in water application (% of control)

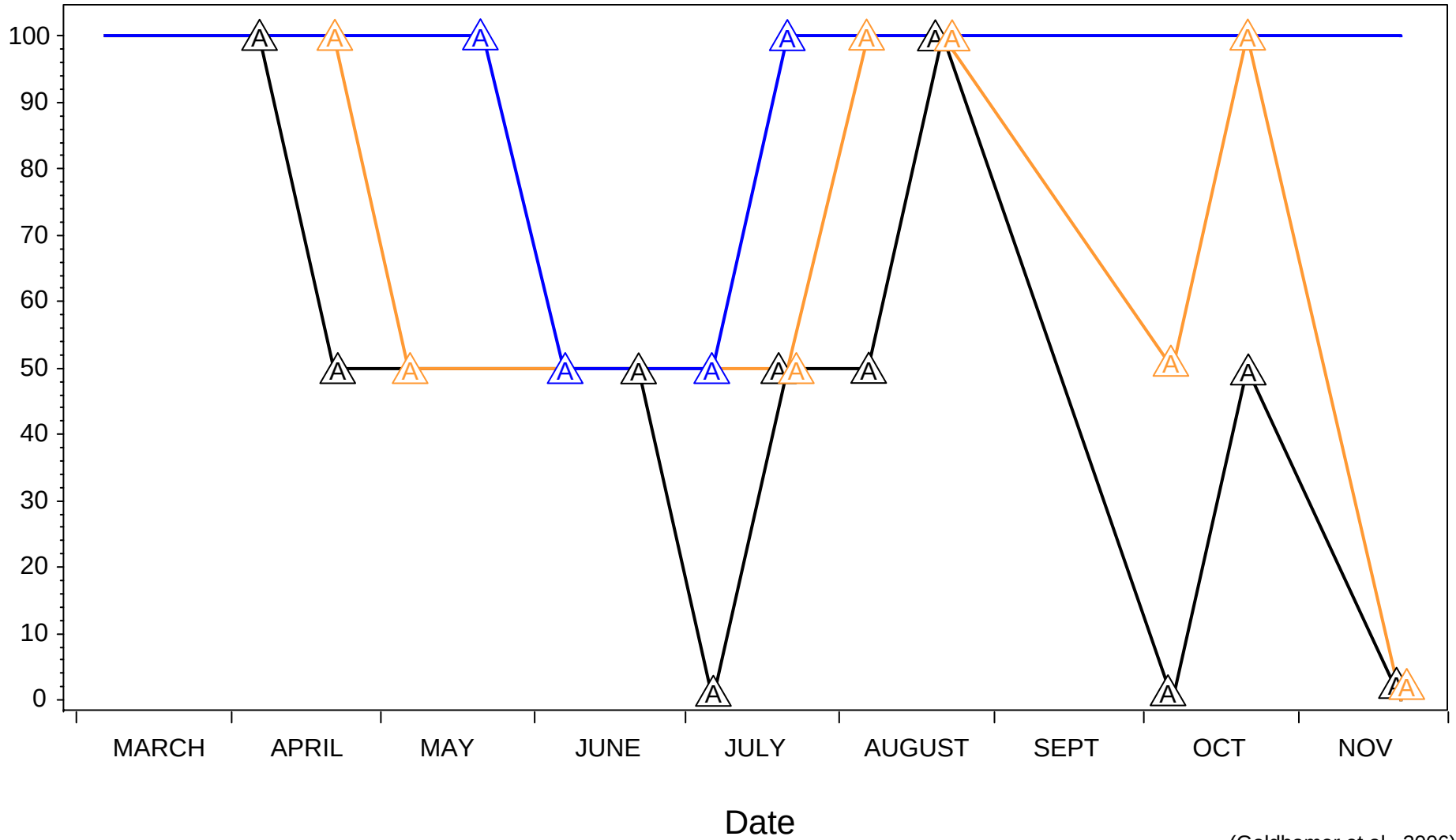
Some deficit early, most deficit post-harvest



(Goldhamer et al., 2006)

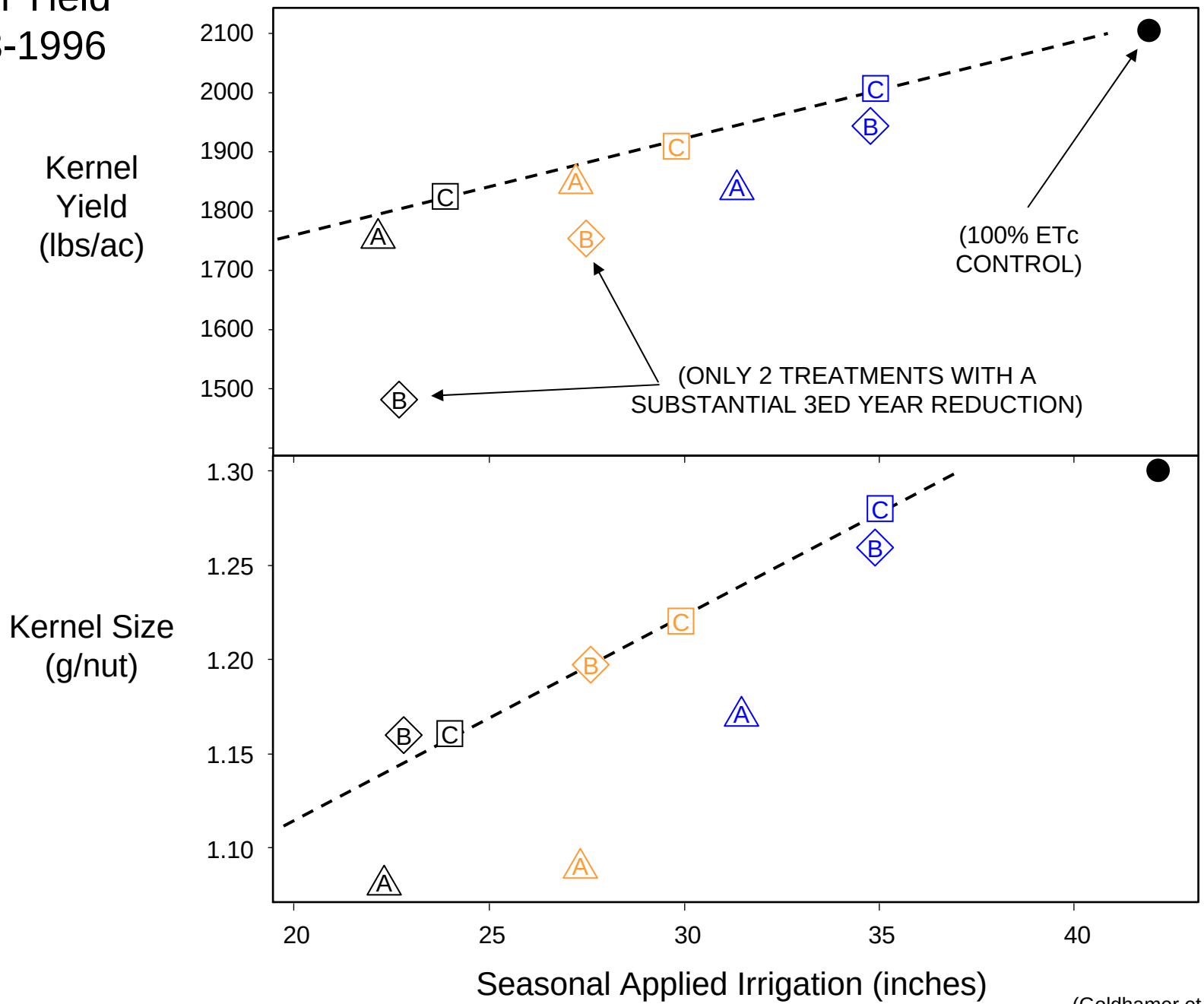
“C” Seasonal pattern in water application (% of control)

More deficit early, less deficit postharvest

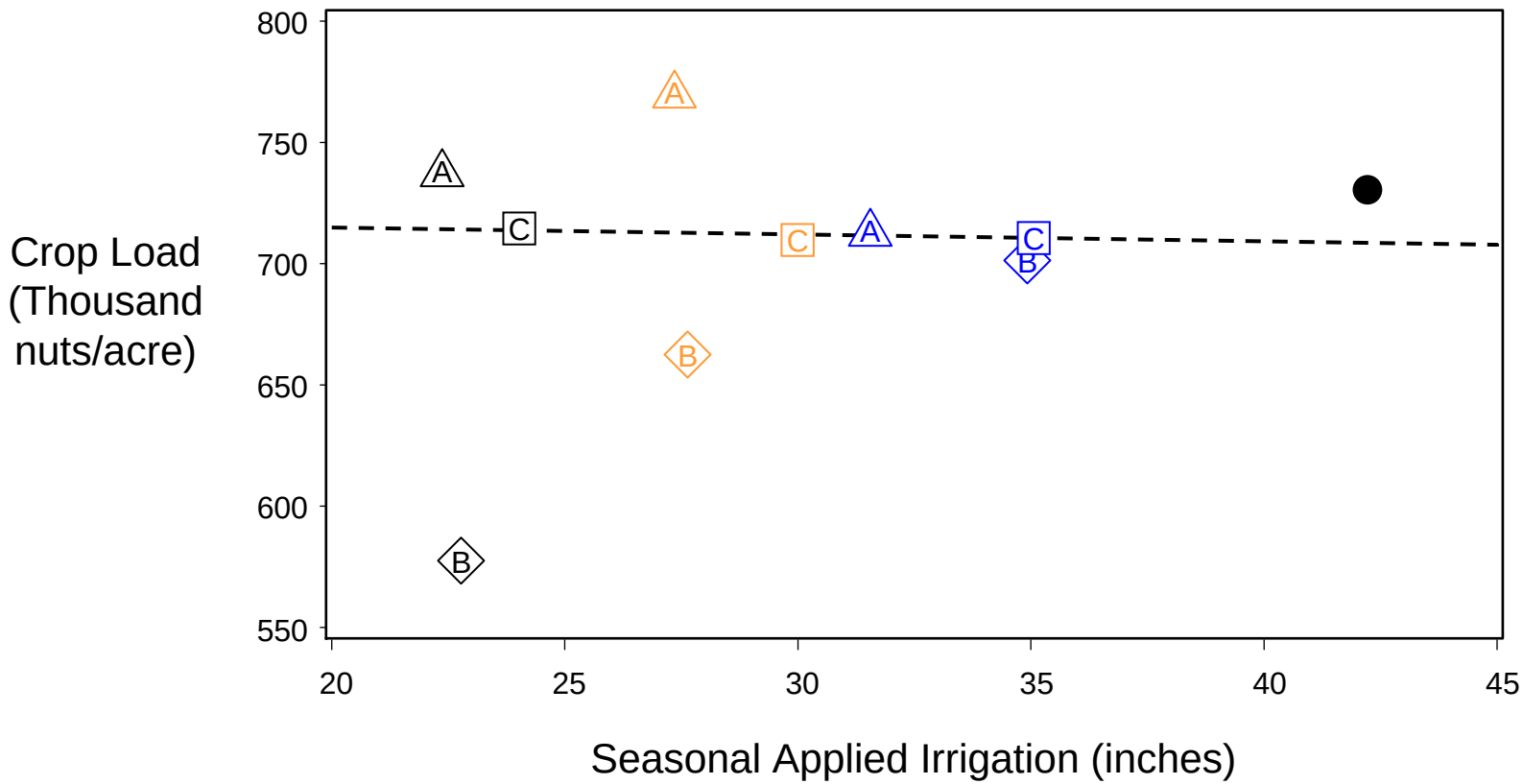


(Goldhamer et al., 2006)

Mean Yield 1993-1996

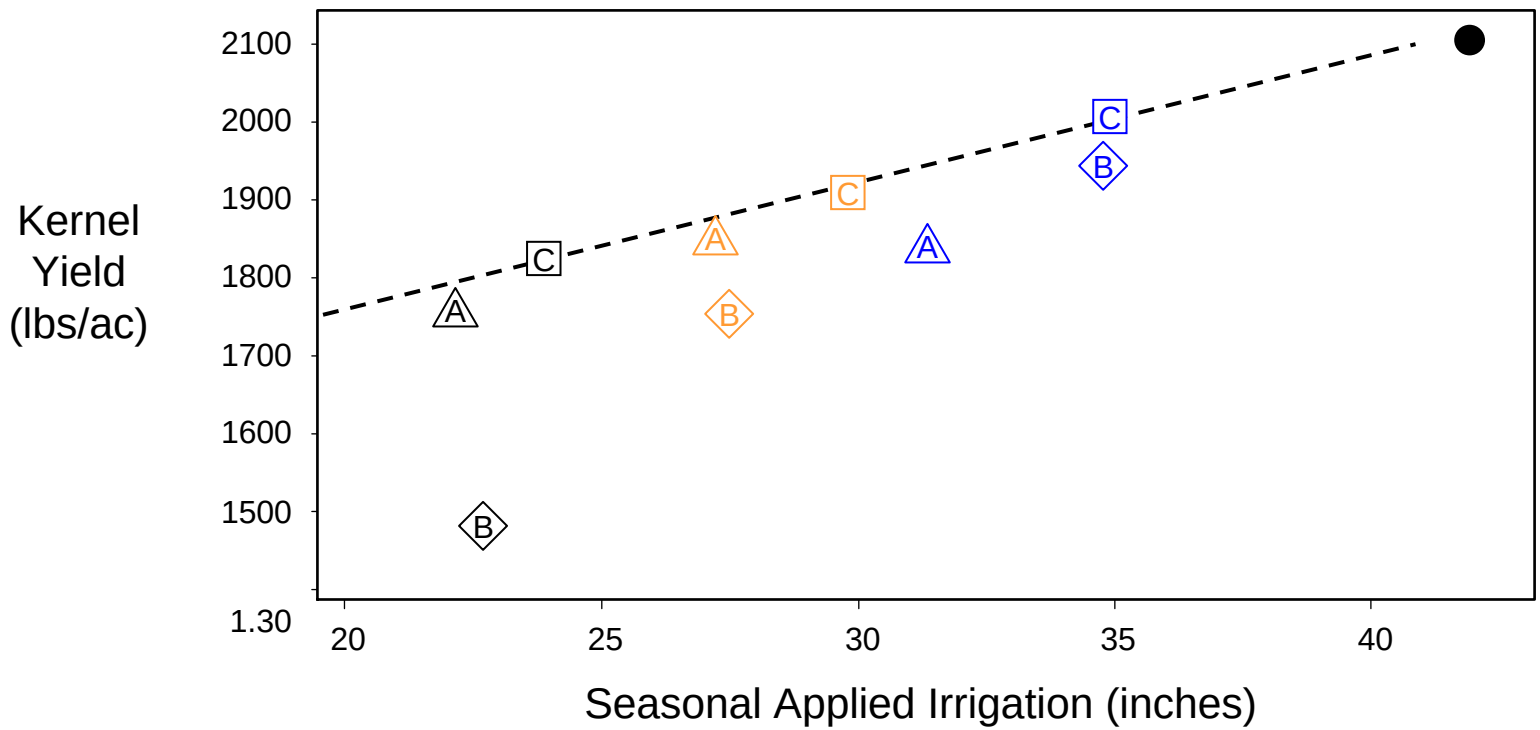


(Goldhamer et al., 2006)



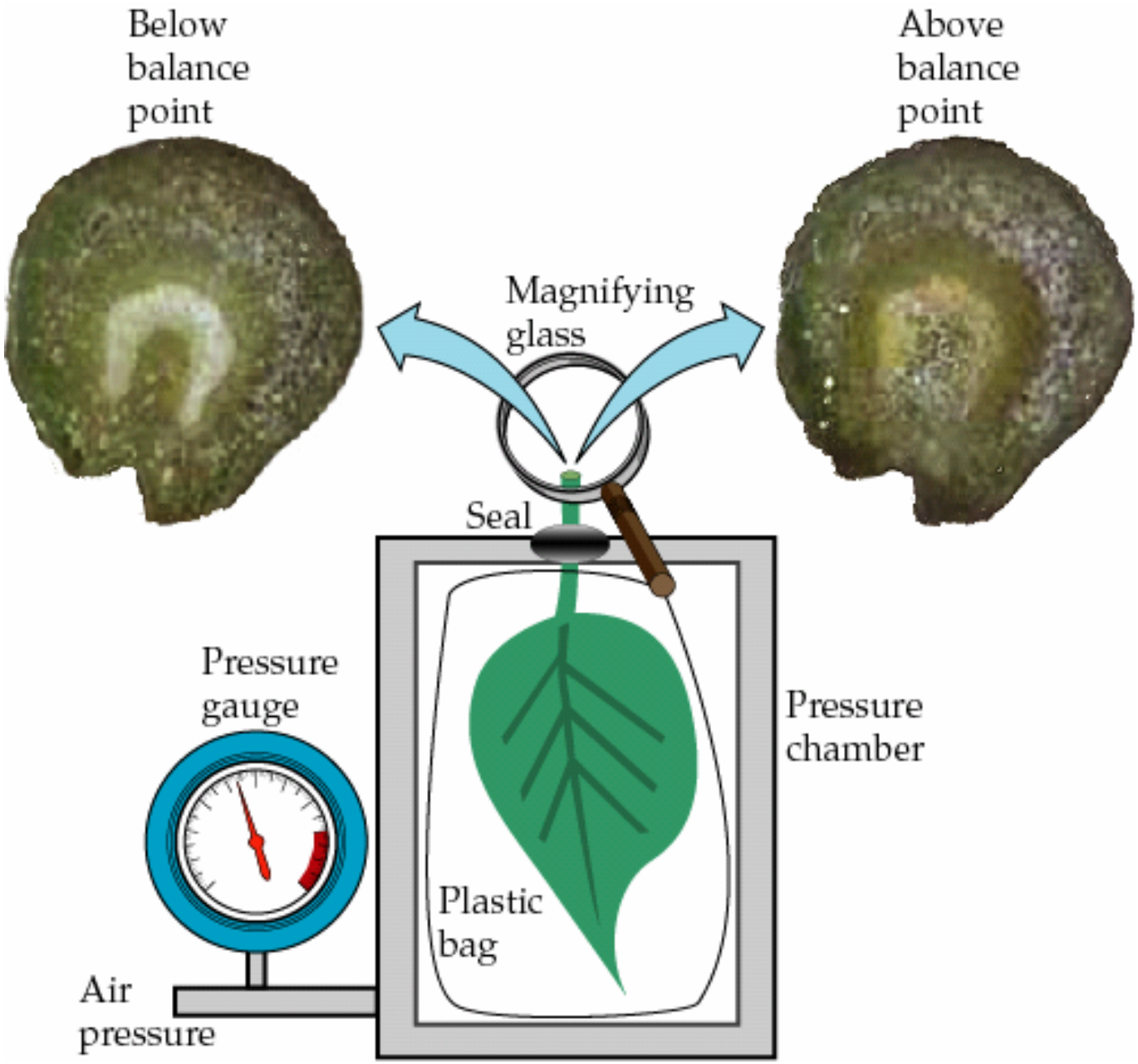
(Goldhamer et al., 2006)

Question: is the amount and timing of irrigation all you need to know to describe the stress experienced by the tree?



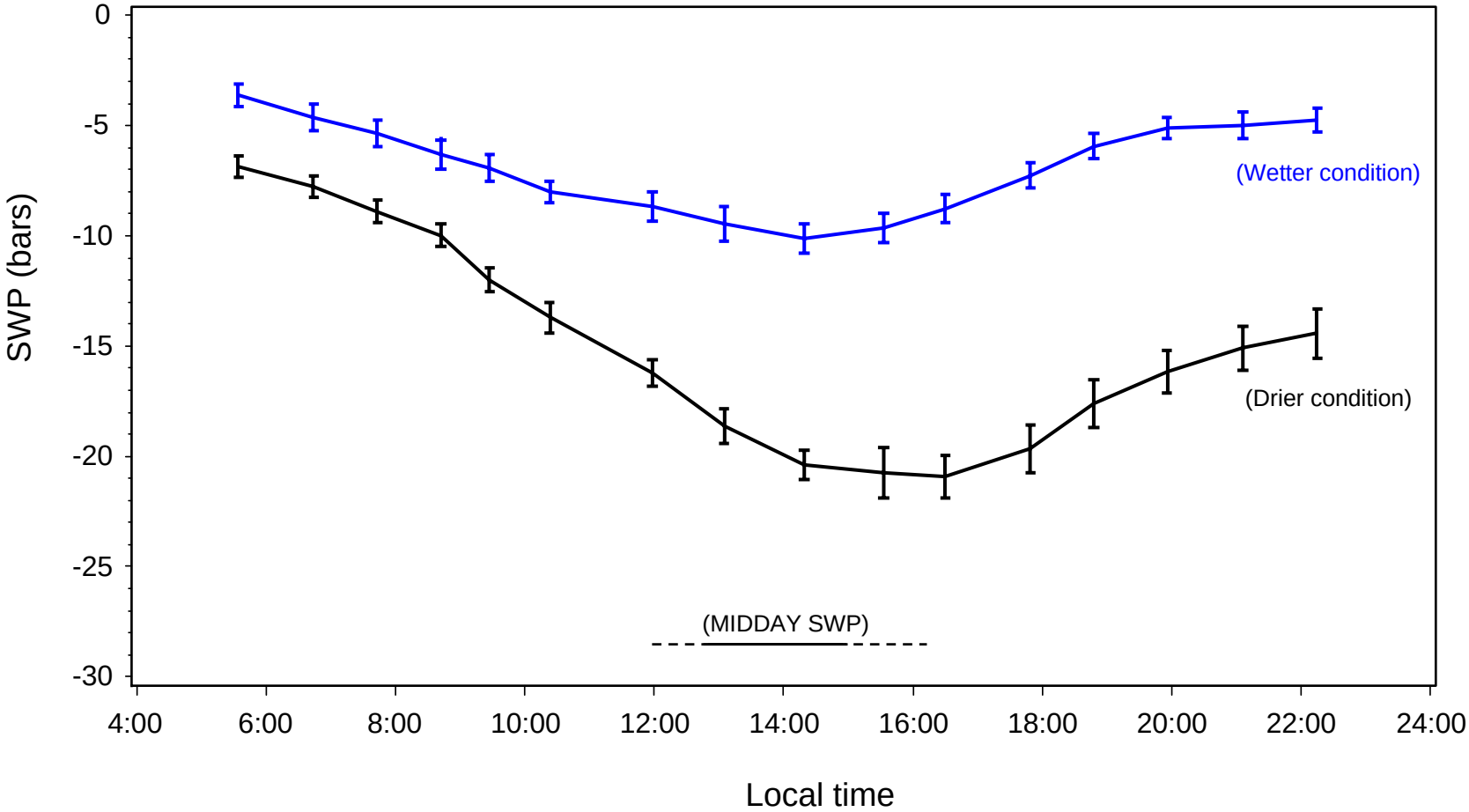
(Goldhamer et al., 2006)

Answer:
probably not,
maybe better to
ask the tree?


Below balance point
Above balance point
Magnifying glass
Seal
Pressure gauge
Pressure chamber
Plastic bag
Air pressure

Example of the daily pattern in stem water potential (SWP) in Almonds

(Magnum ranch, Lassen Land Co., August 4, 2005)



Midday SWP values in Almond

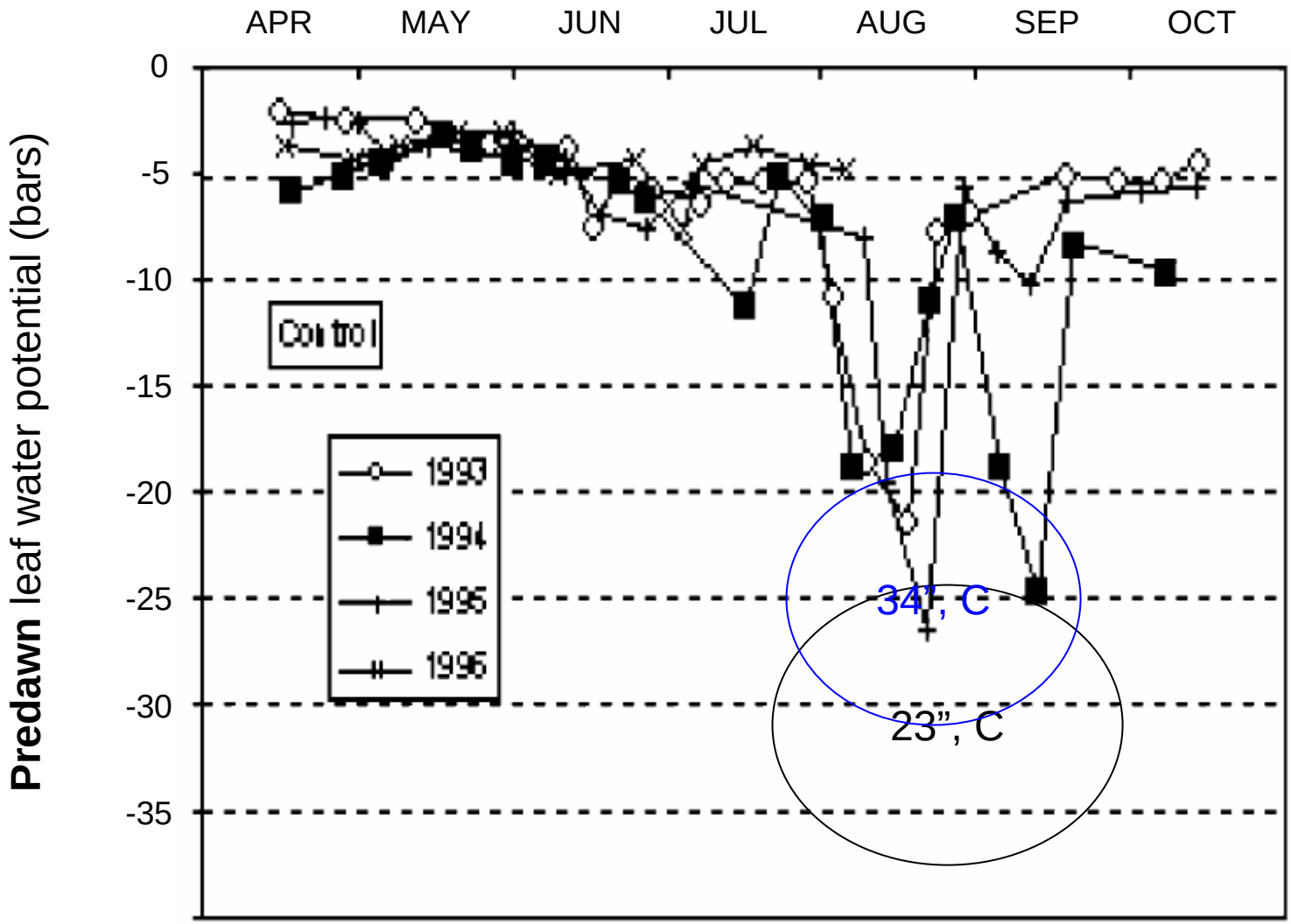
Expected range even under fully irrigated conditions

Will reduce overall growth of young trees, and shoot growth of older trees, but may also have some beneficial effects on older trees

Interior leaf yellowing and drop usually apparent. Not unusual to find under almond production conditions, but probably reduces tree productivity, particularly if these levels occur regularly

Leaf drop, flagging, wilting. Can occur under almond production conditions, particularly around harvest.

Goldhamer study, predawn water potential



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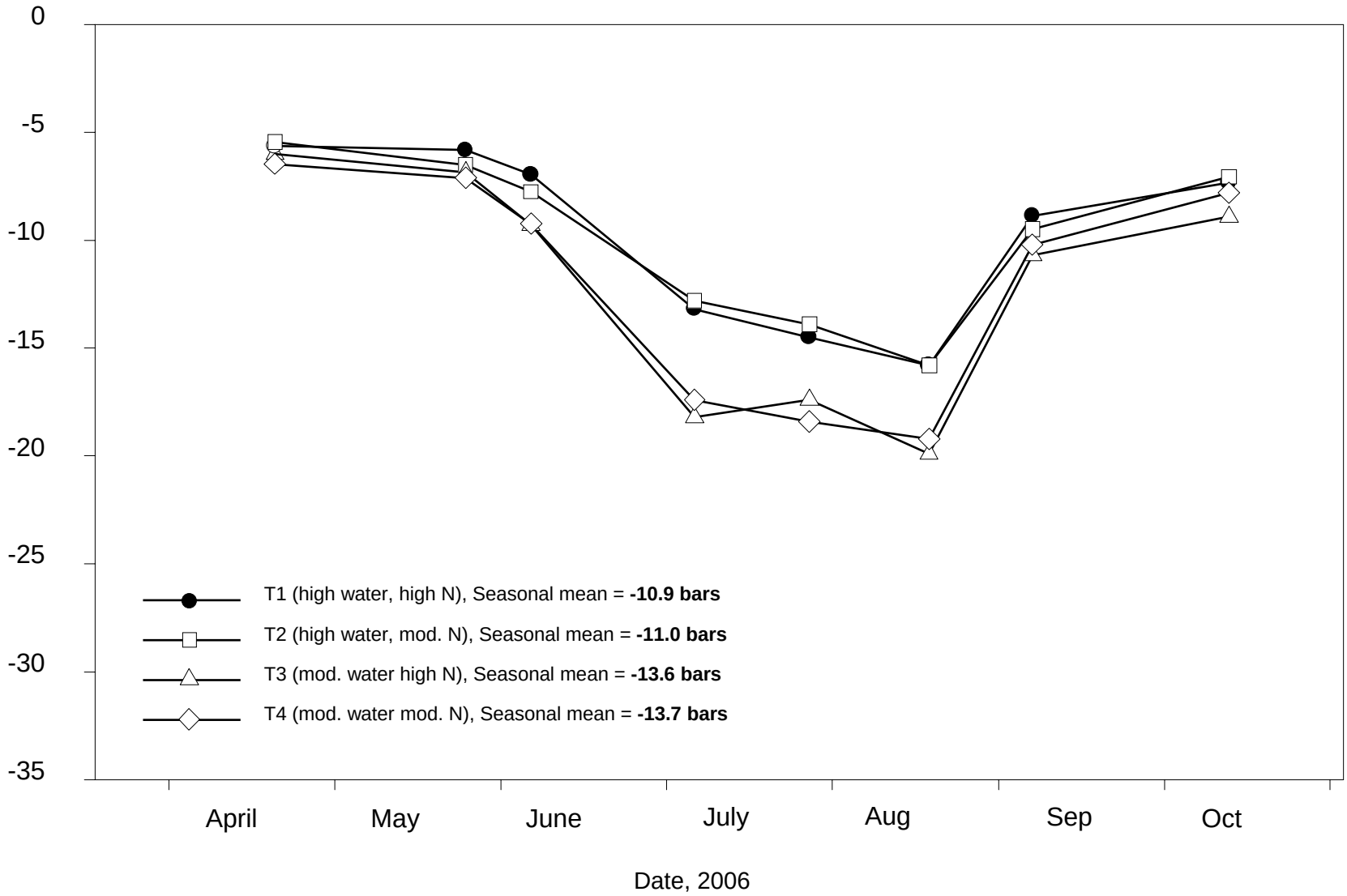
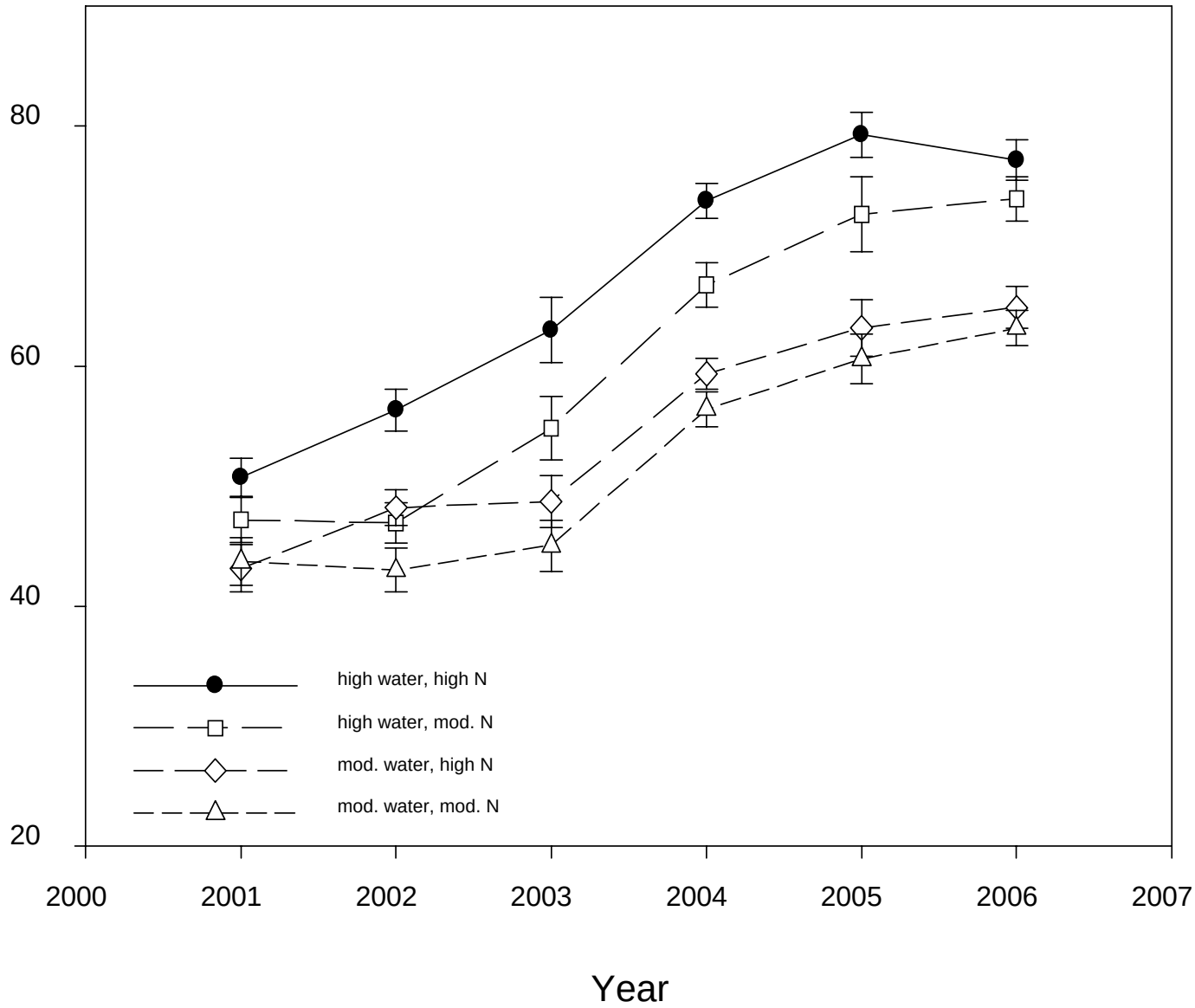
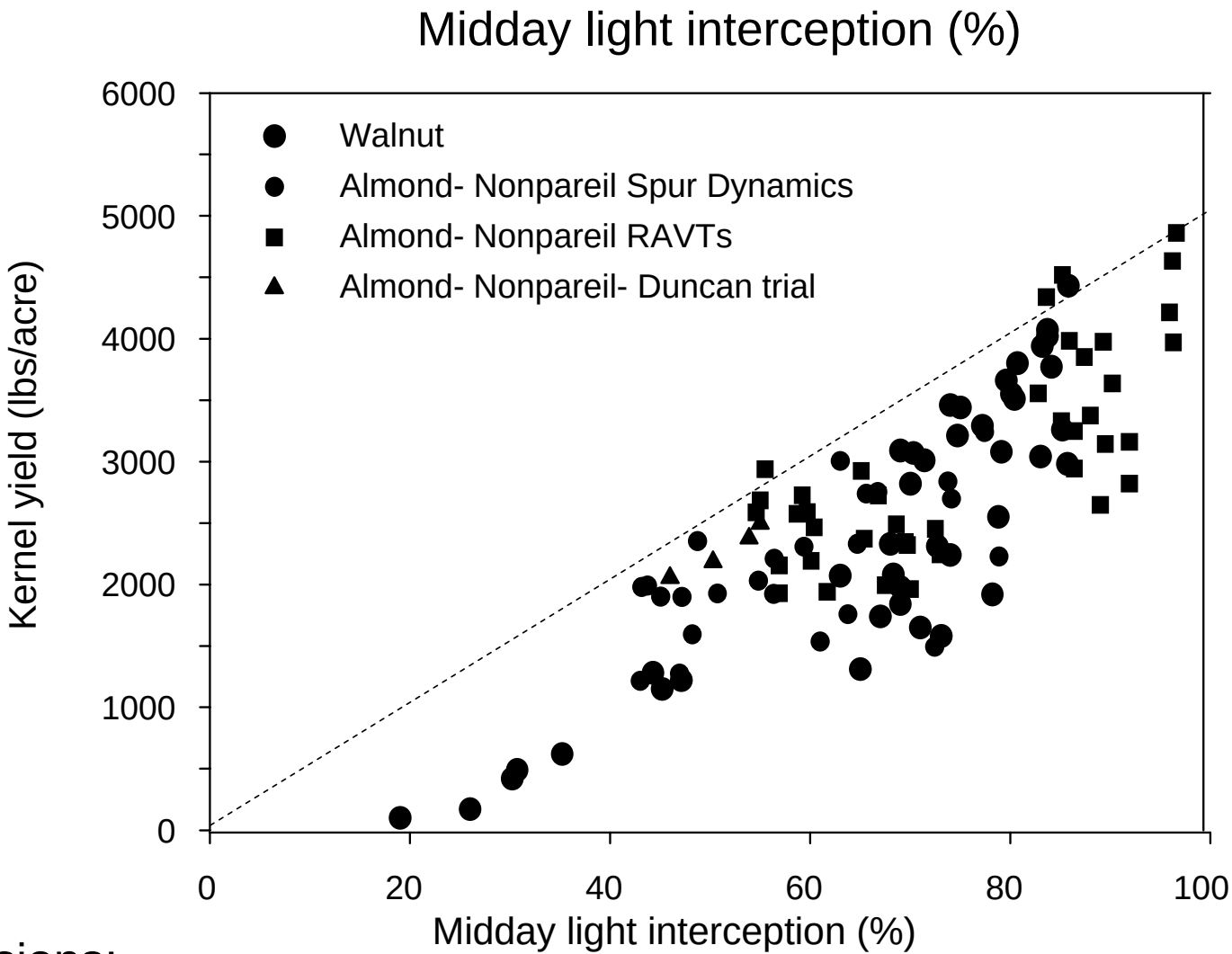
Example: **Midday** stem water potential (bars) in 2006,
Lampinen et al., Spur Dynamics



Lampinen study, canopy development (5th leaf – 11th leaf orchard)



(Lampinen study)

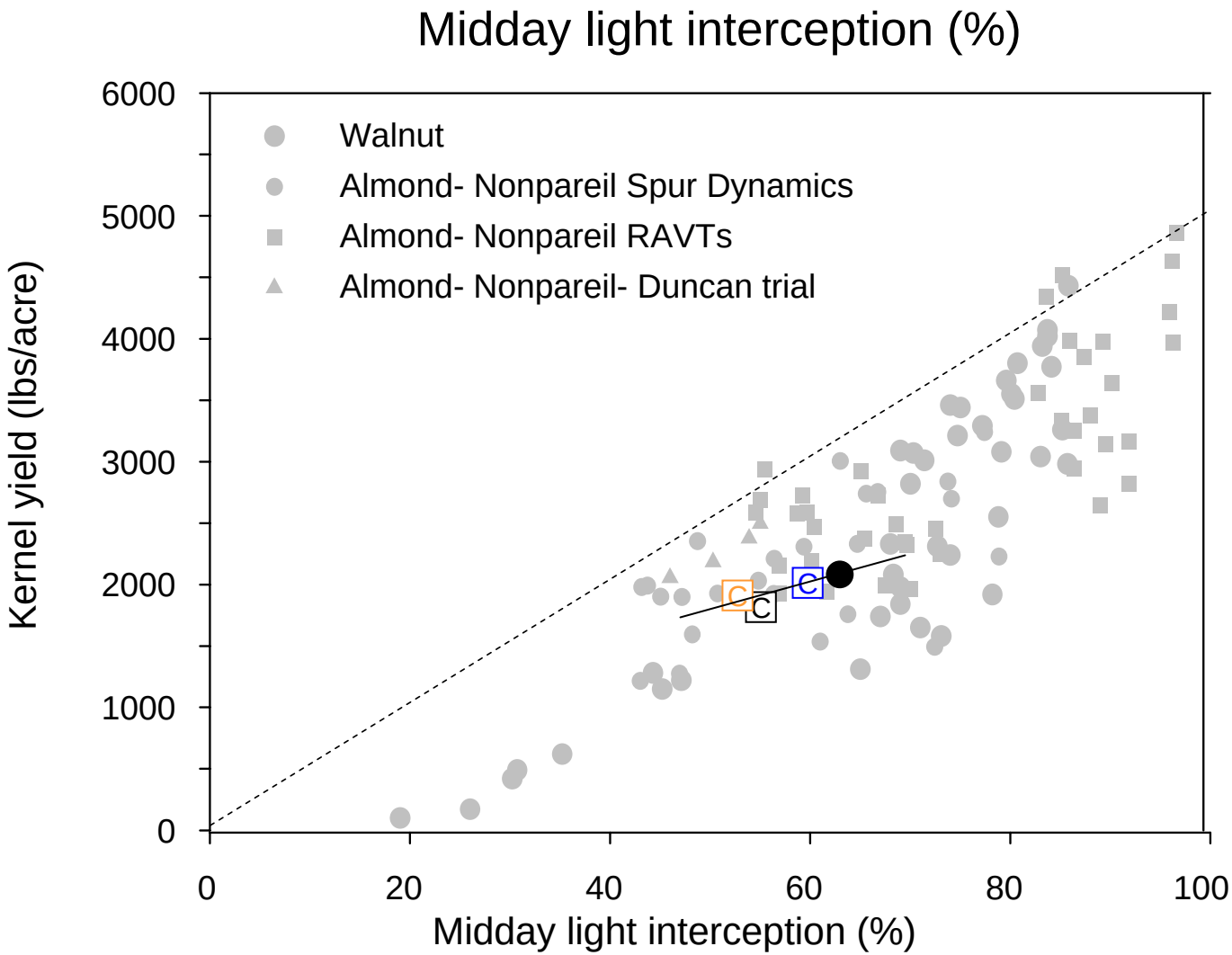


Conclusions:

- Canopy development determines yield potential

- Approximately 10% loss in rate of canopy development per bar of seasonal average midday stem water potential deficit

(Lampinen study)



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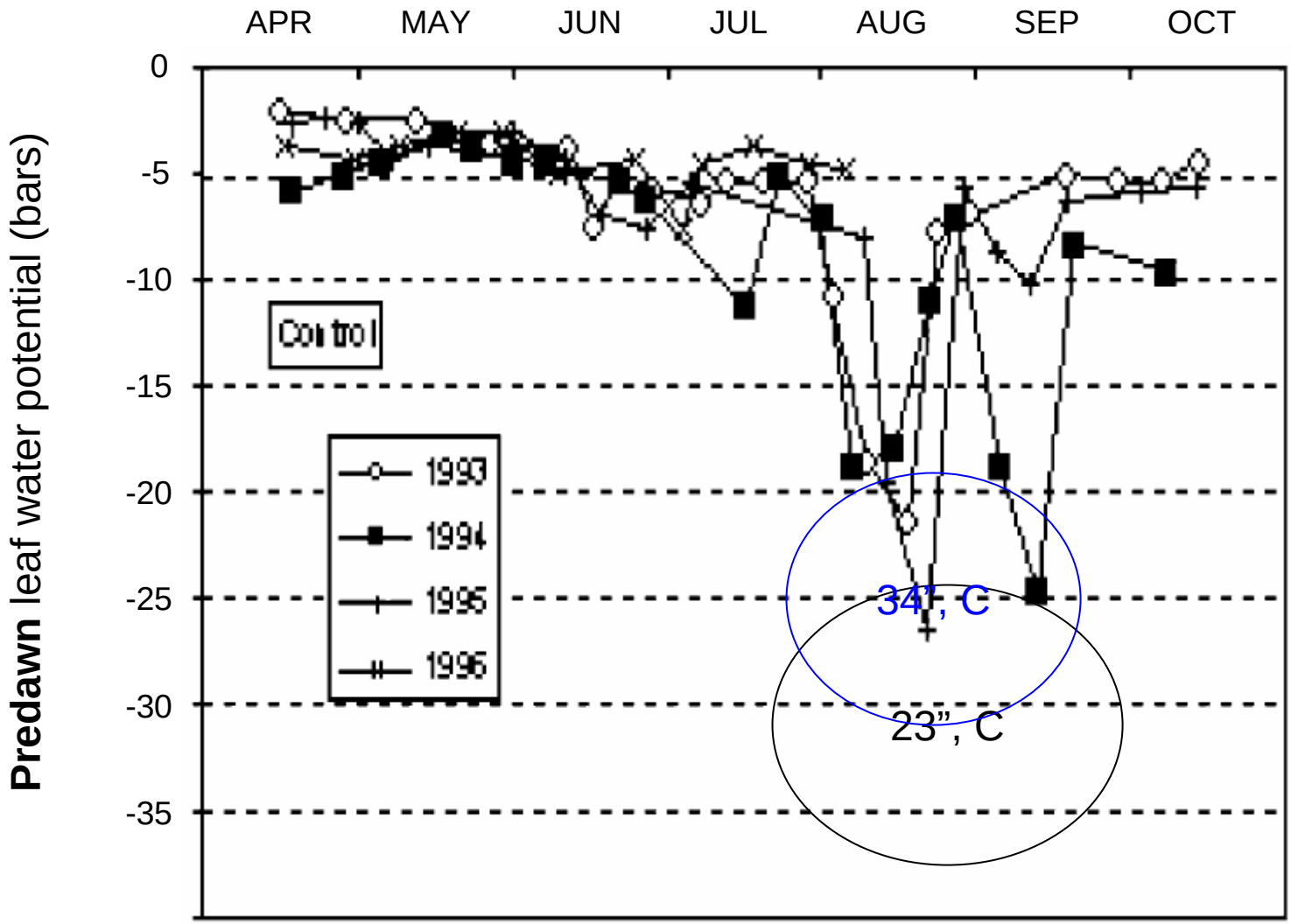
(Lampinen study)

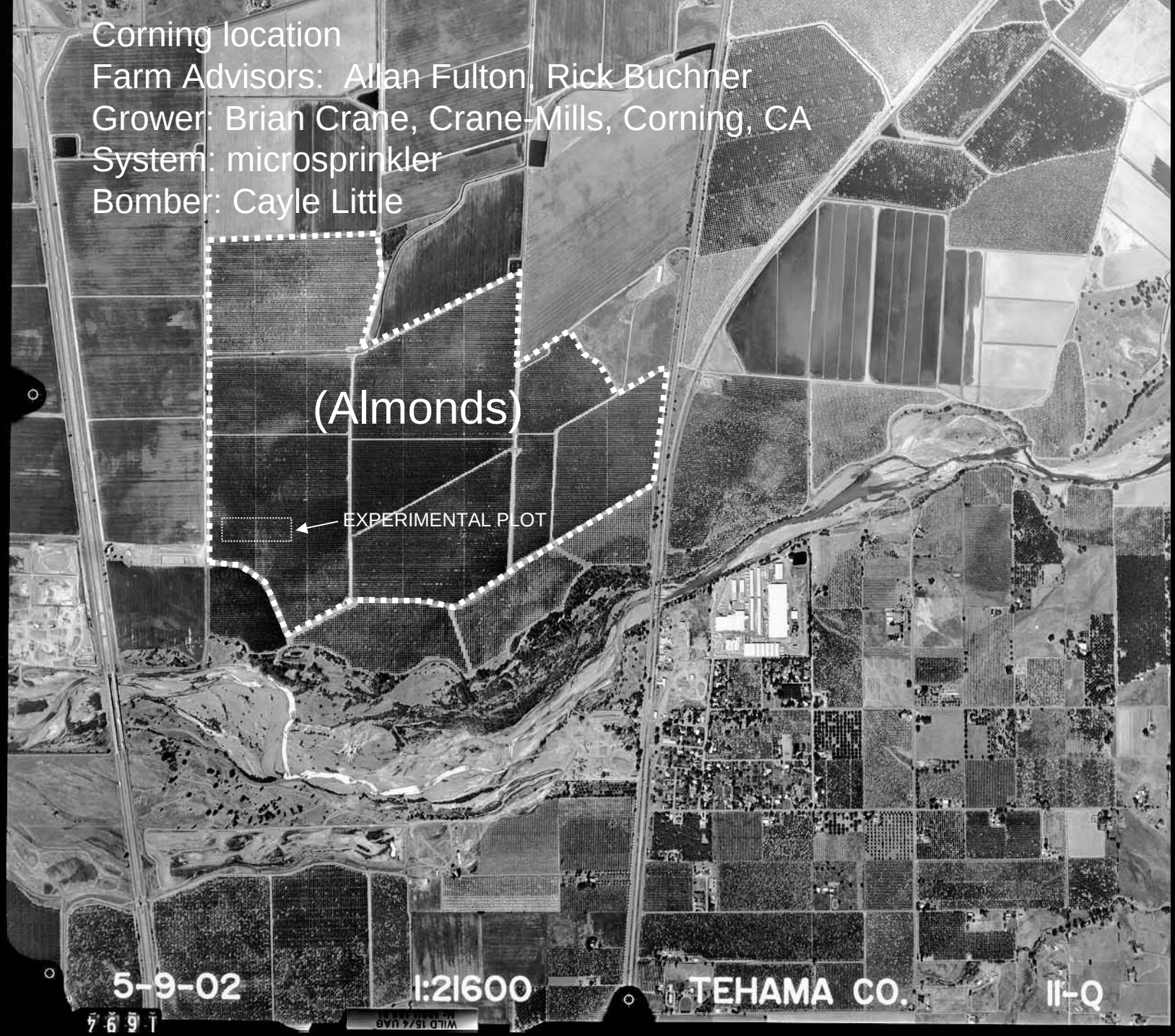
Goldhamer study, predawn water potential



(Goldhamer et al., 2006)

Question: Is it possible that stress can be determined by factors other than irrigation amount and timing?

Answer: Yes – we have a good example of a non-uniform field that required substantial irrigation compensation to make it uniform.


Corning location
Farm Advisors: Allan Fulton, Rick Buchner
Grower: Brian Crane, Crane-Mills, Corning, CA
System: microsprinkler
Bomber: Cayle Little
(Almonds)
EXPERIMENTAL PLOT
5-9-02
1:21600
TEHAMA CO.
II-Q


5-9-02
WEST
(gravel)
EAST
(silt)

% Hull Split, Carmel variety

(East/West difference similar in all varieties)

	Date, 2000					
	10 Aug	16 Aug	22 Aug	31 Aug	6 Sep	14 Sep
East (Average SWP = -8.4 bars)	0%	0%	5%	13%	32%	40%
West (Average SWP = -14.1 bars)	4%	23%	60%	83%	85%	91%

Problems with uneven hull split timing:

- Uncertain timing for hull split spray
- Irrigation management problems
- Uneven/delayed harvest

NonPareil variety (Corning) – Hull Split (RDI treatment)

2001:

East (silt)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	20	45	70	100

West (gravel)

Date	JUL 13	JUL 20	JUL 27	AUG 1	AUG 13
% HS	2	25	55	75	100

2003:

East (silt)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	96	100	100

West (gravel)

Date	JUL 29	AUG 7	AUG 15	AUG 22
% HS	29	88	100	100

Corning location –irrigation summary (RDI)

Soil	2002		2003		2004	
	Water applied	Cutoff date	Water applied	Cutoff date	Water applied	Cutback date
East (silt)	24”	10-Jul	14”	1-Jul	18”	7-Jun
West (gravel)	40”	25-Aug	41”	4-Sep	36”	16-Sep
ETc	43”		40”		42”	

Very long cutoff/cutback OK on East (silt) soil

2001 - 2004 Almond RDI sites:

County	Location	Soil type	Age (yr)	Irrigation
Tehama	Corning(E)	Silt-Loam	9	Microsprinkler
Tehama	Corning (W)	Gravel-Loam	9	Microsprinkler
Butte	Chico	Vina-Loam	9	Solid-set Sprinkler
Colusa	Arbuckle	Gravel-Loam (II)	13	Single line drip
Solano	Dixon	Yolo-S/CLoam	8	Solid-set Sprinkler
Madera	Madera	Dinuba FSL	10	Microsprinkler
Kern	Shafter	Sandy Loam	15	Microsprinkler

Question: Can we use RDI in the same location(s) over many years without reducing yield?

Four year yield summary

(lbs. nutmeats per acre)

Treatment	2001 (2 sites)	2002 (7 sites)	2003 (7 sites)	2004 (7 sites)
Grower	2,400	3,170	2,860	2,650
RDI	2,430	3,080	2,660	2,680

Selected sites where differences in stress only occurred during hull split (15 “paired” comparisons)

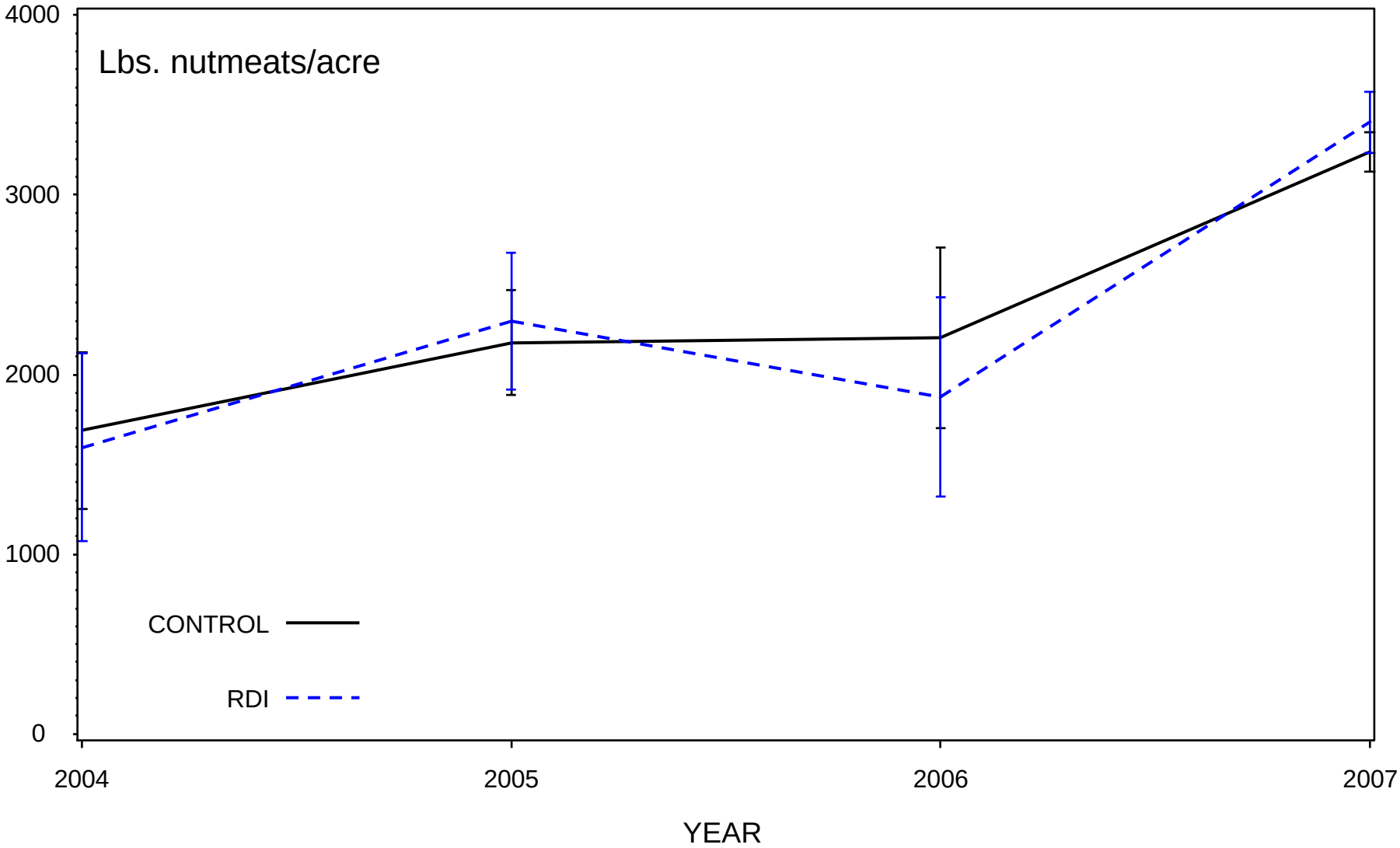
	Irrigation Treatment	
(Measured Value)	Grower	RDI
SWP (bar)	-11.1 ± 1.7	-14.7 ± 2.1
Yield (lbs/ac)	2,812 ± 787	2,858 ± 751
Nut Size (g)	1.22 ± 0.19	1.21 ± 0.20

Four year (2001 – 2004) harvest effects summary

Location	Hull rot (strikes/tree)		Days RDI advance in HS	Other effects
	Grower	RDI		
Corning (silt)	0.0	0.0	5	
Corning (gravel)	0.0	0.0	6	
Chico	1.1	2.2	0	
Arbuckle	0.0	0.0	0	
Dixon	4.4	2.4	1	60% mummy reduction, '02
Madera	20.1	5.1	4	Grower required 2 shakes, '02
Kern	24.0	17.5	0	50% sticktight reduction, '03, '04

Magnum Ranch, Lassen Land co. RDI study.

Nutmeat yields, 2004 - 2007



Benefits of RDI (mild stress)
for almonds during hull split:

1) Speed up Hull Split (use water as a management tool)
2) Reduce Hull rot
3) Reduce Sticktights (Improve Harvestability)
4) Save Water
5) No negative impact on yield