Innovations in Agricultural Water Management

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Topics

Systems

1) Management
2) Changing

Irrigation Scheduling

1) Soil monitoring; Water budget
2) Plant monitoring

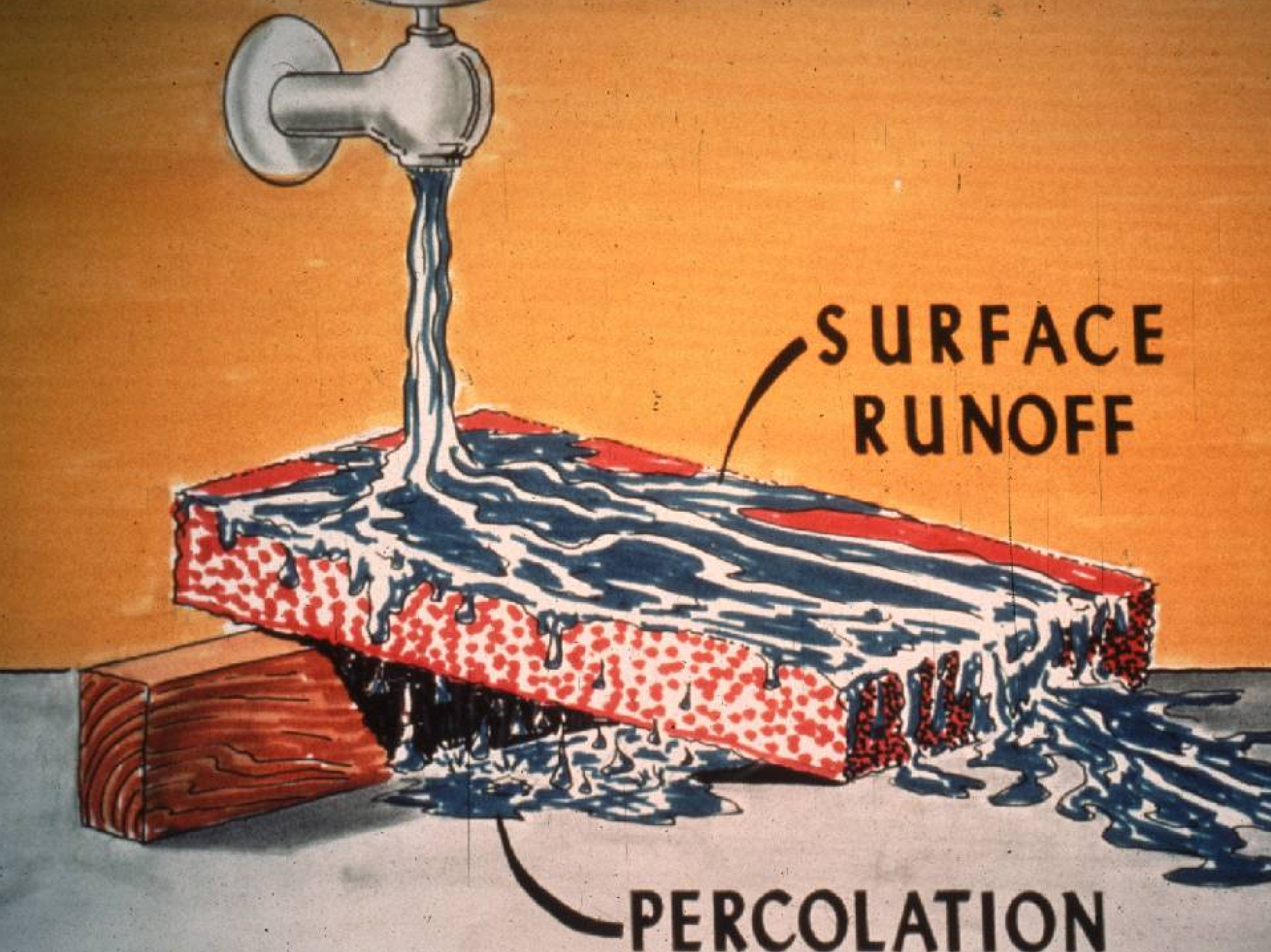
Reducing Consumptive Use

Future

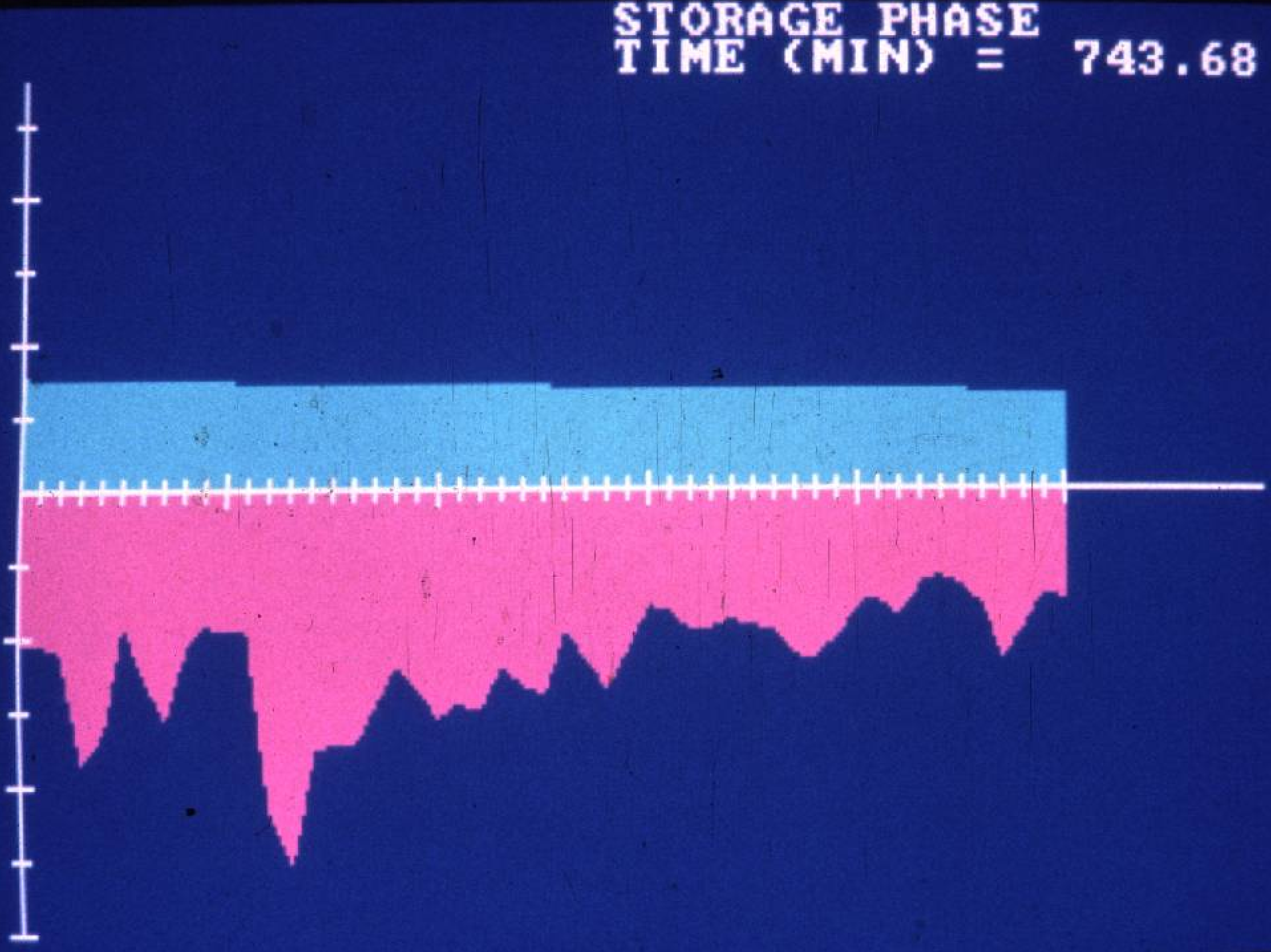
Traditional approaches for reducing agricultural water use: Systems.

1. Improving management.

2. Changing from gravity to pressurized.


SURFACE
RUNOFF
PERCOLATION


© DN


STORAGE PHASE
TIME (MIN) = 743.68


www.nebraskaphotos.com

Systems

1. Improve management.

2. Changing to pressurized.

Can improve application uniformity; i.e. reduce losses to deep percolation and runoff, but does this reduce the consumptive use of water?

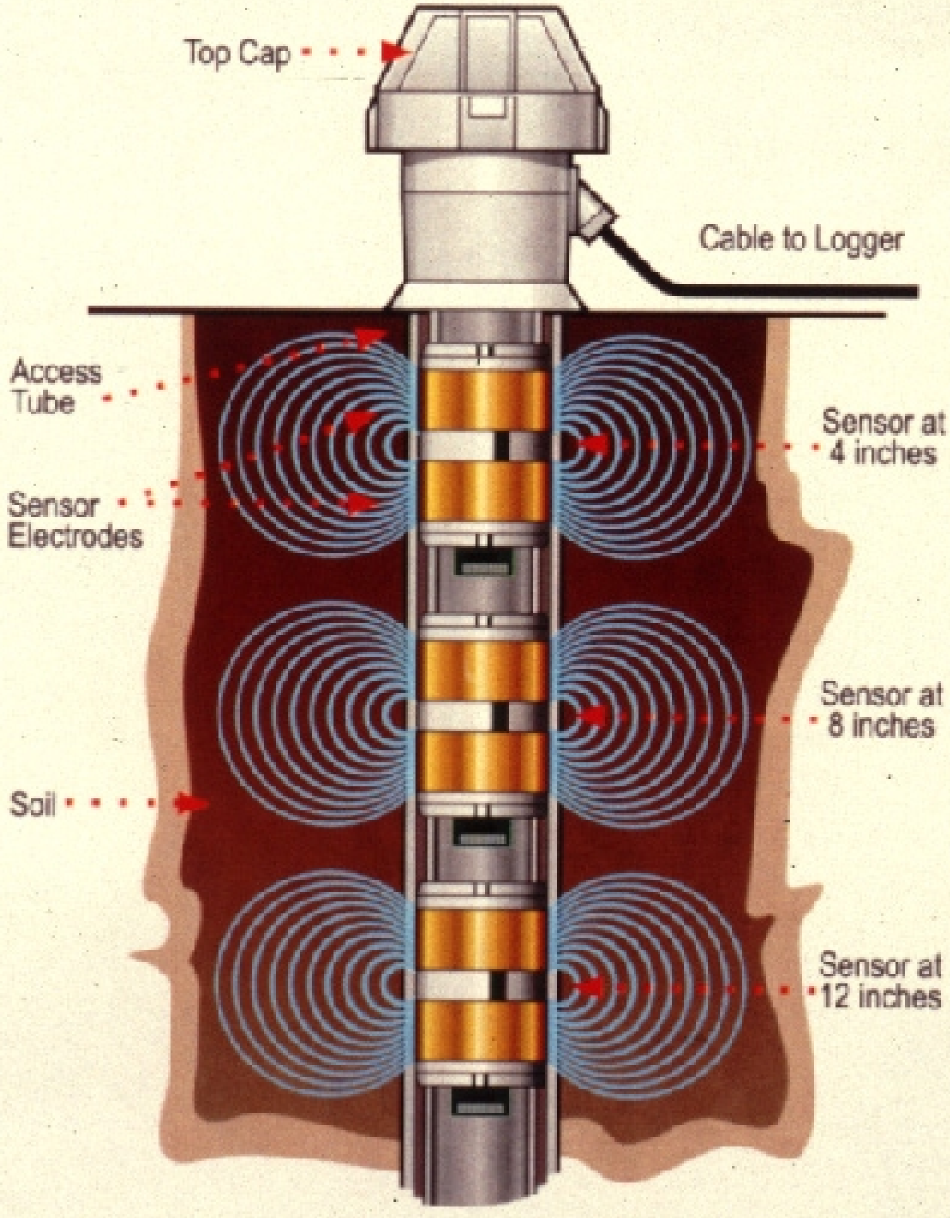
Traditional Irrigation Scheduling Concepts

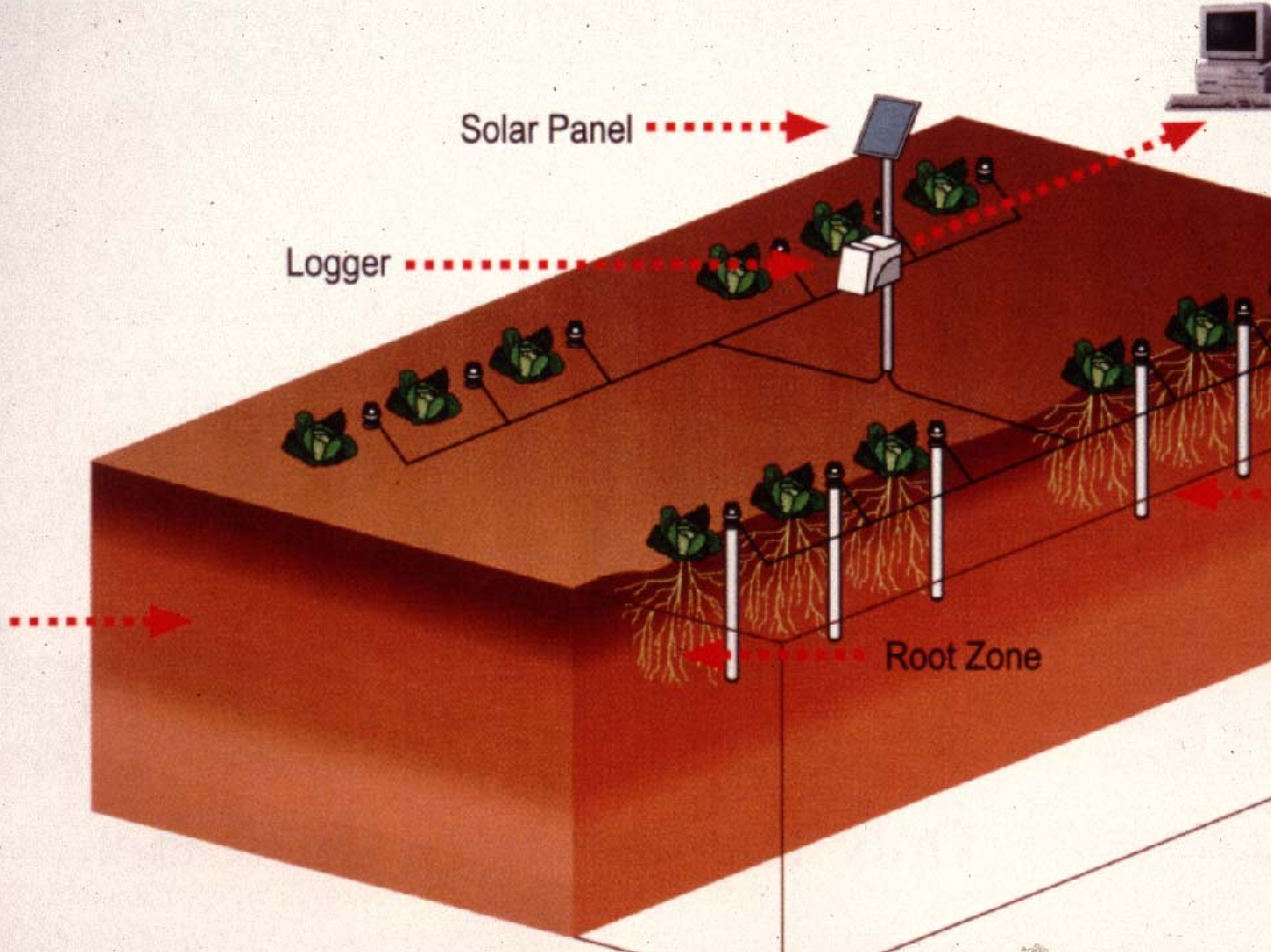
1) Soil monitoring.
2) Water budget.


WATERMARK

EnviroSCAN Probe

Cut-away diagram to the 12 inch sensor. Sensors are available for depths of up to 216 inches.





Solar Panel
Logger
Root Zone

Shortcomings of Soil Monitoring

1) Accuracy of measurement.
2) Few measurements per acre.
3) Interpretation of data.
4) Costs.

Water Budget

ETc = Kc x ETo

Orchard Water Use	=	Crop Coefficient	x	Reference Crop Water Use

California Irrigation Management Information System

Department of Water Resources

CIMIS (California Irrigation Management Information System)

Daily Report

Rendered in ENGLISH Units.
February 10, 2003 - February 16, 2003
Printed on February 17, 2003

Porterville - San Joaquin Valley - Station 169

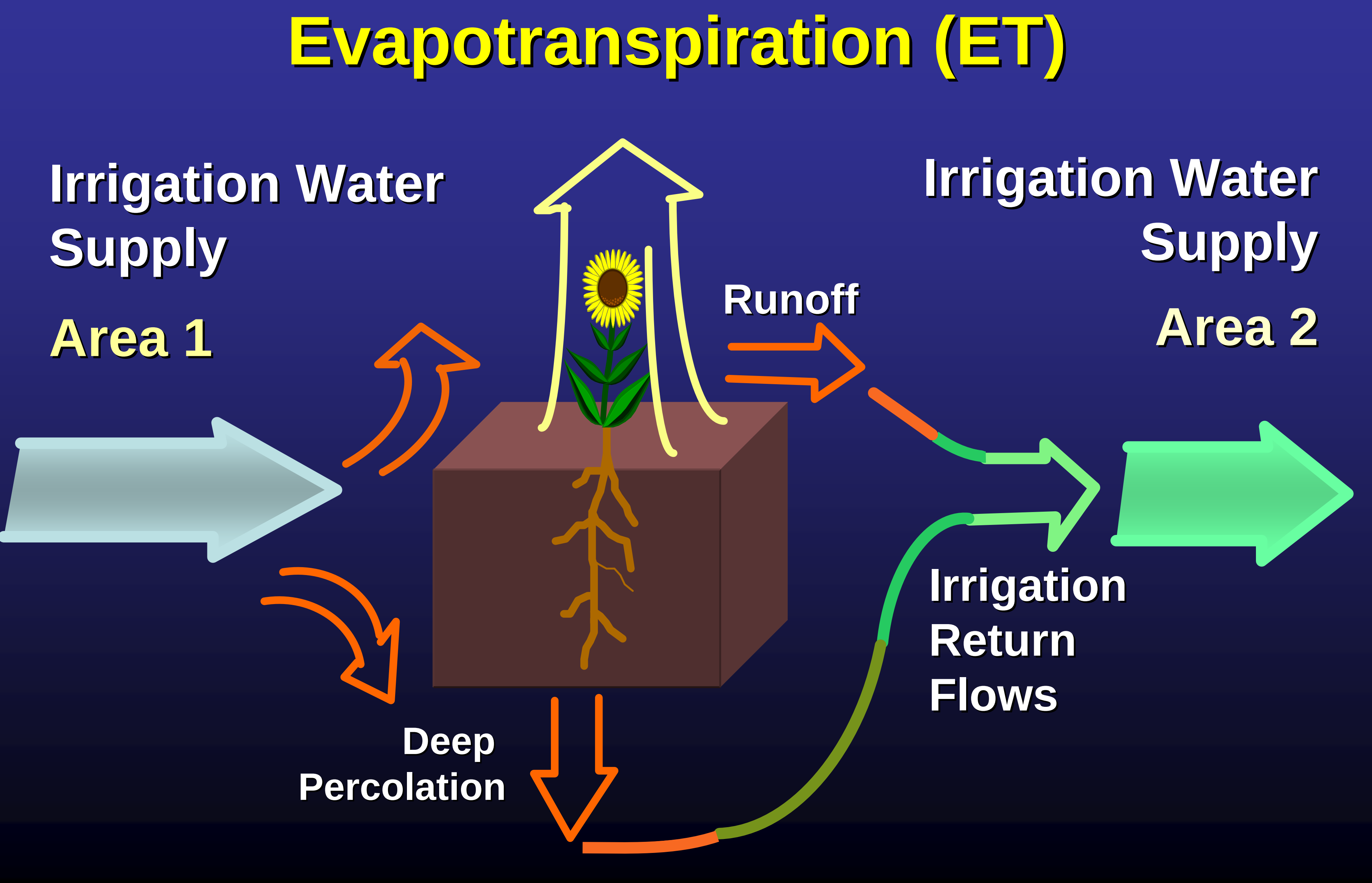
Date	CIMIS ETo (in)	Precip (in)	Sol Rad (Ly/day)	Avg Vap (mBars)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Max Rel Hum (%)	Min Rel Hum (%)	Avg Rel Hum (%)	Dew Pt (° F)	Avg wSpd (MPH)	Wnd Run (miles)	Avg Soil Temp (°F)
02/10/2003	0.08	0.00	304	6.2	62.2	29.3	46.1	85	32	59	32.4	3.1	73.7	50.6
02/11/2003	0.08	0.11	298	9.5	64.5	43.5	52.0	88	49	72	43.1	4.2	101.4	51.2
02/12/2003	0.00	0.66	47	11.7	55.0	44.7	50.9	94	88	92	48.7	3.5	85.4	52.3
02/13/2003	0.08	0.01	306	12.9	66.4	47.0	56.8	94	63	81	51.2	3.2	76.5	53.0
02/14/2003	0.03	0.00R	67	12.5	62.6	32.0	57.2	93	67	78	50.4	2.8	66.5	54.5
02/15/2003	0.07	0.00	279	12.3	66.8	49.6	56.9	92	58	78	49.9	2.9	70.0	55.0
02/16/2003	0.06	0.13	227	11.5	63.3	47.8	55.4	92	59	77	48.2	3.4	81.8	55.9
Total	0.40	0.91	218	10.9	63.0	42.0	53.6	91	59	77	46.3	3.3	79.3	53.2

Flag Legend

Shortcomings of Water Budget

1) Accuracy of CIMIS ETo.
2) Accuracy of Kc.
3) Applicability of regional data to a specific farm.
4) Application efficiency estimates.
5) Usefulness for RDI limited.

Reducing Losses ≠ "Saving" Water



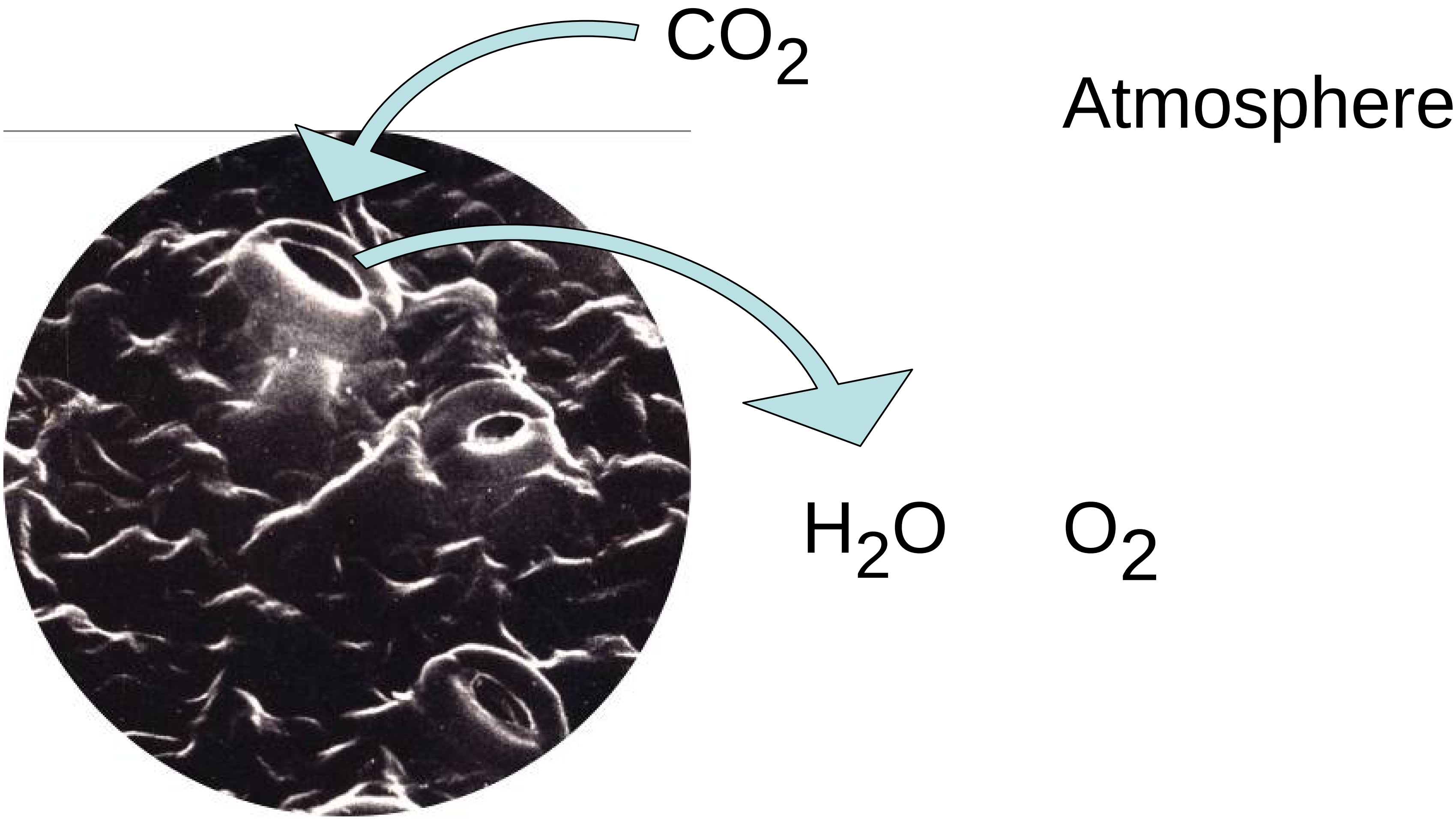
To reduce consumptive use, only options are:

decrease

E and/or T

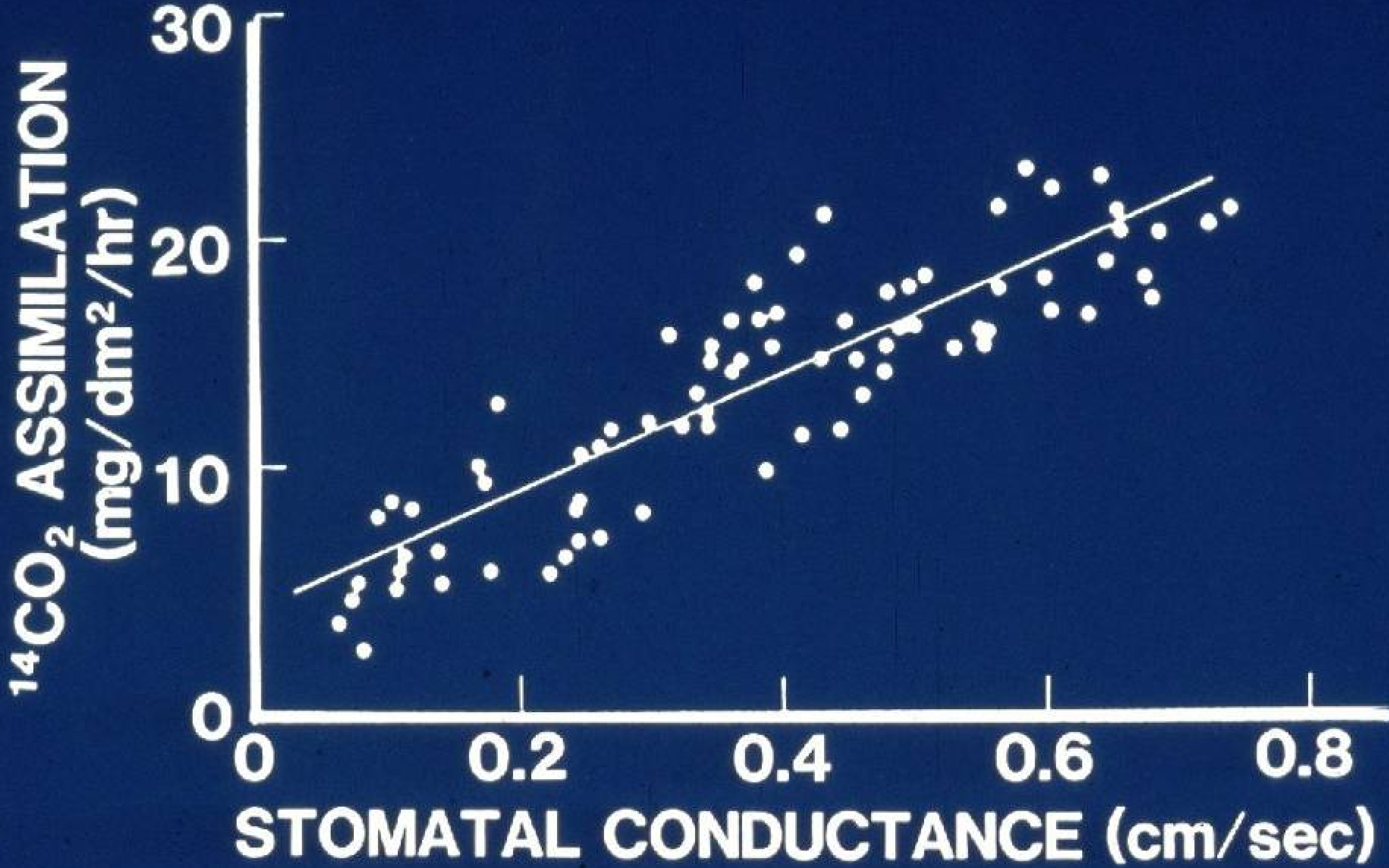

CATERPILLAR
QUINN

Can we reduce Transpiration?



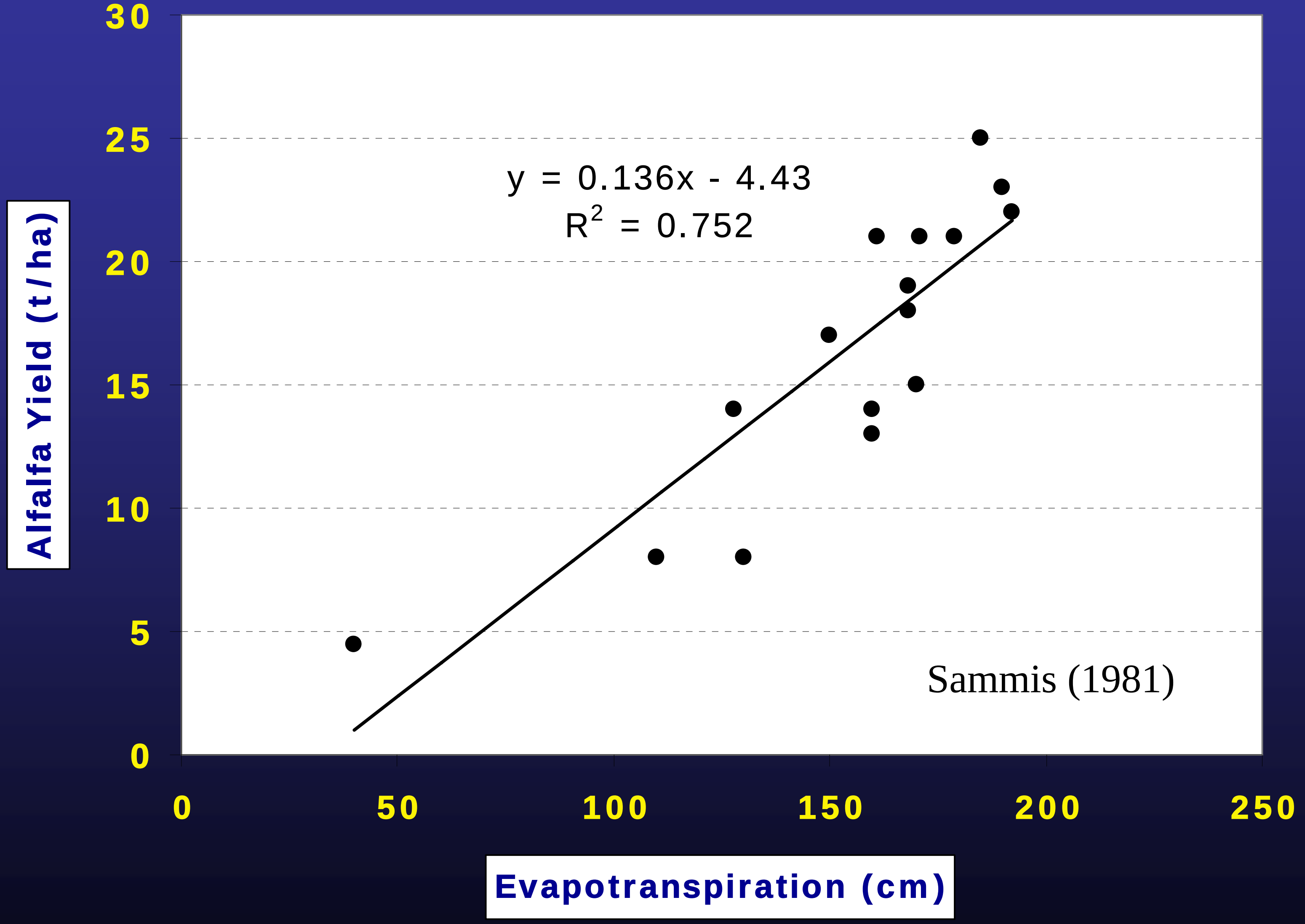
$$6\ CO_2 + 12\ H_2O \xrightarrow{\text{Light}} C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

(Sugar)

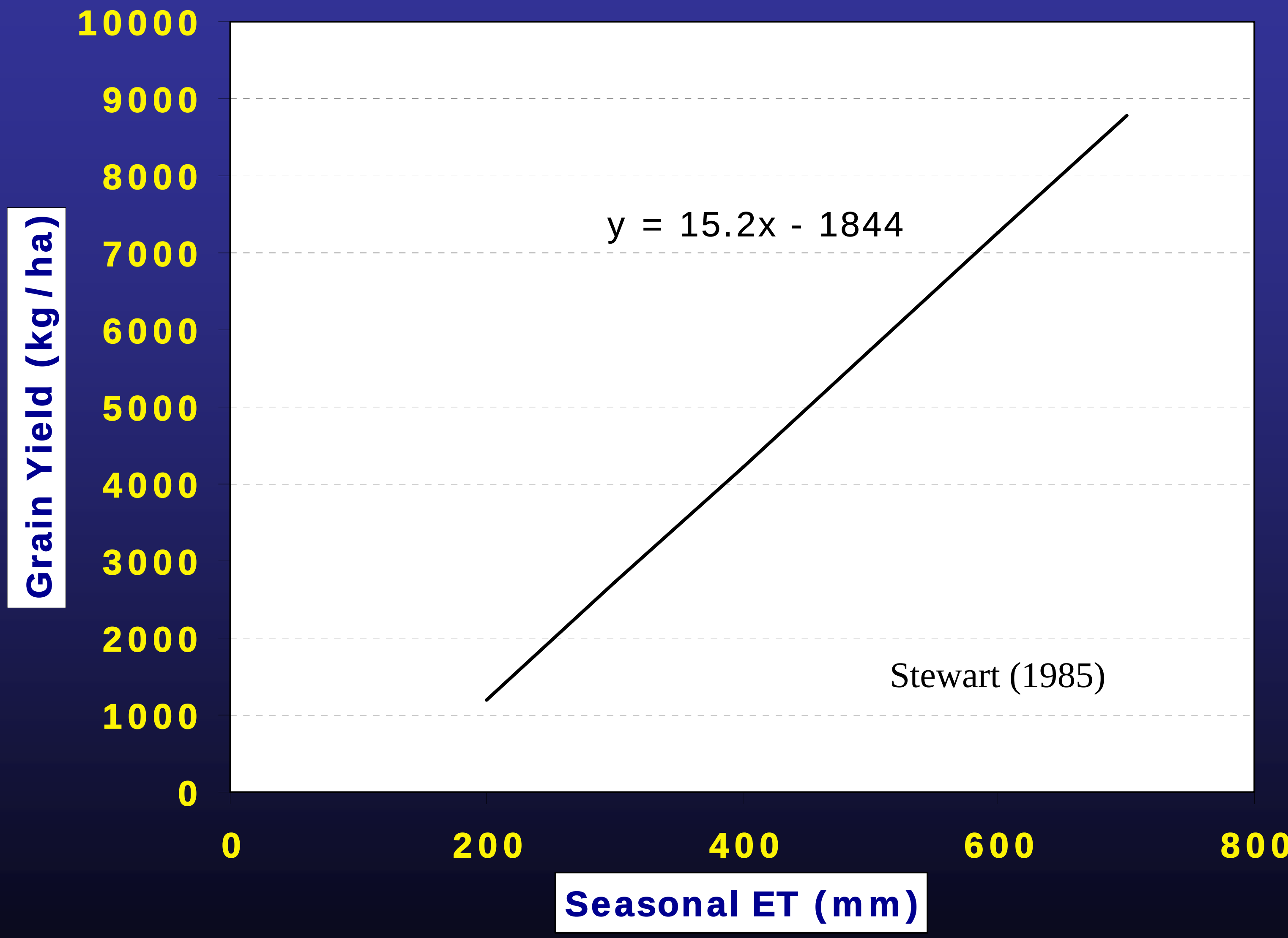


30
20
10
0
$^{14}CO_2$ ASSIMILATION (mg/dm^2/hr)
0
0.2
0.4
0.6
0.8
STOMATAL CONDUCTANCE (cm/sec)

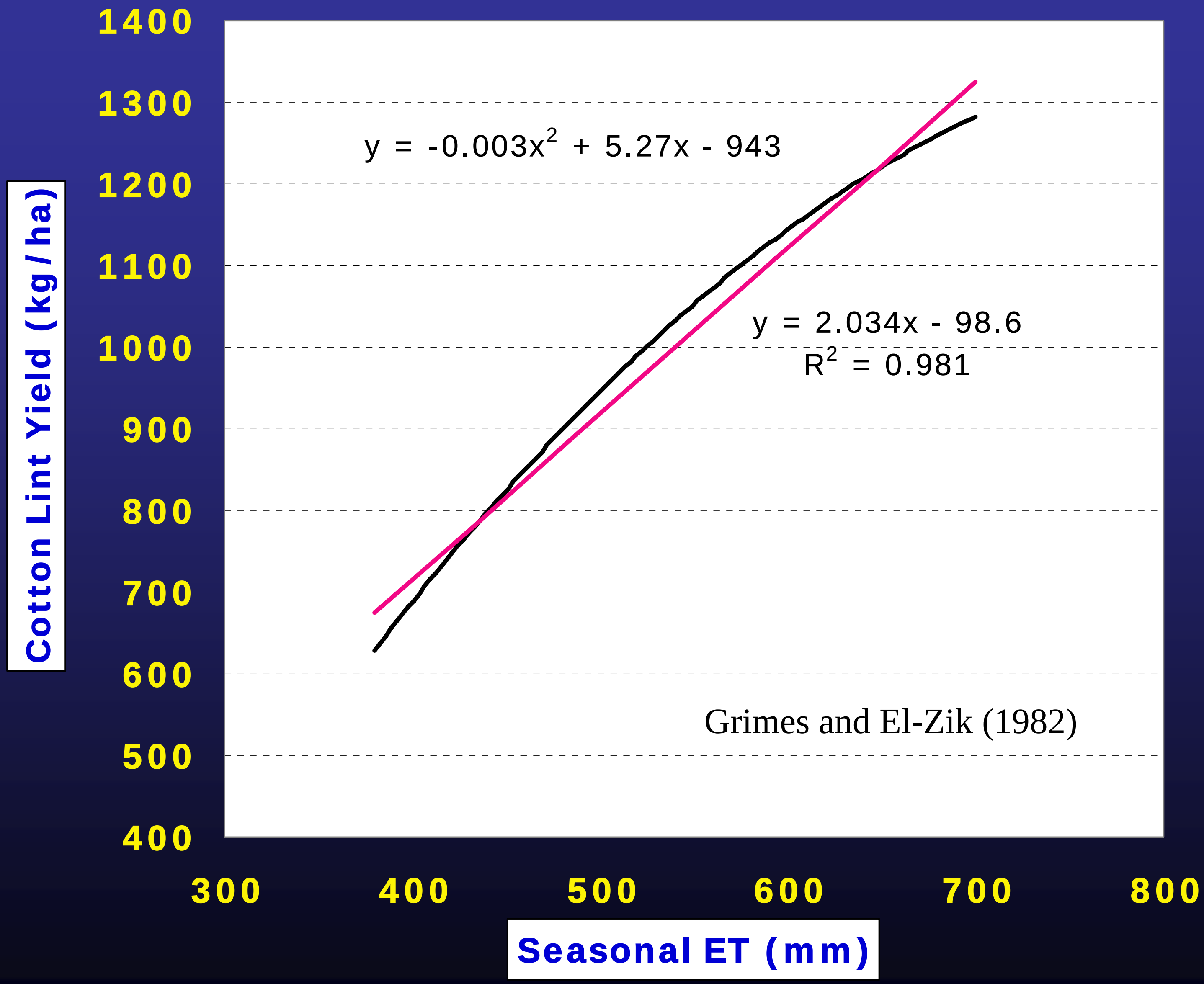
Alfalfa Production Function; New Mexico



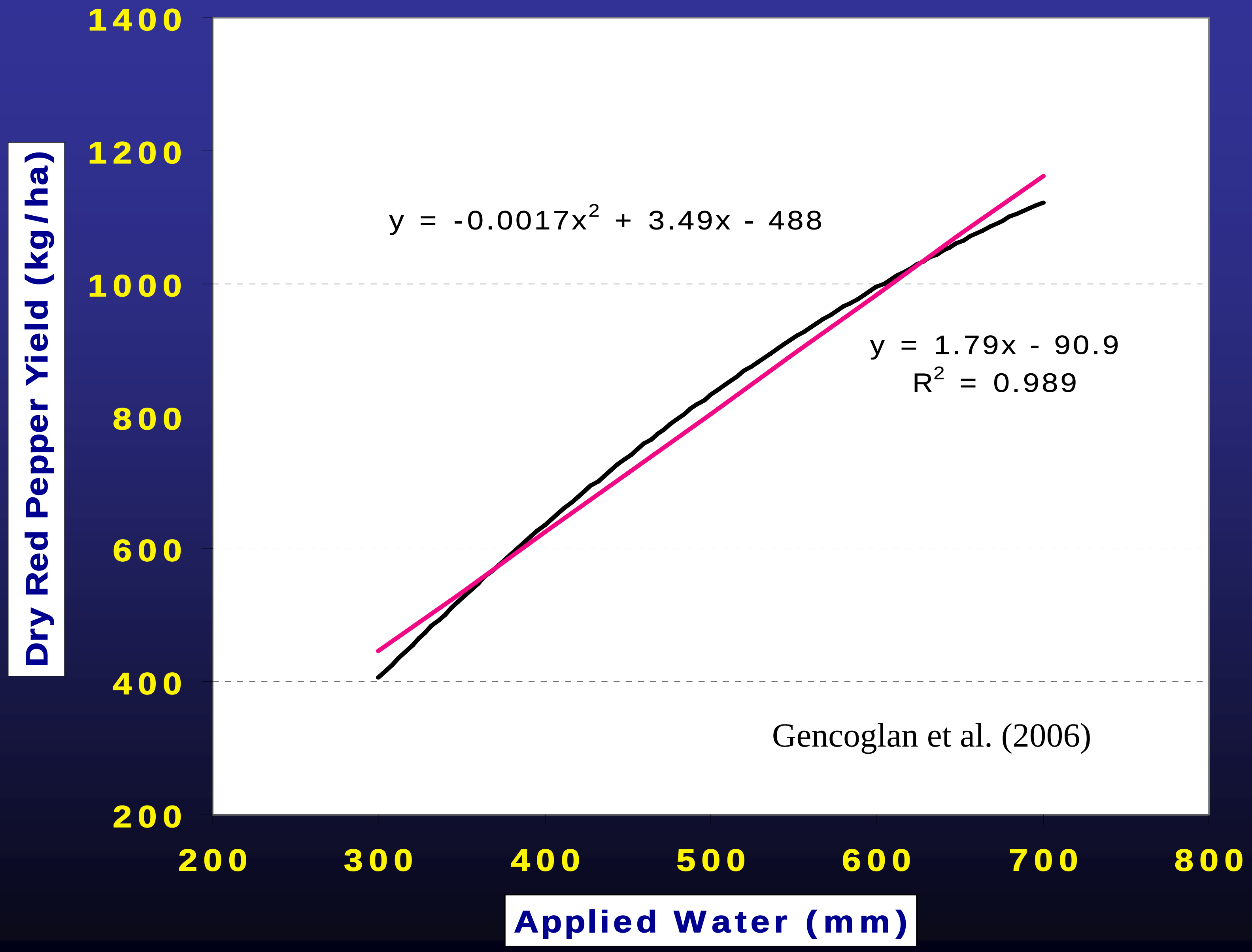
Sorghum Production Function; S. Great Plains

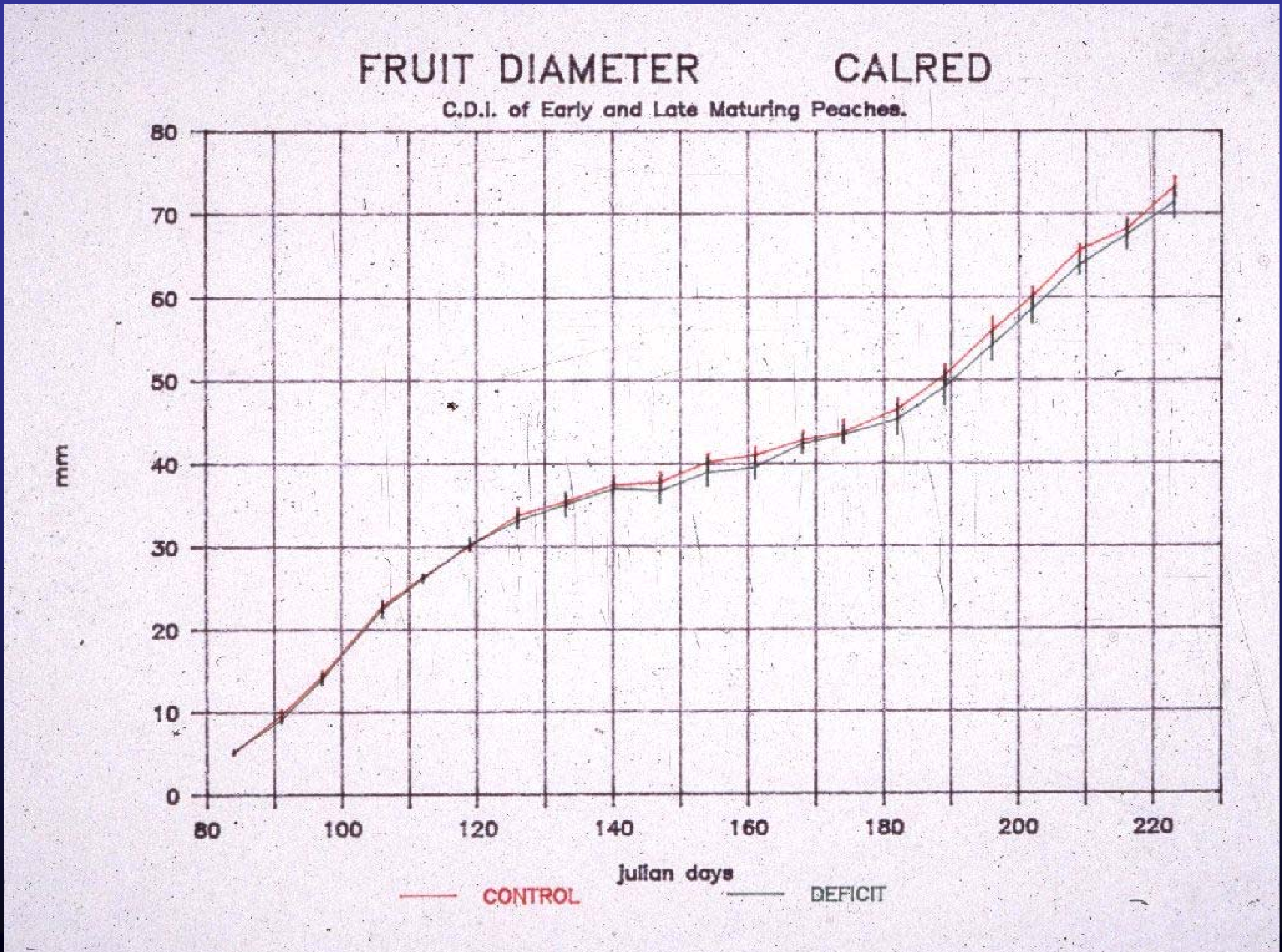


Cotton Production Function; S. J. Valley



Red Pepper Production Function; Turkey

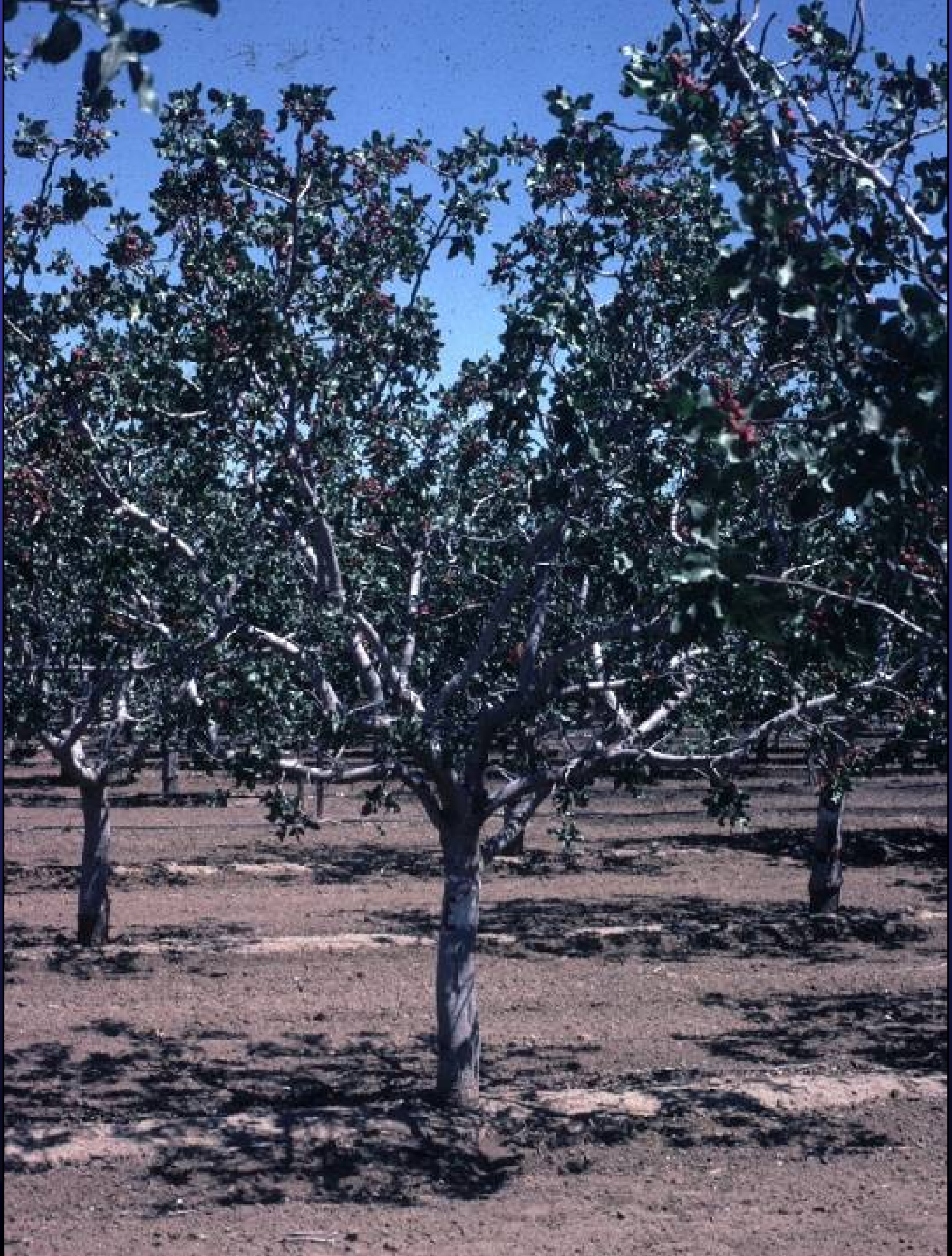


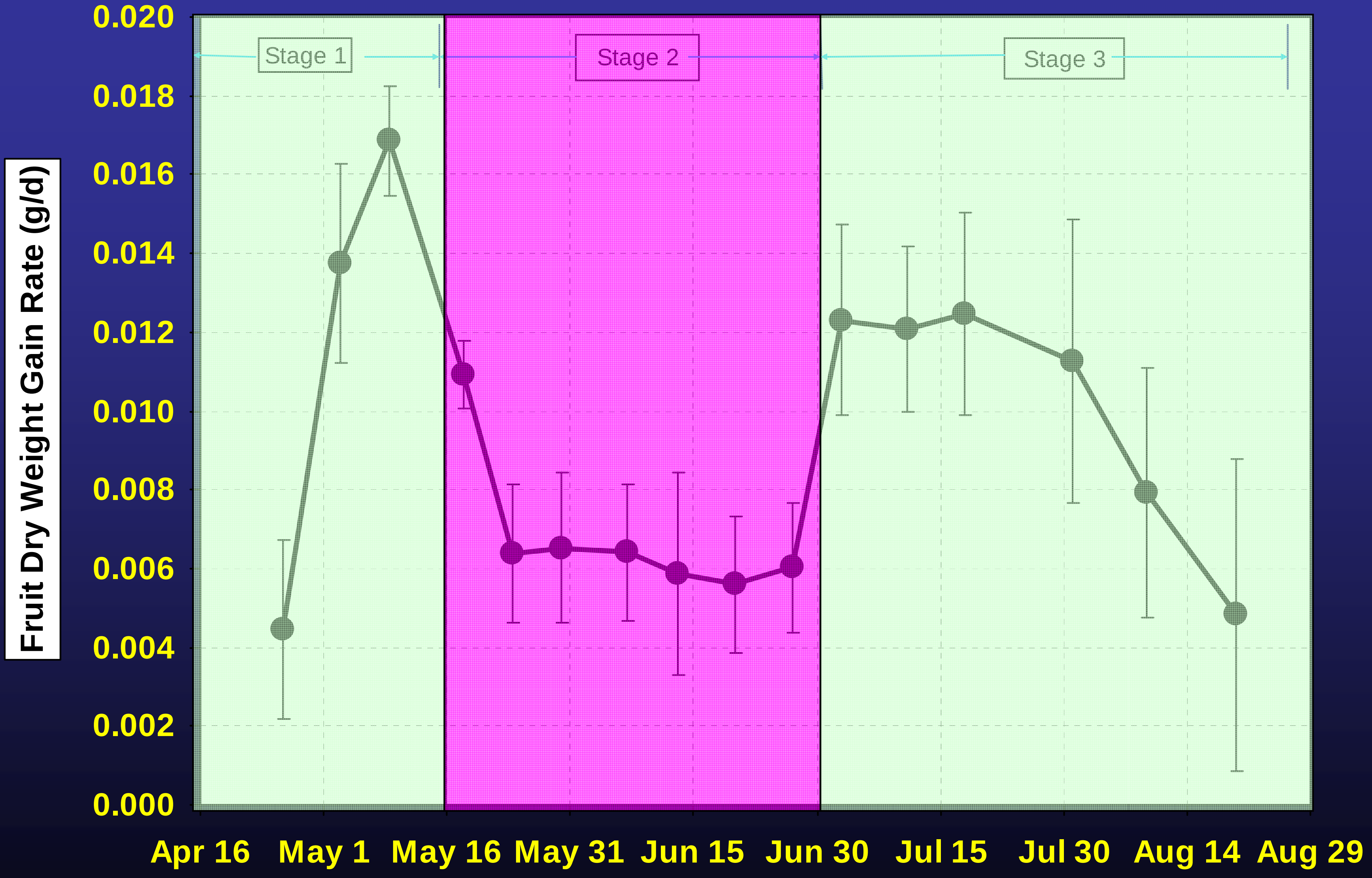

FRUIT DIAMETER CALRED
C.D.I. of Early and Late Maturing Peaches.
mm
0
10
20
30
40
50
60
70
80
80
100
120
140
160
180
200
220
julian days
CONTROL
DEFICIT

Regulated Deficit Irrigation (RDI)

Planned water deficits at specific crop developmental stages that control vegetative growth without negatively affecting production.

Goals: Solve horticultural problems;
Reduce water use;
Achieve higher farm profits.




Fruit Dry Weight Gain Rate (g/d)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Stage 1
Stage 2
Stage 3
Apr 16
May 1
May 16
May 31
Jun 15
Jun 30
Jul 15
Jul 30
Aug 14
Aug 29

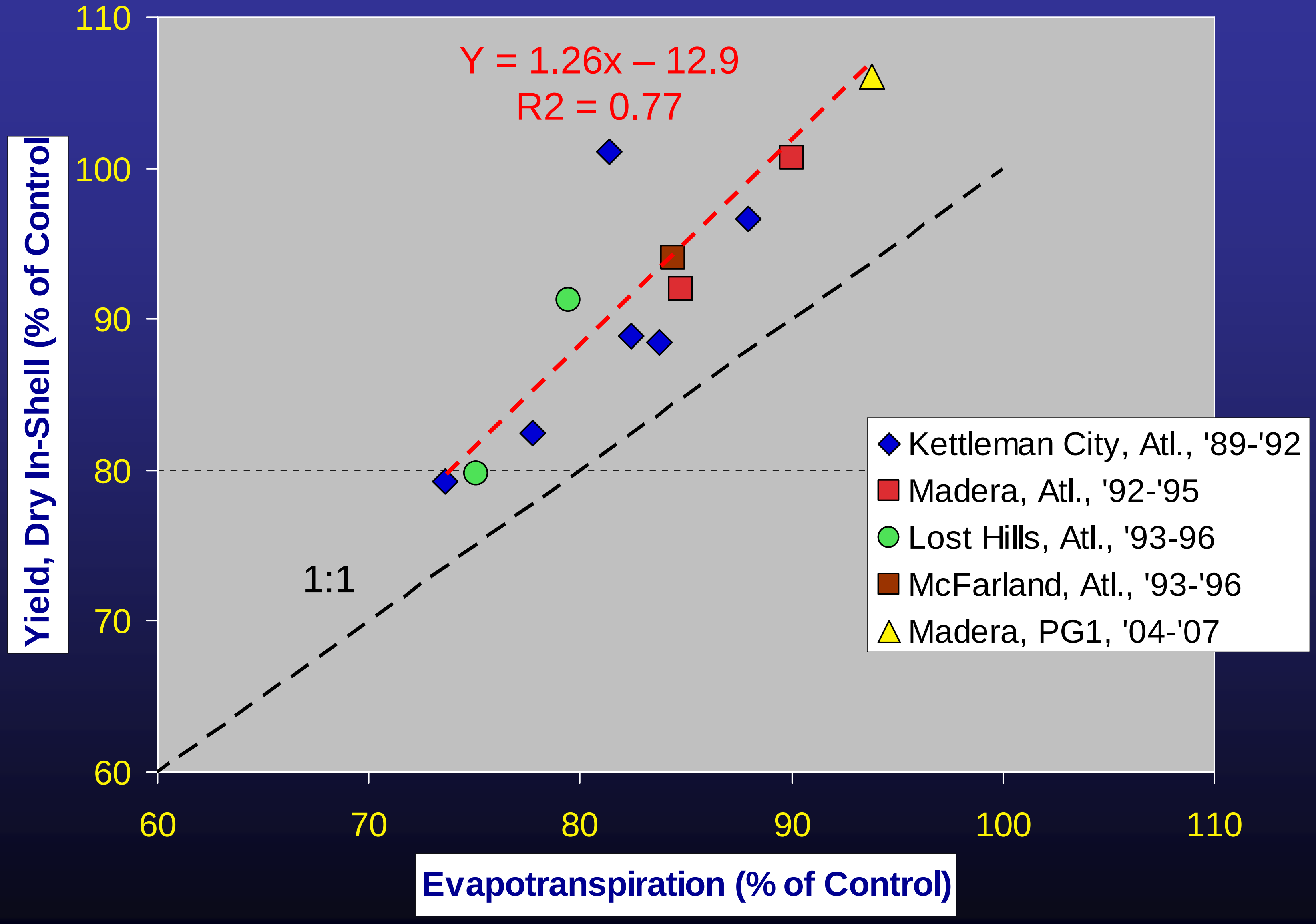
Mean (1991-92) Yield and Component Results

Treatment	Split Nut Weight (g/nut)	Blanks and Aborted Nuts (% nut load)	Shell Splitting (% filled nuts)	Total Nut Load (No./tree)	Mechanical Removal of Split Nuts (% splits)	Yield of Dry,Split Nuts at Harvest (lb/acre)	Irrigation Water Use Efficiency (gals H20/lb product)
0% Stage 1	1.24 b*	21.5 ab	87.8 d	12252	85.5 bc	2828 d	296 bc
0% Stage 2	1.29 bc	22.0 ab	73.6 b	10881	91.4 bc	2239 bc	296 bc
0% Stage 3	1.18 a	27.6 c	43.6 a	11187	72.6 a	1014 a	419 a
0% Postharvest	1.30 bc	22.8 abc	78.8 bc	11411	88.8 bc	2451 bcd	350 ab
50% Stage 2; 25% PH	1.30 bc	21.2 ab	81.7 cd	10874	89.5 bc	2744 cd	256 c
Control	1.32 c	22.5 ab	79.5 bc	11457	88.8 bc	2714 cd	333 ab

NSD

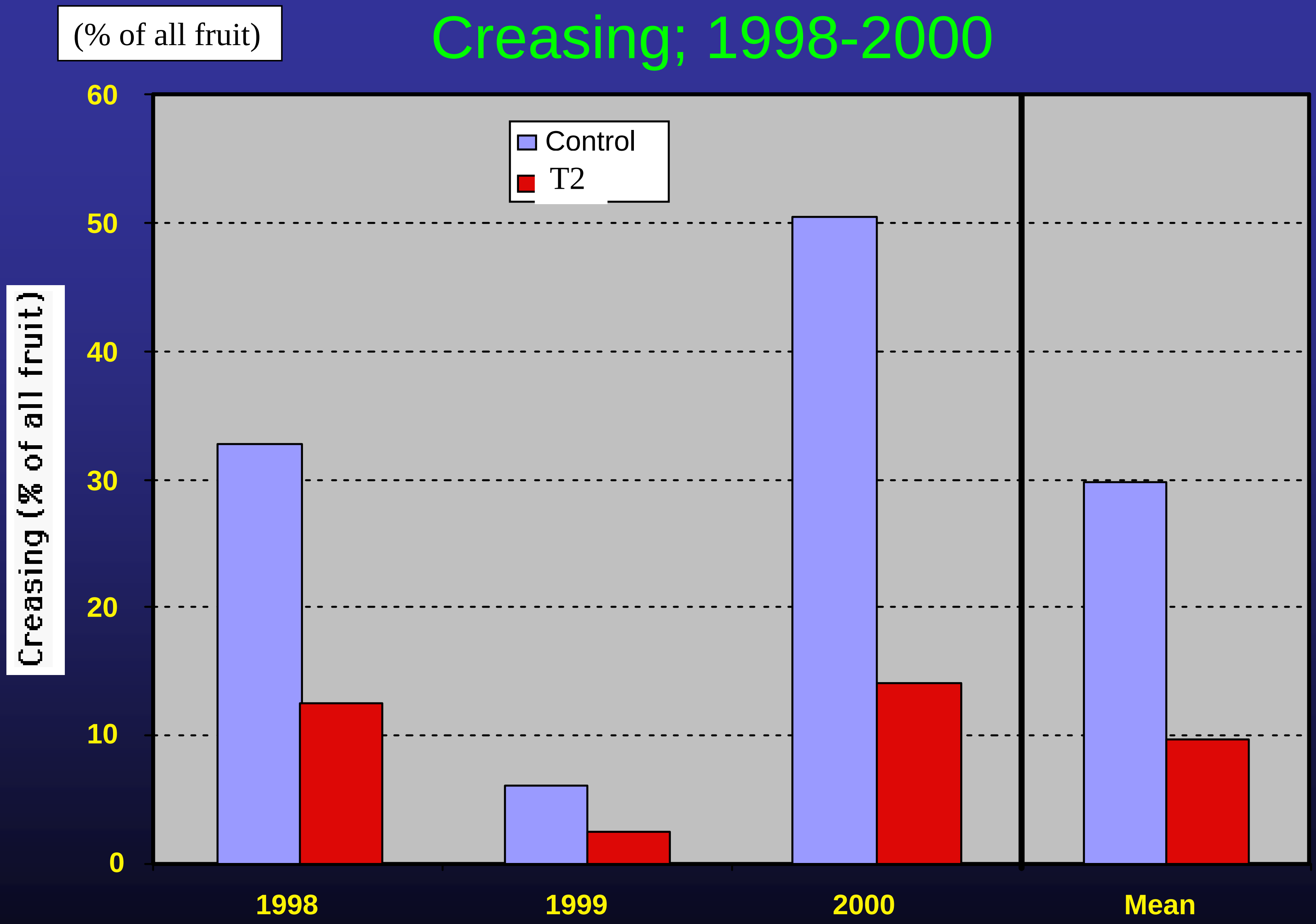
* Values followed by the same letter are not statistically different at p=0.05.

Only Stage 2 and PH Stress

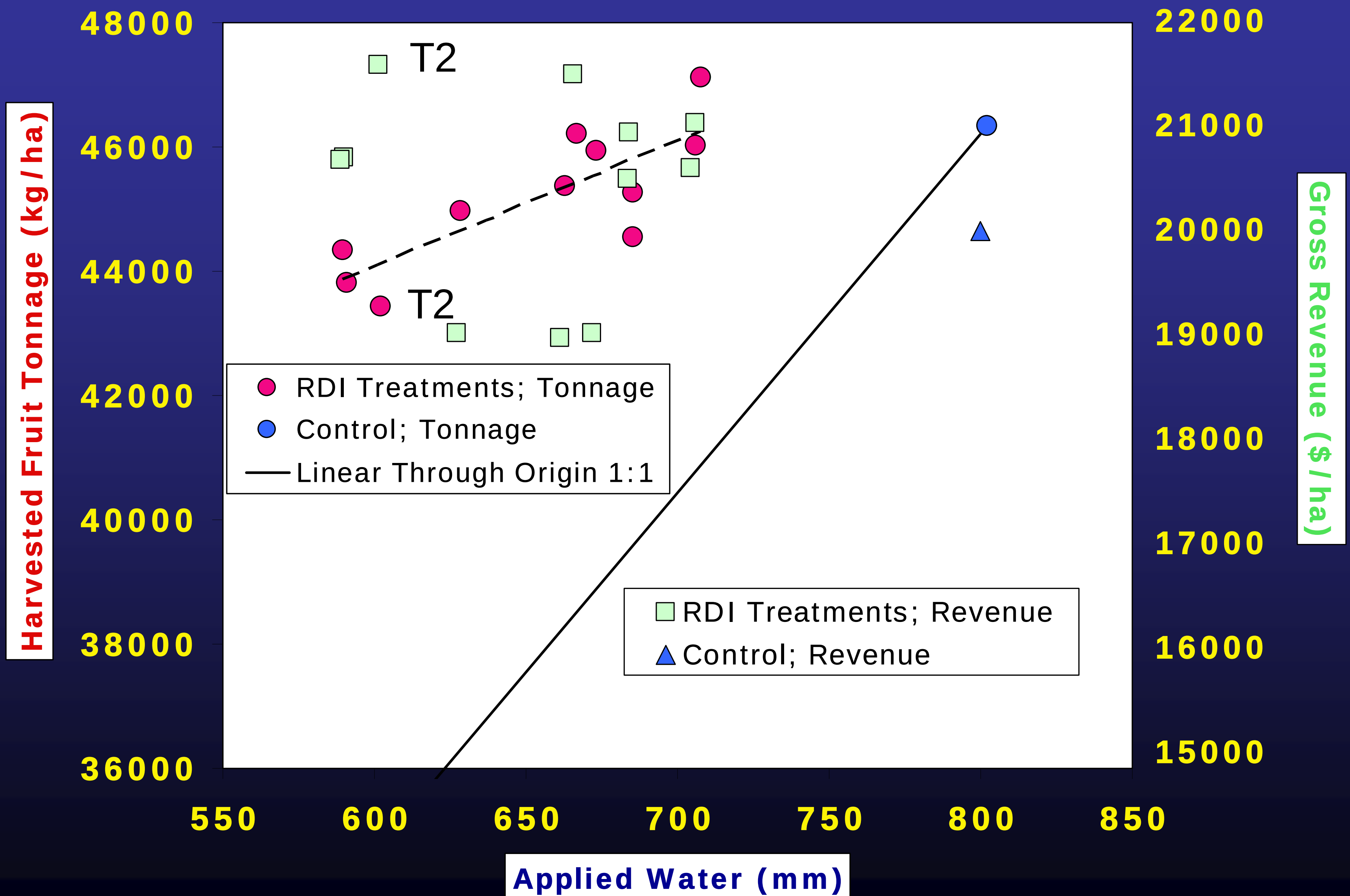


	15	2	3	4	5	6	7	8	9	11	12
Apr 16-30	0	100	100	100	100	100	100	100	100	100	100
May 1-15	0	100	100	100	100	100	100	100	100	100	100
May 16-31	0	25	50	50	100	100	100	100	100	100	100
Jun 1-15	100	25	50	50	100	100	100	100	100	100	100
Jun 16-30	100	25	50	50	100	100	100	100	100	100	100
Jul 1-15	100	25	100	50	0	25	50	25	50	50	100
Jul 16-31	100	100	100	100	0	25	50	25	50	50	100
Aug 1-15	100	100	100	100	100	100	100	25	50	50	100
Aug 16-31	100	100	100	100	100	100	100	100	100	50	100
Sept. 1-15	100	100	100	100	100	100	100	100	100	100	100
Sept. 16-30	100	100	100	100	100	100	100	100	100	100	100
Oct 1-15	100	100	100	100	100	100	100	100	100	100	100
Oct 16-31	100	100	100	100	100	100	100	100	100	100	0
Nov 1-15	100	100	100	100	100	100	100	100	100	100	0
Nov 16-30	100	100	100	100	100	100	100	100	100	100	0
Dec 1-15	100	100	100	100	100	100	100	100	100	100	0
Dec 16-31	100	100	100	100	100	100	100	100	100	100	100
Applied (mm)	646	602	708	667	591	685	706	590	673	663	685
Deficit (mm)	156	200	94	135	211	117	96	212	129	139	117
Water Saved (%)	15%	19%	9%	13%	20%	11%	9%	20%	12%	13%	11%

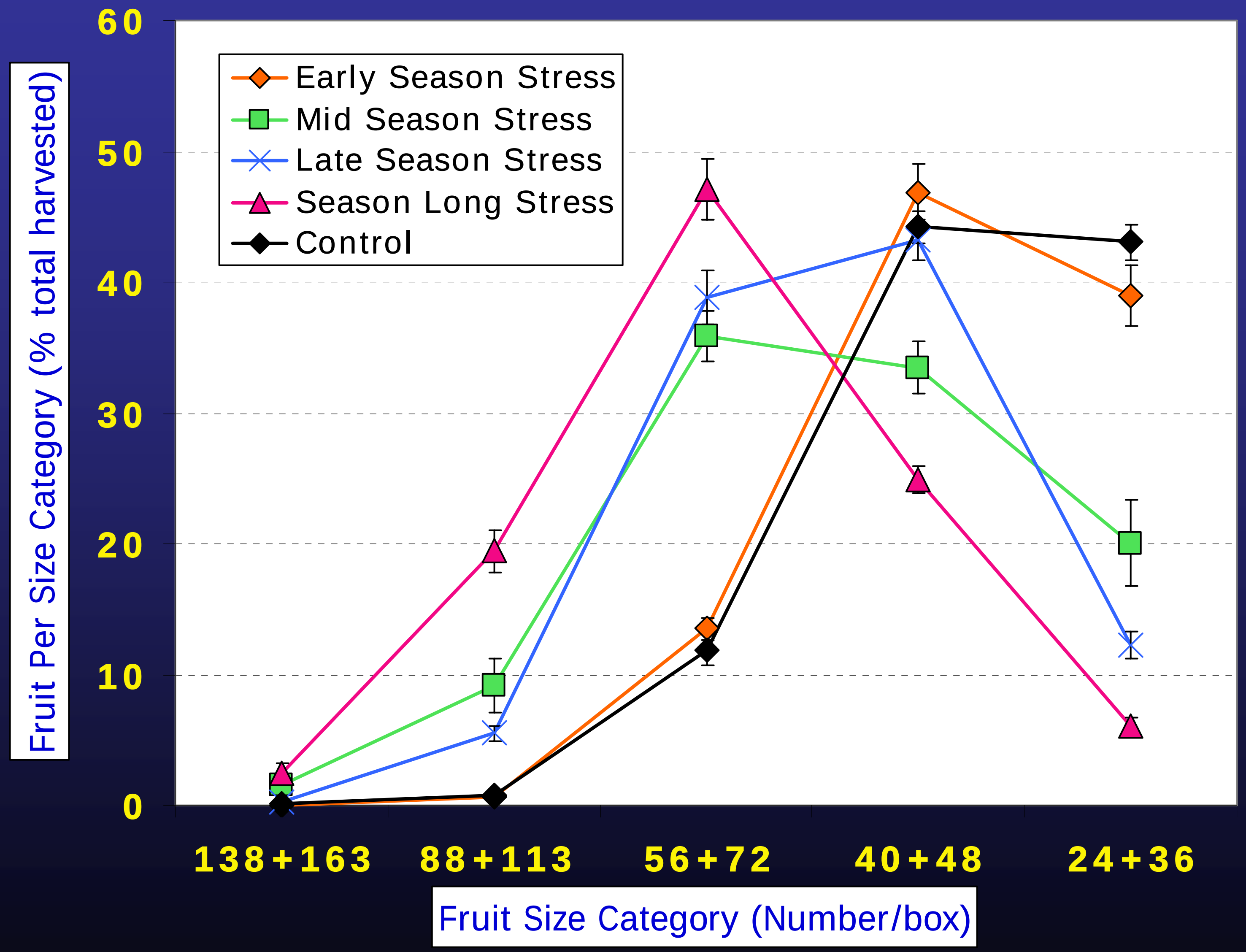
Creasing; 1998-2000



Mean 1998-2000, Navel Oranges, 'Frost Nucellar'



Fancy	$12.26	$12.26	$14.15	$7.50	$5.00	$0.00
Choice	$7.62	$7.62	$6.44	$5.72	$3.00	$0.00



2004-6 Mean Results; Late Harvest Navels

Seasonal Stress Period	2003-5 Mean Applied Water (mm)	Single Fruit Wt. (g)	Harvest Fruit Load (No./tree)	Gross Fruit Yield (kg/ha)	Gross Revenue ($/ha)	Water Productivity (kg/m3)	Irrigation-Revenue Productivity ($/m3)
Early	610	379 c*	138 a	30270	7571 a	4.77 ab	1.24 ab
Mid	635	310 b	215 c	34620	11253 ab	5.29 bc	1.85 bc
Late	742	301 b	201 bc	34130	16159 c	4.46 ab	2.24 c
Season Long	431	257 a	198 bc	28630	15358 bc	6.37 c	3.63 d
Control	944	392 c	155 ab	34000	8924 a	3.50 a	0.98 a

* Values in each column not followed by the same letter are statistically different based on Fisher's LSD at 5%.

** NSD; No significant differences.

The Fresno Bee
Special Report
December 15, 2002

LAST GASP

A Fresno Bee Special Report on

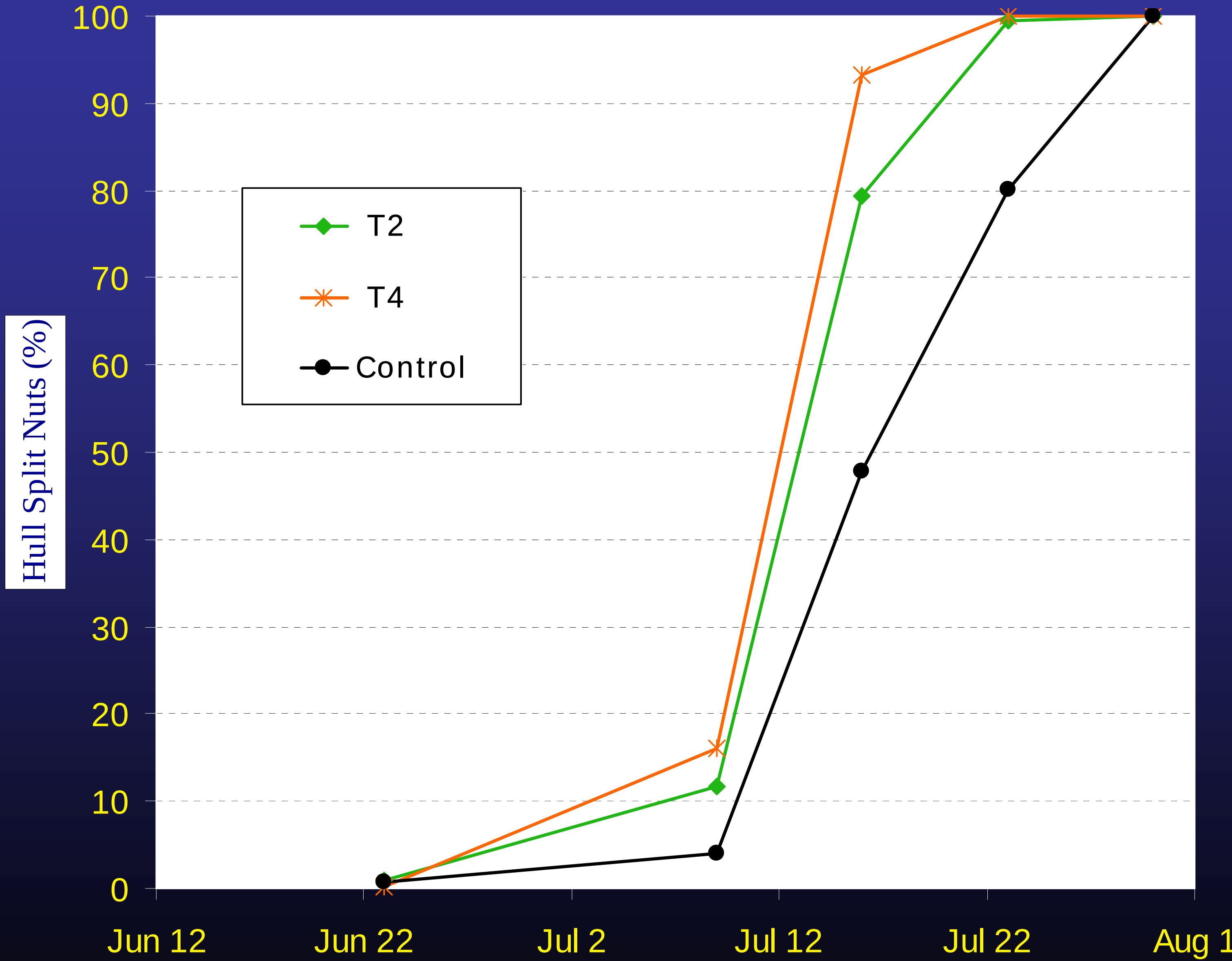
VALLEY AIR QUALITY

Last Gasp

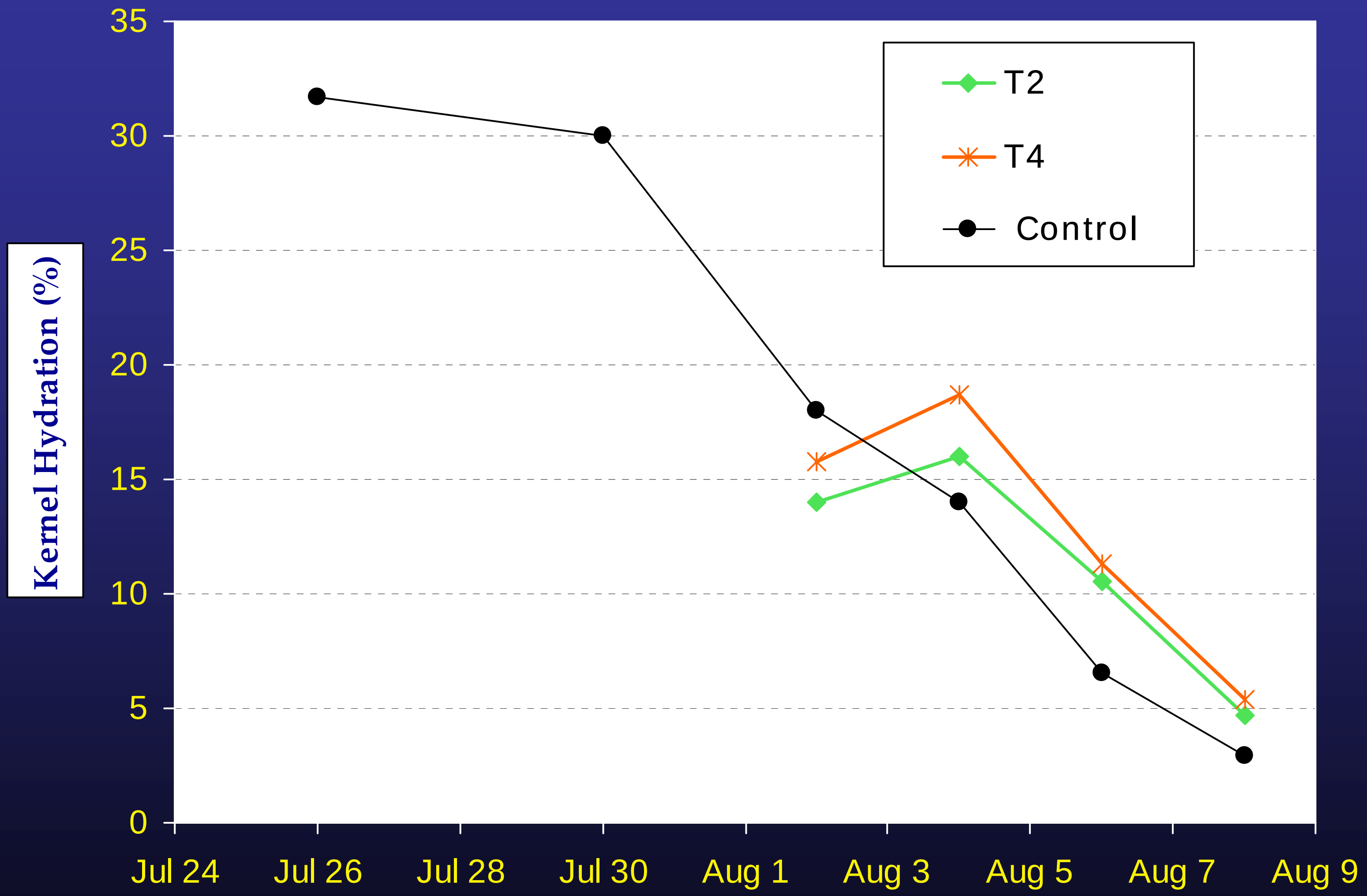
We live in what many now say is the nation's worst air basin. What are the challenges to improving the air in the coming years?

Can we exploit horticultural impacts of water stress to eliminate ground drying and thus, eliminate dust, kernel contamination with soil borne pathogens, AND better maintain tree water status during and after harvest?

Hull Splitting; Non Pareil; 2004



Kernel Hydration; Non Pareil; 2004



Non Pareil; 2004

Irrigation Regime	Applied Water (mm)	Kernel Dry Wt. (g)	Kernel (%)	Fruit Load (#/tree)	Yield 5% H_2O (kg/ha)	Water Productivity (g/m3)	Sticktight Nuts (No./tree)
T2	1033	1.49 ab	30.3	7010	2324	225	19.6
T4	979	1.44 a	30.0	7080	2246	229	25.0
Control	1119	1.60 b	30.9	6510	2319	207	22.2
			NSD	NSD	ND	NSD	NSD

Hull Rot; Teviotdale et al.; 1997

	Hull Rot Strikes (#/tree)	Dead Wood (inches/tree)	Kernel Wt. (gms)	Shell Wt. (gms)	Hull Wt. (gms)	Whole Unit Wt. (gms)
Control	297	508	1.19	0.93	4.12	6.24
RDI	49	33	1.14	0.95	4.19	6.28
RDI % Di	-84.5	-93.5	-4.2	+2.2	+1.7	+0.6
	*	*	NSD	NSD	NSD	NSD

RDI Management Options (Triggers)

1. Water Budget
2. Soil-based-instruments
3. Plant-based
   a. Leaf water potential.
   b. Fruit or other tissue growth.
   c. Canopy temperature


MinuteMaid

Table 7.2

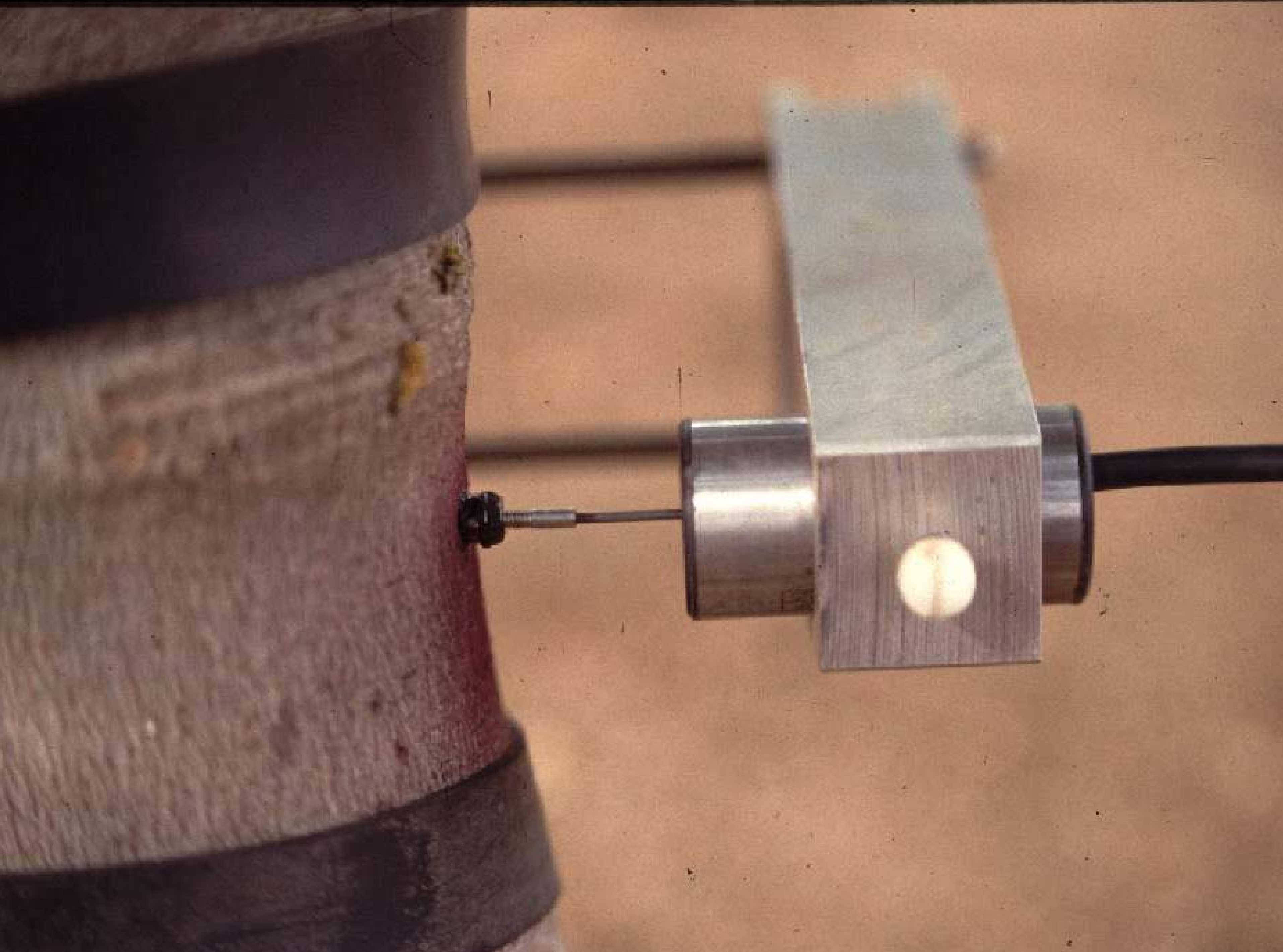
Relative Sensitivity to Water Stress of Various Plant Processes

Process affected	Sensitivity to stress: Very sensitive → Insensitive; Reduction in tissue Ψ_w required to affect the process (MPa): 0 — 1 — 2
Cell growth (−)	
Wall synthesis[b] (−)	
Protein synthesis[b] (−)	
Protochlorophyll formation[c] (−)	
Nitrate reductase level (−)	
ABA synthesis (+)	
Stomatal opening[c] (−)	
mesophytes	
some xerophytes	
CO_2 assimilation[c] (−)	
mesophytes	
some xerophytes	
Respiration (−)	
Xylem conductance[d] (−)	
Proline accumulation (+)	
Sugar level (+)	

Shortcomings of the Pressure Chamber

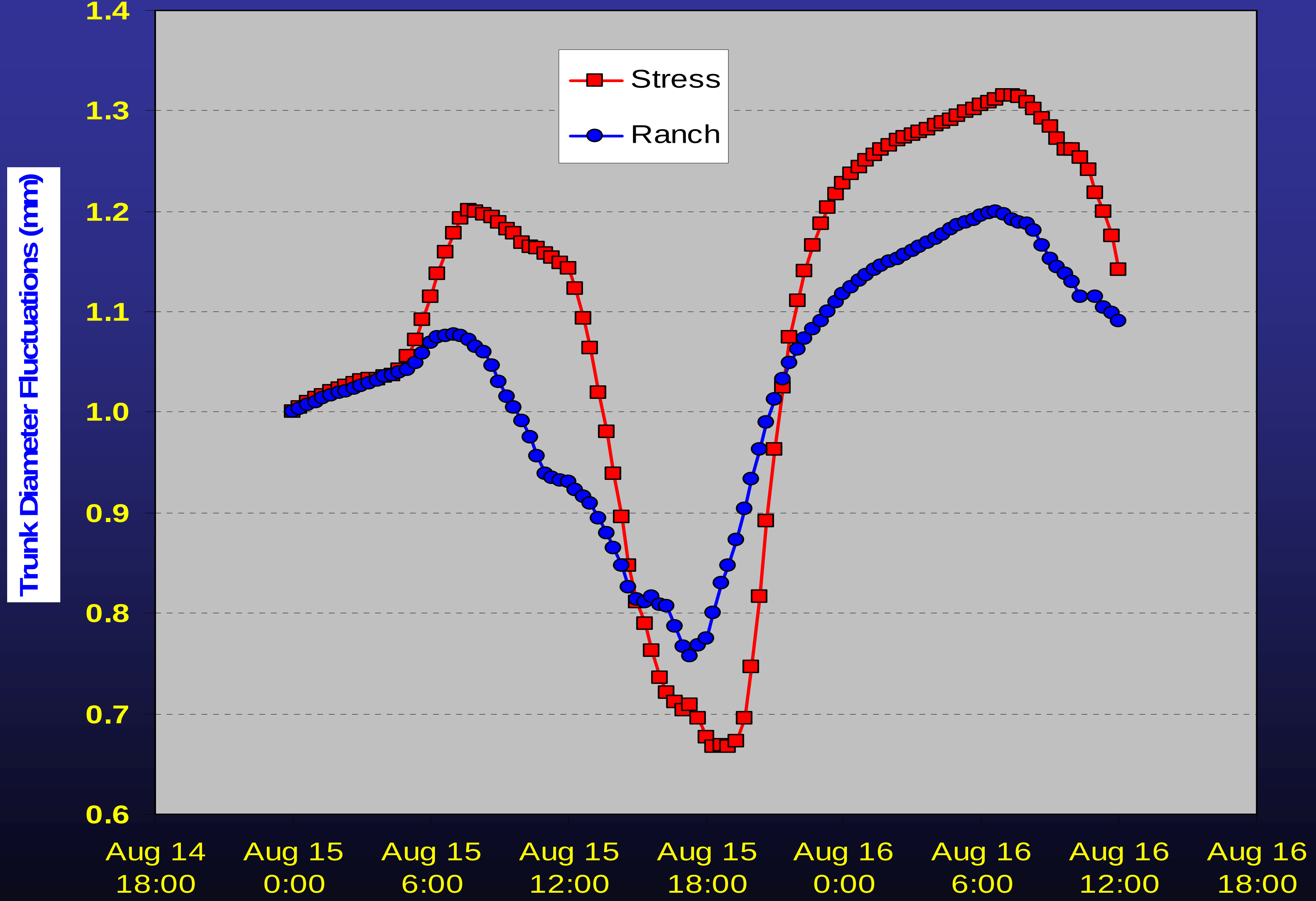
1) Manually taken; can’t be automated.
2) Requires trips to the field and operator.
3) Limited time period to take measurements; noon-2:30 pm.

Thus, can’t adequately characterize a field.

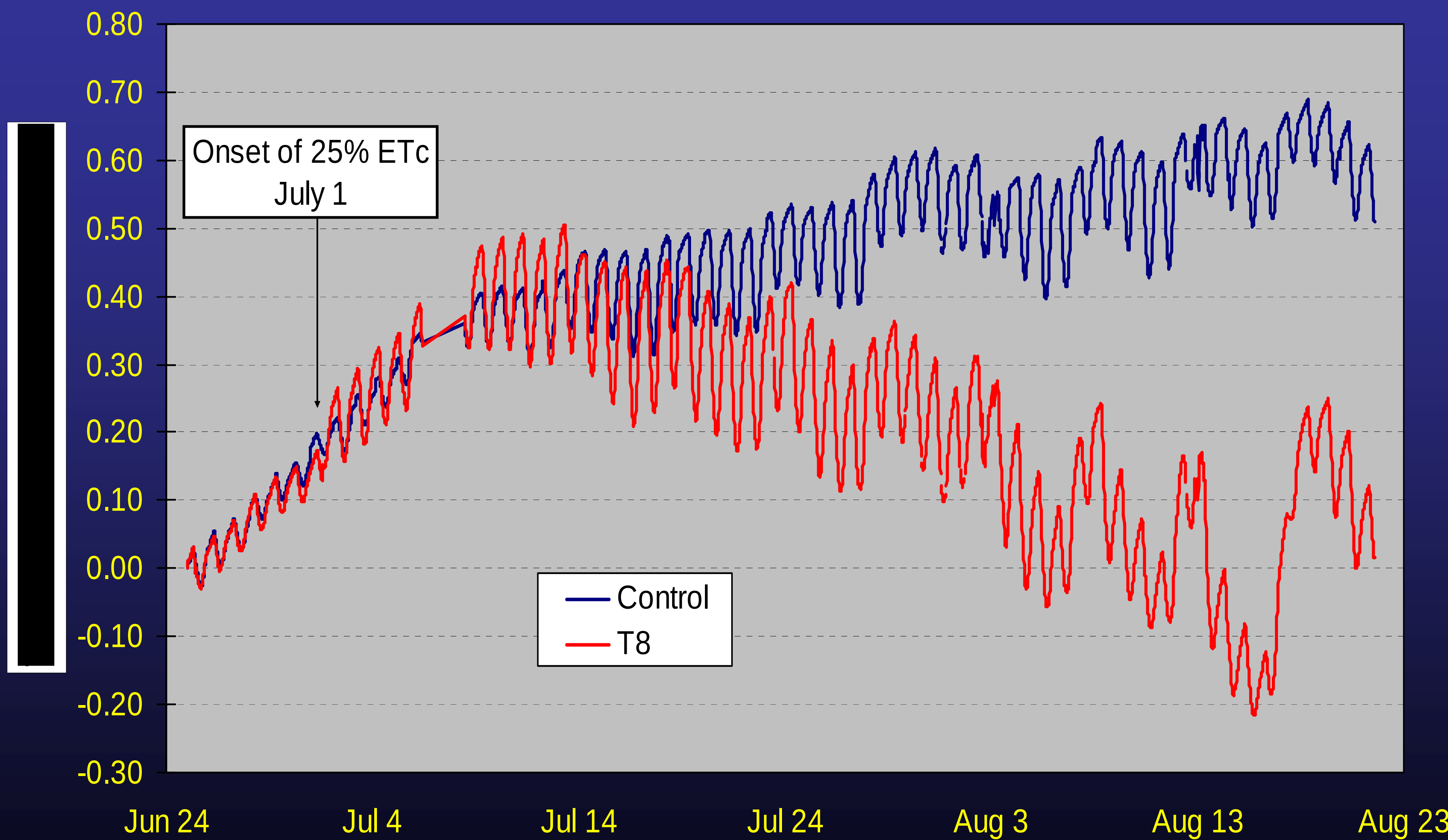


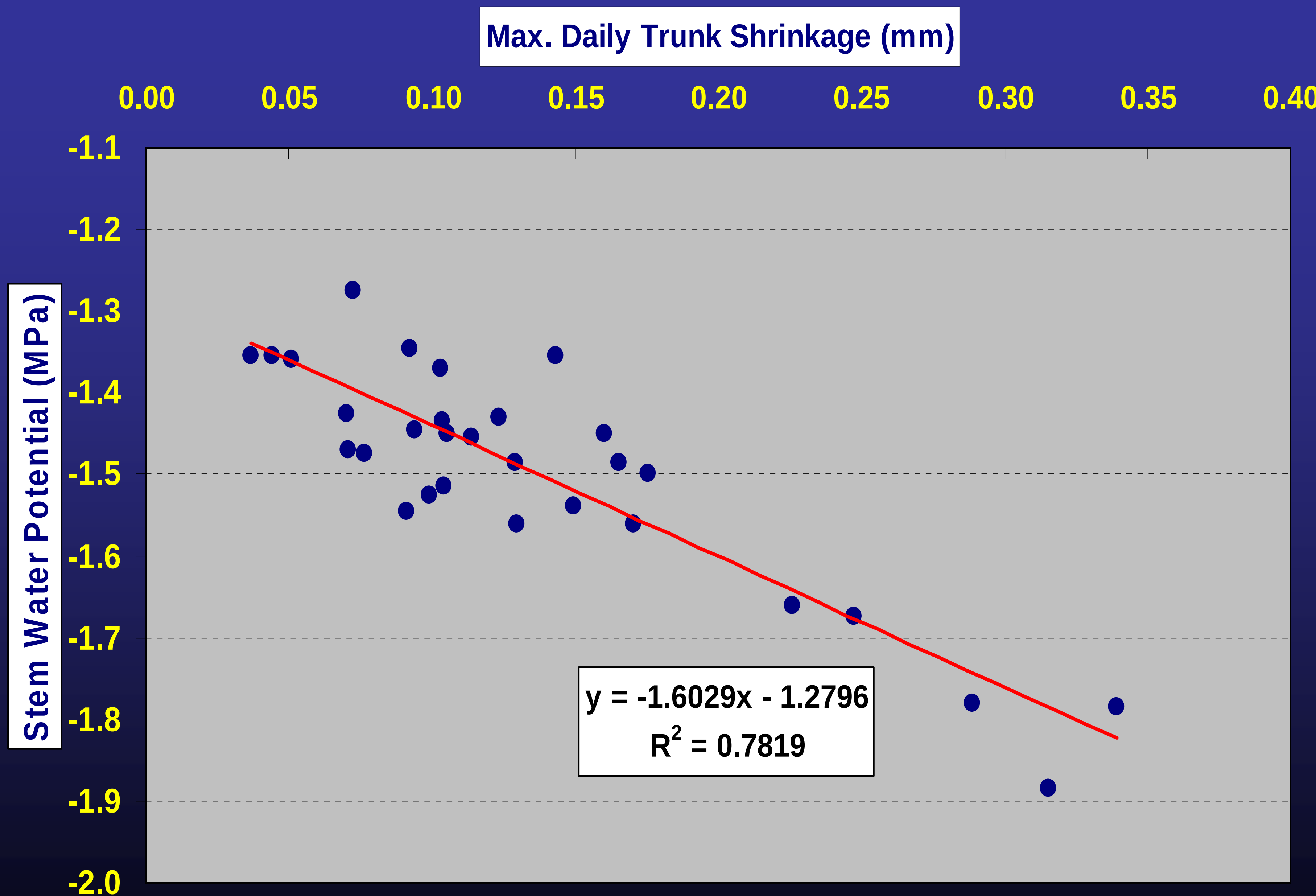

GREENLEE
CHEST

Mature Almond Trees; San Joaquin Valley

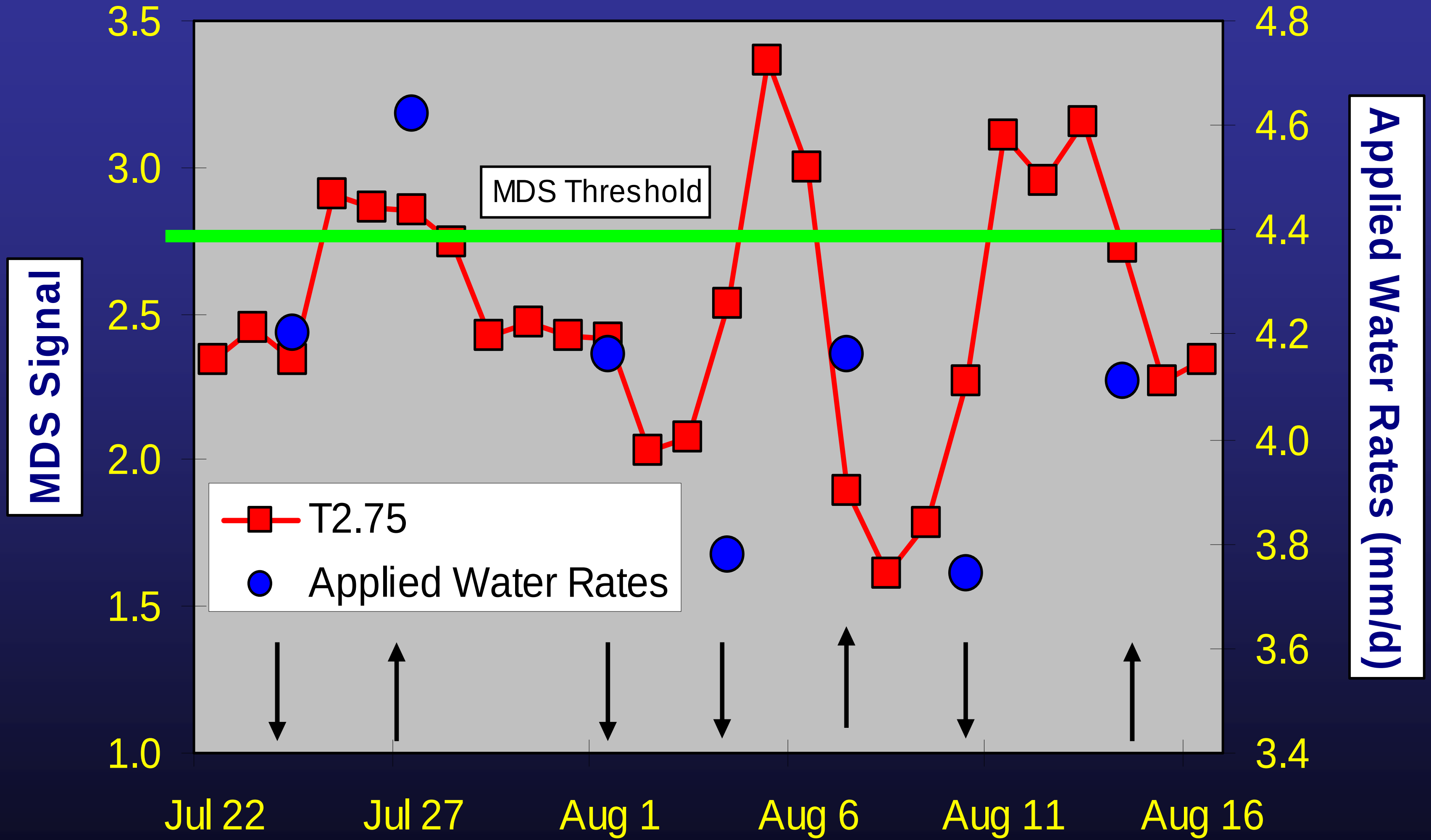


Citrus; San Joaquin Valley




Max. Daily Trunk Shrinkage (mm)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Stem Water Potential (MPa)
-1.1
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2.0
y = -1.6029x - 1.2796
R^2 = 0.7819

MDS Signal and Threshold Scheduling Approach



Desirable Characteristics of LVDTs

1. Indicator related to tree water status.
2. Signal strength greater than SWP.
3. Continuously records.
4. Electronic, automated.
5. Can be incorporated into controller.
6. Minimal labor required.

Is it feasible to install sensors on install individual trees on enough trees to adequately characterize an orchard?

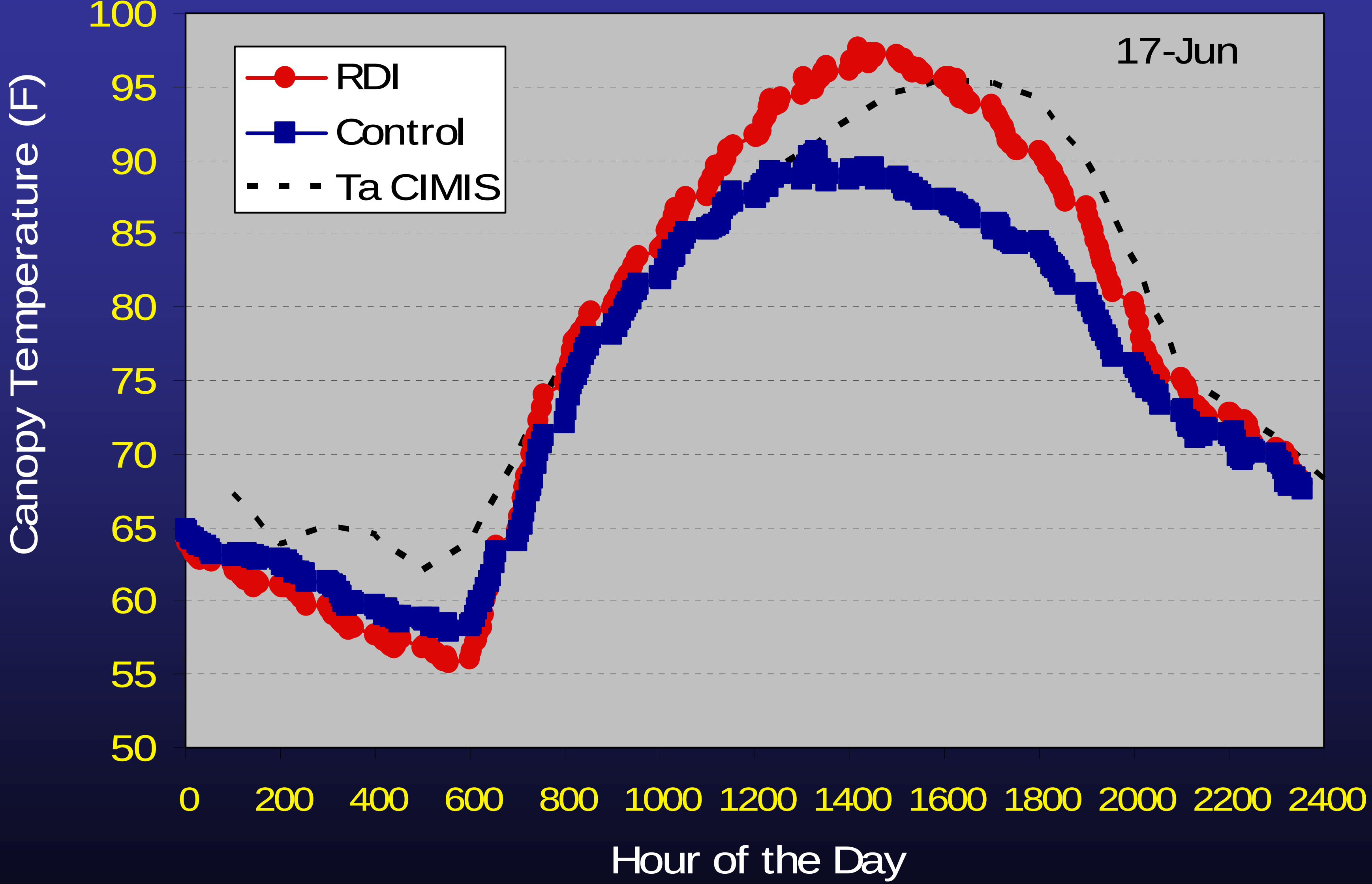
No.

- Cost.
- Data interpretation.
- Repair and maintenance.

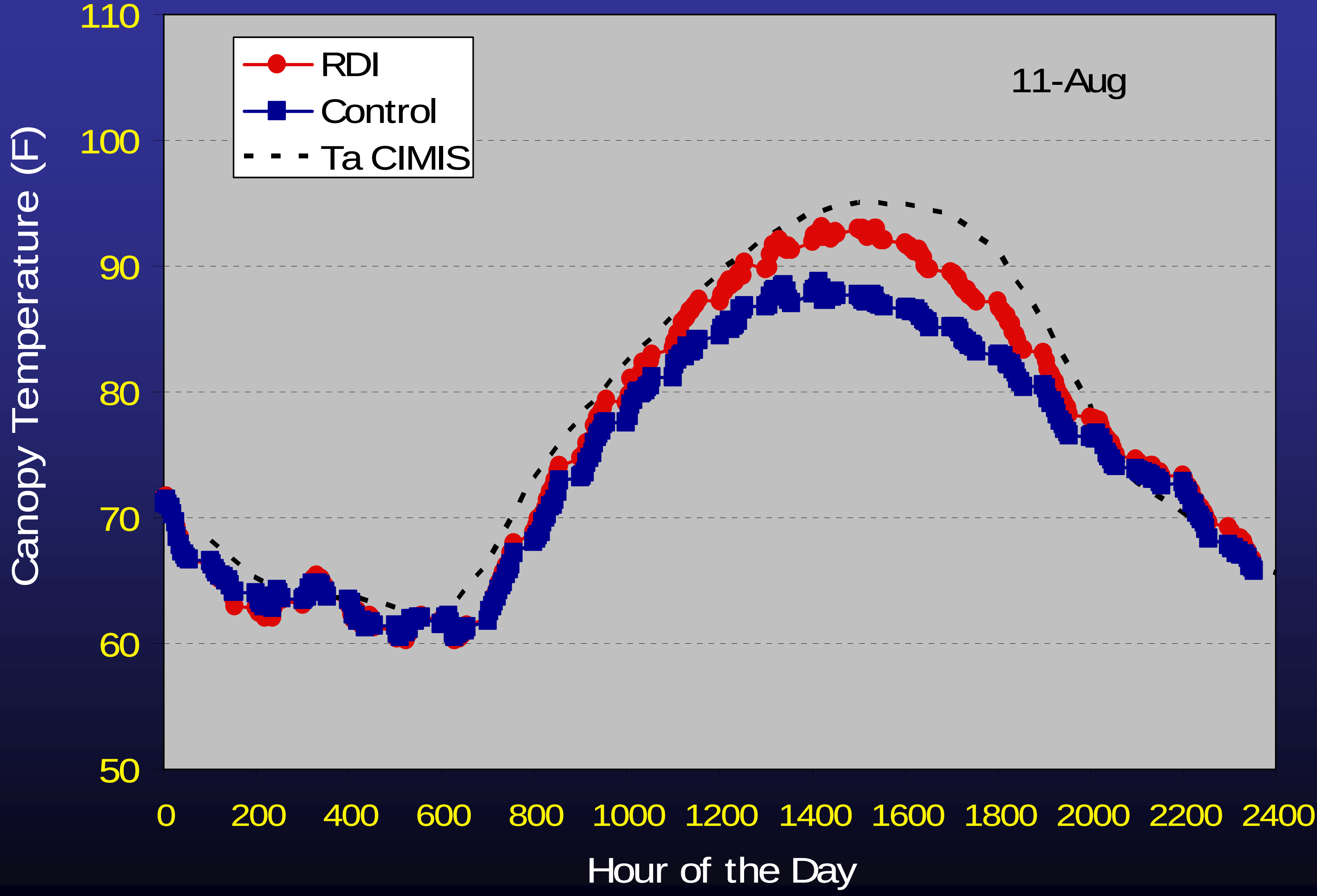
Are there other useful indicators of tree stress?


EVEREST
INTERSCIENCE
CENTIGRADE
21.8
DATA
RATE
BATT
FAST
OUT

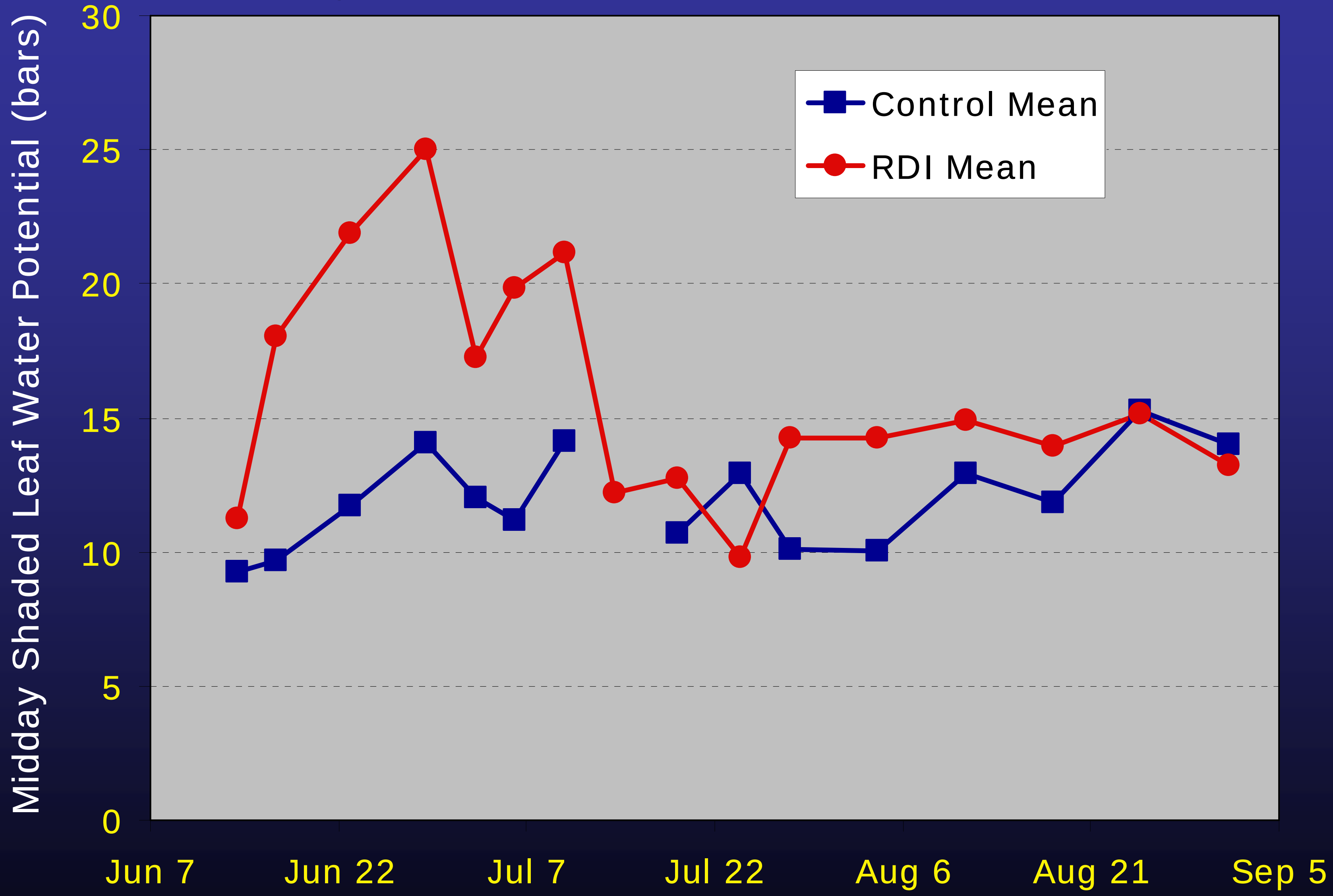
Canopy, Air Temperature; High Stress



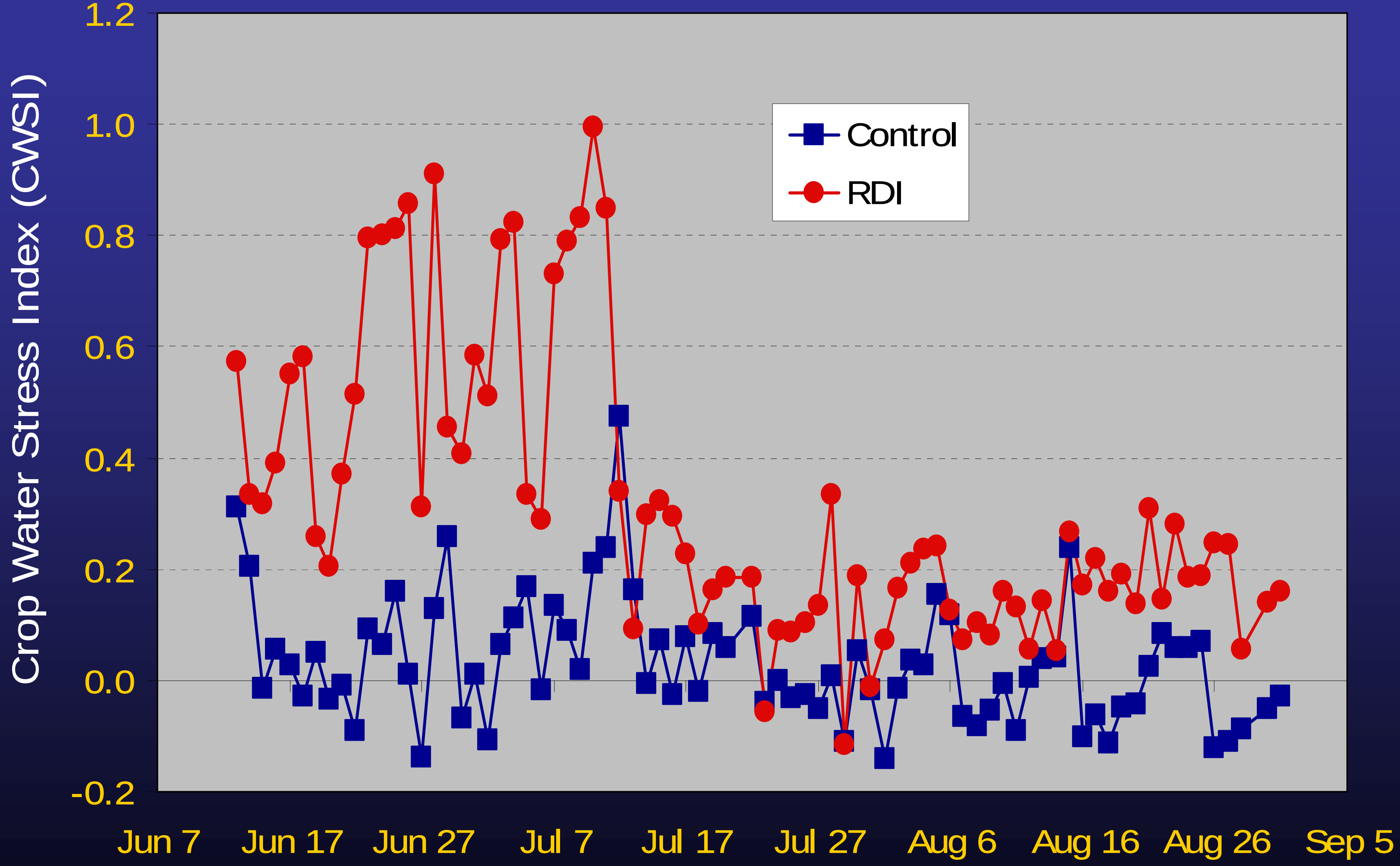
Canopy, Air Temperature; Low Stress



Midday Shaded Leaf Water Potential



Crop Water Stress Index (CWSI)



Possible Platforms

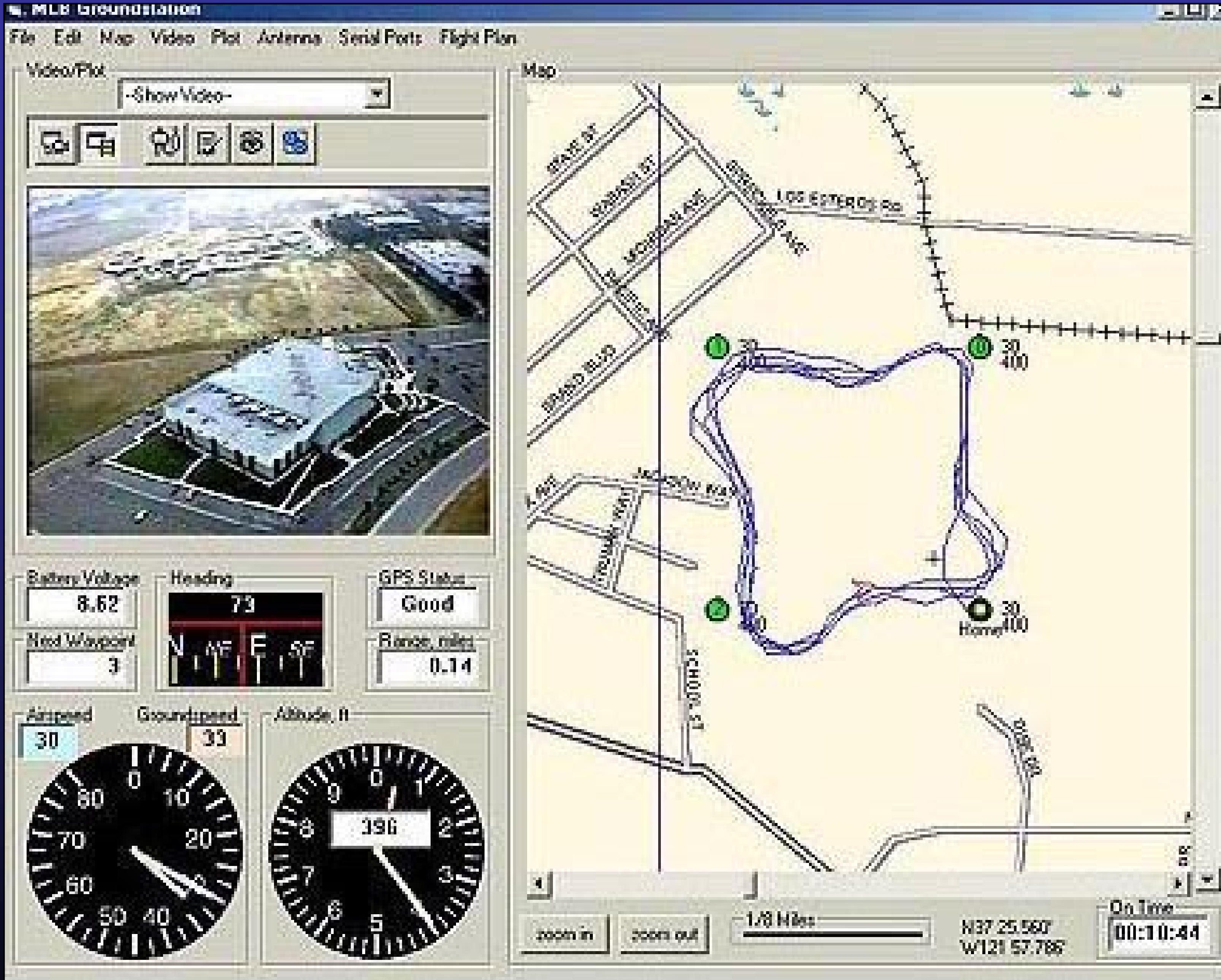
Satellites

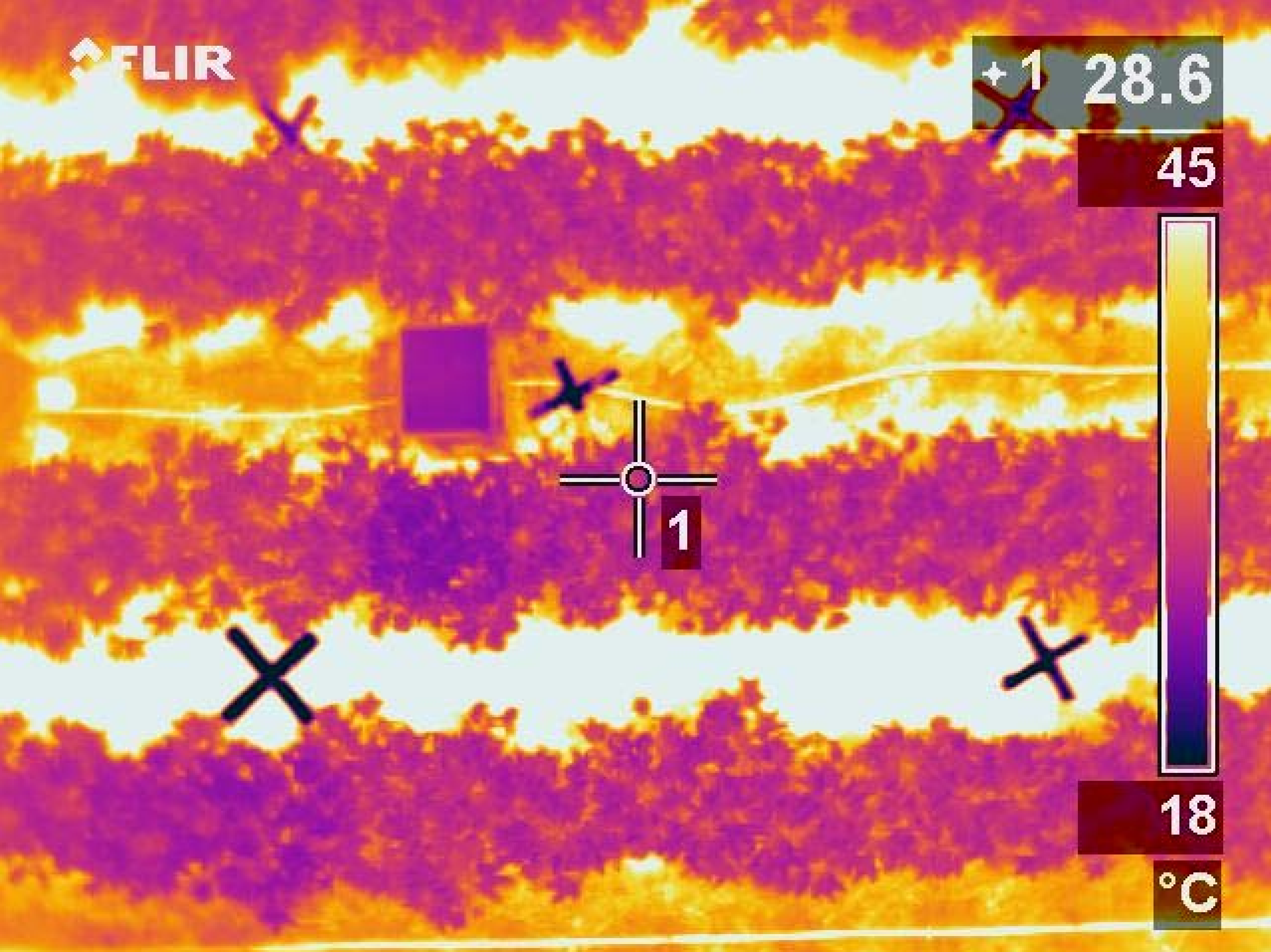
Altitude: 200-300 miles
Orbit Time: 94 mins
Return Time: 16 days
Swath Width: 10 miles
Pixel Size: 8 ft

ImageAire Lite ii

Small UAV for Geothermal Observations

Geoff Bland/614.6, Ted Miles/569


MLB Groundstation
File Edit Map Video Plot Antenna Serial Ports Flight Plan
Video/Plot
-Show Video-
Map
LOS ESTEROS Rd
Battery Voltage
8.62
Heading
73
GPS Status
Good
Next Waypoint
3
Range, miles
0.14
Airspeed
30
Groundspeed
33
Altitude, ft
396
Home
zoom in
zoom out
1/8 Miles
N37 25.560'
W121 57.786'
On Time
00:10:44



FLIR
+1 28.6
45
1
18
°C

Barriers to innovation adoption

1. Real/perceived risk of:
   a. production and/or profit losses.
   b. reallocation of water supply.
2. Grower resistance to change.
3. Unwillingness to have higher level of management.
4. Holes in knowledge and technology.
5. Insufficient incentives.