Drought Irrigation Strategies For Pistachio

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Tree Response To Water Stress

Sustained Deficit Irrigation; Mid 1980s

Regulated Deficit Irrigation; 1990s-Current

Optimal RDI Strategies for Different Drought Scenarios


7 17 '85

Reasons for Droughts

1) Weather

2) Government

Traditional Approaches For Reducing Agricultural Water Use

1. Changing irrigation systems.

2. Improving management.

Traditional Scheduling Concepts

1) Soil/Plant based monitoring.
2) Water budget.

Water Budget

$$ETc = Kc \times ETo$$

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.
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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	0.00 R	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

Non-Traditional Approach For Reducing Agricultural Water Use

Reducing consumptive use; evapotranspiration (ETc)

Can we reduce Surface Evaporation?

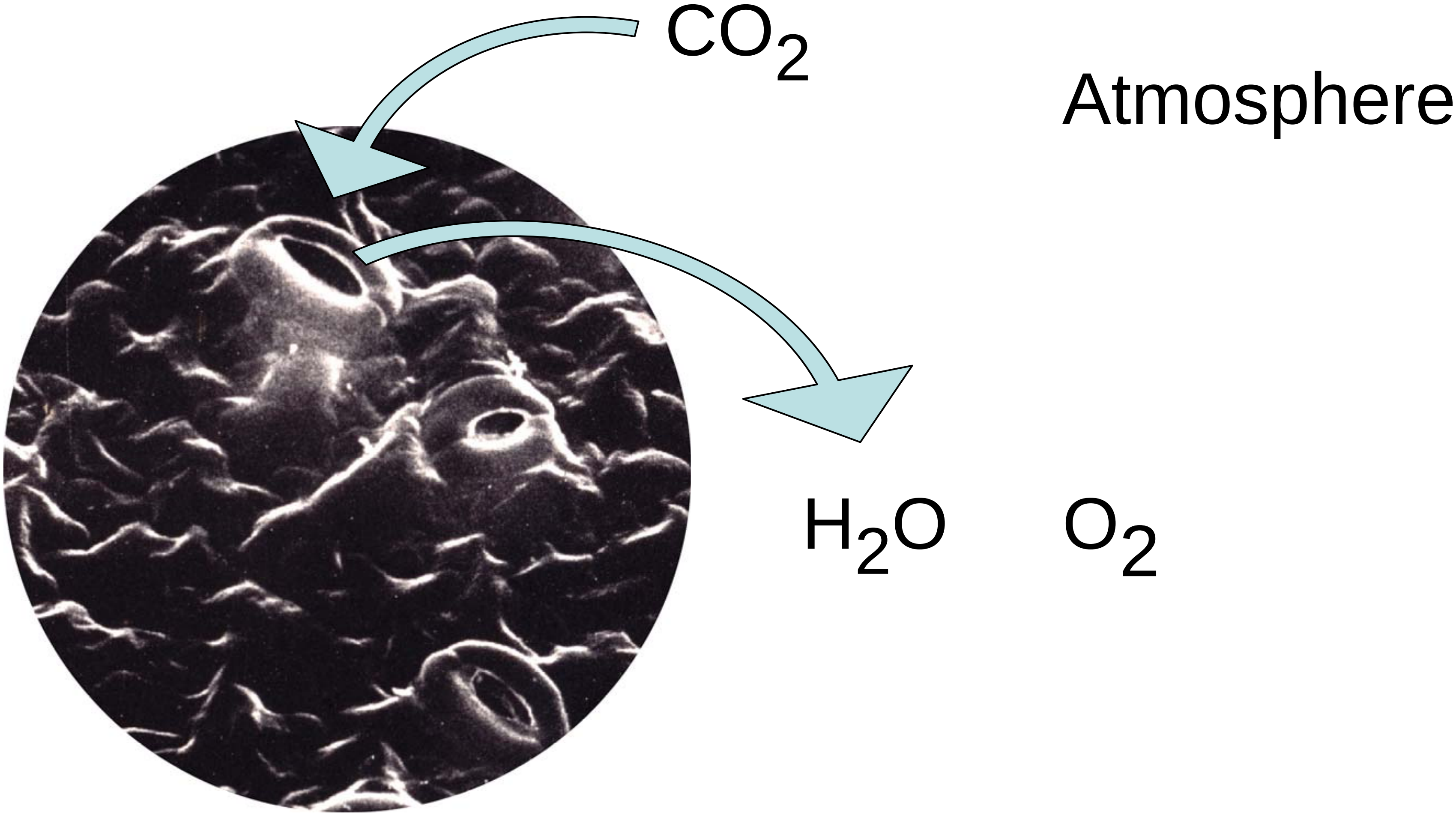
Irrigation Frequency vs. Duration

Wet surface as infrequently as possible.

Insure that when you irrigate with longer duration of application, don't "overirrigate."


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)

Nobel Lecture

"So today, we dumped another 70 million tons of global-warming pollution (CO_2) into the thin shell of atmosphere surrounding our planet, as if it were an open sewer."

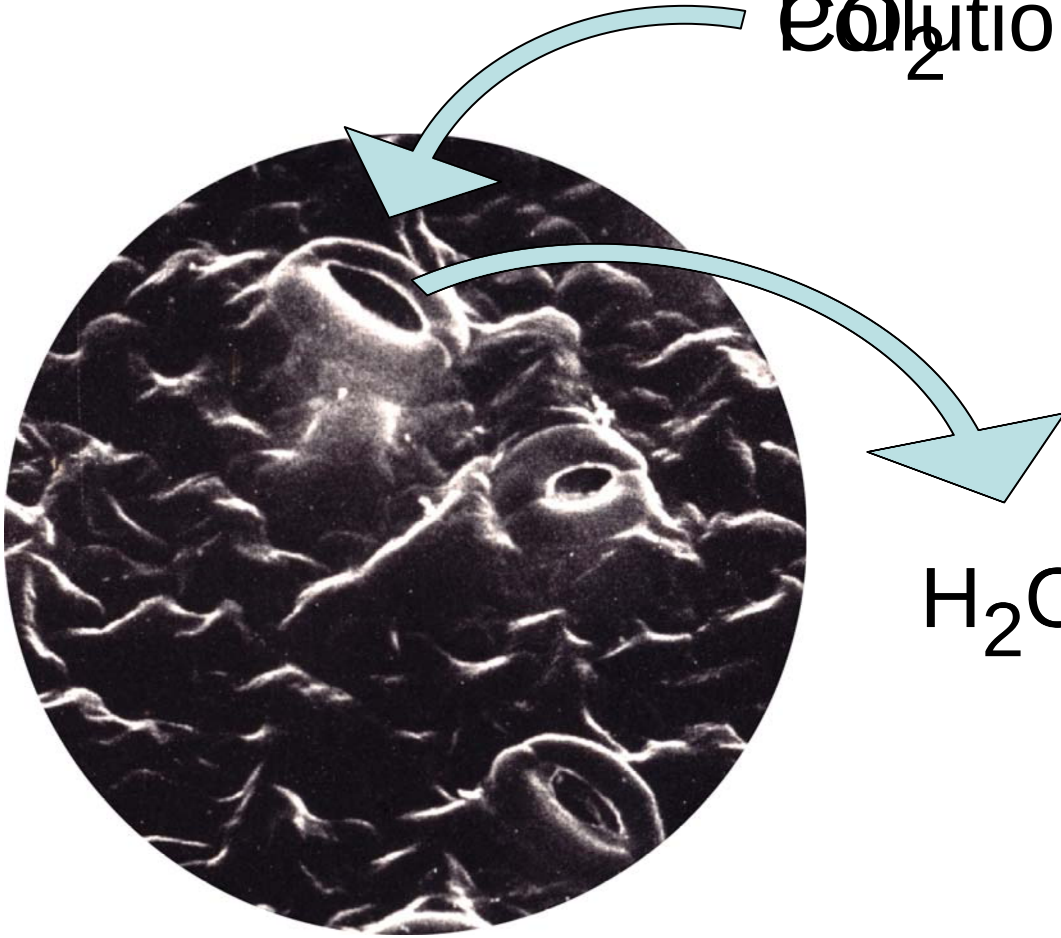
Albert R. Gore
Nobel Prize Acceptance Lecture
Oslo, Norway, 10 December 2007

CO_2

Pollution

Atmosphere

Open Sewer



H_2O O_2

Light

Pollution

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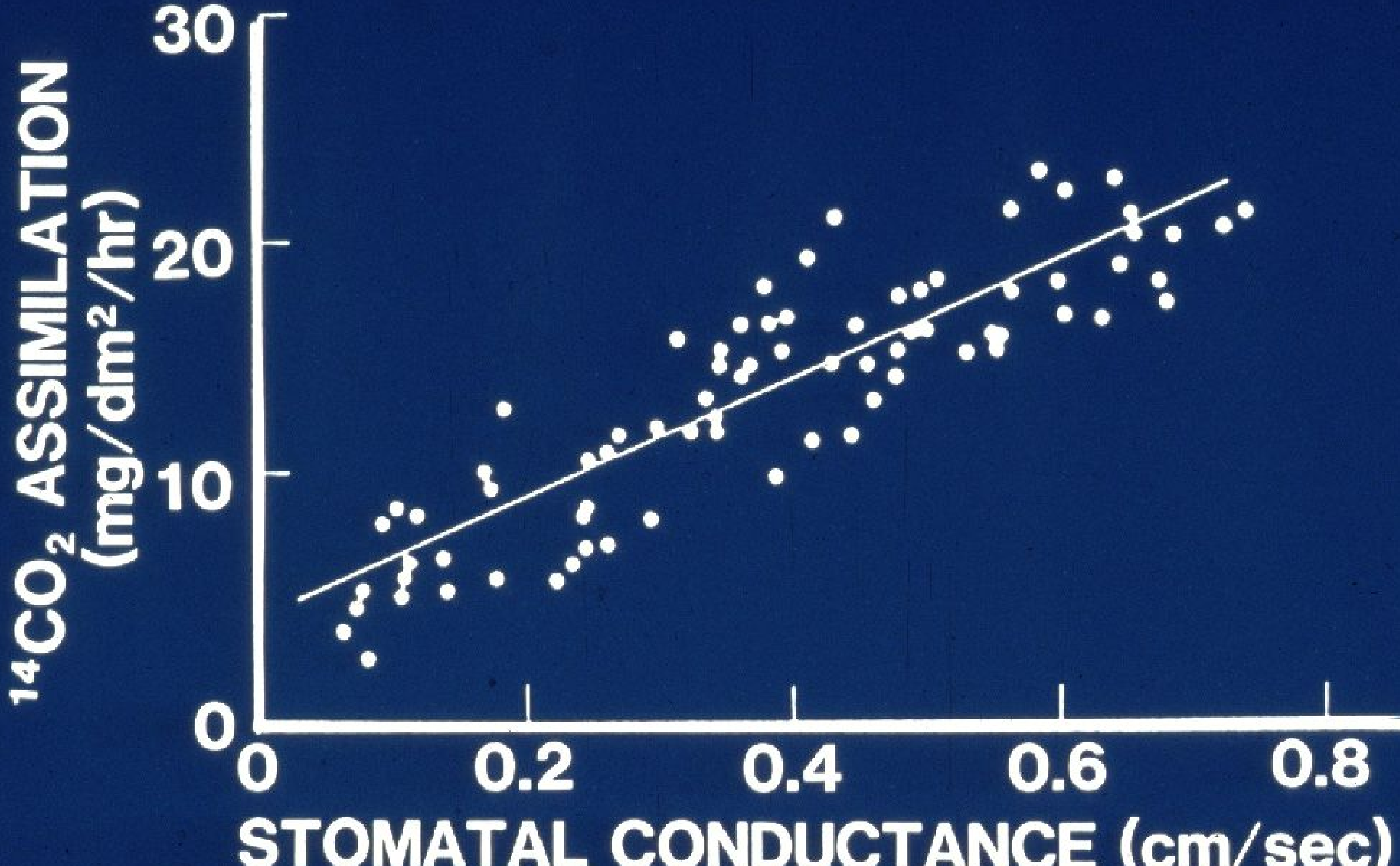
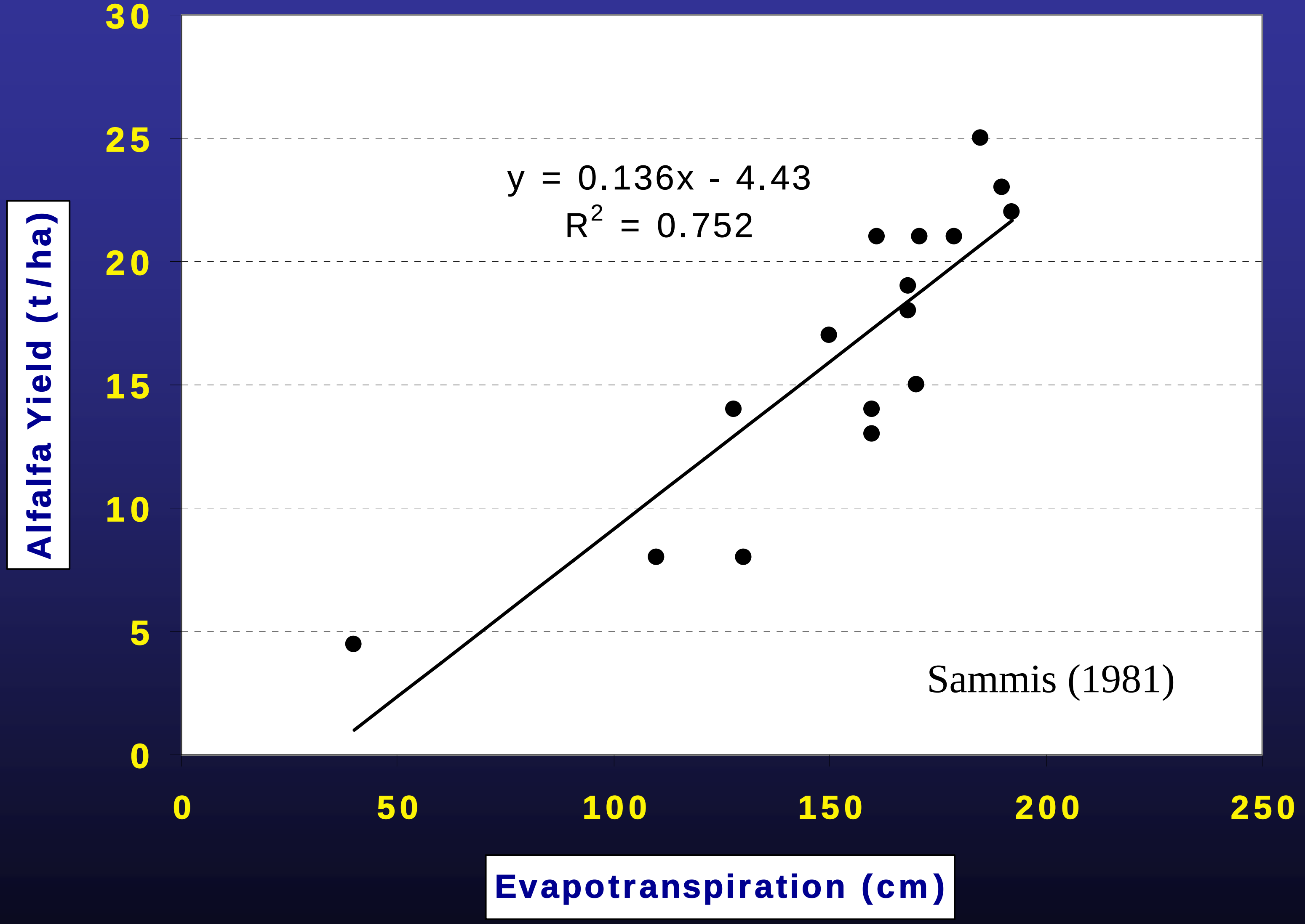
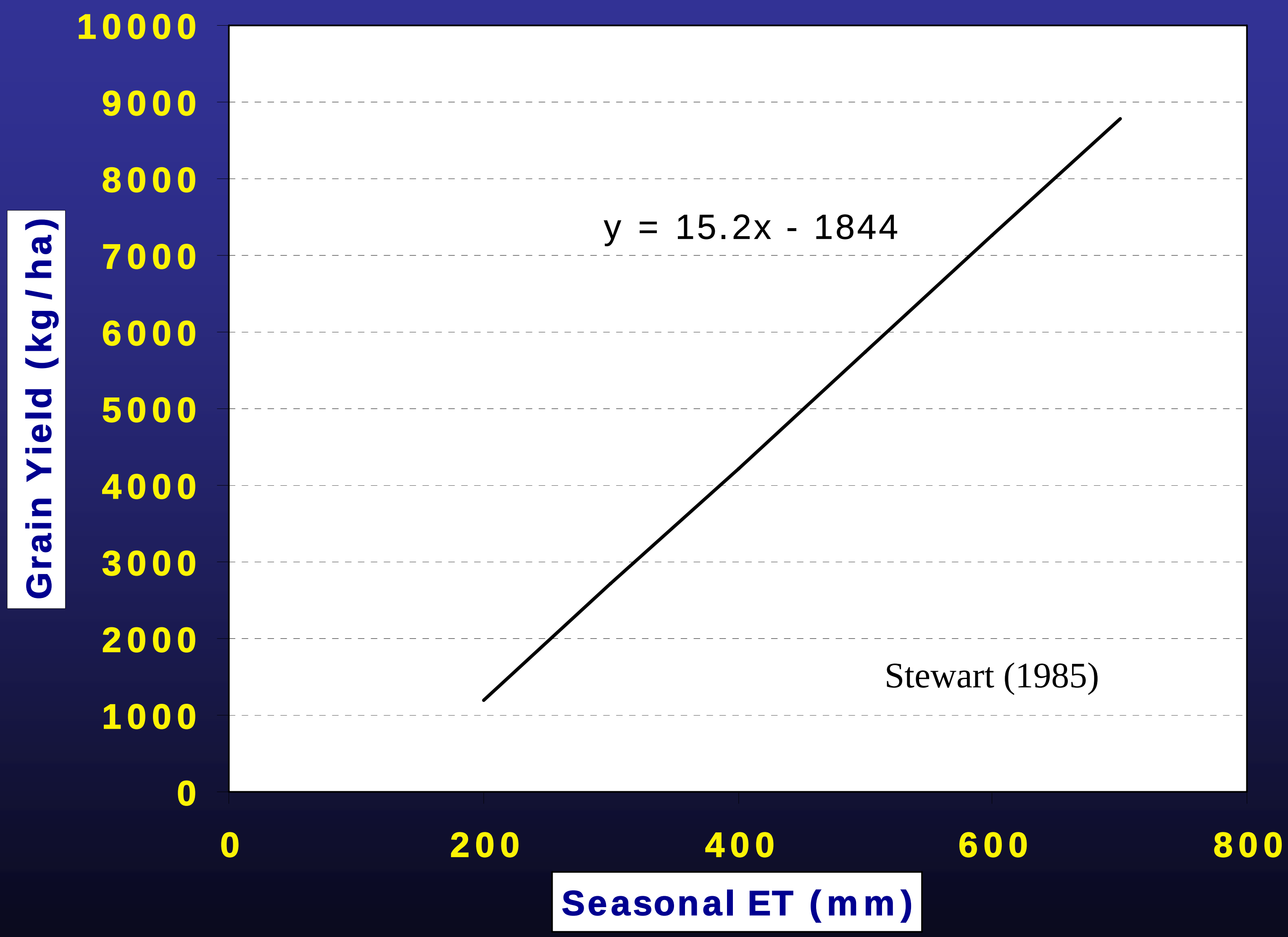


30
20
10
0
0
0.2
0.4
0.6
0.8
STOMATAL CONDUCTANCE (cm/sec)
14CO2 ASSIMILATION (mg/dm2/hr)

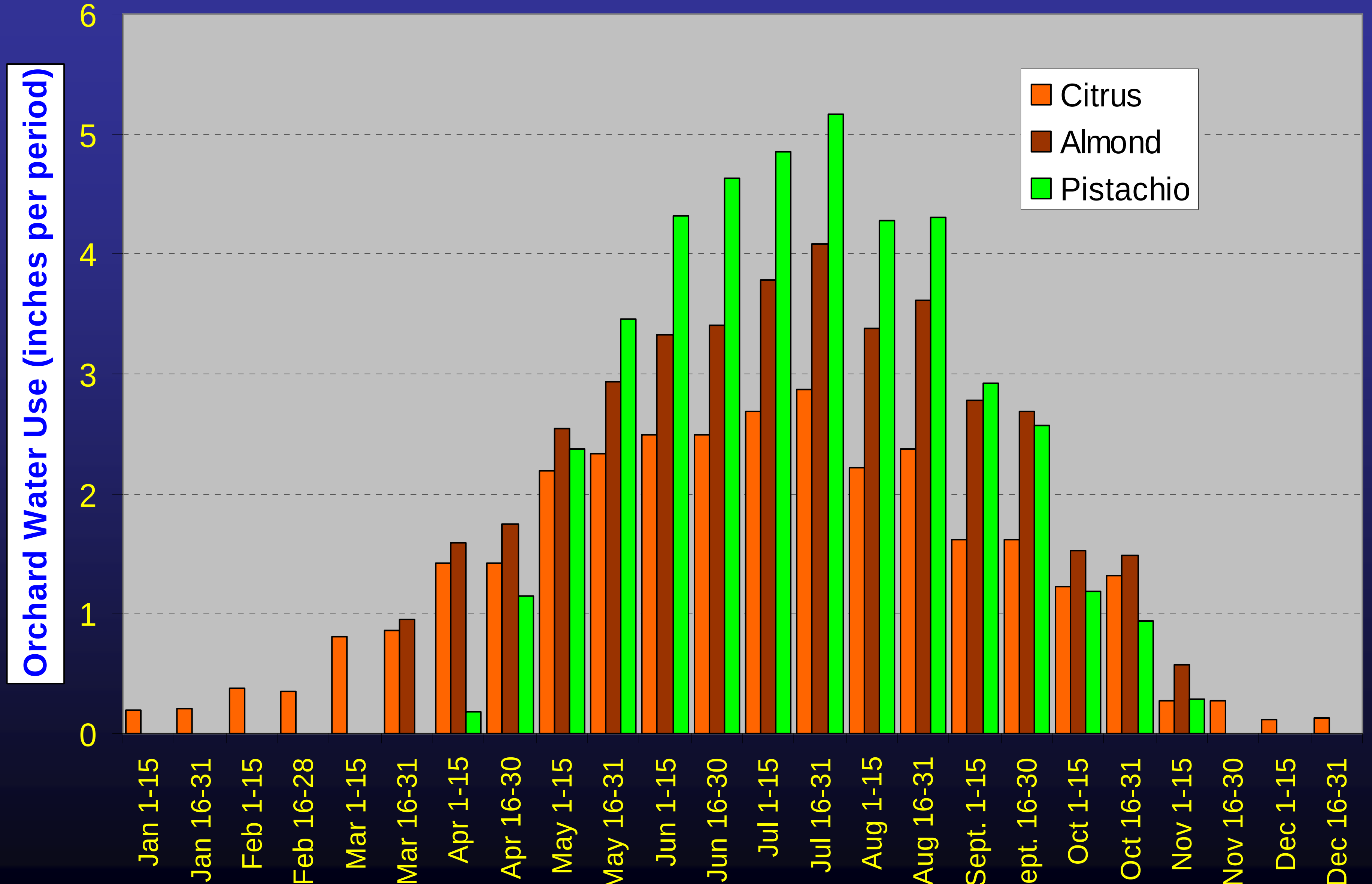
Alfalfa Production Function; New Mexico



Sorghum Production Function; S. Great Plains



Mature Orchard Water Use (ETc); Lost Hills

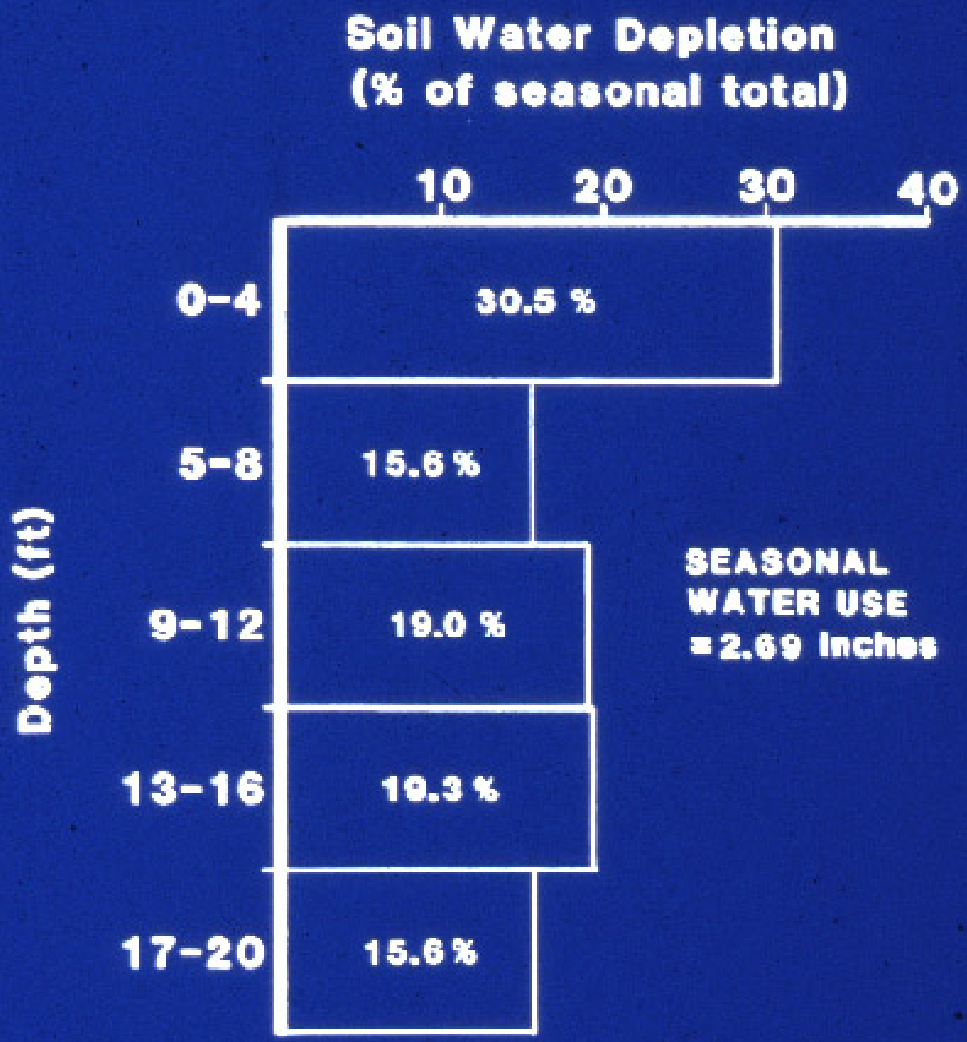


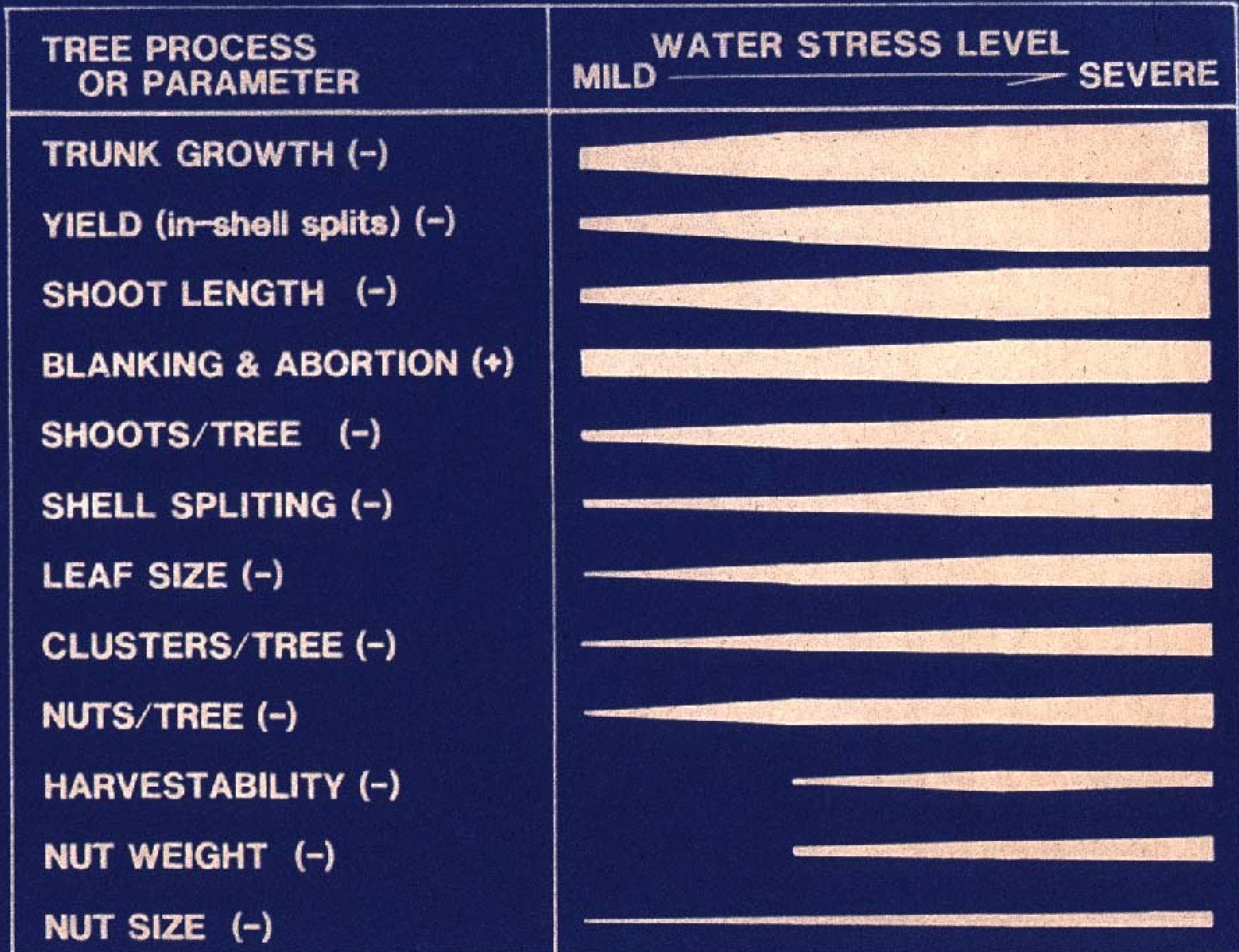
Effects of Sustained Deficit Irrigation

Late 1980s; Kettleman City

- Dryland
- 25% ETc (11.5 inches)
- 50% ETc (23 inches)
- 75% ETc (35 inches)
- 100% ETc (46 inches)

SOIL WATER EXTRACTION PATTERN, 2nd YEAR STRESS Apr. 13- Nov. 1




TREE PROCESS OR PARAMETER
WATER STRESS LEVEL
MILD
SEVERE
TRUNK GROWTH (-)
YIELD (in-shell splits) (-)
SHOOT LENGTH (-)
BLANKING & ABORTION (+)
SHOOTS/TREE (-)
SHELL SPLITING (-)
LEAF SIZE (-)
CLUSTERS/TREE (-)
NUTS/TREE (-)
HARVESTABILITY (-)
NUT WEIGHT (-)
NUT SIZE (-)

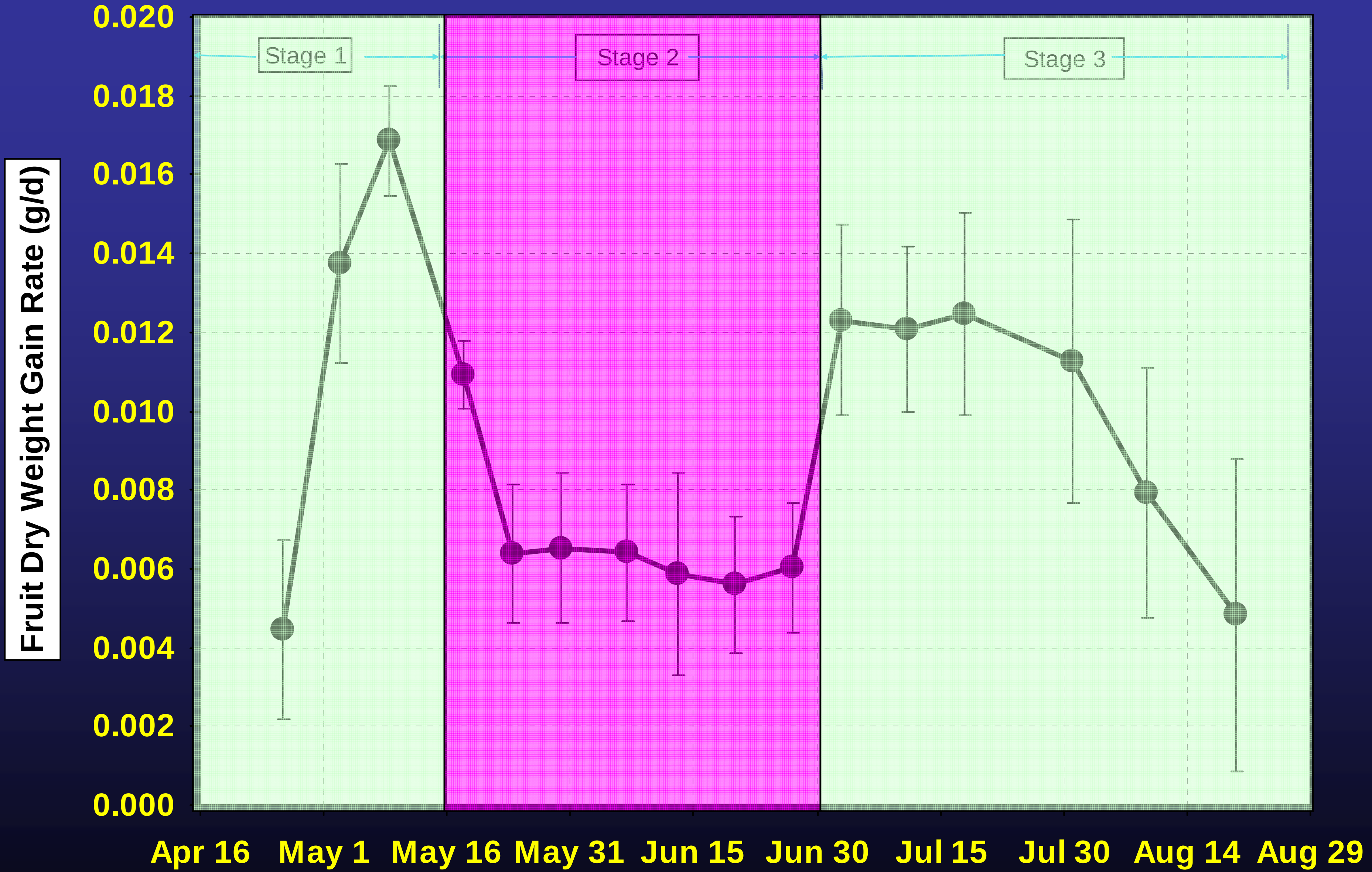
Drought Tolerance:

= Ability to Survive

≠ High Productivity

Regulated Deficit Irrigation (RDI)

* Work in Australia and New Zealand on stone fruits.
* Identified stress tolerant growth stages; usually during slow fruit growth.
* Purposely imposed stress during these periods in order to save water and achieve horticultural benefits.



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

Effects of Regulated Deficit Irrigation

Early 1990s; Kettleman City

Treatments:

- Evaluate sensitivity of each crop growth stage to water stress.

- Test effectiveness of various degrees of stress during Stage 2 and postharvest.

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.

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0% Postharvest	1.30 bc	22.8 abc	78.8 bc	11411	88.8 bc	2451 bcd	350 ab
25% Stage 2; 50% PH	1.32 c	21.0 ab	75.9 bc	10889	88.4 bc	2400 bcd	303 bc
25% Stage 2; 25% PH	1.32 c	22.1 ab	78.1 bc	10426	88.8 bc	2412 bcd	296 bc
0% Stage 2; 25% PH	1.28 bc	24.6 bc	75.3 bc	10942	84.7 b	2150 b	288 bc
50% Stage 2; 50% PH	1.30 bc	19.0 a	81.0 bcd	10615	91.7 c	2624 bcd	295 bc
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

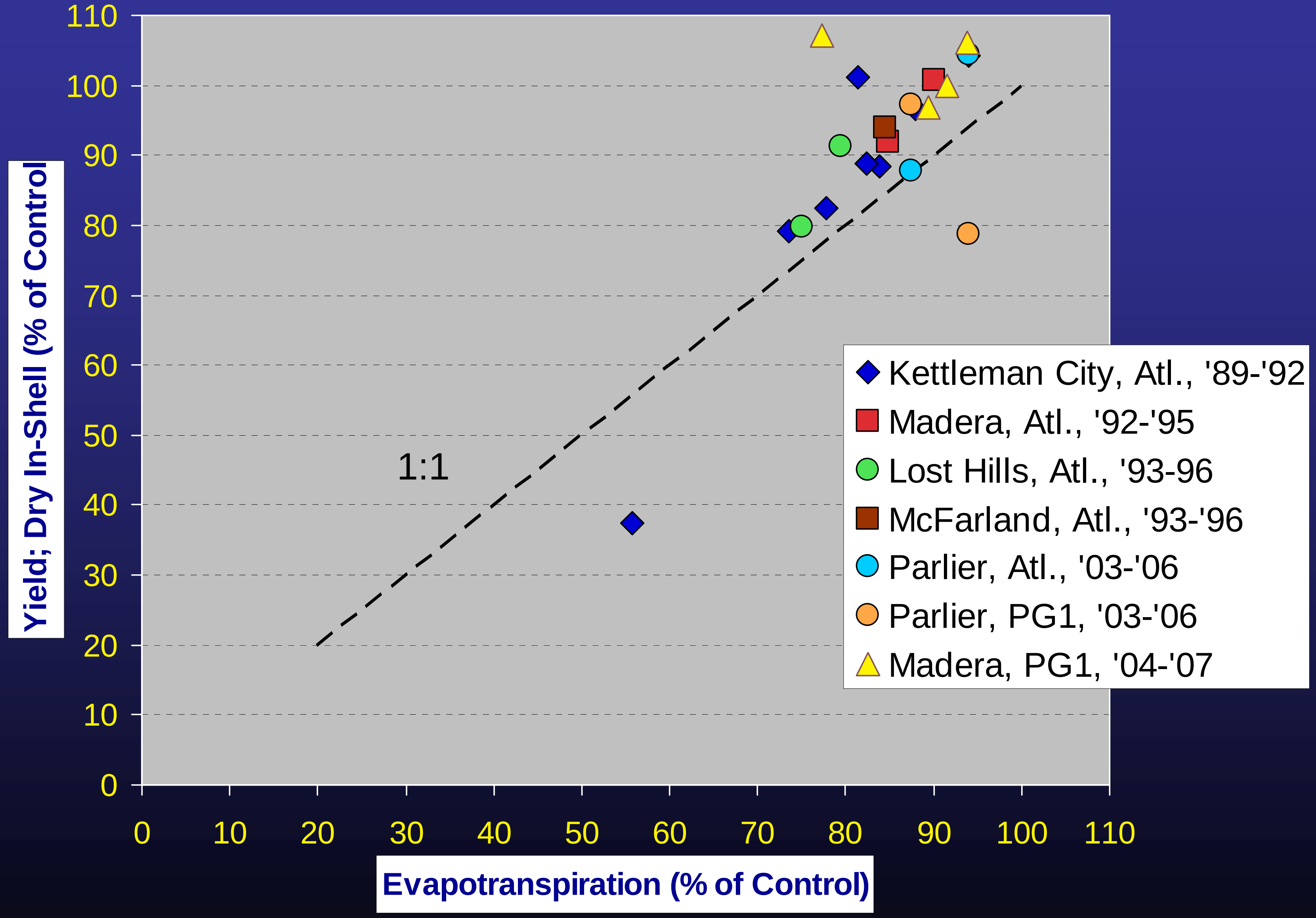
NSD

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

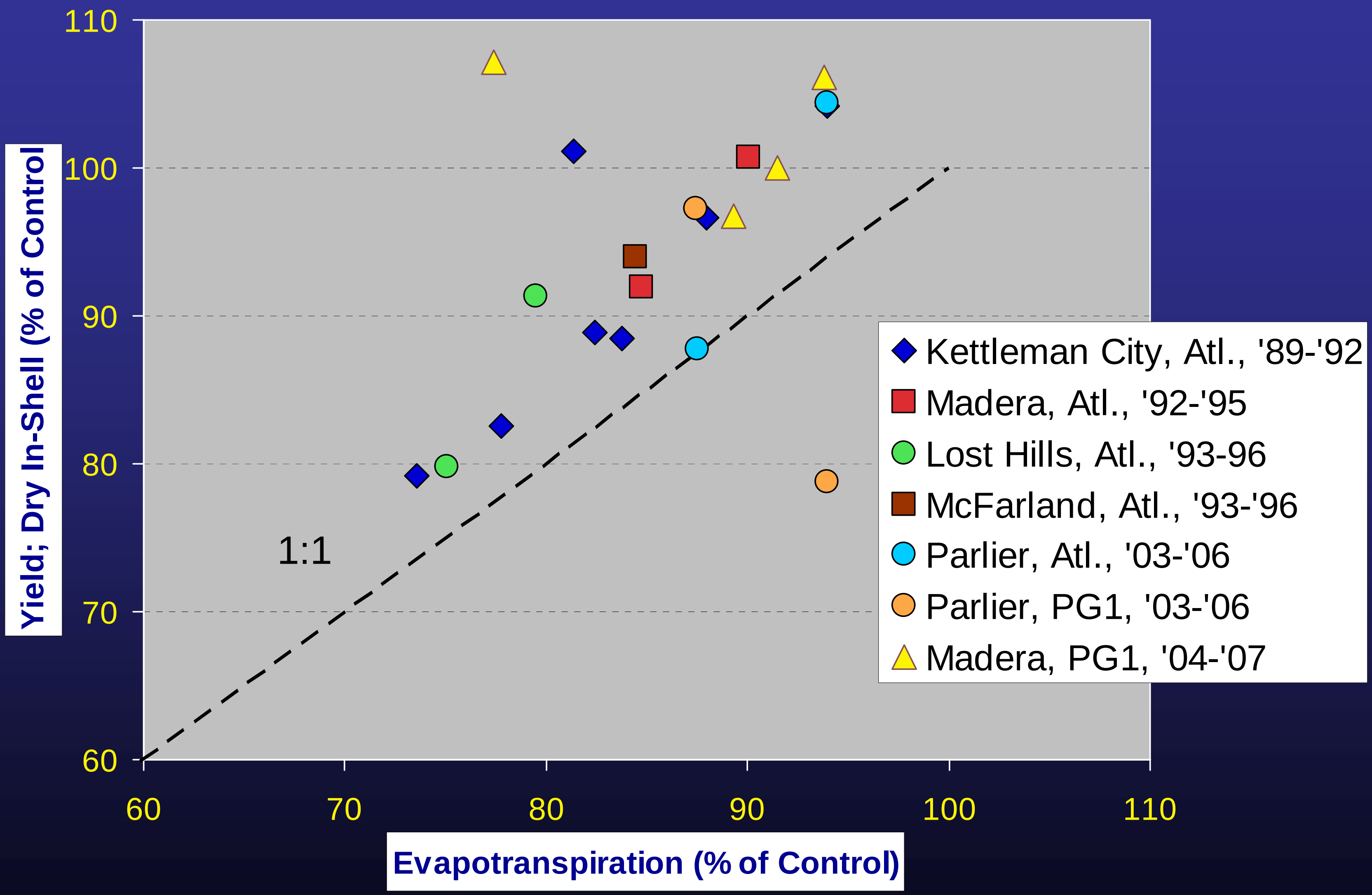
Pistachio RDI Experiments in SSJV

- Kettleman City, Atlantica, ’89-’92
- Madera, Atlantica, ’92-’95
- McFarland, Atlantica, ’93-’96
- Lost Hills, Atlantica, ’93-’96
- Parlier, Atlantica, ’03-’06
- Parlier, PG1, ’03-’06
- Madera, PG1, ’04-Current

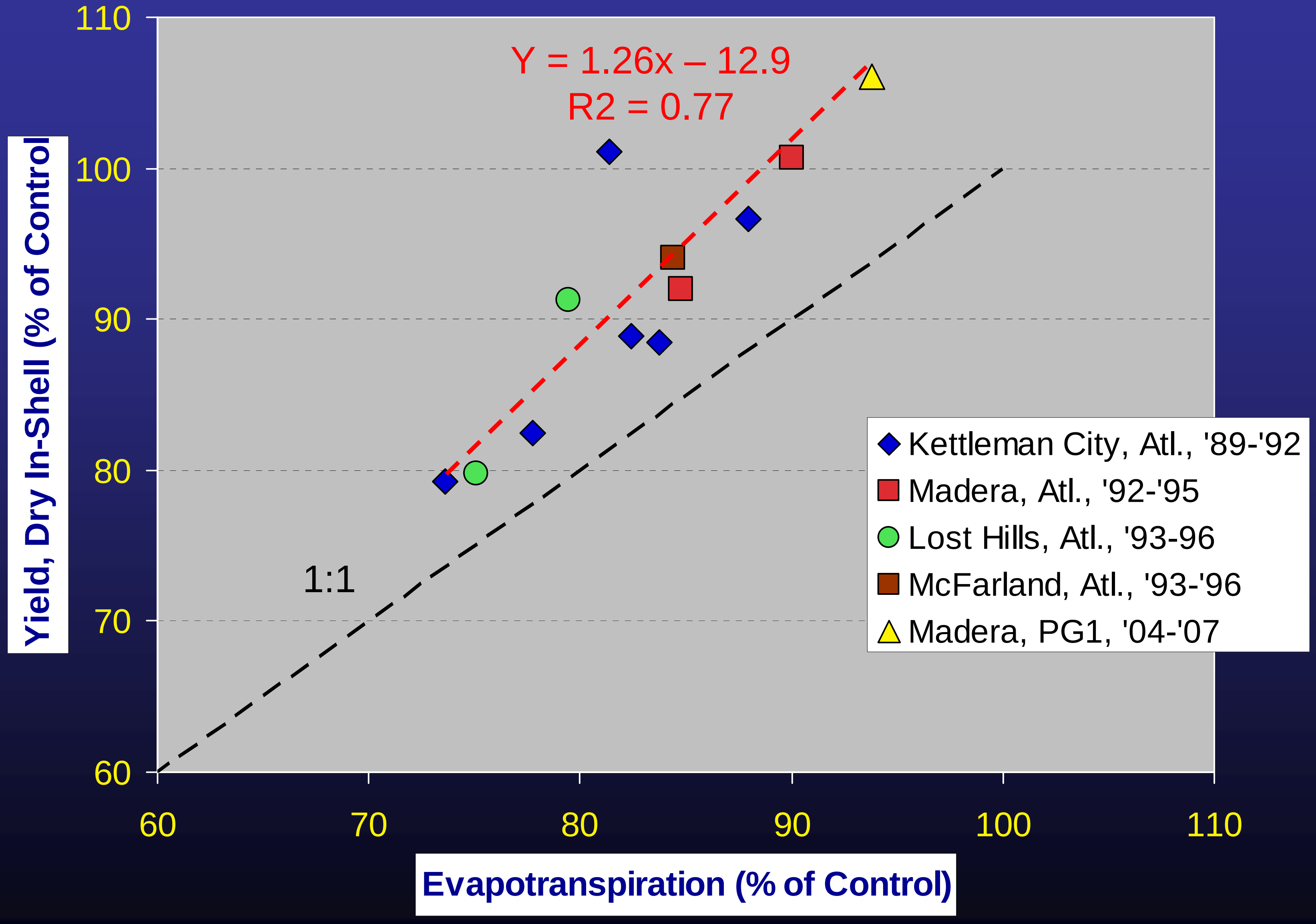
Mean of Last 2 Exp. Yrs; All Stress Stages



Mean of Last 2 Exp. Yrs; All Stress Stages



Only Stage 2 and PH Stress

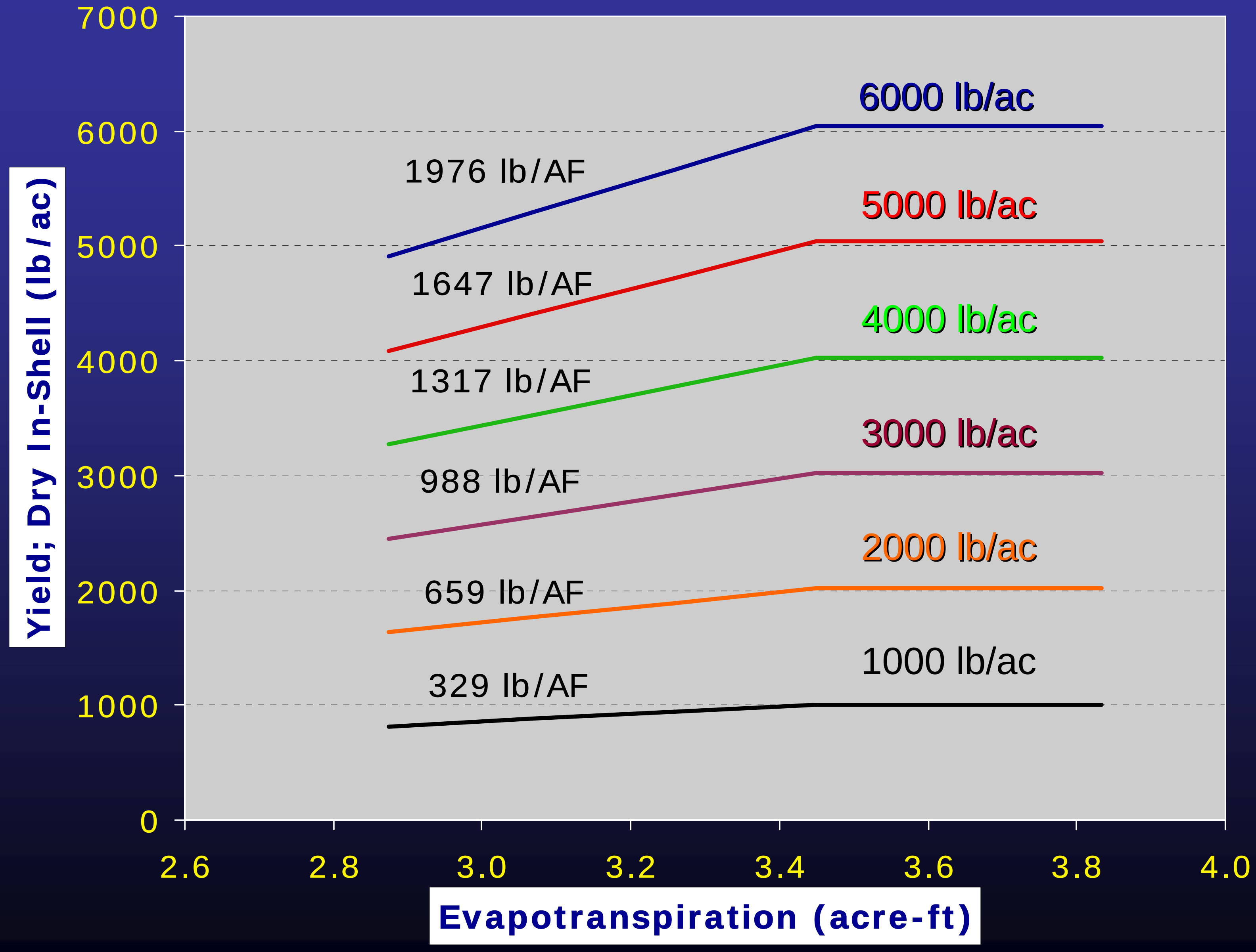


To convert % to yield; ETc values, Assume:

1) Yields will range from 1000 to 6000 lb/ac.
2) Potential ETc (consumptive use) is 46 inches (3.83 acre-ft).
3) We will stress only Stage 2 and postharvest.

How do we estimate impact of stress on yields and determine value of water?

Cropping Load Impacts on Water Prod.



	Normal ETo (inches)	Kc	Normal ETc (inches)	40" Case RDI Factor (%)	36" Case RDI Factor (%)	24" Case RDI Factor (%)	18" Case RDI Factor (%)
Apr 1-15	2.4	0.07	0.2	100	100	10	10
Apr 16-30	2.8	0.43	1.2	100	100	10	10
May 1-15	3.3	0.68	2.2	100	100	10	10
May 16-31	3.7	0.93	3.4	50	50	25	0
Jun 1-15	3.9	1.09	4.3	50	50	25	0
Jun 16-30	4.2	1.17	4.9	50	50	25	0
Jul 1-15	4.4	1.19	5.2	100	100	80	70
Jul 16-31	4.6	1.19	5.5	100	100	80	70
Aug 1-15	5.0	1.19	6.0	100	100	80	70
Aug 16-31	4.7	1.12	5.3	100	100	80	70
Sept. 1-15	3.7	0.99	3.7	100	100	80	70
Sept. 16-30	2.5	0.87	2.1	100	25	10	0
Oct 1-15	1.9	0.67	1.3	100	25	10	0
Oct 16-31	1.6	0.50	0.8	100	25	10	0
Nov 1-15	0.8	0.35	0.3	100	25	10	0
Seasonal ETc			46.3	40.0	36.6	24.4	18.3

Are there useful indicators of tree stress?


Fully Irrigated; July 9


Stressed; July 9

Conclusions from Pistachio Irrigation Studies

- Pistachio trees are extremely drought tolerant.
- Pistachio trees have the potential to use large amounts of water.
- Mid May thru early July (Stage 2) is most stress tolerant, followed by postharvest, and leafout to mid May (Stage 1); early July to harvest (Stage 3) is least stress tolerant.

Thank You