

Water management under drought cutbacks

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**University of California
Cooperative Extension**

Agriculture & Natural Resources

Olive bearing habit

- olives bloom on one year old shoots
- over-cropping:
 - decreases fruit size
 - decreases shoot growth
 - decreases flowering next season
 - aggravates alternate bearing



Relationship between olive tree growth and production

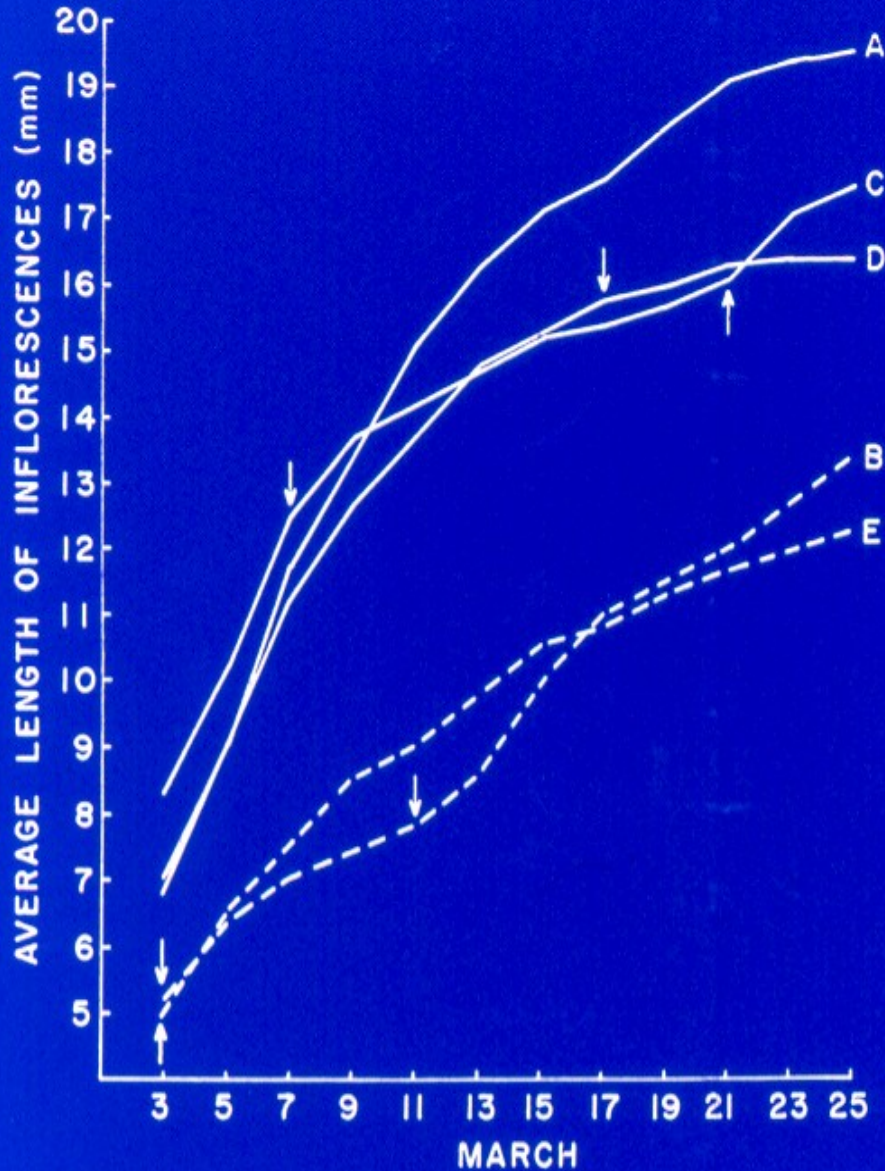
- Farm with two seasons in mind
 - produce a moderate, high quality current crop
 - generate sufficient vegetative growth for next season's bloom and crop
 - minimizes alternate bearing
- Practice fruit thinning in the heavy crop year
 - Improves size, can help generate shoot growth if water is short

Water management

- *shoot growth & bloom*
- *fruit sizing*
- *total yield*
- *alternate bearing*



Inflorescence growth vs. timing of March water stress



A -- Continuous ample soil moisture.

C -- Moisture deficit in mid-March, at intermediate flower development.

D -- Moisture deficit in late March.

B -- Moisture deficit in early March, an early stage of flower development.

E -- Continuous moisture deficiency.

Early spring water stress effects on Barouni olives

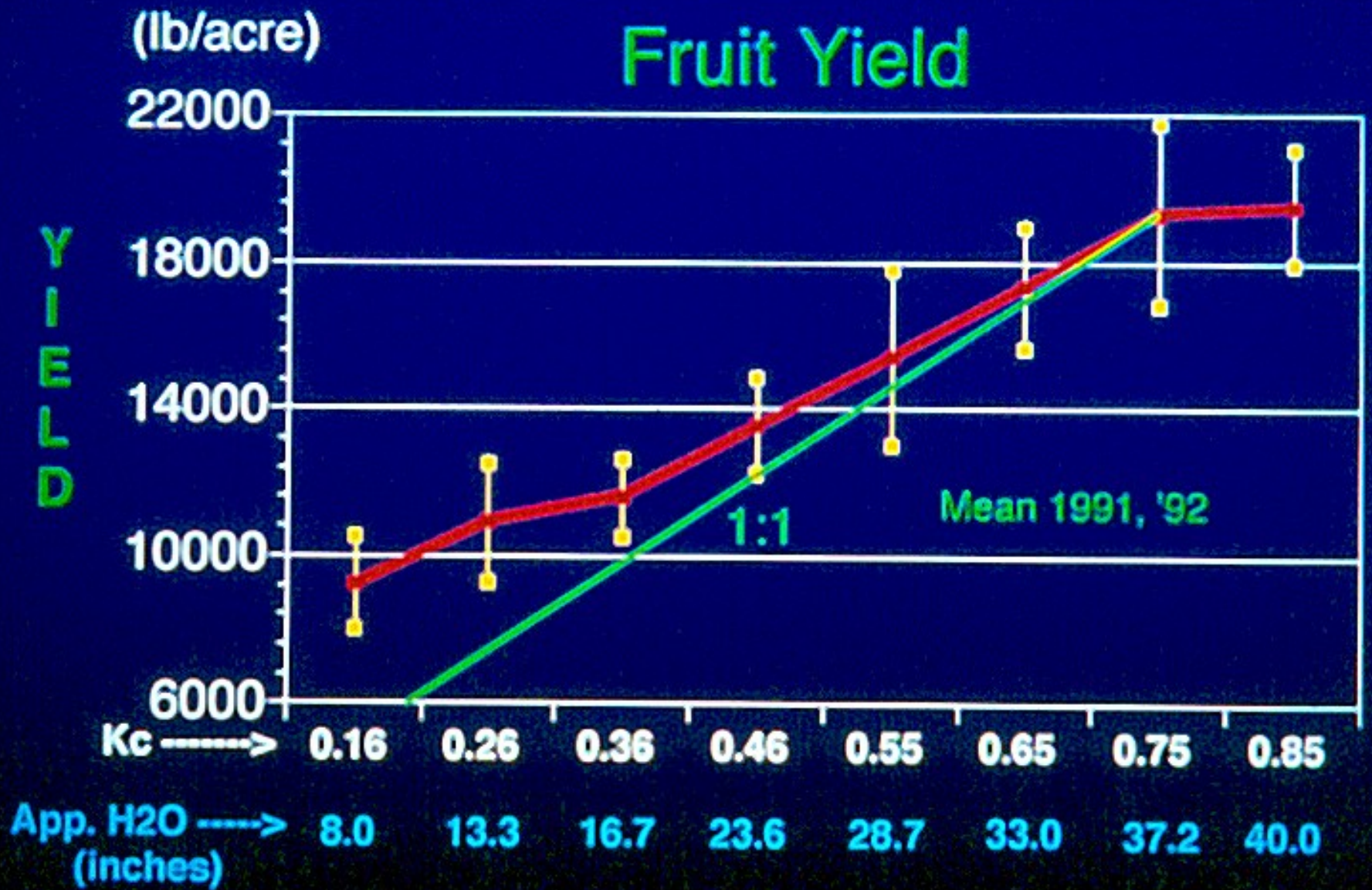
<u>Water Stress Timing</u>	<u>% Leaf Drop</u>	<u># Flowers/ Inflorescence</u>	<u>% Perfect Flowers</u>	<u># Fruits / 100 Inflorescences</u>
Control (No stress)	2.8	15.7	27.4	3.3
3/3-3/11	12.2	4.9	65.4	4.3
3/7-3/21	8.4	8.7	4.0	0.1
3/18-4/4	4.8	8.3	9.3	0.6
3/1-4/4	12.5	6.7	0.6	0.3
P = .05	---	3.2	21.4	---

Dr. Goldhammer, Irrigation Specialist, UC KAC, early 1990's
Narrow Differential Irrigation Trial

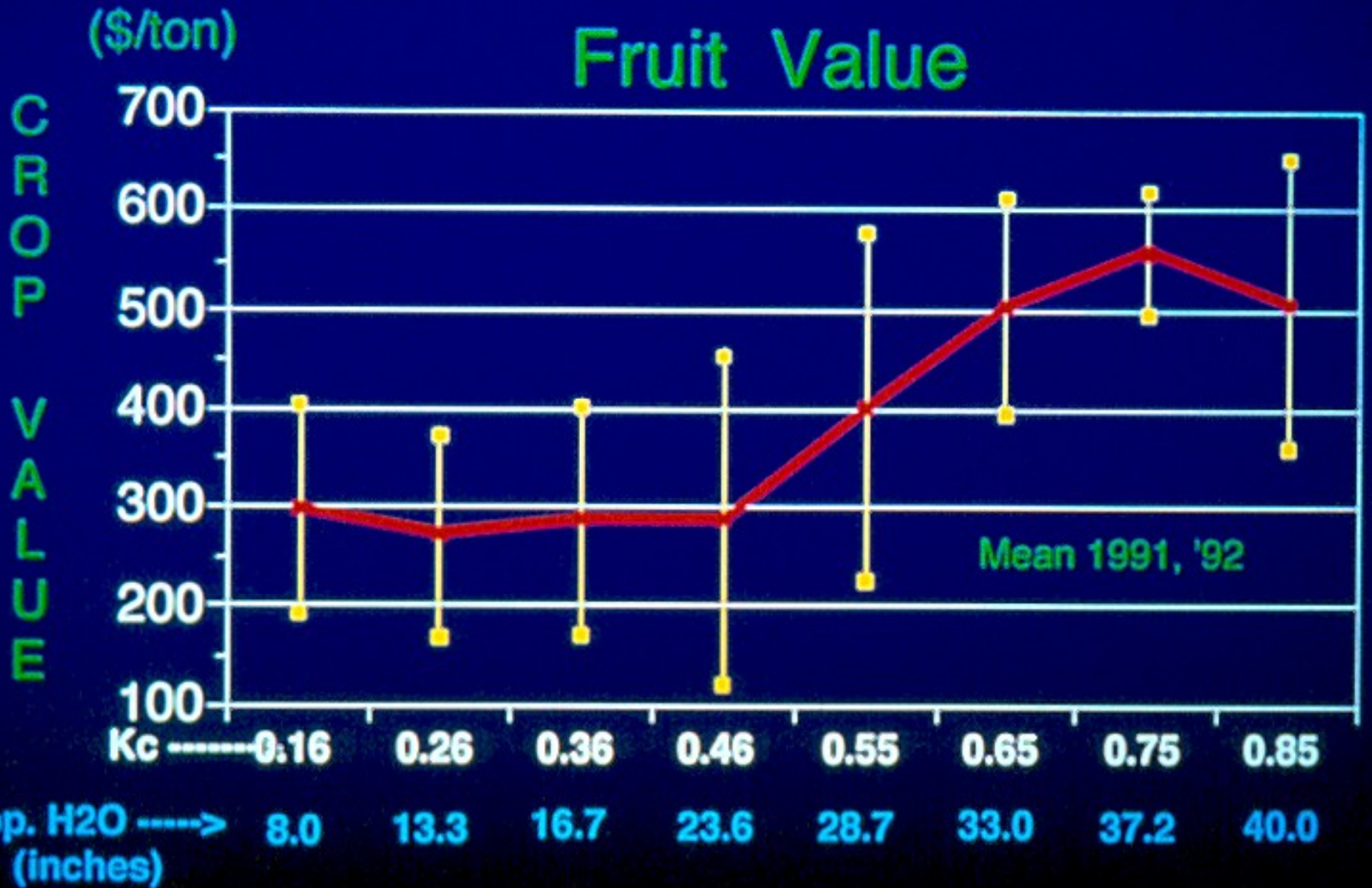
Percent of Control	(Kc) Crop Coefficient	Applied Water Acre-in/Acre
25%	.16	8.9
40%	.26	14.2
55%	.36	19.5
70%	.46	24.9
85%	.55	30.2
100%	.65	35.5
115%	.75	40.8
130%	.85	46.2

8 Irrigation Treatments with 6 Replications

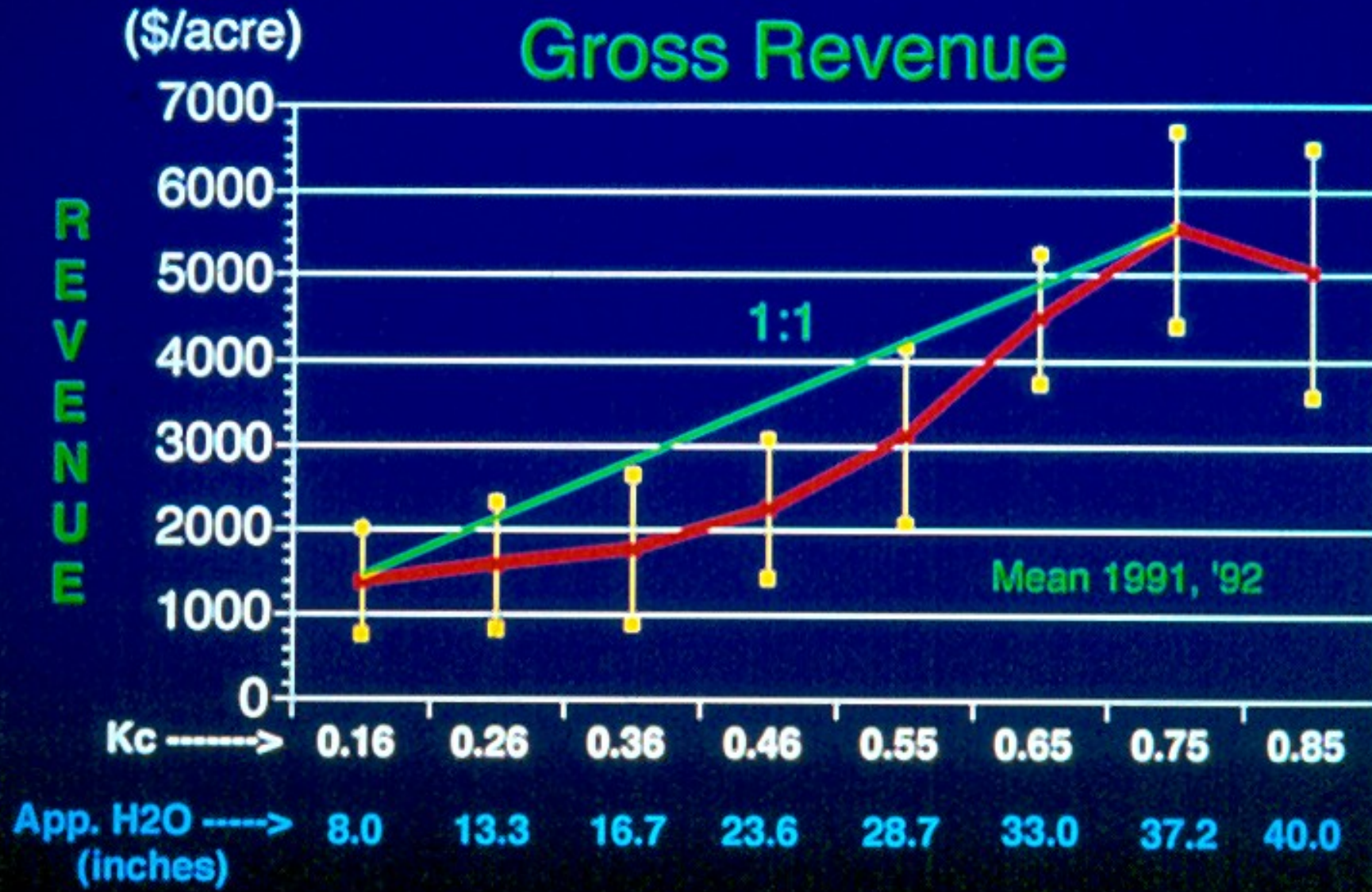
Fruit Yield



Fruit Value



Gross Revenue



Summary

- Olive crop coefficient (K_c) 0.65-0.75
- Orchard water use (ET_c)
 - 36 to 41 acre-in/acre in Sac & SJV
- More water improved gross revenue
 - up to 41 acre-in/acre

Summary

- *Sustained* deficit irrigation drastically reduces yield
 - Flowering is accelerated
 - Shoot growth is reduced
 - Fruit size -- most sensitive component
 - Fewer fruits & smaller sizes
- BUT, olive is drought tolerant
 - Tree will survive with little to no irrigation

Evapotranspiration (ET)

- Evaporation - water evaporation from soil
- Transpiration - water evaporation from leaves
- Climate
 - Solar Radiation ↑ - ET ↑ (day length)
 - Humidity ↓ - ET ↑
 - Temperature ↑ - ET ↑
 - Wind ↑ - ET ↑
- Tree canopy size (> 50% cover = 100% ET)

Calculating orchard water use (clean cultivated) in Orland

	<u>ETo (inches)</u>	<u>Kc</u>	<u>ETc (inches)</u>
March	3.1	0.75	2.3
April	4.8	0.75	3.6
May	6.7	0.75	5.0
June	7.4	0.75	5.6
July	8.8	0.75	6.6
August	7.3	0.75	5.5
September	5.6	0.75	4.2
October	3.8	0.75	2.9
November	1.7	0.75	1.3
TOTAL	49.2		37.0

WEEKLY SOIL MOISTURE LOSS IN INCHES

(Estimated Evapotranspiration)

08/05/05 through 08/11/05

West of Sacramento River**East of Sacramento River**

Weekly Water Use	Accum'd Seasonal Use	Crop (Leafout Date)	Weekly Water Use	Accum'd Seasonal Use
1.78	32.92	Pasture	1.63	30.66
1.71	31.81	Alfalfa	1.56	29.58
1.36	24.92	Olives	1.23	23.29
1.16	21.50	Citrus	1.06	19.97
1.71	29.95	Almonds (3/1) *	1.56	27.80
1.71	28.83	Prunes (3/15) *	1.56	26.73
1.71	27.18	Walnuts (4/1) *	1.56	25.11
1.53	30.19	Urban Turf Grass	1.42	28.24

WEEKLY APPLIED WATER IN INCHES¹

50%	60%	70%	80%	90%	← Efficiency →	50%	60%	70%	80%	90%
2.7	2.3	1.9	1.7	1.5	Olives	2.5	2.1	1.8	1.5	1.4
2.3	1.9	1.7	1.5	1.3	Citrus	2.1	1.8	1.5	1.3	1.2
3.4	2.9	2.4	2.1	1.9	Almonds (3/1)	3.1	2.6	2.2	2.0	1.7
3.4	2.9	2.4	2.1	1.9	Prunes (3/15)	3.1	2.6	2.2	2.0	1.7
3.4	2.9	2.4	2.1	1.9	Walnuts (4/1)	3.1	2.6	2.2	2.0	1.7

¹ The amount of water required by a specific irrigation system to satisfy evapotranspiration. Typical ranges in irrigation system efficiency are: Drip Irrigation, 80%-95%; Micro-sprinkler, 80%-90%; Sprinkler, 70%-85%; and Border-furrow, 50%-75%.

For further information, contact the Tehama Co. Farm Advisor's office at 527-3101.

ET data

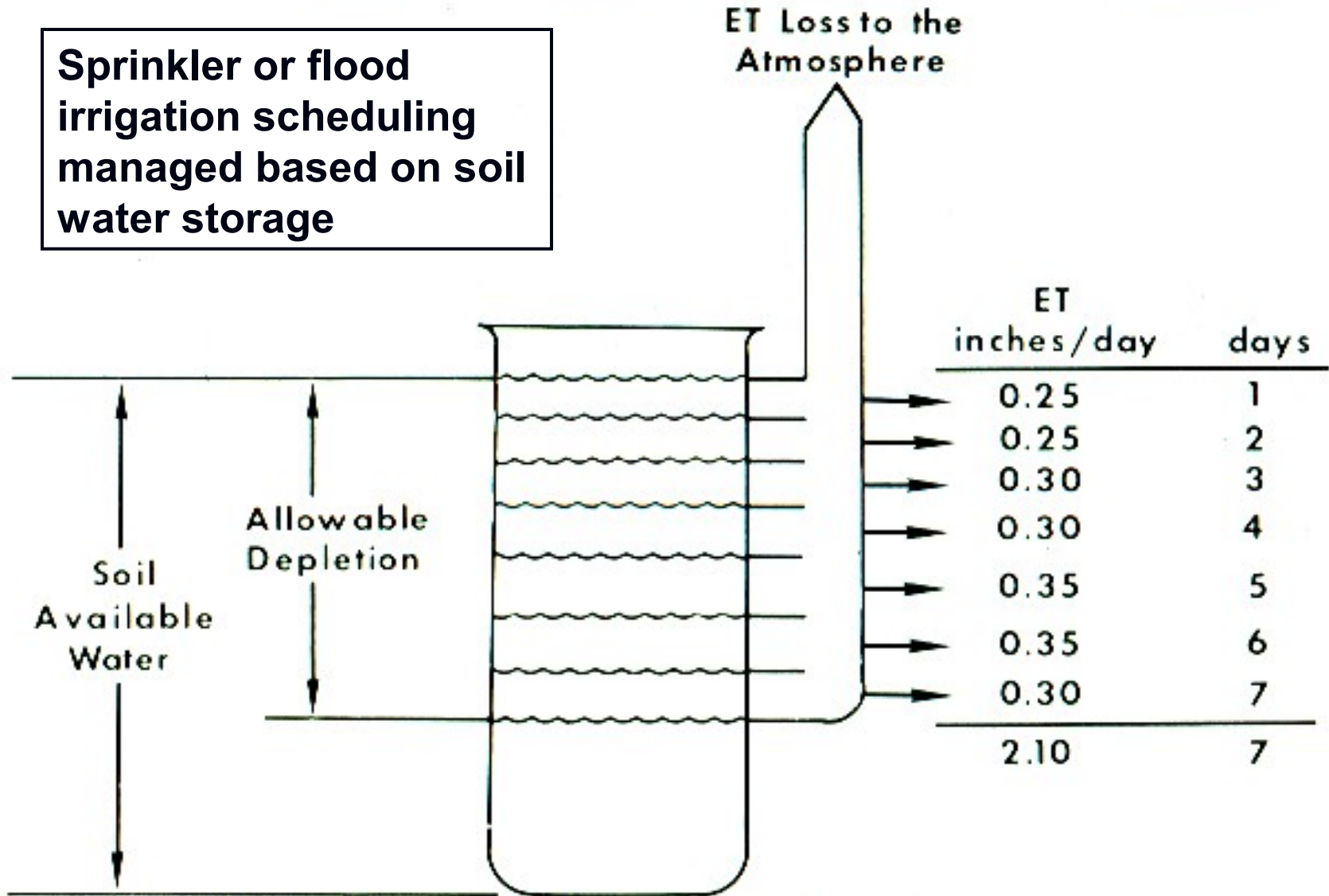
- ETc local papers

- ETo DWR CIMIS website

www.cimis.water.ca.gov

The Water Budget Method of Irrigation

Sprinkler or flood irrigation scheduling managed based on soil water storage



IRRIGATE

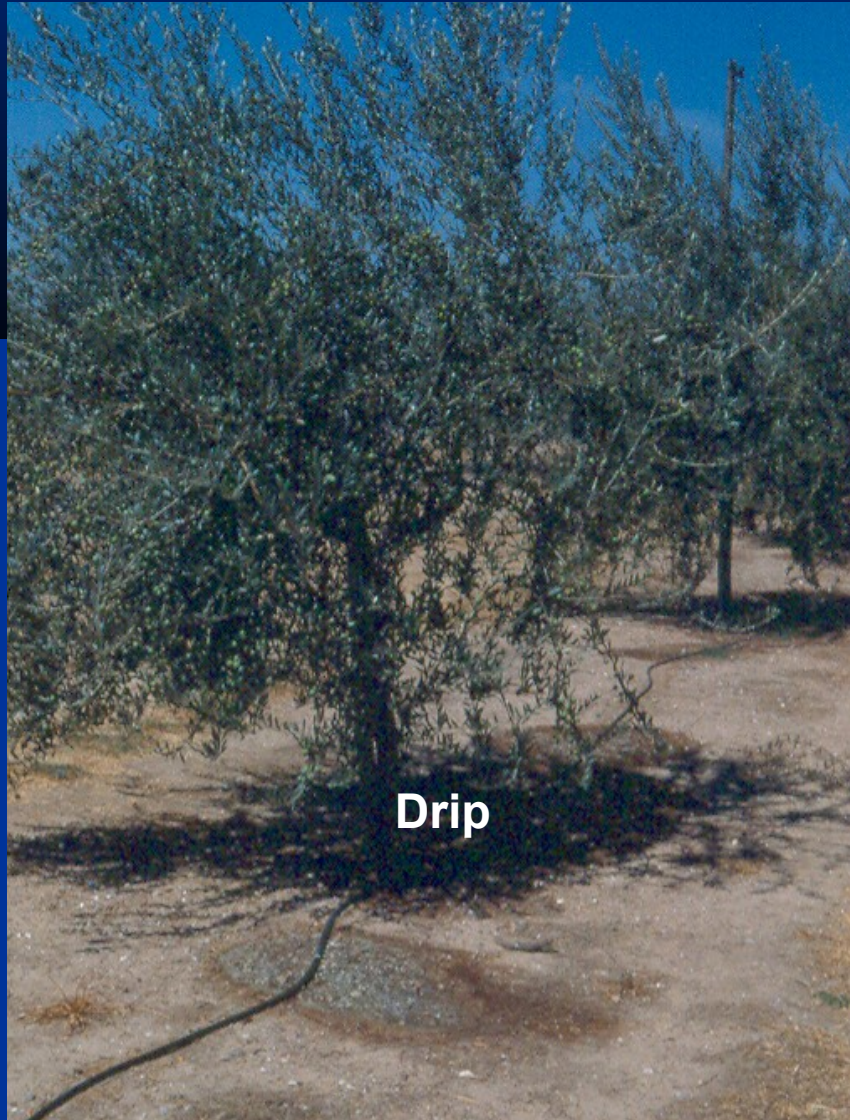
1. When?-----After 7 days

2. How much?-- Apply 2.10 inches of water + losses
(Efficiency consideration)

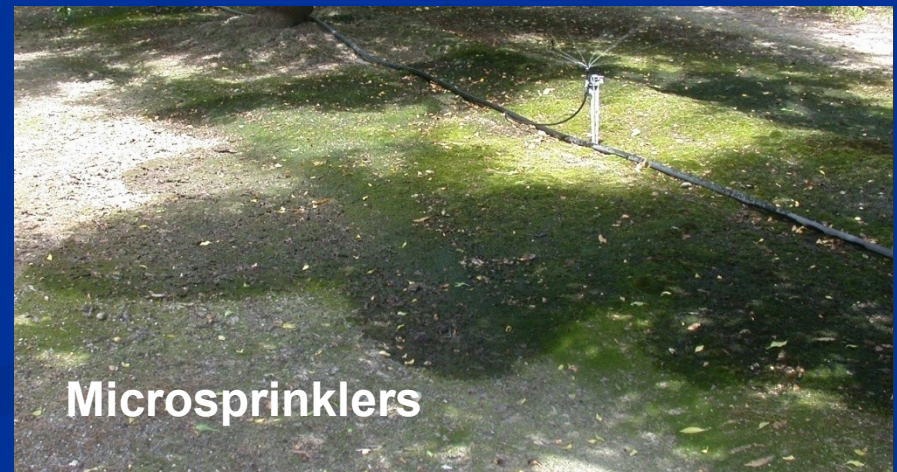
Control water applications with an efficient irrigation system

- **Heavy cropping years:**
 - Water more to promote shoot growth
 - No water deficit early in the season
 - Mature trees ~ 45 - 55% ETC
 - Young trees = full ETC
- **Light cropping years:**
 - Water less to save water
 - Usually plenty of shoot growth
 - Mature trees ~ 35 - 45% ETC
 - Young trees = full ETC

Low volume irrigation scheduling



- Use is determined by ET
- Drip or micro-sprinkler irrigation replaces what trees use every day or two
- Soil water holding capacity not important
- Keep emitters 2-3 feet away from trunk



Low volume irrigation scheduling

- Determine how much water to apply
 - Crop ET - climate, canopy size
 - Days between irrigations
- Determine how long to irrigate
 - ET between irrigations
 - Uniformity of irrigation system
 - Application rate of drippers or micro-sprinklers

Low volume irrigation scheduling

- ETc 6.6 inches in July / 31 days = 0.21 inches/day
- Irrigated 2 days ago, assume ETc = 0.25 inch/day, must replace 0.5 inch of water use
 - 1 acre inch = 27,154 gal / 2 = 13,577 gallons/half-inch
 - 22' x 22' = 90 trees/acre
 - 13,577 / 90 = 151 gallons per tree
- Determine how long to irrigate
 - Assume double line drip w/ eight, 1gal/hr emitters/tree
 - 151 gallons use / 8 gal/hr application rate = 19 hrs run time every other day

Dr. Goldhammer, Irrigation Specialist, UC KAC, mid 1990's

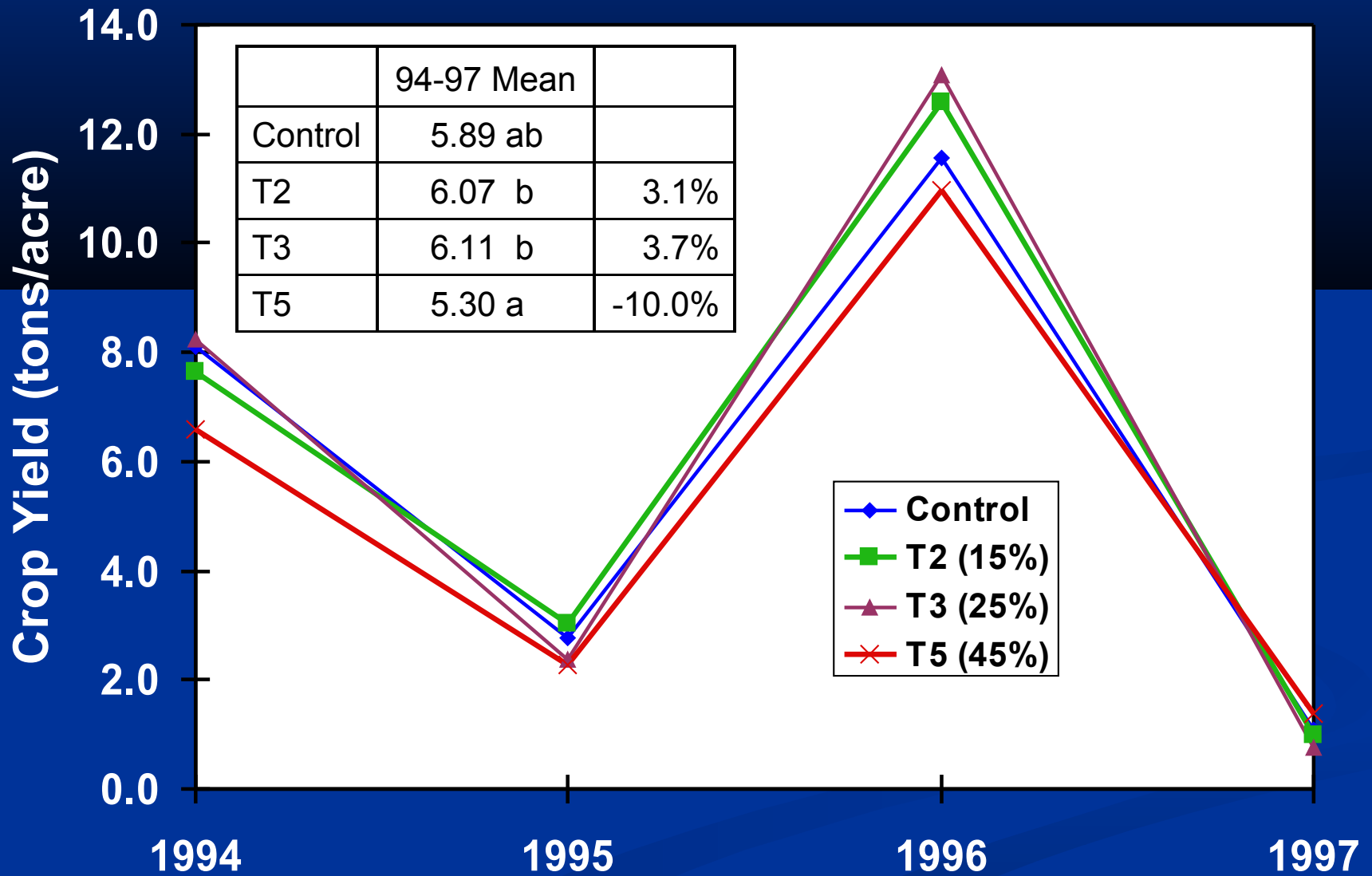
Regulated Deficit Irrigation trial

Irrigation Regime (% water saved)	Individual Fresh Fruit Wt. (g)	Fruit Load (#/tree)	Total Fruit Yield (tons/acre)	Crop Value (\$/ton)	Gross Revenue (\$/acre)
Control	4.12	19690	8.12	412	3340
T2 (13%)	4.15	18200	7.65	431	3310
T3 (21%)	4.11	20010	8.25	430	3580
T5 (40%)	4.23	16070	6.61	426	2800
	NSD	NSD	NSD	NSD	NSD

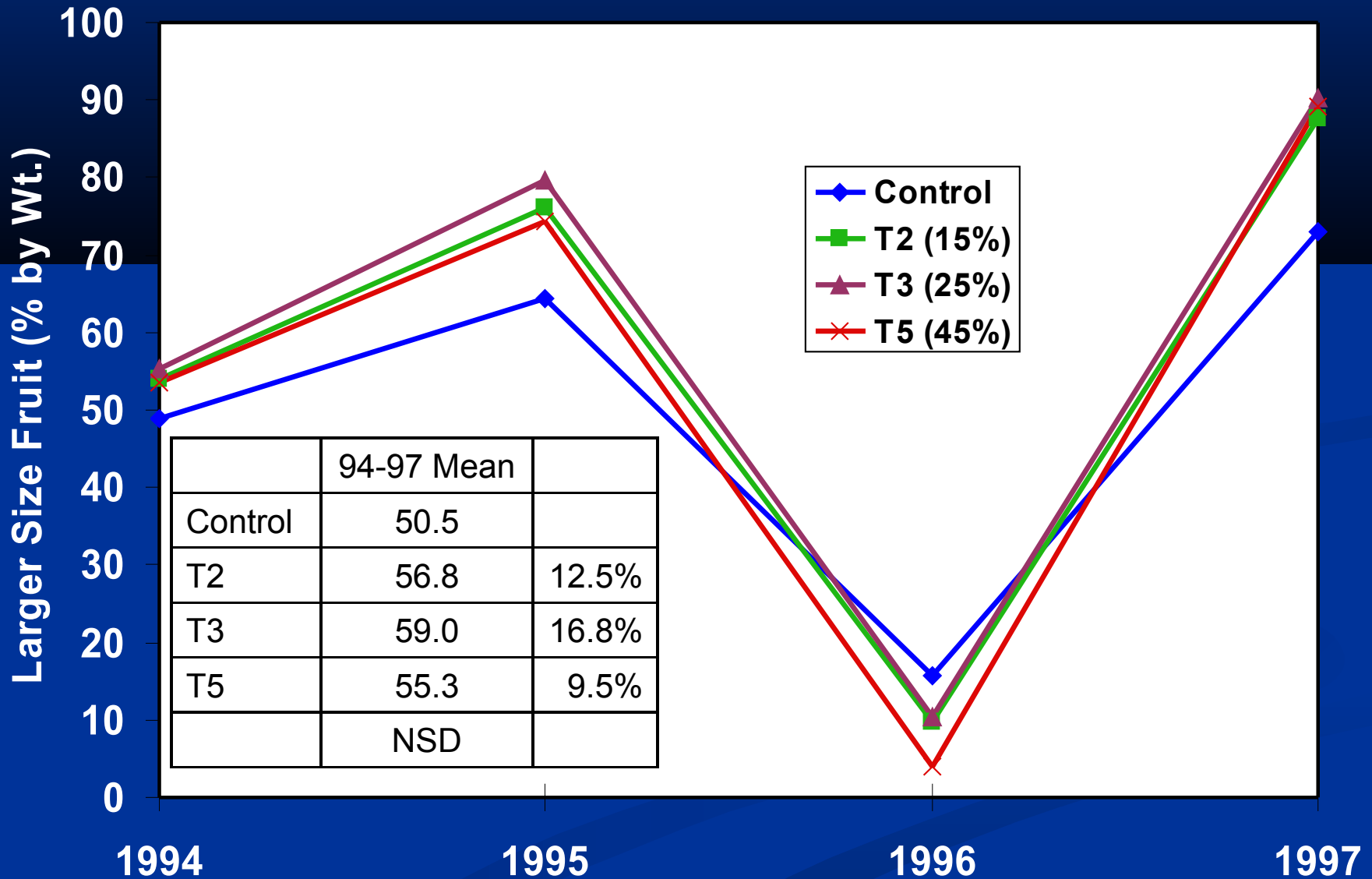
Regulated Deficit Irrigation, a controlled stress

Date	Treatment 1 Full ETc (in.)	RDI%	Treatment 2 Irrigation (in.)	RDI%	Treatment 3 Irrigation (in.)	RDI %	Treatment 5 Irrigation (in.)
Mar 1-15	1.2	100	1.2	100	1.2	100	1.2
Mar 16-31	1.2	100	1.2	100	1.2	100	1.2
Apr 1-15	1.8	100	1.8	100	1.8	100	1.8
Apr 16-30	1.8	100	1.8	100	1.8	100	1.8
May 1-15	2.3	100	2.3	100	2.3	100	2.3
May 16-31	2.5	100	2.5	100	2.5	50	1.3
Jun 1-15	2.9	100	2.9	50	1.5	50	1.5
Jun 16-30	2.9	50	1.5	50	1.5	25	0.7
Jul 1-15	3.1	50	1.6	50	1.6	25	0.8
Jul 16-30	3.3	50	1.7	50	1.7	25	0.8
Aug 1-15	2.7	100	2.7	50	1.4	25	0.7
Aug 16-31	2.8	100	2.8	100	2.8	50	1.4
Sep 1-15	2.0	100	2.0	100	2.0	50	1.0
Sep 16-30	2.0	100	2.0	100	2.0	100	2.0
Oct 1-15	1.2	100	1.2	100	1.2	100	1.2
Oct 16-31	1.3	100	1.3	100	1.3	100	1.3
Nov 1-15	0.5	100	0.5	100	0.5	100	0.5
TOTAL (in.)	35.5		31.0		28.3		21.5
Water Saved (in.)			4.6		7.4		14.0
Water Saved (%)			12.9%		20.8%		39.5%

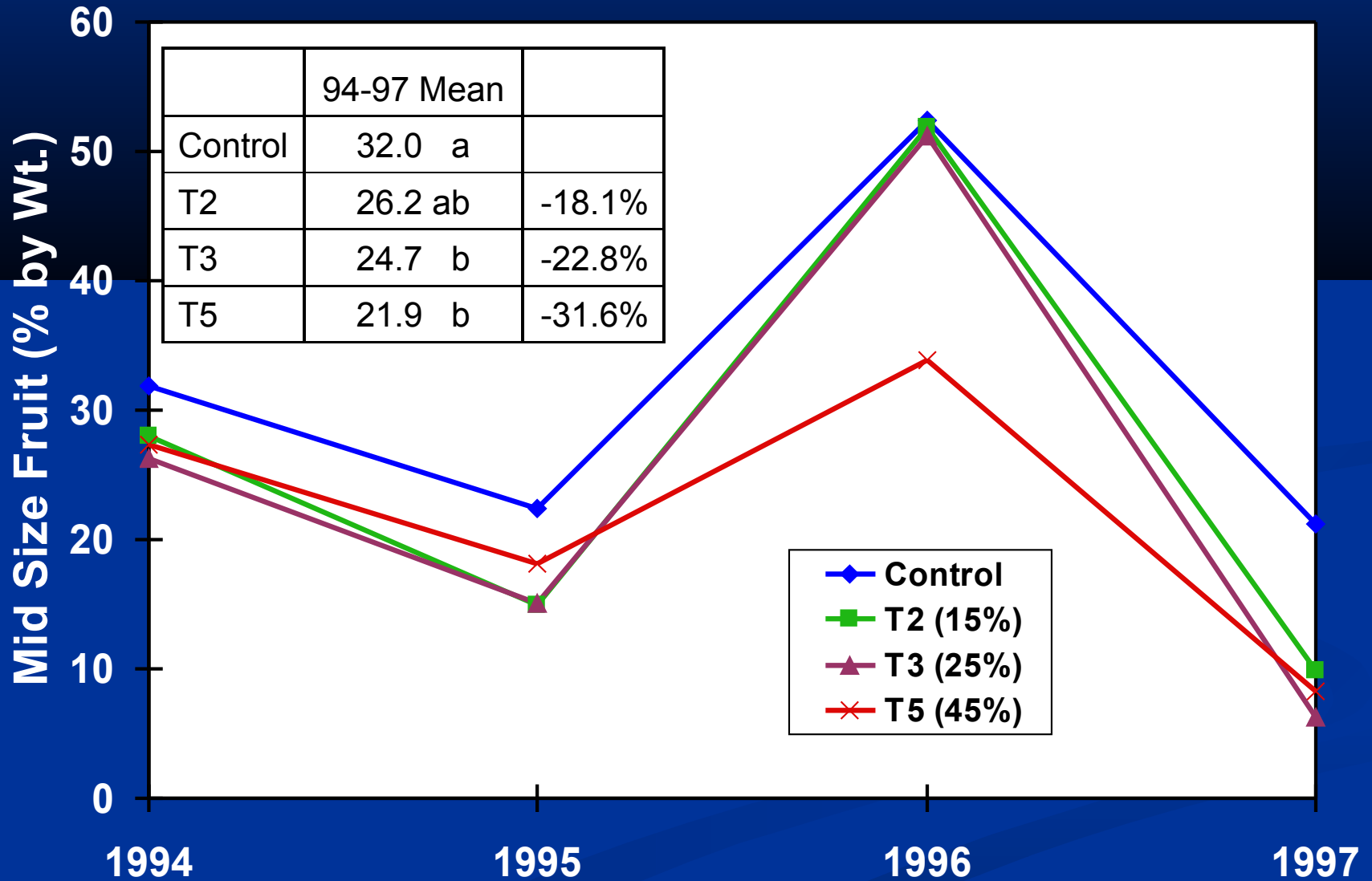
Gross Fresh Fruit Yield



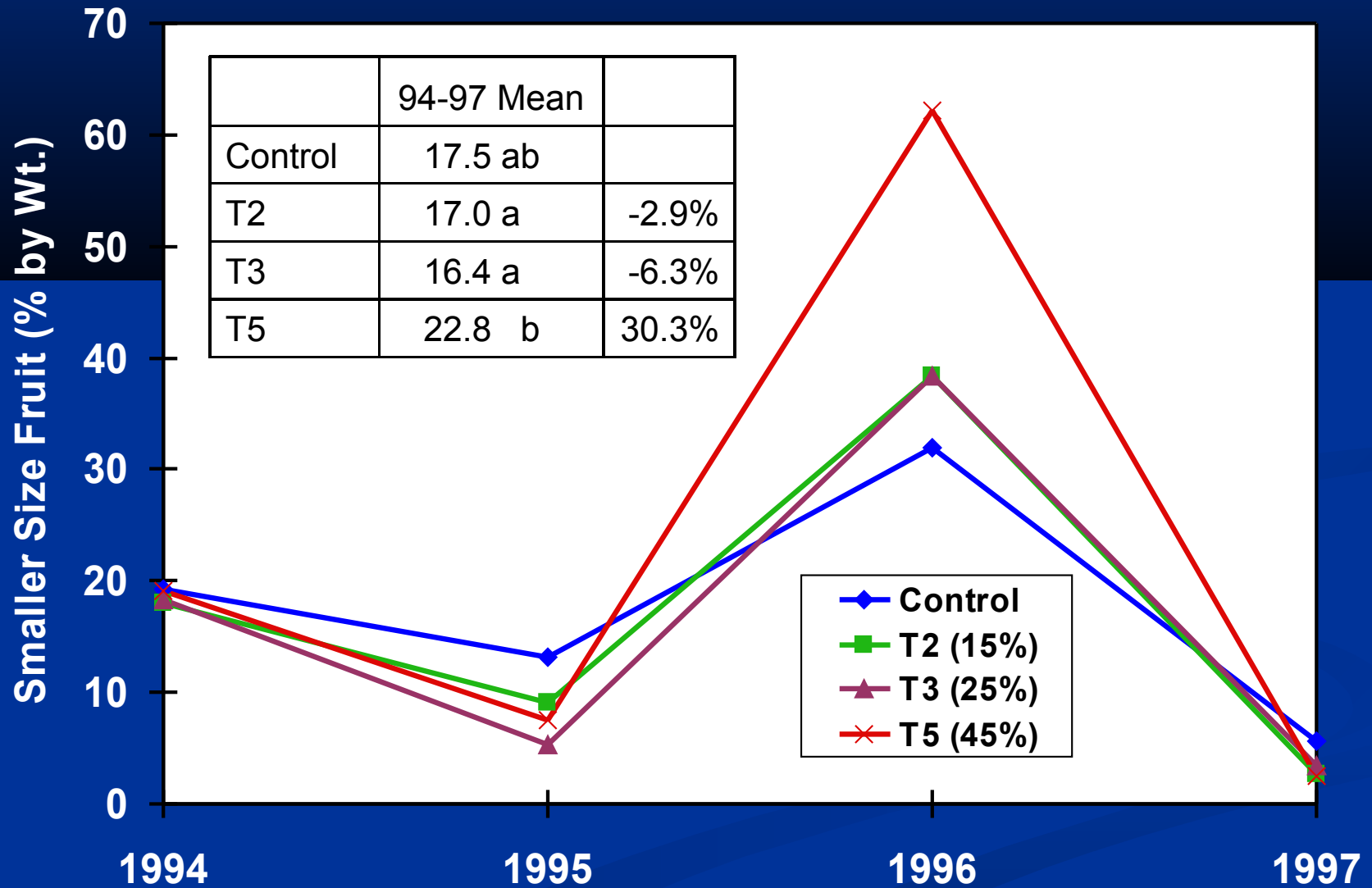
Jumbo + Ex. Large + Large + Medium Sizes



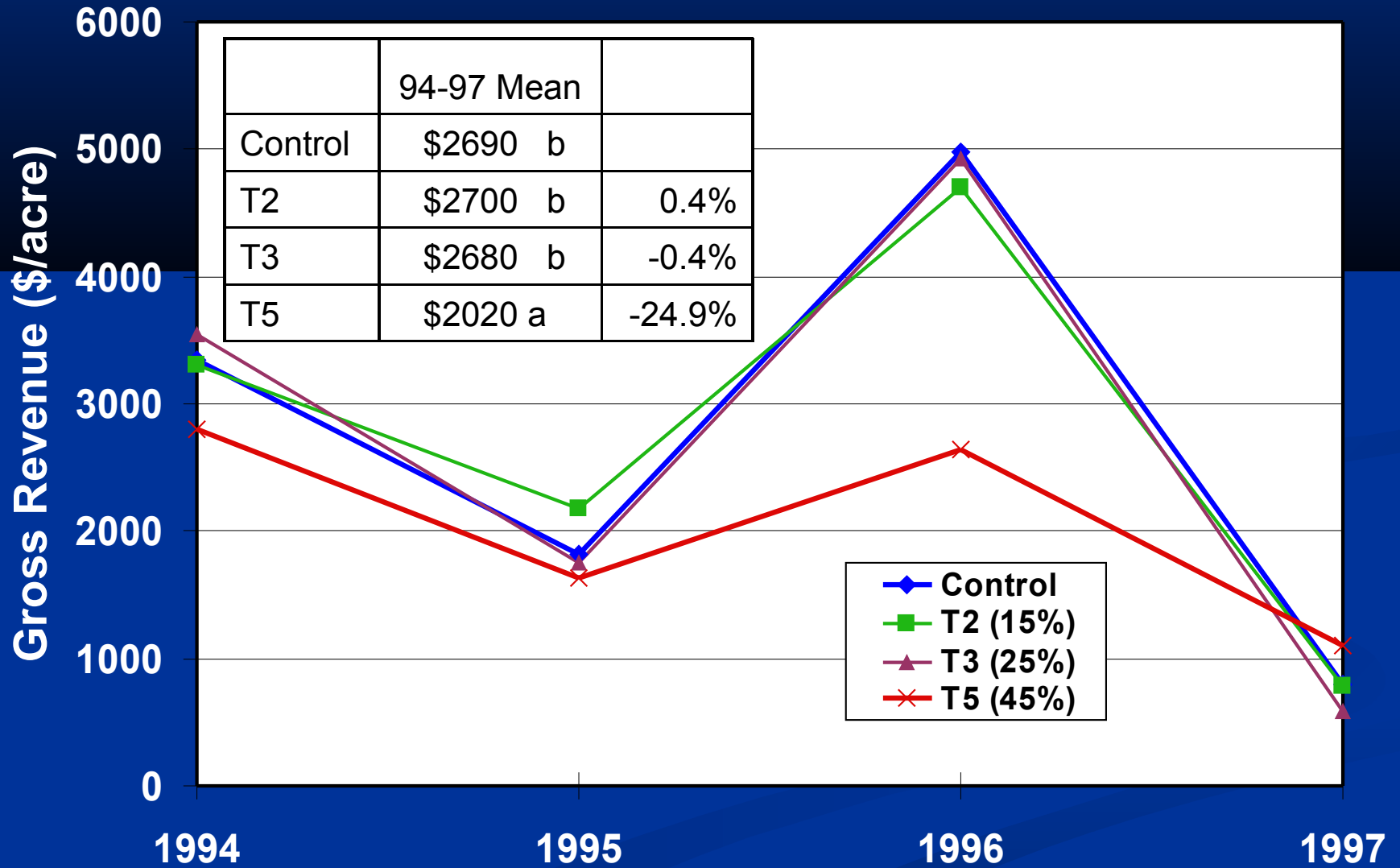
Small + Petite Size Fruit



Sub-Petite + Undersize + Cull Size Fruit



Gross Revenue



Summary

- ✓ Fruit growth slows during *regulated deficit irrigation (RDI)*
 - accelerates upon return to full irrigation
- ✓ RDI saved up to 21% (7.4 in) of normal water use (35.4 in)
 - no effect on fruit size

Summary

- ✓ Olive RDI is a strategy that can save water while maintaining good yield of high quality fruit
- ✓ MUST know what you're doing
 - good control of water applications

Dr. Steve Grattan, Irrigation Specialist, UC Davis, early 2000's
Joe Connell, Farm Advisor, Butte County, Maria Jose Berenguer-Merelo

Narrow Differential Irrigation trial for Oil Olives

Treatment Color Code	Applied Water (gallons/tree)	% ET Treatment
Red	90	15
Orange	156	25
Yellow	313	40
Green	469	57
Grn-White	625	71
White	782	89
Blue	938	107



Increasing water



15% ET

***SHD Oil
Olives***

***By July,
tree
density
affected***



41% ET

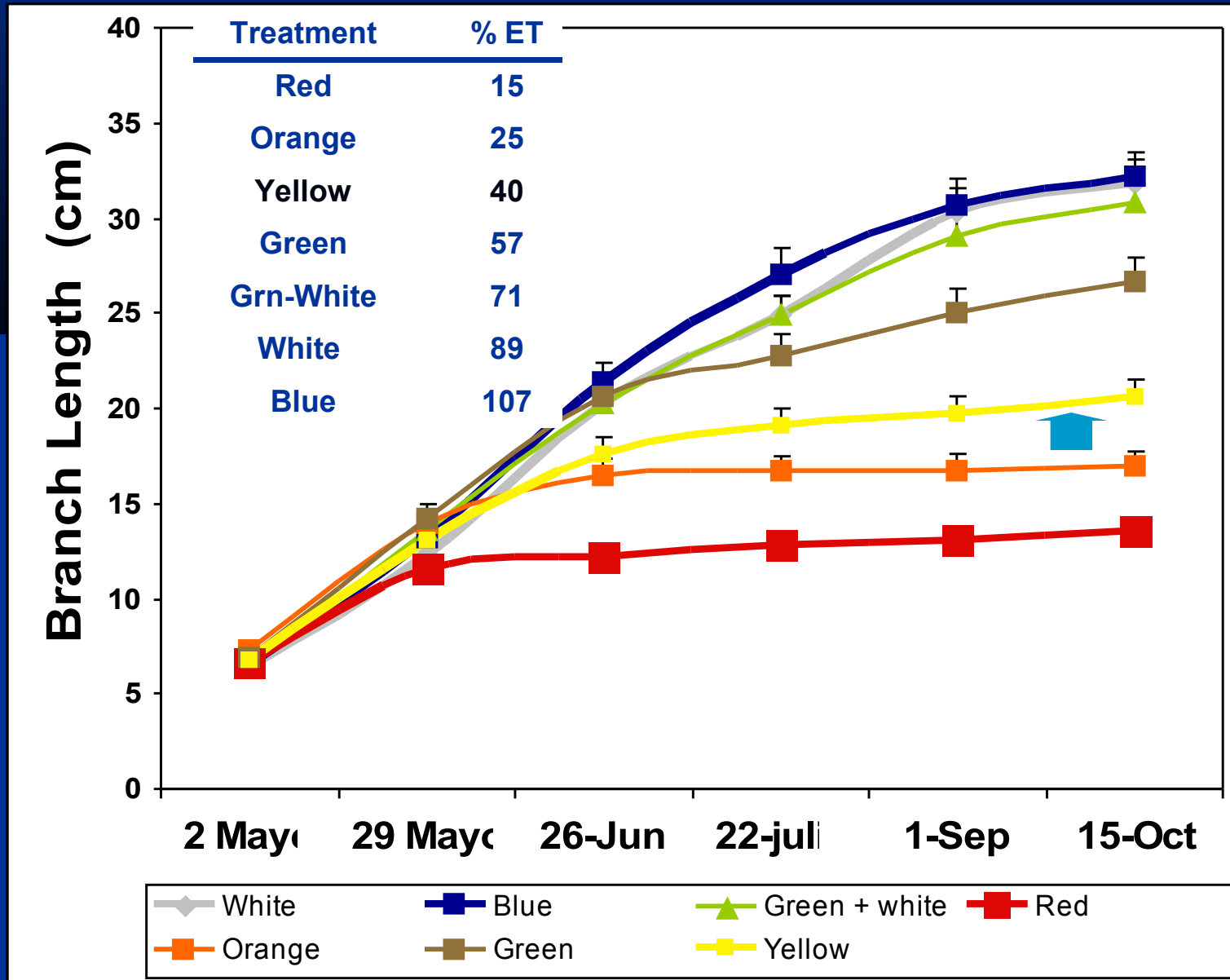


90% ET

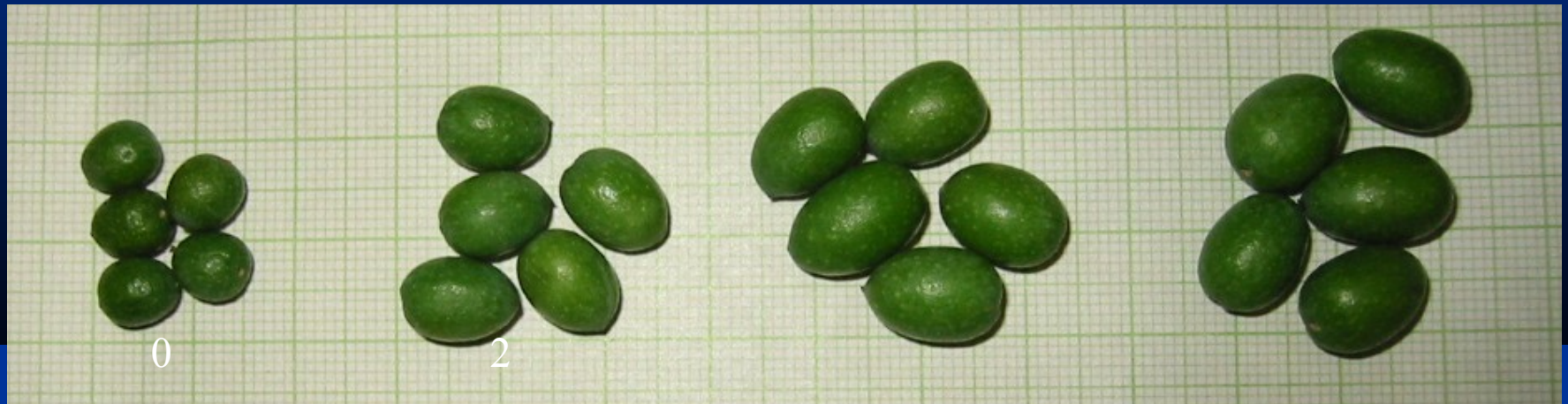


107% ET

Water stress reduced vegetative growth



Water stress reduced fruit size



15% ET

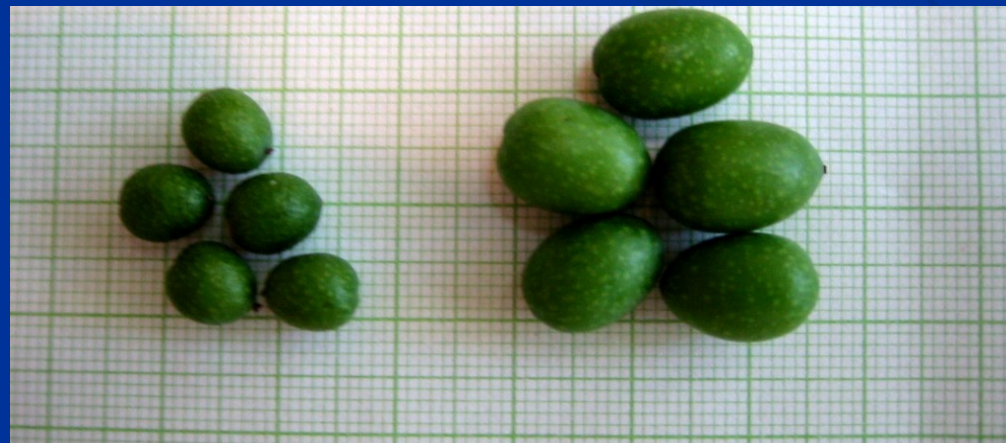
40% ET

71% ET

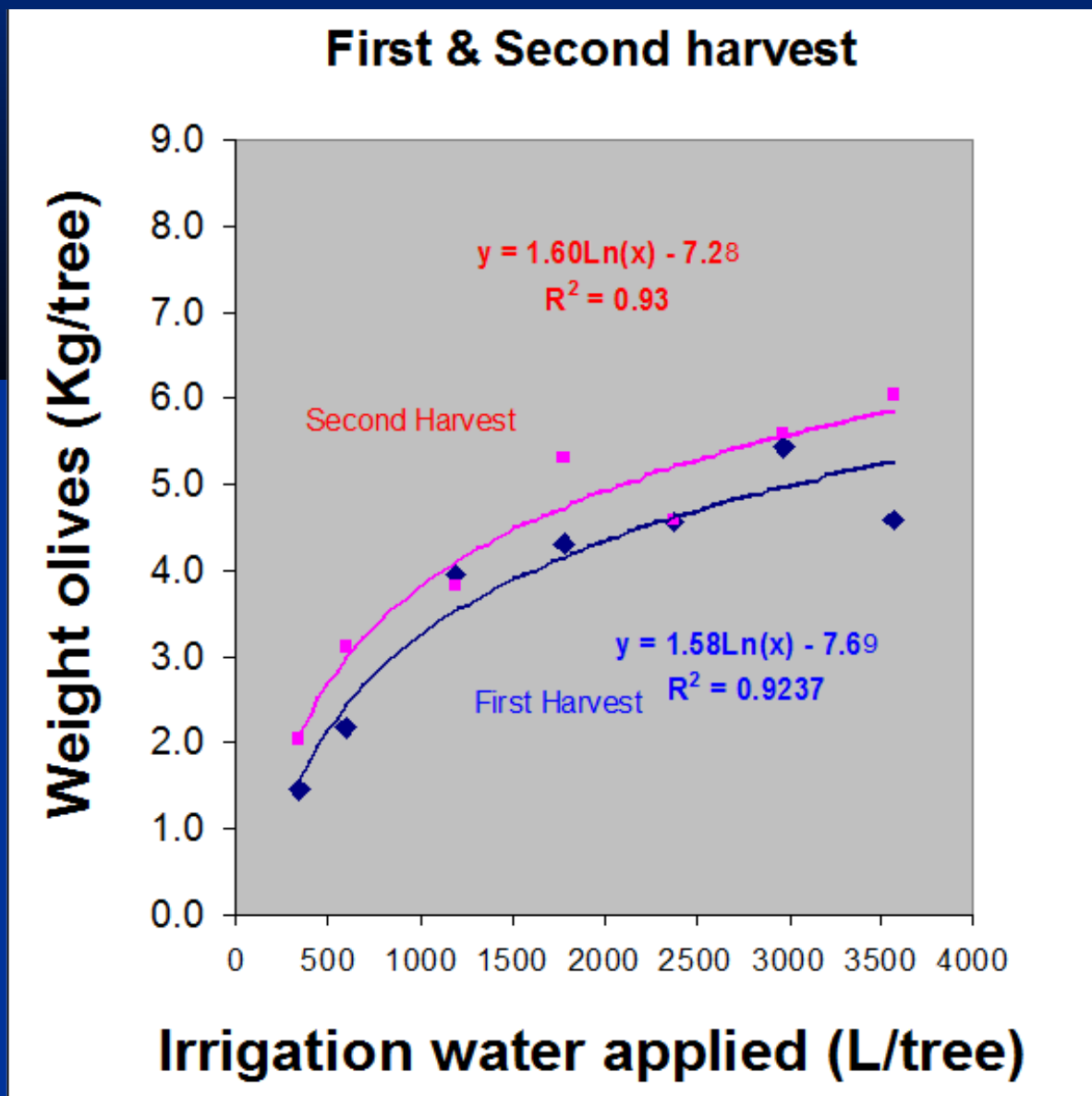
107% ET

Driest

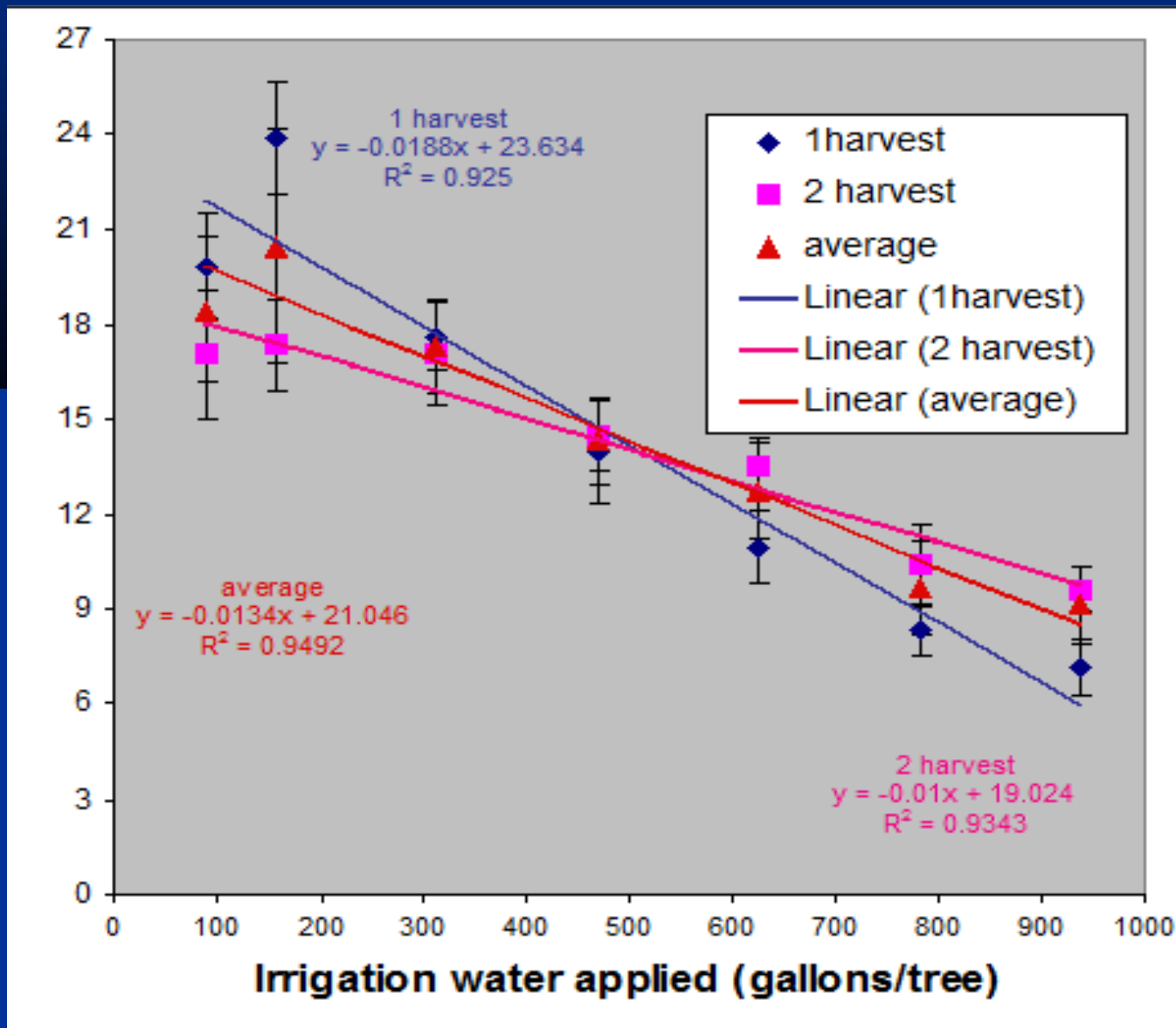
Wettest



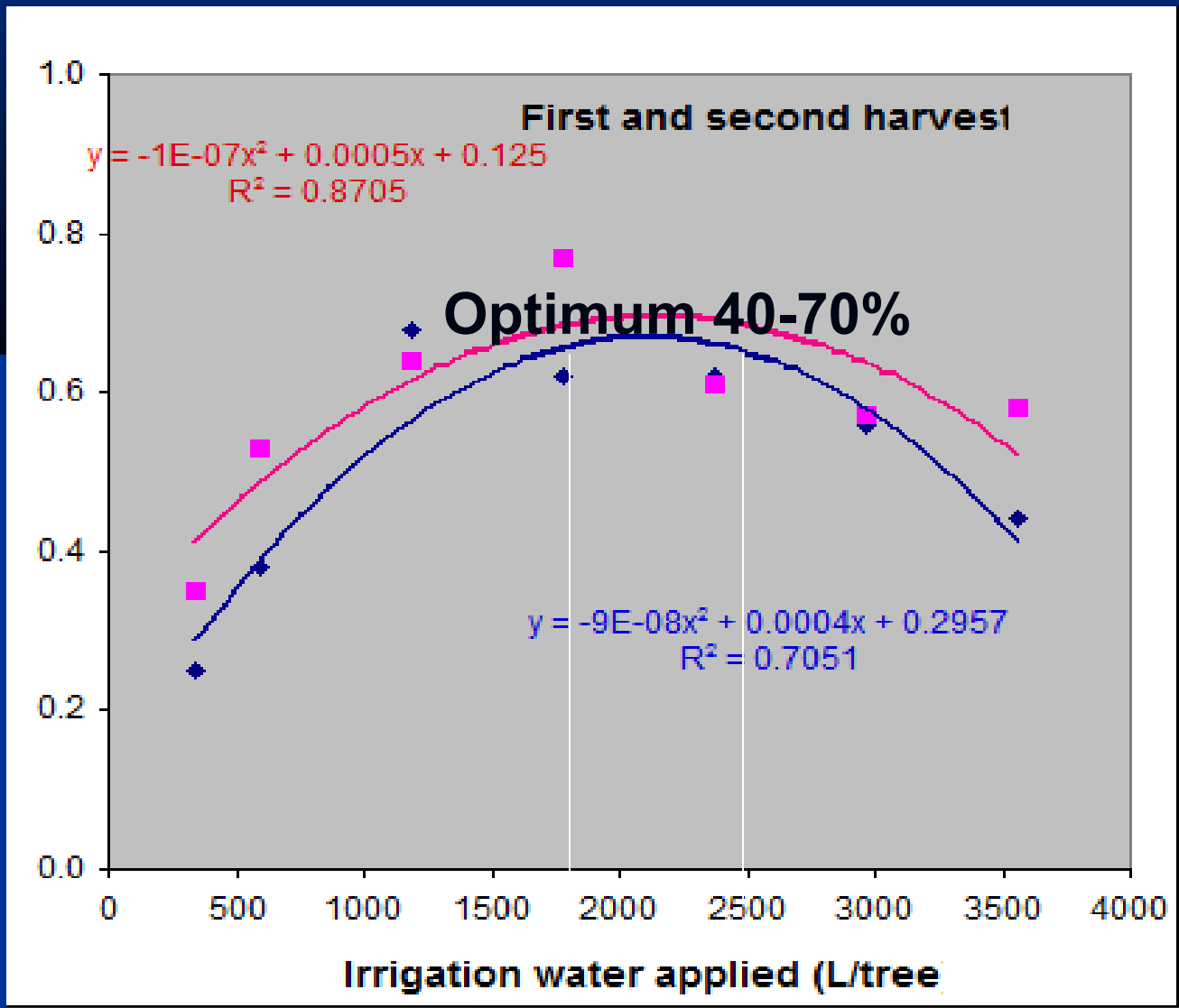
Fresh weight at October 31 & November 18 harvests



Percent oil content



Total oil production per tree



Best irrigation level for olive oil production ranges between 50 and 70% ET



- Higher crop yield
 - Makes up for less oil per fruit
- Good shoot growth
- Good return bloom

Paul Vossen, Farm Advisor, Sonoma Co. and Vito Polito, UC Davis

Fruitiness, bitterness, and pungency of olive oils as influenced by irrigation

Treatments	Fruitiness	Bitterness	Pungency
15% ET	3.6 a	6.0 a	4.9 a
25% ET	3.2 b	4.2 b	3.9 b
40% ET	2.7 c	1.7 c	1.9 c
57% ET	2.6 c	0.93 d	1.1 d
71% ET	2.1 d	0.3 d	0.3 e
89% ET	1.8 d	0.22 d	0.22 e
107% ET	1.7 d	0.20 d	0.2 e

Best irrigation level for olive oil flavor is 35% to 55% ET

- High level of pleasant fruitiness
- Both ripe fruit and green character
- More complexity and depth
- Higher polyphenol content
- Balanced bitterness
- Balanced pungency
- Excess irrigation = bland oils

Olive oil summary

- To optimize olive oil production, don't fully irrigate
- Oil production optimized between 40 and 70% ET
 - Best production...high end of this range
 - Best oil quality...lower end
- Full irrigation of oil olives
 - increases pumping costs
 - promotes unnecessary vegetative growth
 - can reduce flowering
 - increases pruning costs



Thank you!

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