Irrigation of Olives --- What can be done if water is short?

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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

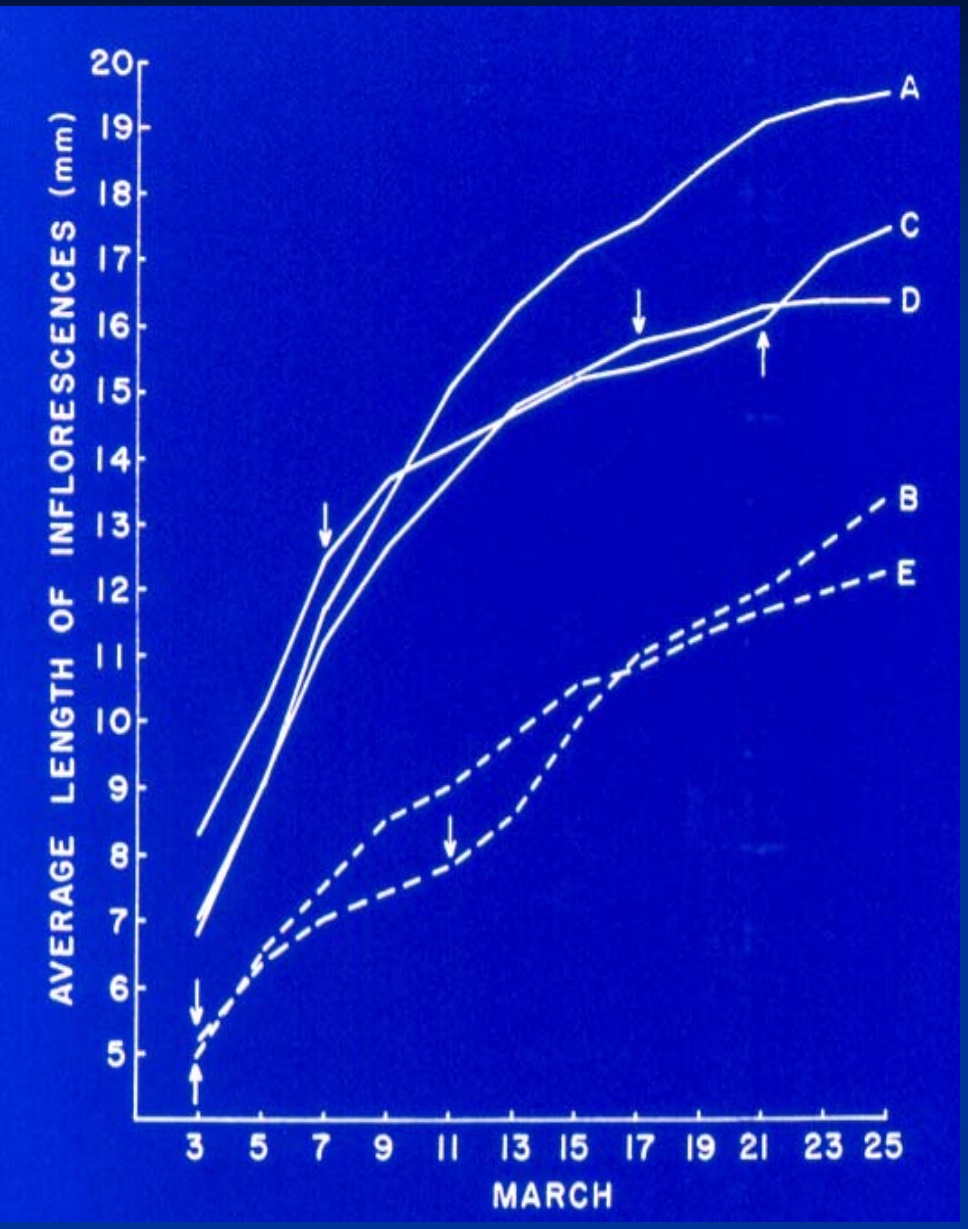
Relationship between olive tree growth and production

- 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.

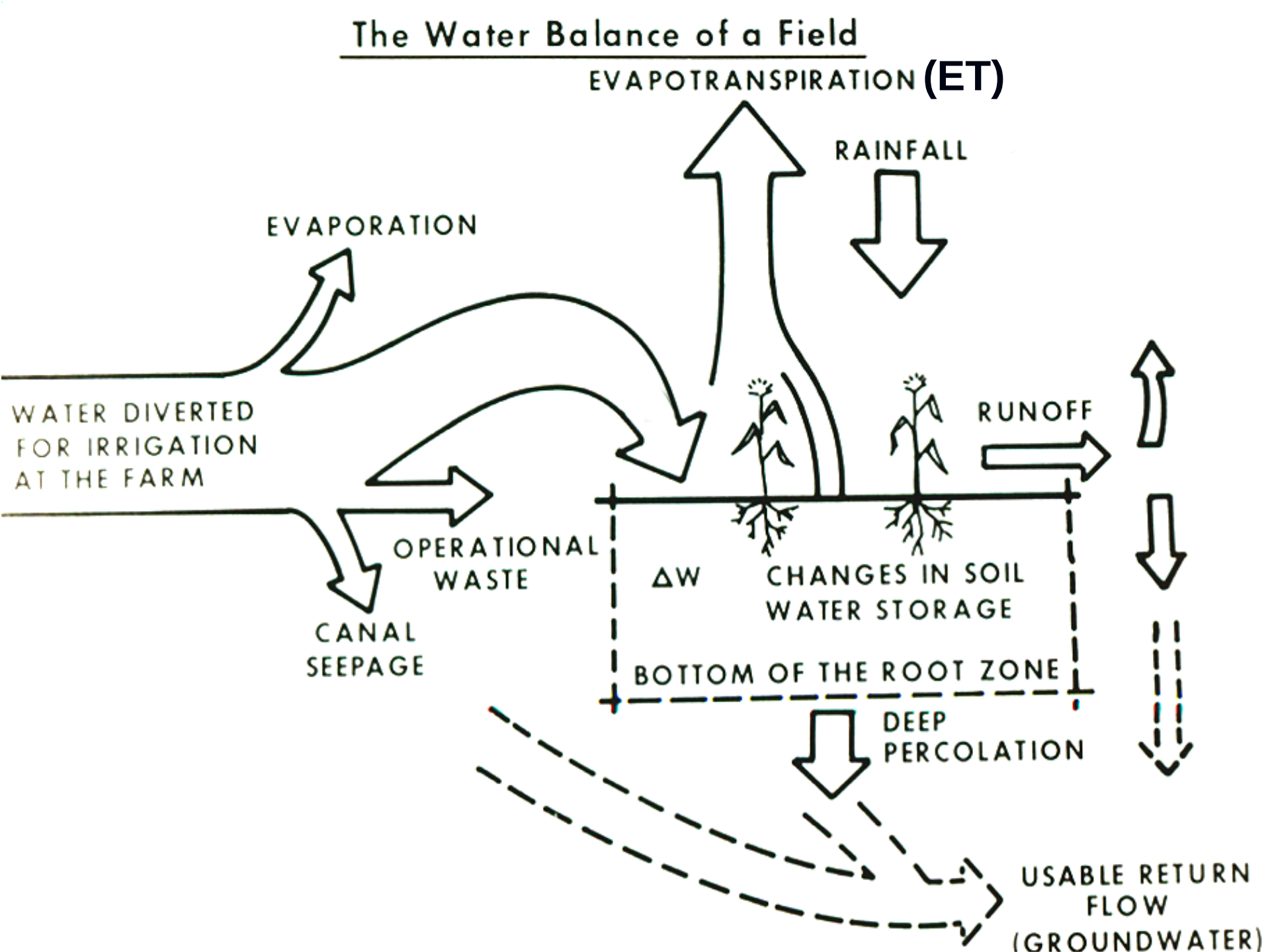
E -- Continuous moisture deficiency.

Source: Dr. H.T. Hartmann
UCD Pomology

Early spring water stress effects on Barouni olives

Water Stress Timing	% Leaf Drop	# Flowers/ Inflorescence	% Perfect Flowers	# Fruits / 100 Inflorescences
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	---

Source: Dr. H.T. Hartmann
UCD Pomology, 1960


The Water Balance of a Field
EVAPOTRANSPIRATION (ET)
RAINFALL
EVAPORATION
WATER DIVERTED FOR IRRIGATION AT THE FARM
RUNOFF
OPERATIONAL WASTE
CANAL SEEPAGE
ΔW
CHANGES IN SOIL WATER STORAGE
BOTTOM OF THE ROOT ZONE
DEEP PERCOLATION
USABLE RETURN FLOW (GROUNDWATER)

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)

Enterprise-Record Sunday, August 14, 2005

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 INCHES[1]

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…

- Local papers
- DWR CIMIS website www.cimis.water.ca.gov

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

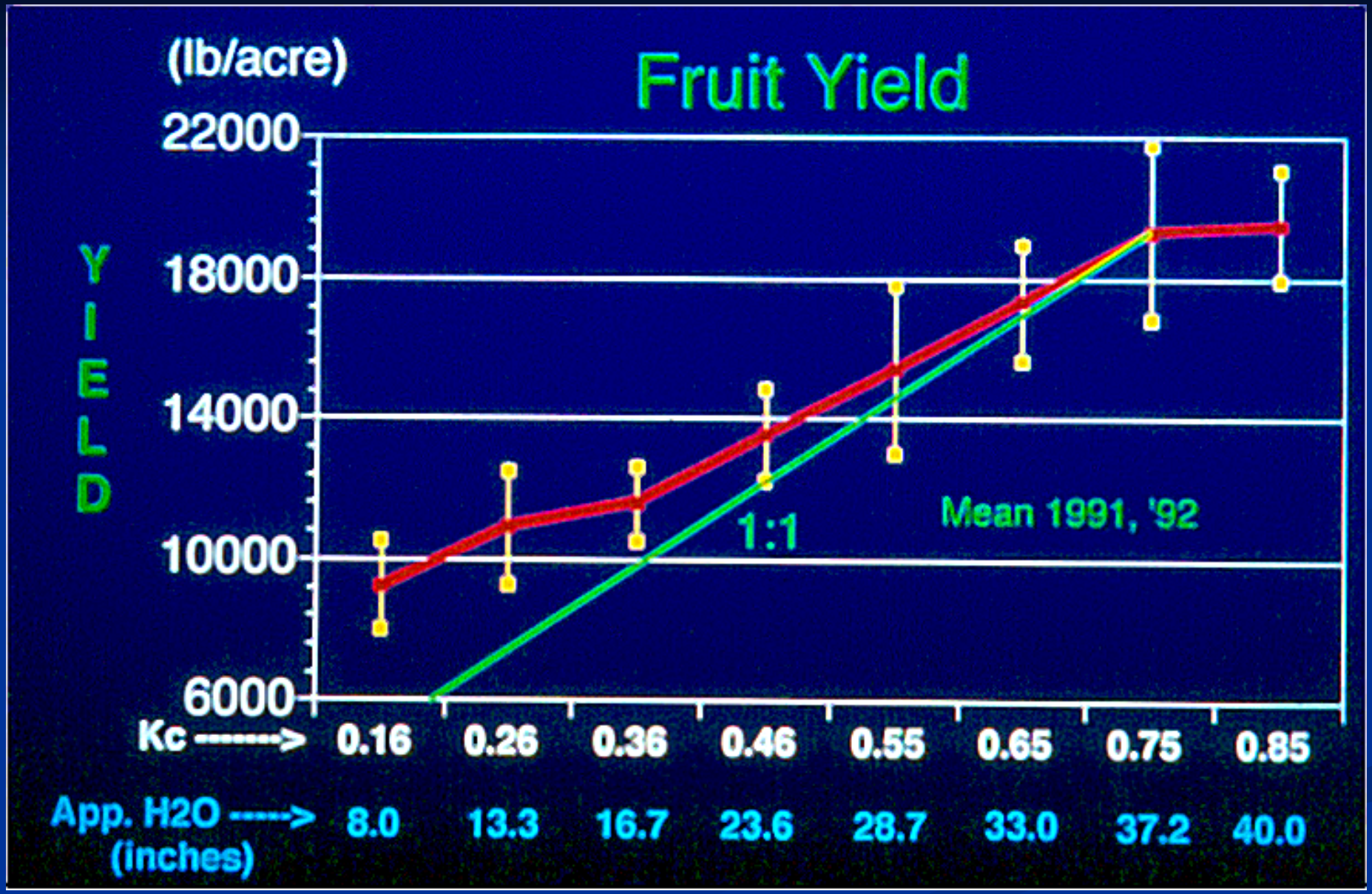
Narrow Differential Irrigation Trial ---

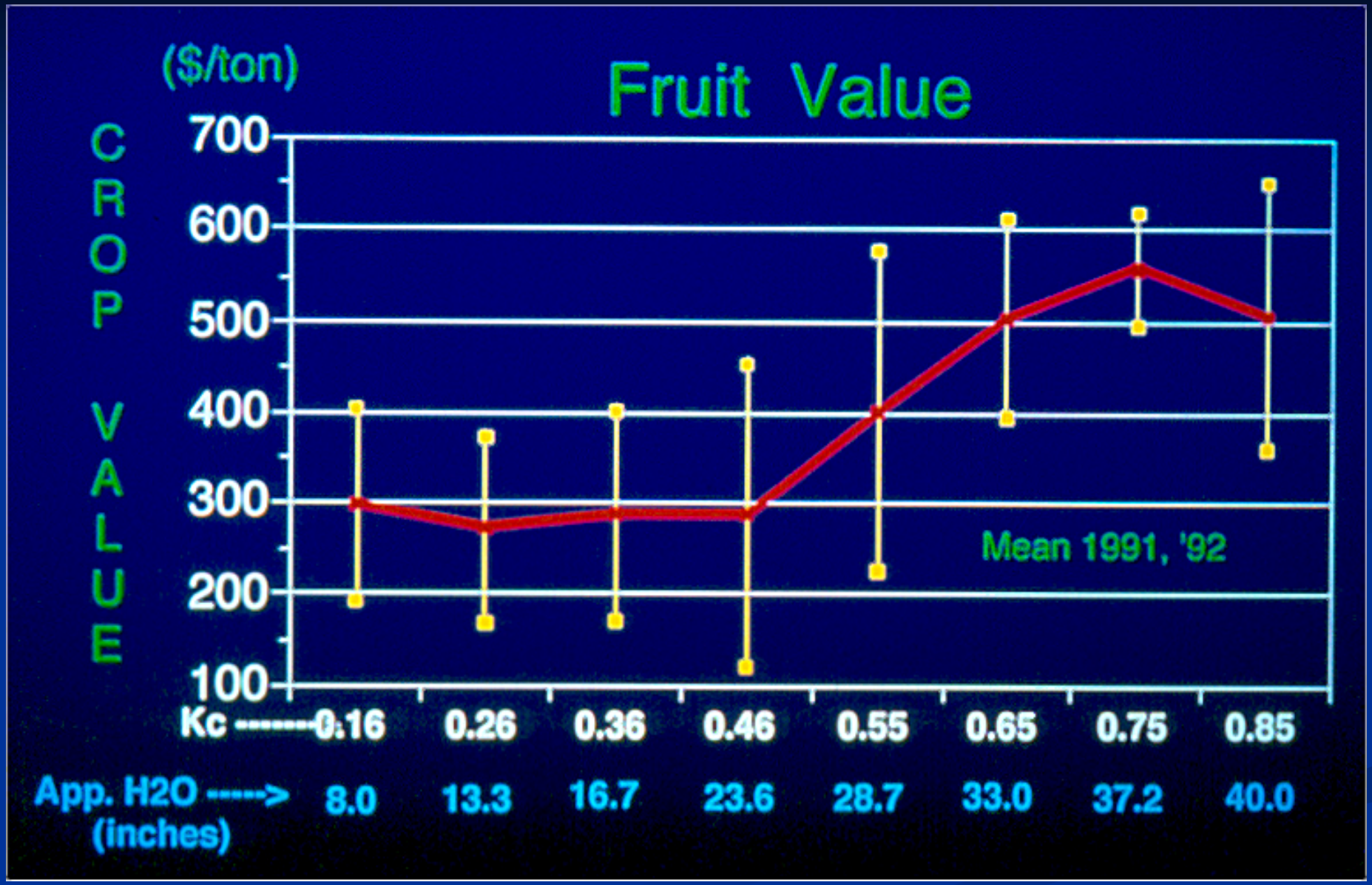
Percent of Control	(Kc) Crop Coefficient	Applied Water Acre-in/Acre
25%	.16	8.9
40%	.26	14.2
55%	.36	19.5
70%	.46	24.9
85%	.55	30.2
100%	**.65**	**35.5**
115%	.75	40.8
130%	.85	46.2

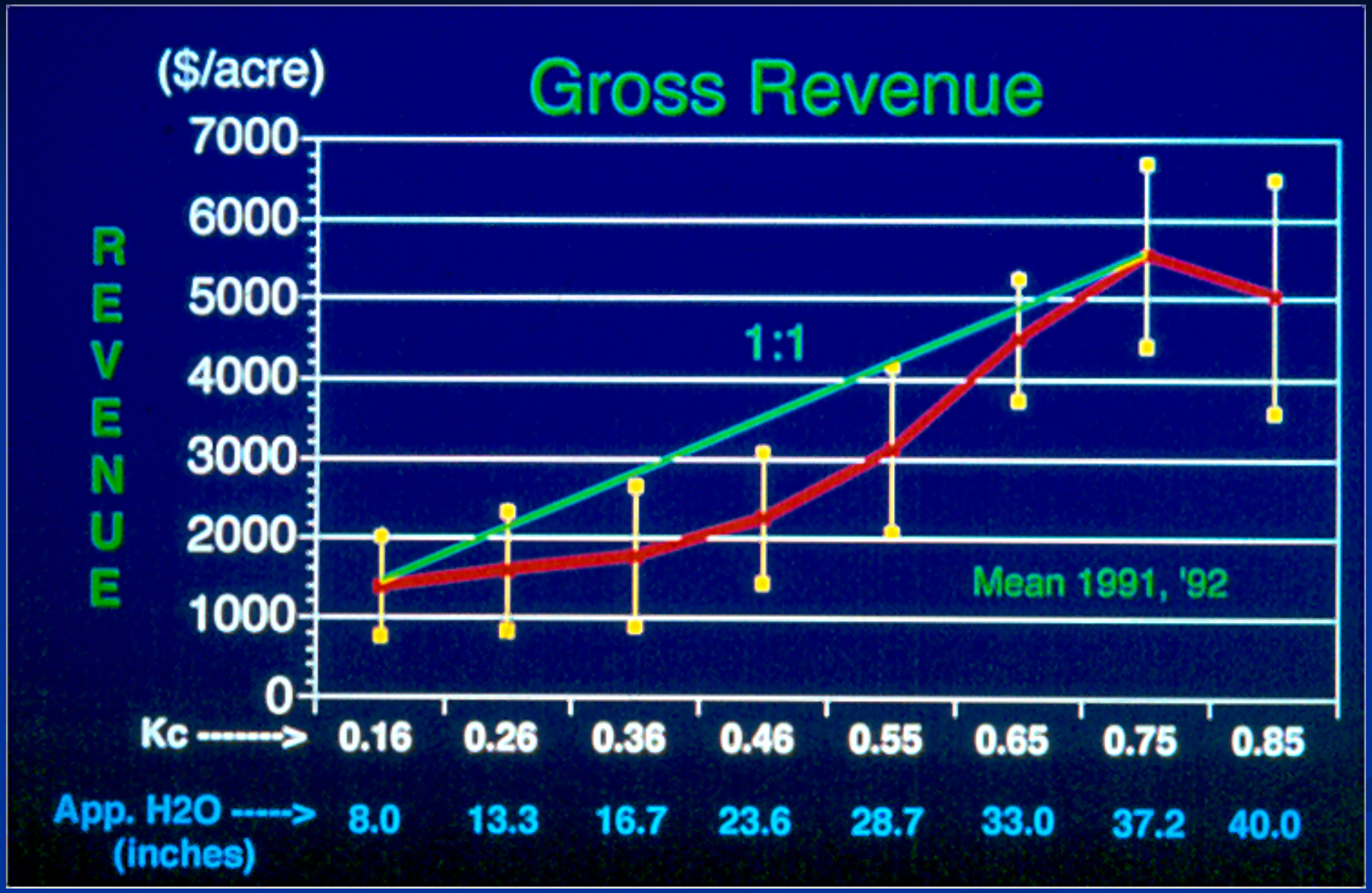
8 Irrigation Treatments with 6 Replications

Yield components in olive:

- ✓ Shoot growth & bloom
- ✓ Fruit load
- ✓ Fruit size distribution (value)
- ✓ Oil Content


Fruit Yield
(lb/acre)
YIELD
22000
18000
14000
10000
6000
1:1
Mean 1991, '92
Kc ------> 0.16 0.26 0.36 0.46 0.55 0.65 0.75 0.85
App. H2O -----> (inches) 8.0 13.3 16.7 23.6 28.7 33.0 37.2 40.0


Fruit Value
($/ton)
CROP VALUE
700
600
500
400
300
200
100
Mean 1991, '92
Kc ------- 0.16 0.26 0.36 0.46 0.55 0.65 0.75 0.85
App. H2O -----> (inches) 8.0 13.3 16.7 23.6 28.7 33.0 37.2 40.0


Gross Revenue
($/acre)
REVENUE
7000
6000
5000
4000
3000
2000
1000
0
1:1
Mean 1991, '92
Kc ------->
0.16
0.26
0.36
0.46
0.55
0.65
0.75
0.85
App. H2O ----->
(inches)
8.0
13.3
16.7
23.6
28.7
33.0
37.2
40.0

Summary ---

- Olive crop coefficient (Kc) 0.65-0.75
- Orchard water use (ETc)
  - 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

Average Reference Crop Water Use, ETo, inches

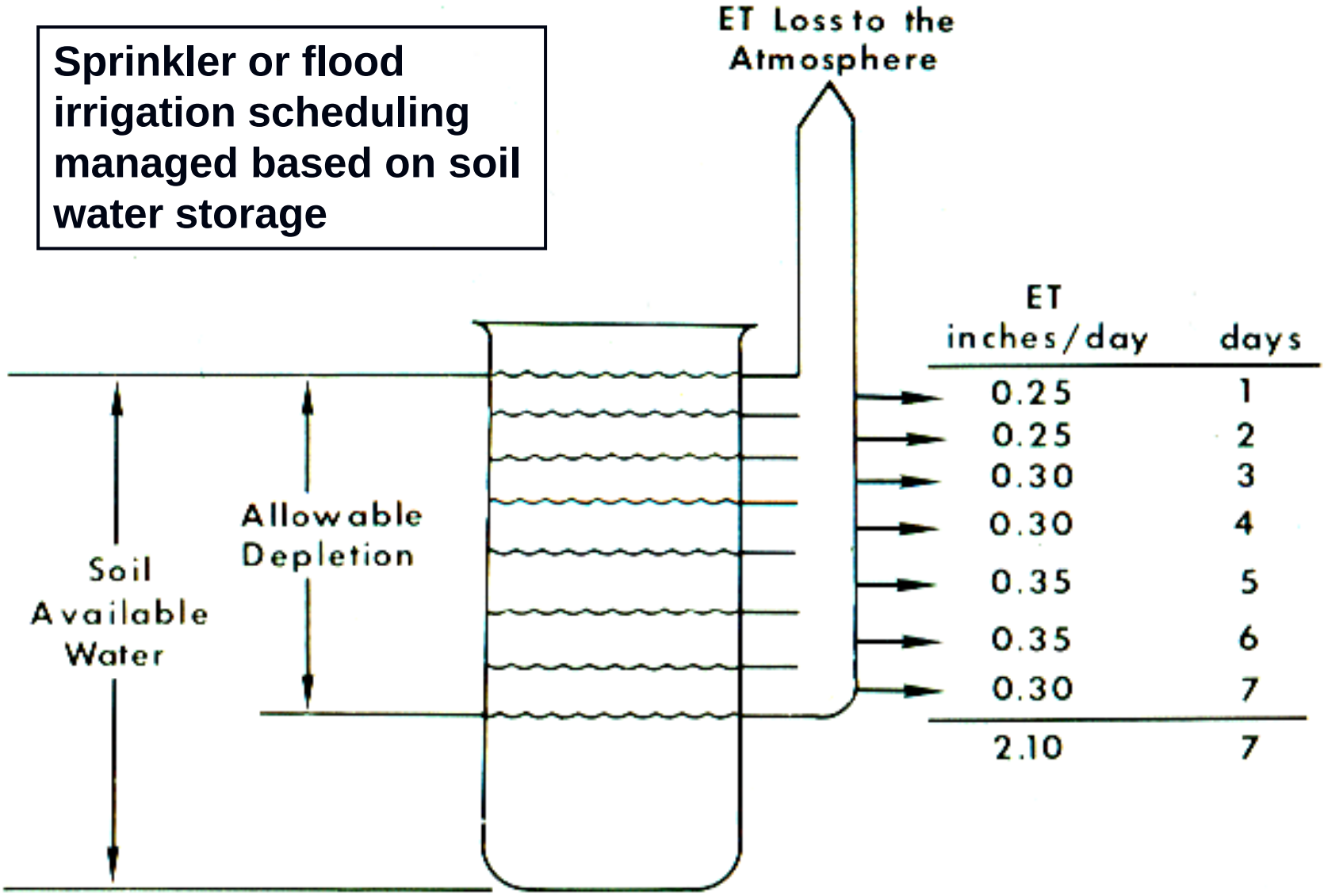
	Fresno	Orland	St. Helena
March	3.3	3.1	2.8
April	4.8	4.8	3.9
May	6.7	6.7	5.1
June	7.8	7.4	6.1
July	8.4	8.8	7.0
August	7.1	7.3	6.2
September	5.2	5.6	4.8
October	3.2	3.8	3.1
November	1.4	1.7	1.4
TOTAL	**47.9**	**49.2**	**40.4**

Calculating orchard water use (clean cultivated) in Orland

	ETo (inches)	Kc	ETc (inches)
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**

The Water Budget Method of Irrigation

Sprinkler or flood irrigation scheduling managed based on soil water storage

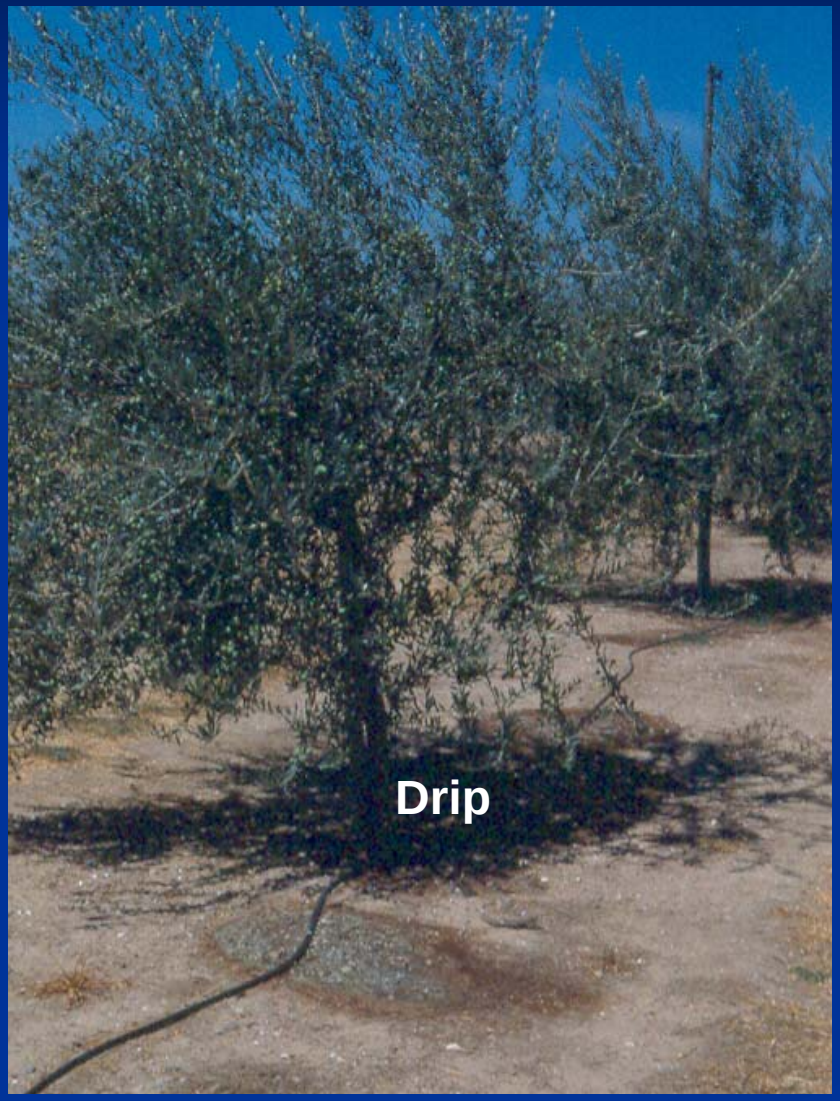


ET inches/day	days
0.25	1
0.25	2
0.30	3
0.30	4
0.35	5
0.35	6
0.30	7
2.10	7

IRRIGATE

1. When?--------After 7 days
2. How much?-- Apply 2.10 inches of water + losses (Efficiency consideration)

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…

- ET 6.6 inches in July / 31 days = 0.21 inches/day
- Irrigated 2 days ago, assume ET = 0.25 inch/day, must replace 0.5 inch of water use
  - 1acre 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

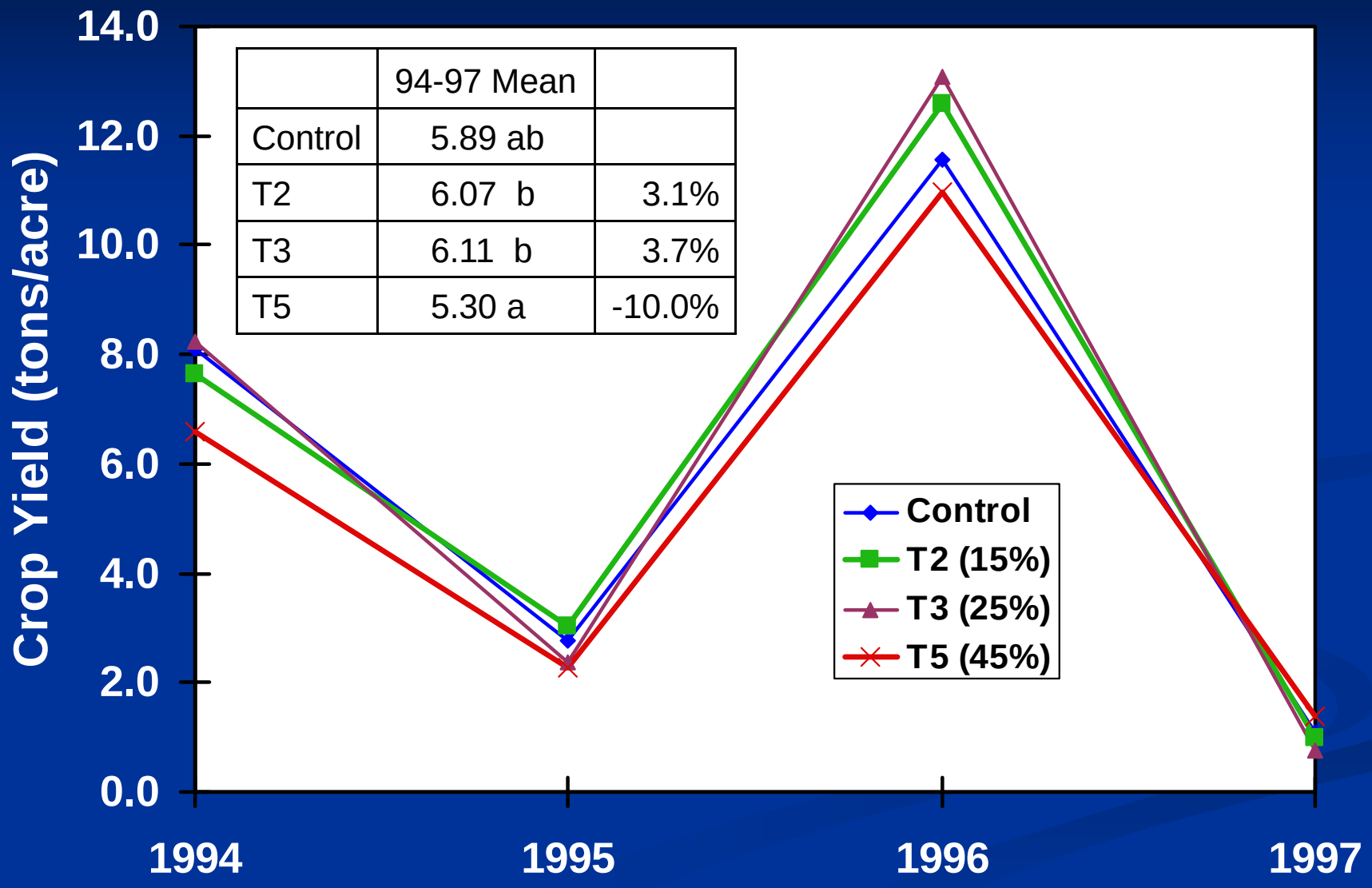
Regulated Deficit Irrigation trial ----

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

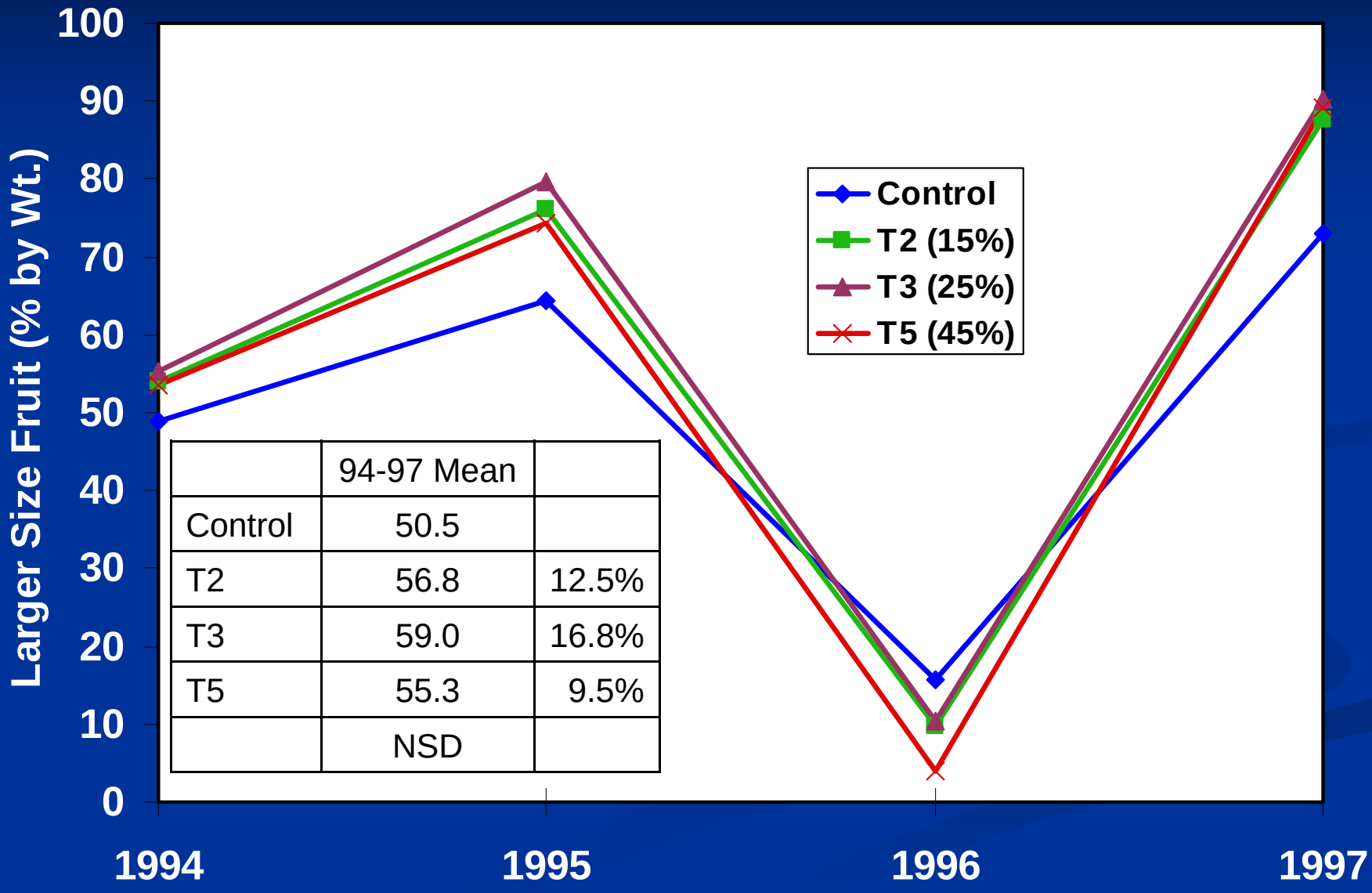
Date	Treatment 1 Full ETc (in.)	RDI%	Treatment 2 Irrigation (in.)	RDI%	Treatment 3 Irrigation (in.)	RDI %	Treatment 5 Irrigation (in.)
Mar 1-15	1.2	100	1.2	100	1.2	100	1.2
Mar 16-31	1.2	100	1.2	100	1.2	100	1.2
Apr 1-15	1.8	100	1.8	100	1.8	100	1.8
Apr 16-30	1.8	100	1.8	100	1.8	100	1.8
May 1-15	2.3	100	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**	**50**	**0.7**
Jul 1-15	3.1	**50**	**1.6**	**50**	**1.6**	**50**	**0.8**
Jul 16-30	3.3	**50**	**1.7**	**50**	**1.7**	**50**	**0.8**
Aug 1-15	2.7	100	2.7	**50**	**1.4**	**50**	**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	100	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



	94-97 Mean	
Control	5.89 ab	
T2	6.07 b	3.1%
T3	6.11 b	3.7%
T5	5.30 a	-10.0%

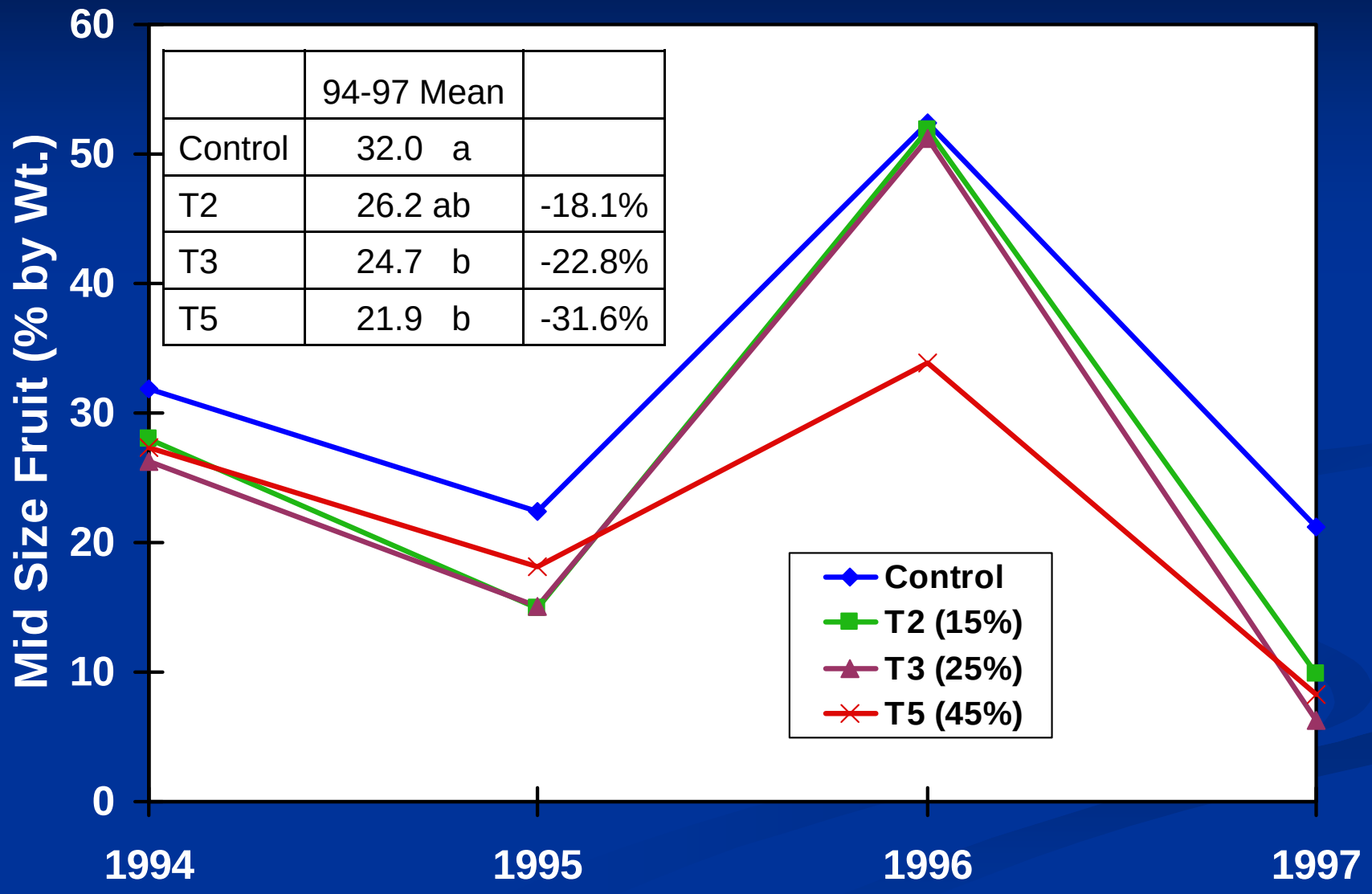
Jumbo + Ex. Large + Large + Medium Sizes



	94-97 Mean	
Control	50.5	
T2	56.8	12.5%
T3	59.0	16.8%
T5	55.3	9.5%
	NSD	

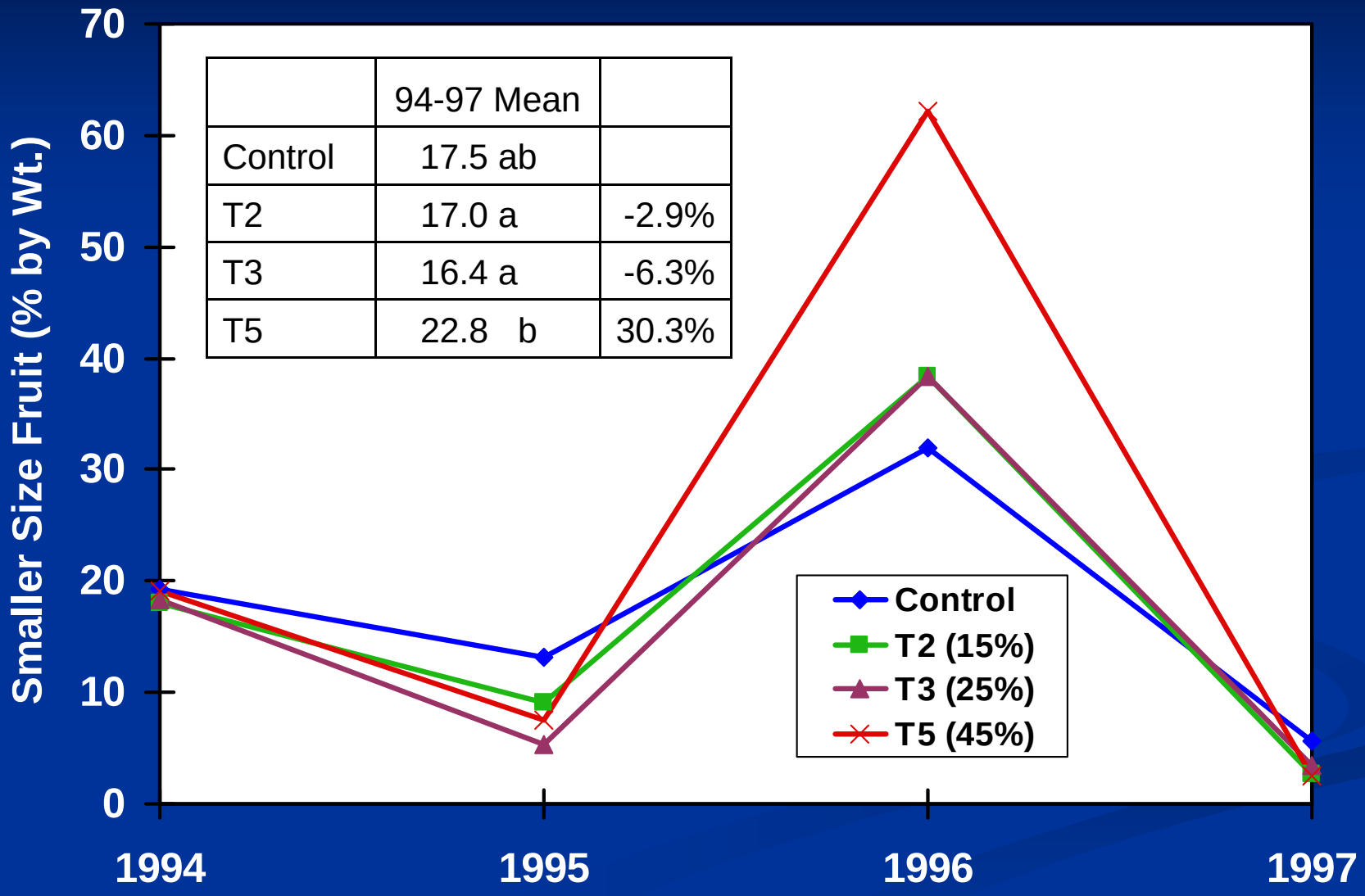
Small + Petite Size Fruit

	94-97 Mean	
Control	32.0 a	
T2	26.2 ab	-18.1%
T3	24.7 b	-22.8%
T5	21.9 b	-31.6%

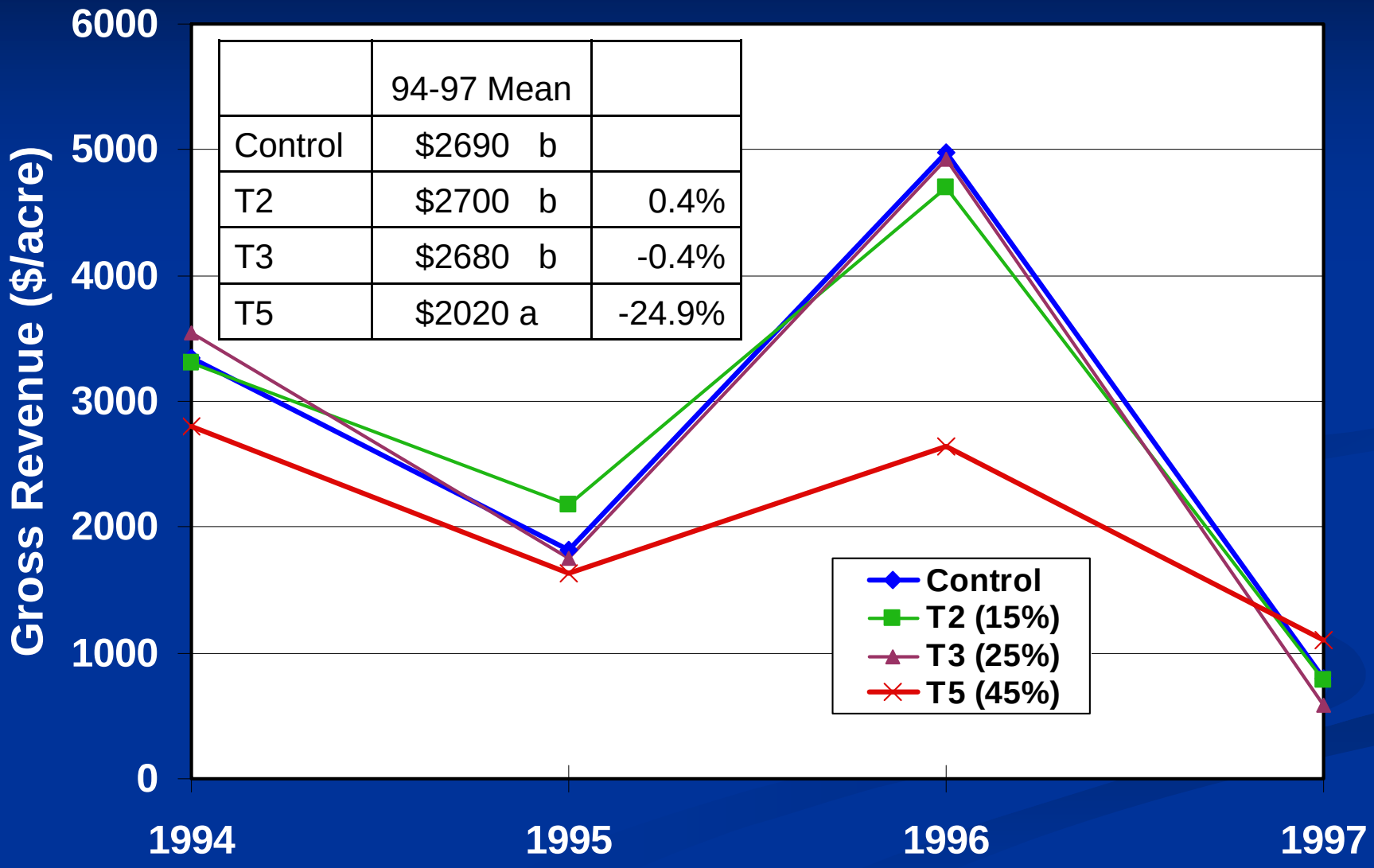


Sub-Petite + Undersize + Cull Size Fruit

	94-97 Mean	
Control	17.5 ab	
T2	17.0 a	-2.9%
T3	16.4 a	-6.3%
T5	22.8 b	30.3%



Gross Revenue



	94-97 Mean	
Control	$2690 b	
T2	$2700 b	0.4%
T3	$2680 b	-0.4%
T5	$2020 a	-24.9%

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

15% ET

SHD Oil Olives

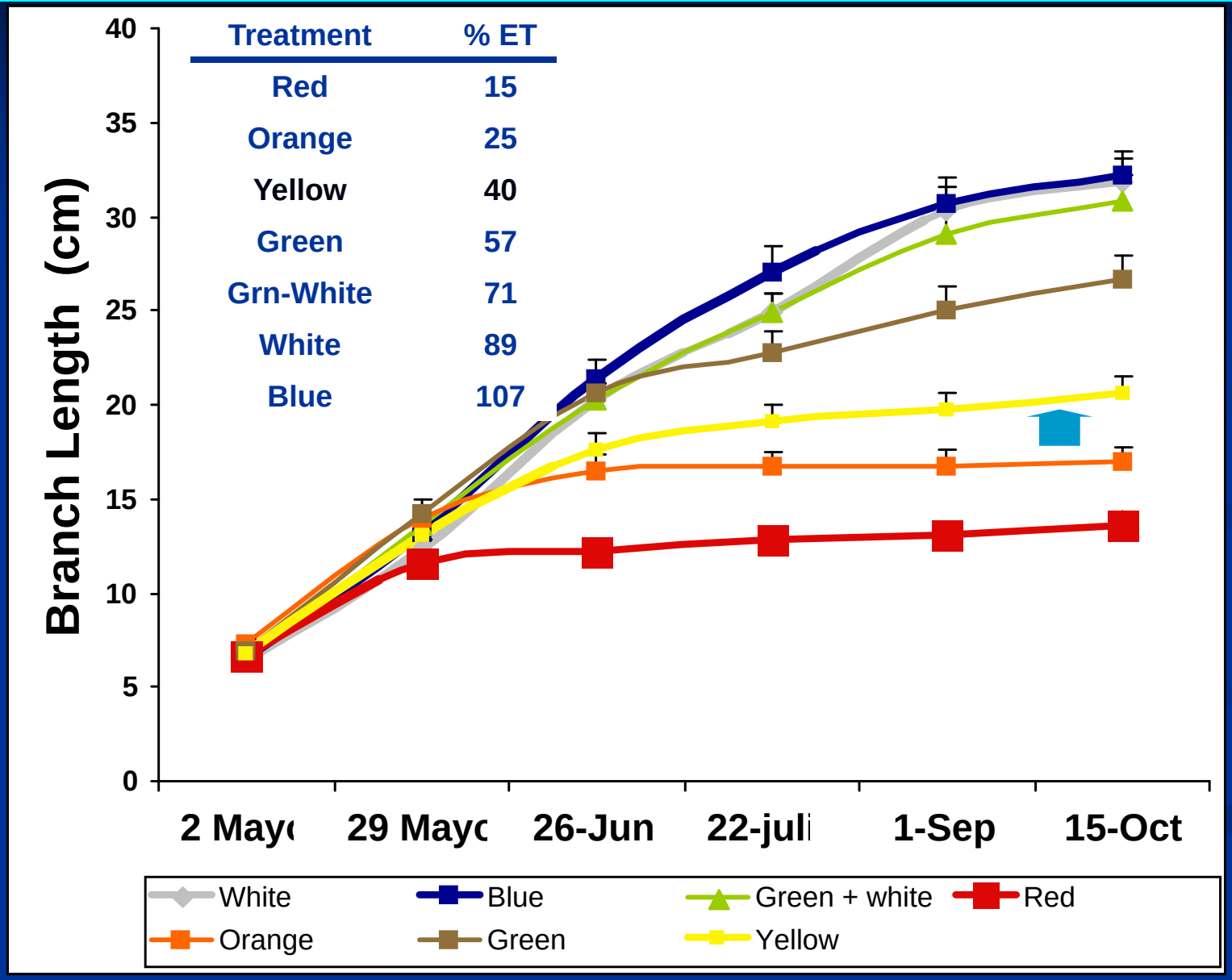
By July, tree density obviously affected.

41% ET

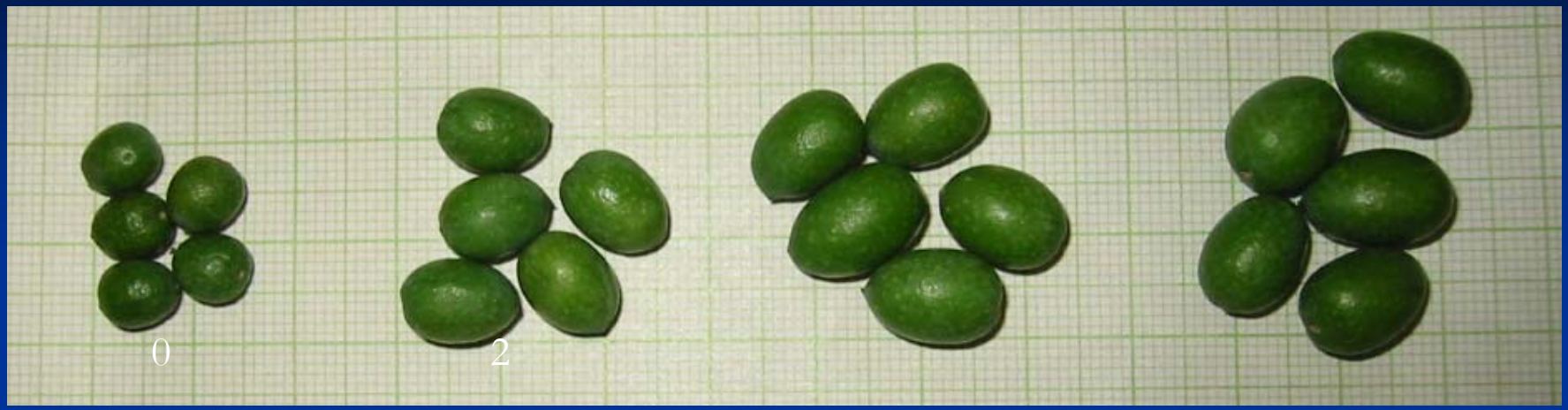
90% ET

107% ET

Water stress reduced vegetative growth

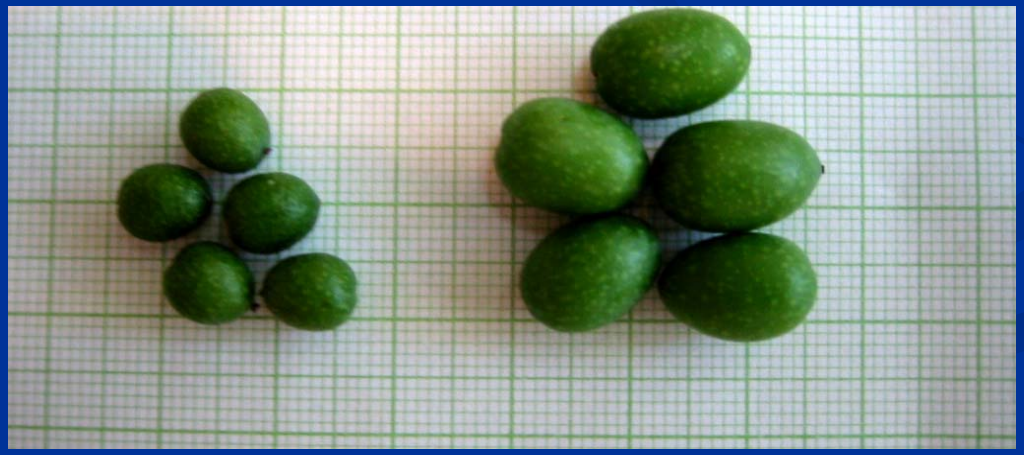


Water stress reduced fruit size

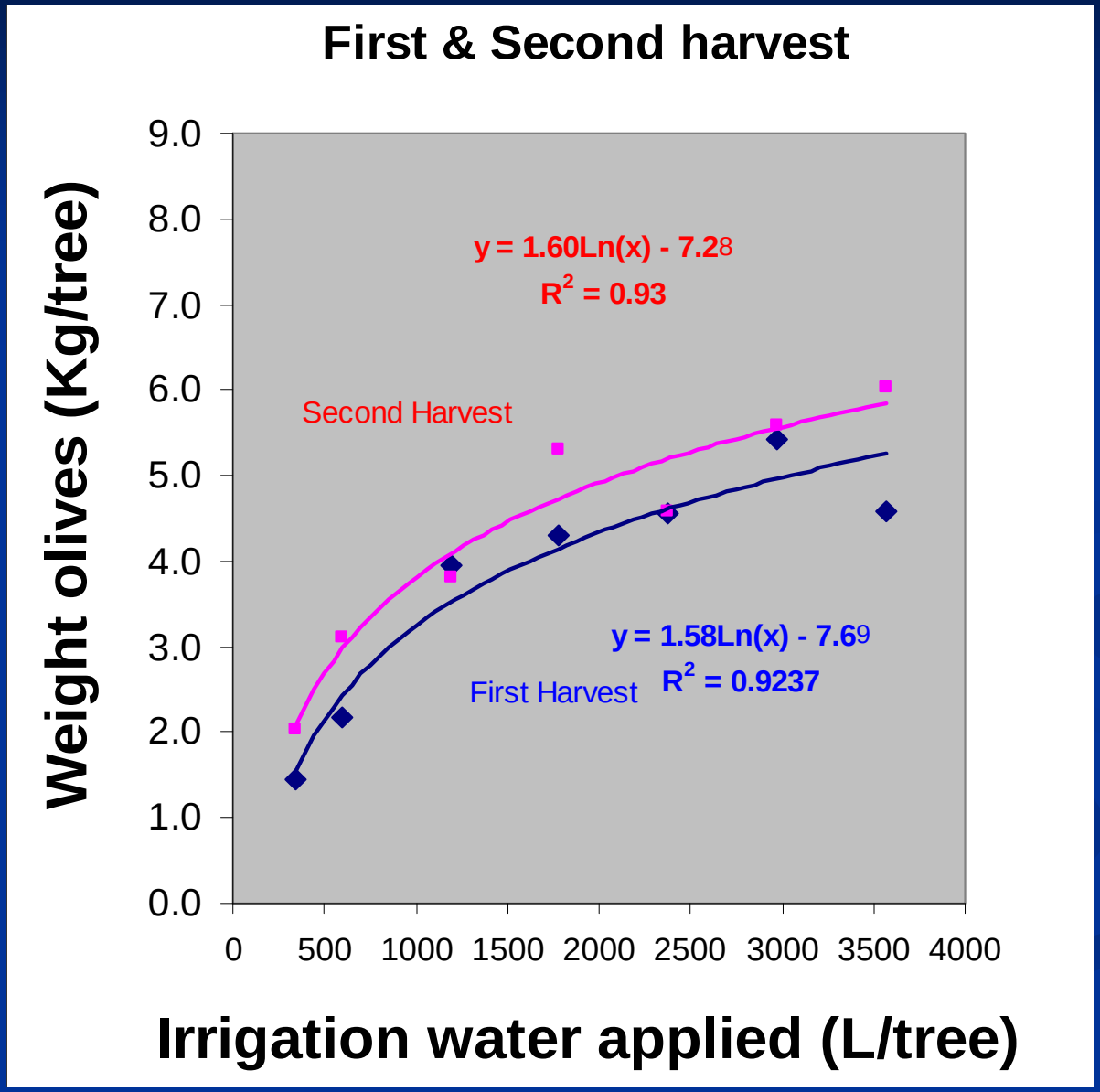


15% ET 40% ET 71% ET 107% ET

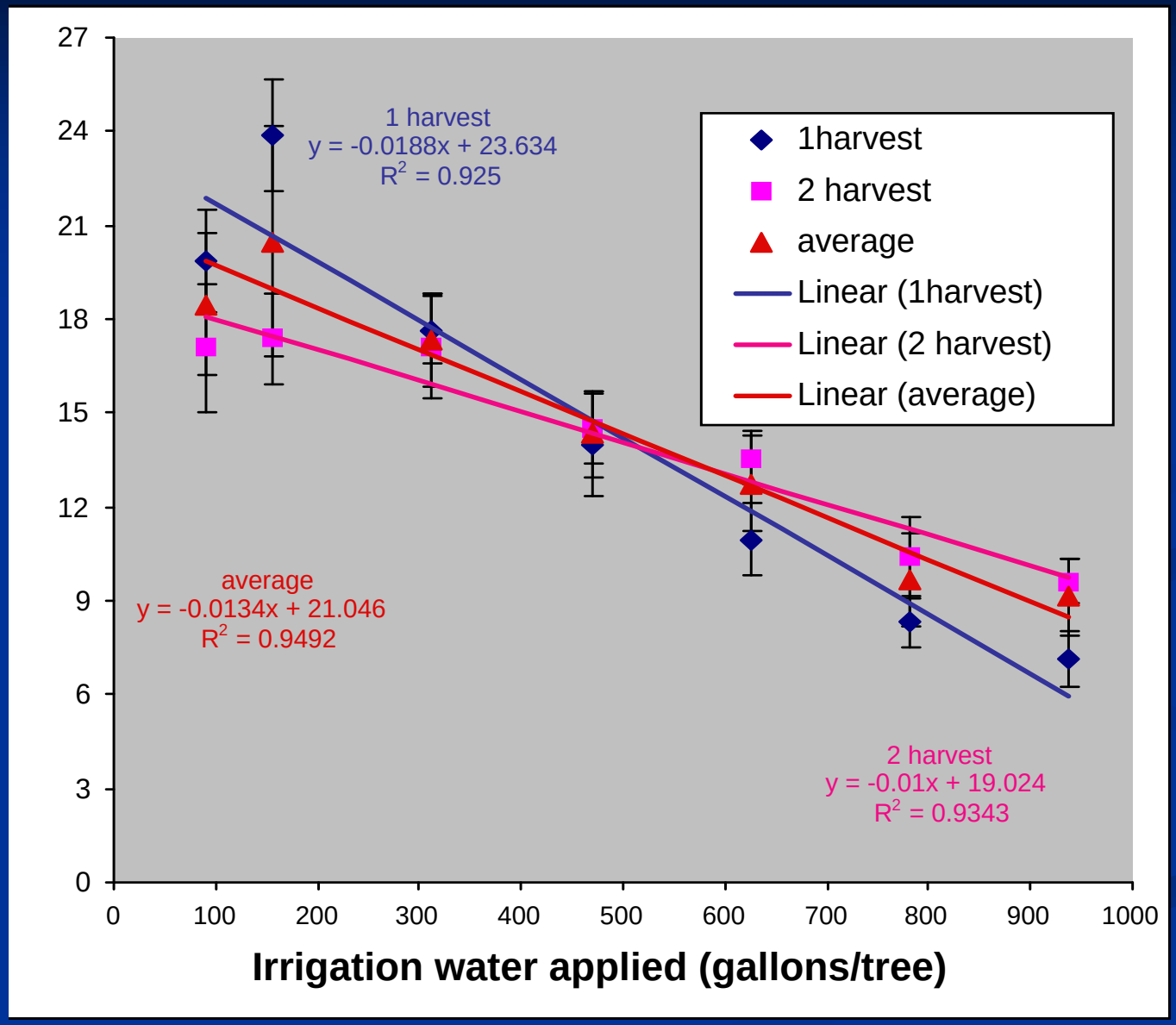
Driest Wettest



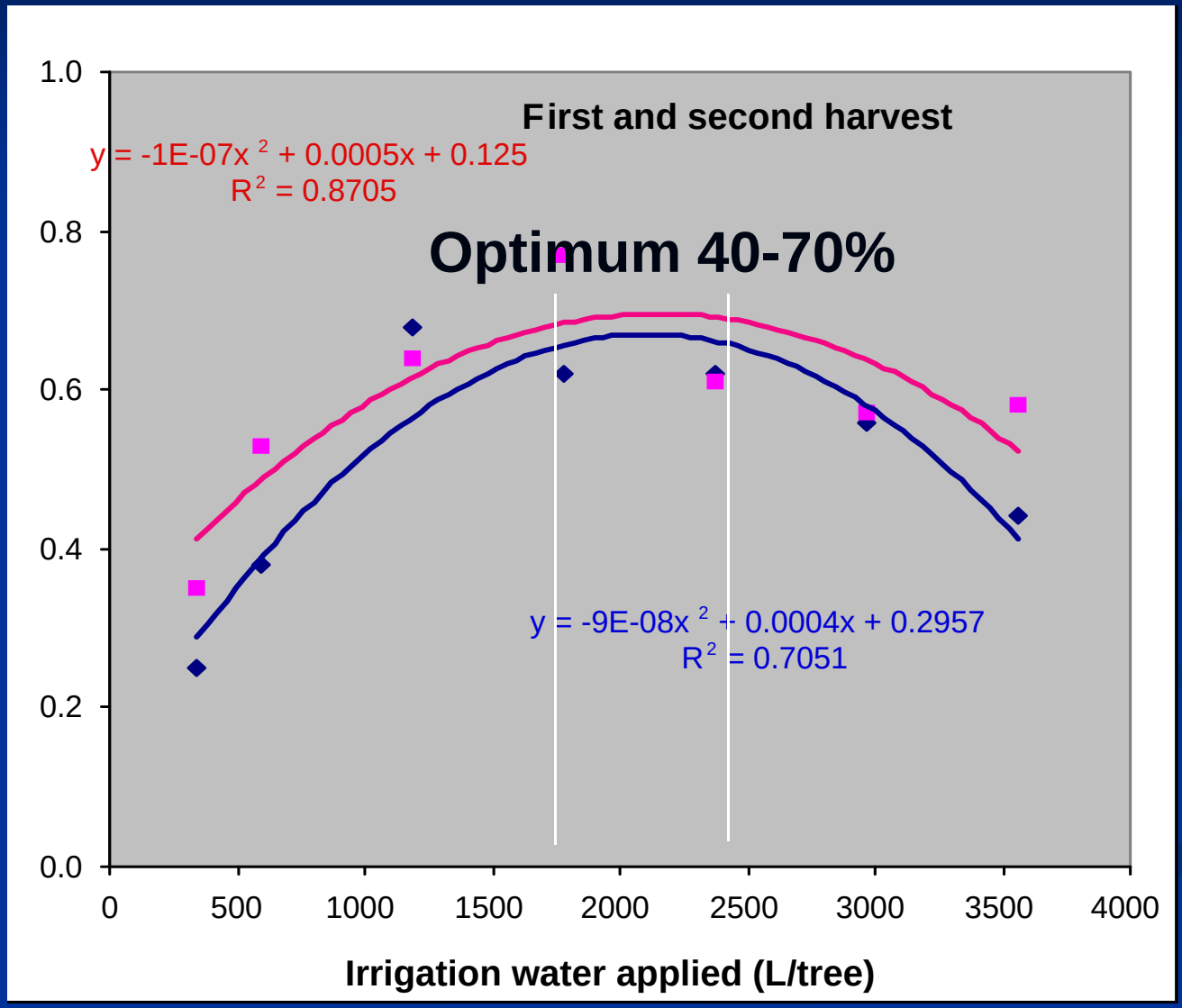
Fresh weight at October 31 & November 18 harvests



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

Questions?

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Agriculture & Natural Resources
Central Valley Region