Maintaining Almond Yields With *Less Water*

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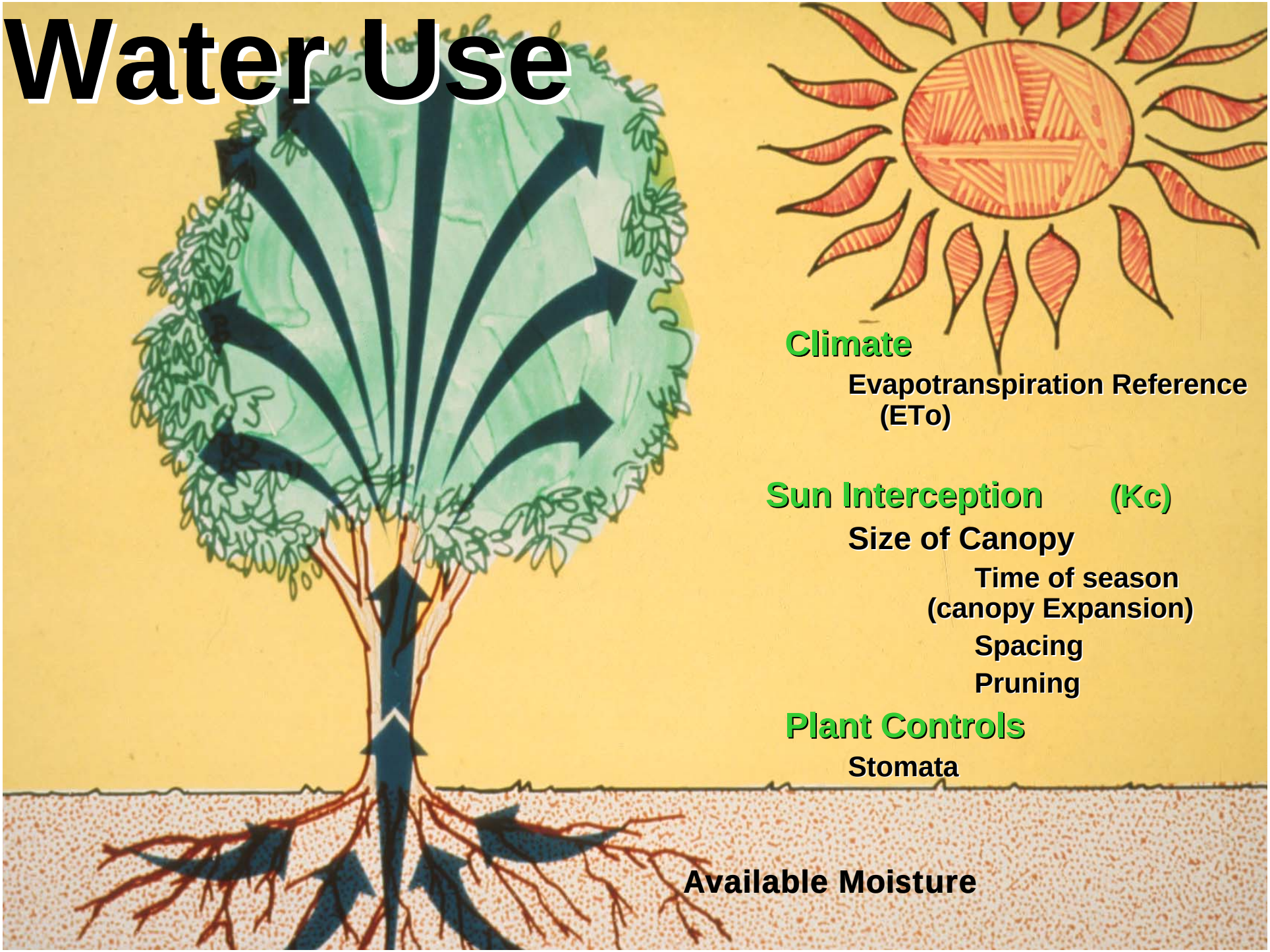
Water Conservation

- Application Efficiency
  - System Design/ Uniformity
- Proper Irrigation Scheduling
- Runoff Collection and Reuse
- Reduce Evaporation
  - Targeted Application / micro irrigation / buried drip
- Reduce Transpiration

Water Use



Climate

Evapotranspiration Reference (ETo)

Sun Interception (Kc)

Size of Canopy

Time of season (canopy Expansion)

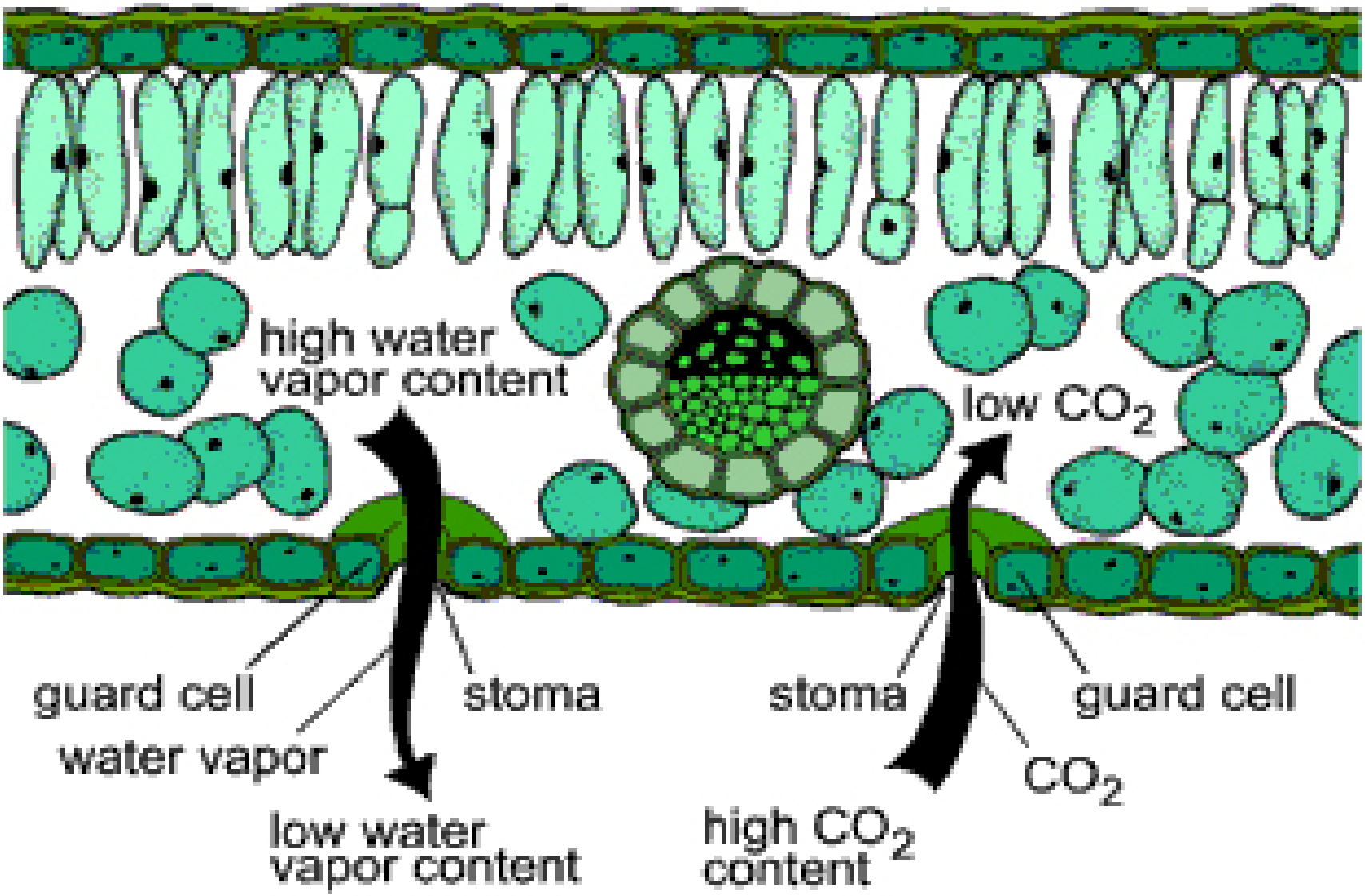
Spacing

Pruning

Plant Controls

Stomata

Available Moisture



Stomata open to allow carbon dioxide (CO_2) to enter a leaf and water vapor to leave.


10 8'91

Site Conditions

- Irrigation System: full coverage sprinkler
- Experimental Area: 10 acres
- Soil Type: deep, sandy loam
- Location: San Joaquin Delta College Farm, Manteca, CA
- Trees: Nonpareil, Price, Peerless; 12-yrs old in 1990; uniform stand
- Rootstock: Nemaguard

1990-93 Treatments

- T1 = 100%, full water use
- T2 = 70%, postharvest deficit
- T3 = 70%, midseason deficit
- T4 = 50%, midseason & postharvest deficit
- T5 = 50%, midseason deficit
- T6 = 66%, plant indicated irrigation

Plant Indicated Irrigation

An irrigation management strategy

- provides for full water use through June 15

For the remainder of the season

- uses a pre-dawn leaf water potential threshold of -12 bars as an indication of when to irrigate. Stem Water Potential ? -16 to -18 bars

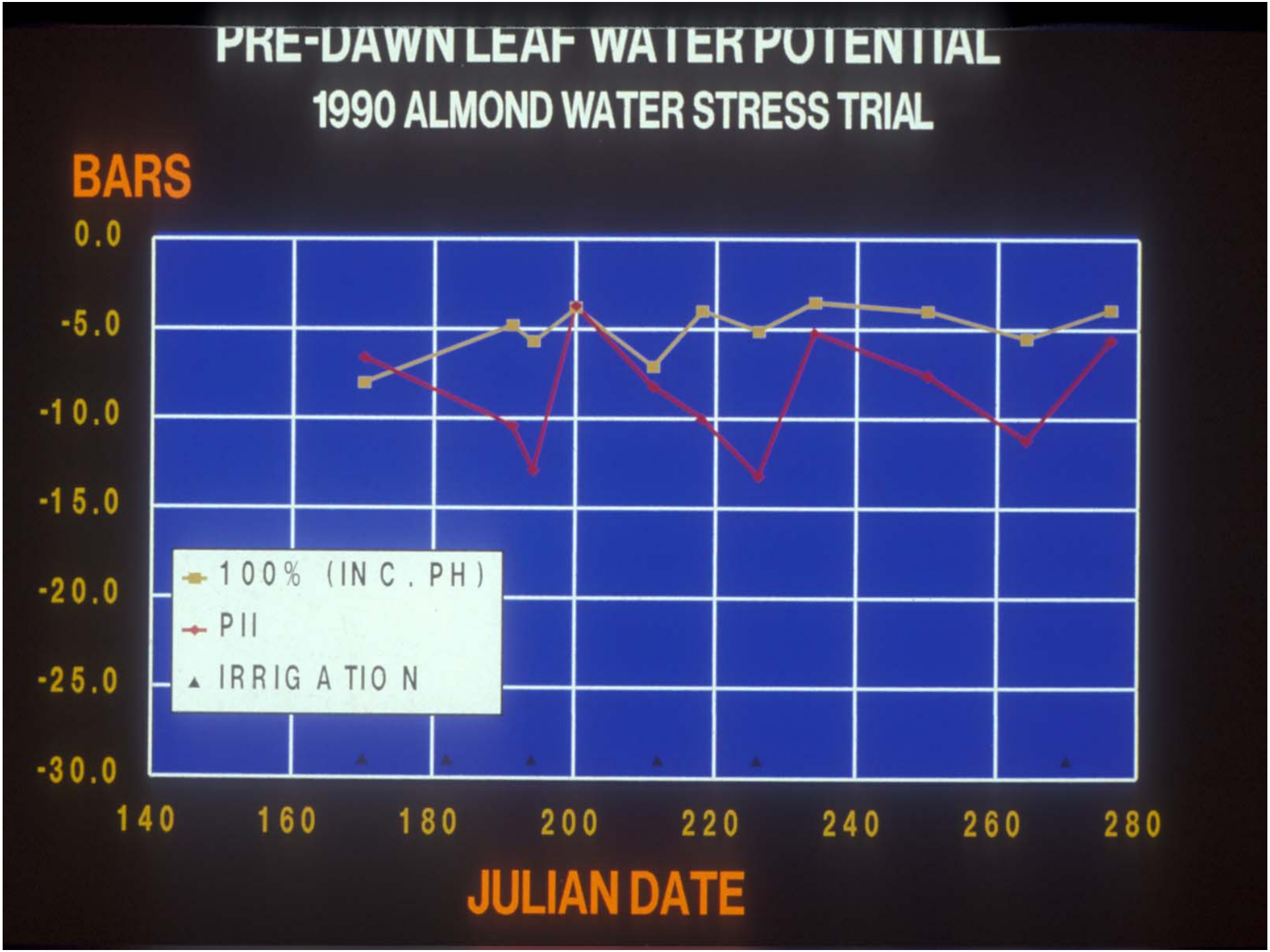
Mid-day Stem Water Potential

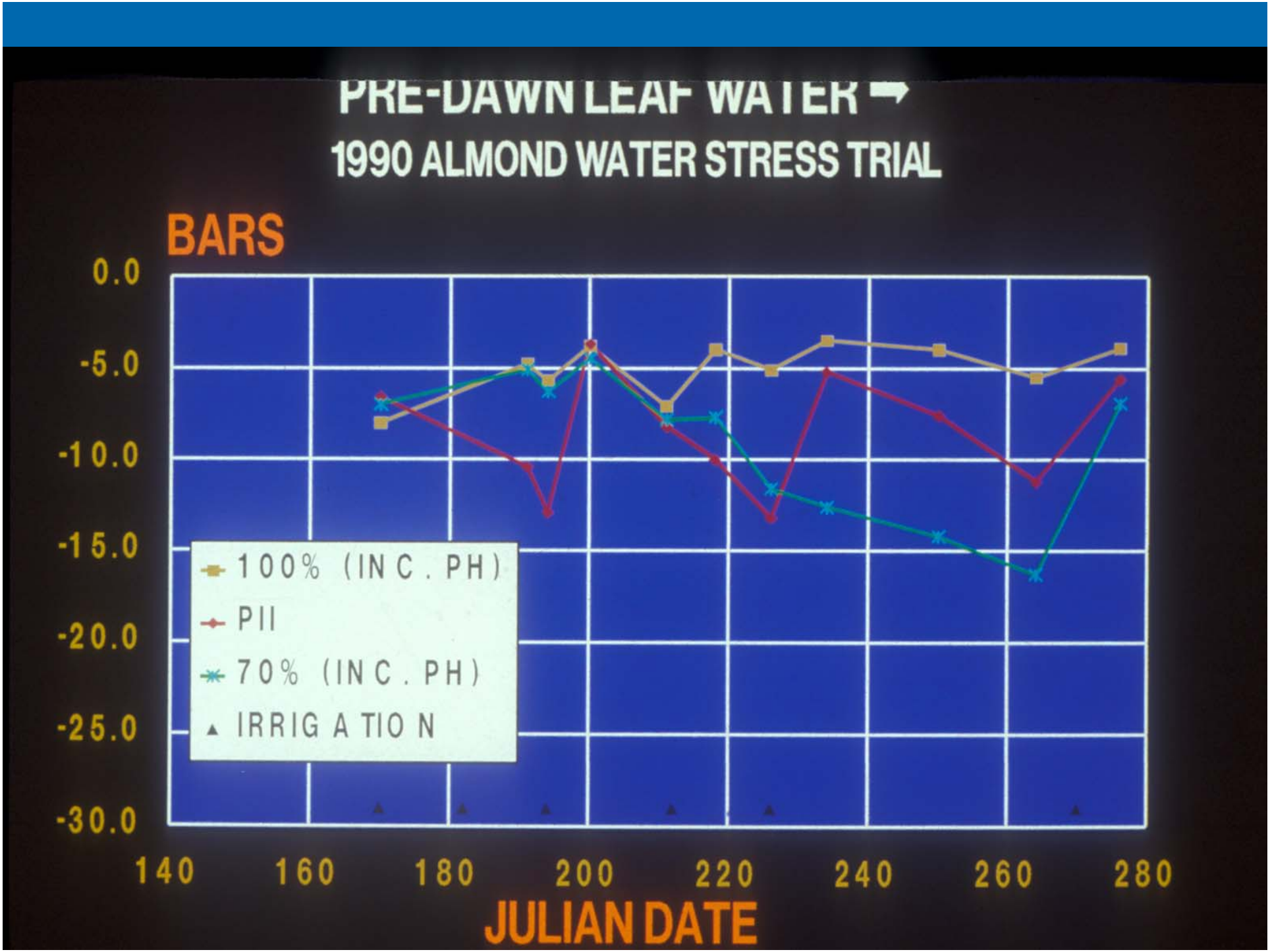
Tree Water Stress

- Measured as midday *stem* water potential
  - Using a pressure chamber
    - aka pressure bomb


pms
INSTRUMENT CO.
Corvallis, Oregon USA
www.pmsinstrument.com


8
10
12
14
16
18
20
150
100
200
50
250
300
psi
BAR
BAR


PRE-DAWN LEAF WATER POTENTIAL
1990 ALMOND WATER STRESS TRIAL
BARS
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
100% (INC. PH)
PII
IRRIGATION
140
160
180
200
220
240
260
280
JULIAN DATE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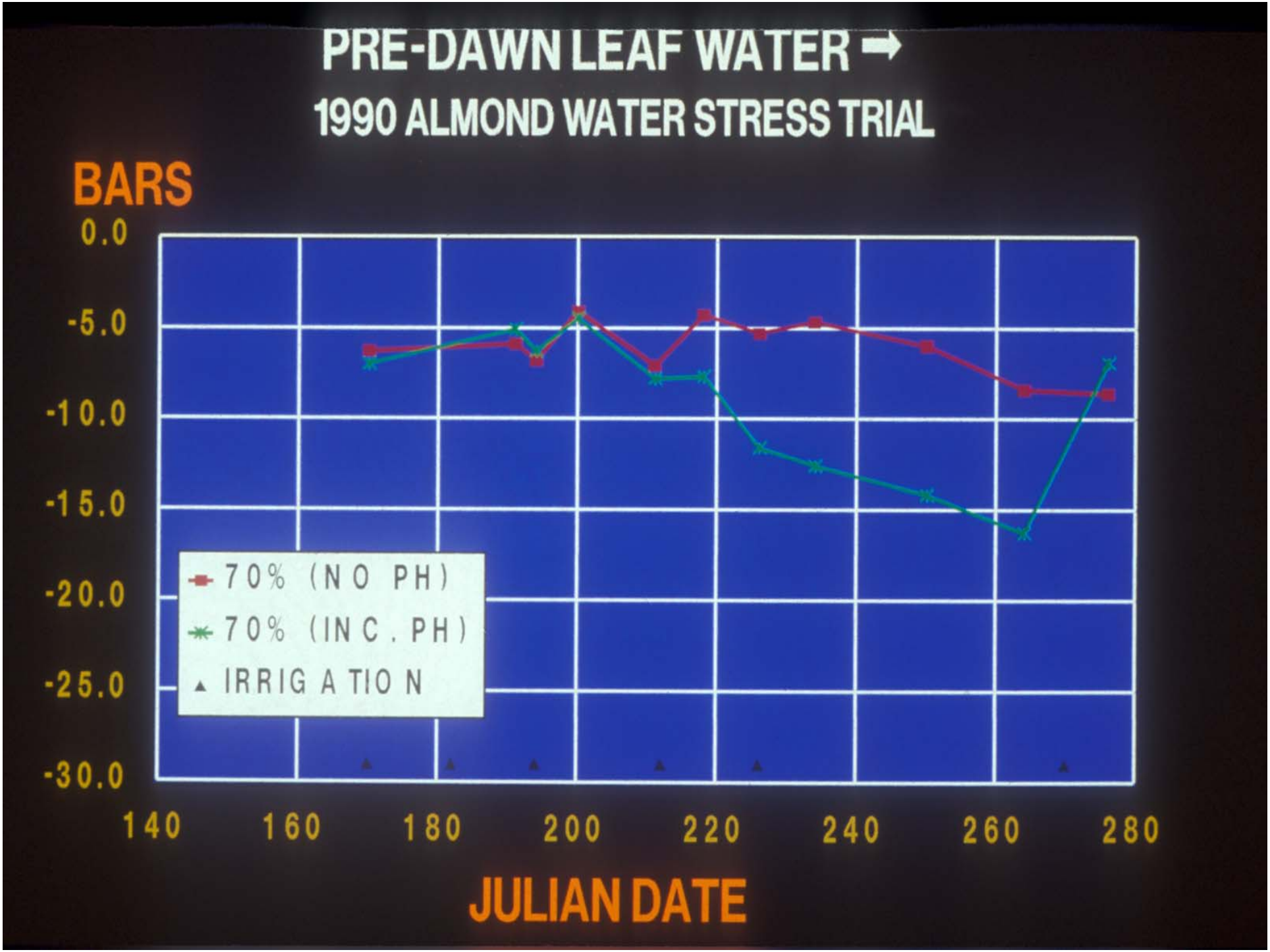
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1990 ALMOND WATER STRESS TRIAL
BARS
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
70% (NO PH)
70% (INC. PH)
IRRIGATION
140
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280
JULIAN DATE

Combined Years, 1990-93

Treatment	Seasonal Use	Consumptive Water Use
1 (100% use)	100	37.4
2 (70% use) (postharvest deficit)	72	26.9
3 (70% use) (midseason)	66	24.7
4 (50% use) (midseason & postharvest deficit)	52	19.8
5 (50% use) (midseason deficit)	50	18.5
6 Pii	66	24.7

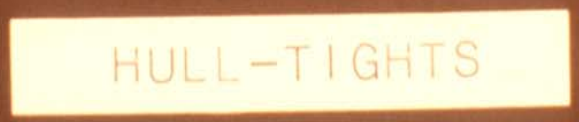
Combined Years, 1990-93

Treatment		Deficit Timing	Nut Load (nuts/tree x1000)	Avg Kernel Mass (g)	Prunings (lbs/tree)
1	100% use	none	**15.8 ab***	**1.28 a**	**38.8 a**
2	70% use	postharvest deficit	**13.7 d**	**1.22 b**	**25.6 c**
3	70% use	midseason deficit	**14.1 cd**	**1.09 de**	**27.1 c**
4	50% use	midseason & postharvest	**15.2 abc**	**1.12 d**	**32.2 abc**
5	50% use	midseason deficit	**14.6 bcd**	**1.08 e**	**27.7 bc**
6 (Pii)			**16.3 a**	**1.17 c**	**34.4 ab**
P value			**0.0012**	**0.000**	**0.003**

*Common letters among means within columns denote no significant difference at $P \leq 0.05$.

Combined Years, 1990-93

Treatment		Deficit Timing	Hull Tights Wt (% of Meat Yield)
1	100% use	none	**0.7 b**
2	70% use	postharvest deficit	**0.3 b**
3	70% use	midseason deficit	**4.8 b**
4	50% use	midseason & postharvest	**0.5 b**
5	50% use	midseason deficit	**23.1 a**
6	(Pii)		**0.5 b**
P value			**0.000**



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Results

- 1st Year

No significant differences with up to 50% of full water requirement

Results

After 4 years of imposed deficits

- Yields reduced by 25-36%
- Pii not significantly reduced
- Yield reductions a result of
  - Nut load
  - Nut size

Residual Effects of Water Deficits & Irrigation Strategies on Almonds

Results

After 1 year of full water

- Average of 10% yield increase
- Lowest 1993 yield resulted in highest % increase (16%)

Results

After 2 years of full water

- Yields improved to average

  99.4% of full water treatment

Drought Strategy

- Through mid-June – No Water Stress
- Mid-June to harvest – Water Stress

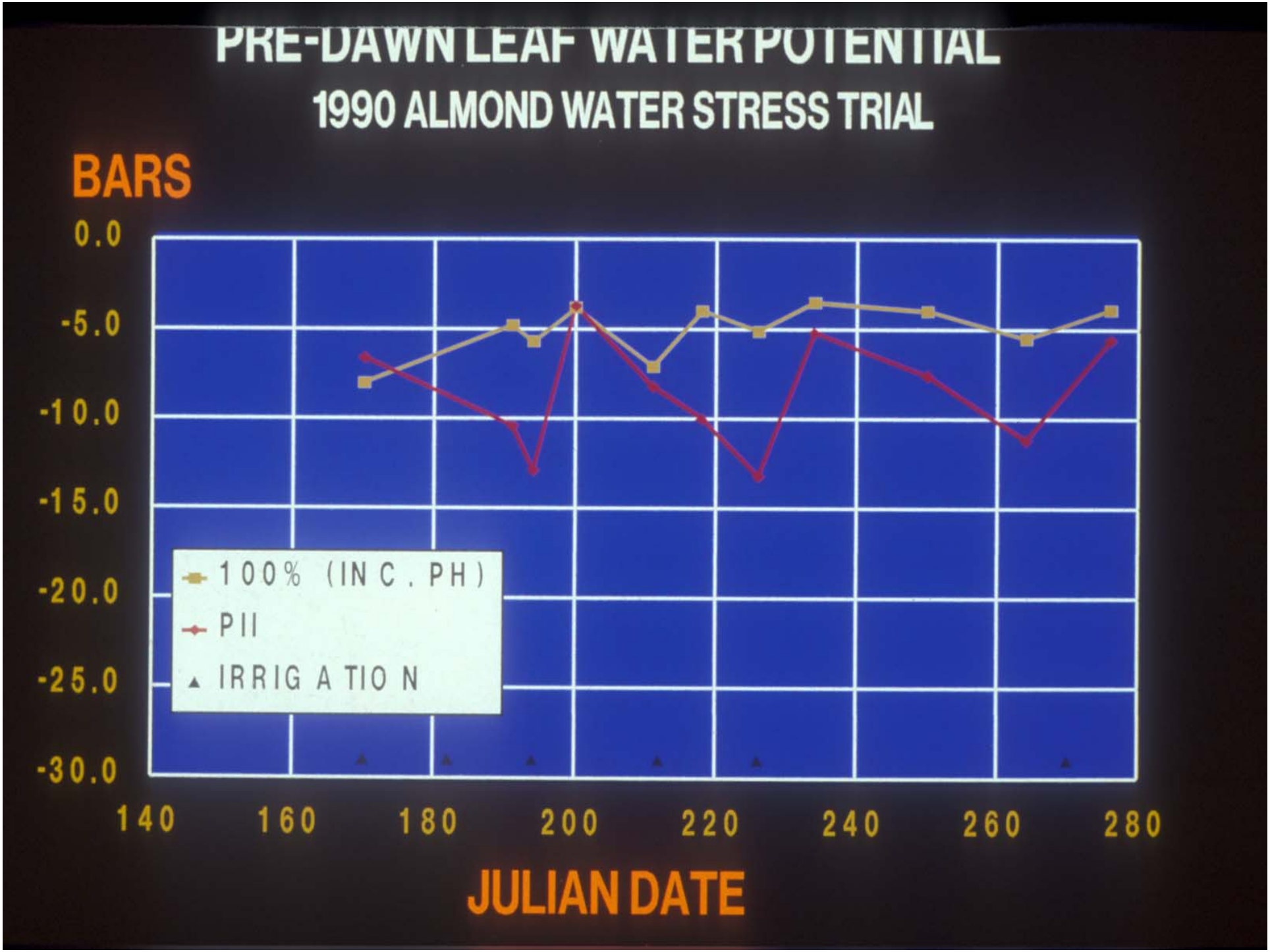
  2” water at hullsplit
- Postharvest – Water Stress ?

Three Methods

- Use Stem water potential with thresholds for a particular stage of development
- Use ET estimates and reduce by a fraction of full water use
- Measure soil moisture and apply at a threshold value

Tree Water Stress

- Measured as midday *stem* water potential
  - Using a pressure chamber
    - aka pressure bomb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140
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Calculate Full Potential Water Use

- ETo x Kc = Full Potential Water Use
- Use weekly summed data

Almond Water Use

Manteca Normal California, inches

Date	ETo	Kc	Historical ETc
March 16-31	2.32	0.54	1.25
April 1-15	2.54	0.60	1.52
April 16-30	2.88	0.66	1.90
May 1-15	3.27	0.73	2.39
May 16-31	3.65	0.79	2.88
June 1-15	3.80	0.84	3.19

March 16 - June 15th	13.14

Almond Water Use

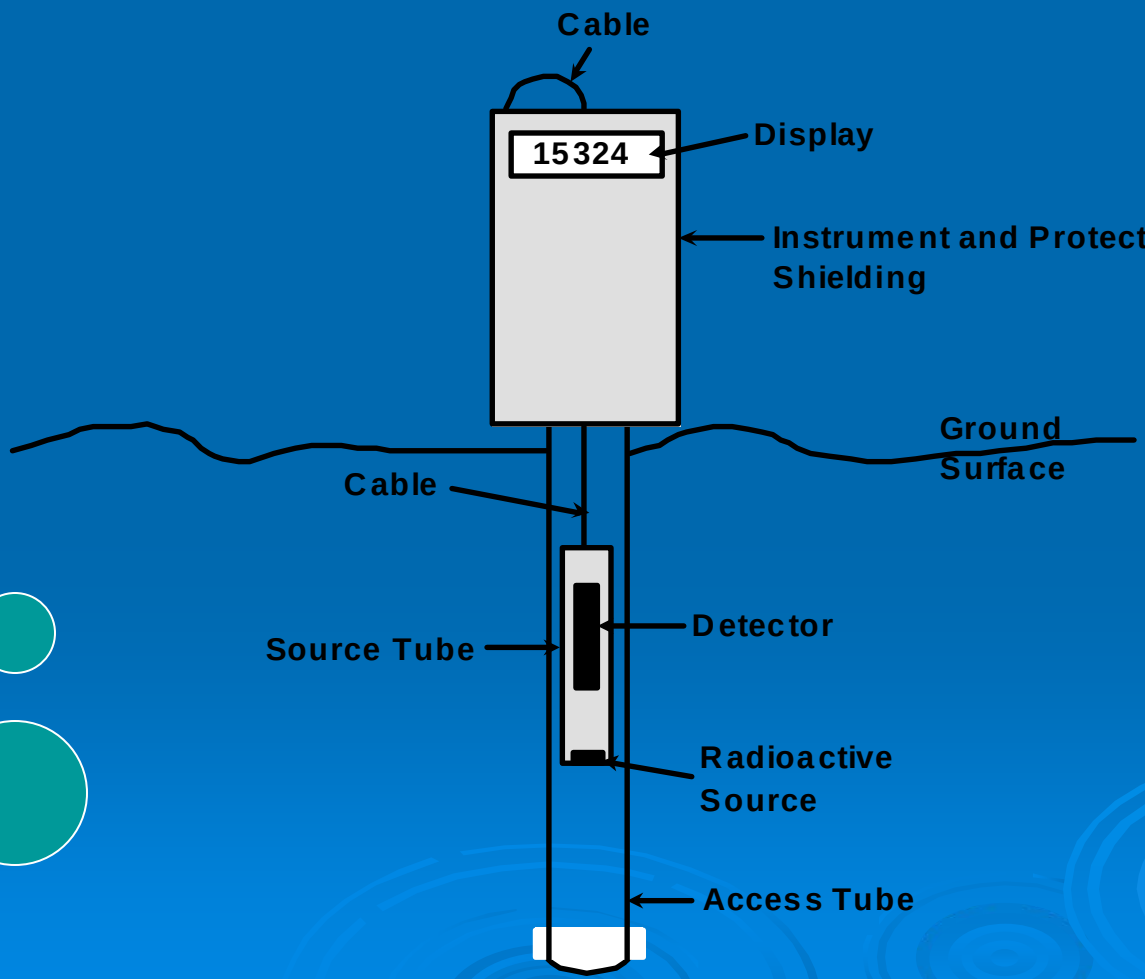
Manteca Normal, California, inches

			Historical
Date	**ETo**	**Kc**	**ETc**
June 16-30	3.98	0.86	3.42
July 1-15	4.08	0.93	3.80
July 16-31	3.94	0.94	3.70
August 1-15	3.65	0.94	3.43
August 16-31	3.49	0.94	3.28
September 1-15	2.88	0.94	2.71
September 16-30	2.38	0.91	2.16
October 1-15	1.96	0.85	1.67
October 16-31	1.56	0.79	1.23
November 1-15	1.08	0.7	0.76
June 16 – Nov 15			26.17

Soil Moisture Monitoring

- Devices:
  - Quantitative-- A number inches in rootzone
    - Neutron Probe
    - Dielectric Devices

Neutron Scatter / Probe



Wet

Dry

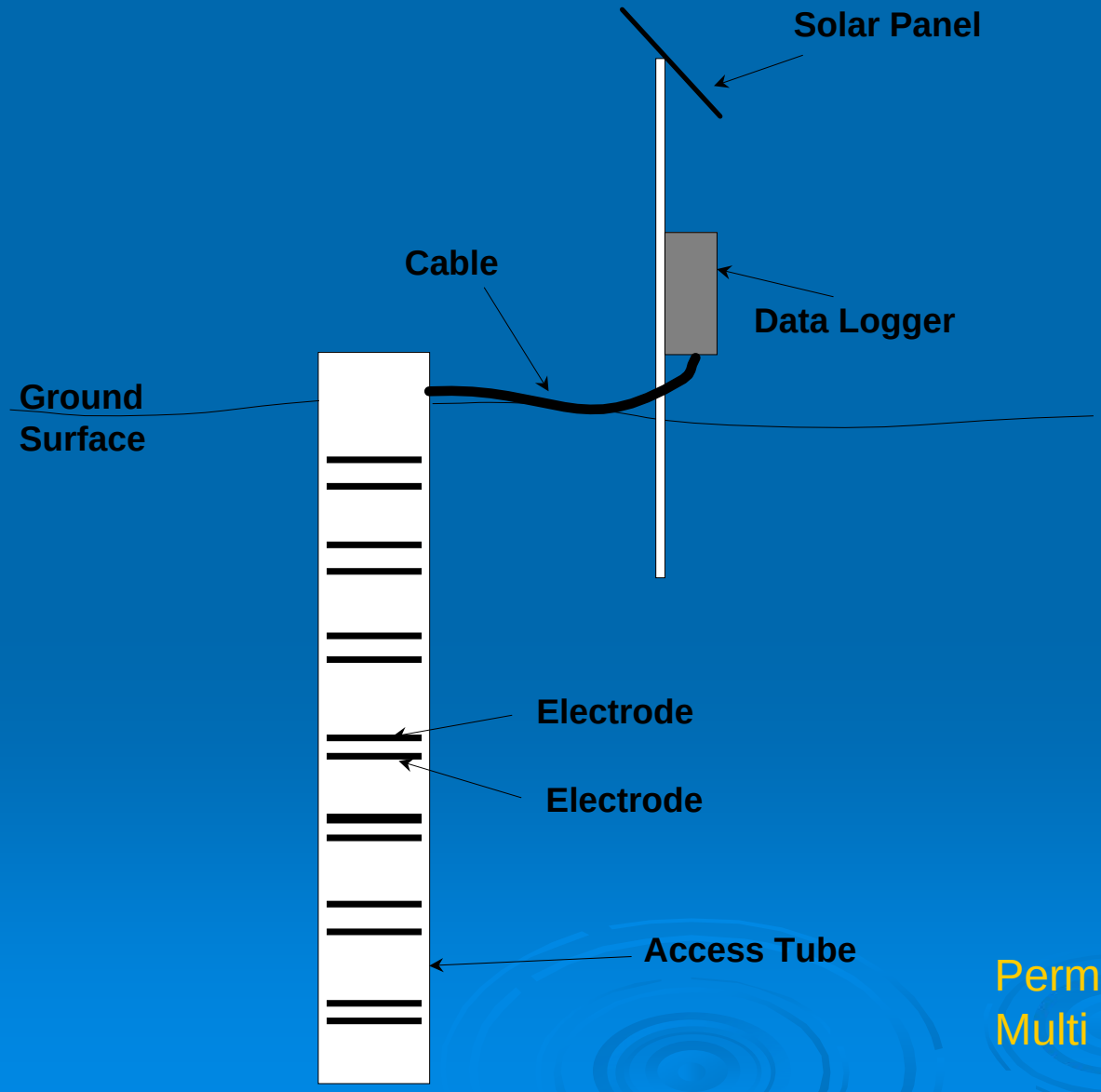
Soil Dielectric

- The dielectric permittivity is a measure of the capacity of a non-conducting material to transmit electromagnetic waves or pulses.

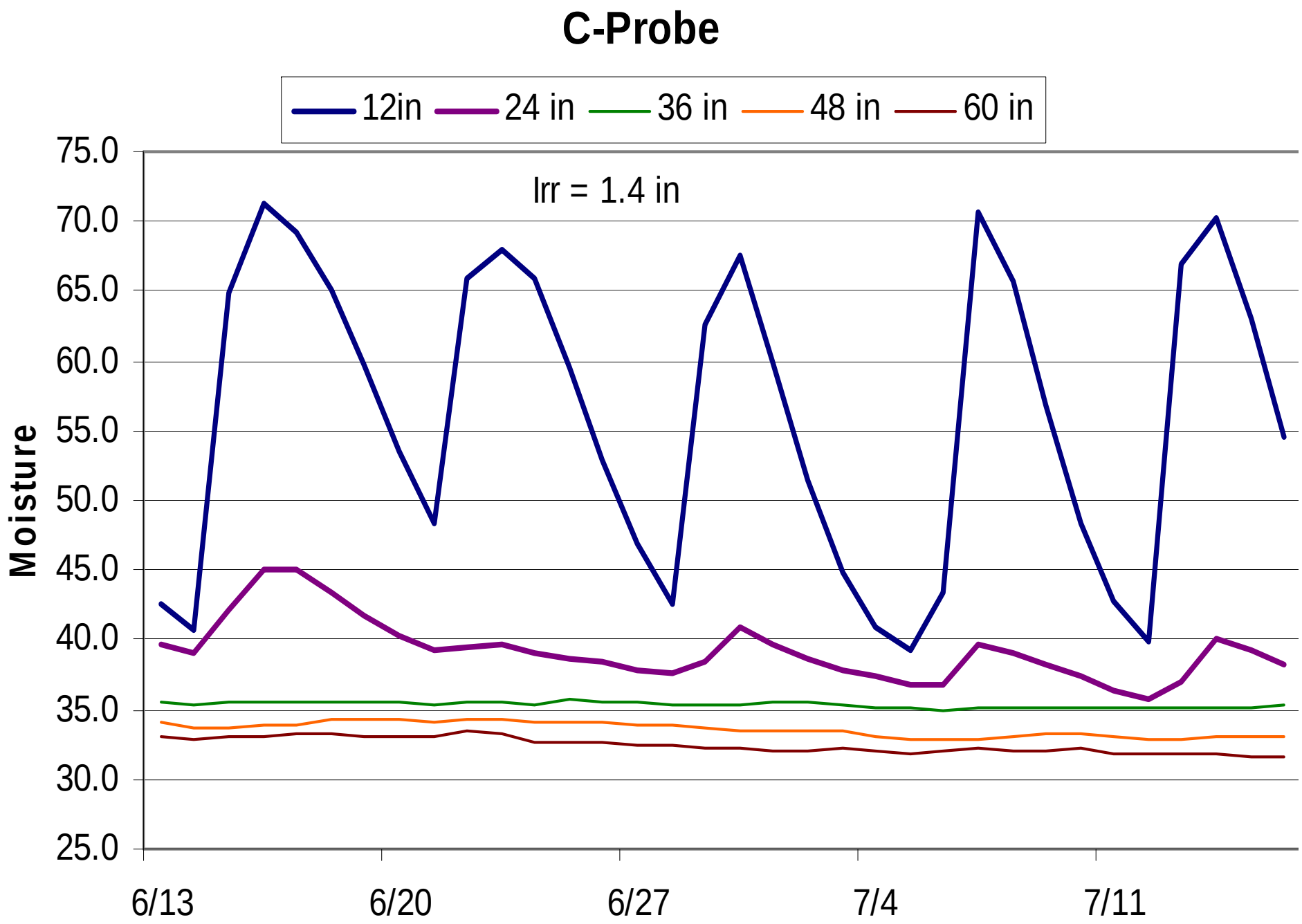
- Dielectric Permittivity
  - Air = 1
  - soil minerals = 3 to 5

    (denser soils have higher apparent permittivities).
  - Water 81

Dielectric Devices



Permanent/logging
Multi depth


C-Probe
12in
24 in
36 in
48 in
60 in
Irr = 1.4 in
Moisture
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
6/13
6/20
6/27
7/4
7/11

Data Handling / Telemetry

- Wide range available
  - Direct hand held “pod” collection
  - Cell phone modem to data processing to internet acc

Soil Moisture Monitoring

- Devices:
  - Qualitative Devices--- A water status at point of reading
    - Tensiometers
    - Moisture Blocks

Soil Moisture Monitoring

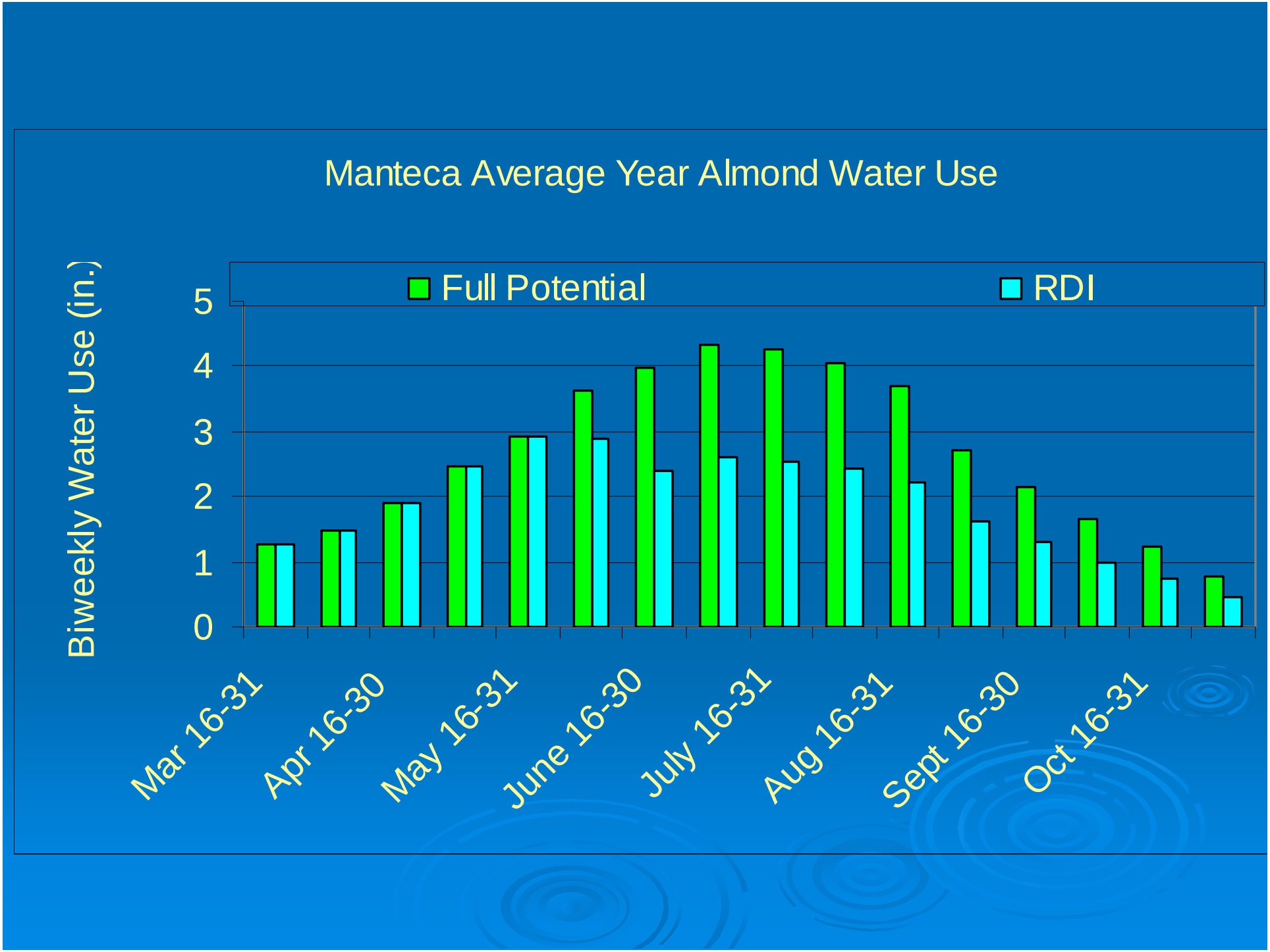
Issues:

Placement

Small point measurements

Not easily used for volumetric types of scheduling

Use a threshold value across depths


Manteca Average Year Almond Water Use
Biweekly Water Use (in.)
Full Potential
RDI
0
1
2
3
4
5
Mar 16-31
Apr 16-30
May 16-31
June 16-30
July 16-31
Aug 16-31
Sept 16-30
Oct 16-31

All Non-Beneficial Water Losses Should Be Minimized

- Do not exceed the water holding capacity of the root zone in the spring--- water will be lost to deep percolation
- Eliminate runoff from one area to another by turning the system off when runoff begins.
- Use off peak power or irrigate at night to minimize evaporative losses.


Eliminate or minimize cover crops or weeds which can compete for water use
ROUNDUP
12 OZ
15 6 '94

Evaluate and upgrade irrigation systems improve distribution uniformity

More Severe Strategy

- Requires a cut back leaf out to June 15
  - -12 t0 -14 bars mid-day stem water potential
- June 15th to harvest
  - -20 to -25 bars
- Postharvest?