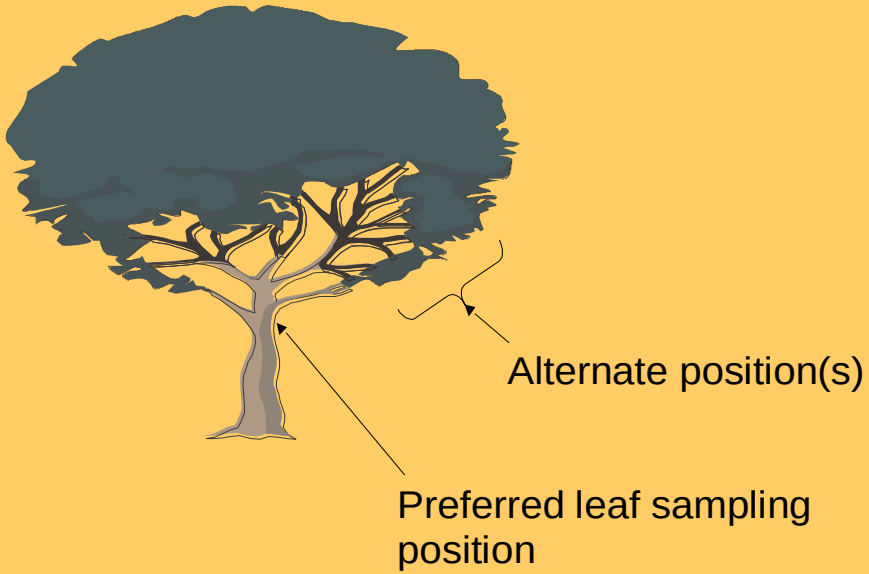
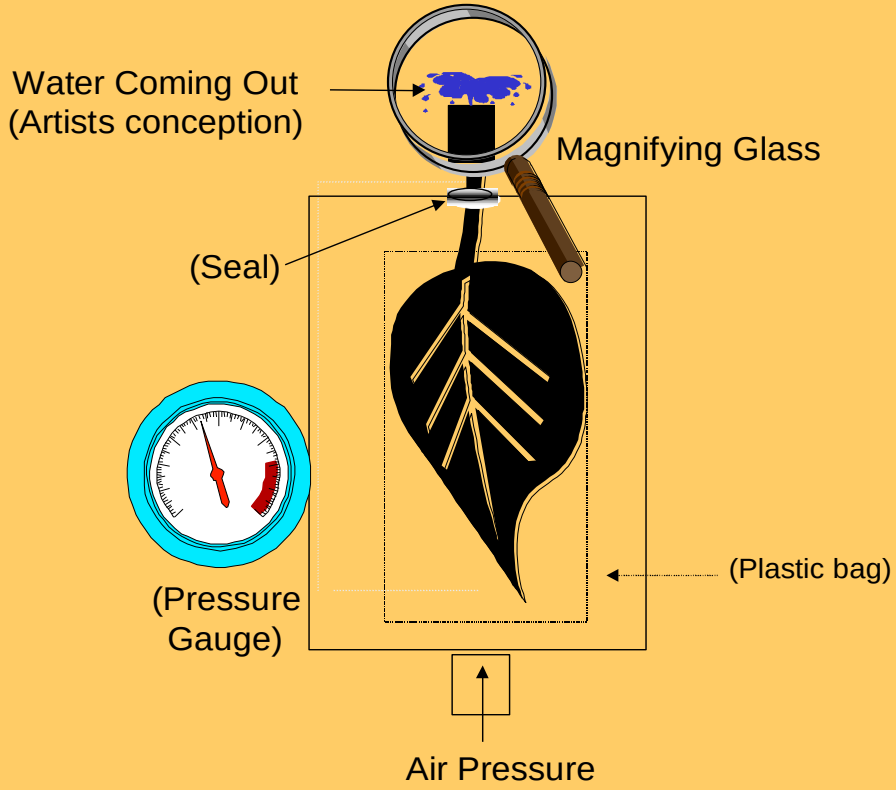
# Research Update – Stem Water Potential Baseline and Mechanical Hedging of Oil Olive

Bill Krueger UCCE Farm Advisor,
Glenn and Tehama Countiesw

# How is Tree Stress (Stem Water Potential) Measured, Conceptually?

Plant based irrigation scheduling



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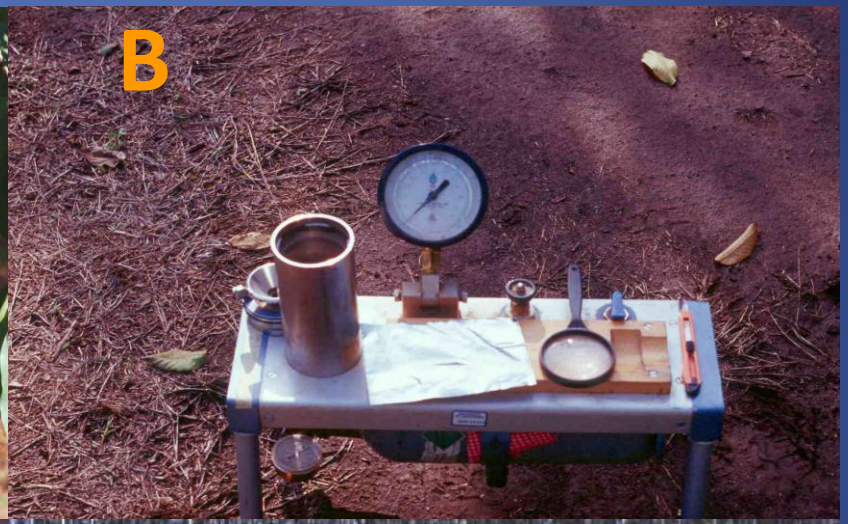
# How is midday SWP Measured in the Field?



# TENTATIVE GUIDELINES FOR INTERPRETING PRESSURE CHAMBER READINGS (MIDDAY STEM WATER POTENTIAL-SWP) IN WALNUT, ALMOND, AND DRIED PLUM. UPDATED MAY 2007.

Allan Fulton and Richard Buchner, UCCE Farm Advisors, Tehama County, Joe Grant, Farm Advisor, San Joaquin County, Terry Prichard, Bruce Lampinen, Larry Schwankl, Extension Specialists, UC Davis, and Ken Shackel, Professor UC Davis.

| Pressure Chamber Reading (- bars) | WALNUT | ALMOND | PRUNES |
|---|---|---|---|
| 0 to –2.0 | Not commonly observed | Not commonly observed | Not commonly observed |
| -2.0 to –4.0 | Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ETc), long term root and tree health may be a concern, especially on California Black rootstock. | | |
| -4.0 to –6.0 | Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed. | | |
| -6.0 to –8.0 | Mild to moderate stress, shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development. | Low stress, indicator of fully irrigated conditions, ideal conditions for shoot growth. Suggest maintaining these levels from leaf-out through mid June. | Low stress, common from March to mid April under fully irrigated conditions. Ideal for maximum shoot growth. |
| -8.0 to –10.0 | Moderate to high stress, shoot growth in non-bearing trees may stop, nut sizing may be reduced in bearing trees and bud development for next season may be negatively affected. | | Suggested levels in late April through mid June. Low stress levels enabling shoot growth and fruit sizing. |
| -10.0 to –12.0 | High stress, temporary wilting of leaves has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. Nut size likely to be reduced. | Mild to moderate stress, these levels of stress may be appropriate during the phase of growth just before the onset of hull split (late June). | Suggested mild levels of stress during late June and July. Shoot growth slowed but fruit sizing unaffected. |
| -12.0 to –14.0 | Relative high levels of stress, moderate to severe defoliation, should be avoided. | | Mild to moderate stress suggested for August to achieve desirable sugar content in fruit and to reduce "dry-away" (drying costs). |
| -14.0 to –18.0 | Severe defoliation, trees are likely dying. | Moderate stress in almond. Suggested stress level during hull split, Help control diseases such as hull rot and alternaria, if diseases are present. Hull split occurs more rapidly | Moderate stress acceptable in September. |
| -18.0 to –20.0 | Crop stress levels in English walnut not observed at these levels. | Transitioning from moderate to higher crop stress levels | Moderate to high stress levels. Most commonly observed after harvest. Generally undesirable during any stage of tree or fruit growth. Most appropriately managed with post-harvest irrigation |
| -20 to -30 | | High stress, wilting observed, some defoliation | |
| Less than – 30 | | Extensive defoliation has been observed | High stress, extensive defoliation |

* These guidelines are tentative and subject to change as research and development with the pressure chamber and midday stem water potential progress. This table should not be duplicated without

Around -60

Complete defoliation

# Stem Water Potential Baseline

- Predicts what stem water potential should be under varying environmental conditions when water is not limiting

# Vapor Pressure Deficit

- Moisture in air at saturation – moisture in air at current time
- Calculated using temperature and relative humidity

# Midday stem water potential measurements, 2010 mature walnut orchard after adjusting irrigation management.

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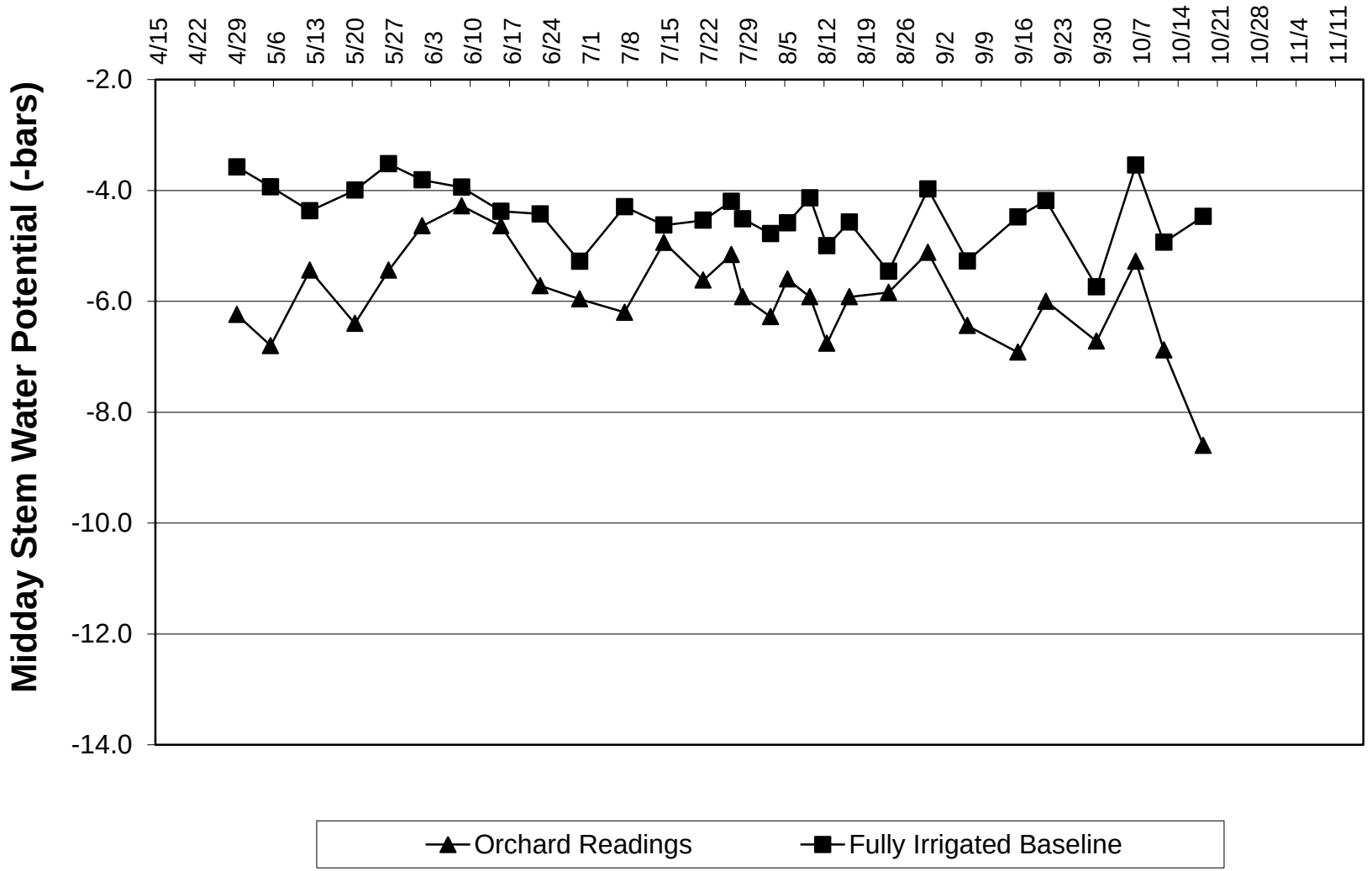
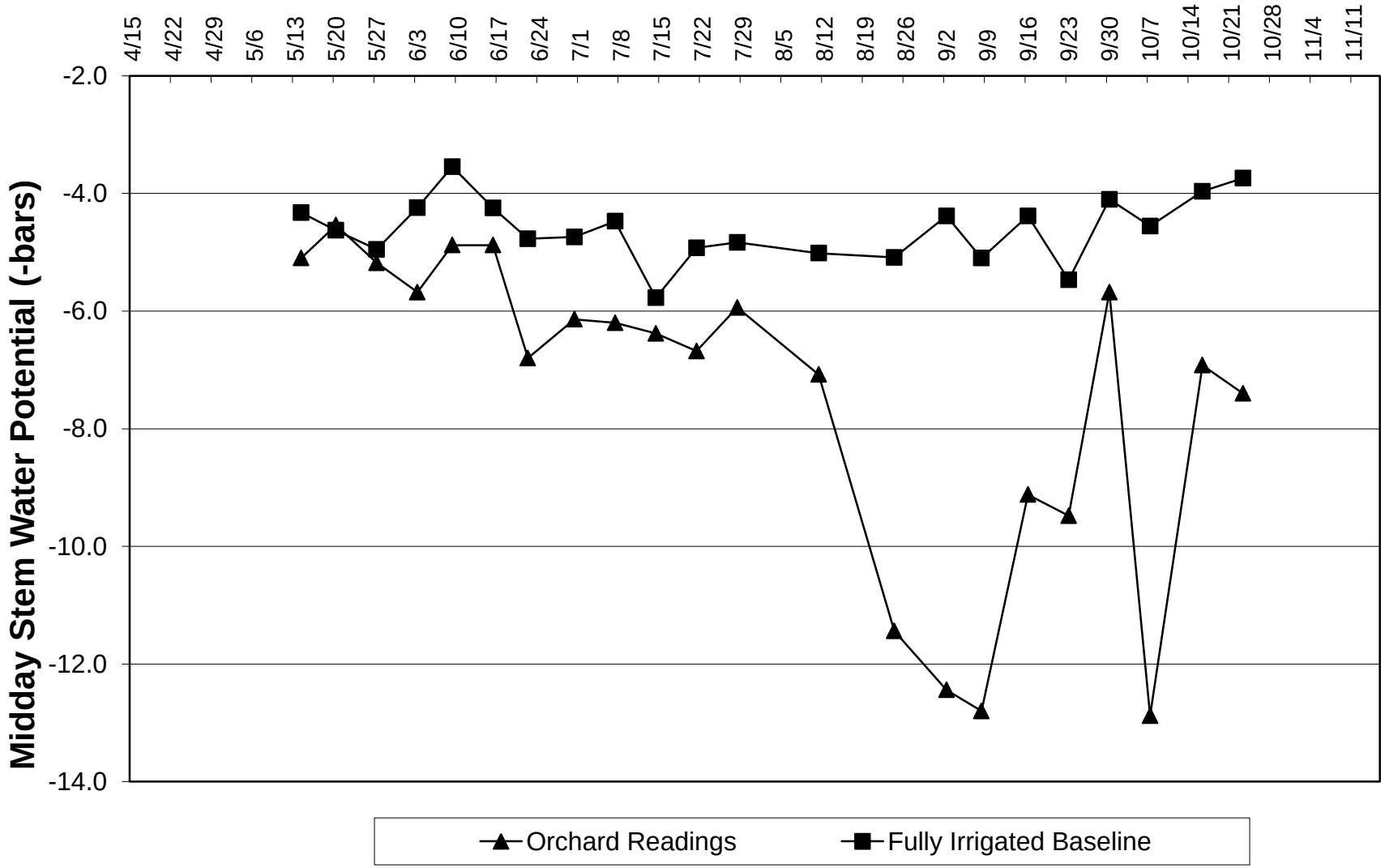
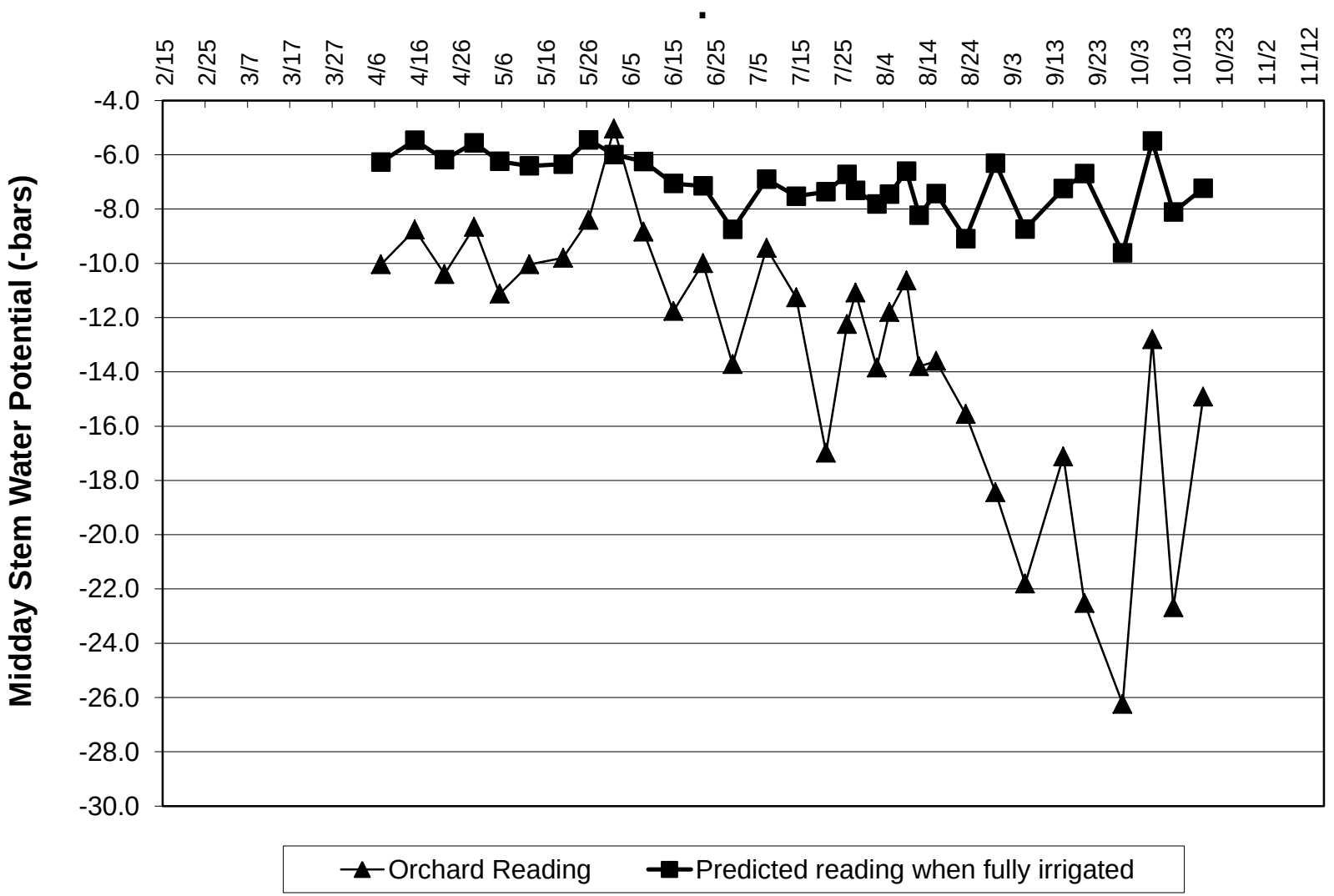


# Midday stem water potential measurements and baseline estimates, 2009 walnut orchard.

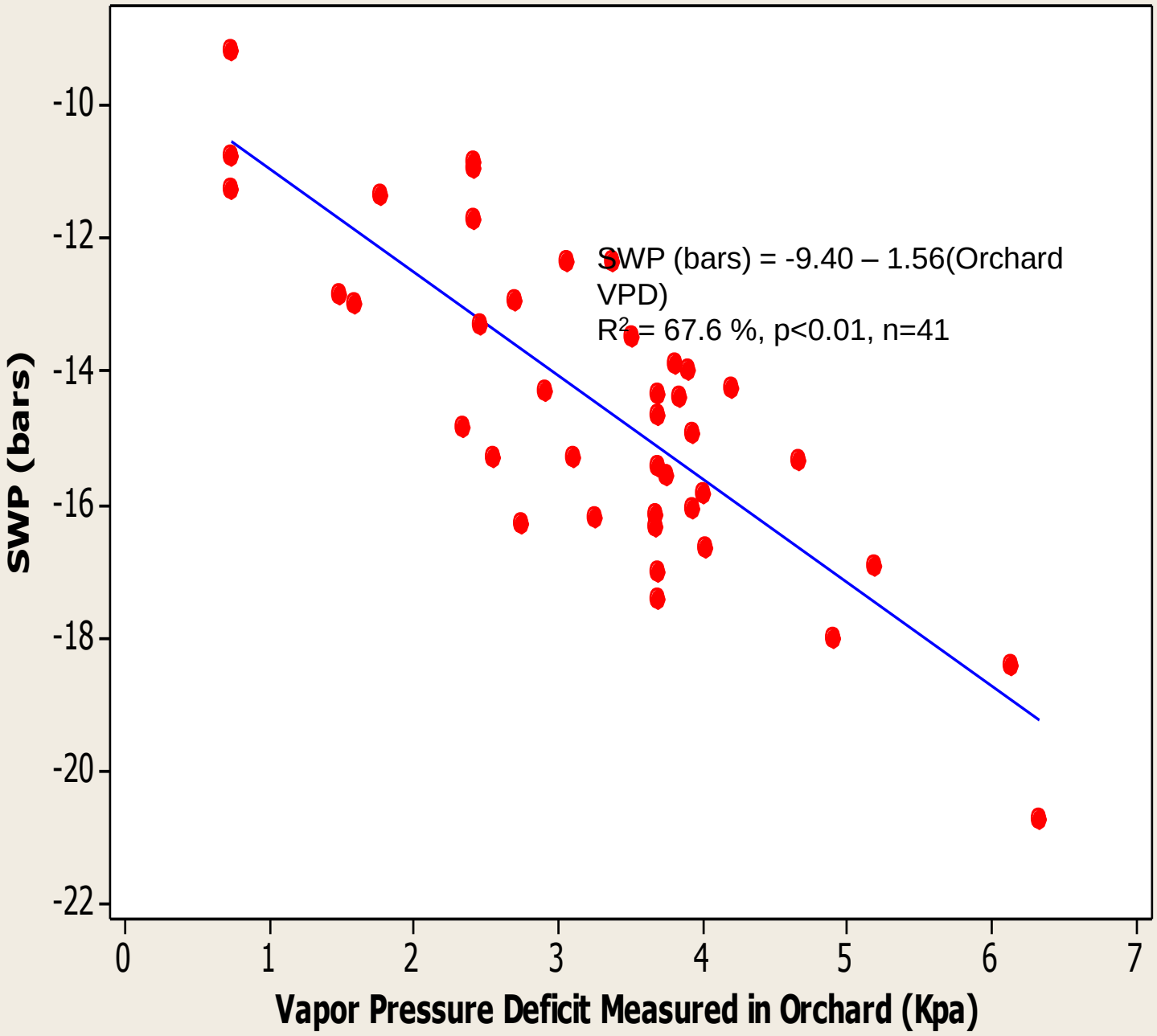


# Midday Stem Water Potential Measurements, 2010 Almond Orchard



# Materials and Methods

- Preliminary data consisting of SWP readings was collected from fully irrigated orchards in preceding seasons
- Three full canopy fully irrigated  mature orchards were selected in 2011
- SWP reading taken to represent a wide range of temperature and relative humidity conditions
- VPD calculated and correlated to SWP readings

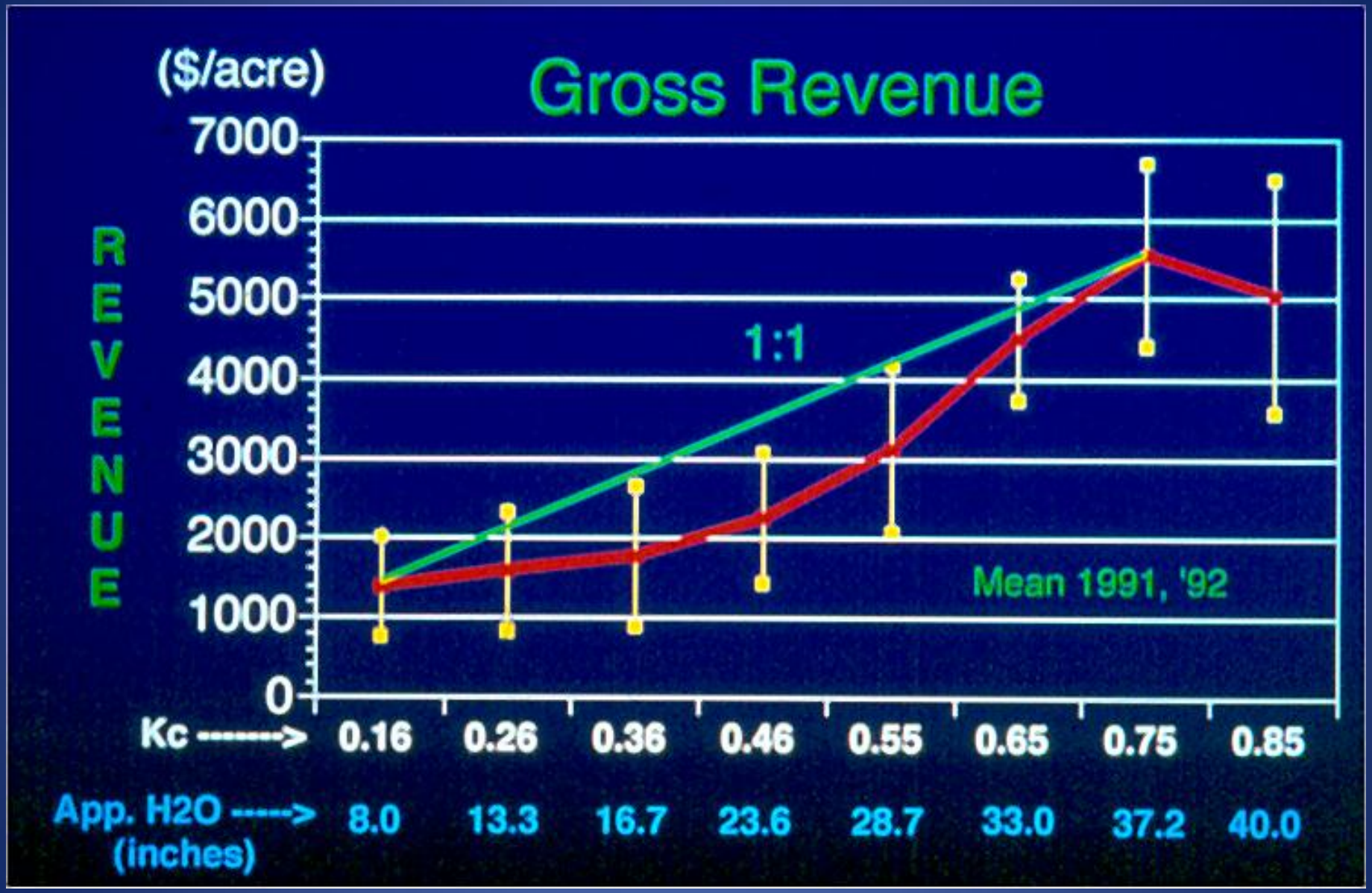

SWP (bars) = -9.40 – 1.56(Orchard VPD)
R² = 67.6 %, p<0.01, n=41
SWP (bars)
-10
-12
-14
-16
-18
-20
-22
0
1
2
3
4
5
6
7
Vapor Pressure Deficit Measured in Orchard (Kpa)

# Predicted baseline mid-day stem water potential in olives over a range of weather condition when soil moisture is not limiting.

| Air Temp (F) | Air Relative Humidity 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | -11.88 | -11.74 | -11.61 | -11.47 | -11.33 | -11.19 | -11.05 | -10.92 | -10.78 | -10.64 | -10.50 | -10.36 | -10.23 | -10.09 | -9.95 | -9.81 |
| 62 | -12.06 | -11.92 | -11.77 | -11.62 | -11.47 | -11.32 | -11.18 | -11.03 | -10.88 | -10.73 | -10.58 | -10.44 | -10.29 | -10.14 | -9.99 | -9.84 |
| 64 | -12.26 | -12.10 | -11.94 | -11.78 | -11.62 | -11.46 | -11.31 | -11.15 | -10.99 | -10.83 | -10.67 | -10.51 | -10.35 | -10.19 | -10.04 | -9.88 |
| 66 | -12.46 | -12.29 | -12.12 | -11.95 | -11.78 | -11.61 | -11.44 | -11.27 | -11.10 | -10.93 | -10.76 | -10.59 | -10.42 | -10.25 | -10.08 | -9.91 |
| 68 | -12.68 | -12.50 | -12.32 | -12.14 | -11.95 | -11.77 | -11.59 | -11.41 | -11.22 | -11.04 | -10.86 | -10.68 | -10.49 | -10.31 | -10.13 | -9.95 |
| 70 | -12.92 | -12.72 | -12.53 | -12.33 | -12.13 | -11.94 | -11.74 | -11.55 | -11.35 | -11.16 | -10.96 | -10.77 | -10.57 | -10.38 | -10.18 | -9.99 |
| 72 | -13.16 | -12.95 | -12.74 | -12.54 | -12.33 | -12.12 | -11.91 | -11.70 | -11.49 | -11.28 | -11.07 | -10.86 | -10.65 | -10.45 | -10.24 | -10.03 |
| 74 | -13.42 | -13.20 | -12.98 | -12.75 | -12.53 | -12.31 | -12.08 | -11.86 | -11.64 | -11.41 | -11.19 | -10.97 | -10.74 | -10.52 | -10.29 | -10.07 |
| 76 | -13.70 | -13.46 | -13.22 | -12.99 | -12.75 | -12.51 | -12.27 | -12.03 | -11.79 | -11.55 | -11.31 | -11.07 | -10.83 | -10.60 | -10.36 | -10.12 |
| 78 | -14.00 | -13.74 | -13.49 | -13.23 | -12.98 | -12.72 | -12.46 | -12.21 | -11.95 | -11.70 | -11.44 | -11.19 | -10.93 | -10.68 | -10.42 | -10.17 |
| 80 | -14.31 | -14.04 | -13.76 | -13.49 | -13.22 | -12.95 | -12.67 | -12.40 | -12.13 | -11.85 | -11.58 | -11.31 | -11.04 | -10.76 | -10.49 | -10.22 |
| 82 | -14.64 | -14.35 | -14.06 | -13.77 | -13.47 | -13.18 | -12.89 | -12.60 | -12.31 | -12.02 | -11.73 | -11.44 | -11.15 | -10.86 | -10.56 | -10.27 |
| 84 | -14.99 | -14.68 | -14.37 | -14.06 | -13.75 | -13.44 | -13.13 | -12.81 | -12.50 | -12.19 | -11.88 | -11.57 | -11.26 | -10.95 | -10.64 | -10.33 |
| 86 | -15.36 | -15.03 | -14.70 | -14.36 | -14.03 | -13.70 | -13.37 | -13.04 | -12.71 | -12.38 | -12.05 | -11.72 | -11.39 | -11.05 | -10.72 | -10.39 |
| 88 | -15.75 | -15.39 | -15.04 | -14.69 | -14.34 | -13.98 | -13.63 | -13.28 | -12.93 | -12.57 | -12.22 | -11.87 | -11.52 | -11.16 | -10.81 | -10.46 |
| 90 | -16.16 | -15.78 | -15.41 | -15.03 | -14.66 | -14.28 | -13.91 | -13.53 | -13.16 | -12.78 | -12.40 | -12.03 | -11.65 | -11.28 | -10.90 | -10.53 |
| 92 | -16.60 | -16.20 | -15.80 | -15.40 | -15.00 | -14.60 | -14.20 | -13.80 | -13.40 | -13.00 | -12.60 | -12.20 | -11.80 | -11.40 | -11.00 | -10.60 |
| 94 | -17.06 | -16.63 | -16.20 | -15.78 | -15.35 | -14.93 | -14.50 | -14.08 | -13.65 | -13.23 | -12.80 | -12.38 | -11.95 | -11.53 | -11.10 | -10.68 |
| 96 | -17.54 | -17.09 | -16.64 | -16.18 | -15.73 | -15.28 | -14.83 | -14.37 | -13.92 | -13.47 | -13.02 | -12.57 | -12.11 | -11.66 | -11.21 | -10.76 |
| 98 | -18.05 | -17.57 | -17.09 | -16.61 | -16.13 | -15.65 | -15.17 | -14.69 | -14.21 | -13.73 | -13.24 | -12.76 | -12.28 | -11.80 | -11.32 | -10.84 |
| 100 | -18.59 | -18.08 | -17.57 | -17.06 | -16.55 | -16.04 | -15.53 | -15.02 | -14.51 | -13.99 | -13.48 | -12.97 | -12.46 | -11.95 | -11.44 | -10.93 |
| 102 | -19.16 | -18.62 | -18.07 | -17.53 | -16.99 | -16.45 | -15.91 | -15.36 | -14.82 | -14.28 | -13.74 | -13.19 | -12.65 | -12.11 | -11.57 | -11.03 |
| 104 | -19.76 | -19.18 | -18.60 | -18.03 | -17.45 | -16.88 | -16.30 | -15.73 | -15.15 | -14.58 | -14.00 | -13.43 | -12.85 | -12.28 | -11.70 | -11.13 |
| 106 | -20.38 | -19.77 | -19.16 | -18.55 | -17.94 | -17.33 | -16.72 | -16.11 | -15.50 | -14.89 | -14.28 | -13.67 | -13.06 | -12.45 | -11.84 | -11.23 |
| 108 | -21.05 | -20.40 | -19.75 | -19.11 | -18.46 | -17.81 | -17.16 | -16.52 | -15.87 | -15.22 | -14.58 | -13.93 | -13.28 | -12.64 | -11.99 | -11.34 |
| 110 | -21.74 | -21.06 | -20.37 | -19.69 | -19.00 | -18.31 | -17.63 | -16.94 | -16.26 | -15.57 | -14.89 | -14.20 | -13.51 | -12.83 | -12.14 | -11.46 |
| 112 | -22.47 | -21.75 | -21.02 | -20.30 | -19.57 | -18.84 | -18.12 | -17.39 | -16.66 | -15.94 | -15.21 | -14.48 | -13.76 | -13.03 | -12.31 | -11.58 |
| 114 | -23.24 | -22.47 | -21.70 | -20.94 | -20.17 | -19.40 | -18.63 | -17.86 | -17.09 | -16.32 | -15.55 | -14.78 | -14.01 | -13.25 | -12.48 | -11.71 |
| 116 | -24.05 | -23.24 | -22.42 | -21.61 | -20.79 | -19.98 | -19.17 | -18.35 | -17.54 | -16.73 | -15.91 | -15.10 | -14.28 | -13.47 | -12.66 | -11.84 |
| 118 | -24.90 | -24.04 | -23.18 | -22.32 | -21.45 | -20.59 | -19.73 | -18.87 | -18.01 | -17.15 | -16.29 | -15.43 | -14.57 | -13.71 | -12.84 | -11.98 |
| 120 | -25.79 | -24.88 | -23.97 | -23.06 | -22.15 | -21.24 | -20.33 | -19.41 | -18.50 | -17.59 | -16.68 | -15.77 | -14.86 | -13.95 | -13.04 | -12.13 |

# Using Stem Water Potential

- Take reading at end of irrigation cycle
- Determine if water is limiting
- Control Regulated deficit irrigation to achieve yield objectives

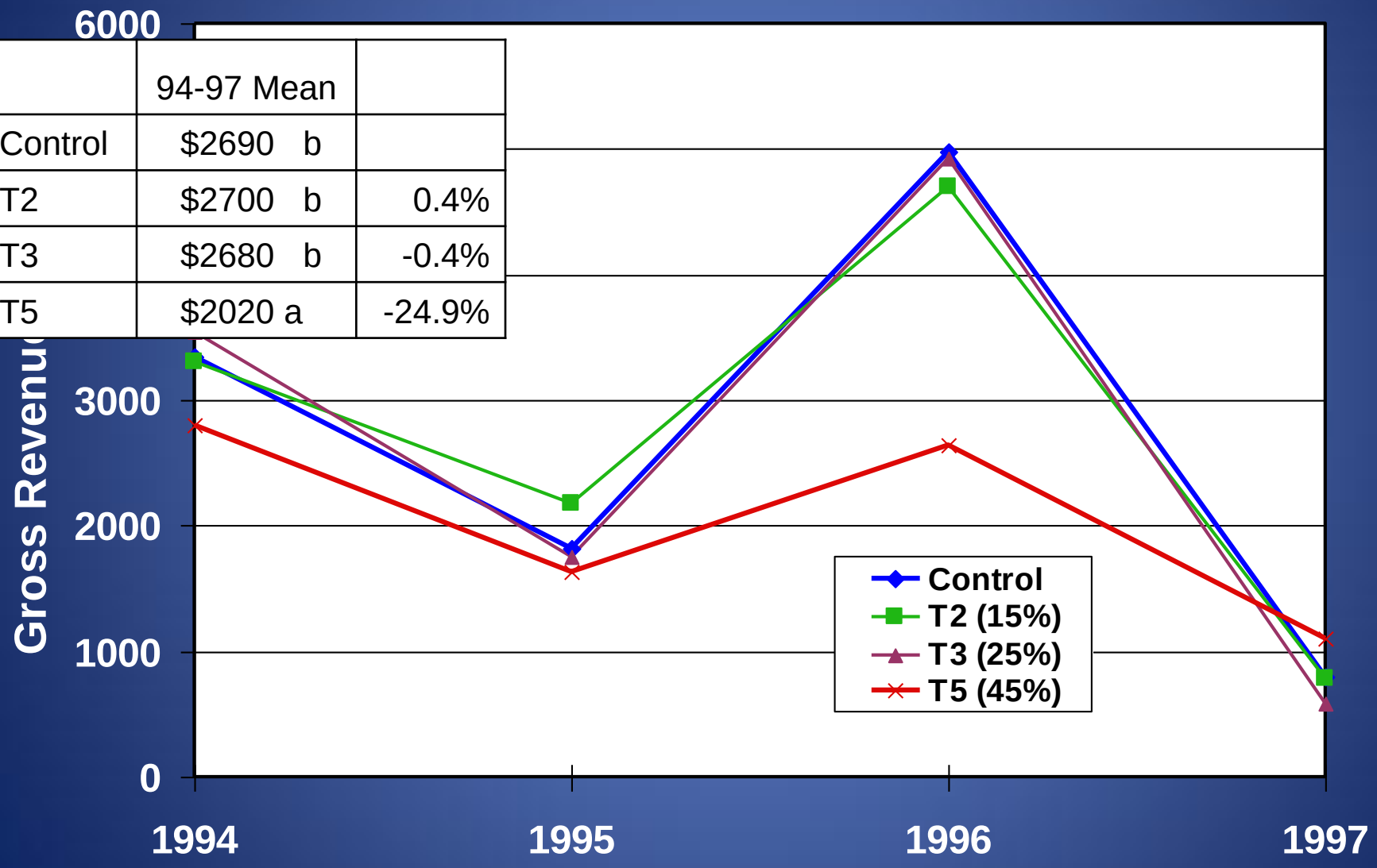

Gross Revenue
($/acre)
REVENUE
7000
6000
5000
4000
3000
2000
1000
0
1:1
Mean 1991, '92
Kc ------->
0.16
0.26
0.36
0.46
0.55
0.65
0.75
0.85
App. H2O ----->
(inches)
8.0
13.3
16.7
23.6
28.7
33.0
37.2
40.0

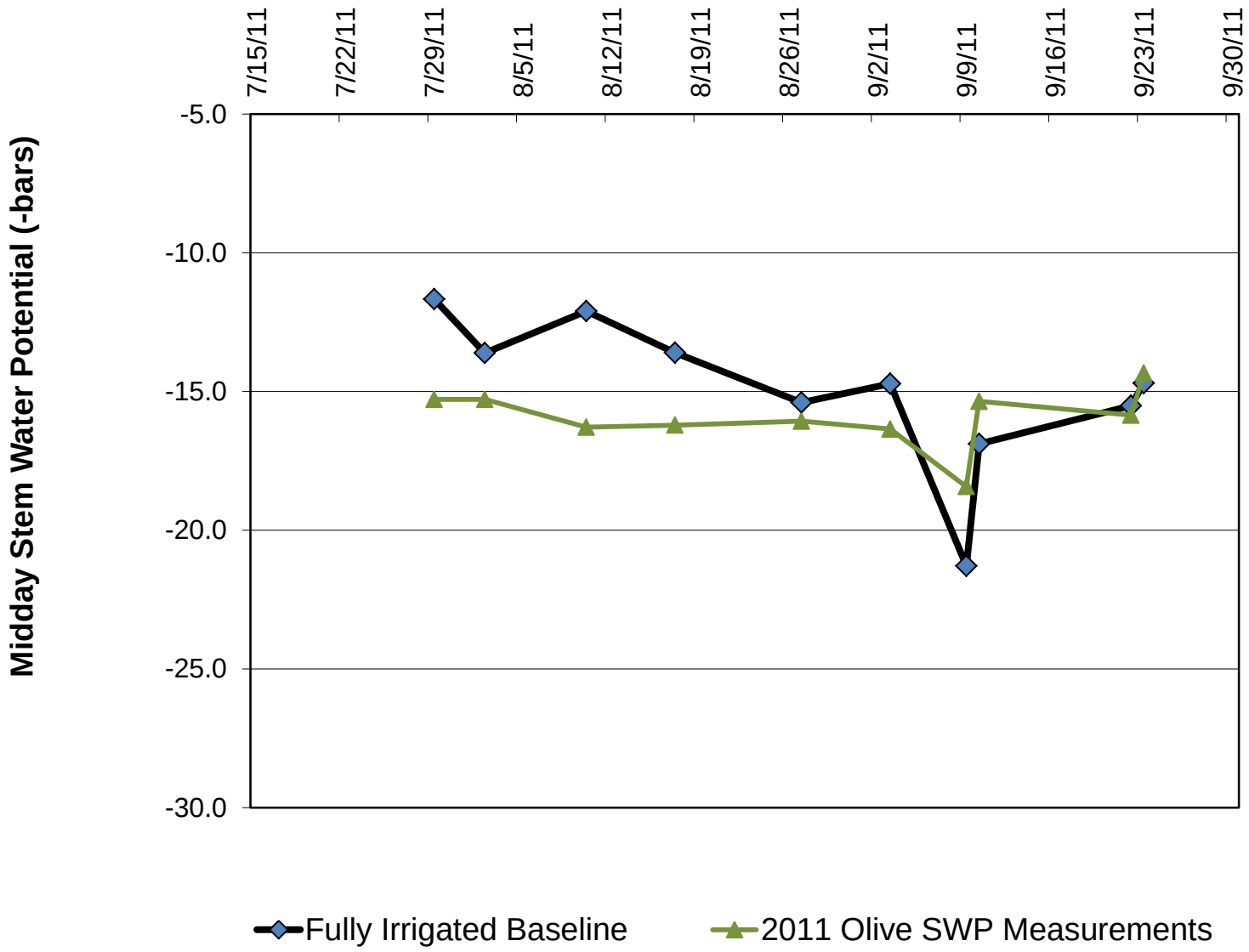
# *Regulated Deficit Irrigation, a controlled stress*

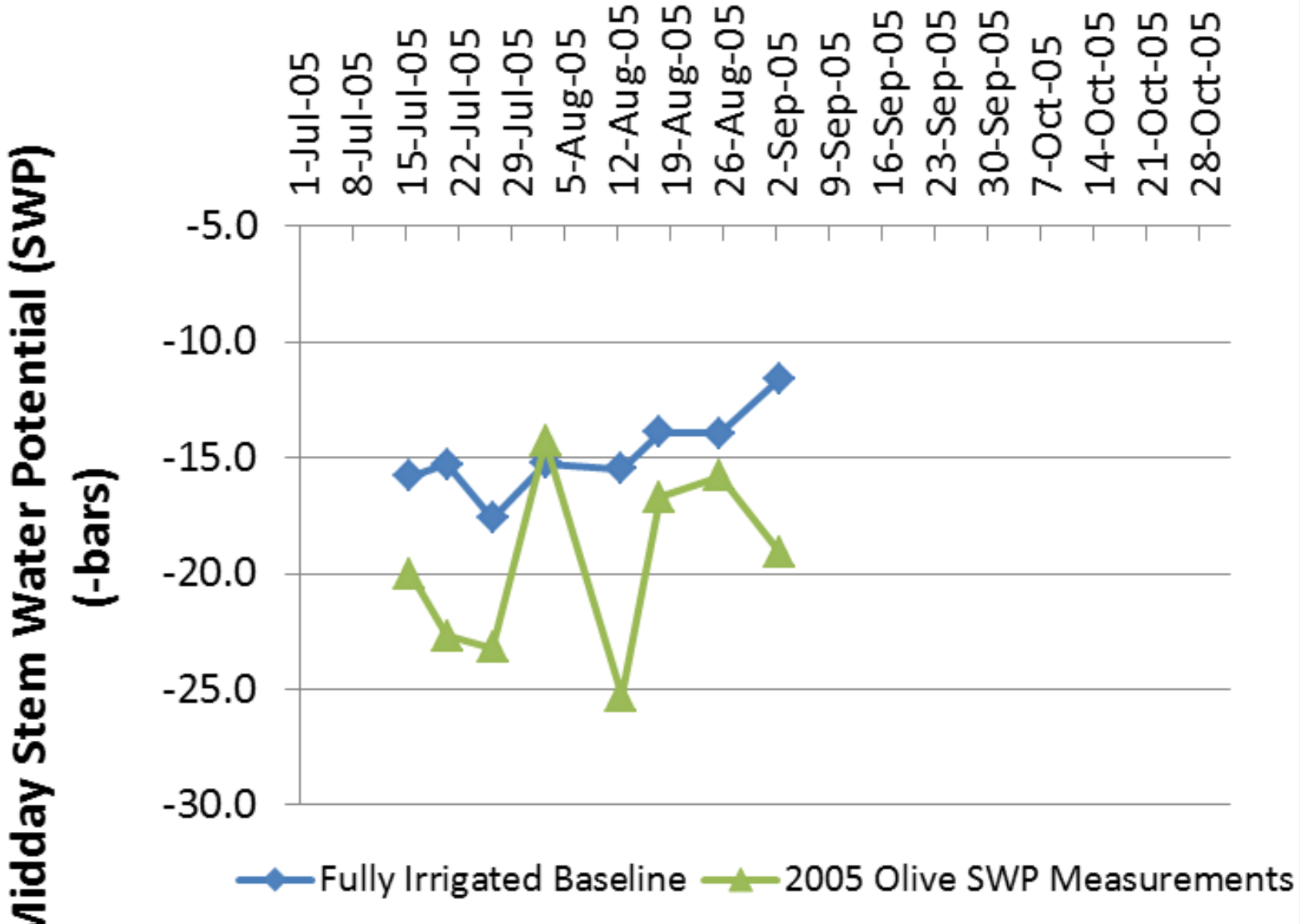
| Date | Treatment 1 Full ETc (in.) | RDI% | Treatment 2 Irrigation (in.) | RDI% | Treatment 3 Irrigation (in.) | RDI % | Treatment 5 Irrigation (in.) |
|---|---|---|---|---|---|---|---|
| Mar 1-15 | 1.2 | 100 | 1.2 | 100 | 1.2 | 100 | 1.2 |
| Mar 16-31 | 1.2 | 100 | 1.2 | 100 | 1.2 | 100 | 1.2 |
| Apr 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 Revenue

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



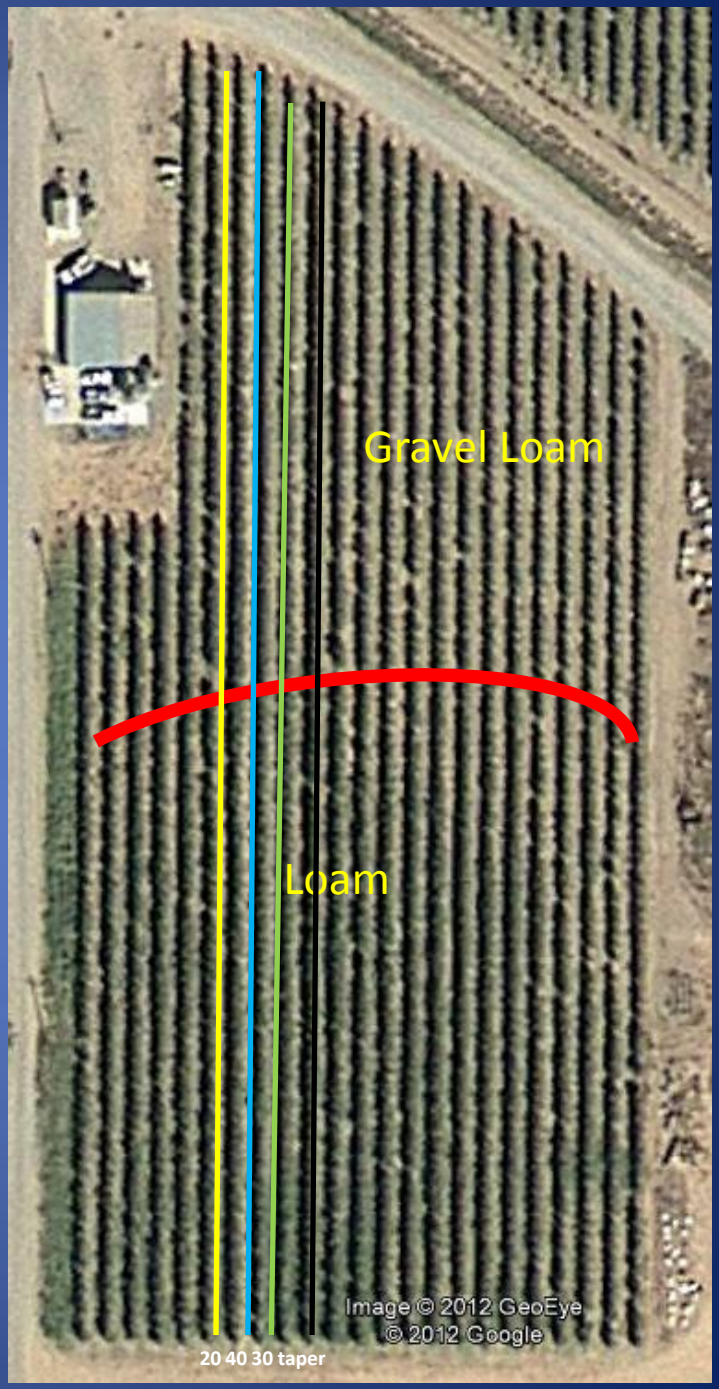

Midday Stem Water Potential (-bars)
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
Fully Irrigated Baseline
2011 Olive SWP Measurements


Midday Stem Water Potential (SWP) (-bars)
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
1-Jul-05
8-Jul-05
15-Jul-05
22-Jul-05
29-Jul-05
5-Aug-05
12-Aug-05
19-Aug-05
26-Aug-05
2-Sep-05
9-Sep-05
16-Sep-05
23-Sep-05
30-Sep-05
7-Oct-05
14-Oct-05
21-Oct-05
28-Oct-05
Fully Irrigated Baseline
2005 Olive SWP Measurements

# RDI Trial

- 20% ETo
- 40% ETo
- 30% ETo
- Tapered ETo (40, 30, 20%)

Treatments applied ~ August 1 at about 1 ½ weeks after pit hardening



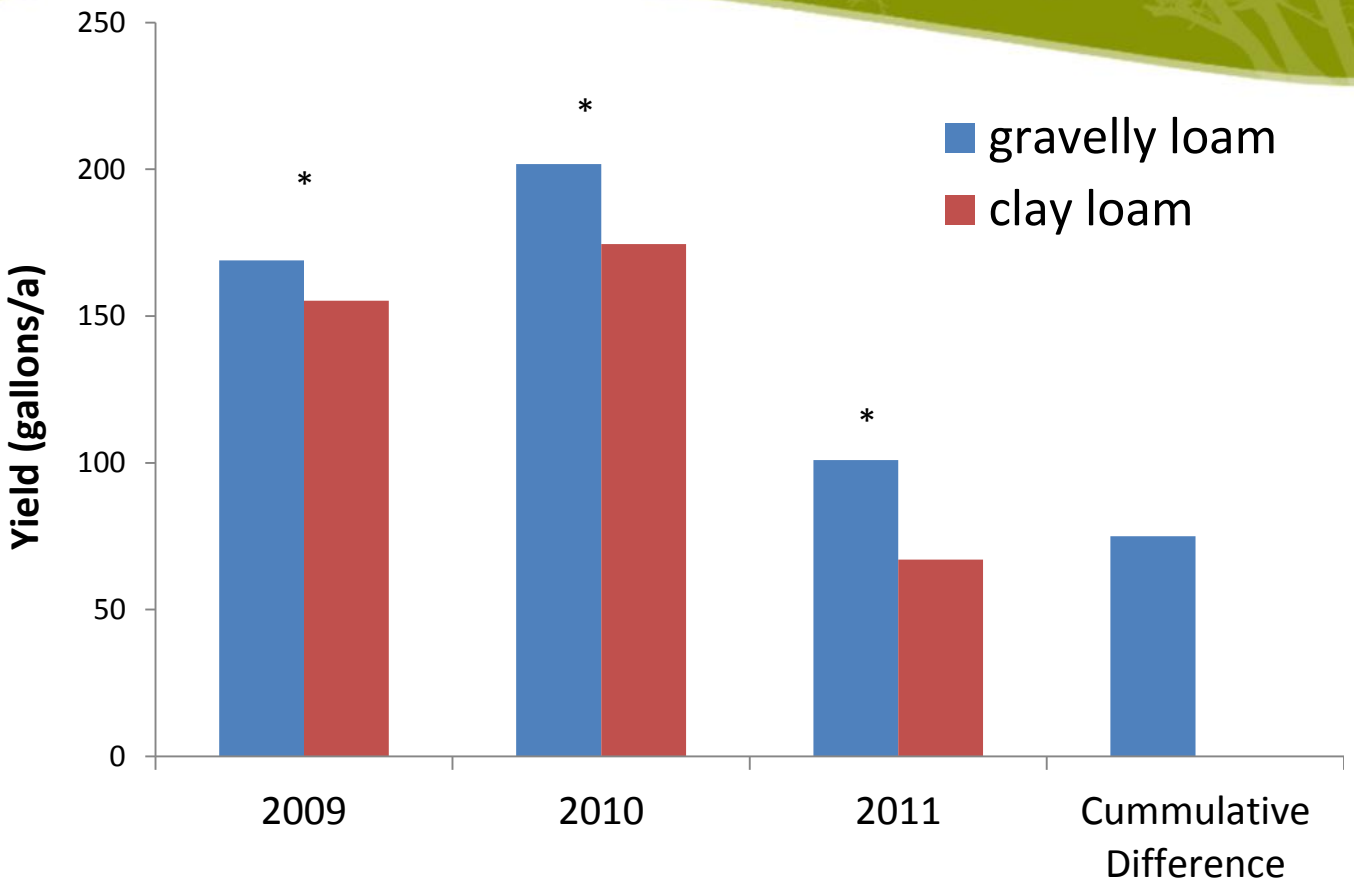
# Yields


250
200
150
100
50
0
Yield (gallons/a)
2009
2010
2011
40 % Eto
30 % Eto
40-20 % Eto
20 % Eto

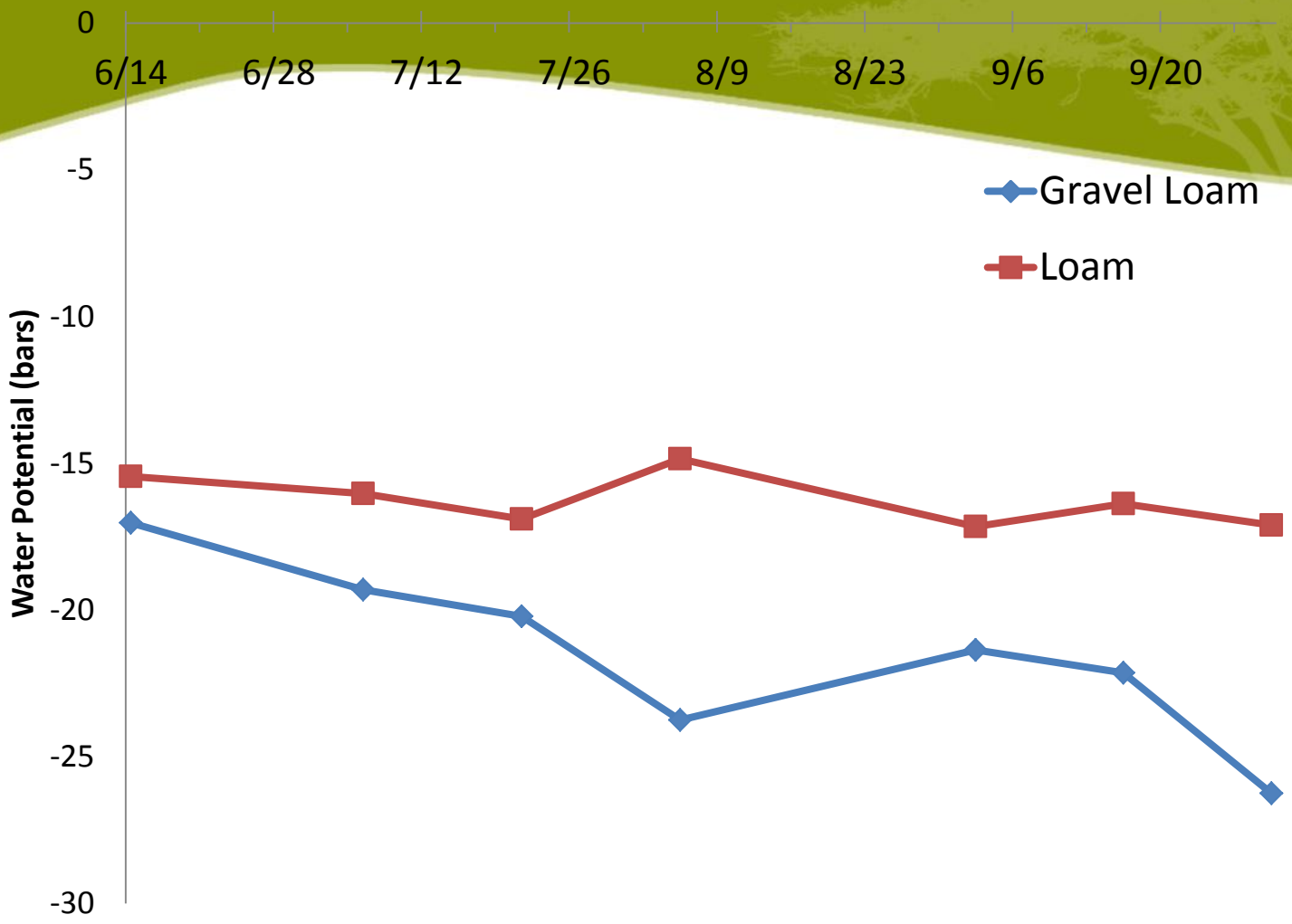
# Tree Growth - 2011

| Treatment | Shoot Growth (cm) [1] | Trunk Growth (cm) [1] | Pruning Wt. (lbs) (20 trees) |
|---|---|---|---|
| 40 % Eto | 13.4 | 1.18 | 179 |
| 30 % Eto | 11. 7 | 1.09 | 138 |
| Taper Eto | 14.3 | 1.46 | 180 |
| 20 % ETo | 13.3 | 0.66 | 167 |
| | ns | ns | ns |
| **Gravel** | 9.2 B | 0.58 B | 101 B |
| **Loam** | 17.1 A | 1.57 A | 231 A |

# Oil Yields


250
200
150
100
50
0
Yield (gallons/a)
*
*
*
gravelly loam
clay loam
2009
2010
2011
Cummulative Difference

# 2011


0
6/14
6/28
7/12
7/26
8/9
8/23
9/6
9/20
-5
-10
-15
-20
-25
-30
Water Potential (bars)
Gravel Loam
Loam

# Mechanically Hedging Super High Density Hedgerow Olives

- Initiated spring of 2010
- Treatments

  4 row blocks replicated 4X

  1. Hand Pruned Control – all 4 rows
  2. one row hedged both sides 18 to 20 inches from center wire each year
  3. One side of two rows hedged at same distance each year

  Cycle completed in 4 years

# COR – “Gable or Rooftop”

# 2010 Results

- Canopy diameter was largest for the hand pruned trees, intermediate for those hedged on one side and smallest for those hedged on two sides
- Trunk diameters were equal for the hand pruned treatments and those hedged on one side and significantly smaller for those hedged on 2 sides,
- There were no significant differences in yield

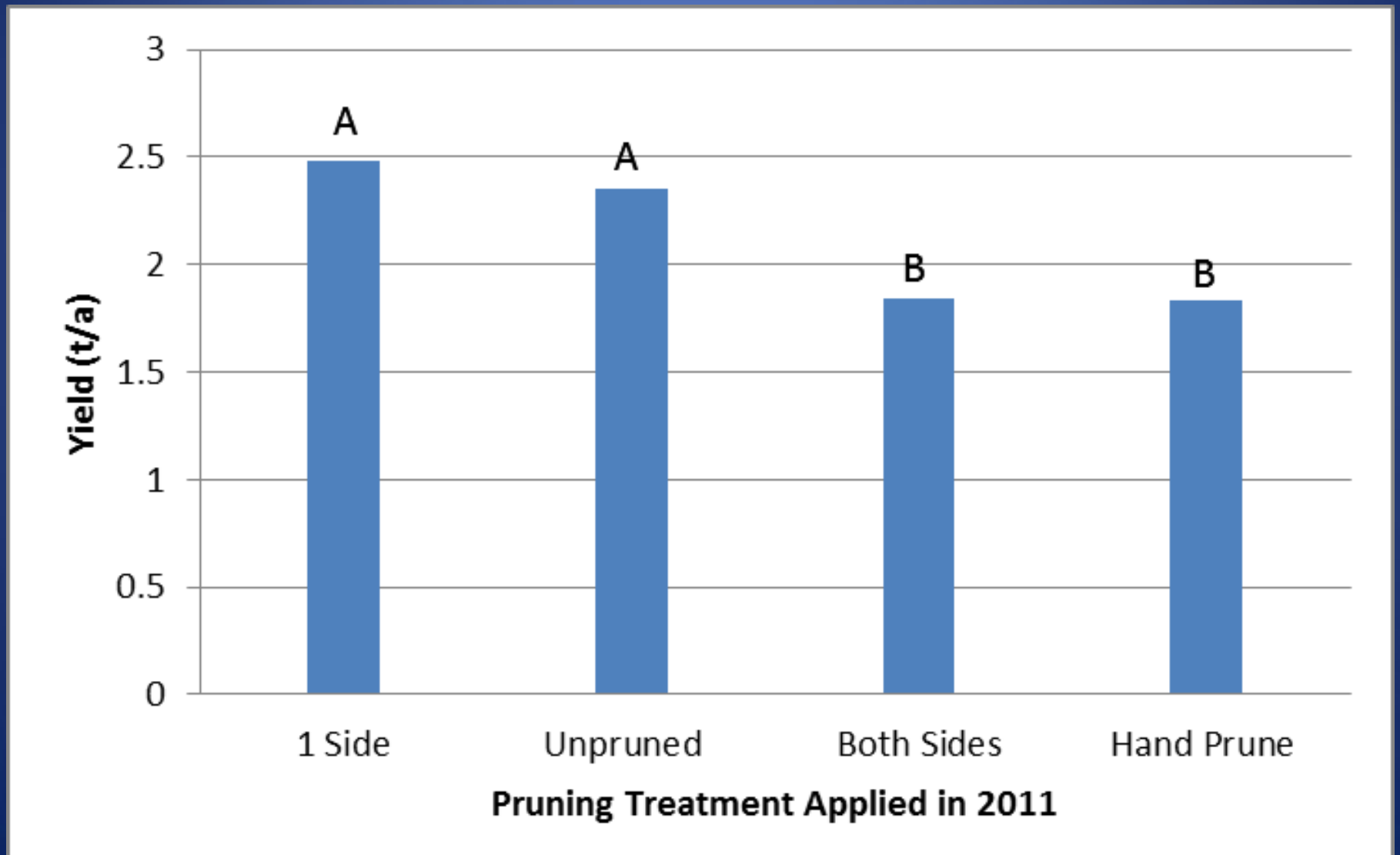
# Double Side Hedging

Hedged 2 Sides 2011

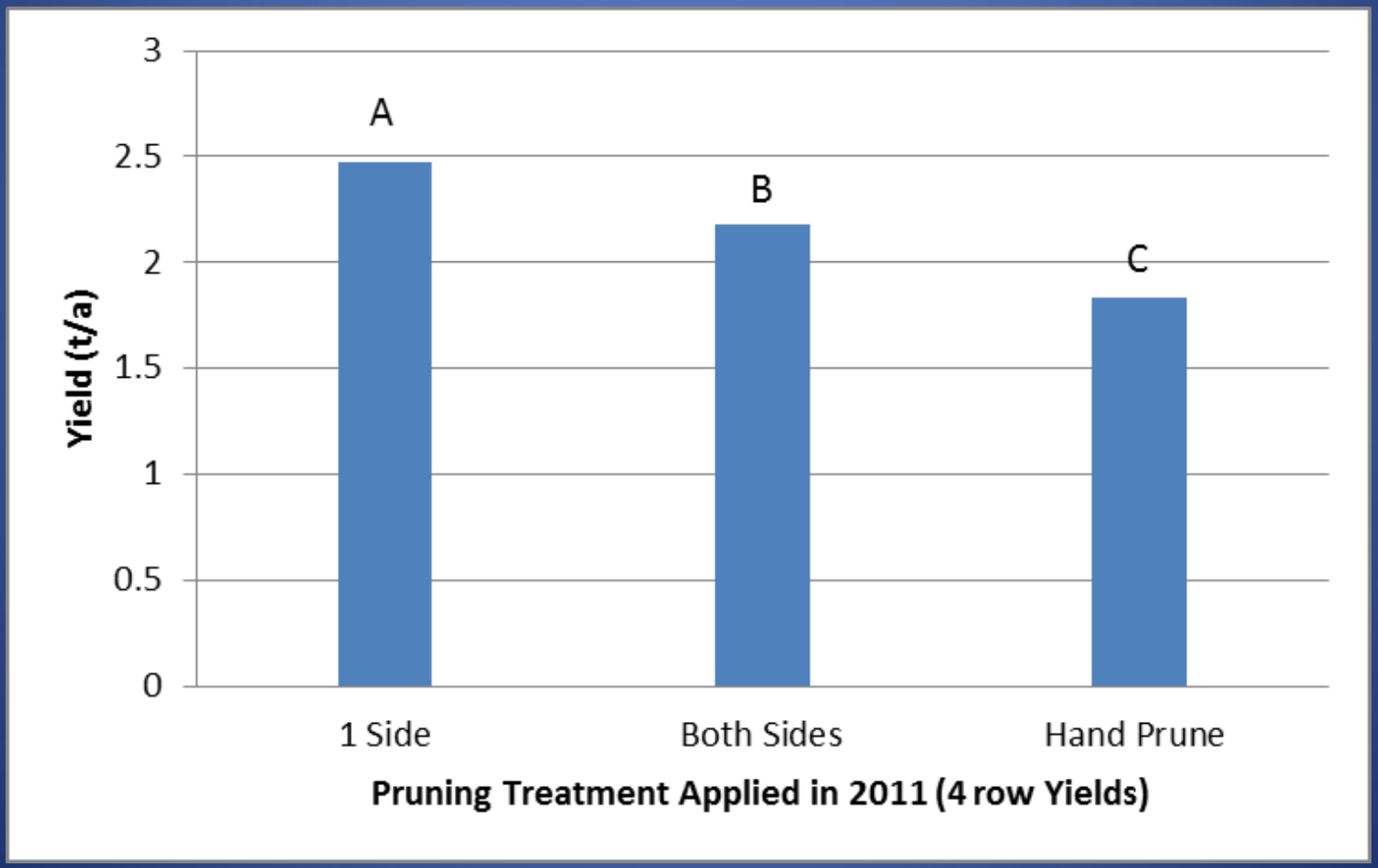

Unpruned 2 years

Hedged 2 Sides 2010

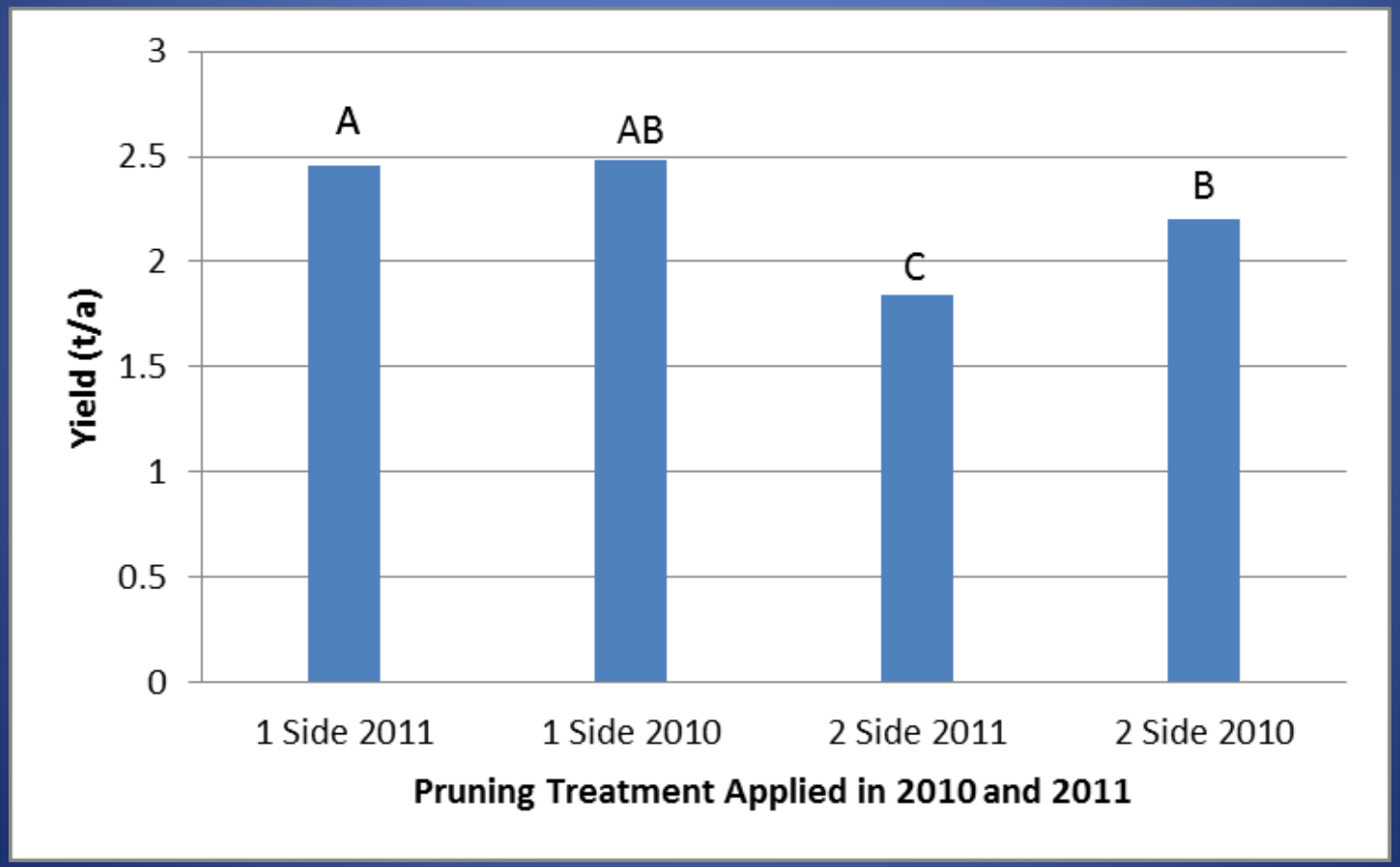
# 2011 Yield


3
2.5
2
1.5
1
0.5
0
Yield (t/a)
A
A
B
B
1 Side
Unpruned
Both Sides
Hand Prune
Pruning Treatment Applied in 2011

# 2011 Yield for Four Row Block



# 2011 Yields From Rows Pruned in 2010 and 2011



# Cumulative Yields for 2010 and 2011