Early Season and Summer Water Management in Walnut

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Things I will cover

- Impacts of water management on canopy growth, yield and quality in walnut
  - When should you start irrigating in spring
  - Possible ways to save water without hurting or even improving returns
  - If you have limited water, how should you allocate it?
    - Young orchards?
    - Older productive blocks?
  - Impacts of water stress and excessively wet conditions on nut quality
  - Leaf symptoms of under and over-irrigation

When should you start irrigating in the spring?

Early season water management and physiological indicators for irrigation management in walnut

Objectives:

Field test four levels of SWP for the start of irrigation in the spring.

Why?

Irrigation is a compromise between too wet for root health and too dry for maximum production. Grower concern not to “fall behind” in the spring may lead to a syndrome of shallow roots and unhealthy trees. We need plant-based (SWP) information on when to start irrigating in the spring.

Objective 1: Investigate impacts of date of start of irrigation on productivity in walnut

PIs: Ken Shackel, Allan Fulton, Bruce Lampinen

9 year old Chandler/Pdx orchard in Tehama County

RCBD, 5 blocks, 5 irrigation treatments:

- Grower

Or wait for:

- 1 bar below baseline
- 2 bars below baseline
- 3 bars below baseline
- 4 bars below baseline

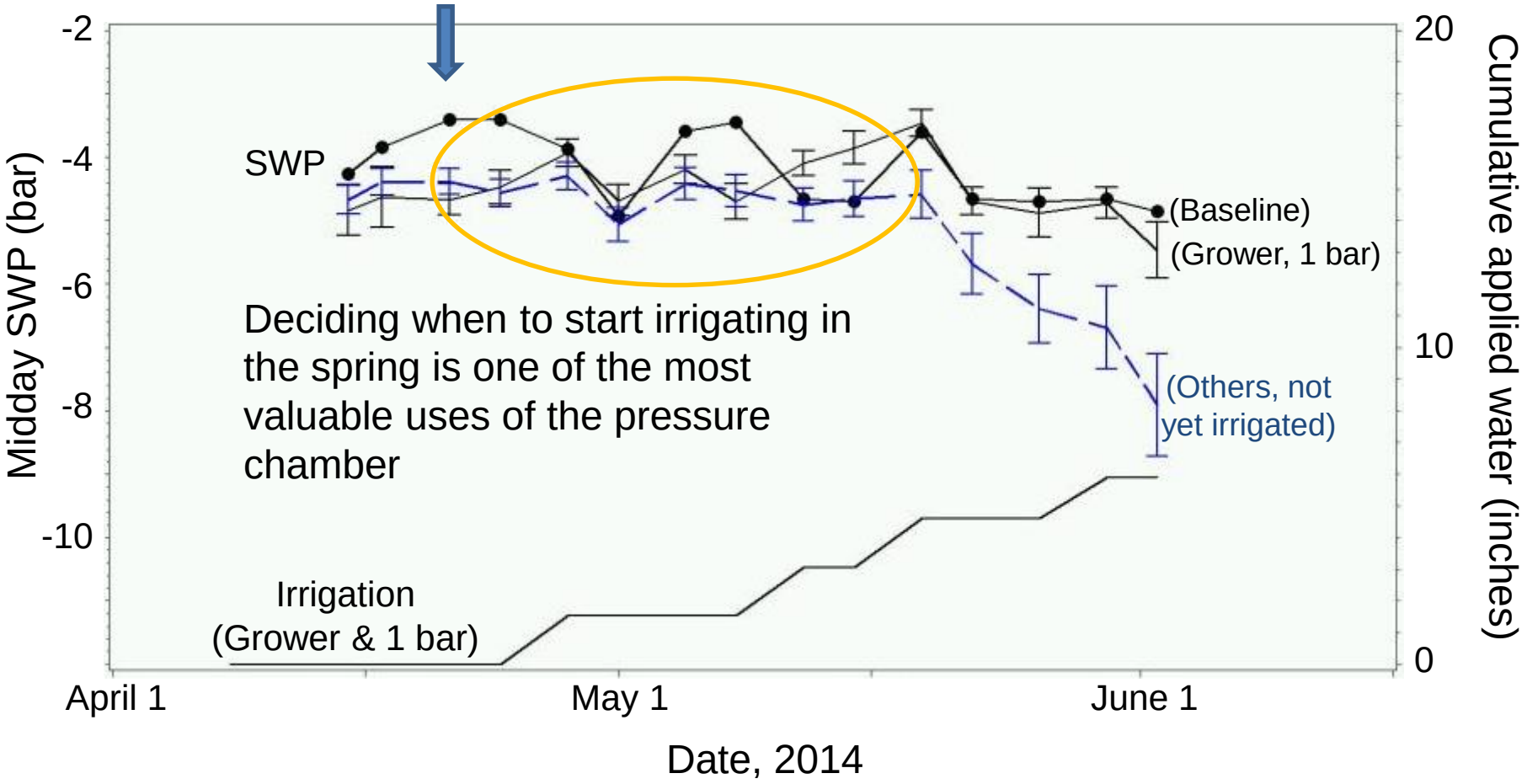
before starting irrigation, then irrigate as Grower.

Question:

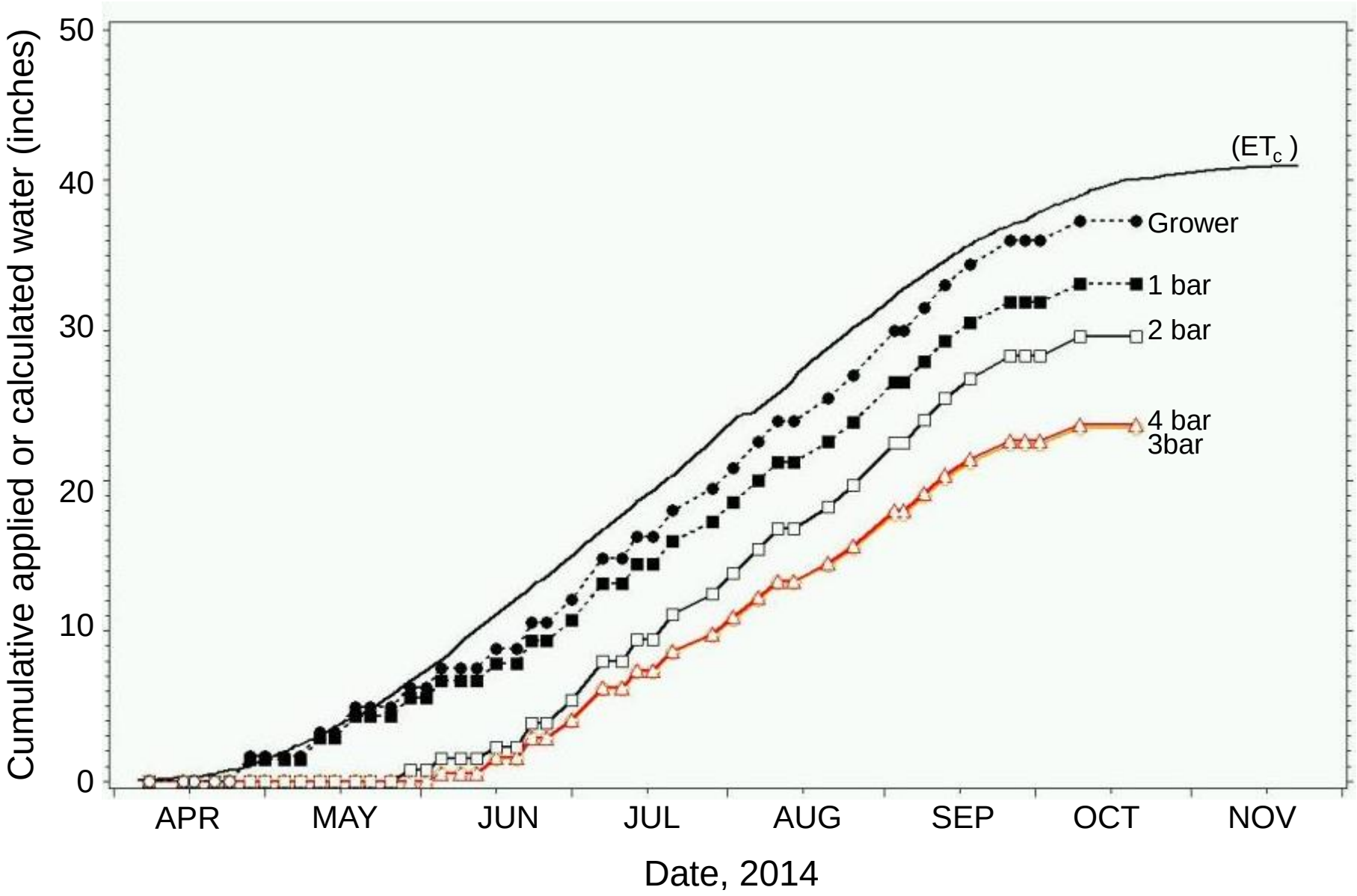
Will a later start date mean that the trees will always be "behind?"

Monitor: Irrigation amounts, soil water, SWP, PAR, Yield/Quality, Tree health

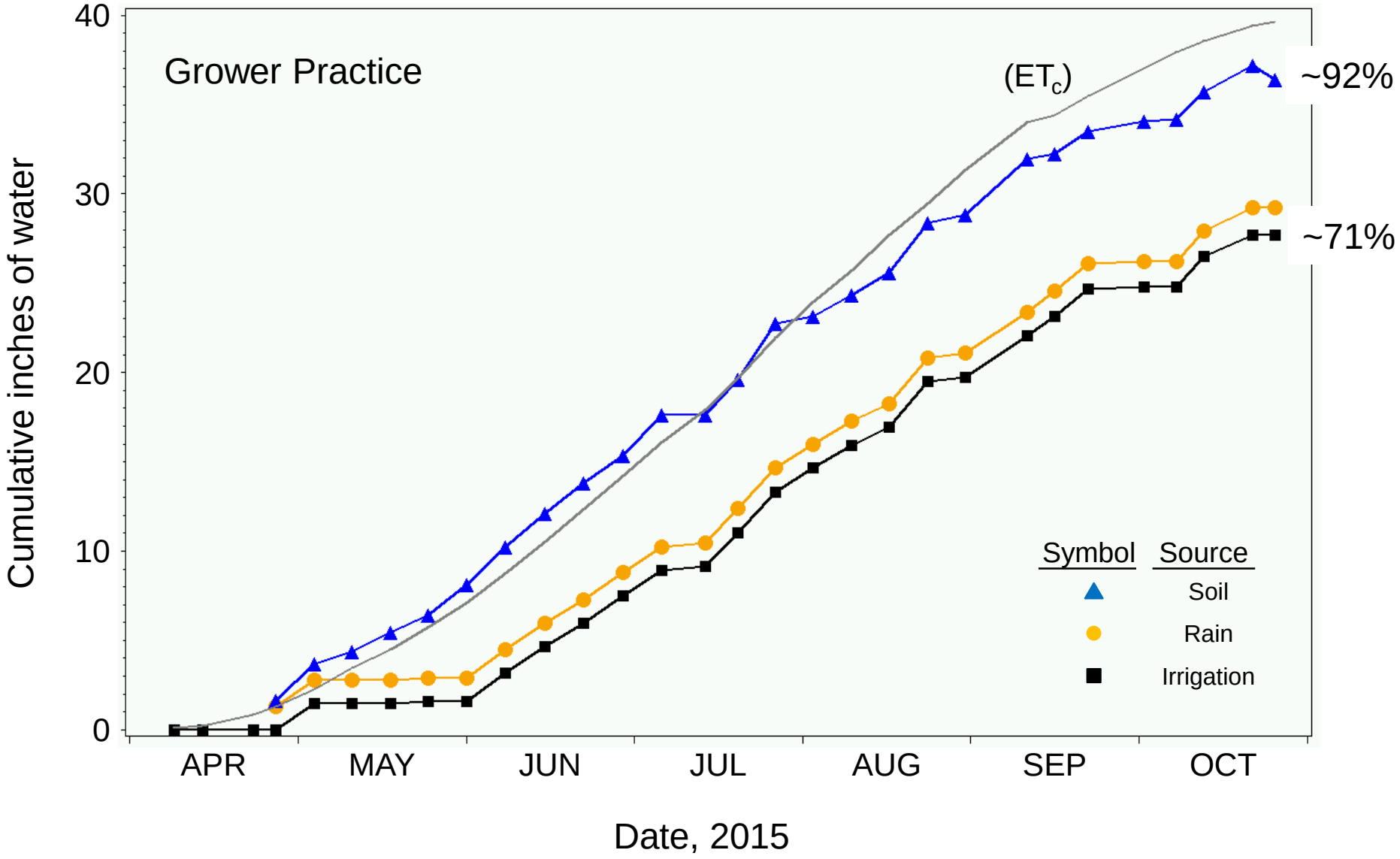
Detail: Grower and 1 bar were started at the same time (late April). But the non-irrigated 'control' group showed that a clear divergence from baseline didn't start until about a month later!



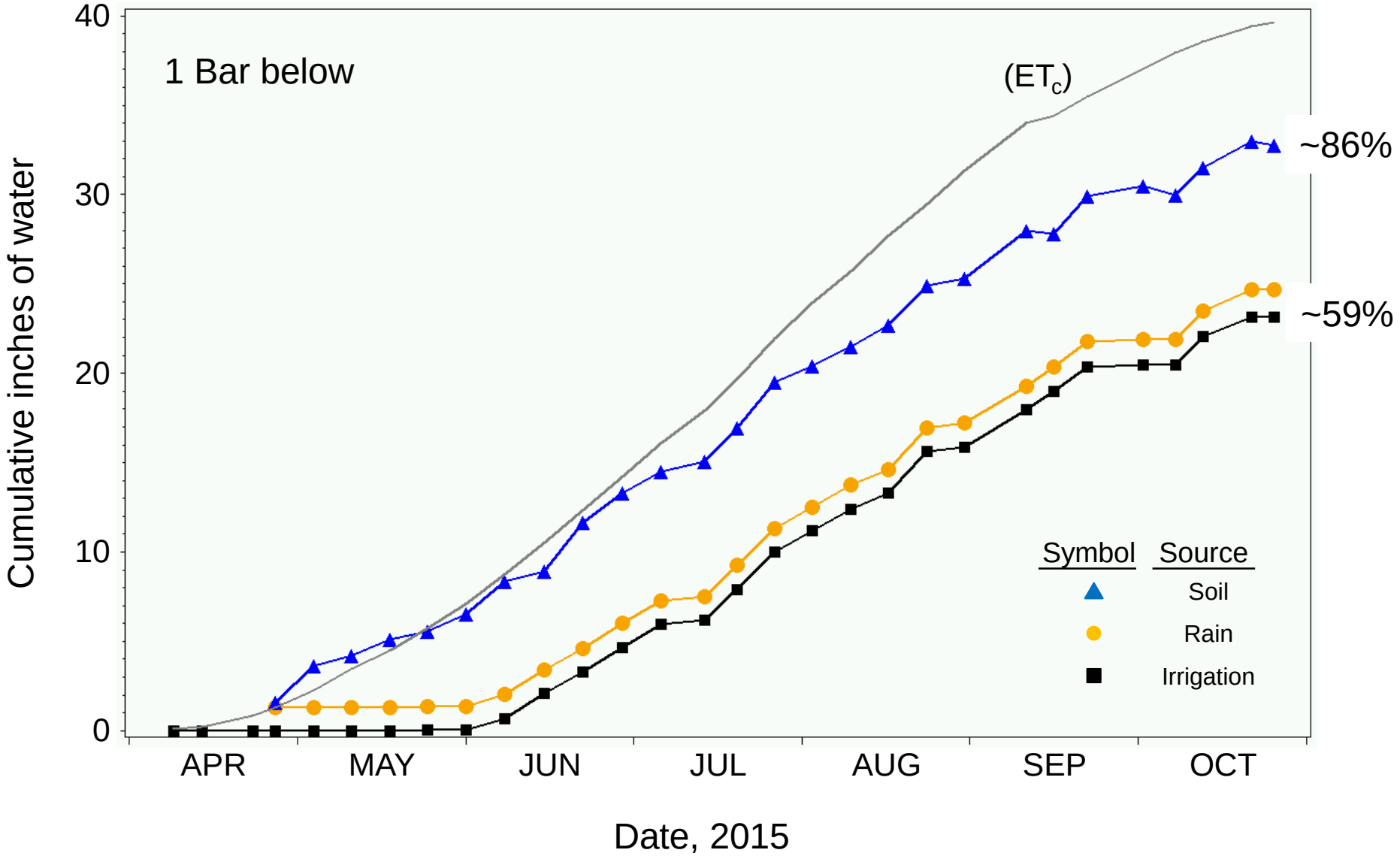
2014 Results: Cumulative applied irrigation



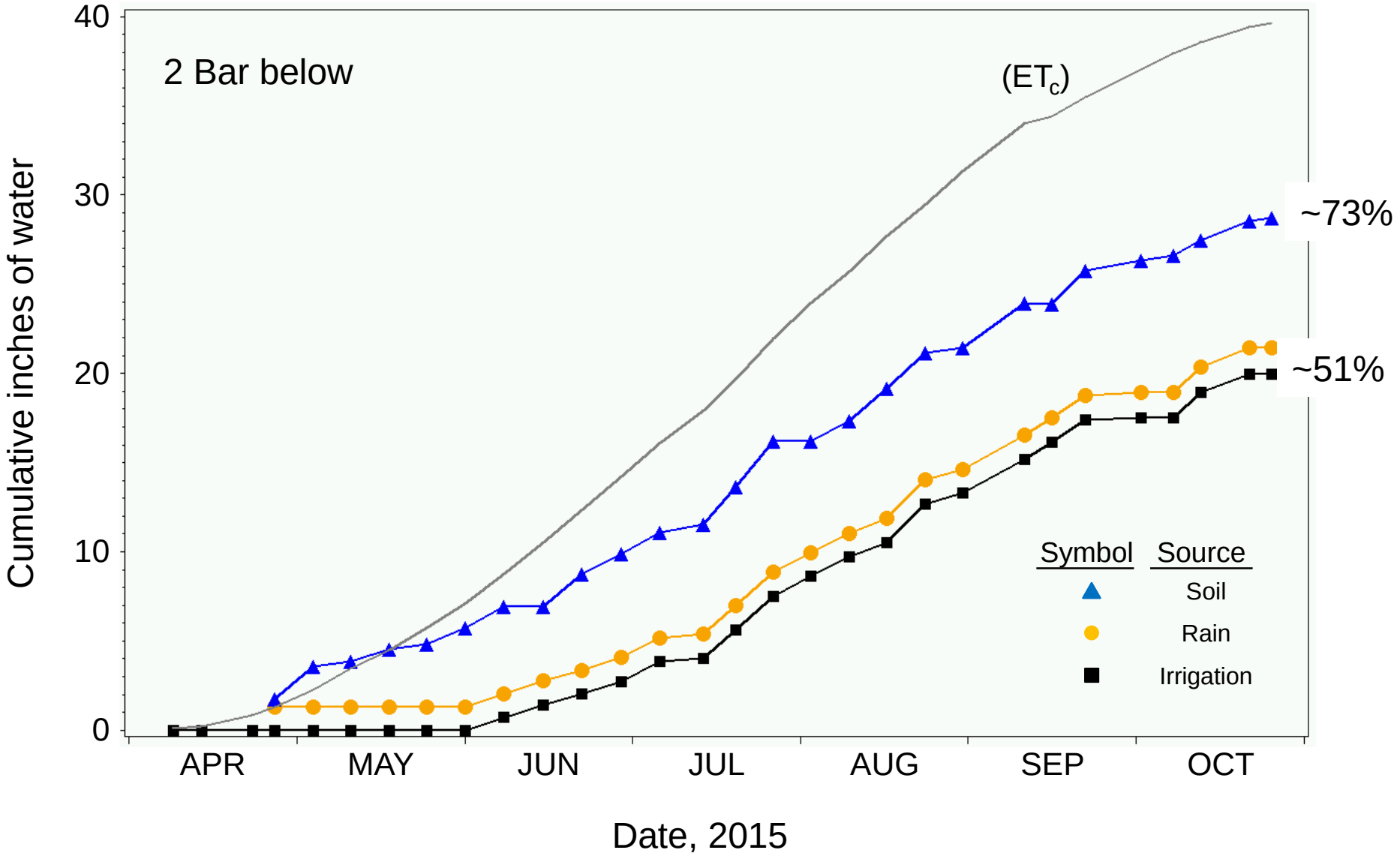
Orchard water balance estimates



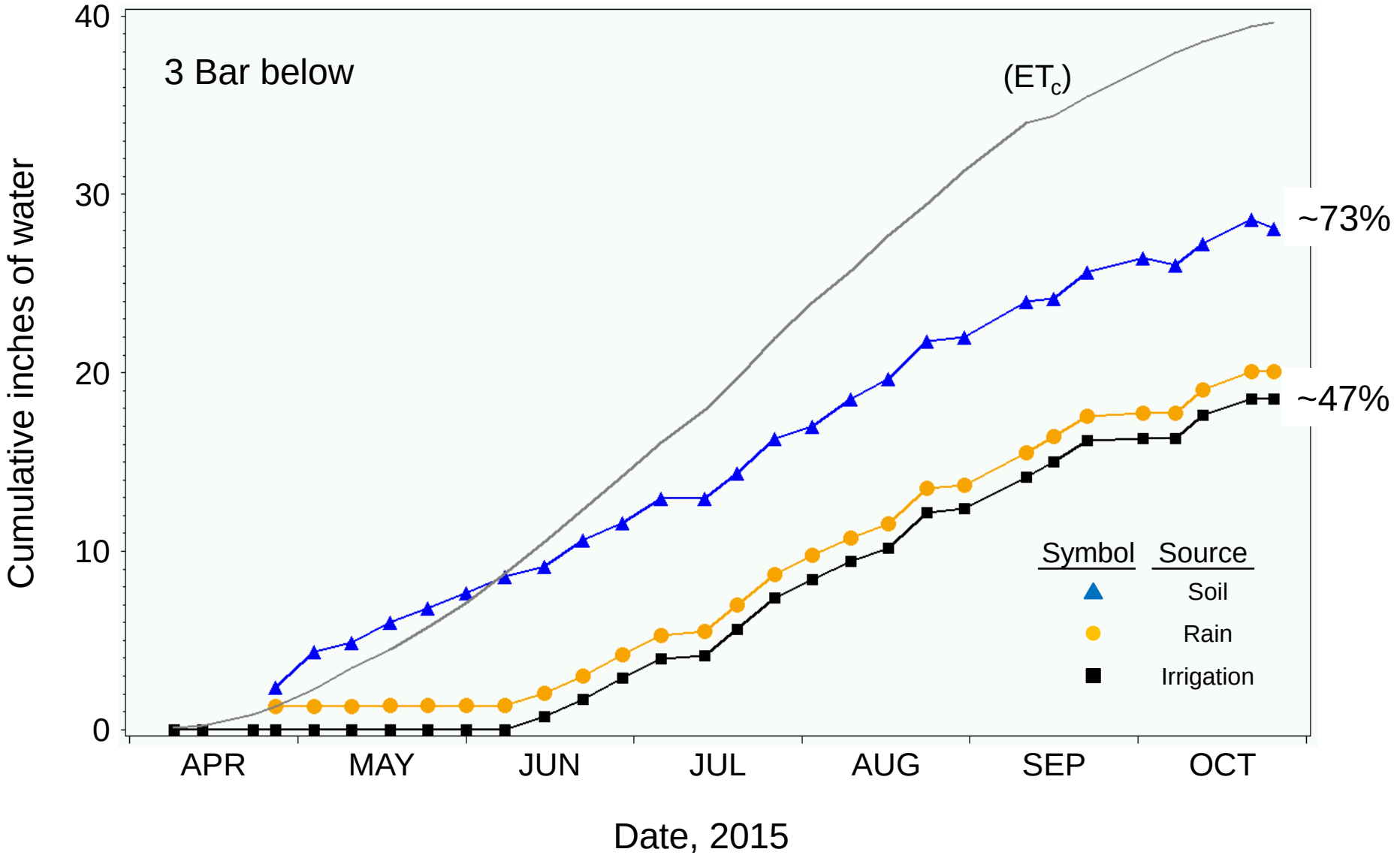
Orchard water balance estimates



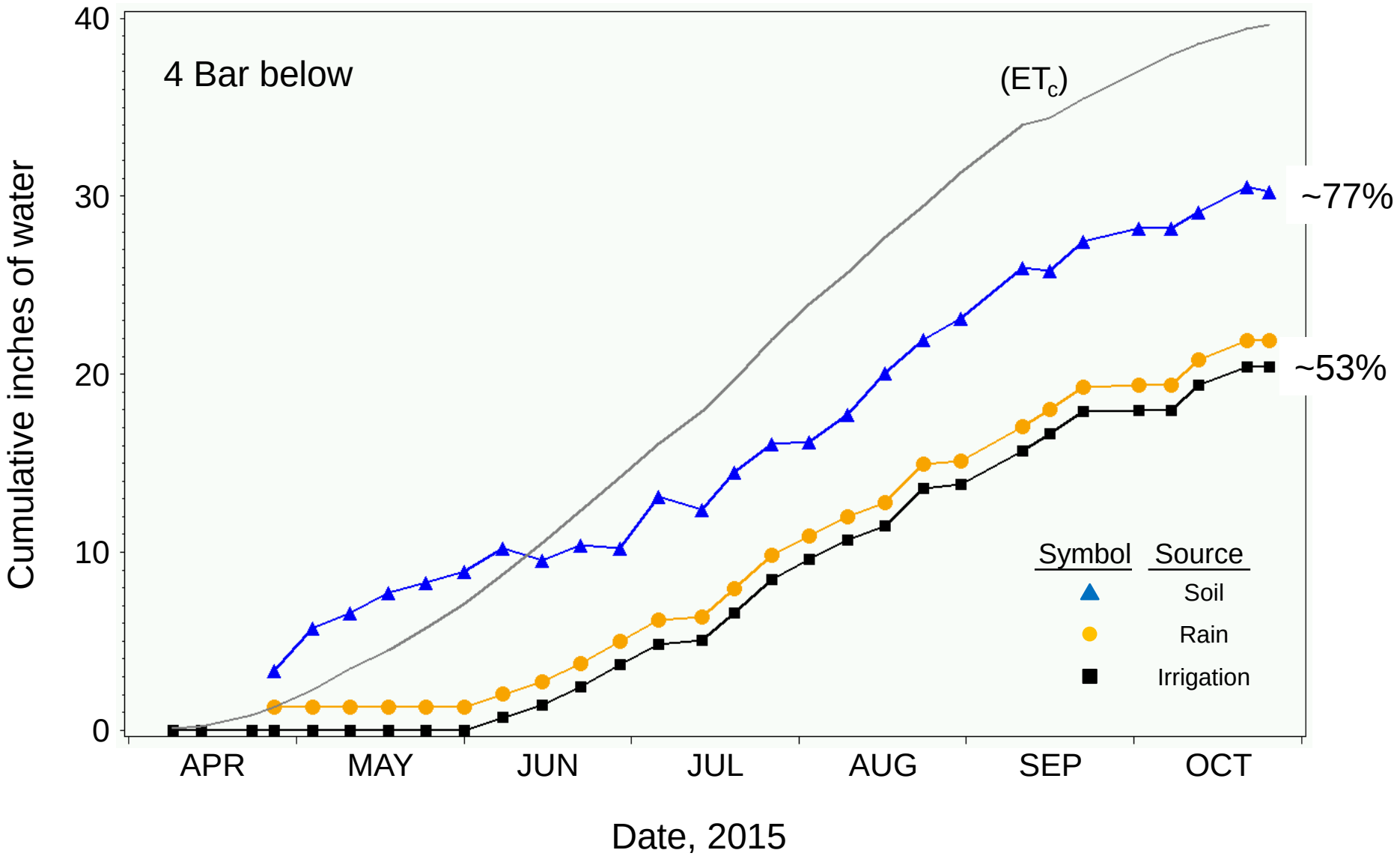
Orchard water balance estimates



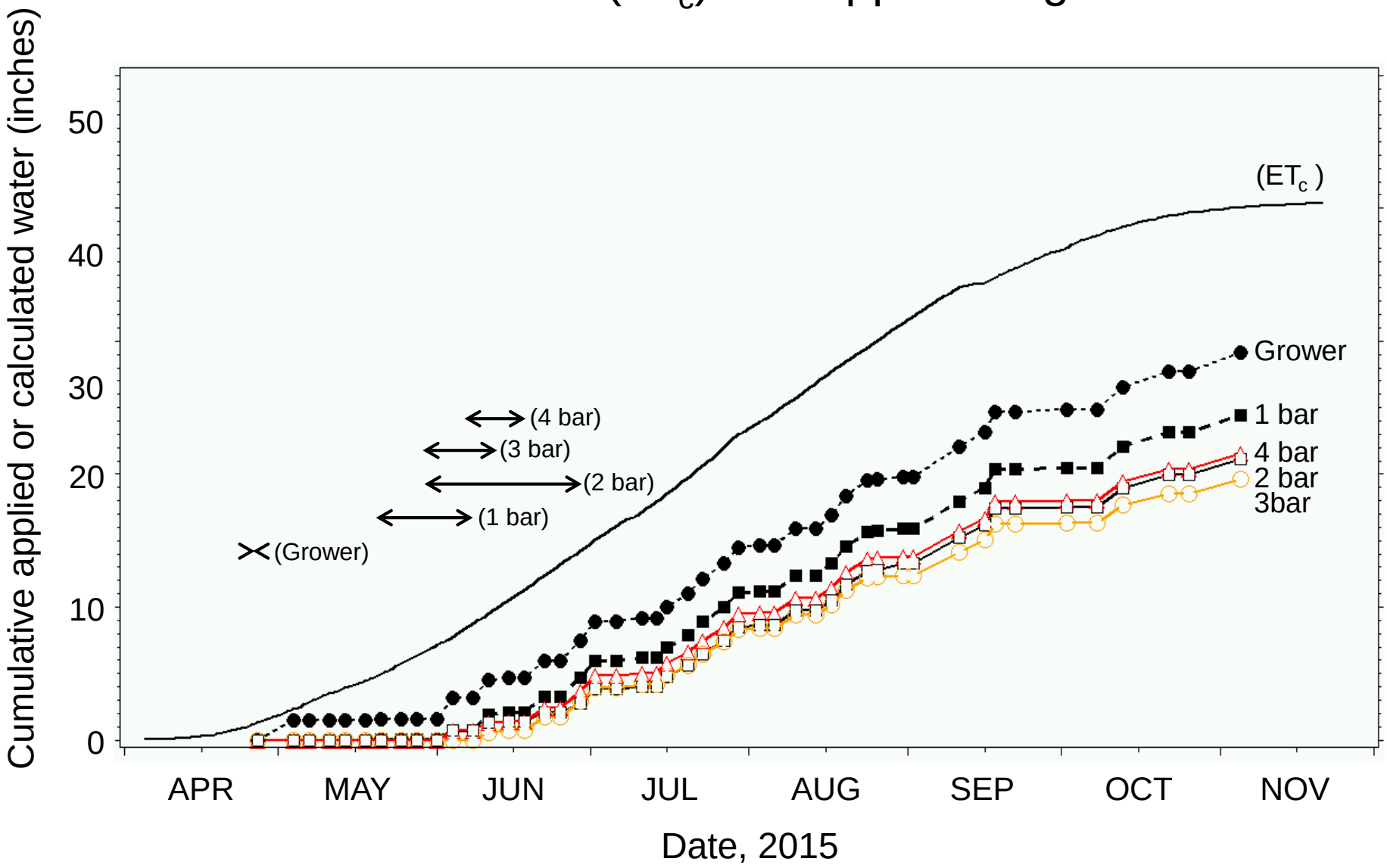
Orchard water balance estimates



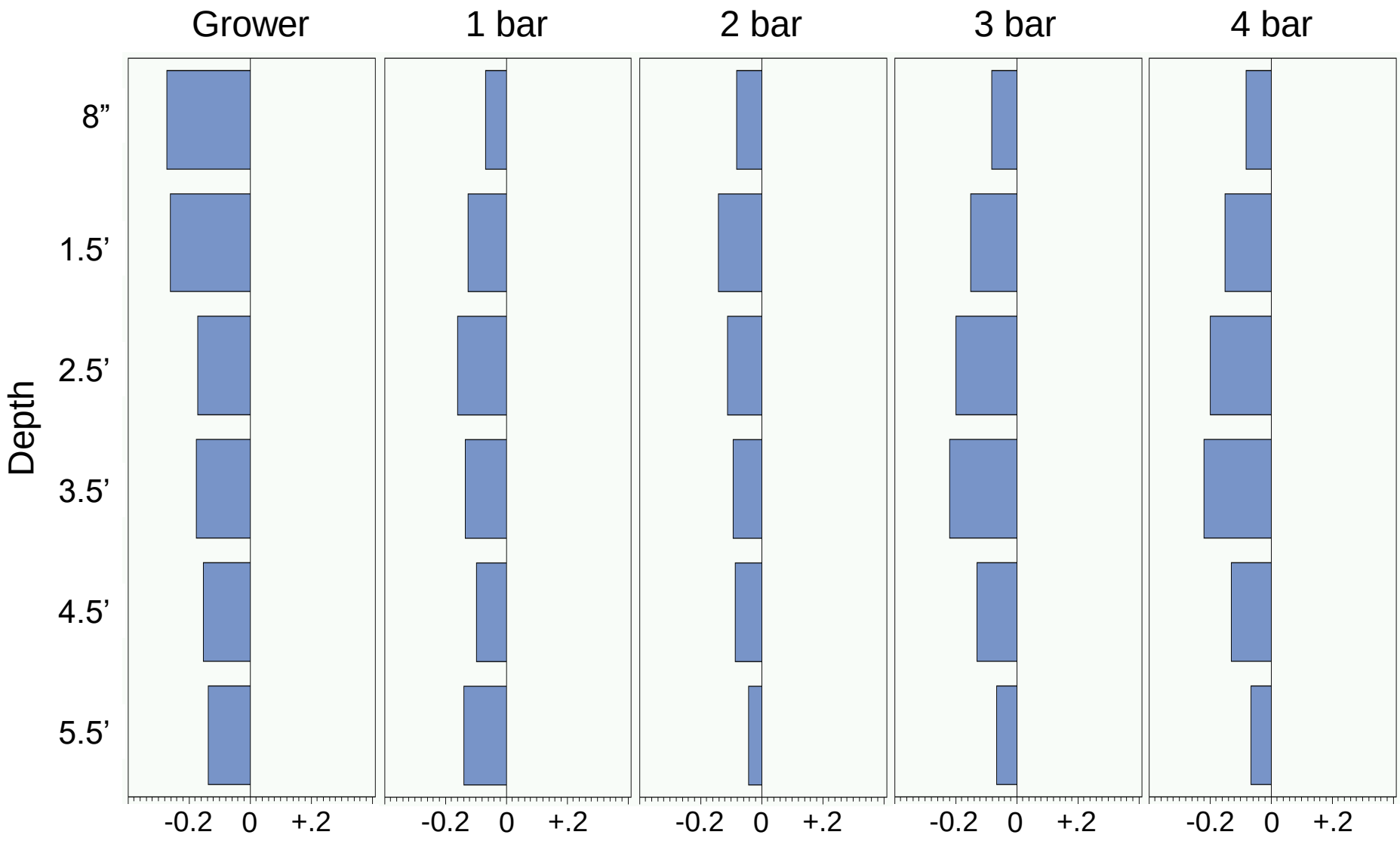
Orchard water balance estimates



Orchard demand (ET_c) and applied irrigation



Pattern of water depletion with soil depth in May:
Peak activity at shallow depths in Grower compared to other treatments.



Treatment yield data

2014	Plot Yield (tons/ac)		Tree sample nut weight (g)		Plot PAR		Plot Yield/PAR	
Treatment	tons/ac	(% Grower)	Weight	(% Grower)	PAR	(% Grower)	Y/P	(% Grower)
1 bars below	1.85	100	10.3a	98	86	102	0.022	98
Grower	1.84	100	10.4a	100	84	100	0.022	100
2 bars below	1.72	93	10.1ab	97	88	104	0.020	90
3 bars below	1.71	93	9.4 bc	91	85	101	0.020	91
4 bars below	1.68	91	9.1 c	87	88	104	0.019	88

2015	Plot Yield (tons/ac)		Tree sample nut weight (g)		Plot PAR		Plot Yield/PAR	
Treatment	tons/ac	(% Grower)	Weight	(% Grower)	PAR	(% Grower)	Y/P	(% Grower)
Grower	2.58 a	100	9.42a	100	89.3	100	0.027 a	100
1 bars below	2.49 ab	96	9.18ab	97	88.8	99	0.028 ab	97
2 bars below	2.26 ab	87	9.22ab	98	90.8	102	0.025 ab	85
3 bars below	2.18 ab	84	8.89 b	94	89.1	100	0.024 ab	84
4 bars below	2.09 b	81	8.44 c	90	89.9	100	0.023 b	80

Treatment nut quality data

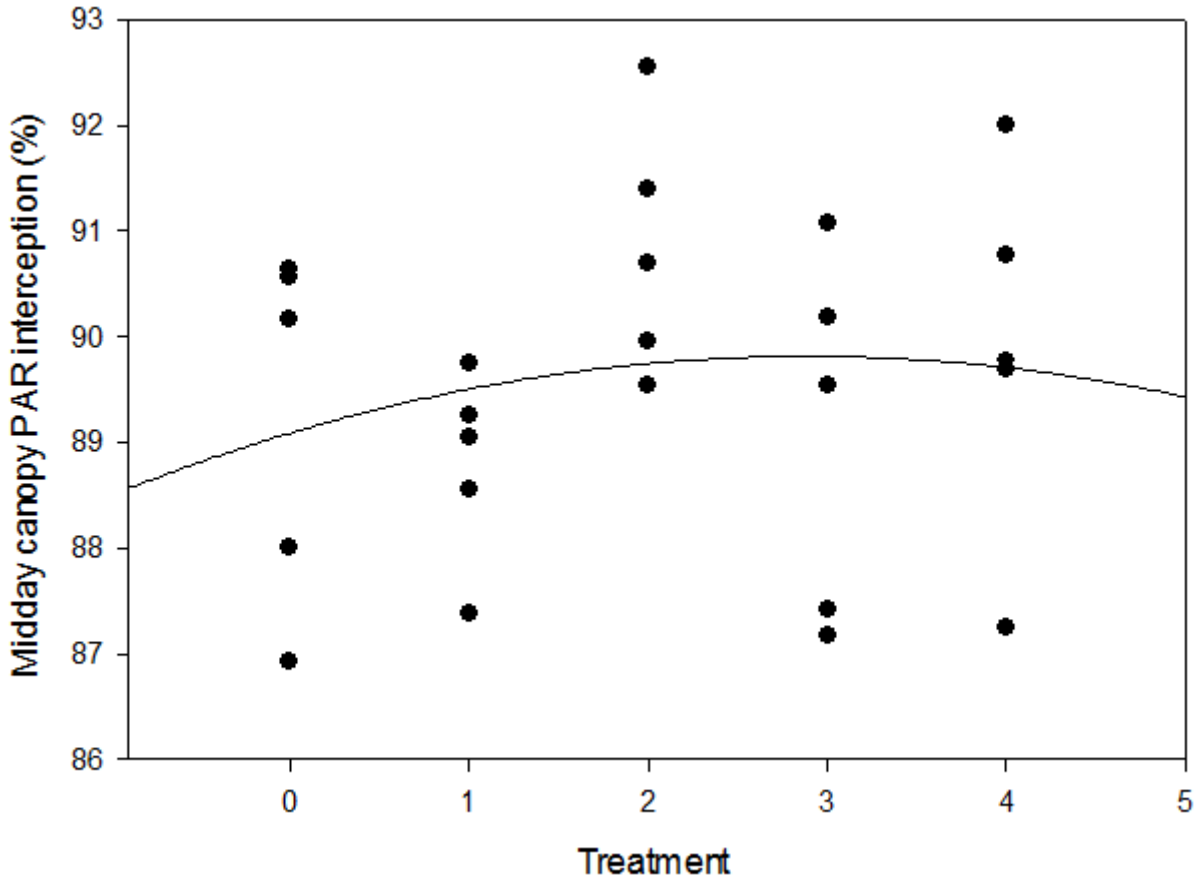
2014

Treatment	Nut weight (g)	LgJm (%)	LgSd (%)	Shrivel (%)	Mold (%)	OffGr. (%)	Ex. Lt. (%)	RLI	Relative Value
Grower	10.4 a	78.7 a	78.9 a	2.8	1.6	2.3	60	53.5	0.88
1 bars below	10.3 a	76.9 ab	77.8 a	2.6	2.1	2.8	63	54.2	0.89
2 bars below	10.1 ab	75.1 ab	76.0 a	1.7	2.2	2.5	59	54.1	0.90
3 bars below	9.4 bc	61.1 bc	62.9 ab	2.0	1.3	1.9	56	53.1	0.88
4 bars below	9.1 c	49.2 c	52.0 b	2.6	1.6	2.2	61	53.8	0.89

2015

Treatment	Nut weight (g)	LgJm (%)	LgSd (%)	Shrivel (%)	Mold (%)	OffGr. (%)	Ex. Lt. (%)	RLI	Relative Value
Grower	9.4 a	63 a	68 a	2.4	0.9	1.6	47	54.8	0.92
1 bars below	9.2 ab	59 a	63 a	2.3	0.8	1.3	52	55.2	0.91
2 bars below	9.2 ab	59 a	65 a	2.1	1.1	1.6	43	55.1	0.91
3 bars below	8.9 b	54 ab	58 ab	2.6	1.3	2.0	40	54.9	0.93
4 bars below	8.4 c	44 b	48 b	2.5	1.5	2.2	43	54.5	0.93

Midday canopy PAR interception July 2015



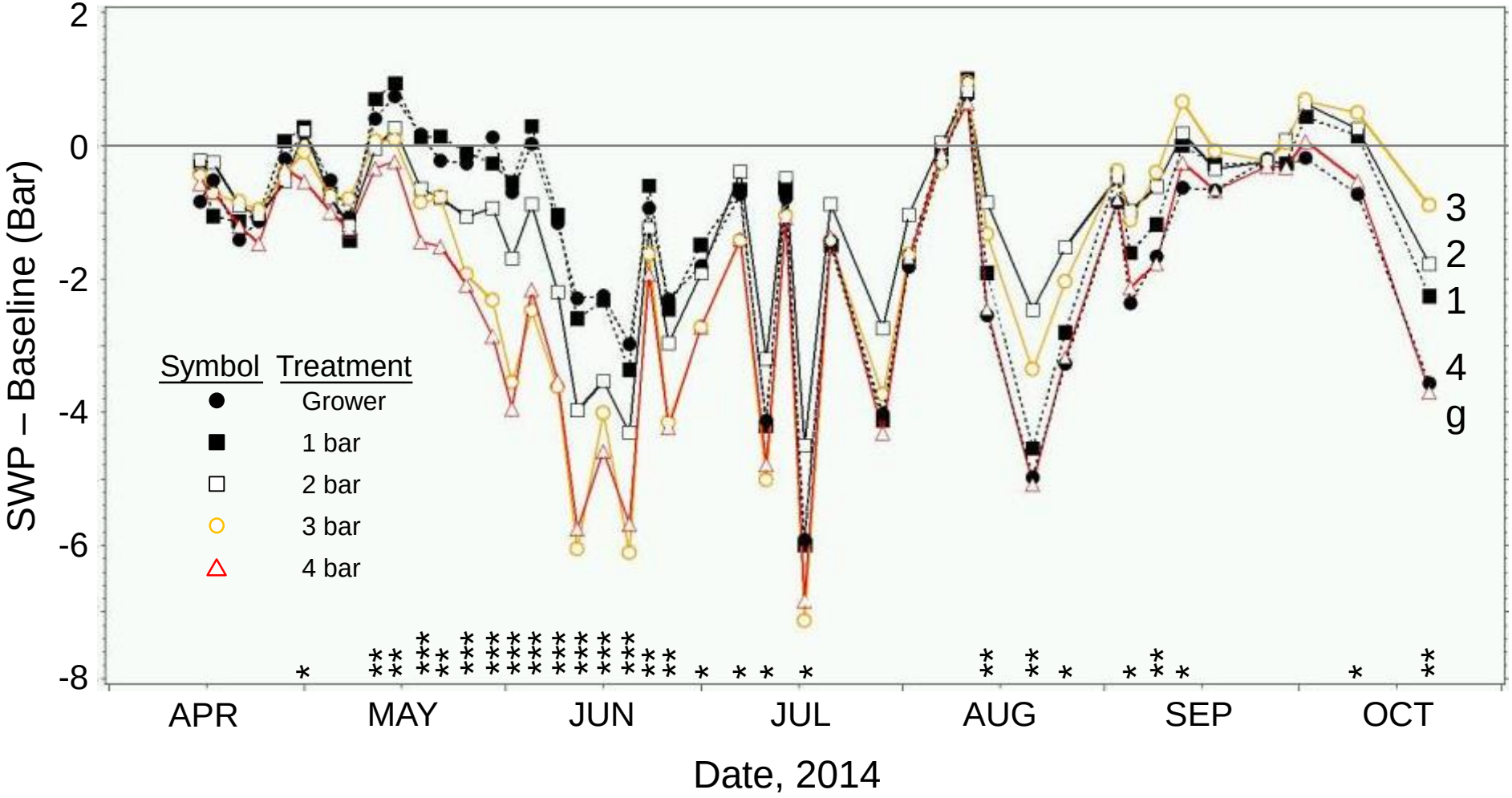
2014 results summary

Treatment	% ET_c Applied	% water savings over grower	% yield loss compared to grower
Grower	94		
1 bar	82	12	1
2 bar	73	21	7
3 bar	58	27	8
4 bar	59	27	8

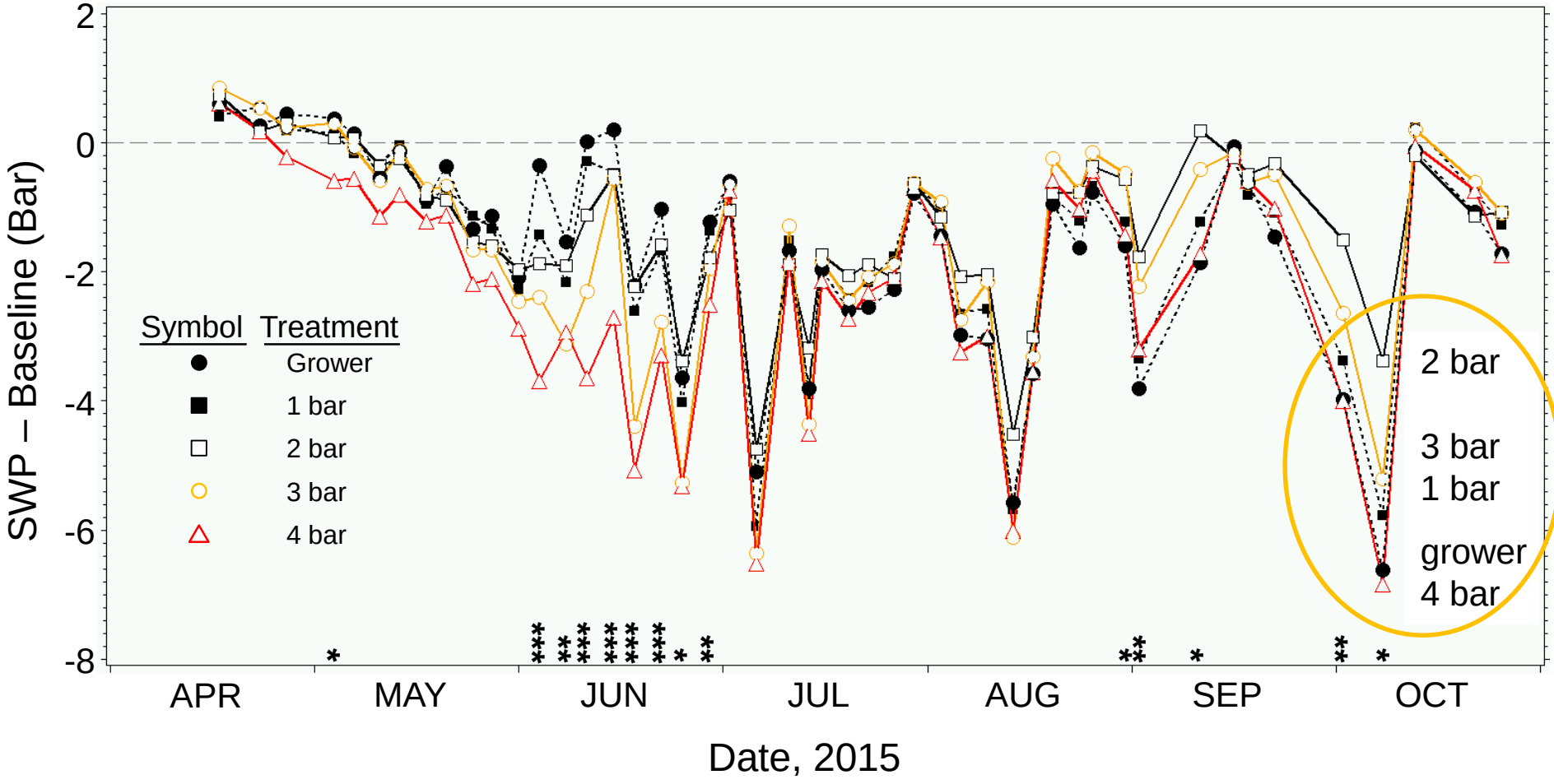
2015 results summary

Treatment	% ET_c Applied	% water savings over grower	% yield loss compared to grower
Grower	71	0	
1 bar	59	17	4
2 bar	51	28	13
3 bar	47	34	16
4 bar	53	25	19

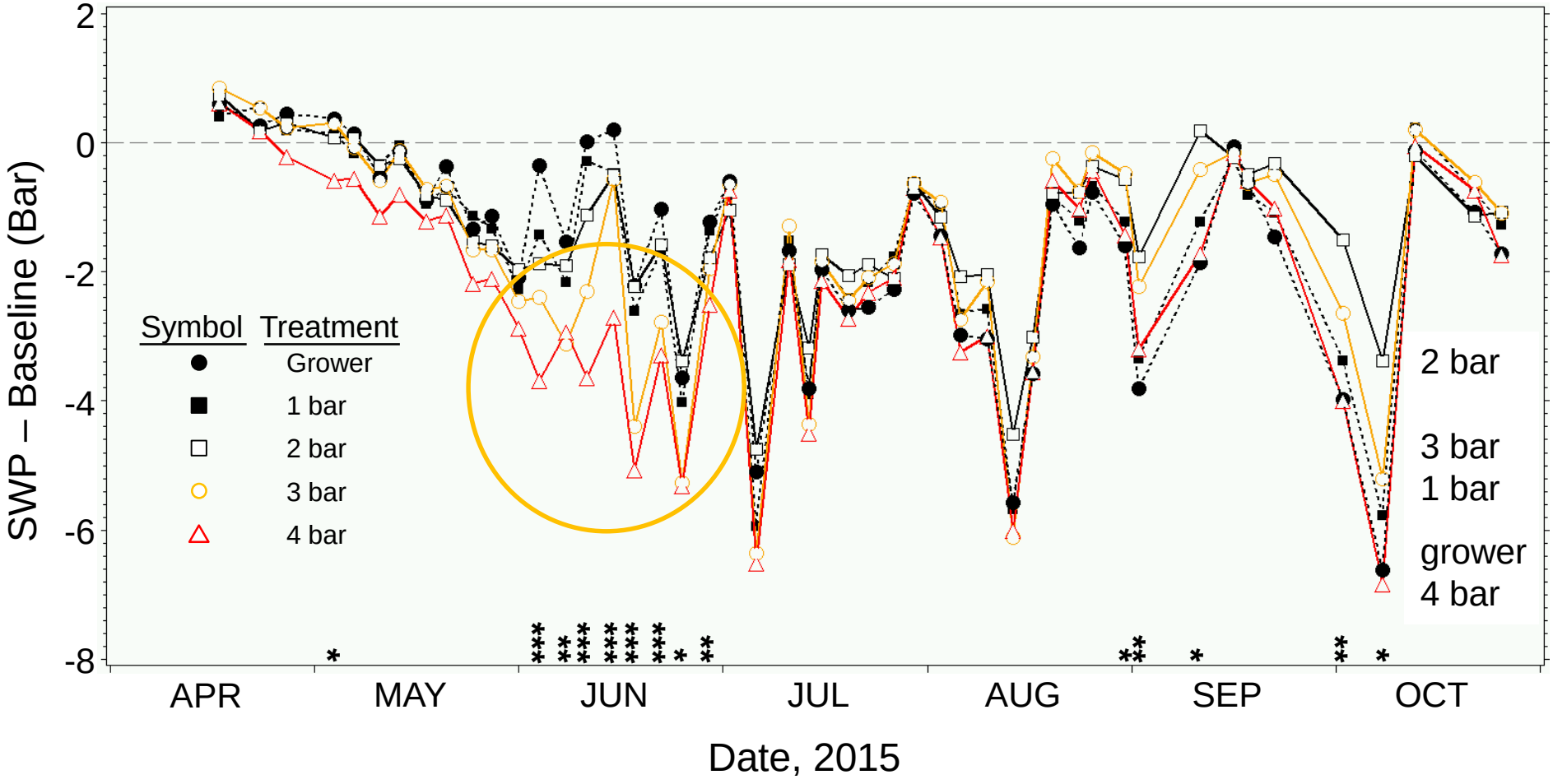
Results: Seasonal (SWP-Baseline)



Midday SWP (difference from baseline)

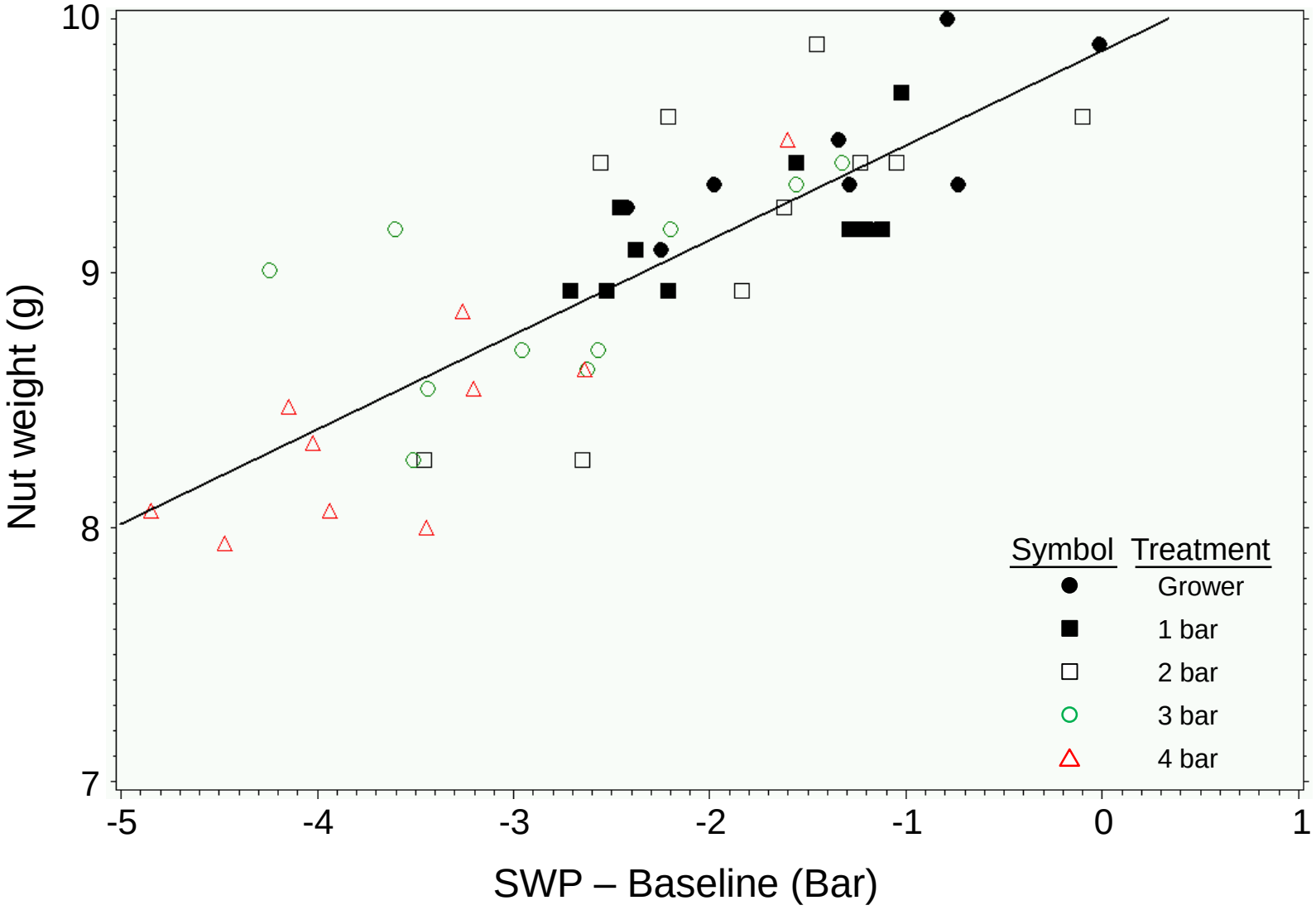


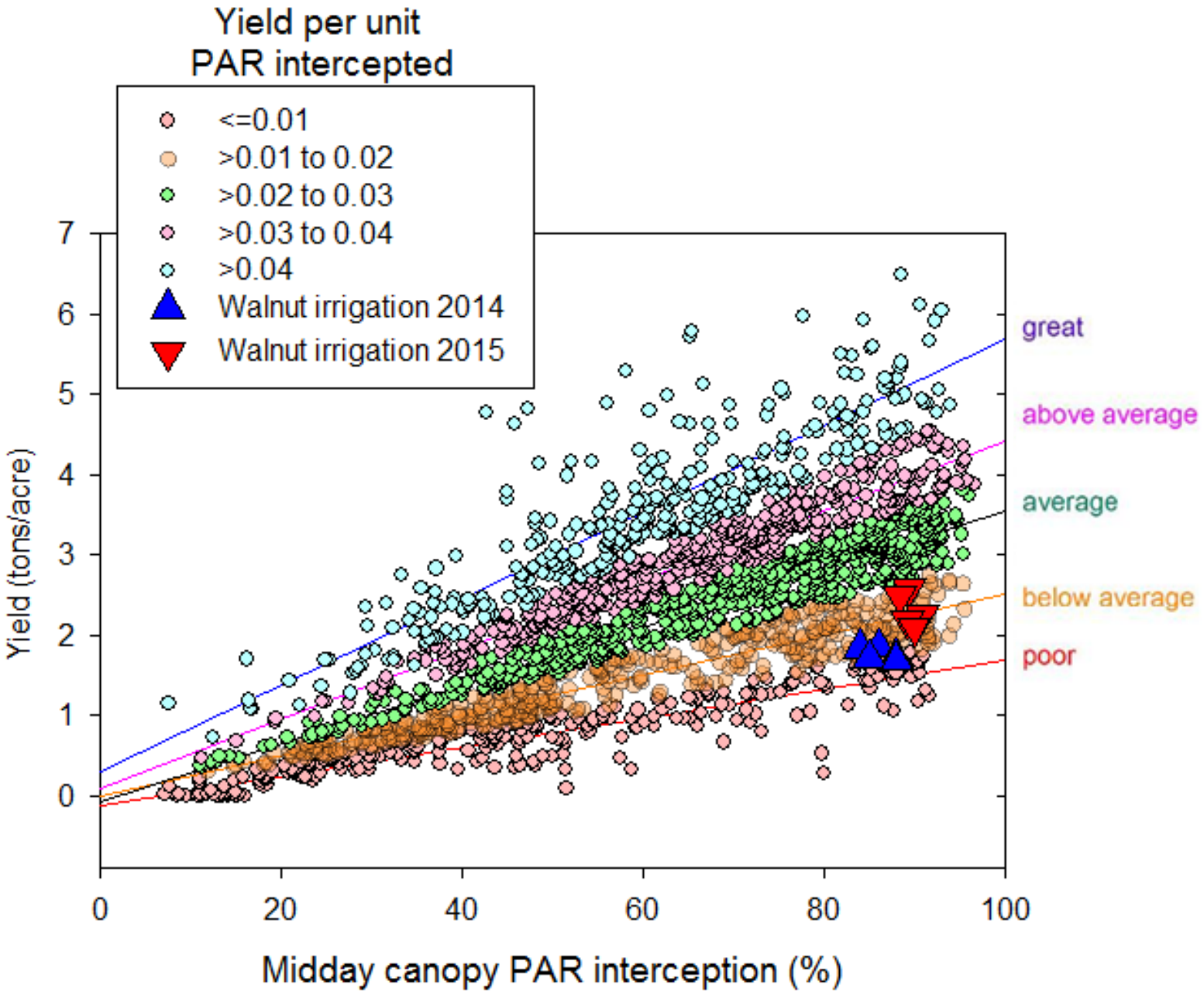
Midday SWP (difference from baseline)

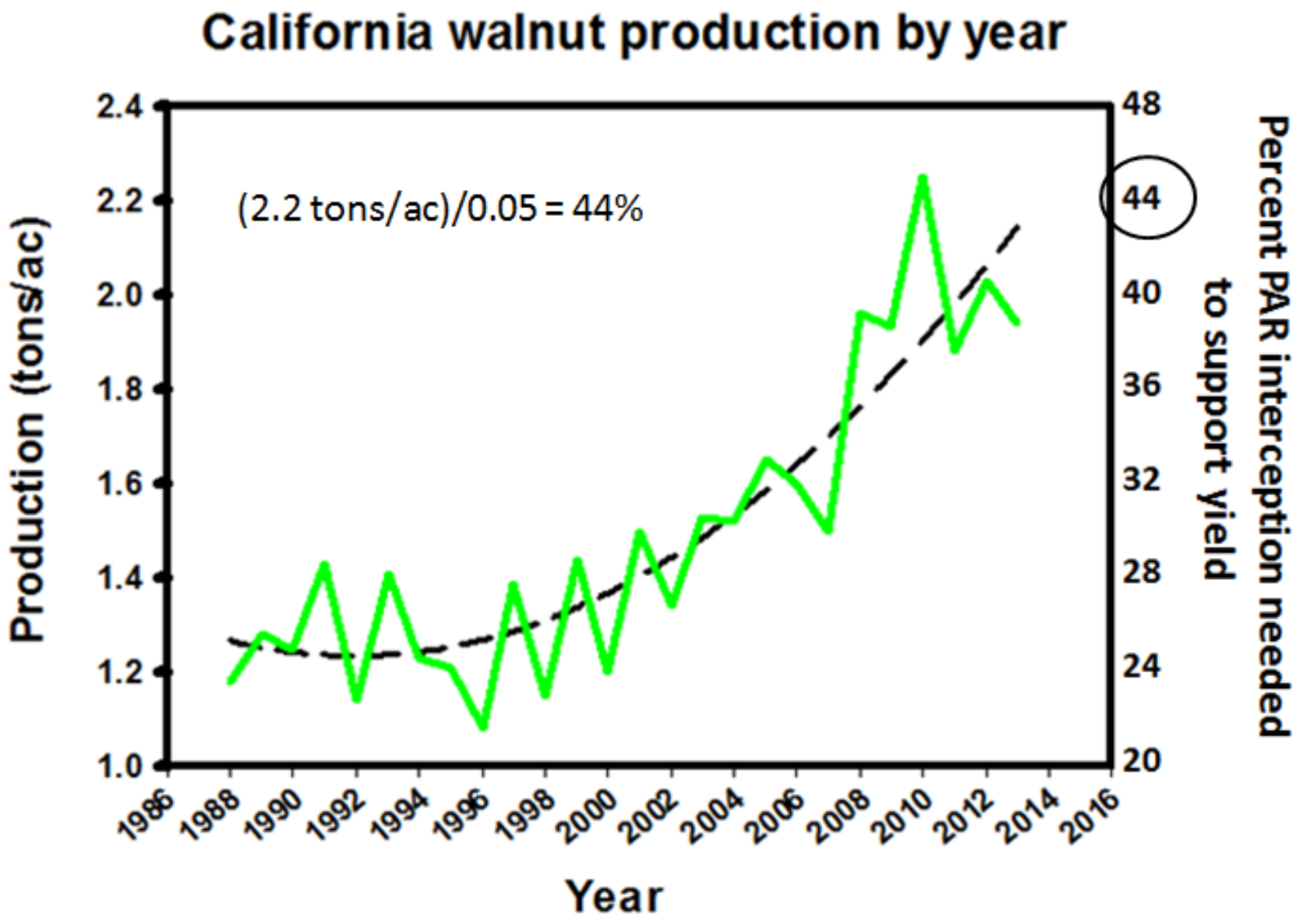


Nut size & SWP in June (individual trees)

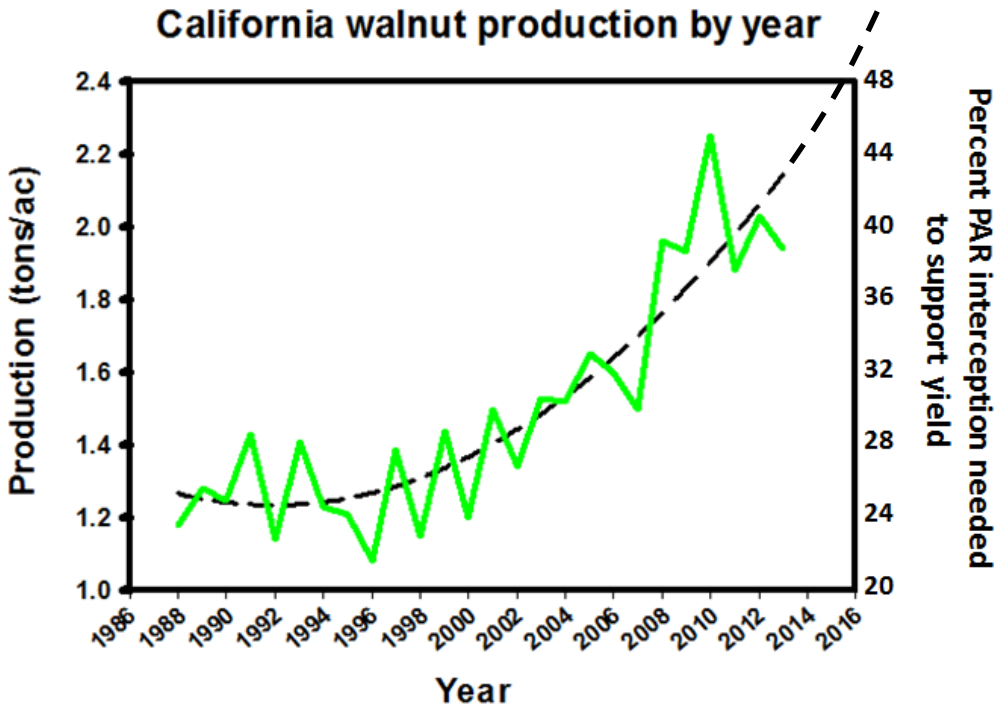
$r^2 = 0.67^{***}$




Yield per unit
PAR intercepted
<=0.01
>0.01 to 0.02
>0.02 to 0.03
>0.03 to 0.04
>0.04
Walnut irrigation 2014
Walnut irrigation 2015
Yield (tons/acre)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
Midday canopy PAR interception (%)
great
above average
average
below average
poor


California walnut production by year
(2.2 tons/ac)/0.05 = 44%
Production (tons/ac)
Percent PAR interception needed to support yield
Year
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
48
44
40
36
32
28
24
20
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

4.0 tons/acre = ~80% PAR interception
by approximately 2028



4.0 tons/acre = ~80% PAR interception
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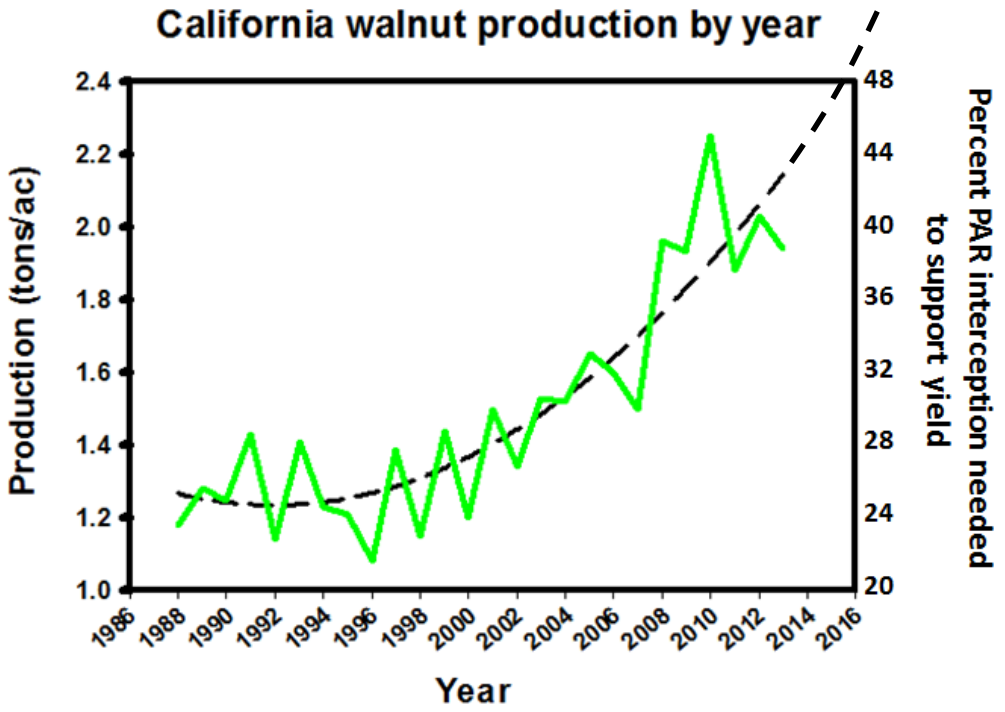


It takes a lot more water to produce 4 tons/ac compared to 1 ton/ac (likely 4 times as much)

<1 ton/acre potential production

~ 4 tons/acre potential production

Drought impacts more severe now

Future drought related cutbacks can potentially have much larger impacts than in previous droughts- Impact on your orchards will depend on winter rainfall and canopy cover/productivity

1991-1992

State Water Project water deliveries were 50% of normal

Average walnut orchard was producing 1.25 tons/acre so would have required about 17 inches of water

2015

Average walnut orchard produced about 2 tons/acre so would require about 34 inches of water

Best orchards producing about 4 tons/acre so would require about 56+ inches of water

If State Water project delivered 50% of normal

Average orchard deficit 1991-1992 = 8.5 inches

Average orchard deficit 2015 = 17 inches

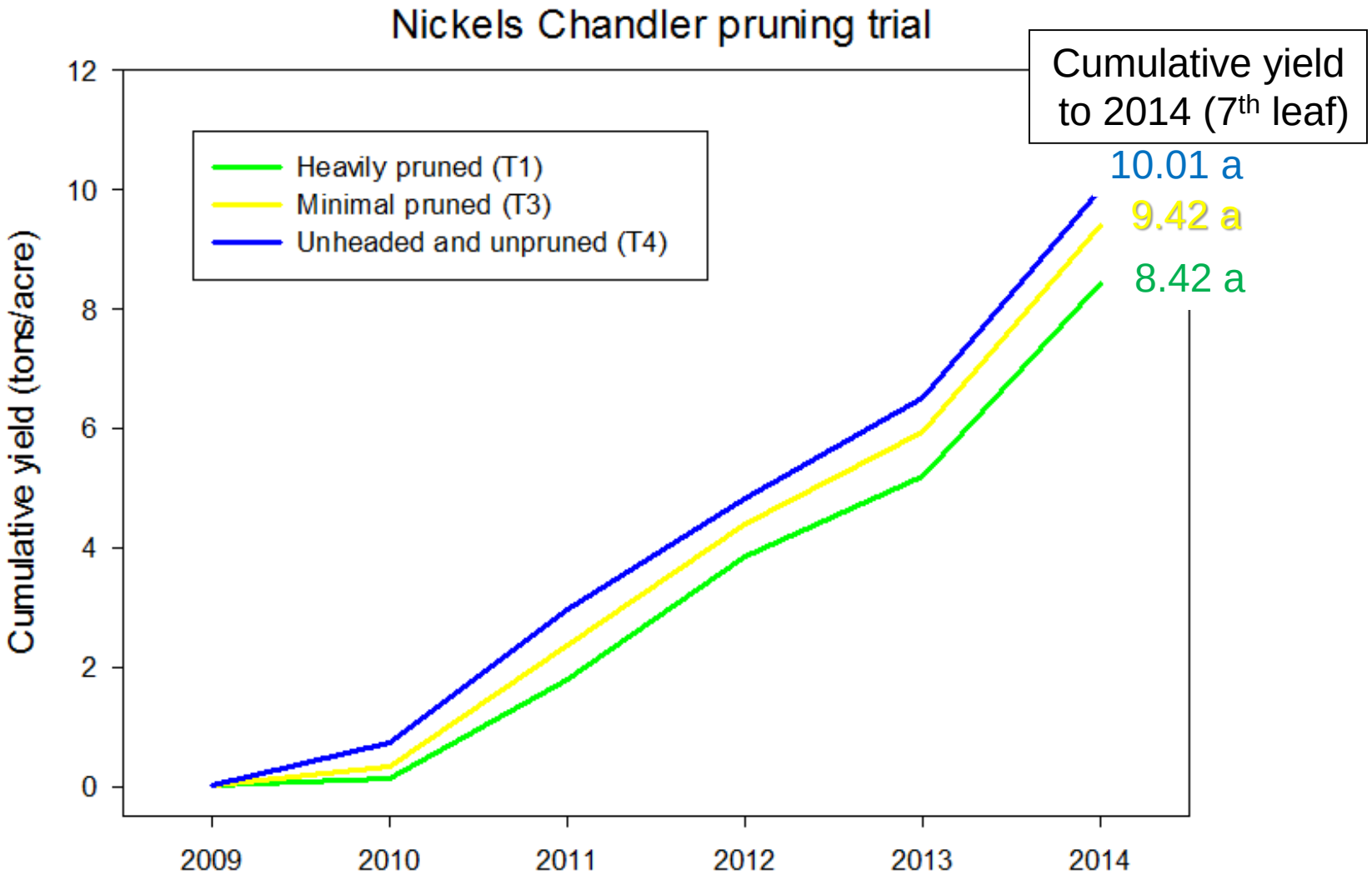
Best orchard deficit 2015 = 22 inches

Chandler Pruning Trial- Nickels Soil Lab

(in collaboration with Janine Hasey)

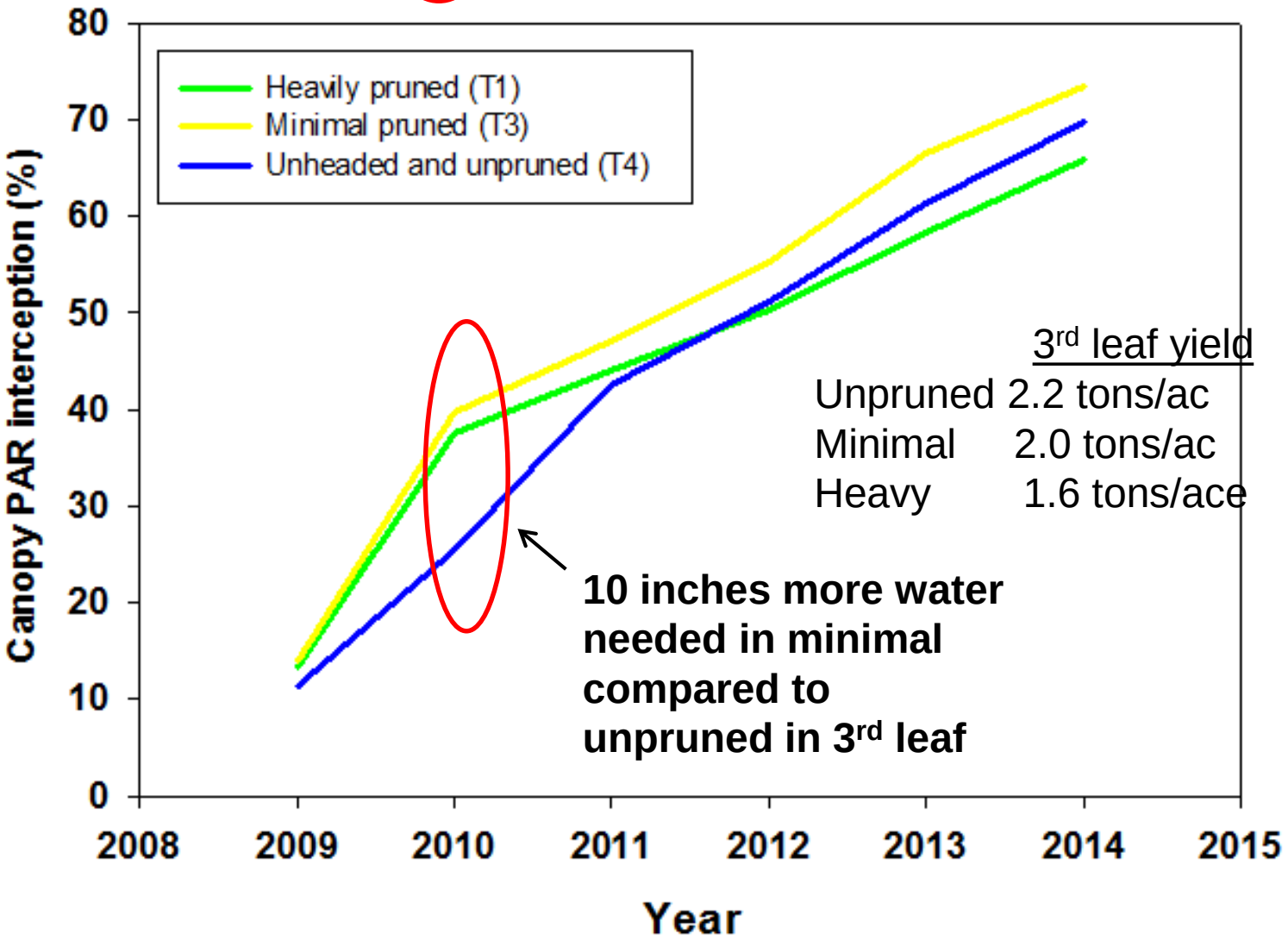
- Planted in 2008 at 15’ x 22’ spacing
- Nursery budded on Paradox seedling
- Pruning treatments imposed March 2009
- Treatments
  - Heavily pruned
  - Minimally pruned
  - Unheaded/unpruned

Tree age 2 3 4 5 6 7



Water needed to support canopy based on proportion of 42 inches needed at 60% canopy

Age 2 3 4 5 6 7



Unpruned

Minimally pruned

Water use efficiency for pruned versus unpruned treatments Years 2-6 summary

Treatment	Total water needed based on canopy size (years 2-6)	Cumulative yield (tons/acre)	Water use efficiency expressed as pounds of walnuts produced per inch of water applied	Water use efficiency (% of unpruned)
Unpruned	134	6.51	97	100
Minimally pruned	156	5.93	76	78
Heavily pruned	142	5.20	73	75

Not pruning can increase water use efficiency in years 2-6 by 20 to 25%

Influence of Water Relations on Canopy Development and Yield Potential

Stress that impacts canopy development in early life of orchard can impact production for many years

	Fully watered	8%decrease in year 2
Year 3	30% (1.5 tons/ac)	22% (1.1 tons/ac)
Year 4	40% (2.0 tons/ac)	32% (1.6 tons/ac)
Year 5	50% (2.5 tons/ac)	42% (2.1 tons/ac)
Year 6	60% (3.0 tons/ac)	52% (2.6 tons/ac)
Year 7	70% (3.5 tons/ac)	62% (3.1 tons/ac)
Year 8	80% (4.0 tons/ac)	72% (3.6 tons/ac)
Year 9	90% (4.5 tons/ac)	82% (4.1 tons/ac)
Total	21 tons/ac	18.2 tons/ac

10% increase per year after year 2 in both

This is equal to a cumulative difference of 2.8 tons/ac from one time stress event in year 2

This is equal to 224 tons (448,000lbs) less yield over first 9 years for an 80 acre orchard- this would have paid for a lot of $5000 pressure chambers

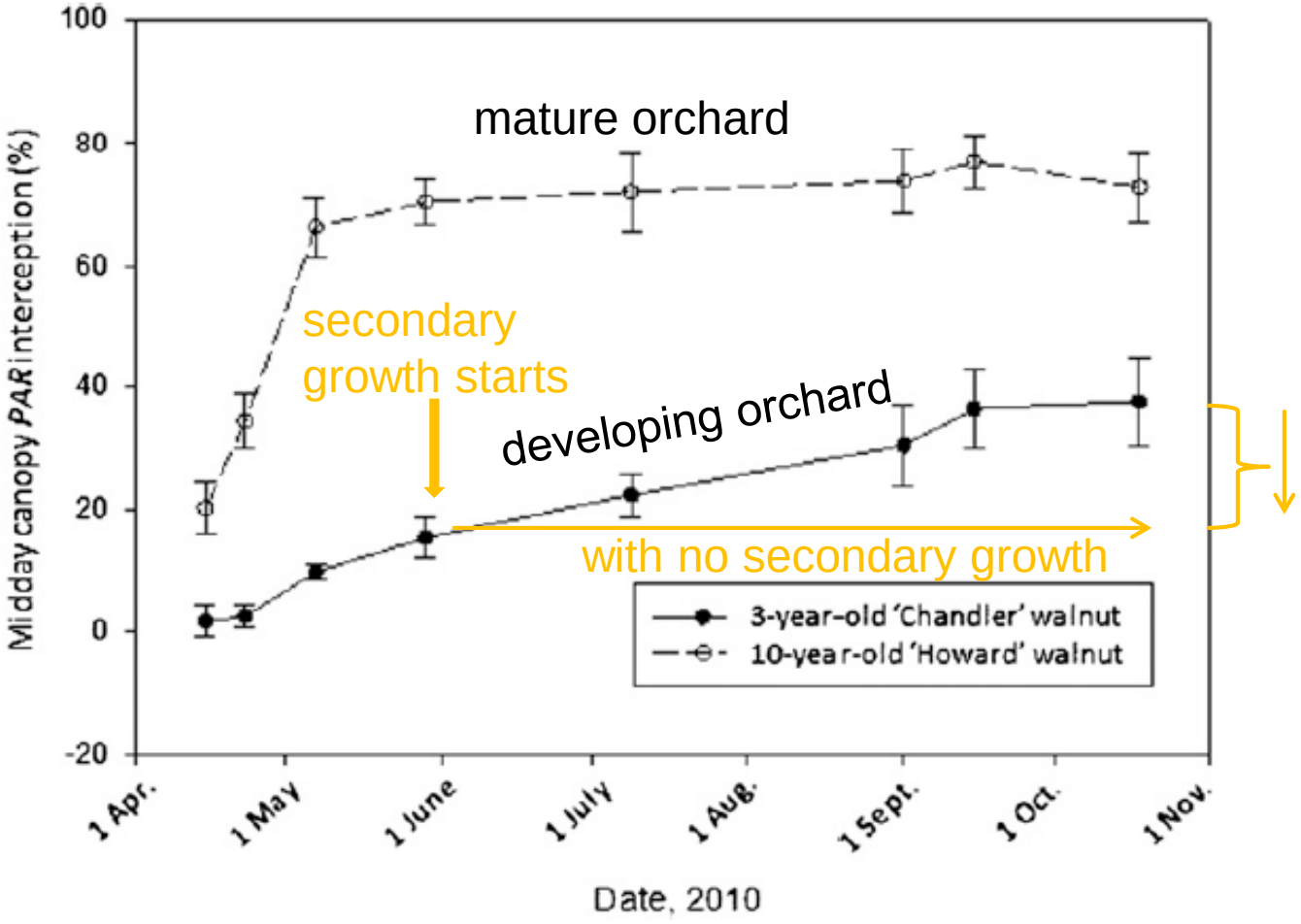
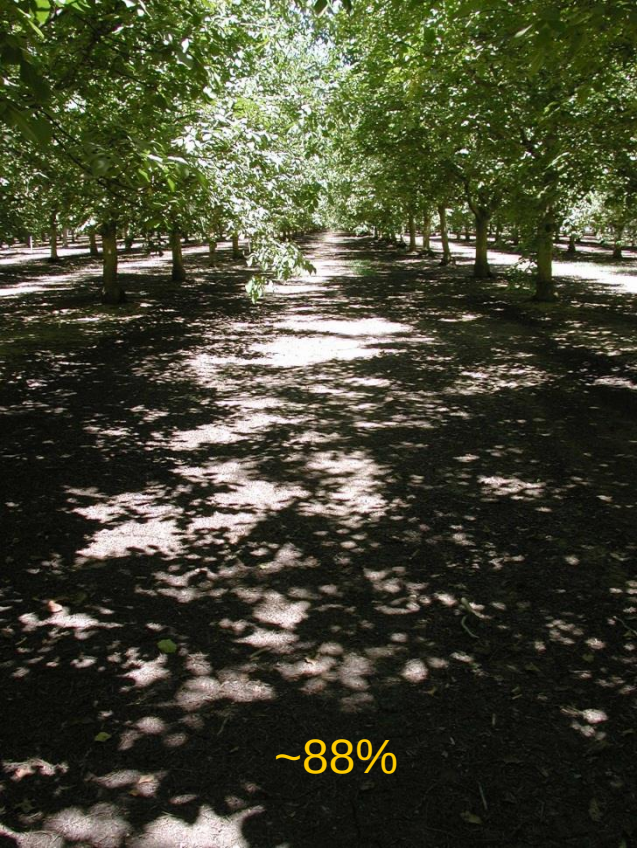


Fig. 6. Midday canopy photosynthetically active radiation (*PAR*) interception for a growing 3-year-old 'Chandler' walnut orchard and a mature 10-year-old 'Howard' walnut orchard in Colusa County, CA, over the 2010 season. Both datasets were for replicated trials with six replications for each data point. Bars indicate ±2 SE calculated using SAS Proc Means (SAS version 9.2; SAS Institute, Cary, NC).

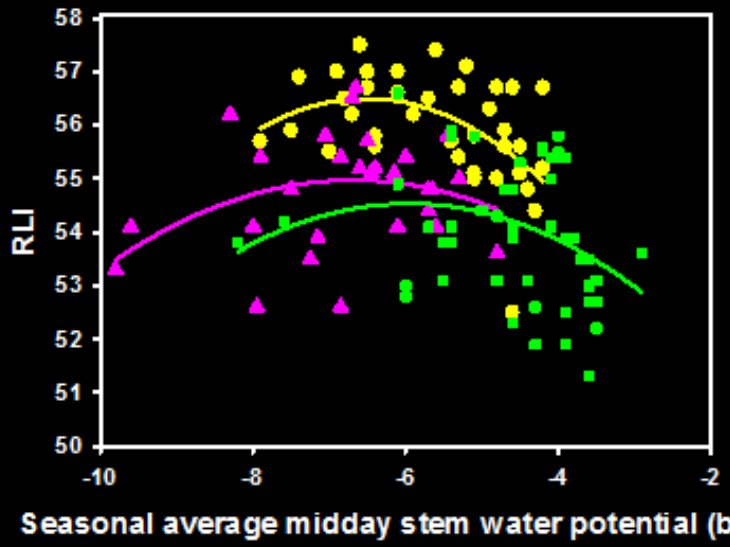
Slower canopy development due to shortage or excess of water can have large impacts on returns

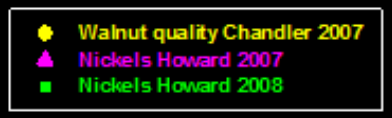


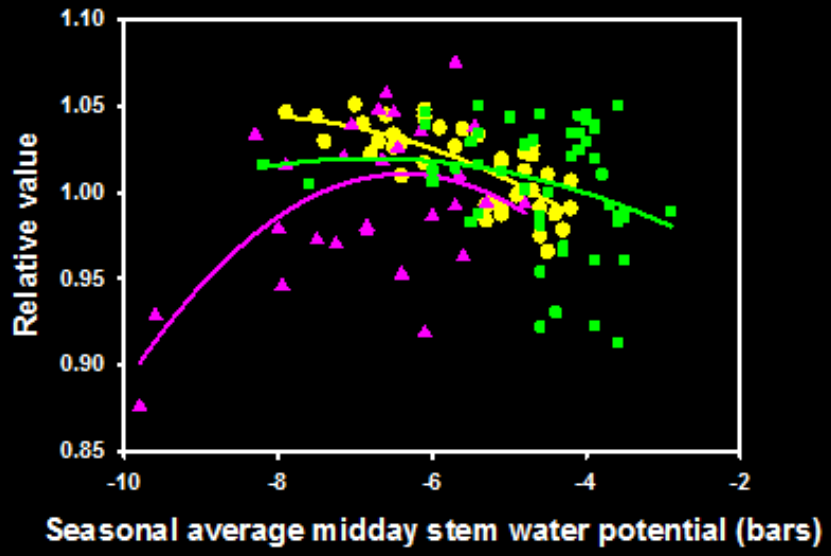
-$8,250 per acre over 9 years

-$14,850 per acre over 9 years

wetter →


RLI
58
57
56
55
54
53
52
51
50
-10
-8
-6
-4
-2
Seasonal average midday stem water potential (bars)


Walnut quality Chandler 2007
Nickels Howard 2007
Nickels Howard 2008


Relative value
1.10
1.05
1.00
0.95
0.90
0.85
-10
-8
-6
-4
-2
Seasonal average midday stem water potential (bars)

Irrigation management is critical for maximum productivity

- Deciding when to start irrigating in spring is an important decision made easier with the pressure chamber
  - Starting to irrigate later may provide benefits in terms of water saving and possibly increased rooting depth
- The less you prune in years 2-6, the higher the water use efficiency
- Stress from lack of water can result in major long term impacts on canopy size and yield
  - If you are short on water, you might want to consider biasing applications towards young orchards to prevent long term compounding of losses
- Either too much or too little water can lead to pellicle color problems
- Orchard water use will be directly related to canopy size and although orchards may have survived previous droughts, todays high light interception orchards may be more severely impacted

Appearance of a healthy walnut tree at a -5 to -7 bar midday stem water potential

Symptoms of stress from lack of water

- At -9 bars, extension growth of shoots ceases (lose growing red leaves)

Symptoms of stress at -11 to -12 bar- yellowing and drop of inner canopy shaded leaves- leaf drop usually does not start until trees reach a midday stem water potential of about -11 to 12 bars

Interior leaf yellowing and drop may also occur due to shading without stress- this was the case here.

Shriveled hull indicates more severe stress- usually about -13 to -16 bars (severe stress)

Leaf symptoms of over-irrigation in walnut- often on outer canopy leaves but can be anywhere

If secondary bud (near nut) does not start growing by mid-June it is usually because the tree is too wet

Typical appearance of a tree that was too wet in spring- may be water stressed later in summer due to compromised root system

Production problems related to irrigation

Too much water

1) Poor canopy growth
2) Nut quality problems
3) Sunburn
4) Tree dieback
5) *Phytophthora* root rot
6) Low levels of productivity per unit light intercepted

Too little water

1) Poor canopy growth
2) Nut quality problems
3) Sunburn

Leaf damage symptoms observed only on excessively wet trees


Questions?