

Water Management in Walnuts: Spotlight on Early Season

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Topics

- Dry winter of 2017/18 and how it might play into early season irrigation
- Why spotlight on early season irrigation?
- Update on field experimentation where we maneuver early season irrigation

Status of 2017/18 winter – how dry?

Location	October	November	December	January	February	March	Total
	Average Monthly Rainfall (inches)						
Red Bluff (Gerber)	1.2	2.8	4.2	5.0	4.1	3.2	20.5
Chico (Durham)	1.4	3.3	4.6	4.8	4.4	4.3	22.8
Williams	0.8	2.4	2.9	3.3	2.6	1.8	13.8
	Measured Rainfall (inches) in 2017/18 Winter						
Gerber CIMIS #222	0.2	2.2	0.0	3.1 ¹	?	?	5.5
Durham CIMIS #12	0.5	4.0	0.1	3.5	?	?	8.1
Williams CIMIS # 250	0.2	0.1	0.0	2.3	?	?	2.6

¹ Precipitation reported for the 2017/18 winter is for January 1-31, 2018.

How does winter rainfall compare to Water Holding Capacity of Soils?

Soil Texture	Inch/foot soil	Inch/5 feet soil
Fine sand	1.1	5.5
Sandy loam	1.4	7.0
Fine sandy loam	1.8	9.0
Loam	2.0	10.0
Silt loam	2.1	10.5
Clay loam	2.0	10.0
Clay	2.2	11.0

2017/18 Location	Total Rainfall (inches)
Gerber	5.5
Durham	8.1
Williams	2.6

Benefits of winter irrigation when rainfall is low

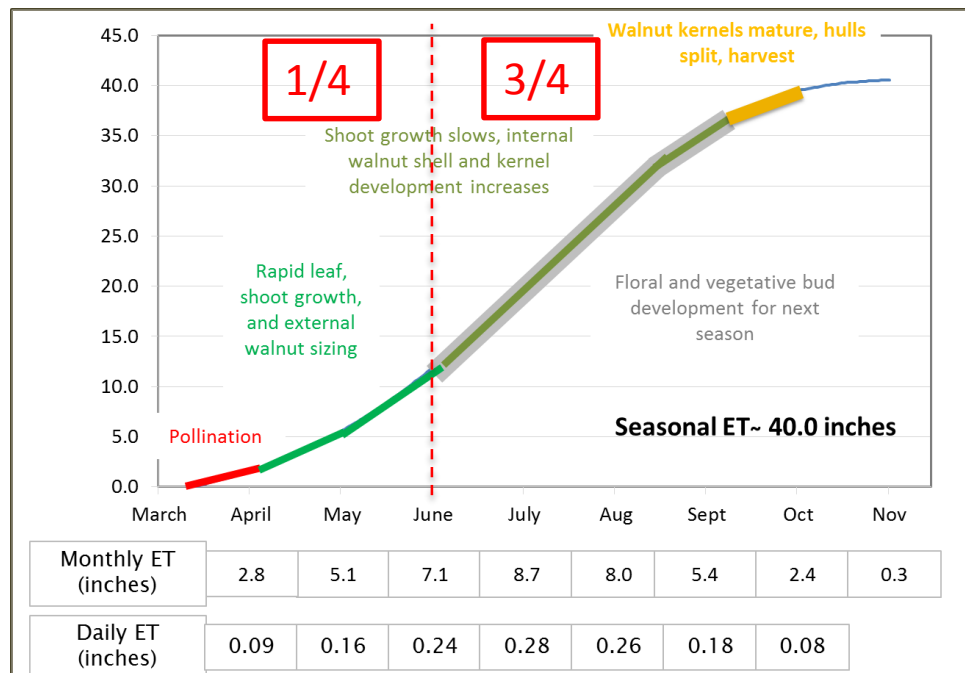
- A full winter soil moisture profile should delay first crop irrigation
 - Achieve warmer soils to support root growth and better aeration to discourage root diseases.
 - Improve orchard access to manage walnut blight.

Why spotlight early season water management?



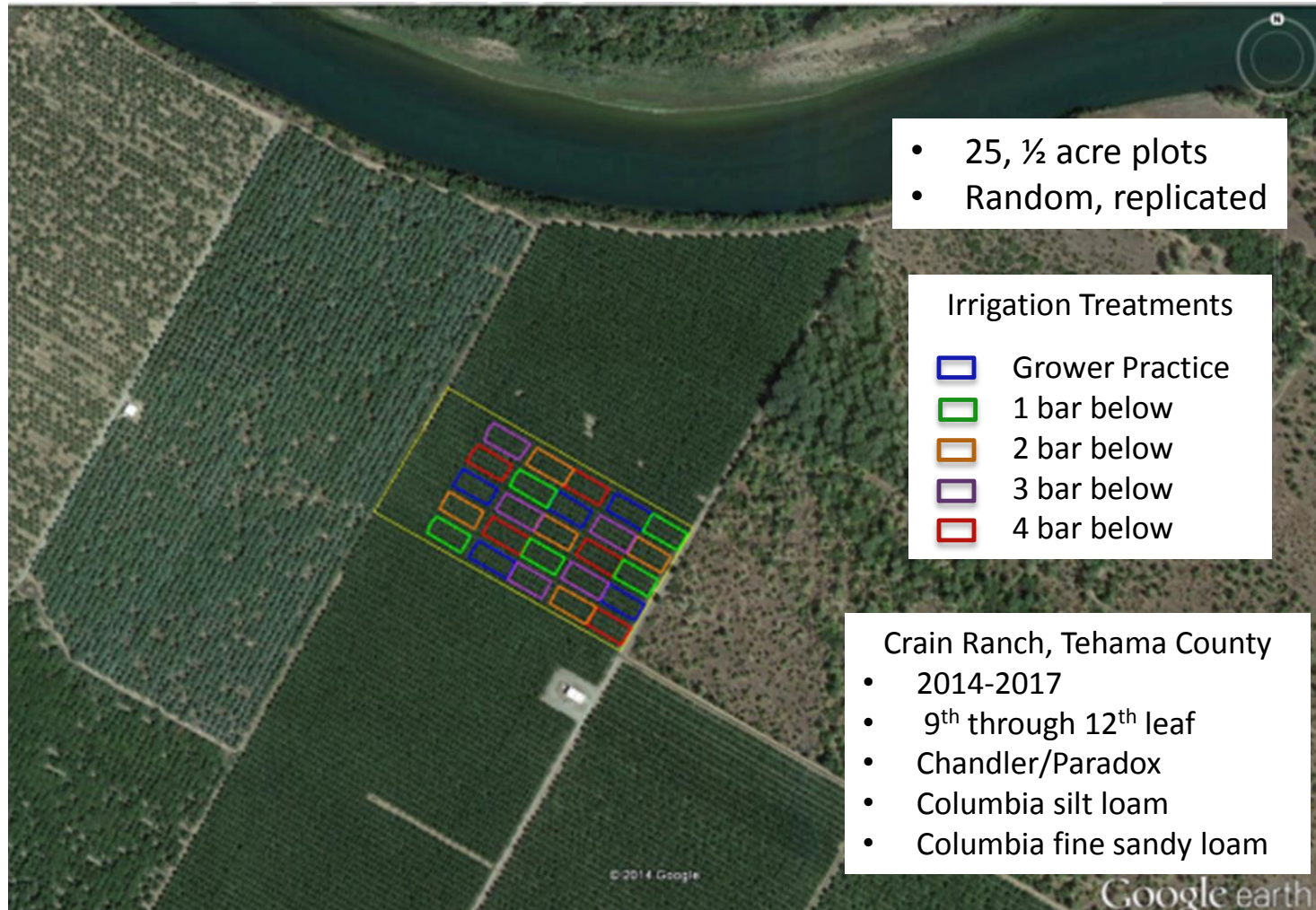
Long term root and tree health

Period of expansive growth but relatively low water use



Source: UC ANR free on line publication 8533. Figure 1. Drought strategies for California walnut.

Field experimentation – maneuvering the start of irrigation season to learn about impacts



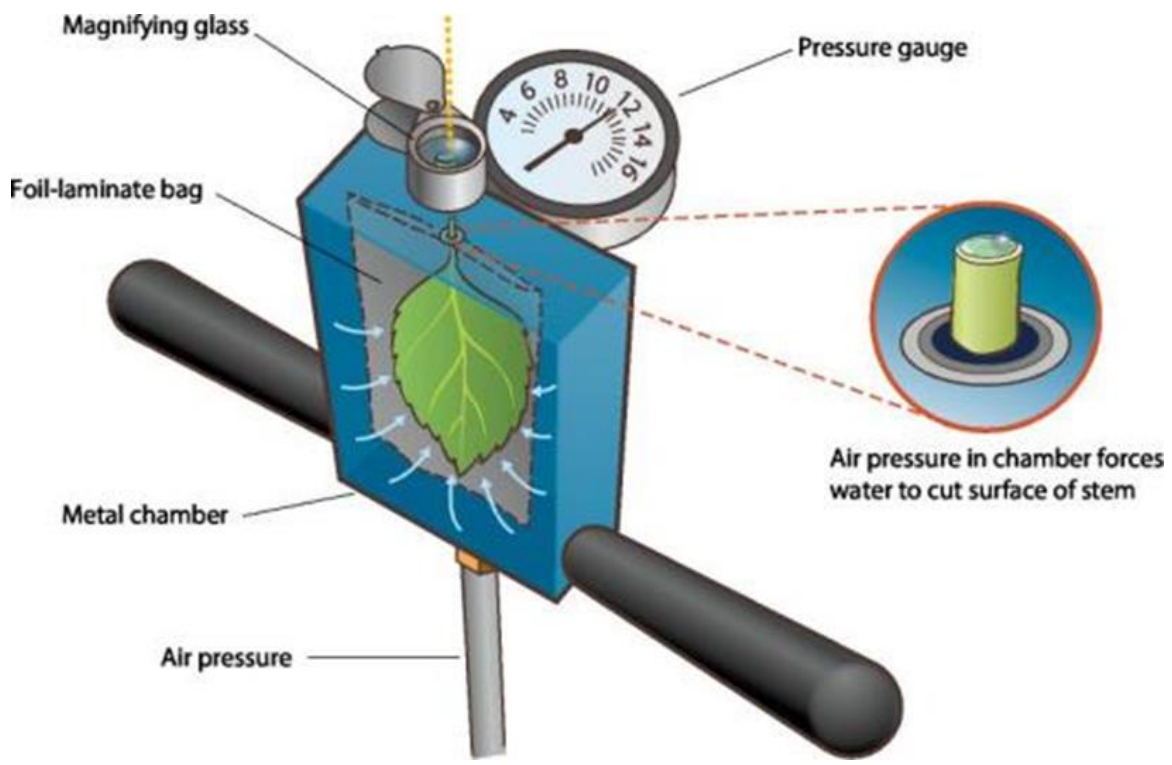
Project team

- Hal Crain, Crain Ranch
- Allan Fulton, UCCE, Tehama County
- Carol Haynes, UCCE, Tehama County
- Bruce Lampinen, UCCE, Davis
- Bob Mahoney, UCCE, Tehama County
- Sam Metcalf, UC Davis, Plant Sciences
- Ken Shackel, UC Davis, Plant Sciences



- Funded by California Walnut Research Board!

Monitored tree water stress with a pressure chamber



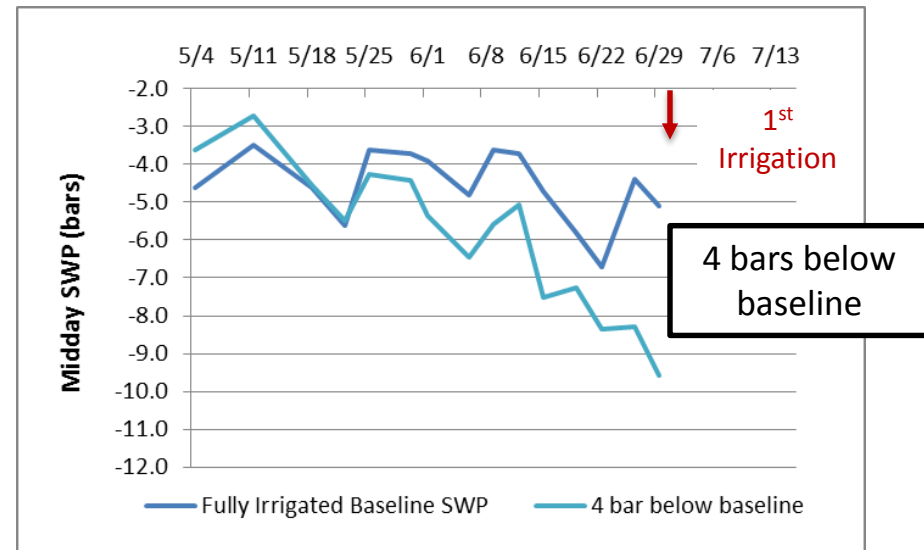
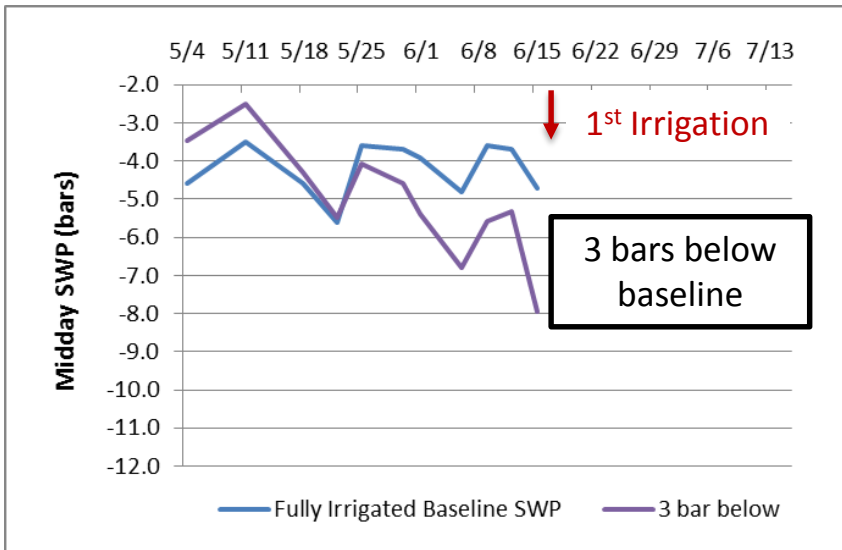
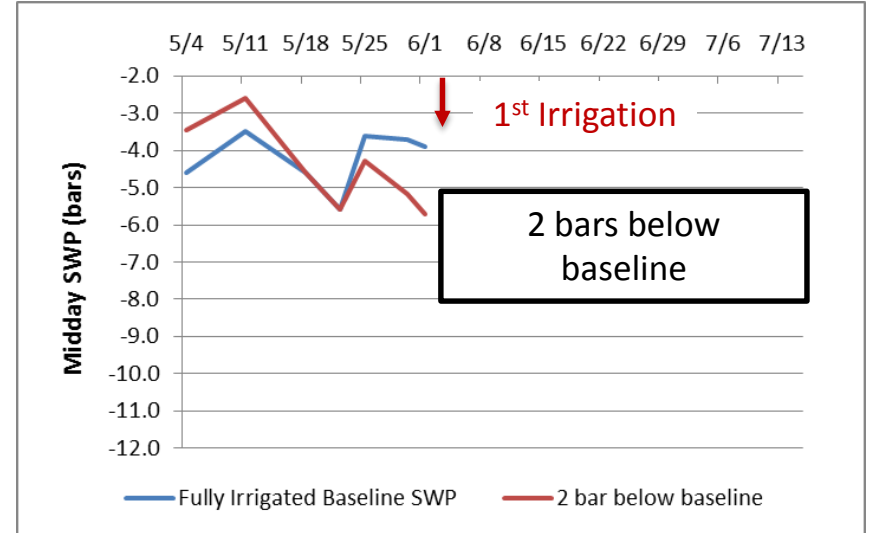
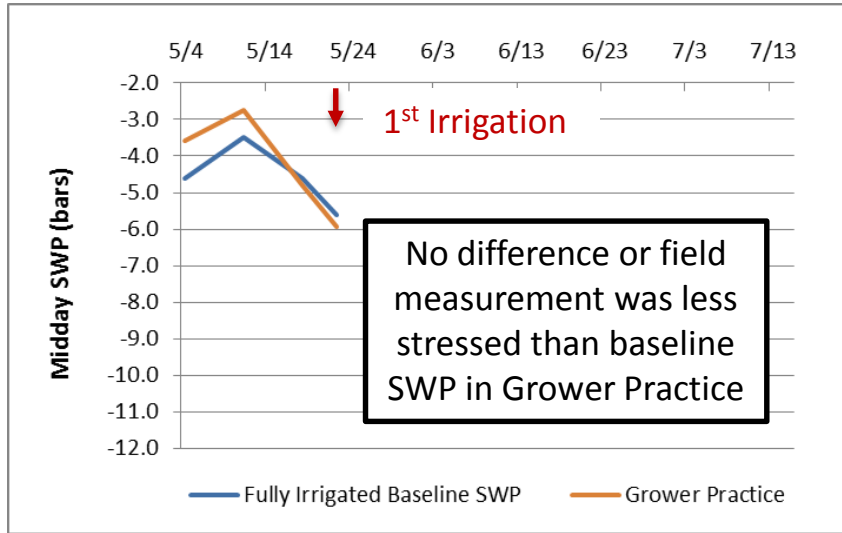
Baseline SWP (bars) to expect for fully irrigated walnut trees under different conditions of air temperature and relative humidity.

Temperature (°F)	Air relative humidity (RH, %)						
	10	20	30	40	50	60	70
75	-4.5	-4.3	-4.2	-4.0	-3.8	-3.6	-3.4
80	-4.8	-4.6	-4.3	-4.1	-3.9	-3.7	-3.5
85	-5.2	-5.0	-4.7	-4.4	-4.1	-3.9	-3.6
90	-5.6	-5.2	-4.9	-4.6	-4.3	-4.0	-3.7
95	-6.0	-5.7	-5.3	-5.0	-4.6	-4.3	-3.9
100	-6.5	-6.1	-5.7	-5.3	-4.9	-4.5	-4.0
105	-7.2	-6.7	-6.2	-5.7	-5.2	-4.8	-4.3
110	-7.8	-7.3	-6.7	-6.2	-5.6	-5.0	-4.5
115	-8.7	-8.0	-7.4	-6.7	-6.0	-5.4	-4.8

SWP levels in walnut, consideration of how SWP might compare to baseline values under various weather conditions, and the corresponding water stress symptoms to expect.

SWP range (bars)	General Stress Level	Baseline consideration	Water stress symptoms in walnut
Higher than -2	None	(Likely above typical baseline)	(Not commonly observed)
-2 to -4	None	At or above typical baseline	Fully irrigated. Commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ET _c). If sustained, long term root and tree health may be a concern, especially on California Black rootstock
-4 to -6	Minimal	May equal or be as much as 2 bars below typical baseline	High rate of shoot growth visible, suggested level from leaf-out until mid-June when nut sizing is completed
-6 to -8	Mild	May equal baseline under hot, dry conditions, but may be 2 to 4 bars below baseline under normal or cooler weather	Shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development or quality.
-8 to -10	Moderate	May be 1 to 2 bars below baseline under hot, dry conditions but 4 to 6 bars below baseline under normal or cooler weather	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.
-10 to -12	High	Likely 3 to 4 bars below baseline under hot, dry conditions and 6 to 8 bars below baseline in normal or cooler weather.	Temporary wilting of leaves and shrivel of hulls has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. If sustained, nut size will likely be reduced with darker kernel color.

How the pressure chamber was used to guide irrigation start date in 2017

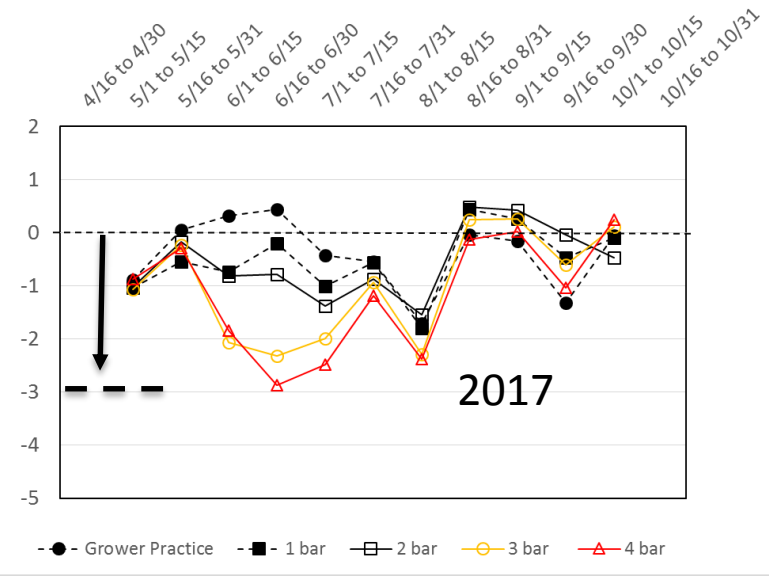
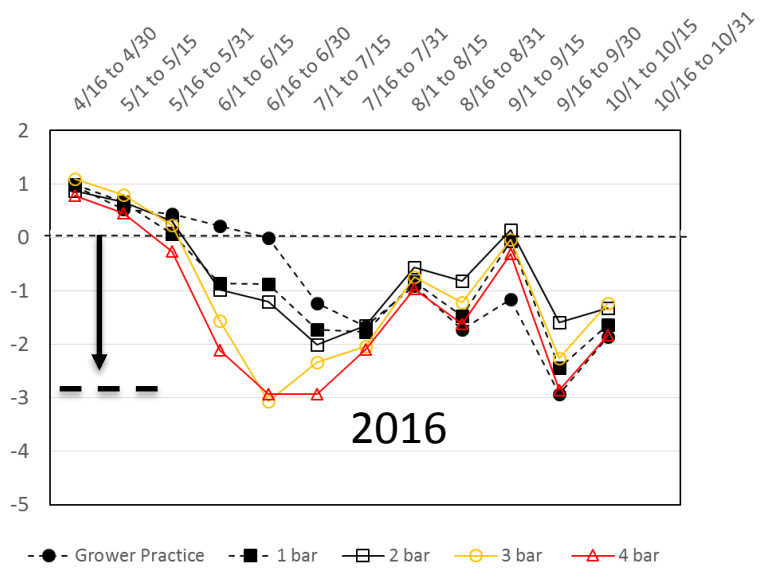
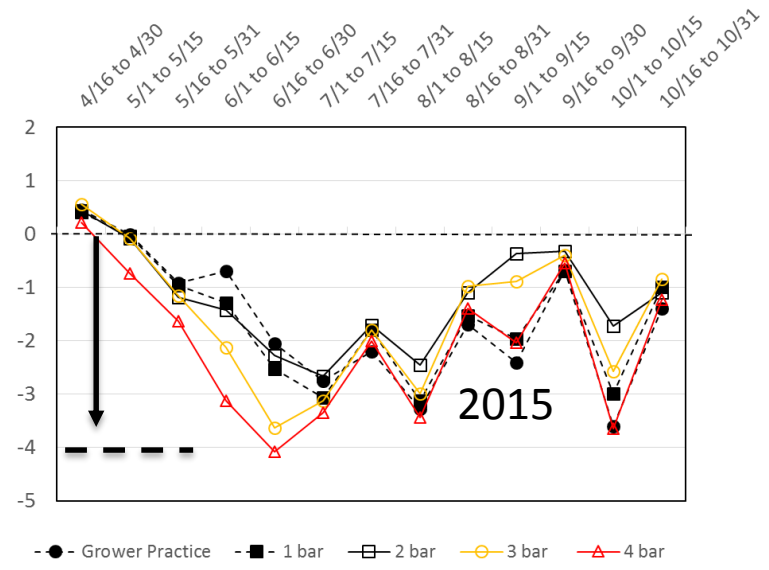
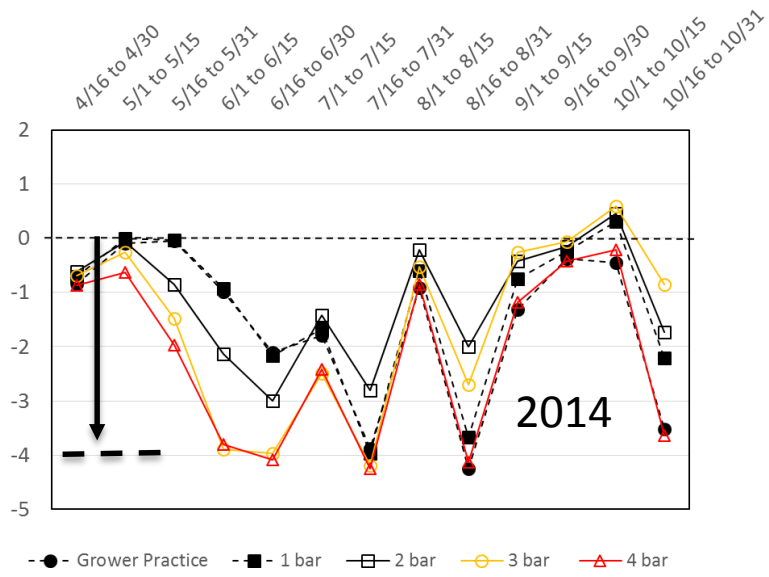


General relationship between early season SWP irrigation thresholds and irrigation start date.

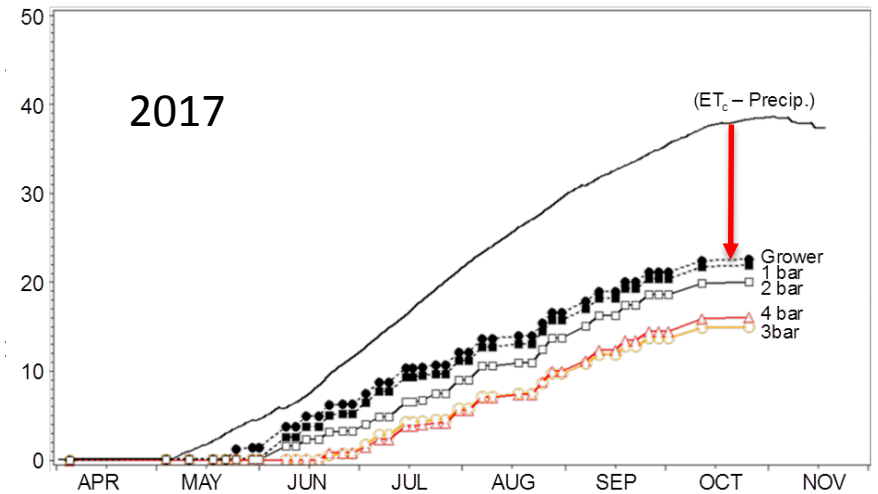
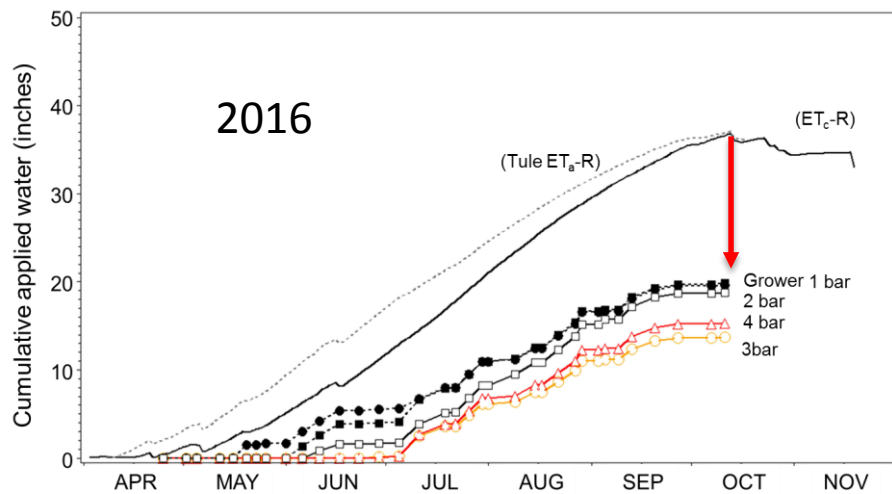
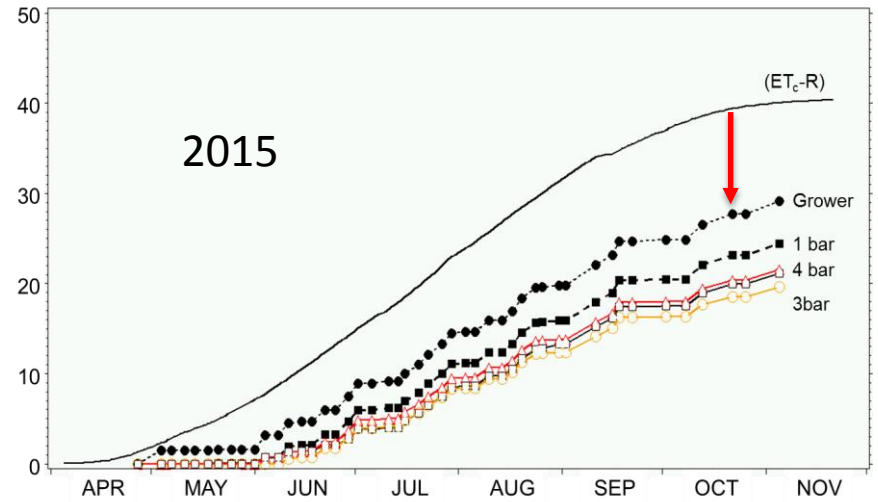
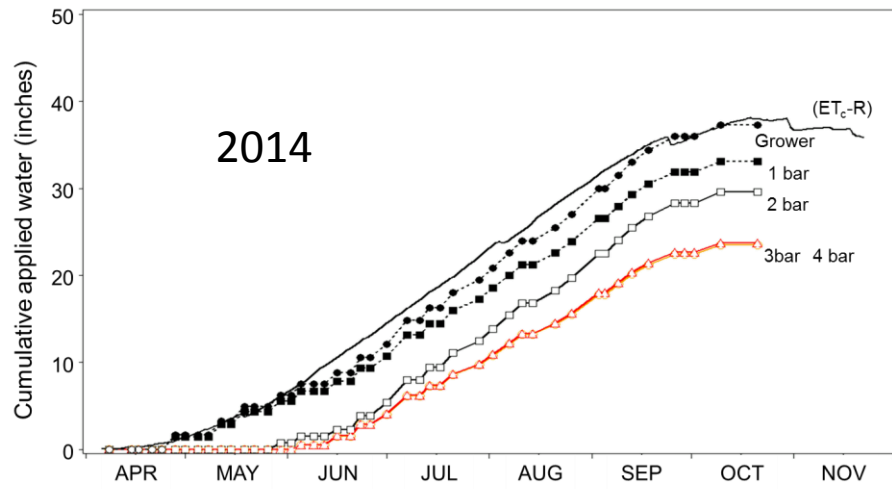
SWP just before the first irrigation (bars below baseline)	Approximate Irrigation Start Date
Grower Practice At or near Baseline (0)	Late April to mid May
1	Mid to Late May
2	Early to Mid June
3	Mid to Late June
4	Late June to Early July

Midday Stem Water Potential Levels, 2014 -2017

Bars below fully irrigated baseline



Effect of early season water stress on applied water needed to supply irrigation demand demand (ET_c minus in-season rainfall)

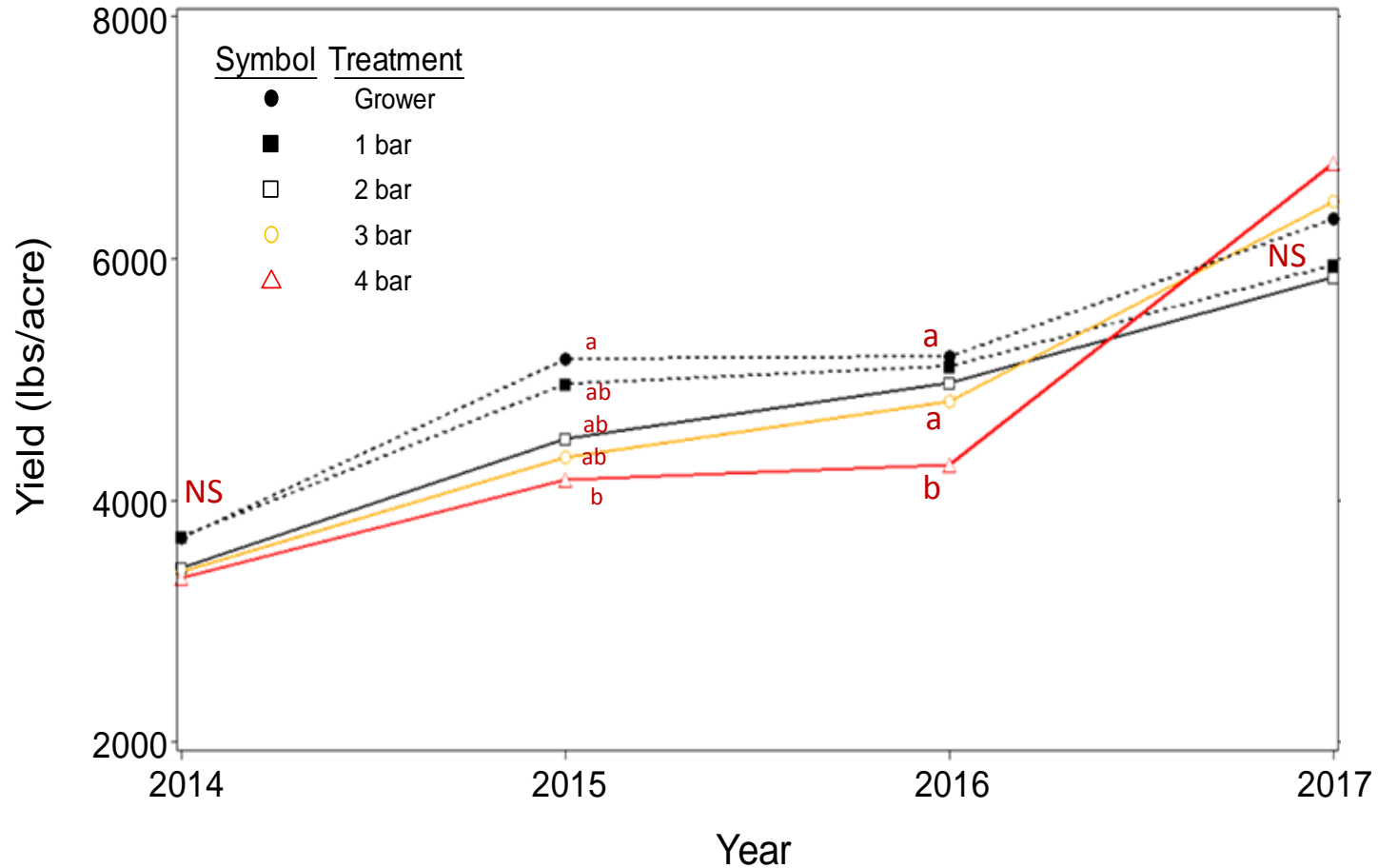


Effect of early season SWP irrigation thresholds on canopy light interception.

SWP just before the first irrigation (bars below baseline)	Approximate Irrigation Start Date	Percent Canopy Light Interception (PAR)			
		2014	2015	2016	2017
Grower Practice At or near Baseline (0)	Late April to mid May	84	89.3	87.5	83.5
1	Mid to Late May	86	88.8	87.0	87.9
2	Early to Mid June	88	90.8	87.8	88.7
3	Mid to Late June	85	89.1	86.3	86.7
4	Late June to Early July	88	89.9	89.0	88.1

No significant differences in canopy light interception across early season irrigation treatments all four seasons.

Four-year yield trends



Effect of early season water stress on Chandler walnut quality. Values are averages over three years (2014-16).

SWP just before the first irrigation (bars below baseline)	Approximate Irrigation Start Date	Nut Weight (grams)	Percent Large Sound	Percent Jumbo and Large	RLI	Percent Mold	Percent Shivel	Percent Edible Kernel
At or near Baseline (0)	Late April to mid May	10.4 a ¹	79.1 a	77.4 a	54.5	1.3	2.3	45.5
1	Mid to Late May	10.1 ab	75.7 ab	73.5 ab	55.1	1.3	2.6	45.7
2	Early to Mid June	10.1 ab	75.6 ab	73.5 ab	55.0	1.6	1.8	45.4
3	Mid to Late June	9.7 bc	68.3 bc	66.7 bc	54.4	1.8	2.5	45.8
4	Late June to Early July	9.3 c	57.7 c	57.7 c	54.7	1.6	2.7	46.1

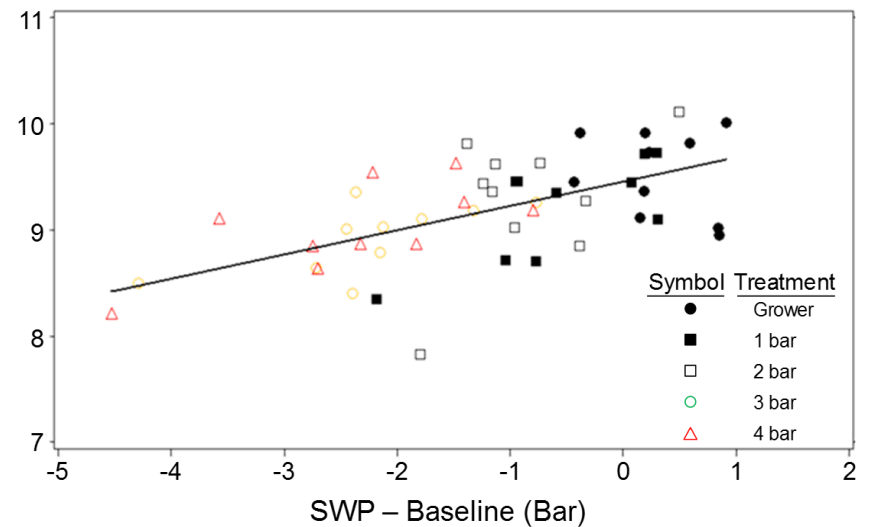
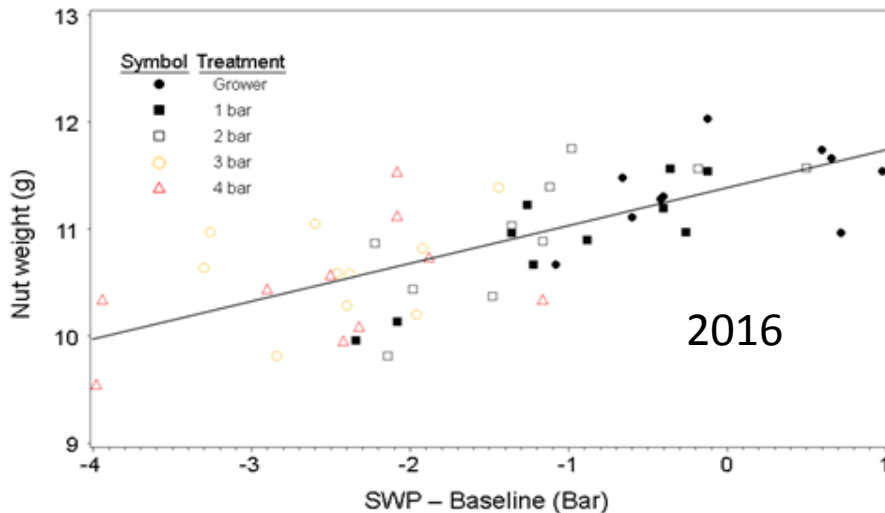
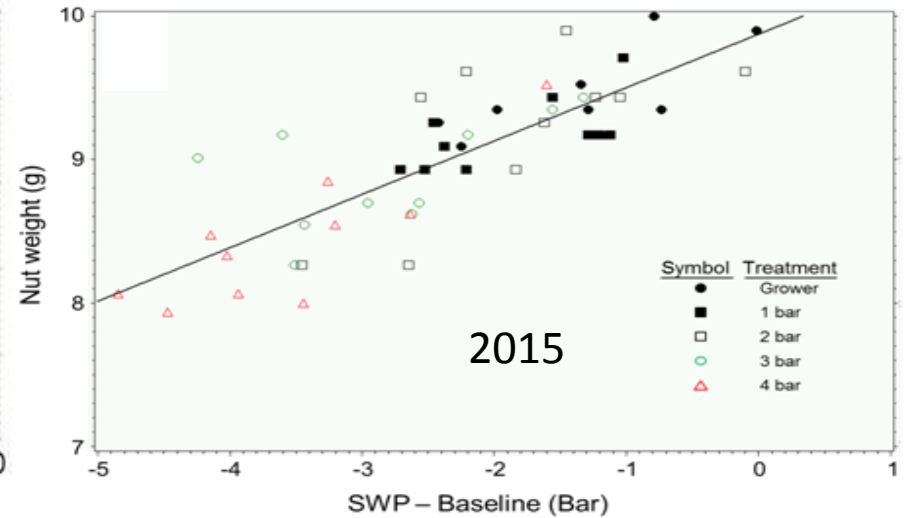
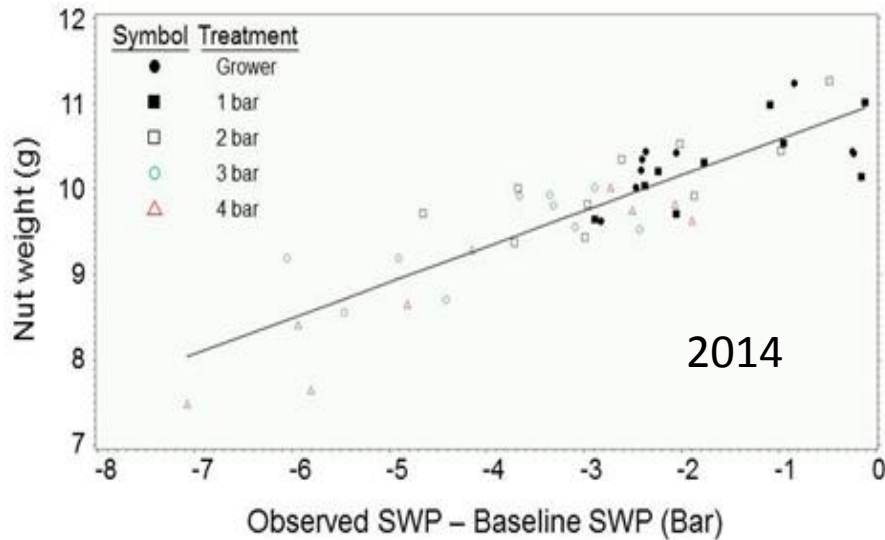
¹ Different **red** letter designations behind values indicate statistically different quality responses to irrigation start date and early season crop water stress.

Effect of early season water stress on Chandler walnut quality in 2017.

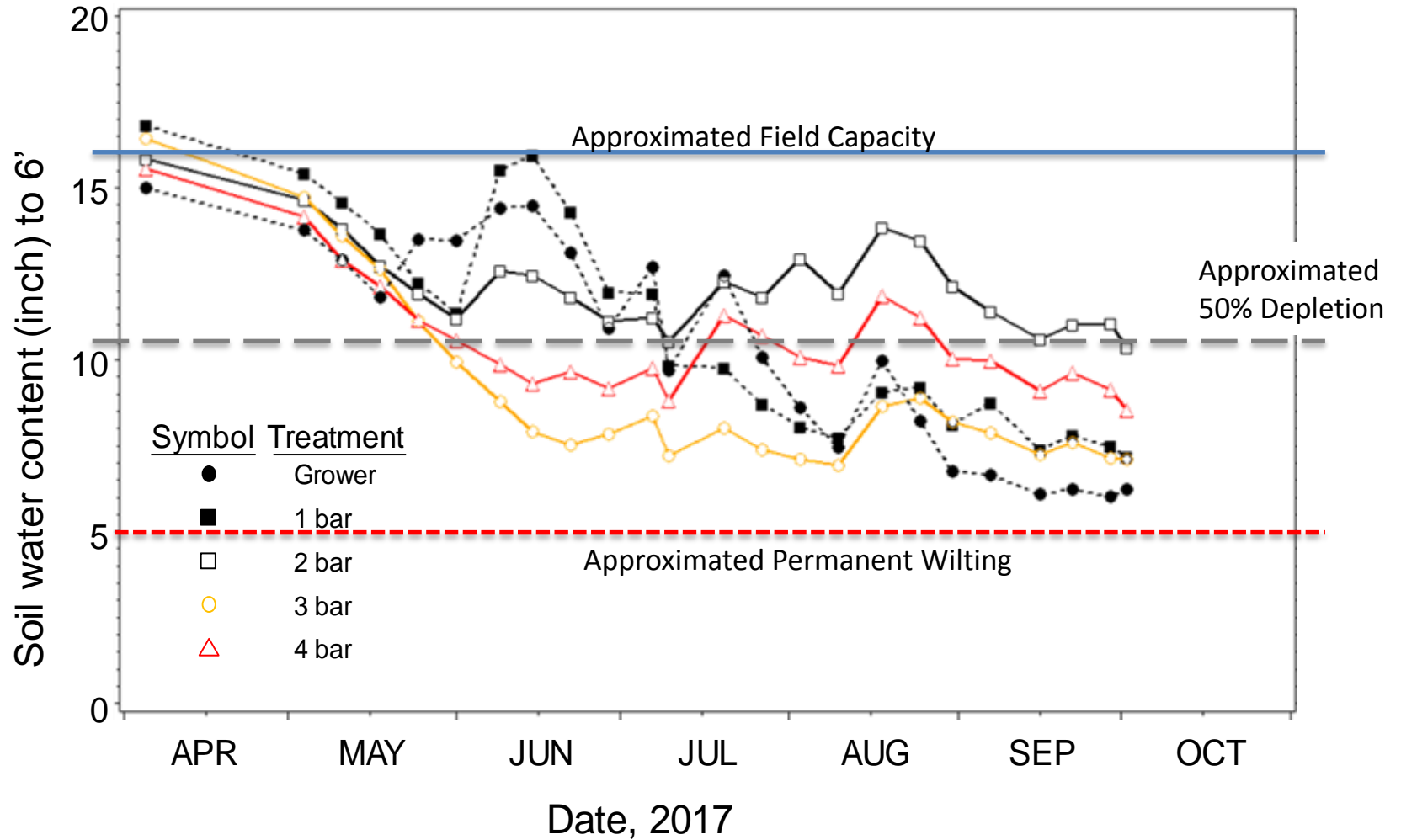
SWP just before the first irrigation (bars below baseline)	Approximate Irrigation Start Date	Nut Weight (grams)	Percent Large Sound	Percent Jumbo and Large	RLI	Percent Mold	Percent Shivel	Percent Edible Kernel
At or near Baseline (0)	Mid May	9.5	76.0	71.0	56.0	1.1	3.6	47.2
1	Late May	9.2	71.0	65.0	55.8	1.3	2.8	47.3
2	Early to Mid June	9.3	73.0	69.0	56.2	2.1	3.2	46.4
3	Mid to Late June	8.9	67.0	63.0	55.4	2.0	2.7	48.2
4	Late June to Early July	9.0	71.0	66.0	55.4	2.0	3.3	47.3

¹ There were no statistically different walnut quality responses to irrigation start date and early season water stress in 2017.

Relationship of nut weight to average observed midday stem water potential in the month of June



2017 volumetric soil moisture levels (representative of 2014-16 levels too)



So what has been learned, so far?

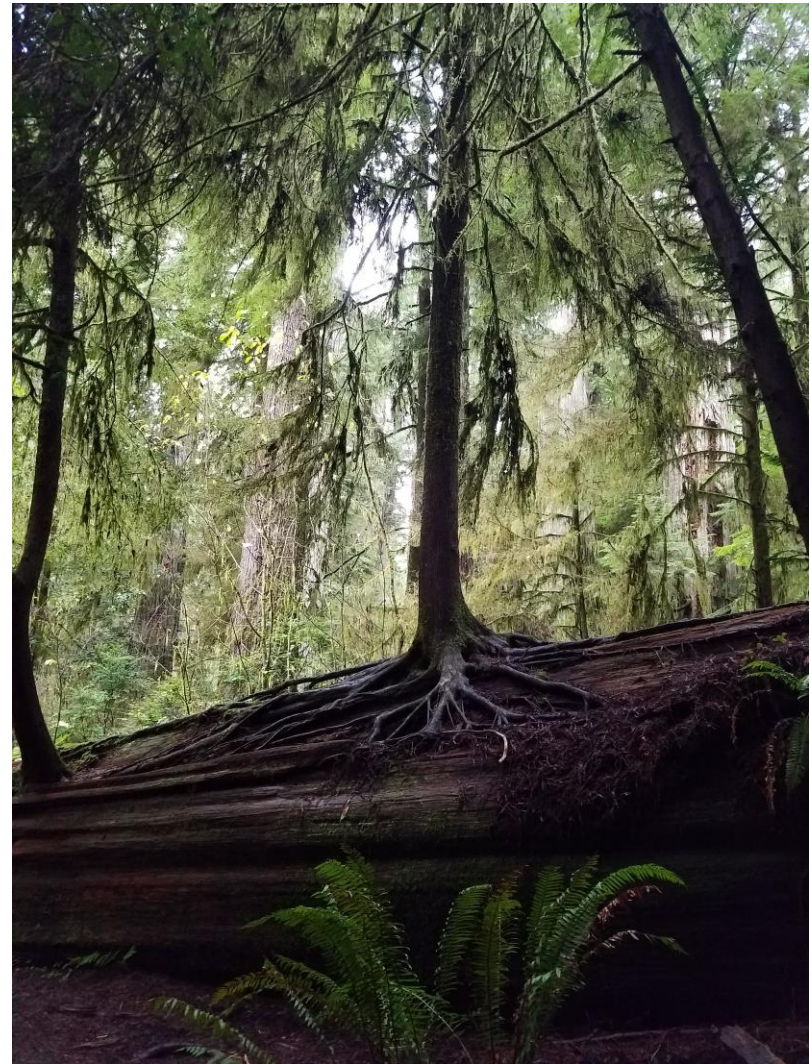
- When balancing production potential with orchard health, managed delays in early season irrigation have merit.
- Delaying early season irrigation does not necessarily mean the orchard will experience more stress in the summer and fall.
- Nut weight and size is likely to be negatively impacted when early season irrigation is delayed into June, but there may be irrigation strategies to mitigate this once irrigation begins.
- Edible yield, which crop payment is associated with was not affected by any level of early season water stress any season.
- Reasonable delays in early season irrigation offers a way to save on energy and water costs.
- Potentially more benefit and less risk of harm from managed delays in early season irrigation than deficit irrigation in mid summer and fall.

Curious findings?

- During first two years of experiment, midday SWP fluctuated more due to delays in irrigation than last two years. Could it be related to an earlier history of more intensive irrigation?
- Meanwhile applied water diminished over time and was much less than ET. So, are ET estimates too high or is the crop getting the water it needs elsewhere?
- Higher yields in 2017 in the 3 and 4 bar (most stressed) treatments was surprising. Will trend continue?

Working theories

- The trees adapt and acclimate with time.
- Delaying early season irrigation appears to be promoting healthier trees and root systems.
- Delaying irrigation start could be affecting orchard microclimate and interacting with foliar diseases.



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Opportunities to learn more

- We may continue this experiment one more season to see if higher yield trends continue in the plots with longer delays and greater early season water stress.
- We'd like to test this early season irrigation concept (adding a wrinkle to address nut weight) in other orchards with different growing conditions.
- We'd like to continue more developmental research with plant sensors of tree stress to assess trees adaptive capacity
 - Dendrometer – on market
 - Mini stem water potential sensor – in development
 - Micro tensiometer – in development
 - Thermal sensing – various methods in various stages of use

Thank you! Questions?

