Update on Training Walnuts During Canopy Development Phase and Irrigation Management- Benefits in a Low Crop Price Year

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Presented at Tri County Walnut Day, February 7, 2019

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Walnut training trials

Nickels Howard training trial 2004-2010 (Lampinen and Edstrom)
Nickels Chandler training trial 2009-2016 (DeBuse, Lampinen and Hasey)
Chandler training trial Merced County 2012-2016 (Doll and Lampinen)
Forde training trial Yolo County 2012-2015 (DeBuse and Lampinen)
Howard training trial Butte County 2012-2014 (Hasey and Lampinen)
Tulare training trial Tulare County 2012-2013 (Fichtner and Lampinen)
Forde training trial CSU Chico Butte County 2012-2016 (Hasey and Lampinen)
Chandler training trial on Paradox and own-rooted 2012-ongoing (Caprile and Lampinen)
Howard training trial on own-rooted trees 2012-ongoing (Caprile and Lampinen)
Chandler training trial Lake County 2012-2014 (Elkins and Lampinen)
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Chandler training trial CSU Chico Butte County 2016-ongoing (Lightle and Lampinen)
Livermore training trial Kings County 2017-ongoing (Culumber and Lampinen)
Solano training trial Butte County 2017-ongoing (Lightle and Lampinen)

Total of 14 trials have included Chandler (5), Howard (3), Forde (2), Solano (2), Tulare (1) and Livermore (1)

Walnut height of heading at planting trials

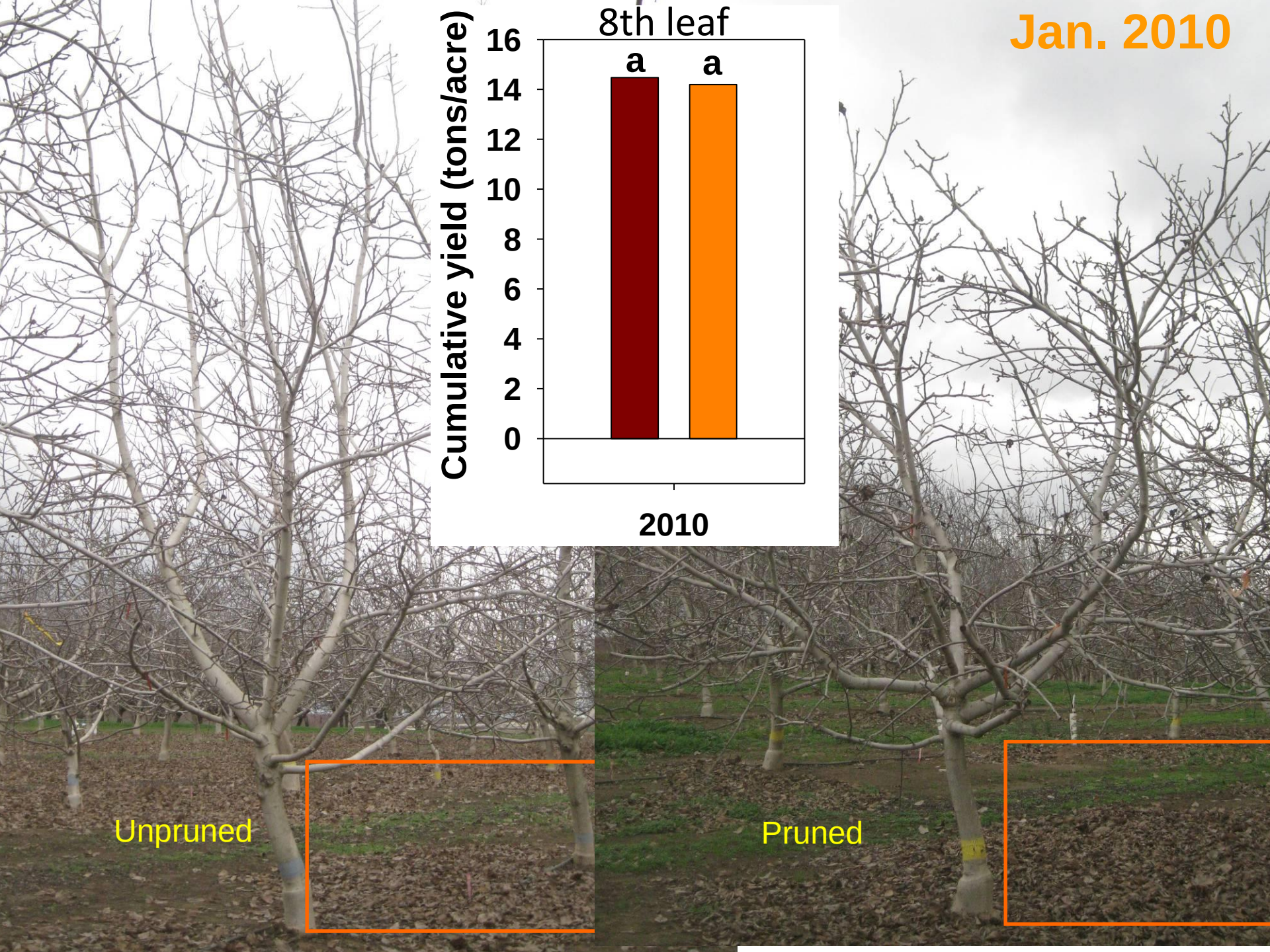
Chandler Howard and Tulare height of heading at planting trial UC Davis Yolo County 2012-2017 (Lampinen)
Chandler height of heading at planting trial Yuba County 2014-15 (Hasey and Lampinen)
Chandler height of heading at planting trial Lake County 2014-16 (Elkins and Lampinen)

Howard Pruning treatments imposed in March 2004- after scaffold selection following second growing season

12’ x 25’ spacing (145 trees/acre)

Unpruned after scaffold selection

Pruned (1/3 of previous year growth each year until tree fills allotted space)


8th leaf
Cumulative yield (tons/acre)
16
14
12
10
8
6
4
2
0
a
a
2010
Jan. 2010
Unpruned
Pruned

Unpruned Howard tree growth over study period

4/16/04	1/9/06	3/15/07	2/9/09	1/12/10
2nd	4th	5th	7th	8th

Howard pruned versus unpruned trial

- After 7 years of treatment imposition, no benefits to pruning

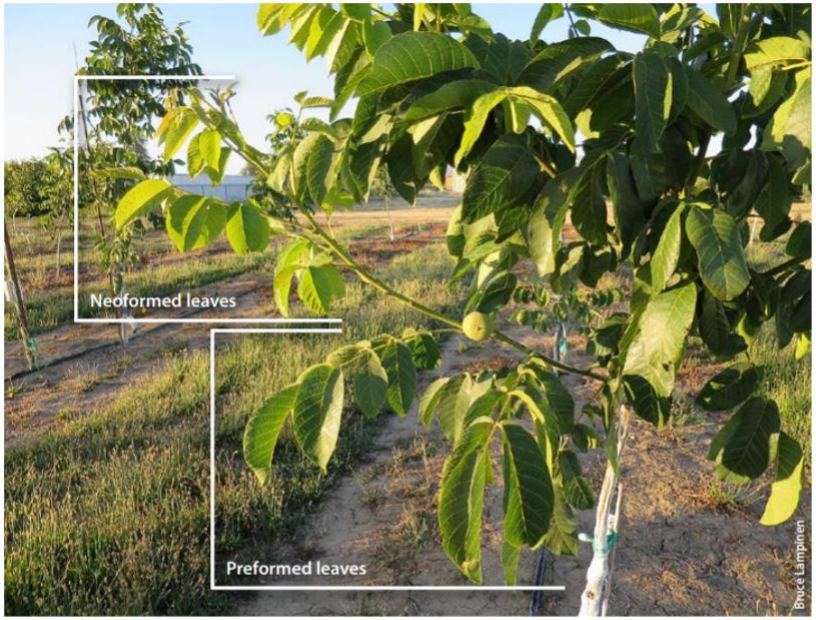
Research Article

Howard walnut trees can be brought into bearing without annual pruning

by Bruce D. Lampinen, John P. Edstrom, Samuel G. Metcalf, William L. Stewart, Claudia M. Negron *and* M. Loreto Contador

CALIFORNIA AGRICULTURE • VOLUME 69, NUMBER 2

APRIL–JUNE 2015



Canopy growth in young walnut trees is bimodal: Preformed growth forms in the bud during the previous season, and neoformed growth forms during the current season.

Chandler pruned versus unpruned trial

- Chandler orchard planted at 15 x 22 ft.
- Planted 2008 at Nickels Soil Lab
- Nursery budded on Paradox rootstock
- March 2009 pruning treatments imposed
- Treatments
  - Heavily pruned
  - Minimally pruned
  - No heading/no pruning

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Chandler pruned versus unpruned trial

Chandler orchard planted at 15 x 22 ft.

Planted 2008 at Nickels Soil Lab

Nursery budded on Paradox rootstock

March 2009 pruning treatments imposed

Treatments

- Heavily pruned
- Minimally pruned
- No heading/no pruning

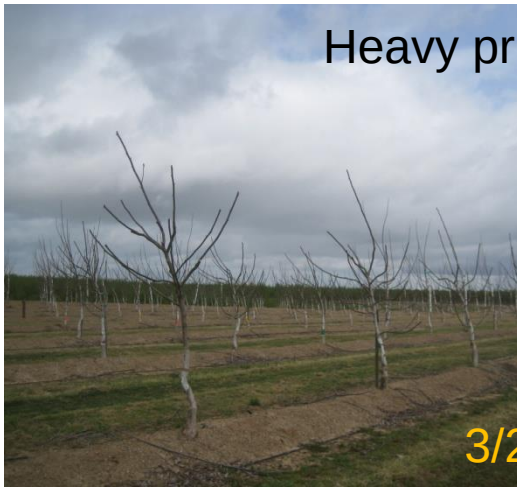
After first growing season

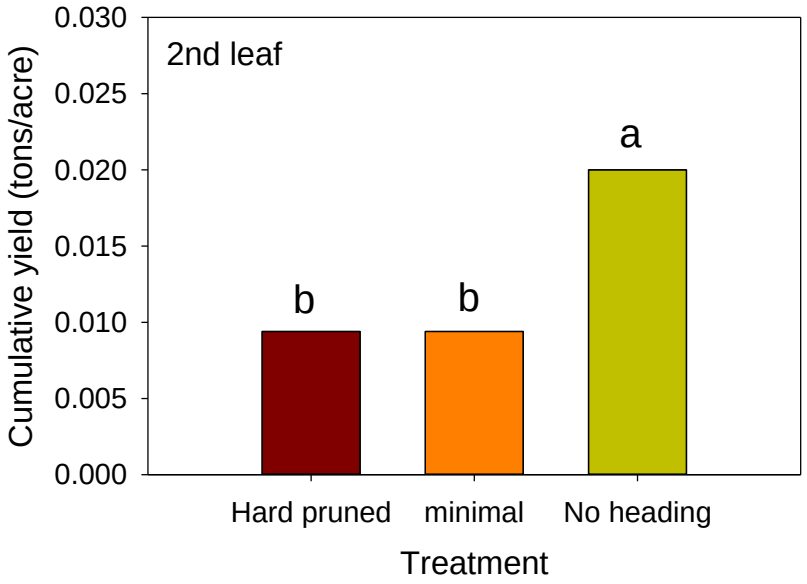
Before pruning- after 2nd leaf

After pruning

After second growing season

Before pruning- after 2nd leaf





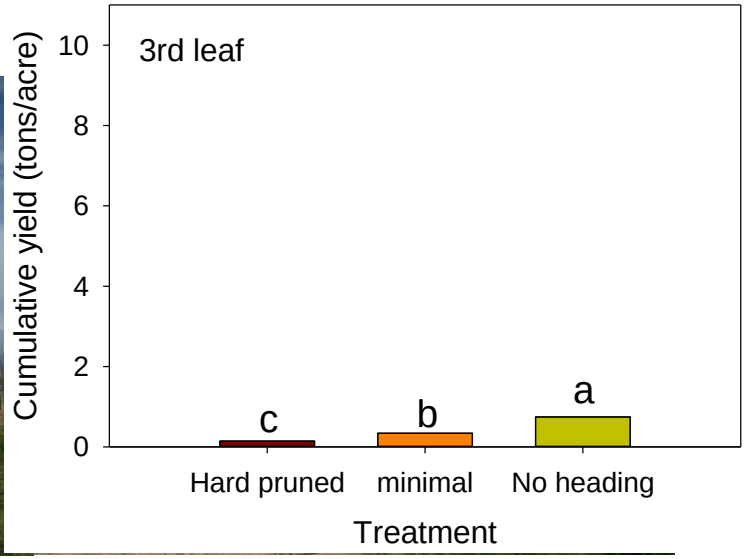
After second growing season

Before pruning- end of 3rd leaf

After pruning

After third growing season

Before pruning- end of 3rd leaf



After third growing season

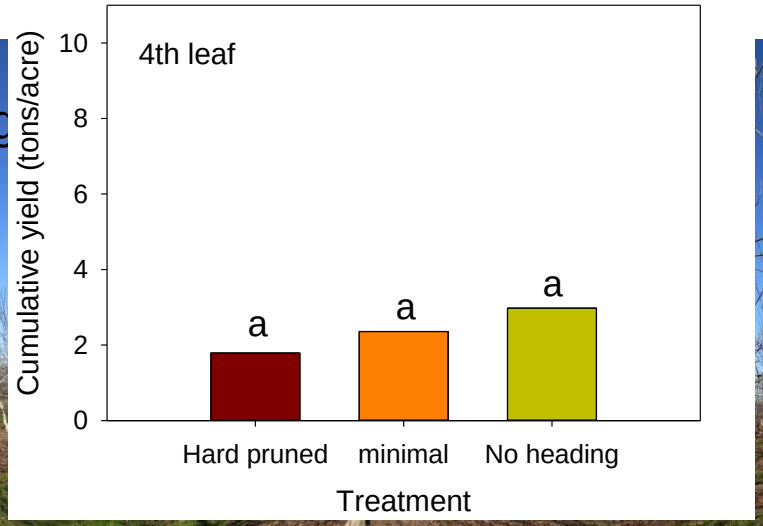
Before pruning- end of 4th leaf

Before pruning

12/30/12 12/30/12 12/30/12

After fourth growing season

Before pruning- end of 4th leaf



12/30/12 12/30/12 12/30/12

After fourth growing season

Heavy pruning

1/30/14

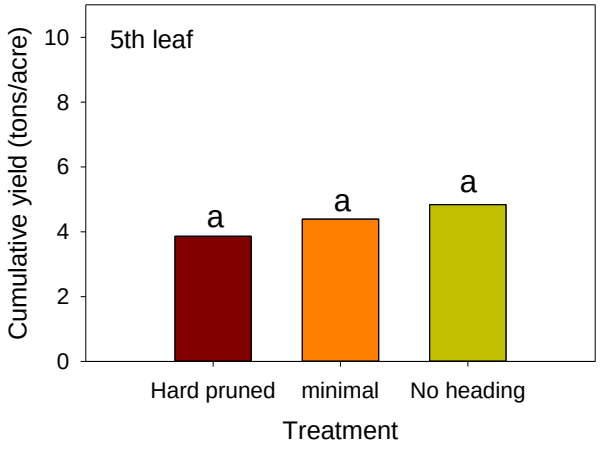
Minimal pruning

1/30/14

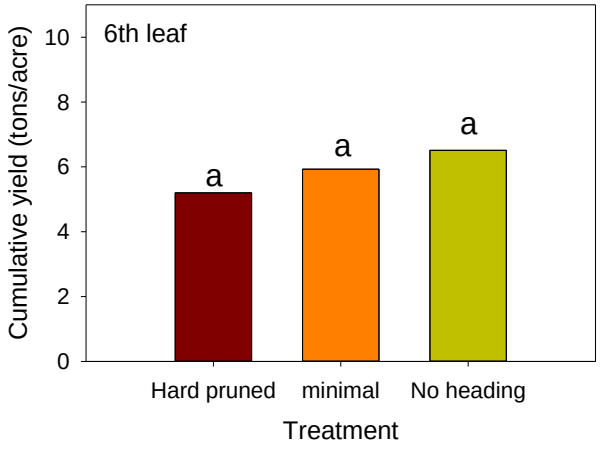
Unheaded/unpruned

1/30/14

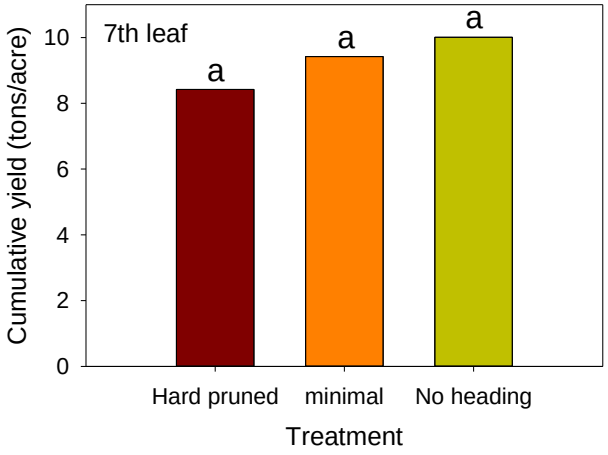
2013

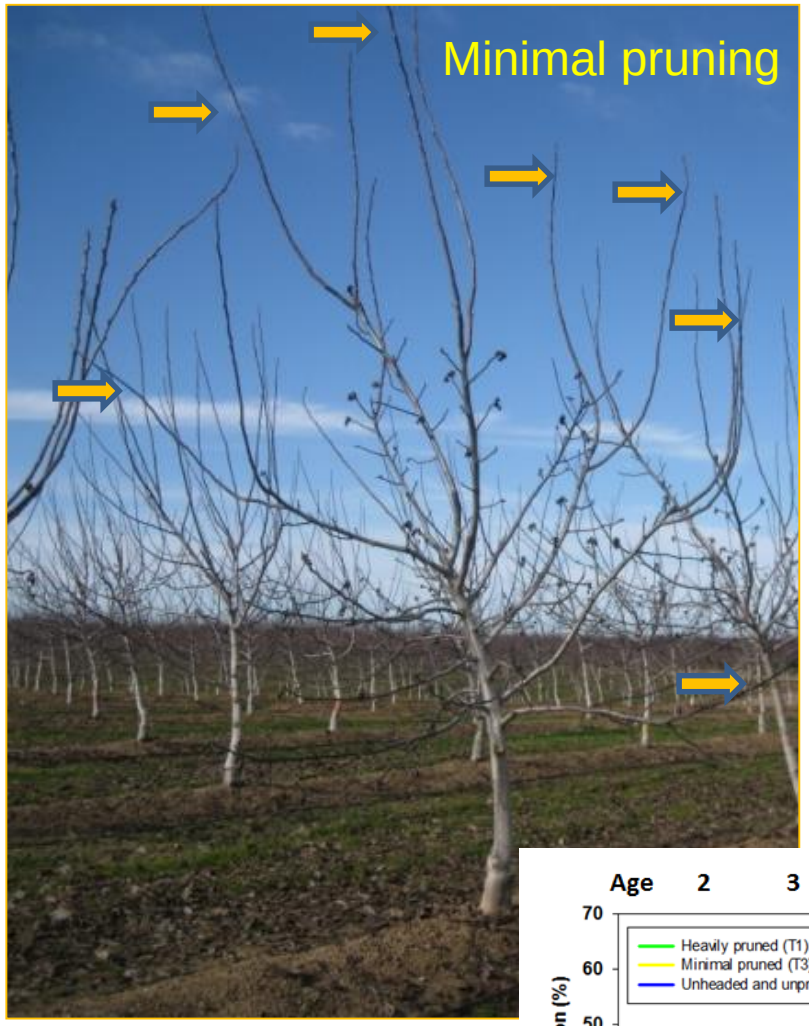


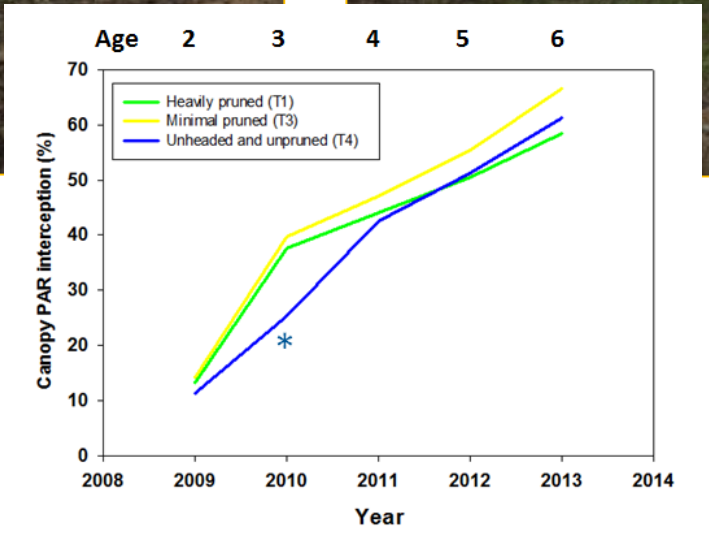
2014



2015

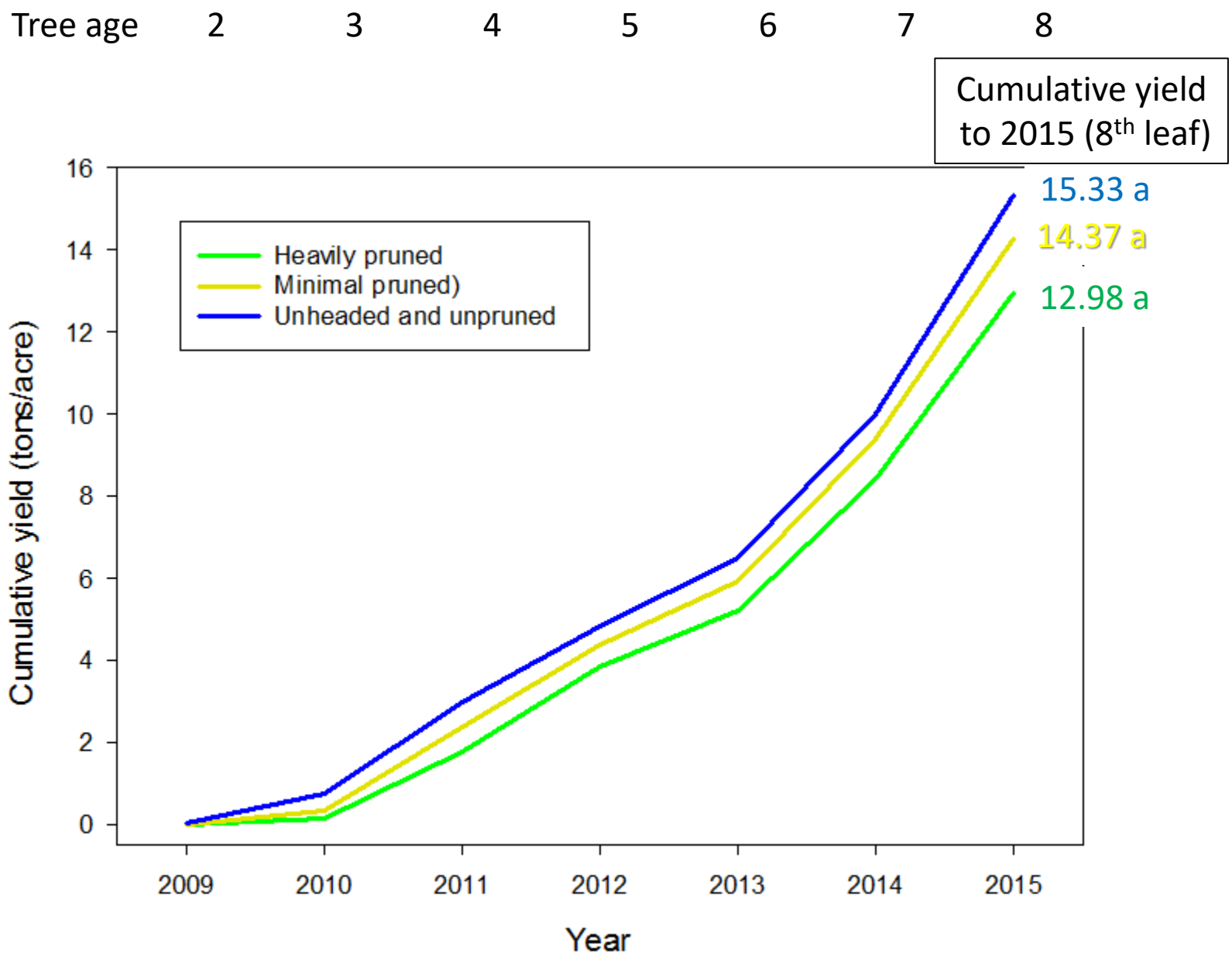






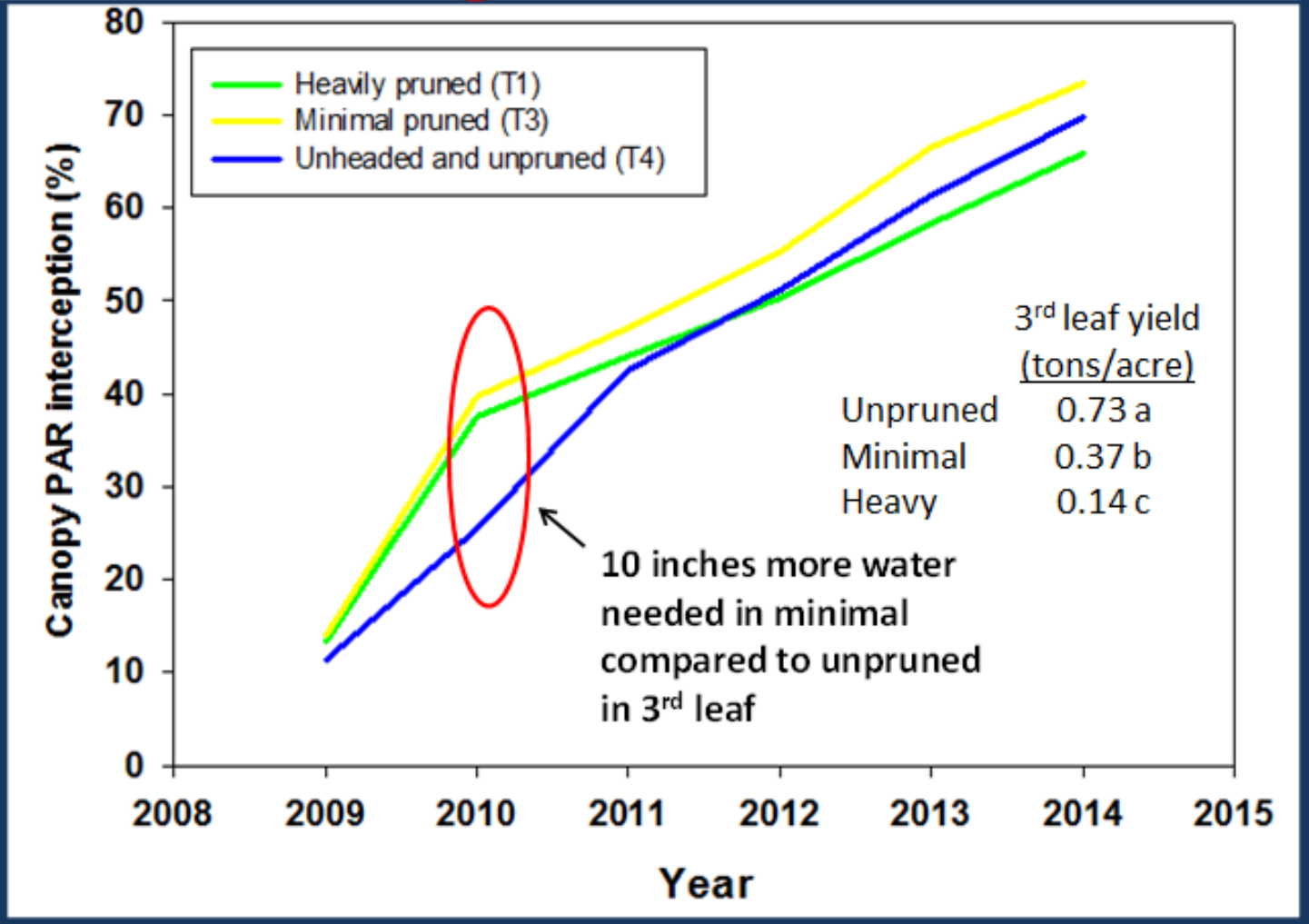
- Light interception significantly lower
- Yield significantly higher

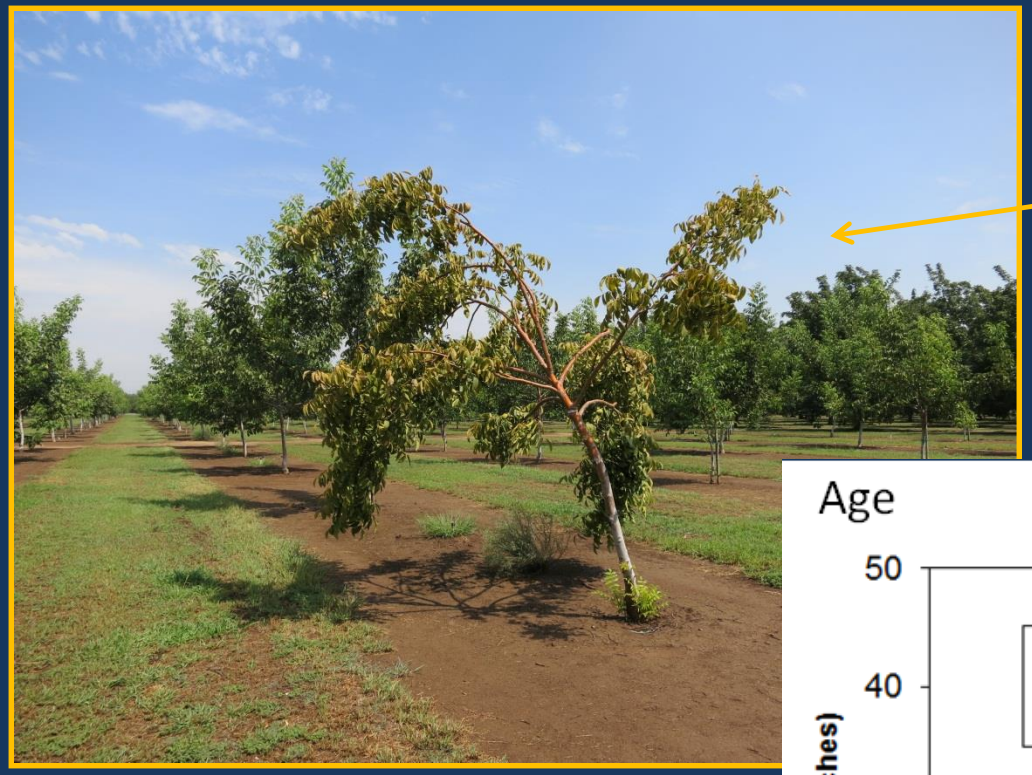
Only broken scaffolds occurred in 2013 in minimum pruned treatments- no broken scaffolds in 2014 or 2015


Tree age 2 3 4 5 6 7 8
Cumulative yield to 2015 (8th leaf)
15.33 a
14.37 a
12.98 a
Heavily pruned
Minimal pruned)
Unheaded and unpruned
Cumulative yield (tons/acre)
0
2
4
6
8
10
12
14
16
2009
2010
2011
2012
2013
2014
2015
Year

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

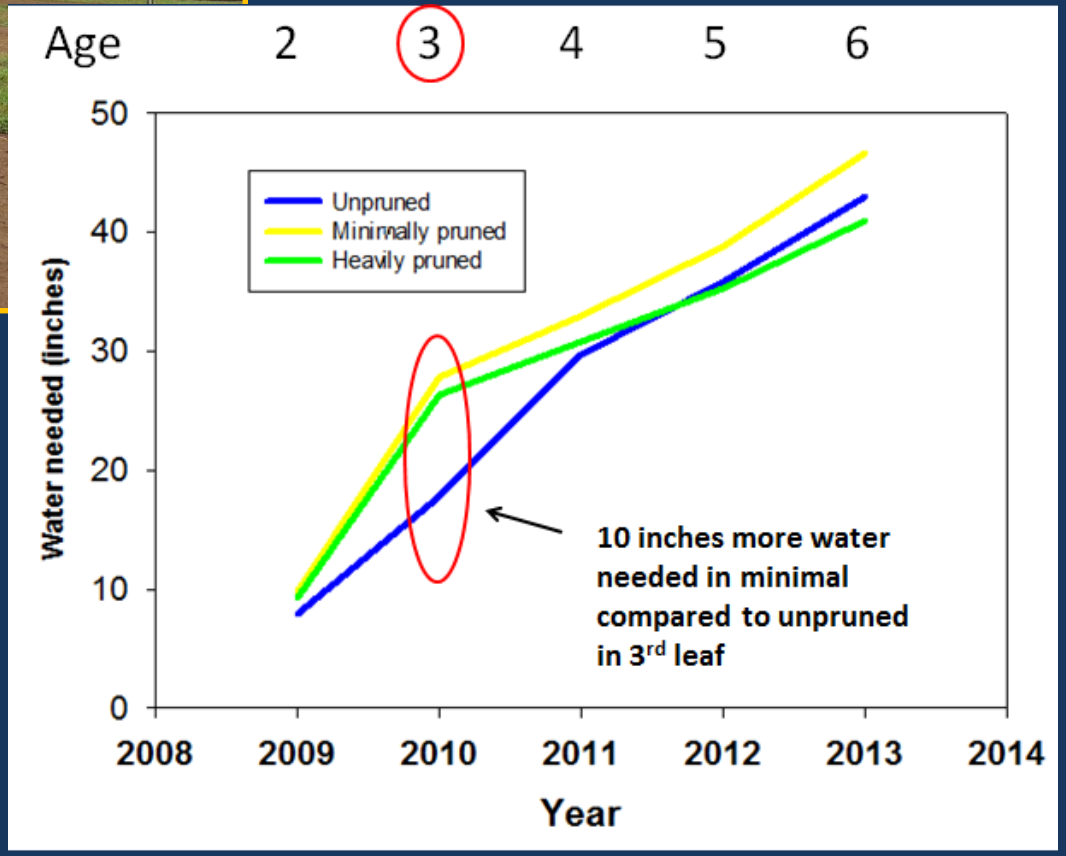
Age 2 3 4 5 6 7





A tree that looks like this has stalled out from overwatering, not from lack of pruning

Based on canopy size, 10 inches more water needed for minimally pruned in 3rd leaf



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

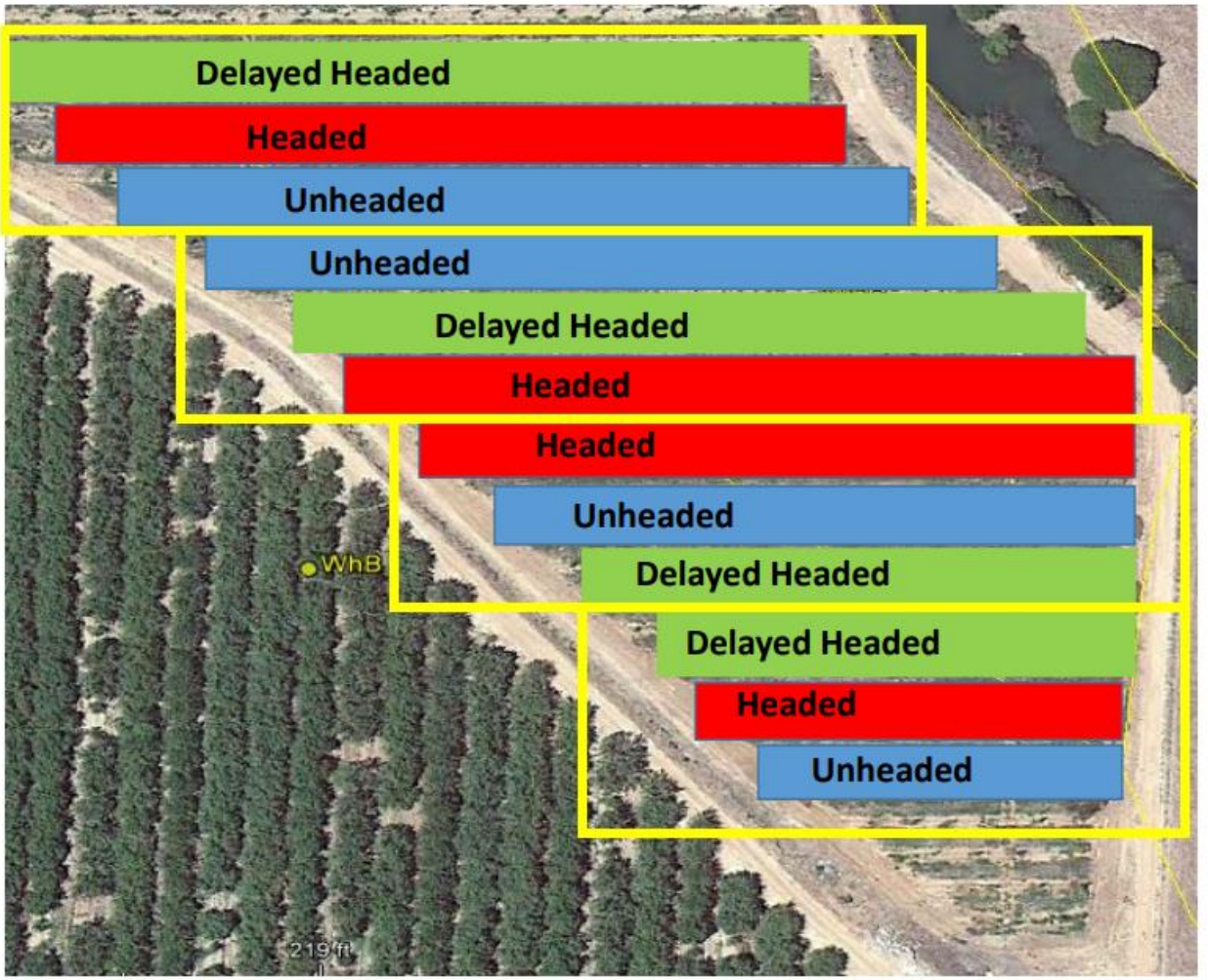
Treatment	Total water needed based on canopy size (years 2-6)	Cumulative yield (tons/acre)	Water use efficiency expressed as pounds of walnuts produced per inch of water applied	Water use efficiency (% of unpruned)
Unpruned	134	10.01	149	100
Minimally pruned	156	9.42	121	81
Heavily pruned	142	8.42	118	79

Chandler pruned versus unpruned trial

- After 8 years of treatment imposition, no benefits to pruning

Chandler training trial Merced County (Doll and Lampinen)

Plot Layout



5th Leaf Chandler in Merced County

Headed

Unheaded, unpruned

Cumulative yield 1500 lbs/acre greater on unheaded compared to headed

Janet Caprile headed and unheaded trials- Contra Costa County

Chandler- own rooted and Paradox rooted

Rootstock Pruning Treatment	After 5th leaf (2015)		
	Trunk Diameter (cm)	Light Intercept (% PAR)	Yield (lb/acre)
Paradox			
Headed	17.2 a	71.2 a	
Unheaded	15.6 b	51.7 b	
	*	*	
Own Rooted			
Headed	16.1	60.7 a	
Unheaded	16.0	55.7 b	
	NS	*	
Combined			
Headed		66.1 a	978.5
Unheaded		53.8 b	1624.0

2017 Cumulative

Yield (lb/acre)	
Headed	3530
Unheaded	4090

As of 7th leaf (2017), the unheaded have out-yielded headed by 560 lbs/acre

Janet Caprile headed and unheaded trials- Contra Costa County

Howard- own rooted

Pruning Treatment	After 4th leaf (2014)			After 5th leaf (2015)		
	Trunk Diameter (cm)	Light Intercept (% PAR)	Yield (lb/acre)	Trunk Diameter (cm)	Light Intercept (% PAR)	Yield (lb/acre)
Headed	13.1 b	48.8 b	133 b	15.5 b	44.1	744 b
Unheaded	13.9 a	55.8 a	620 a	16.7 a	48.3	1954 a
	*	*	*	*	NS	*

2017 Cumulative

Yield (lb/acre)

Headed 3220

Unheaded 4699

As of 7th leaf (2017), the unheaded have out-yielded headed by 1479 lbs/acre

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Grower unpruned trial-
4th leaf Tulare on Paradox
Fresno County

4th leaf guard tree between plots (Chandler on Vlach) that was regrafted in 2014 and not painted the following winter (Yolo County)

Grower unpruned trial-
5th leaf Chandler on VX211
San Joaquin County

2nd leaf Solano pruning trial
Glenn County

Jan. 2018

3rd leaf Chandler clonal rootstock trial at Sierra Gold Nursery, Yuba County- yield for Chandler on RX1 was 1.5 tons/acre in 3rd leaf

Jan. 2018

After 14 years of replicated unpruned trials plus 12 grower trials we have found no benefits to pruning during the orchard development phase except removing branches in the way of traffic

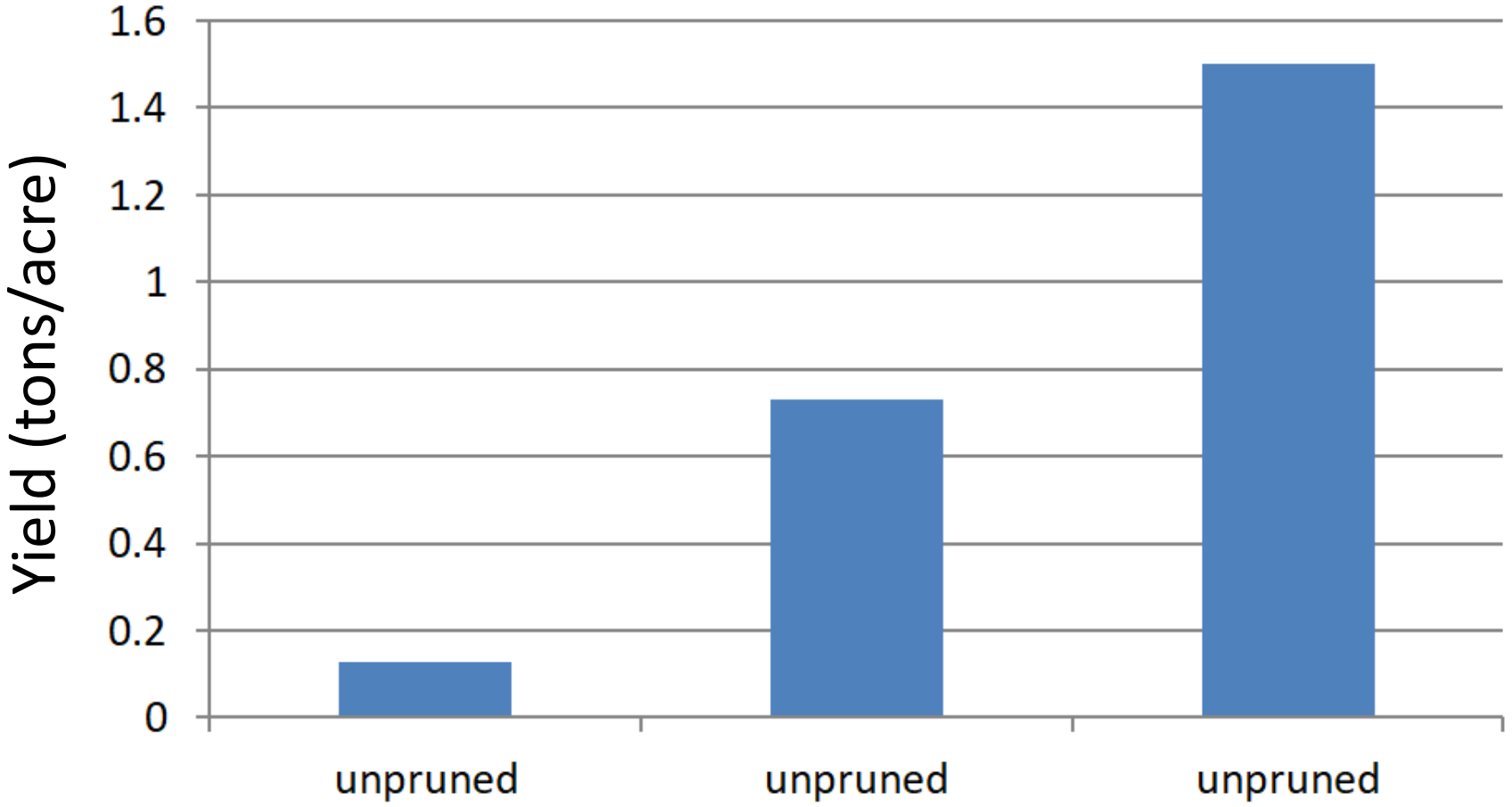
Advantages to no prune training

- Early increased yield
- Nice tree structure
- Less limb breakage in year 5-7
- Trend towards better quality with no prune

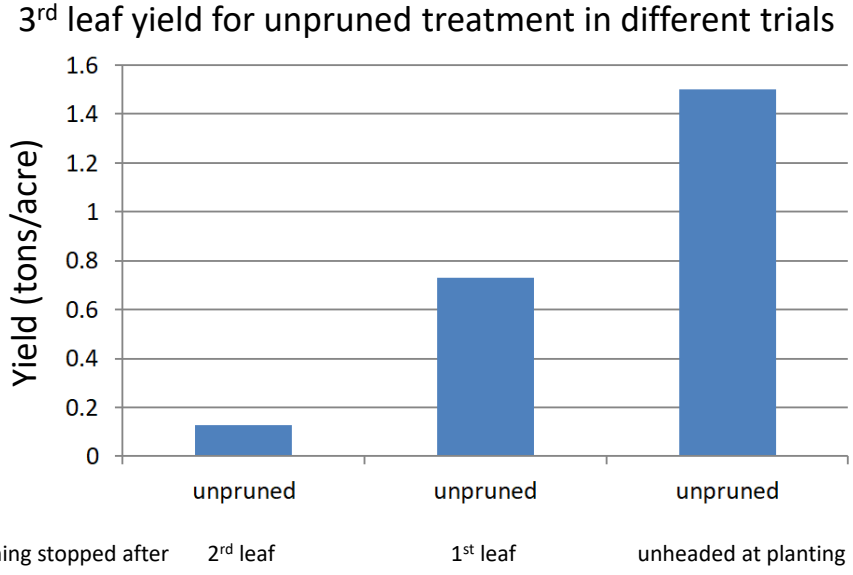
Disadvantages to pruning

- Expensive to prune and dispose of prunings
- Slightly lower quality/size for nuts on pruned
- More scaffold breakage in years after pruning stops
- More rapid shading of lower canopy- this is related to quality problems

3rd leaf yield for unpruned treatment in different trials



Pruning stopped after 2rd leaf | 1st leaf | unheaded at planting


3rd leaf yield for unpruned treatment in different trials
Yield (tons/acre)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
unpruned
unpruned
unpruned
Pruning stopped after 2rd leaf
1st leaf
unheaded at planting

Unheaded June budded Chandler on RX1 planted spring of 2015

June 2015

January 2016

1.5 tons/acre

January 2018

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

PIs: Ken Shackel, Allan Fulton, Bruce Lampinen, Kari Arnold (Hal Crain, Jeff Phillips, cooperators)
Graduate student: Nick Matsumoto

Objective #1: Field test four levels of SWP for the start of irrigation in the spring.

In the spring, use a pressure chamber, measure SWP

1) Let the grower do what he wants.
2) For us, wait to <u>start</u> irrigating, until the trees hit:

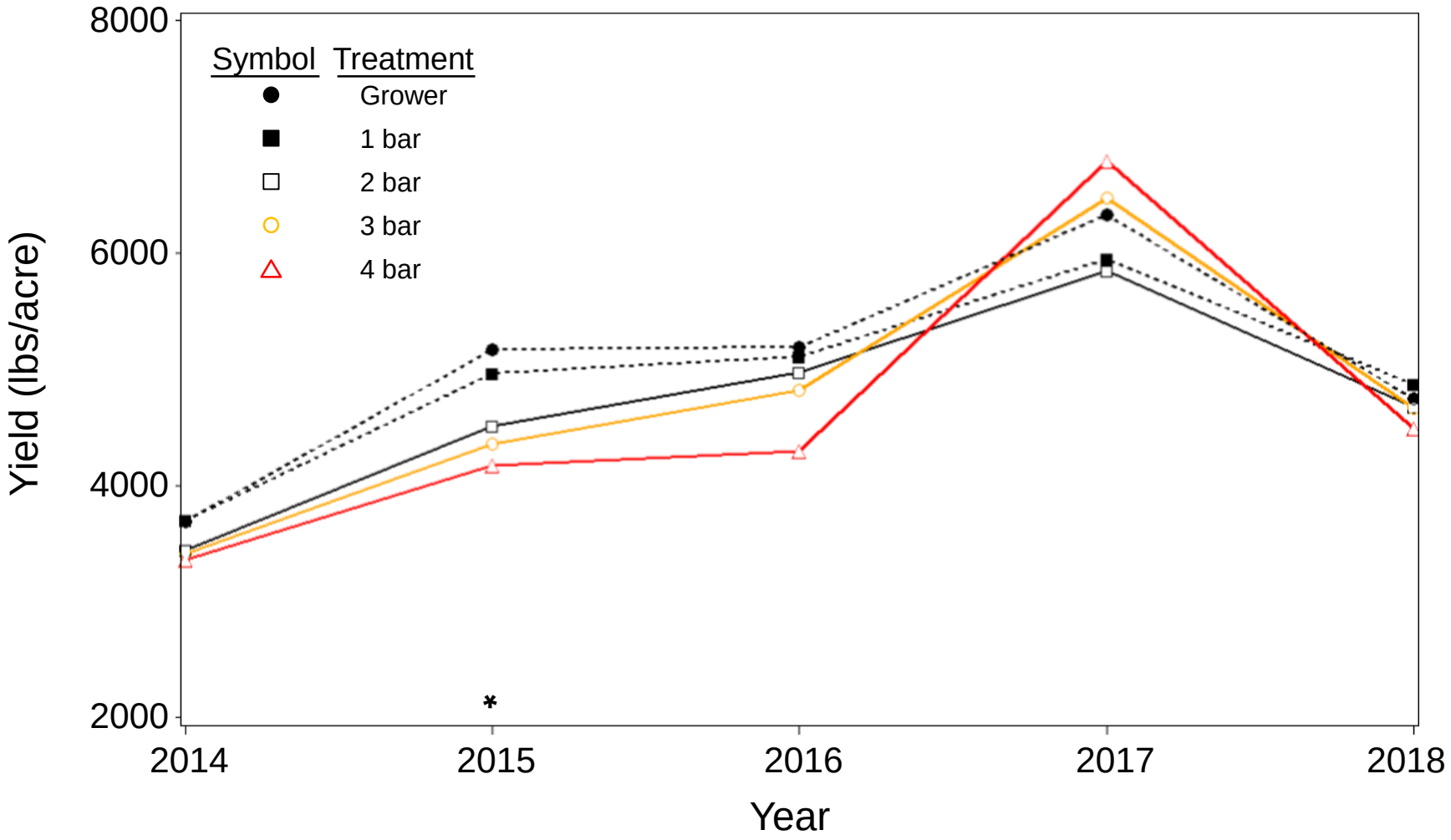
1, 2, 3, or 4 bars below (more stressed than) the ‘baseline’ (fully irrigated) SWP value.

Started 2014

Treatment average yields, 2014-2018

Only 2015 showed a statistical separation between the highest (Grower) and the lowest (4 bar) treatment.

No apparent trend of an increasing yield gap as a result of delaying irrigation.

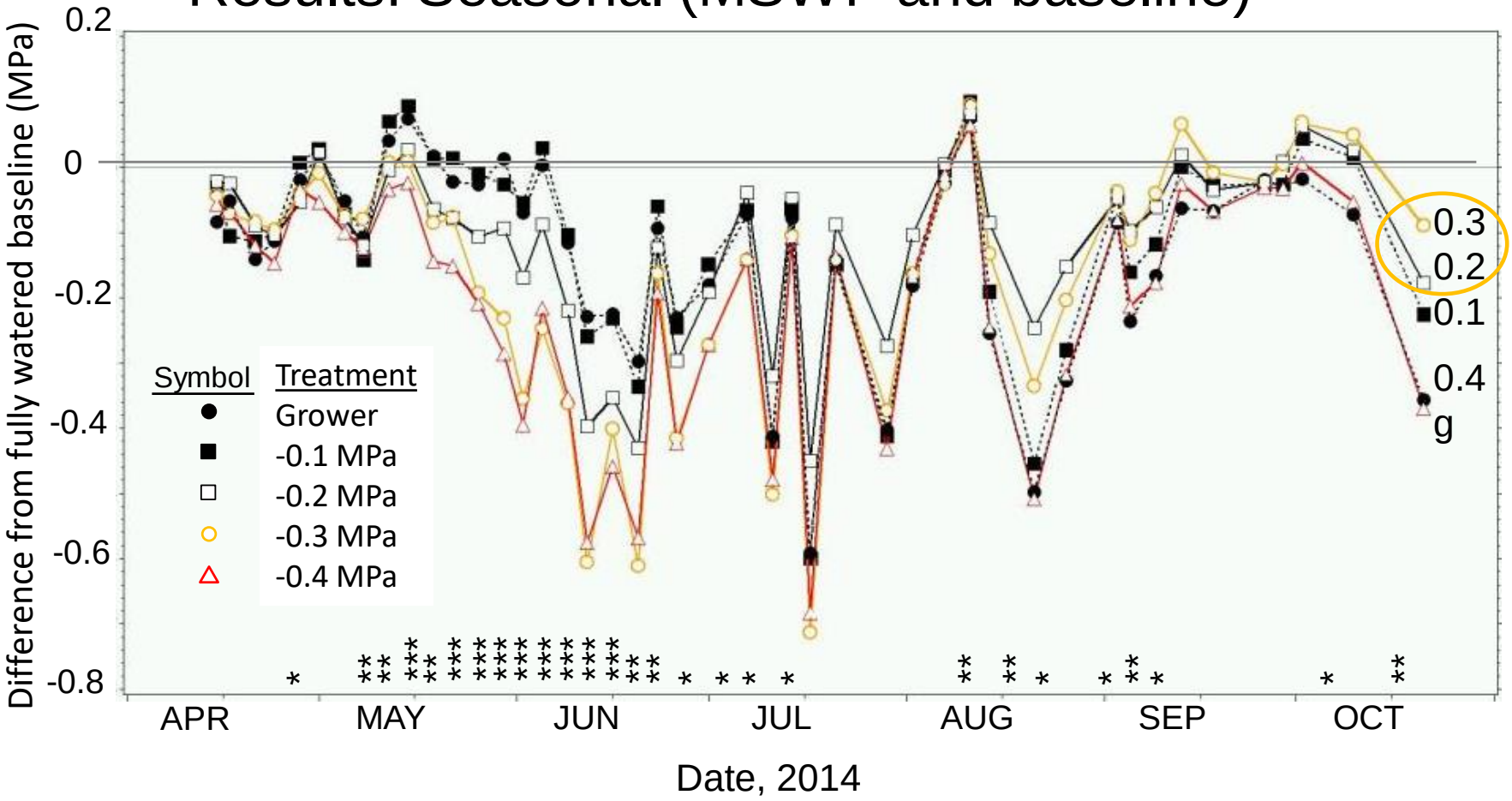


2018 Yields, nut weight, and PAR

As in previous years, the only statistical separation between treatments was in nut weight.

Treatment	Plot yield (tons/ac)	(% G)	Tree sample nut weight (g)	(% G)	Plot PAR	(% G)	Plot yield/PAR	(% G)
Grower	2.38	(100)	10.70 ab	(100)	83.8	(100)	0.028	(100)
1 bar below	2.43	(103)	10.80 a	(101)	79.7	(95)	0.030	(109)
2 bars below	2.34	(99)	9.89 ab	(92)	82.4	(98)	0.028	(101)
3 bars below	2.33	(99)	9.69 ab	(91)	81.3	(97)	0.029	(102)
4 bars below	2.25	(95)	9.59 b	(90)	81.9	(98)	0.027	(97)

Results: Seasonal (MSWP and baseline)

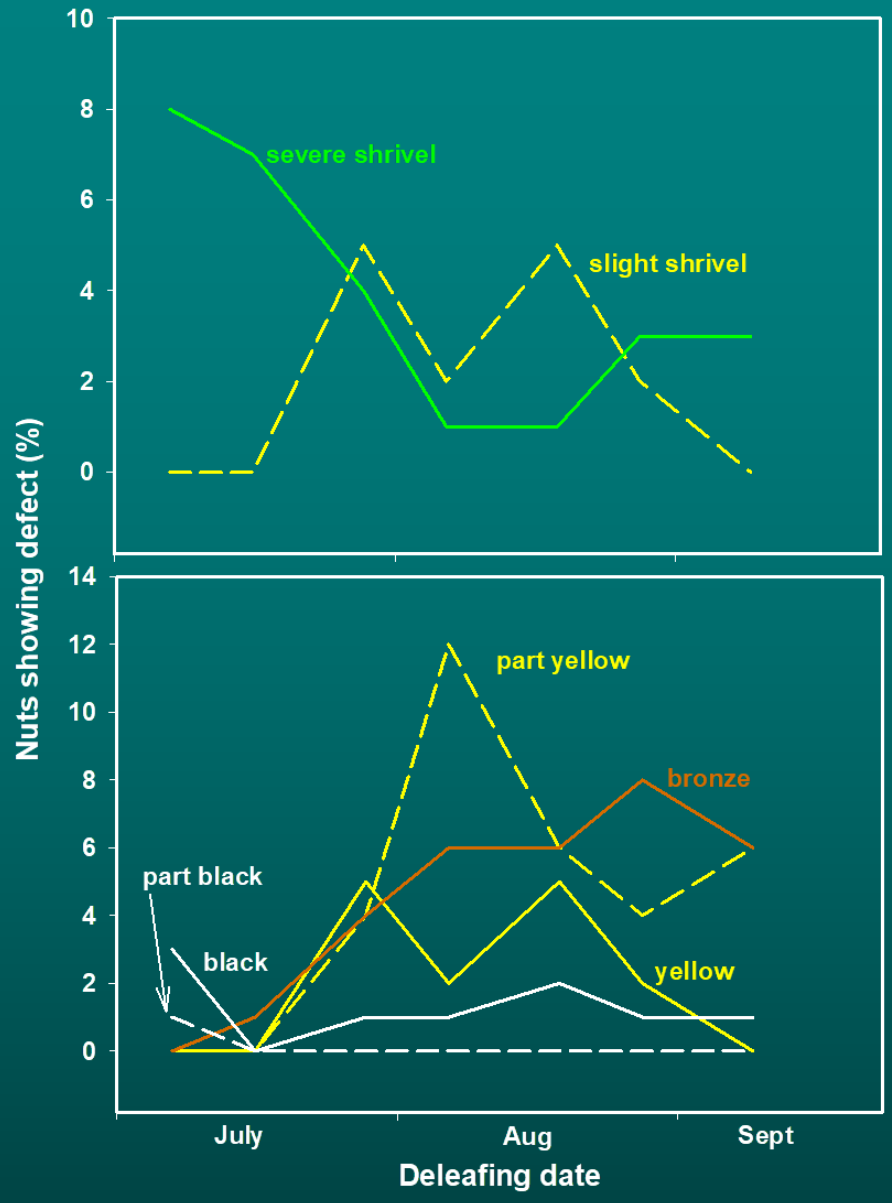


Summary:

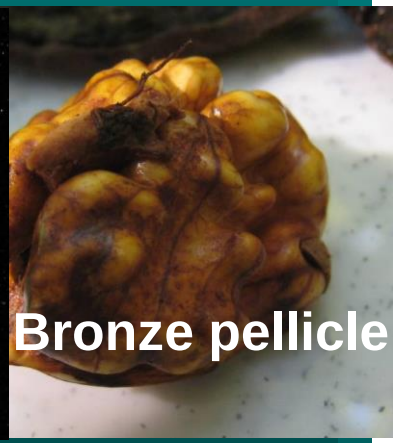
1) This experiment was designed to test whether delaying irrigation in the spring was a good idea that would avoid over-irrigation problems or a bad idea that would cause water stress problems around harvest.
2) It is definitely not a bad idea on this soil in this location, in fact, trees in all delay treatments were less stressed around harvest than the control.
3) Based on grower acceptance it appears to be a good idea, but we have not observed any specific over-irrigation problems that were solved by delaying irrigation.
4) Visually, the grower reports that the delay trees look healthier, so a longer term trial may be needed, although maintaining a “control” treatment in a commercial orchard for this test may be difficult.
5) There is evidence that mild/moderate stress is associated with higher nut load and % edible yield, both of which appear to be key positive factors in orchard economic productivity.

A new trial was initiated on a heavier soil in a commercial walnut orchard in Stanislaus Co. (Patterson, CA).

Quality impacts



Condition	Peak
Thin shell	June
Severe shrivel	early July
Slight shrivel	early Aug
Yellow pellicle	early Aug
Black pellicle	mid- Aug
Bronze pellicle	late Aug/early Sept.



Understanding the role of orchard factors on Amber kernel color and rancidity development (Objective 2)

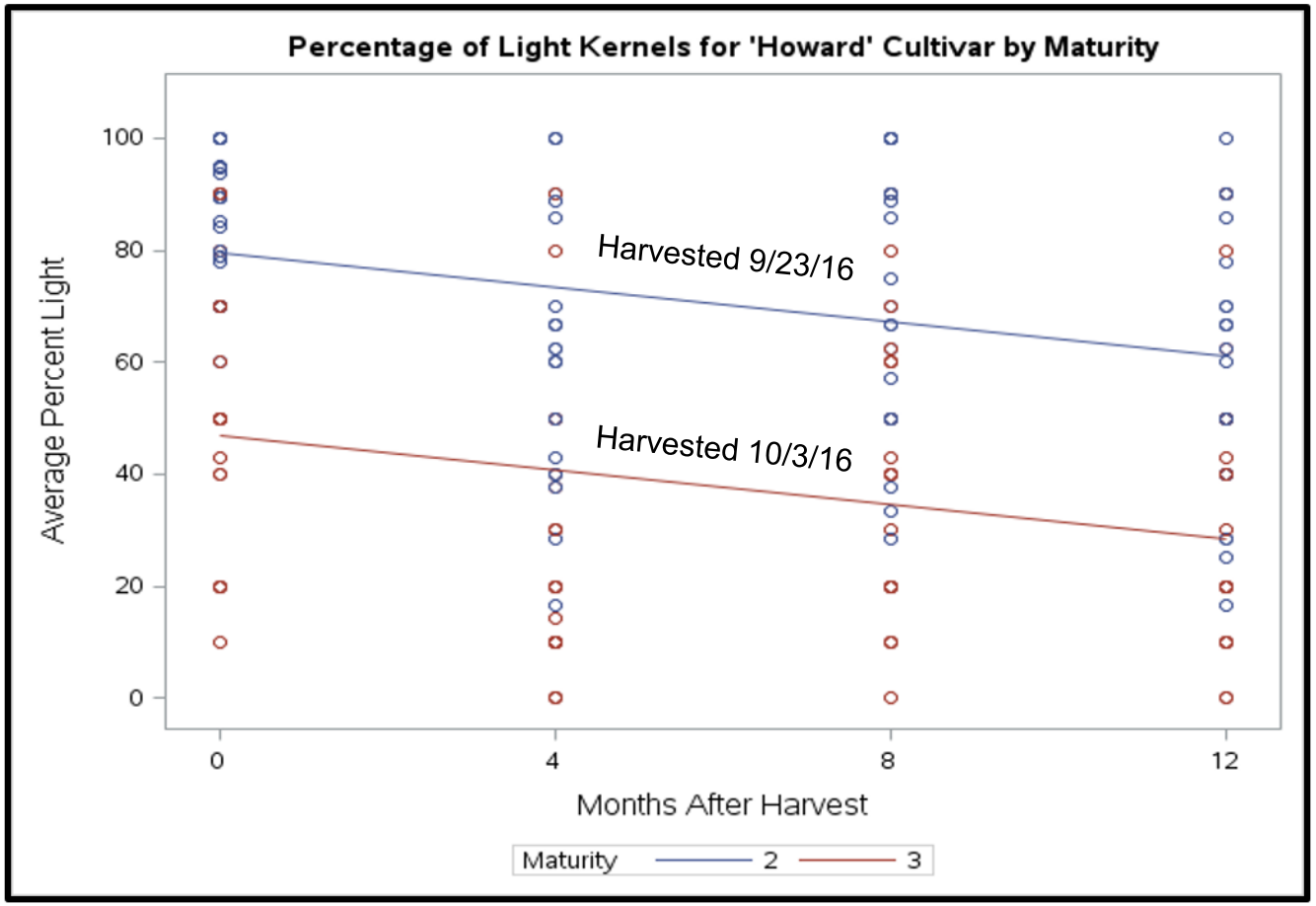
Pomology headquarter

H1-9/23/16
H2-10/03/16

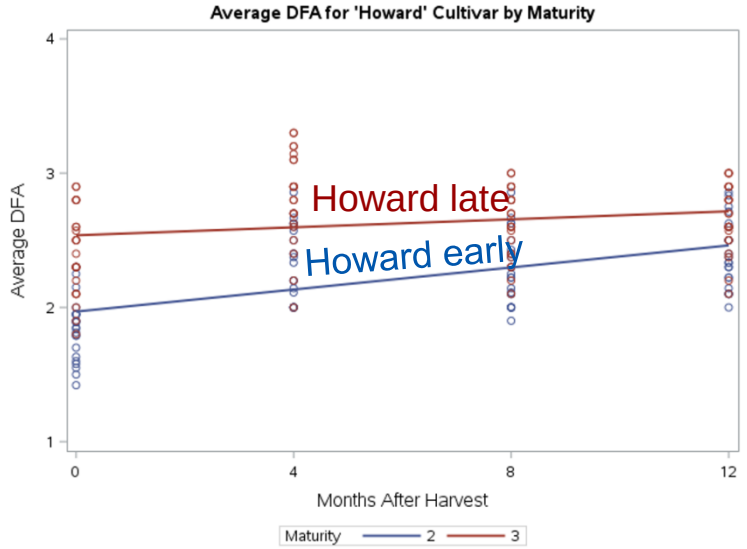
Ch1-10/03/16
Ch2-10/10/16

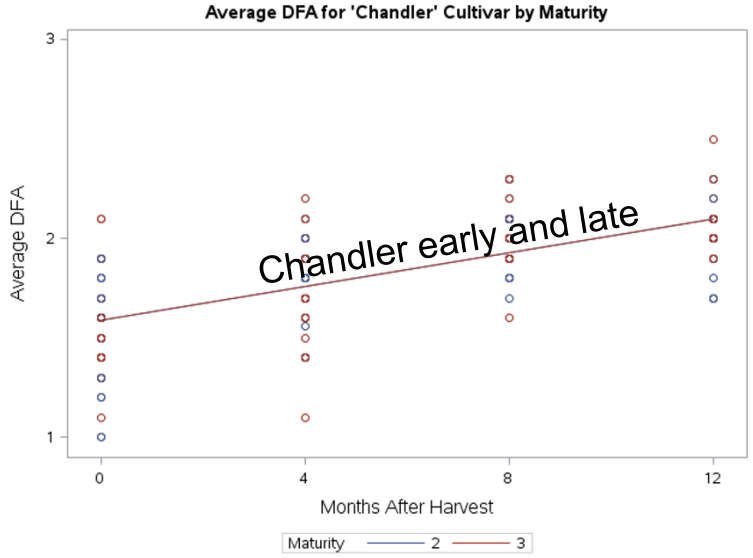
Maturity impact on ‘Howard’ walnut kernel bronzing measured during storage for 12 months (2016)

‘Howard’ Percent E&L by Maturity during storage at 32°F (2016)

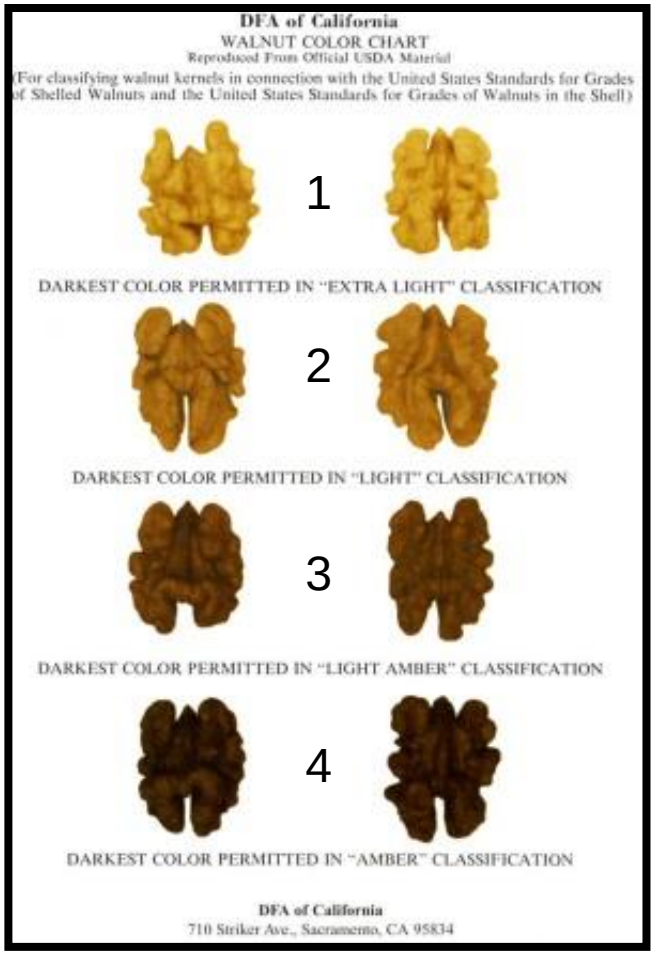


Maturity and irrigation impacts on ‘Howard’ and ‘Chandler’ walnut kernel bronzing over 12 months storage (2016)





Darker pellicle



Effects of preharvest factors on ‘Chandler’ walnut kernel bronzing measured at 2017 harvest

		DFA	Light
Treatment		(1-4)	(%)
Maturity	2	1.8	96.5
	3	2.0	90.6
	P-value	*0.0001*	*0.0129*
Irrigation	Control	1.9	95.4
	Excess	1.9	91.7
	P-value	*0.6699*	*0.1023*
Mat*Irrig	2*Control	1.8	96.7
	2*Excess	1.8	96.3
	3*Control	2.0	94.2
	3*Excess	2.1	87.05
	P-value	*0.4542*	*0.1449*

For Chandler, date of harvest had a significant impact on color in 2017

Effects of preharvest factors on 'Howard' walnut kernel bronzing measured at 2017 harvest

Treatment		DFA	Light
		(1-4)	(%)
Maturity	2=Hull Split	2.1	87.0
	3=HS +Later	2.2	60.4
	P-value	*<0.0001*	*<0.0001*
Irrigation	Control	2.1	81.4
	Excess	2.3	66.0
	P-value	*0.0025*	*0.0011*
Mat*Irrig	2 Control	2.0	90.7
	2 Excess	2.1	83.3
	3 Control	2.2228	72.2
	3 Excess	2.4885	48.7
	P-value	*0.1249*	*0.0734*

For Howard, both date of harvest and irrigation treatment had a significant impact on color (more water and later harvest both mean darker pellicles)

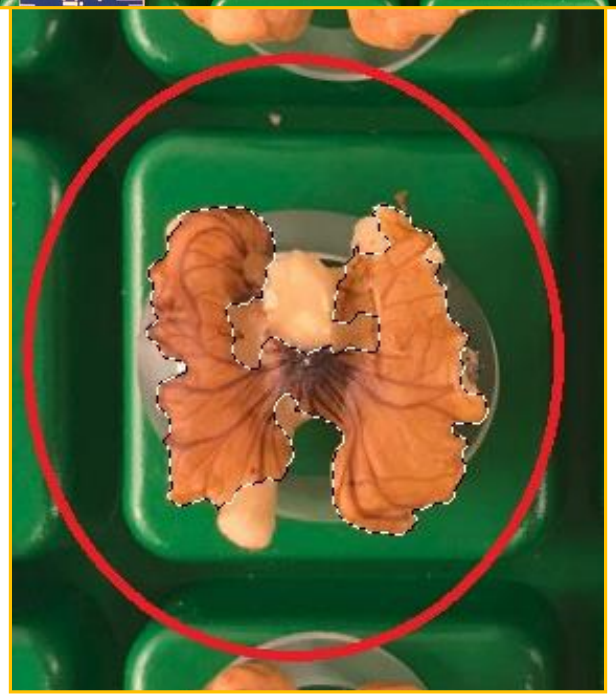
We also did a study looking at variability in quality within trees for the most and least stressed trees

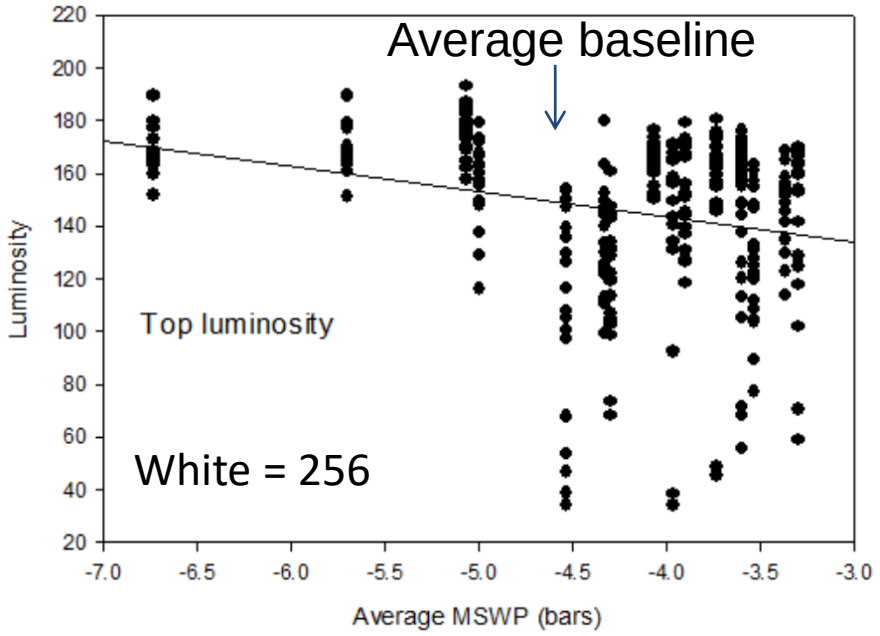
Howard

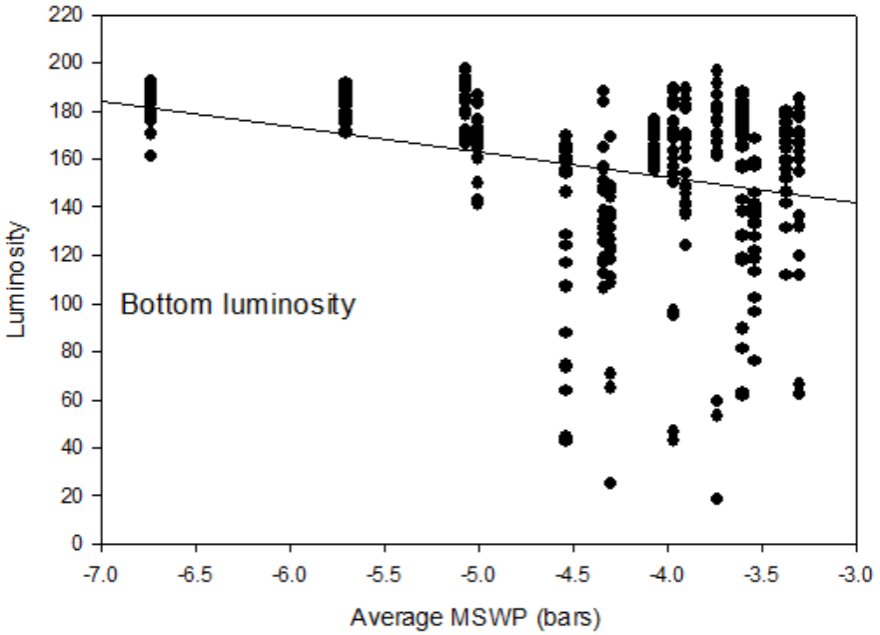
Chandler

We are assessing color with 4 methods

- CDFA color charts
- Minolta colorimeter
- New image analysis system in the Crisosto Lab
- Photoshop image analysis with Lampinen Lab
  - image setup (images shown above)

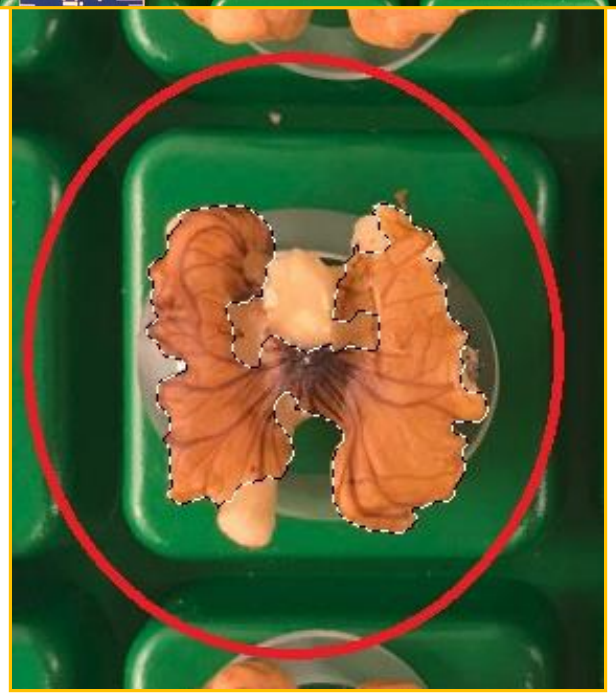


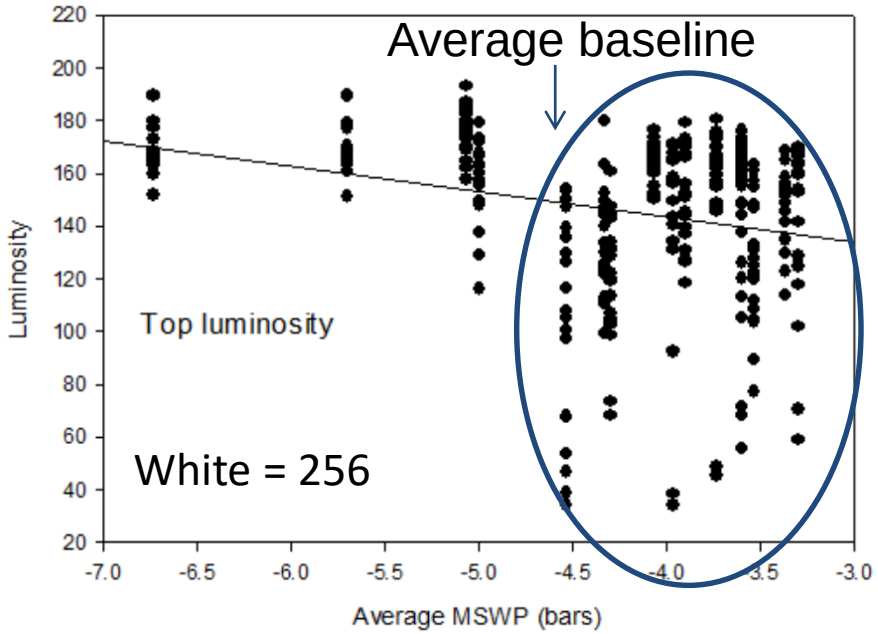


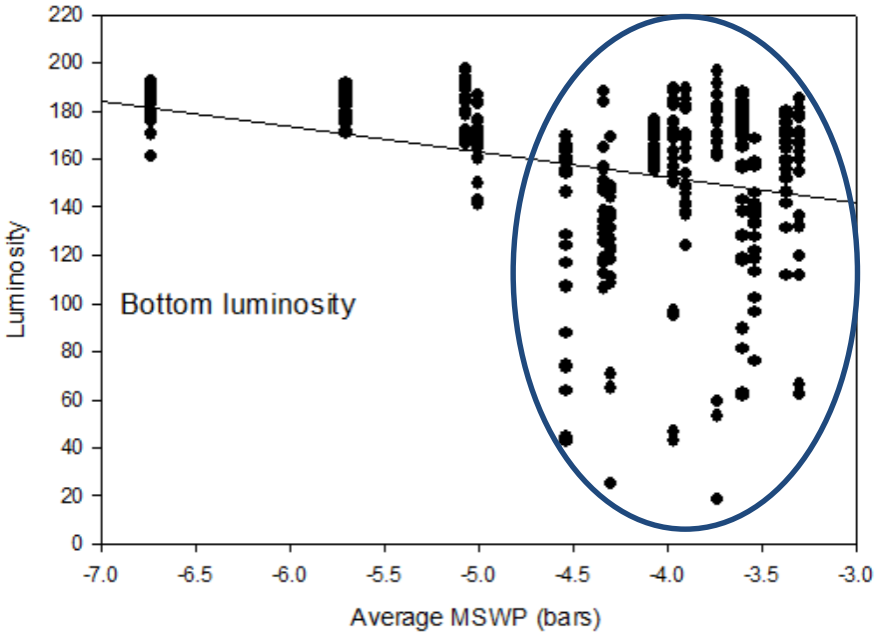


Darker pellicle

wetter

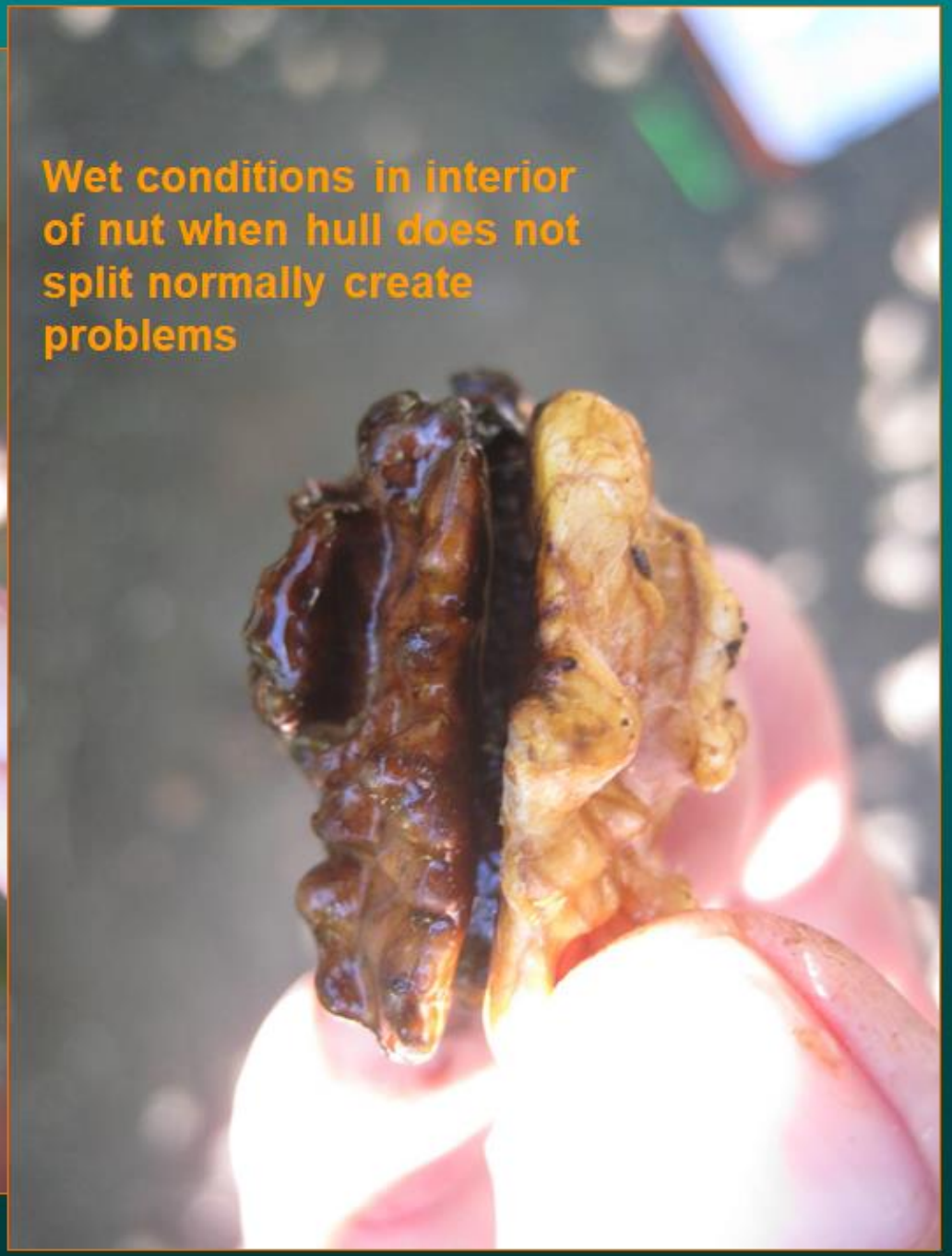






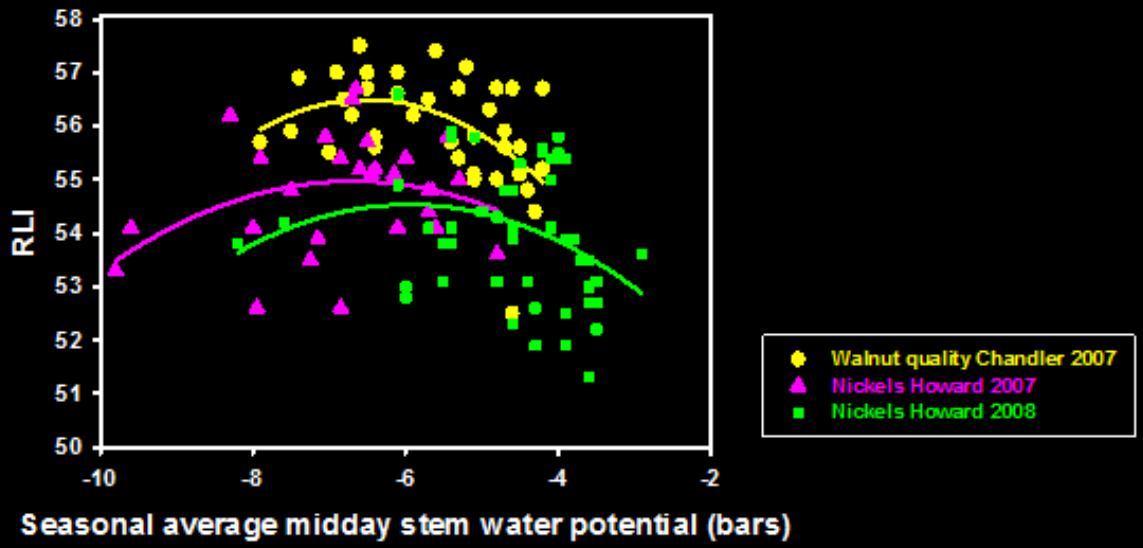
Darker pellicle

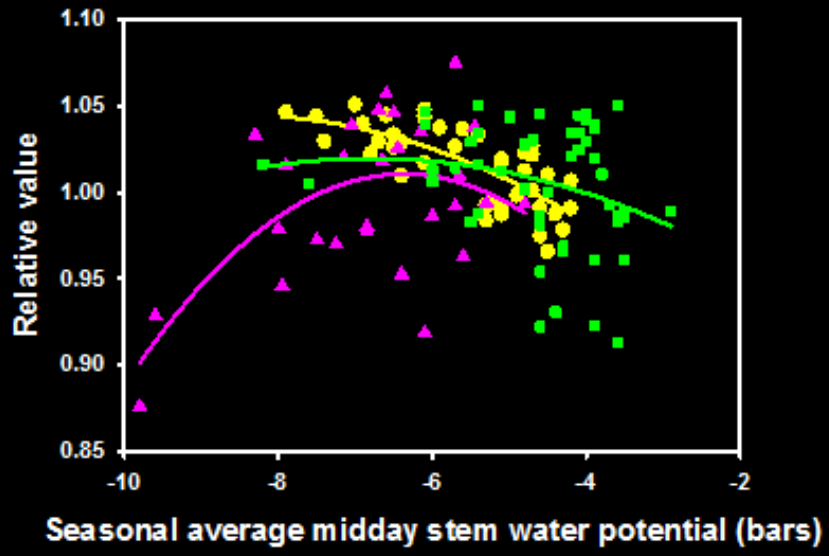
wetter



Nickels Soil Lab Howards 9/30/08

wetter →

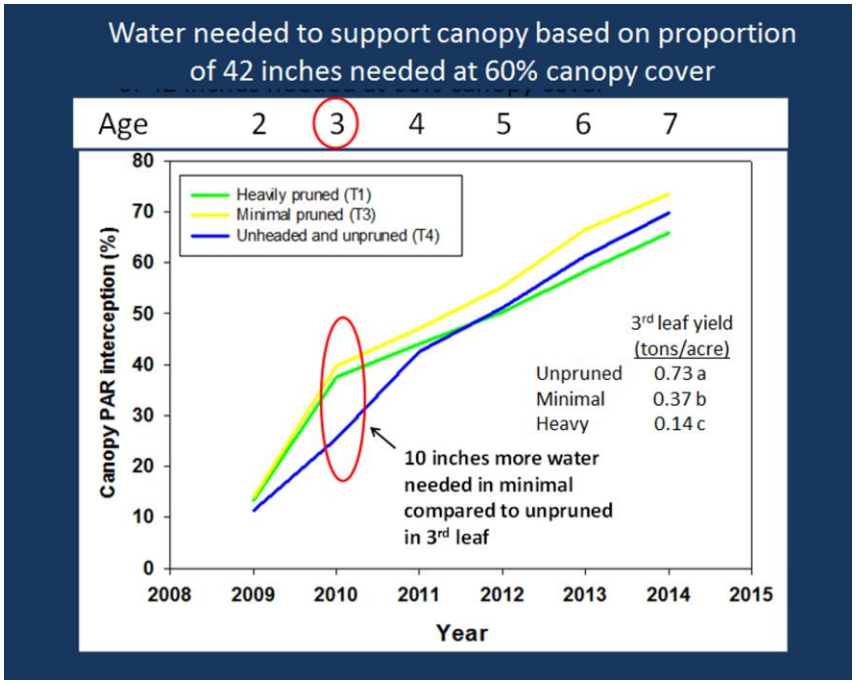

RLI
58
57
56
55
54
53
52
51
50
-10
-8
-6
-4
-2
Seasonal average midday stem water potential (bars)
Walnut quality Chandler 2007
Nickels Howard 2007
Nickels Howard 2008


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)

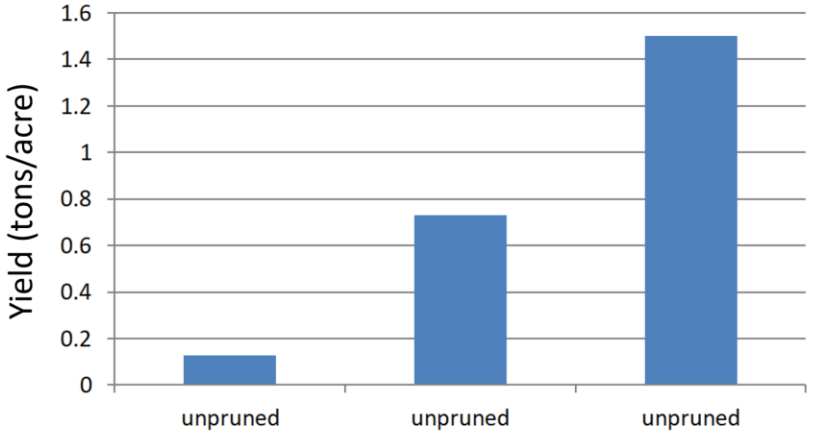
Benefits of improved pruning and water management in a low crop price year

Less pruning- increased water use efficiency in years 1-6

- More crop with less water
- Less costs to dispose of prunings
- Fewer pruning cuts- less disease potential



3rd leaf yield for unpruned treatment in different trials



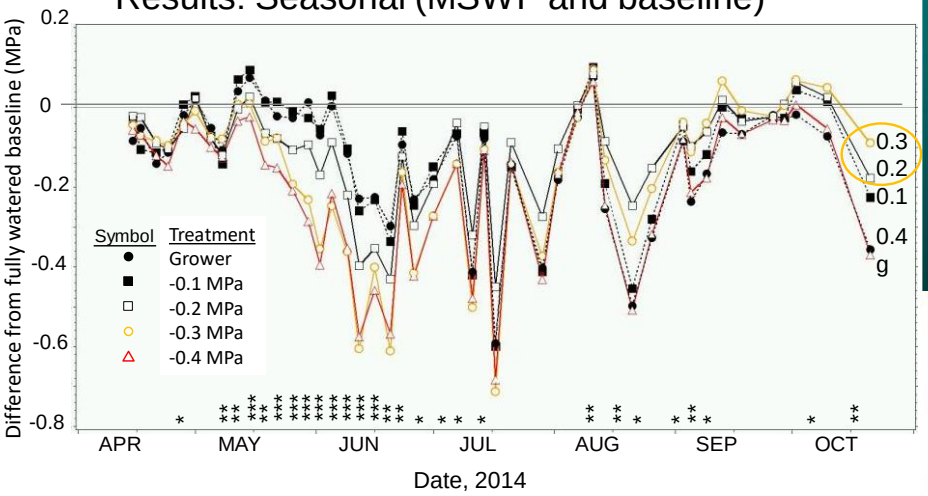
Pruning stopped after 2rd leaf 1st leaf unheaded at planting

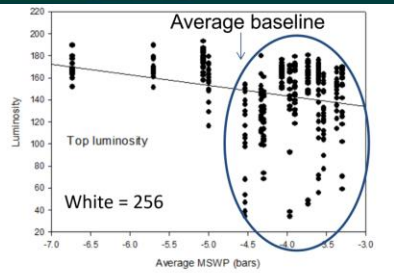
Benefits of improved pruning and water management in a low crop price year

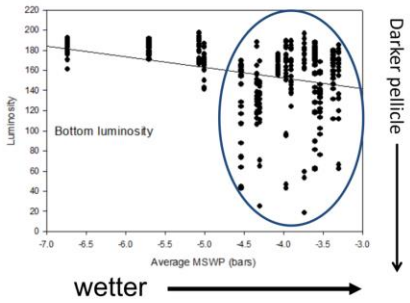
Proper water management during the growing season is beneficial for tree health and monetary returns

- Less stress if trees were irrigated properly early in the season
- Better tree health
- Better kernel fill
- Improved color
- Increased returns

Results: Seasonal (MSWP and baseline)







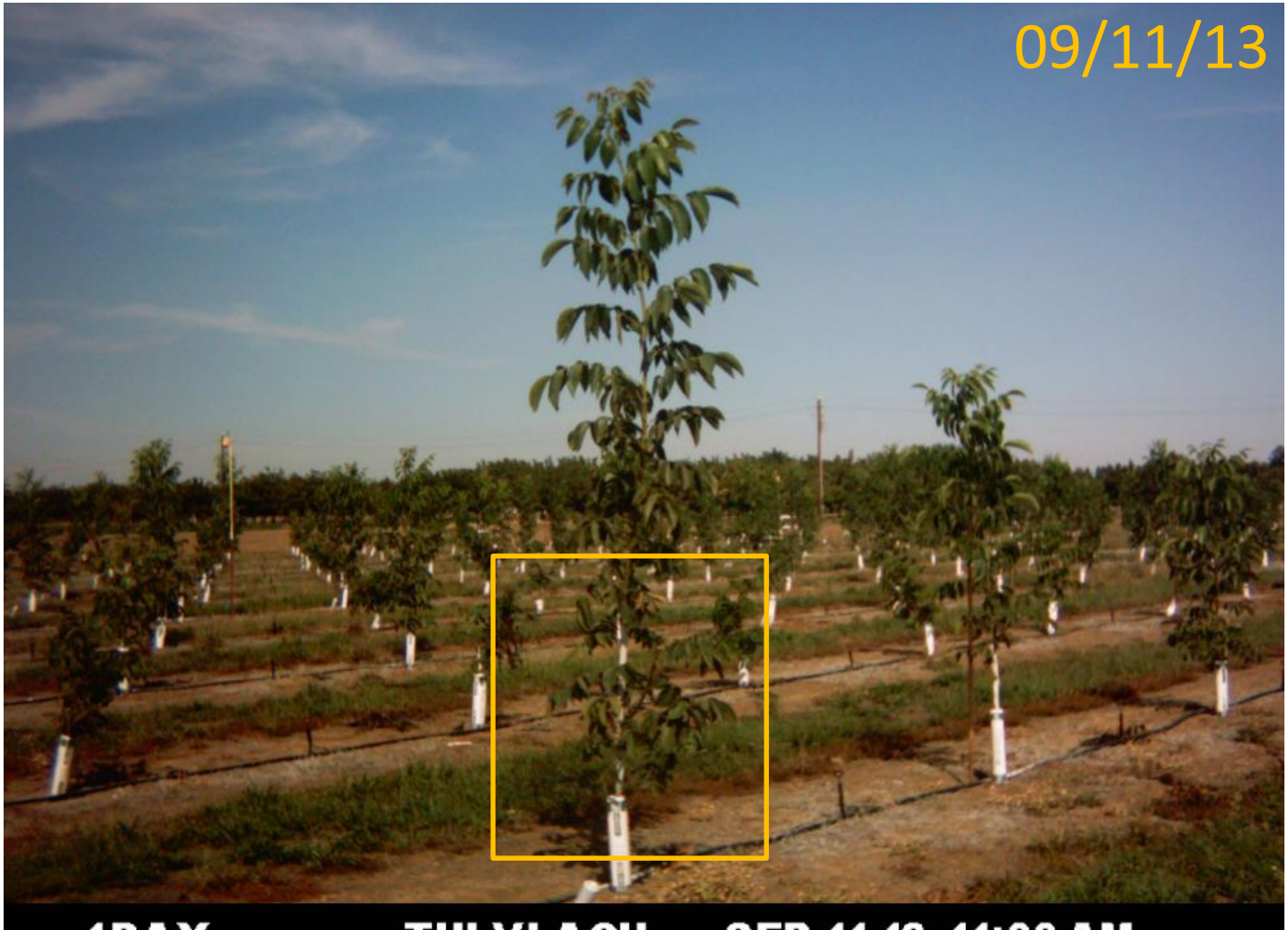
Unheaded Tulare on Vlach

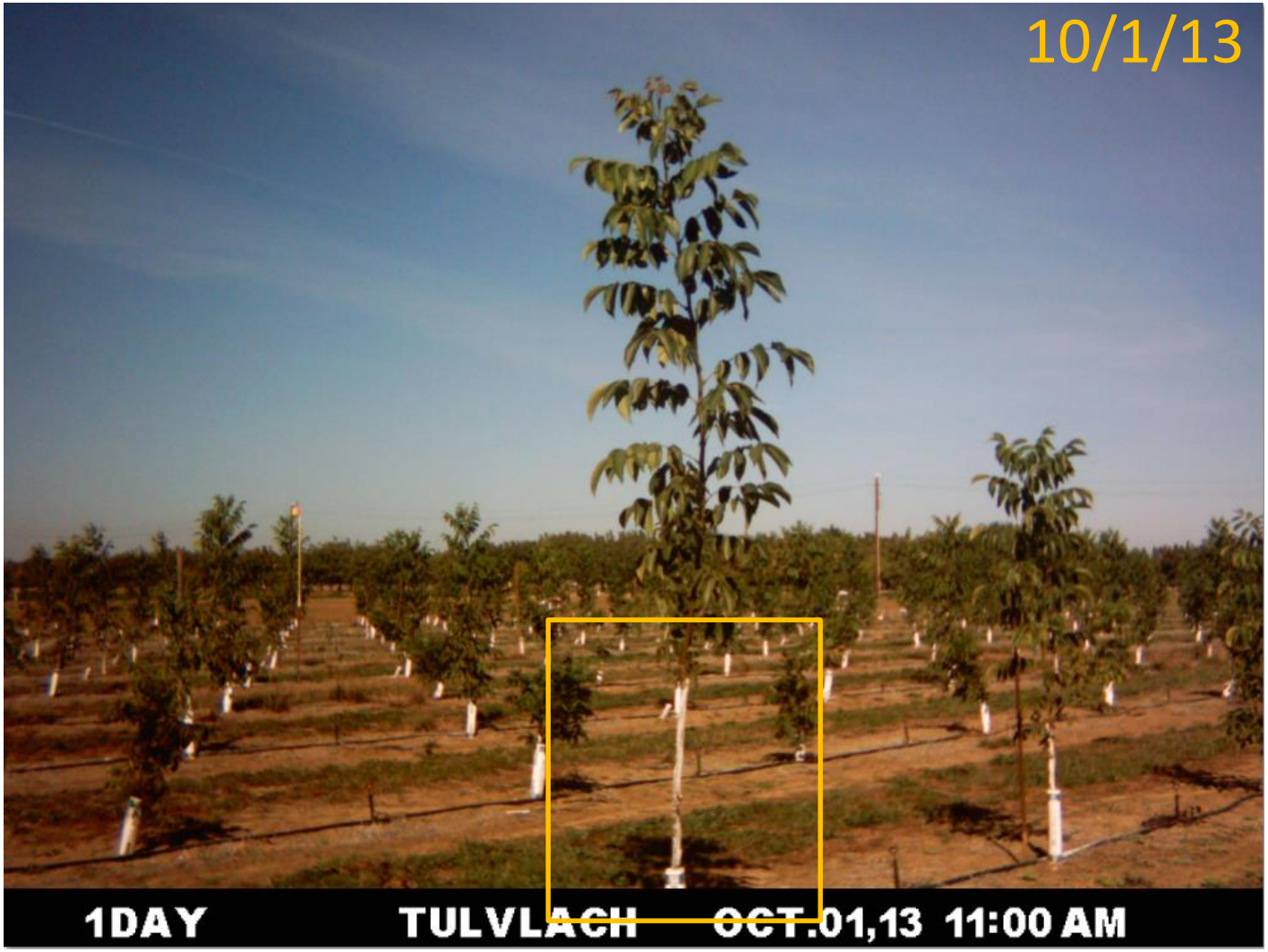
04/10/13

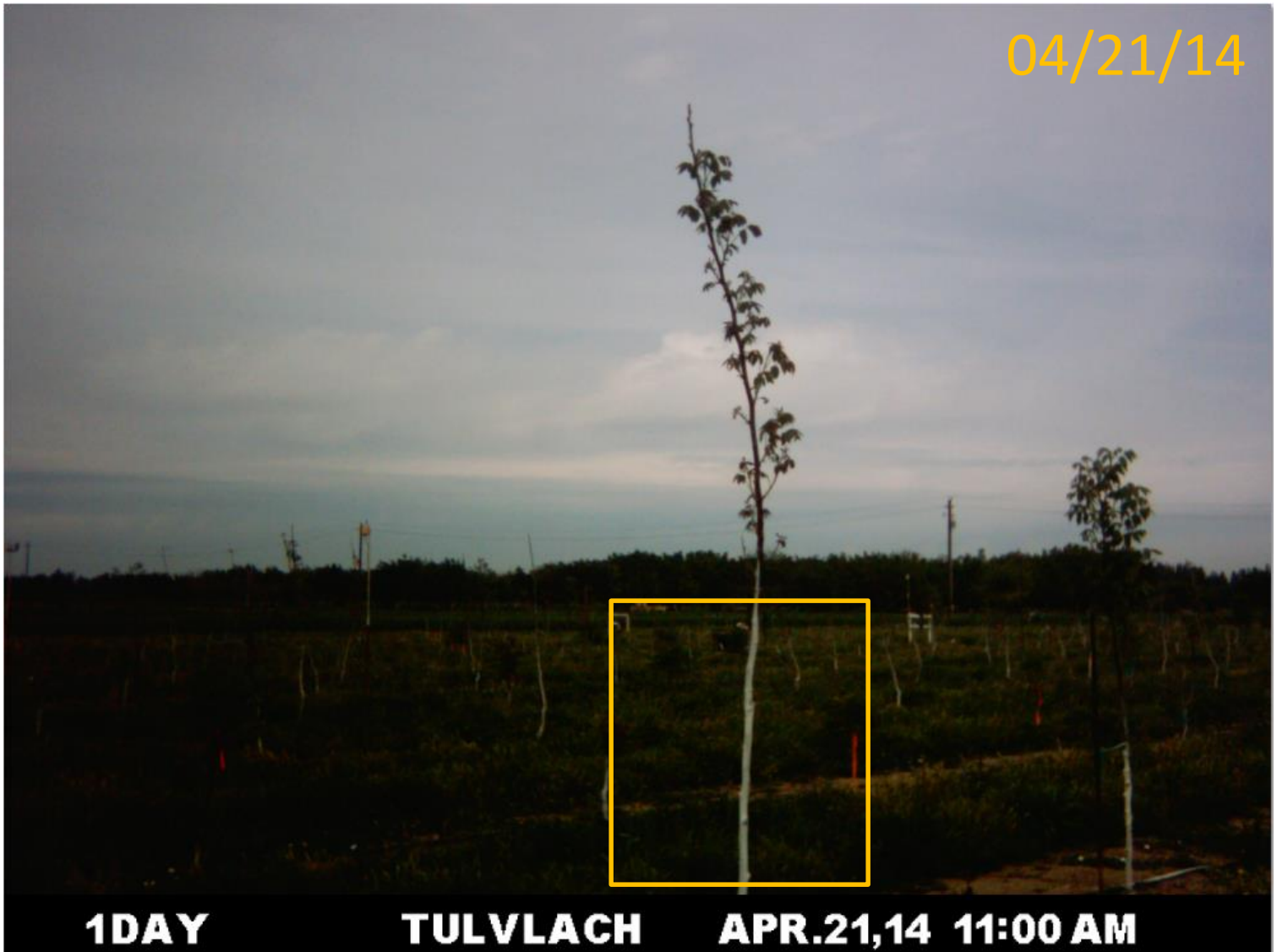

06/10/13

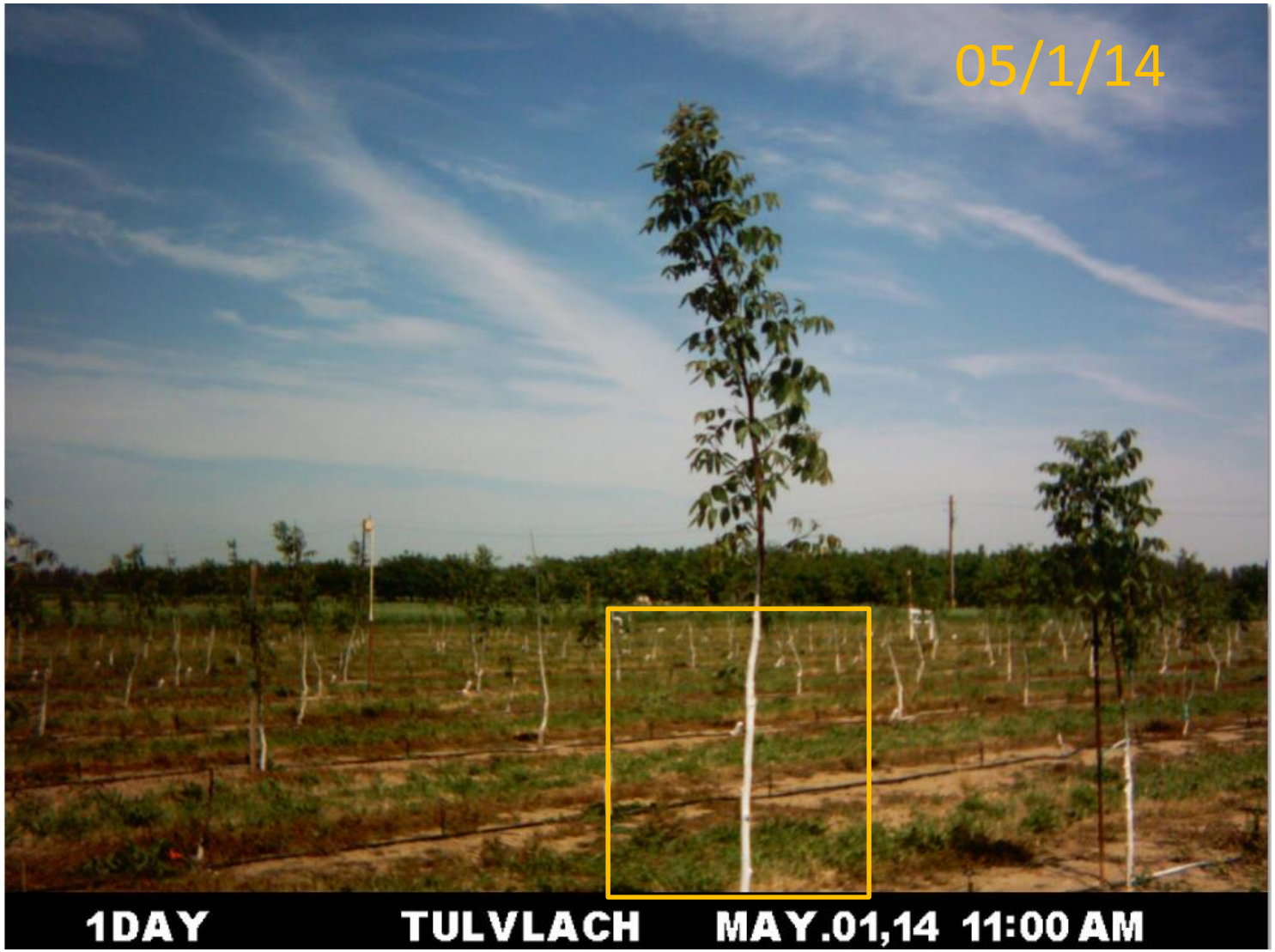

07/10/13

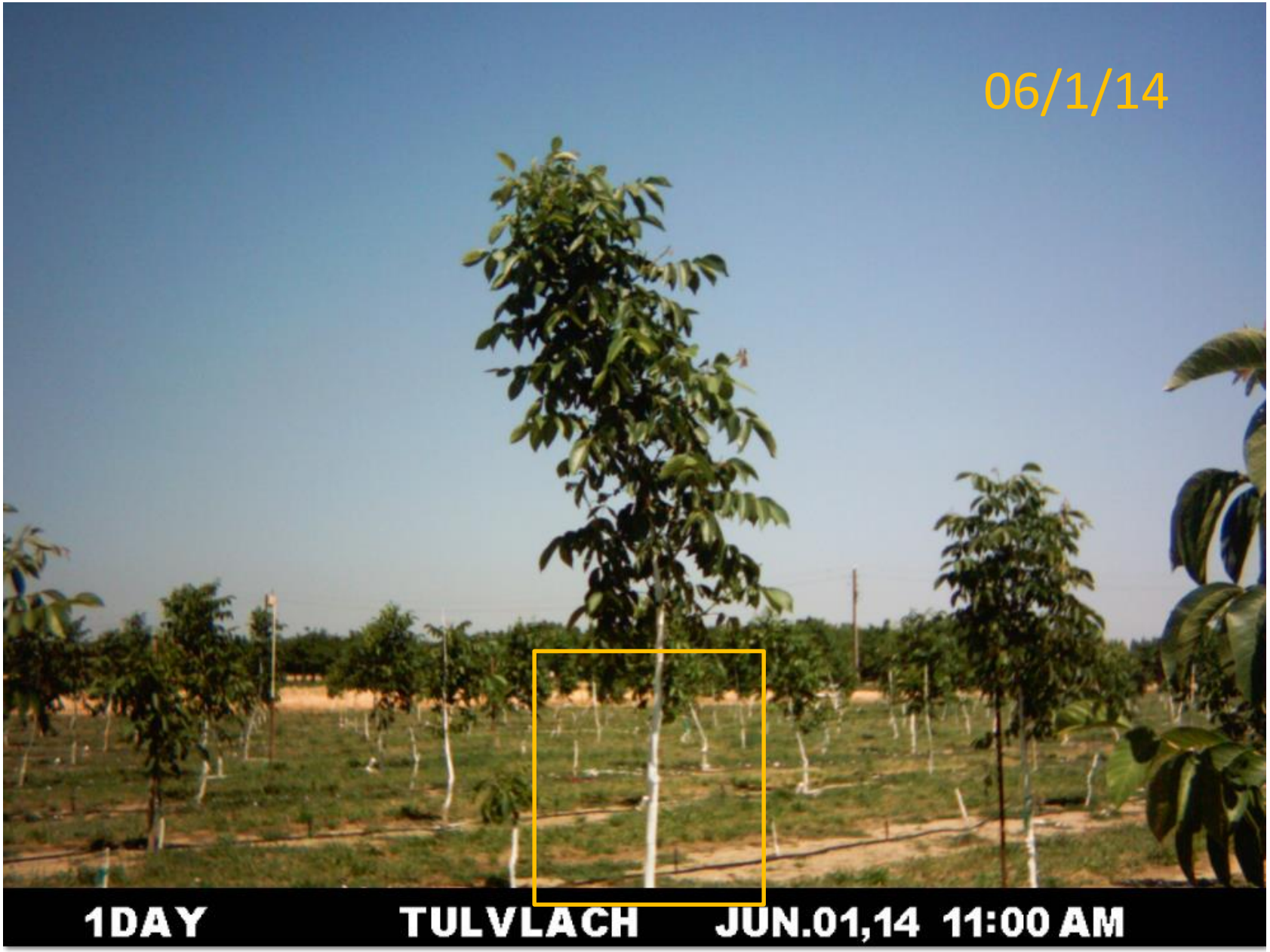

08/10/13

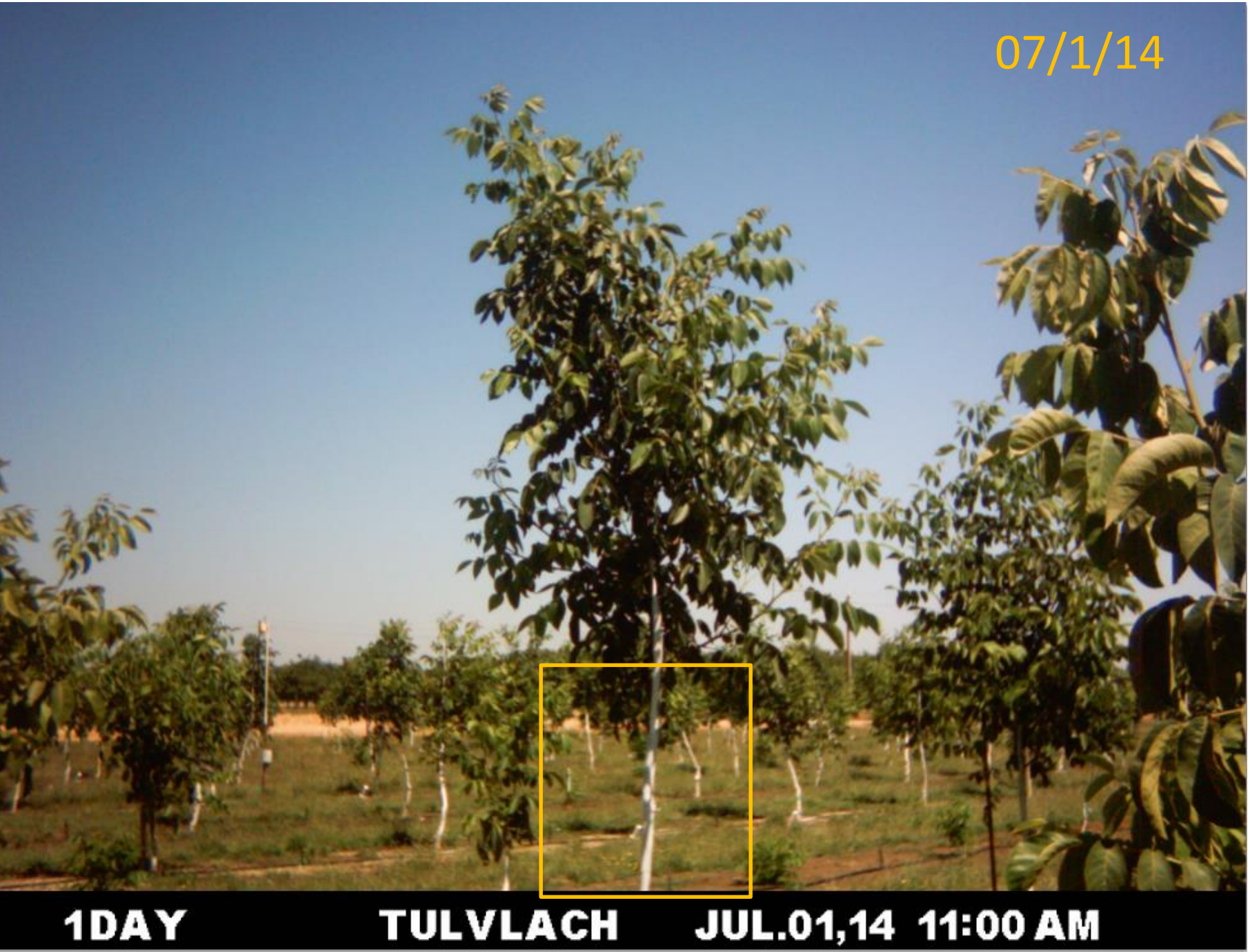

09/11/13

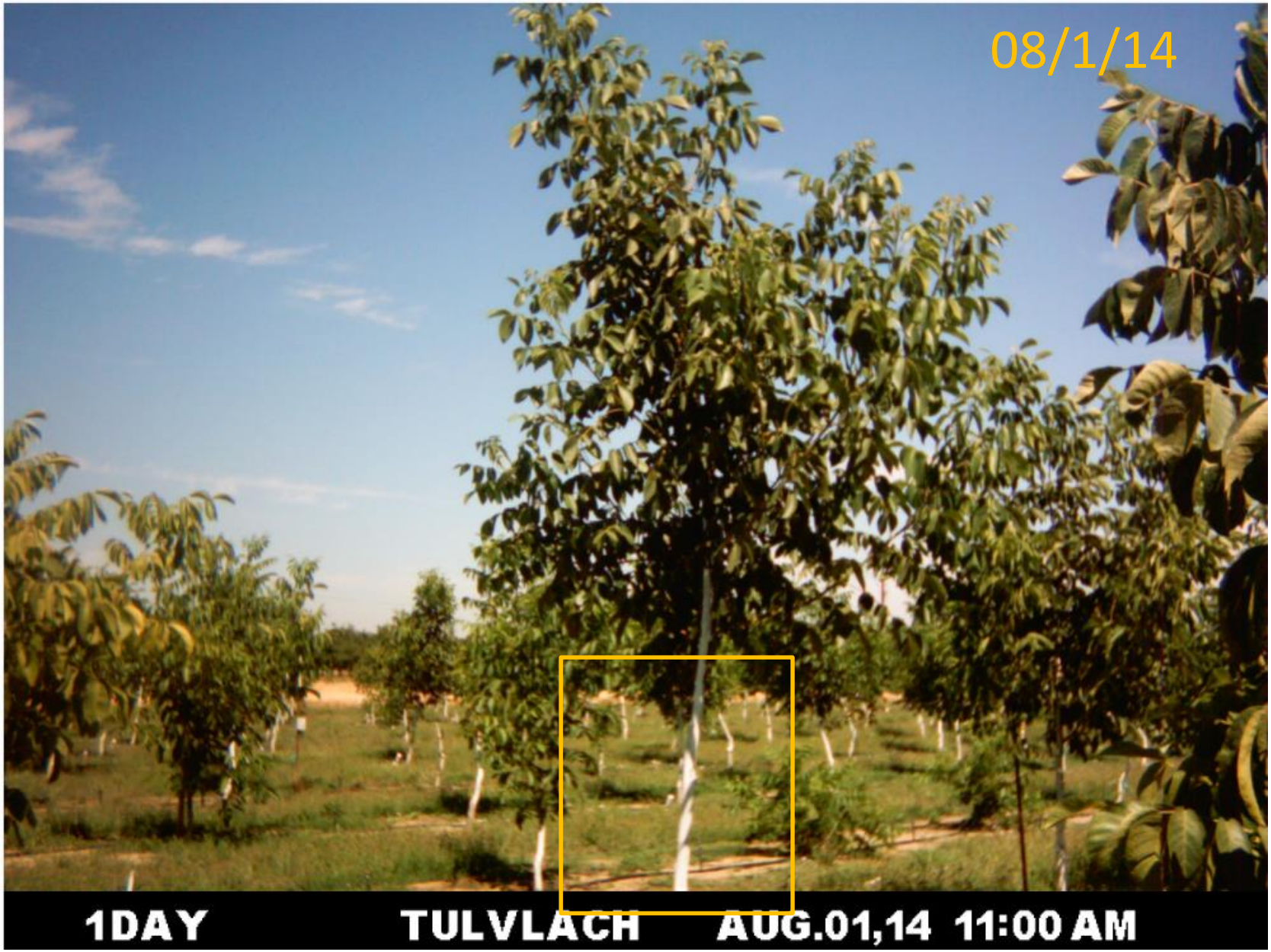

10/1/13
1DAY
TULVLACH
OCT.01,13 11:00 AM


04/21/14
1DAY TULVLACH APR.21,14 11:00 AM

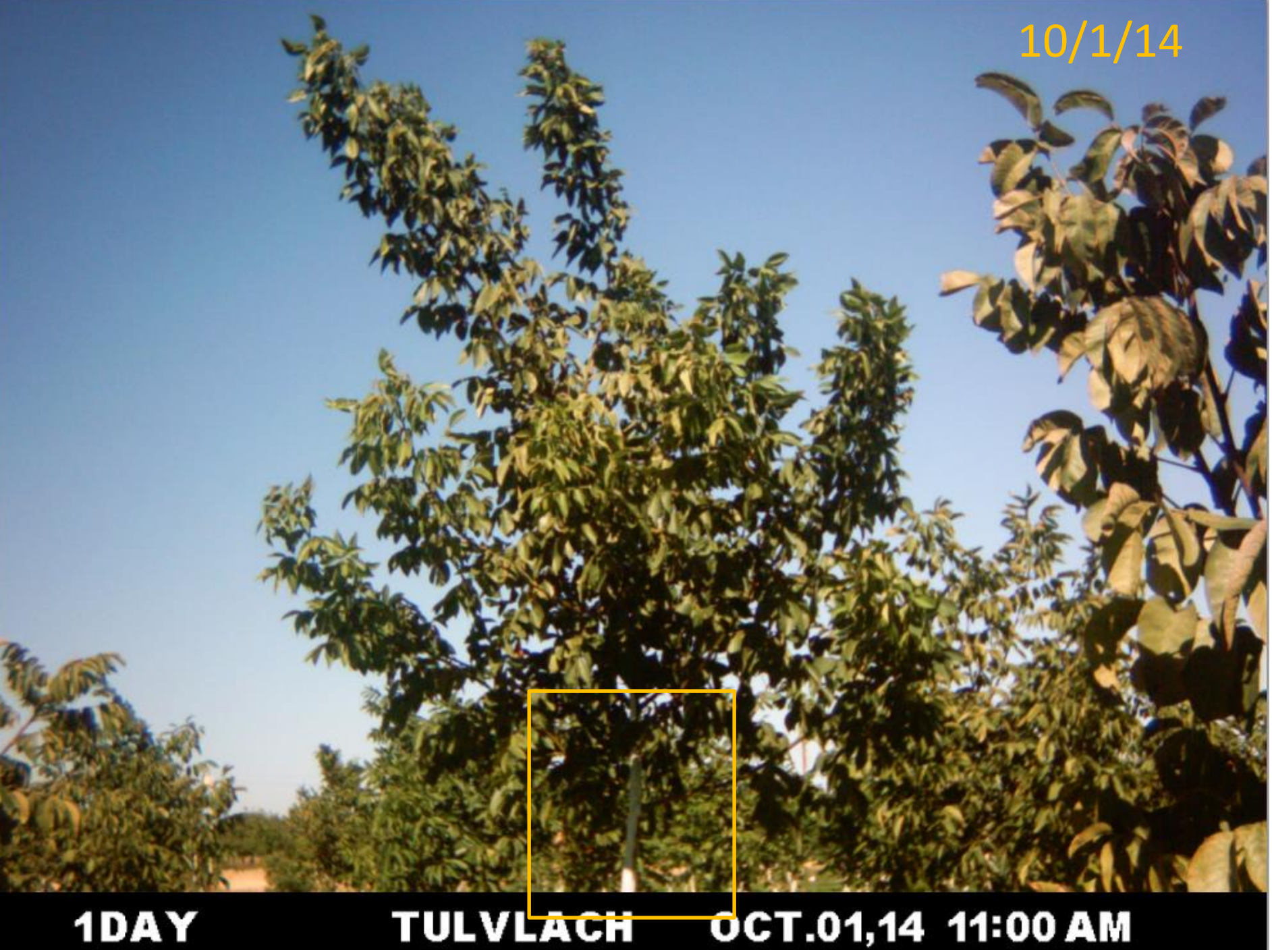

05/1/14
1DAY
TULVLACH
MAY.01,14 11:00 AM


06/1/14
1DAY
TULVLACH
JUN.01,14 11:00 AM


07/1/14
1DAY
TULVLACH
JUL.01,14 11:00 AM


08/1/14
1DAY
TULVLACH
AUG.01,14 11:00 AM


09/1/14
1DAY
TULVLACH
SEP.01,14 11:00 AM


10/1/14
1DAY
TULVLACH
OCT.01,14 11:00 AM


1/3/15
TULVLACH JAN.03,15 11:00 AM


7/25/15


12/15/15


1/15/17


1/22/18

April 2013

Jan 2014

Jan 2015

Jan 2016

Jan 2017

Healthy leaf

Leaf damage symptoms observed only on excessively wet trees

Damage symptoms from excessively wet conditions

Damage symptoms from excessively wet conditions

Damage symptoms from excessively wet conditions


Damage symptoms from excessively wet conditions


Damage symptoms from excessively wet conditions


Damage symptoms from excessively wet conditions


Damage symptoms from excessively wet conditions

Damage symptoms from excessively wet conditions

Damage symptoms from excessively wet conditions

Damage symptoms from excessively wet conditions

Thanks to the California Walnut Board for funding this work

Questions?