Field Evaluation of Almond Varieties

Project No.: 17-Hort2-Lampinen

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Summary:
The next generation Regional Almond Variety Trials were planted in the winter of 2014 in Butte, Stanislaus and Madera counties. Rows of Nonpareil were alternated with 29 varieties and/or selections at all 3 sites. Trees at the Butte, Stanislaus and Madera trial were planted on Krymsk 86, Nemaguard and Hansen 536 rootstocks, respectively, (with the exceptions listed at the bottom of Table 5). Unlike the previous generation Regional Almond Variety Trials, there are four replications of each of the varieties and selections at each of the three sites in the 2014 trials. Bloom overlap of pollenizers with Nonpareil was generally good at all the sites with the exception of UCD 3-40. Yields in 2020 were higher than in past years, primarily due to excellent weather during bloom. Main kernel defects observed in 2020 were doubles, twins, naval orange worm damage, blanks and severe shrivel.

Objective: The objective is to evaluate new almond varieties and selections in replicated trials at three locations in the almond growing areas of California.

Results and discussion:
General observations for each site

Butte.
The average February rainfall in Chico is 4.4 inches but in 2020, no rainfall was measured at the nearest (Durham) CIMIS station. Following excellent bloom density and weather, yields were very high in Chico despite observations of mediocore bee activity. UCD 18-20 which showed some leafing delay and failure symptoms in 2018, displayed these symptoms again in 2020. No bloom or spring foliar diseases were observed in 2020. In the summer of 2018, almond leaf scorch (ALS) was confirmed on Self Fruitful P16.013 and UCD 1-271 by Dr. Lindsey Burbank at USDA-ARS in Parlier. In 2019 ALS symptoms were observed on Self-fruitful P16.013 and Booth. In 2020, ALS symptoms, which in some areas were severe, were observed on all varieties/selections and observed across the field. Because of harvest sequence, irrigation was kept off in the trial for over 1 month (from well before the first shaking of varieties on August 10, until the final pick up on September 11). Because of this extreme drought there was significant defoliation both from water stress and mites by September 11. Mummy counts were highest (averaging

200 nuts per tree or more) in Y117-86-03, Winters, and UCD 7-159, the later two of which never reached 100% hull split before being shaken – likely because of hull-tights induced by the extreme water stress. The extensive early defoliation led to the pushing of new leaves across the orchard in October. Trunk/scaffold cankers (especially band canker) are most prevalent in UCD 7-159, Wood Colony, and Sterling, followed by Folsom, and Nonpareil. The heavy crop and original poor scaffold selection (all scaffolds originating from the same plane) resulted in tree loss in several varieites, most notably in Aldrich. Kester on Hansen and Eddie have had extensive tree loss because of gophers, as well as unknown causes.

Stanislaus.
Bloom weather in 2020 was dry and mild with no rain from start to finish, leading to the best yields in this trial so far. There were no obvious signs of bloom or spring foliar diseases in this trial. Severe hull rot (Rhizopus) on Y121-42-99, Folsom, Kester on Hansen rootstock (but not Nemaguard), and 8-201. Moderate hull rot (mostly Rhizopus) on 8-160, Nonpareil, 1-232, 8-27, and Eddie. *Aspergillus niger* hull rot on 1-232. Overall, growth of trees were better than in past years, although there were widespread signs of moderate leaf chlorosis / mottling presumably from alkaline irrigation water and use of Nemaguard rootstock. Trees on Hansen rootstock were much better. Foliar symptoms of moderate zinc and potassium deficiency were evident in some areas/ varieties which were confirmed by leaf tissue analyses. Leaf samples indicated elevated levels of chloride in the trial.

Madera
Bloom conditions were excellent in 2020, with little to no observed diseases. Due to the extremely high nut set, there was some bending and breaking of upright primary and secondary scaffolds. Several scattered trees have died due to gopher damage that is most likely from previous years, and some of the stressed trees also suffered from shothole borer infestations before succumbing. Hull rot continues to be an issue (Fig. 1), and canopy closure in addition to hull rot is resulting in the loss of some lower limbs on all varieties. Some leaffooted bug and stink bug were observed in the orchard at the end of 2020, and these pests will be monitored for in 2021.

Bloom, Hullsplit, Yield and Quality
2020
Butte- UCD 3-40 bloomed considerably earlier than anything else but it is being removed from data collection since it is too early to serve as a pollinizer in these trials. Bloom was fairly compact at the Butte site in 2020 with only about 6 days of difference between full bloom dates for the earliest versus latest varieties (Fig. 2). Bloom overlap was generally good across all varieties and selections. Hullsplit ranged from July 12th to September 1st in 2020 (Fig. 3). Midday canopy PAR interception ranged from 50 to 83% with Nonpareil coming in at 74% (Table 2). Yield ranged from 1741 kernel pounds per acre for Kester on Hansen to 4659 for Nonpareil (Table 3). Yield per unit PAR intercepted ranged from 28.6 for Kester on Hansen to 63.3 for Aldrich (Table 4). Cumulative yield for the Butte site from 2017-2020 ranged from 4896 for UCD1-271 to 13035 for Nonpareil (Table 5).

Stanislaus- Bloom was also fairly compact with good bloom overlap at the Stanislaus site with full bloom ranging from February 17 to February 22. Hullsplit ranged from July 12 to August 31st at the Stanislaus trial in 2020 (Fig. 3). Midday PAR interception varied from 38.3% for UCD8-160 to 66.9% for Kester on Hansen rootstock (Table 6). Yields ranged from 1453 kernel pounds per acre for Y121-43-99 to 3726 for Kester on Hansen rootstock (Table 7). Yield per unit PAR intercepted was very high for some varieties at this site in 2020 ranging from 27.8 for UCD8-27 to 78.7 for Winters (Table 8). Cumulative yield ranged from 5237 kernel pounds per acre for UCD8-27 to 10,828 for Kester on Hansen (Table 9).

Madera- As at the other two sites, bloom was compact at the Madera site in 2020 with full bloom ranging 8 days from Feb. 17 to Feb. 25 (UCD 3-40 was earlier but it is no longer being monitored in these trials). Hullsplit ranged from July 7 to September 6 (Fig. 2). Midday PAR interception ranged from 56% for UCD8-160 to 89% for Folsom in 2020 (Table 10). Eight varieties had PAR interception greater than 80% which is the maximum we recommend so shading is becoming an issue in this trial. Yields in 2020 ranged from 1799 kernel pounds per acre for UCD1-271 to 5004 kernel pounds per acre for Nonpareil (Table 11). Yield per unit PAR intercepted ranged from 22.1 for UCD1-271 to 61.1 kernel pounds per 1% PAR intercepted for Nonpareil (Table 12). Cumulative yields ranged from 4045 for UCD3-40 to 13,446 kernel pounds per acre for Nonpareil (Table 13). Leaf tissue analysis for the Madera site in 2020 are shown in Table 16.

Average cumulative yield for all three sites averaged ranged from 5465 for UCD1-271 to 11,667 for Nonpareil (Table 14). UCD18-20 which is the second top yielding selection or variety overall also has a large number of doubles every year so this may be problematic. Although yields in all 3 trials were significantly higher in 2020, the values are in the same range as our previous McFarland trial in Kern County and significantly higher than in the previous generation trials (Fig. 4).

Outreach activities:
In January 2021, Luke Milliron gave the talk “Almond Variety Evaluation in the Sacramento Valley” at the UCCE Sacramento Valley Almond Grower Meeting.

Materials and methods:
Regional Almond Variety Trials Planted in 2014
The next generation almond variety trials were planted in the winter of 2014 in Butte (Chico State University), Stanislaus (Salida School District Site), and Madera (Chowchilla grower site) counties. The varieties and selections planted are listed in Table 1. The first 30 items are common to all 3 sites and a few different items added at individual sites are listed at the bottom of Table 1. Trees at the Butte, Stanislaus and Madera trial were planted on Krymsk 86, Nemaguard and Hansen 536 rootstocks respectively (with the exceptions listed at the bottom of Table 1). Trees were planted at a spacing of 18’ x 22’ at the Butte site (110 trees/acre), 16’ x 21’ at the Stanislaus site (130 trees/acre) and 12’ x 21’ at the Madera site (173 trees/acre). These densities are significantly higher than the previous generation RAVTs where planting densities for the Butte, San Joaquin and Kern trials were 64, 75 and 86 trees per acre respectively. Of

the items planted in the main trials, fourteen are either partially or fully self-fertile (Table 1).

Bloom, hullsplit, canopy light interception and yield data collection were initiated in 2016. Bloom data were collected approximately every three days and recorded as onset of bloom, full bloom, and the end of petalfall. Hullsplit was recorded from the beginning of the first non-blank splits to completion of hullsplit.

Publications that emerged from this work:

Gordon, P.; Duncan, R.; Milliron, L.; Lampinen, B. (2020). Field Evaluation of Almond Varieties: A Look at Regional Trial Results through Sixth Leaf. *West Coast Nut*. September 17. http://www.wcngg.com/2020/09/17/field-evaluation-of-almond-varieties/

Gradziel, T.; Milliron, L. (2020). Breeding pt. 3: Almond with Tom Gradziel. *Growing the Valley*. February 18. https://www.growingthevalleypodcast.com/podcastfeed/almond

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Table 1. Varieties and selections planted at the next generation regional almond variety trials. Items 1-29 are planted at all 3 sites while additional material planted at individual sites is listed at the end. Trees at the Butte, Stanislaus and Madera sites were planted on Krymsk 86, Nemaguard and Hansen 536 rootstock respectively (exceptions are noted at bottom of table).

#	Variety or selection	Self-fertile*	Source
1	Eddie		Bright's
2	Capitola		Burchell
3	Supareil		Burchell
4	~~Self-fr P13.019~~***	yes	Burchell
5	~~Self-fr P16.013~~***	yes	Burchell
6	Booth		Burchell
7	Sterling		Burchell
8	Bennett		Duarte
9	Nonpareil		Fowler
10	Durango		Fowler
11	Jenette		Fowler
12	Aldrich		Fowler
13	Winters	partial	UCD
14	Sweetheart	partial	UCD
15	Kester (2-19E)*		UCD
16	UCD3-40***		UCD
17	UCD18-20		UCD
18	UCD1-16		UCD
19	UCD8-160	yes	UCD
20	UCD8-27	yes	UCD
21	UCD1-271	yes	UCD
22	UCD1-232	yes	UCD
23	UCD7-159	yes	UCD
24	UCD8-201	yes	UCD
25	Y121-42-99	yes	USDA
26	Y117-86-03	yes	USDA
27	Yorizane (Y116-161-99)**	yes	USDA
28	Y117-91-03	yes	USDA
29	Folsom		Wilson
30	Wood Colony on Kyrmsk 86 (Butte site ony)		
31	Wood Colony on Nemaguard (Madera site only planted one year later after Lone Star was removed)		

*Kester was planted at all three sites on the usual rootstock for the site. In addition, at the Butte and Stanislaus sites it was also planted in the replicated trial on Hansen 536 rootstock.
**Y116-161-99 was released as Yorizane in 2020
***Self-fruitful P16.013 and Self-fruitful P13.019 were eliminated from data collection in 2020 since they have been dropped by the nursery that developed them.

Table 2. 2020 canopy PAR interception for Butte County.

	#reps	Variety or selection	PAR interception (%)	
Butte	4	Supareil	82.7	a
	4	Capitola	78.3	a b
	4	Sweetheart	75.0	a b c
	4	Folsom	74.6	a b c d
	4	UCD18-20	74.6	a b c d
	4	Kester	74.5	a b c d
	4	Nonpareil	74.1	a b c d
	4	Booth	73.8	a b c d
	4	Winters	73.6	a b c d
	4	Y117-91-03	73.3	a b c d e
	4	UCD3-40	72.6	a b c d e
	4	UCD1-16	72.1	a b c d e
	4	Durango	71.3	a b c d e f
	4	UCD8-27	71.2	a b c d e f
	4	Sterling	68.9	b c d e f g
	4	Y117-86-03	68.9	b c d e f g
	4	Aldrich	68.8	b c d e f g
	4	Bennett	68.0	b c d e f g h
	4	Eddie	63.9	c d e f g h
	4	UCD8-201	62.8	c d e f g h
	4	UCD1-232	62.6	c d e f g h
	4	UCD7-159	61.9	d e f g h
	4	Jenette	61.6	d e f g h i
	4	Kester/Hansen	60.7	e f g h i
	4	Yorizane	59.2	f g h i
	4	UCD1-271	56.7	g h i
	4	Wood Colony	55.7	h i
	4	UCD8-160	49.7	i

Table 3. 2020 yield for Butte County.

Butte

#reps	Variety or selection	2020 Yield (kernel lbs/ac)											
4	Nonpareil	4573	a										
4	Aldrich	4353	a	b									
4	Capitola	4116	a	b	c								
4	Durango	3756		b	c	d							
4	Winters	3756		b	c	d							
4	UCD18-20	3746		b	c	d							
4	Booth	3576			c	d	e						
4	UCD7-159	3495			c	d	e	f					
4	Y117-91-03	3423			c	d	e	f					
4	Jenette	3367			c	d	e	f	g				
4	UCD1-16	3336				d	e	f	g	h			
4	Sweetheart	3300				d	e	f	g	h			
4	Wood Colony	3300				d	e	f	g	h			
4	Bennett	3233				d	e	f	g	h			
4	Yorizane	3229				d	e	f	g	h			
4	Sterling	3156				d	e	f	g	h	i		
4	Supareil	3154				d	e	f	g	h	I		
4	UCD8-201	3046				d	e	f	g	h	i	j	
4	Kester	2998				d	e	f	g	h	i	j	
4	UCD1-232	2900					e	f	g	h	i	j	
4	Folsom	2898					e	f	g	h	i	j	
4	Y117-86-03	2753						f	g	h	i	j	
4	Eddie	2595							g	h	i	j	
4	UCD8-160	2567							g	h	i	j	
4	UCD3-40	2543								h	i	j	
4	UCD1-271	2415									i	j	k
4	UCD8-27	2358										j	k
4	Kester/Hansen	1735											k

Table 4. 2020 yield per unit light intercepted for Butte County.

	#reps	Variety or selection	Yield per unit PAR intercepted	
Butte	4	Aldrich	63.3	a
	4	Nonpareil	61.7	a b
	4	Wood Colony	59.0	a b c
	4	UCD7-159	56.6	a b c d
	4	Jenette	54.8	b c d e
	4	Yorizane	54.6	b c d e f
	4	Durango	52.5	c d e f g
	4	Capitola	52.4	c d e f g
	4	UCD8-160	51.7	c d e f g h
	4	Winters	50.9	c d e f g h
	4	UCD18-20	50.2	c d e f g h
	4	UCD8-201	48.5	c d e f g h i
	4	Booth	48.5	d e f g h i
	4	Bennett	47.7	d e f g h i j
	4	Y117-91-03	46.8	d e f g h i j k
	4	UCD1-16	46.3	e f g h i j k
	4	UCD1-232	46.3	e f g h i j k
	4	Sterling	45.6	f g h i j k
	4	Sweetheart	44.0	g h i j k
	4	UCD1-271	42.8	h i j k l
	4	Kester	40.4	i j k l m
	4	Y117-86-03	40.2	i j k l m
	4	Eddie	39.6	i j k l m
	4	Folsom	39.1	j k l m
	4	Supareil	38.1	k l m
	4	UCD3-40	35.1	l m n
	4	UCD8-27	33.2	m n
	4	Kester/Hansen	28.4	n

Table 5. Cumulative yield for Butte County from 2017-2020.

Butte

#reps	Variety or selection	Cumulative yield (kernel lbs/ac)	
4	Nonpareil	12949	a
4	UCD18-20	11412	a b
4	Booth	11312	b
4	Aldrich	10989	b
4	Jenette	10222	b c
4	Y117-91-03	10103	b c d
4	Durango	9944	b c d
4	Winters	9923	b c d
4	Capitola	9727	b c d e
4	Yorizane	9061	c d e f
4	UCD8-201	8979	c d e f
4	UCD8-160	8694	c d e f g
4	Folsom	8693	c d e f g
4	Kester	8660	c d e f g
4	Wood Colony	8654	c d e f g
4	Bennett	8660	c d e f g
4	Y117-86-03	8256	d e f g
4	UCD1-232	8181	d e f g
4	UCD1-16	8171	d e f g
4	UCD7-159	7960	e f g
4	Eddie	7908	e f g
4	Sterling	7888	e f g
4	UCD8-27	7438	f g
4	Sweetheart	7429	f g
4	Supareil	6964	g
4	Kester/Hansen	6953	g
4	UCD3-40	6940	g
4	UCD1-271	4887	h

Table 6. PAR interception for Stanislaus site 2020.

	#reps	Variety or selection	PAR interception (%)									
Stanisaus	4	Kester/Hansen	66.9	a								
	4	Sweetheart	64.4	a	b							
	4	Supareil	63.3	a	b	c						
	4	Y117-91-03	60.8	a	b	c	d					
	4	Booth	58.0	a	b	c	d	e				
	4	Eddie	57.4	a	b	c	d	e	f			
	4	UCD3-40	55.5	a	b	c	d	e	f	g		
	4	Capitola	54.6		b	c	d	e	f	g		
	4	Sterling	54.2		b	c	d	e	f	g	h	
	4	UCD8-27	53.4		b	c	d	e	f	g	h	
	4	Kester	51.2		b	c	d	e	f	g	h	i
	4	UCD18-20	51.1		b	c	d	e	f	g	h	i
	4	Folsom	50.5			c	d	e	f	g	h	i
	4	Bennett	50.3				d	e	f	g	h	i
	4	Nonpareil	49.2				d	e	f	g	h	i
	4	Jenette	48.7				d	e	f	g	h	i
	4	UCD1-271	48.0				d	e	f	g	h	i
	4	UCD8-201	47.0				d	e	f	g	h	i
	4	Aldrich	46.5					e	f	g	h	i
	4	Durango	46.2					e	f	g	h	i
	4	UCD1-16	45.0						f	g	h	i
	4	UCD1-232	44.1						f	g	h	i
	4	Y121-42-99	43.9						f	g	h	i
	4	UCD7-159	43.8							g	h	i
	4	Yorizane	42.5							g	h	i
	4	Y117-86-03	41.9							g	h	i
	4	Winters	40.3								h	i
	4	UCD8-160	38.3									i

Table 7. 2020 yield for the Stanislaus site.

Stanislaus

#reps	Variety or selection	2020 Yield (kernel lbs/ac)	
4	Kester/Hansen	3703	a
4	Nonpareil	3521	a b
4	Aldrich	3098	a b c
4	Capitola	3036	a b c d
4	Y117-91-03	3009	a b c d
3	Bennett	2978	a b c d
4	Durango	2879	b c d e
4	Eddie	2869	b c d e
4	Supareil	2732	c d e f
4	Booth	2701	c d e f
4	Winters	2671	c d e f
4	UCD7-159	2646	c d e f g
4	UCD18-20	2568	c d e f g
4	Y117-86-03	2531	c d e f g
4	Sweetheart	2525	c d e f g
4	Kester	2375	c d e f g
4	Yorizane	2357	c d e f g
4	Sterling	2350	c d e f g
4	Folsom	2273	d e f g
4	UCD1-16	2268	d e f g
4	UCD1-232	2108	e f g h
4	UCD8-160	2074	f g h
3	UCD8-201	2064	f g h
4	UCD3-40	2012	f g h
4	UCD1-271	1975	f g h
4	Jenette	1889	g h
4	UCD8-27	1403	h i
4	Y121-42-99	1089	i

Table 8. Yield per unit PAR intercepted for Stanislaus site 2020.

	#reps	Variety or selection	Yield per unit PAR intercepted								
Stanislaus	4	Winters	78.1	a							
	4	Nonpareil	77.0	a							
	4	Aldrich	66.9	a	b						
	4	Durango	62.3	a	b	c					
	4	UCD7-159	61.1	a	b	c	d				
	4	Y117-86-03	60.6	a	b	c	d	e			
	3	Bennett	57.3	a	b	c	d	e	f		
	4	Capitola	56.0		b	c	d	e	f		
	4	Kester/Hansen	55.8		b	c	d	e	f		
	4	Yorizane	55.0		b	c	d	e	f		
	4	UCD8-160	54.0		b	c	d	e	f		
	4	Folsom	50.8		b	c	d	e	f	g	
	4	UCD18-20	50.5		b	c	d	e	f	g	
	4	UCD1-16	50.2		b	c	d	e	f	g	
	4	Eddie	50.1		b	c	d	e	f	g	
	4	Y117-91-03	49.5		b	c	d	e	f	g	
	4	UCD1-232	47.3		b	c	d	e	f	g	h
	4	Booth	46.7		b	c	d	e	f	g	h
	4	Kester	46.6		b	c	d	e	f	g	h
	3	UCD8-201	43.8			c	d	e	f	g	h
	4	Sterling	43.5			c	d	e	f	g	h
	4	Supareil	42.9			c	d	e	f	g	h
	4	UCD1-271	41.3			c	d	e	f	g	h
	4	Sweetheart	39.2				d	e	f	g	h
	4	Jenette	38.5					e	f	g	h
	4	UCD3-40	36,4						f	g	h
	4	Y121-42-99	29.5							g	h
	4	UCD8-27	26.2								h

Table 9. Cumulative yield for Stanislaus County from 2016-2020.

Stanislaus

#reps	Variety or selection	Cumulative yield (kernel lbs/ac)	
3	Kester/Hansen	11089	a
3	Y117-91-03	9412	b
4	UCD18-20	9290	b
3	Bennett	8950	b c
4	Nonpareil	8520	b c d
4	UCD8-160	8353	b c d e
4	Aldrich	8162	b c d e f
4	UCD7-159	8129	b c d e f
4	Booth	8103	b c d e f
4	Capitola	8069	b c d e f
4	Kester	7993	b c d e f
3	Durango	7969	b c d e f
4	Yorizane	7965	b c d e f
4	Winters	7887	b c d e f
4	Y117-86-03	7778	b c d e f g
3	Sterling	7490	b c d e f g
4	Eddie	7255	c d e f g
3	UCD8-201	7167	c d e f g
4	UCD1-232	6881	d e f g h
4	Sweetheart	6806	d e f g h
4	Folsom	6684	d e f g h
4	Supareil	6644	d e f g h
4	UCD1-271	6537	d e f g h
4	UCD1-16	6496	e f g h
4	Y121-42-99	6208	e f g h
4	Jenette	6185	f g h
4	UCD3-40	5867	g h
4	UCD8-27	5151	h

Table 10. PAR interception for 2020 season for Madera site.

	#reps	**Variety or selection**	**PAR interception (%)**	
Madera	4	Folsom	89.2	a
	4	Booth	85.9	a b
	4	Supareil	84.8	a b c
	4	Sterling	83.8	a b c d
	4	Eddie	83.2	a b c d e
	4	Capitola	82.2	a b c d e f
	4	Nonpareil	81.8	a b c d e f
	4	UCD1-271	81.8	a b c d e f
	4	Kester	79.9	a b c d e f g
	4	Sweetheart	77.2	a b c d e f g
	4	Aldrich	75.6	a b c d e f g h
	4	UCD3-40	75.4	a b c d e f g h
	4	Durango	74.1	a b c d e f g h
	4	UCD18-20	69.6	a b c d e f g h
	4	Bennett	69.5	a b c d e f g h
	4	Y117-86-03	68.8	a b c d e f g h
	4	Yorizane	67.7	b c d e f g h
	4	UCD8-27	67.7	b c d e f g h
	4	UCD7-159	65.9	c d e f g h
	4	Y117-91-03	63.8	c d e f g h
	4	Jenette	63.5	c d e f g h
	4	Wood Colony	63.2	d e f g h
	4	UCD1-16	62.6	d e f g h
	4	Winters	61.8	e f g h
	4	UCD1-232	60.7	f g h
	4	UCD8-201	59.8	g h
	4	UCD8-160	55.6	h

Table 11. 2020 yield for Madera site in 2020.

	#reps	Variety or selection	2020 Yield (kernel lbs/ac)	
Madera	4	Nonpareil	5004	a
	4	Durango	3535	b
	4	Sterling	3470	b c
	4	Booth	3468	b c
	4	Supareil	3443	b c d
	4	Capitola	3337	b c d e
	4	Aldrich	3171	b c d e f
	4	Jenette	3022	b c d e f g
	4	Y117-86-03	3014	b c d e f g
	4	UCD7-159	2931	b c d e f g h
	4	Yorizane	2839	b c d e f g h i
	4	Kester	2809	b c d e f g h i
	4	UCD8-201	2806	b c d e f g h i
	4	Bennett	2787	c d e f g h i
	4	Eddie	2741	c d e f g h i
	4	Wood Colony	2721	d e f g h i
	4	UCD18-20	2695	e f g h i
	3	Sweetheart	2640	e f g h i
	4	Winters	2618	e f g h i
	4	UCD1-16	2555	f g h i
	4	Folsom	2552	f g h i
	4	UCD8-160	2418	f g h i j
	4	Y117-91-03	2327	g h i j
	4	UCD8-27	2314	g h i j
	4	UCD3-40	2184	h i j
	4	UCD1-232	2143	i j
	4	UCD1-271	1799	j

Table 12. Yield per unit PAR intercepted for Madera site in 2020.

	#reps	Variety or selection	Yield per unit PAR intercepted	
Madera	4	Nonpareil	61.1	a
	4	UCD8-201	50.2	a b
	4	Durango	47.5	b c
	4	Jenette	47.2	b c
	4	Wood Colony	46.9	b c
	4	UCD7-159	45.0	b c d
	4	Yorizane	43.8	b c d
	4	Y117-86-03	43.2	b c d
	4	UCD8-160	41.6	b c d
	4	UCD1-16	40.9	b c d e
	4	Winters	40.3	b c d e
	4	Capitola	40.1	b c d e f
	4	Sterling	39.6	b c d e f
	4	Aldrich	39.5	b c d e f
	4	Booth	39.5	b c d e f
	4	Bennett	39.1	b c d e f
	4	Supareil	38.1	b c d e f
	4	UCD18-20	36.9	b c d e f
	4	Y117-91-03	36.6	c d e f
	4	Kester	34.7	c d e f
	4	UCD1-232	34.7	c d e f
	4	UCD8-27	34.2	c d e f
	3	Sweetheart	34.0	c d e f
	4	Eddie	32.4	d e f g
	4	UCD3-40	27.8	e f g
	4	Folsom	27.0	f g
	4	UCD1-271	21.0	g

Table 13. Cumulative yield for 2016-2020 for Madera site.

	#reps	Variety or selection	Cumulative yield (kernel lbs/ac)	
Madera	4	Nonpareil	13446	a
	3	Yorizane	13021	a b
	4	Y117-86-03	12142	a b c
	4	UCD18-20	12118	a b c d
	4	Capitola	11307	a b c d e
	4	Kester	11260	a b c d e
	4	Booth	11176	a b c d e
	4	Jenette	11078	a b c d e
	4	Y117-91-03	10764	b c d e f
	3	Sweetheart	10372	c d e f g
	4	Bennett	10324	c d e f g
	4	UCD8-201	10148	c d e f g
	4	Eddie	10102	c d e f g
	4	Sterling	10061	c d e f g
	4	Aldrich	9855	c d e f g
	4	Winters	9777	c d e f g
	4	Durango	9699	c d e f g
	4	UCD1-16	9650	c d e f g h
	4	UCD8-160	9416	c d e f g h
	4	Folsom	9368	d e f g h
	4	Supareil	9292	e f g h
	4	UCD8-27	8349	f g h
	4	UCD7-159	7756	g h i
	3	UCD1-232	7034	h i
	4	Wood Colony	5374	i j
	3	UCD1-271	4836	i j
	3	UCD3-40	3940	j

Table 15. Main kernel defects for 2020 harvest. Items are listed if they had 6% or more of kernels exhibiting the defect.

Variety or selection	Cumulative yield (lbs/acre)									
Nonpareil	11638	a								
UCD18-20	10940	a	b							
Booth	10197	a	b	c						
Y117-91-03	10140	a	b	c	d					
Yorizane	9742	a	b	c	d	e				
Capitola	9701	a	b	c	d	e				
Aldrich	9668	a	b	c	d	e				
Kester/Hansen	9647	a	b	c	d	e	f			
Y117-86-03	9392		b	c	d	e	f			
Bennett	9331		b	c	d	e	f			
Durango	9316		b	c	d	e	f			
Winters	9195		b	c	d	e	f			
Jenette	9161		b	c	d	e	f			
UCD8-201	8910		b	c	d	e	f	g		
UCD8-160	8821			c	d	e	f	g		
Sterling	8570			c	d	e	f	g		
Eddie	8422			c	d	e	f	g		
Kester**	8374			c	d	e	f	g		
Folsom	8245			c	d	e	f	g	h	
UCD1-16	8106			c	d	e	f	g	h	
Sweetheart	8005				d	e	f	g	h	
Wood Colony*	7985				d	e	f	g	h	
UCD7-159	7966					e	f	g	h	
Supareil	7723					e	f	g	h	
UCD1-232	7396						f	g	h	i
UCD8-27	7049							g	h	i
Y121-42-99*	6208									i
UCD3-40	5731									i
UCD1-271	5473									i

*Stanislaus site only

**Butte and Madera sites

	Trial					
Varieties with defect	Butte	(%)	Stanislaus	(%)	Madera	(%)
Double kernels	UCD 8-27	51	UCD 8-27	24	UCD 8-27	29
	UCD 8-201	44	UCD 8-201	18	UCD 8-201	23
	UCD 1-16	17	UCD 1-16	12	Y117-86-03	18
	Folsom	16			Booth	16
	UCD18-20	15			UCD 1-16	11
	Booth	15			Folsom	8
	Y117-86-03	14			Capitola	7
	Y117-91-03	12			UCD18-20	7
	UCD1-232	9				
	UCD 8-160	8				
	Wood Colony	7				
	Nonpareil	7				
	Kester	6				
Twin kernels (two kernels within the same pellicle)	UCD 8-27	14	UCD 8-27	15	UCD 8-27	13
	Jenette	11	UCD 8-201	12	UCD1-232	10
	UCD 8-201	9	Supareil	9.5	UCD 8-201	10
	UCD 8-160	9	Sweetheart	9.5	Jenette	8
	UCD1-232	6	UCD 3-40	9	Supareil	8
	Booth	6	Booth	9	UCD 1-16	7
			UCD 8-160	7.5	UCD 3-40	6
			Nonpareil	7		
			Bennett	6		
			Folsom	6		
			Jenette	6		
Navel orange worm damage	UCD1-271	7			UCD1-271	12
	UCD 3-40	6			UCD 7-159	9
					UCD 8-27	7
					Y117-91-03	7
					UCD 3-40	7
					Bennett	6
					Eddie	6
					Winters	6
					Y117-86-03	6
					Supareil	6
Blank kernels	UCD1-232	10	UCD 8-27	7.5		
	UCD 8-27	6	Folsom	6.5		
	Y117-86-03	6				
Chipped/broken			UCD 8-27	7.5	UCD18-20	11
			Winters	7		
			Sterling	6.5		
			UCD 8-160	6		

Varieties with defect	Trial Butte	(%)	Stanislaus	(%)	Madera	(%)
Crease	Jenette	17	Jenette	13		
	Capitola	14	UCD 7-159	10		
	Nonpareil	9	Folsom	8		
	Sterling	8	Capitola	7		
	Y117-86-03	7	Supareil	6.5		
	Folsom	6				
	UCD 7-159	6				
Shrivel	Capitola	14				
	Yorizane	9				
	Supareil	7				
	UCD 8-201	6				
Rupture/callous					UCD1-271	28
					Lonestar	14
					UCD1-232	14
					Eddie	14
					UCD 8-160	11
					Yorizane	10
					Y117-91-03	8
					Nonpareil	6
Stain/discolor	UCD1-271	27	UCD 1-271	21	UCD1-232	24
	Yorizane	10	Yorizane	21	UCD1-271	24
	UCD 8-160	9	Bennett	6.5	Eddie	20
	Winters	7	Eddie	4.5	Sweetheart	12
	Kester/Hansen	6	UCD 1-232	4	UCD 8-160	12
					Nonpareil	11
					UCD 3-40	10
					Bennett	10
					Kester	9
					UCD 8-27	9
					Y117-86-03	9
					UCD 8-201	8
					Capitola	6
					Lonestar	6
					Yorizane	6
mold	Eddie	16	UCD 1-232	28		
	UCD1-271	15	UCD 3-40	21		
	Bennett	10	Y117-86-03	21		
	UCD1-232	9	P16.013	20		
	Kester/Hansen	7	UCD 1-271	18		
	Nonpareil	7	Bennett	7.5		
	UCD 7-159	7	UCD 8-160	7		
	Folsom	6	Y117-91-03	6		
	Wood Colony	6				
gum	UCD 3-40	14			Capitola	13
					UCD 8-27	8

Table 16. Nutrient Levels in July-Sampled Leaves. Stanislaus County Regional Almond Variety Trial 2020

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
1-271	2.68 a	0.14 abc	1.94 abc	4.13 bcde	1.23 abc
Folsom	2.63 ab	0.13 abcde	1.65 bcde	3.85 cde	1.18 abcd
Kester/Hansen	2.58 abc	0.13 abcdef	1.34 e	5.10 a	1.21 abc
8-27	2.57 abc	0.14 a	1.73 abcde	3.77 cde	1.08 cdef
P13-019	2.54 abcd	0.13 abcdefg	1.57 bcde	4.19 bcd	1.18 cdef
Sterling	2.54 abcd	0.14 abcd	1.60 bcde	3.77 cde	1.03 def
Sweetheart	2.54 abcd	0.14 ab	1.80 abcde	2.97 f	0.92 f
Y116-161-99	2.48 abcde	0.12 bcdefg	2.01 ab	3.98 bcde	1.14 cde
Kester	2.48 abcde	0.12 efg	1.35 e	3.91 cde	1.13 cde
Y121-42-99	2.47 abcde	0.12 abcdefg	1.97 abc	3.48 ef	1.06 cdef
18-20	2.47 abcde	0.12 bcdefg	1.49 cde	3.64 def	1.13 cde
1-16	2.46 abcde	0.12 abcdefg	1.71 abcde	3.48 ef	0.99 ef
Winters	2.45 abcde	0.13 abcdef	1.36 e	4.27 bcd	1.34 a
8-160	2.45 abcde	0.12 abcdefg	1.54 bcde	4.46 abc	1.18 abcd
1-232	2.44 abcde	0.13 abcdef	1.41 de	4.08 bcde	1.19 abcd
P16.013	2.43 abcde	0.12 abcdefg	1.73 abcde	3.92 bcde	1.17 bcd
Booth	2.42 abcde	0.12 abcdefg	1.89 abcd	3.75 de	1.13 cde
Y117-91-03	2.39 bcde	0.13 abcdef	2.18 a	4.08 bcde	1.15 bcde
Nonpareil	2.38 bcde	0.11 fg	1.75 abcde	3.94 bcde	1.04 def
8-201	2.38 bcde	0.12 defg	1.79 abcde	3.83 cde	1.12 cde
Capitola	2.37 bcde	0.12 defg	1.61 bcde	4.17 bcde	1.31 ab
Eddie	2.35 cde	0.12 abcdefg	1.73 abcde	4.00 bcde	1.21 abc
3-40	2.35 cde	0.12 abcdefg	1.58 bcde	4.62 ab	1.20 abcd
Aldrich	2.34 cde	0.11 g	1.47 bcd	4.22 cde	1.11 cde
Bennett	2.33 cde	0.13 abcdefg	1.70 abcde	4.01 bcde	1.07 cdef
Durango	2.32 cde	0.11 efg	1.36 e	3.95 bcde	1.19 abcd
Supareil	2.29 de	0.12 abcdefg	1.66 bcde	3.84 cde	1.07 cdef
Y117-86-03	2.26 e	0.12 cdefg	1.62 bcde	3.78 cde	1.09 cde
7-159	2.26 e	0.12 abcdefg	1.79 abcde	4.21 bcd	1.17 abcd
Jennette	2.25 e	0.13 abcdefg	1.73 abcde	3.95 bcde	1.13 cde
Critical value	**2.2 - 2.5**	**0.1 – 0.3**	**> 1.4**	**> 2.0**	**> 0.25**

Values followed by the same letters are statistically similar (Tukeys P $\leq$ 0.05)

Table 16 (continued).

	Zn (ppm)	Mn (ppm)	Cl (%)	Na (%)
1-271	18.6 ab	33.3 a	0.26 bcd	0.11 abc
Folsom	13.2 bcd	33.3 a	0.29 abcd	0.08 bc
Kester/Hansen	20.0 a	47.4 a	0.07 e	0.04 c
8-27	12.6 cd	40.6 a	0.31 abcd	0.13 abc
P13-019	14.6 abcd	38.7 a	0.33 abcd	0.10 abc
Sterling	15.8 abcd	34.9 a	0.19 de	0.07 bc
Sweetheart	15.3 abcd	28.2 a	0.23 d	0.06 c
Y116-161-99	14.9 abcd	33.0 a	0.31 abcd	0.16 ab
Kester	11.8 cd	38.4 a	0.32 abcd	0.12 abc
Y121-42-99	13.6 bcd	37.3 a	0.27 bcd	0.06 c
18-20	11.5 cd	27.6 a	0.27 bcd	0.18 a
1-16	10.1 d	31.9 a	0.24 cd	0.07 bc
Winters	14.4 bcd	33.6 a	0.30 abcd	0.17 a
8-160	10.9 cd	36.4 a	0.21 de	0.06 c
1-232	10.9 cd	43.0 a	0.27 bcd	0.08 bc
P16.013	12.9 cd	38.3 a	0.21 de	0.08 bc
Booth	14.9 abcd	31.7 a	0.29 abcd	0.13 abc
Y117-91-03	16.0 abc	27.4 a	0.33 abcd	0.14 ab
Nonpareil	12.4 cd	44.2 a	0.25 bcd	0.08 bc
8-201	10.9 cd	30.5 a	0.28 abcd	0.09 bc
Capitola	16.1 abc	37.0 a	0.32 abcd	0.11 abc
Eddie	12.2 cd	45.5 a	0.29 abcd	0.09 bc
3-40	14.4 bcd	48.4 a	0.26 bcd	0.15 ab
Aldrich	11.9 cd	25.1 a	0.42 a	0.18 a
Bennett	13.9 bcd	49.8 a	0.25 bcd	0.11 abc
Durango	13.1 cd	27.1 a	0.39 ab	0.10 abc
Supareil	11.5 cd	37.6 a	0.19 de	0.06 c
Y117-86-03	10.6 cd	29.8 a	0.33 abcd	0.19 a
7-159	11.4 cd	33.0 a	0.29 abcd	0.09 bc
Jennette	11.4 cd	33.4 a	0.38 abc	0.18 a
Critical value	**>15**	**>20**	**<0.3**	**<0.25**

Leaf nutrient observation summary:

- There were statistically significant differences in all nutrients among varieties, although not always agronomically important.
- Aldrich tends to be lower than average in N, P, K, Zn and Mg but high in Cl and Na
- The three varieties with the highest potassium were USDA varieties Y117-91-03, Yorizane & Y121-42-99 (over 2%)
- Kester on Nemaguard and Hansen were numerically the lowest in K (1.3%)
- Most varieties were deficient in Zn (< 15ppm).
- Hansen increased zinc levels in Kester from 11.8 ppm to 20.0 ppm, compared to Nemaguard
- Chloride toxicity is an emerging problem in this trial. Aldrich, Durango and Jenette have the highest chloride levels while Supareil and Sterling had the lowest
- Kester on Nemaguard had 0.32 % chloride compared to 0.07% for Kester on Hansen rootstock

Table 17. Leaf tissue analyses for Madera RAVT in 2020.

	Nitrogen	
Booth	2.60	a
Kester	2.51	ab
Folsom	2.49	abc
Sweetheart	2.48	abc
Eddie	2.47	abcd
UCD1-271	2.41	abcde
Nonpareil	2.38	abcdef
UCD8-27	2.37	abcdef
Capitola	2.36	abcdef
UCD3-40	2.36	abcdef
UCD18-20	2.33	abcdef
Sterling	2.30	abcdef
UCD1-16	2.28	bcdef
Aldrich	2.26	bcdef
UCD1-232	2.26	bcdef
Jenette	2.24	bcdef
Y117-86-03	2.23	bcdef
Durango	2.23	bcdef
Wood Colony	2.22	bcdef
Winters	2.20	cdef
UCD8-201	2.20	cdef
UCD7-159	2.20	cdef
Bennett	2.19	cdef
Yorizane	2.16	def
UCD8-160	2.16	def
Supareil	2.15	ef
Y117-91-03	2.07	f

	P	
Sweetheart	0.144	a
Folsom	0.143	ab
Sterling	0.142	abc
Booth	0.140	abc
UCD3-40	0.137	abc
UCD1-271	0.136	abc
Kester	0.136	abc
Eddie	0.136	abc
Nonpareil	0.129	abc
Wood Colony	0.126	abc
UCD8-27	0.126	abc
Supareil	0.125	abc
Y117-86-03	0.125	abc
UCD7-159	0.125	abc
Aldrich	0.124	abc
UCD1-16	0.124	abc
Jenette	0.124	abc
Capitola	0.123	abc
UCD1-232	0.122	abc
UCD8-201	0.122	abc
Durango	0.120	abc
UCD18-20	0.119	abc
UCD8-160	0.119	abc
Bennett	0.117	bc
Yorizane	0.116	c
Y117-91-03	0.116	c
Winters	0.116	c

	Potassium	
Folsom	3.03	a
UCD1-271	3.00	ab
Capitola	2.87	abc
Booth	2.77	abcd
Y117-91-03	2.74	abcd
Sterling	2.72	abcd
Eddie	2.75	abcd
Jenette	2.68	abcd
Kester	2.66	abcd
Durango	2.65	abcd
Y117-86-03	2.60	abcd
Wood Colony	2.54	abcd
Supareil	2.52	abcd
Nonpareil	2.51	abcd
UCD8-201	2.47	abcde
UCD7-159	2.43	abcde
UCD1-232	2.41	abcde
Aldrich	2.34	abcde
UCD18-20	2.29	abcde
Bennett	2.28	abcde
UCD8-27	2.22	bcde
Yorizane	2.19	cde
Sweetheart	2.17	cde
UCD8-160	2.12	cde
UCD3-40	2.05	de
UCD1-16	2.01	de
Winters	1.69	e

Fig. 1. Number of hullrot strikes per tree at the Madera site in 2020.

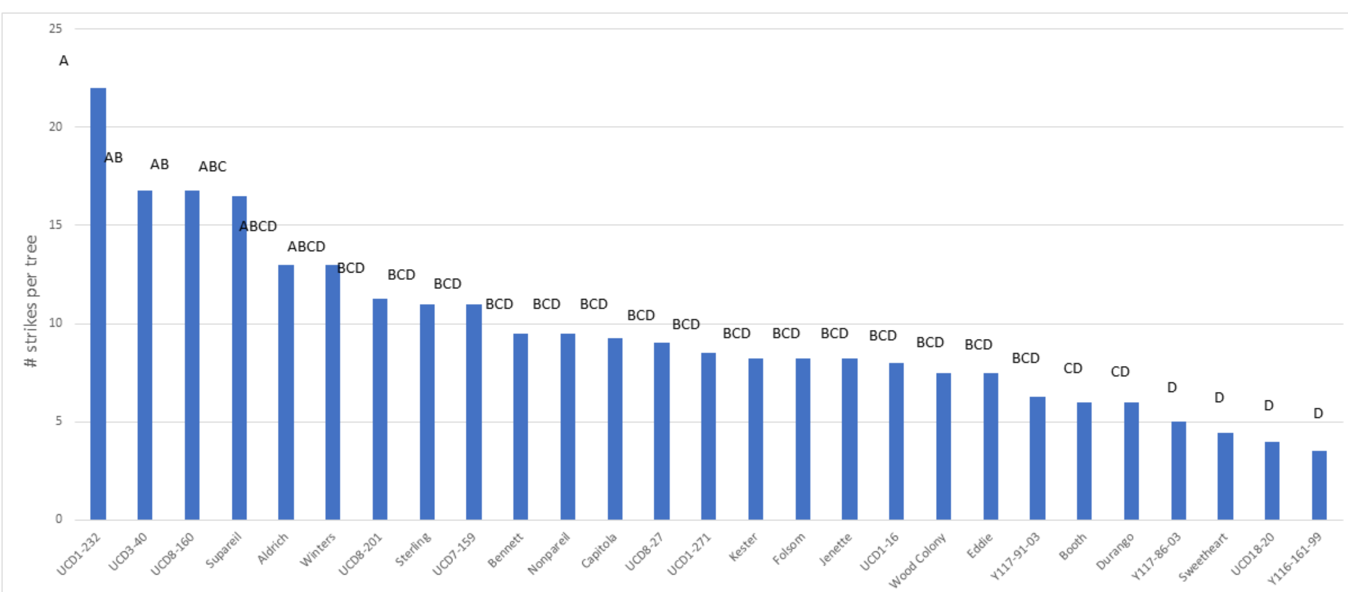


Fig. 2. Bloom data for 2020 by site and variety or selection.

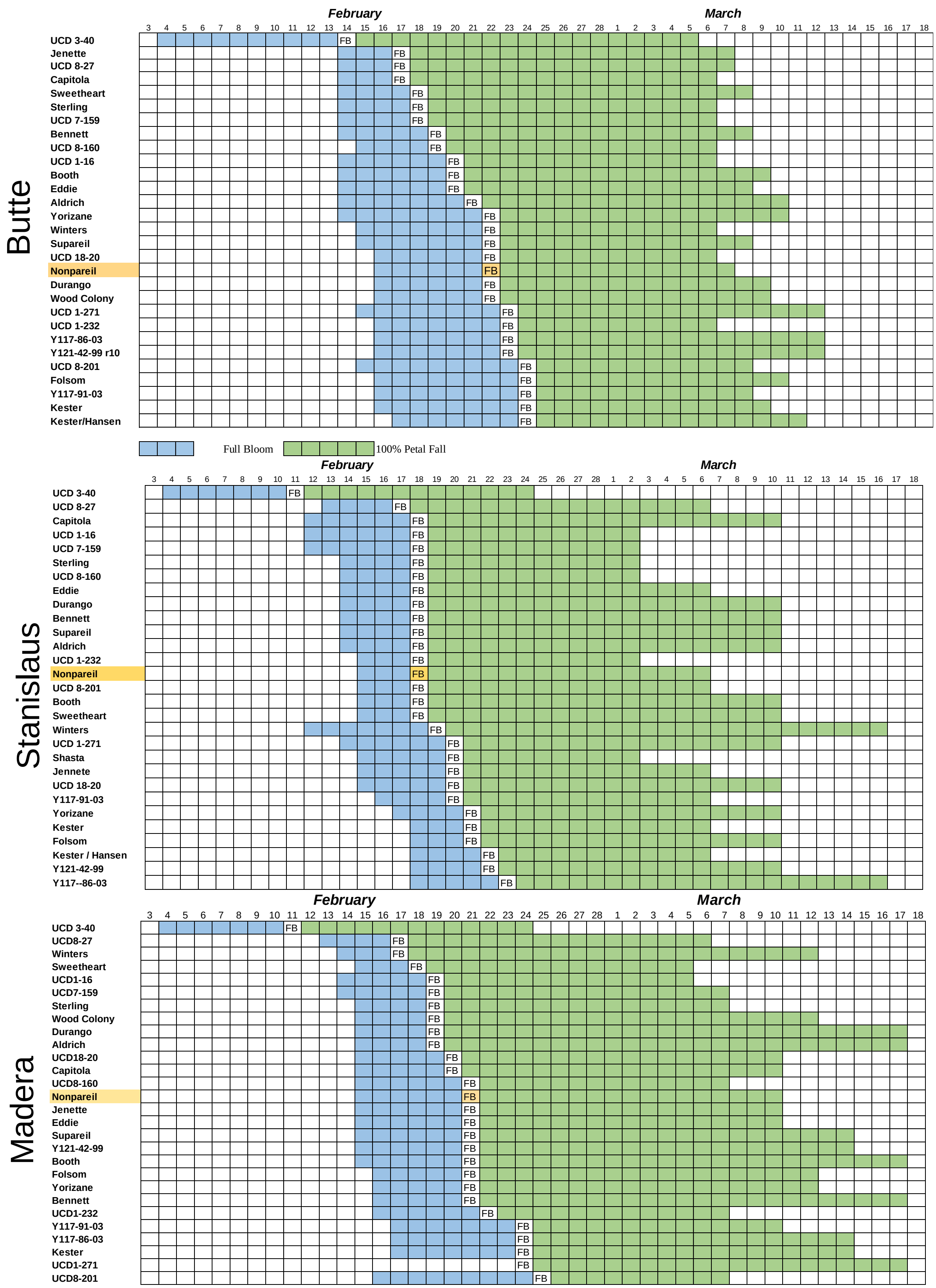


Fig. 3. Hullsplit by site, variety and selection for 2020.

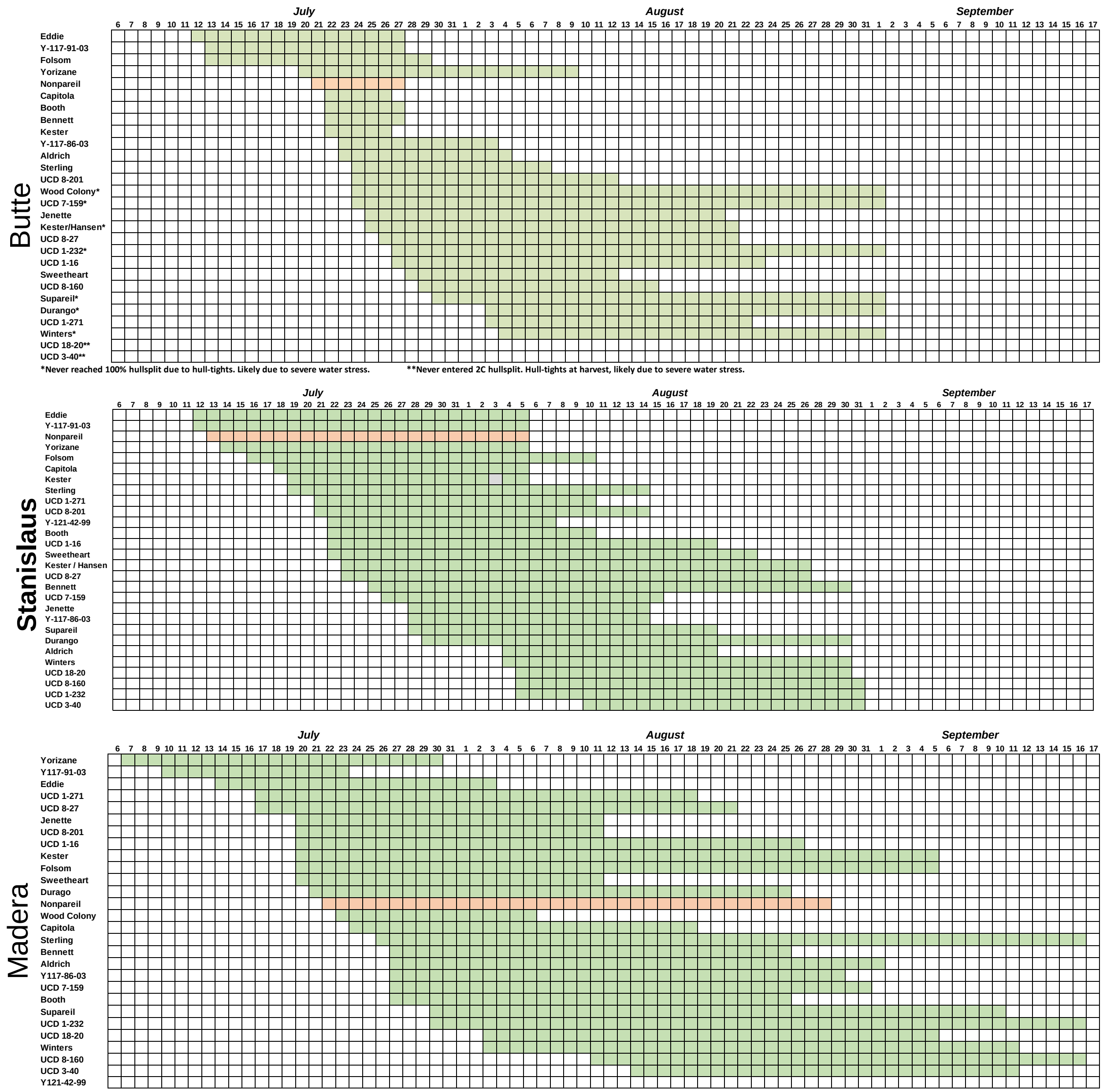


Fig. 4. Average annual yield for all varieties and selections combined at each trial by orchard age. Kern, Butte old and Delta are from the previous generation variety trials and the McFarland trial was in Kern County with Mario Viveros.

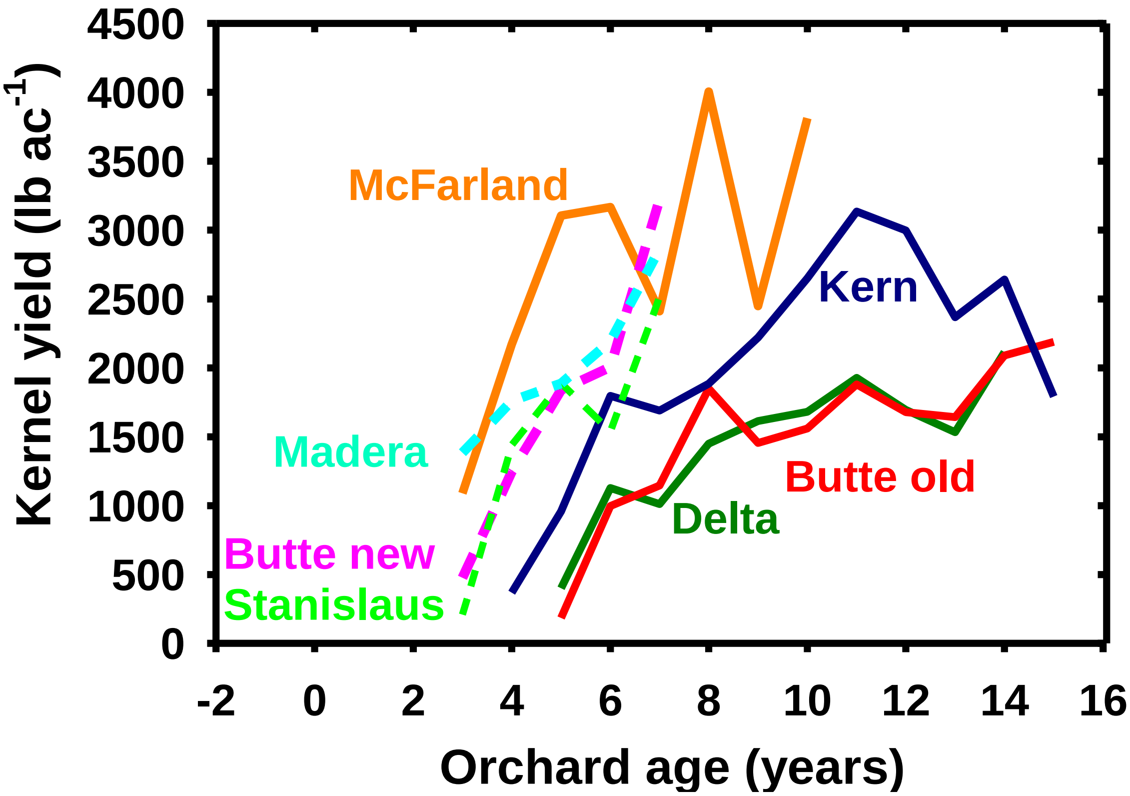
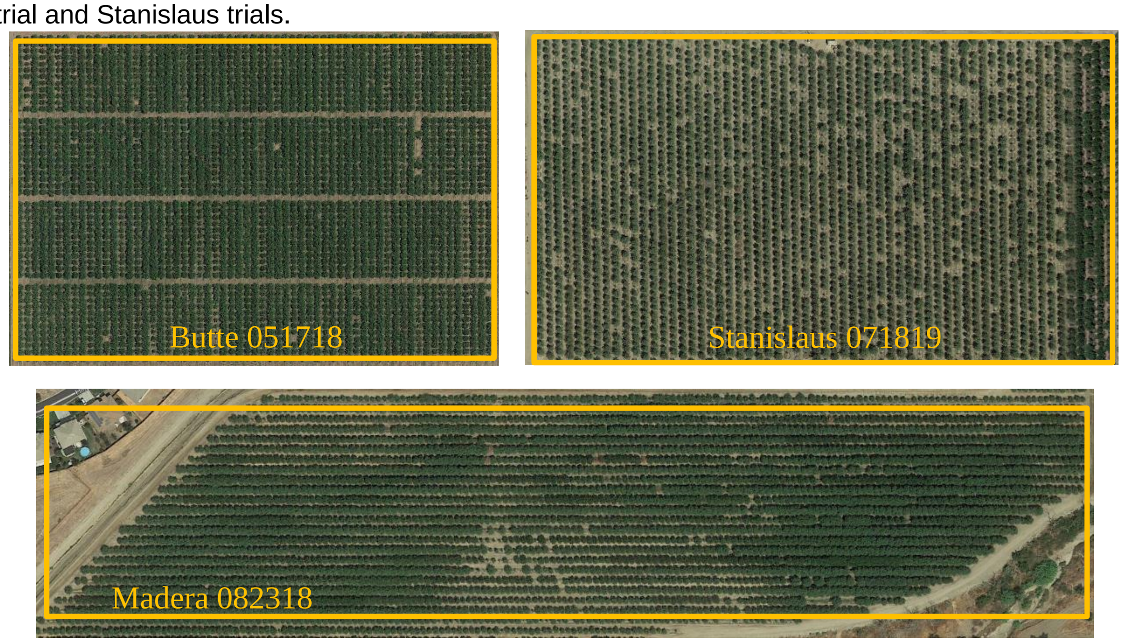


Fig. 5. Google Earth images of the three sites. Note extensive tree loss in several areas at the Madera trial and Stanislaus trials.



Using SWP to Delay the Start of Irrigation in the Spring

Project No.: **HORT5.Shackel**

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A. Summary

It is widely believed that irrigation should be sufficient to match the orchard water requirement (ET-rain) throughout the season, and further, that early season irrigation (i.e., starting soon after leaf out) will maintain a 'bank account' of deep soil moisture to insure against excessive water stress later in the season, particularly at harvest. A growing body of evidence in walnuts however, indicates that a substantial delay in the start of irrigation (i.e., 1-2 months after leaf out), even though it is associated with an increased depletion of soil water, can result in less water stress at harvest, as well as a noticeable improvement in tree appearance, at harvest. The basis for this effect is not clear, but our working hypothesis is that early season irrigation may be detrimental to root development and health, particularly for the deep roots that are important for accessing deeper soil water during harvest. SWP-based irrigation treatments (a control, and a delay until SWP reached 2 or 4 bars drier than fully irrigated baseline) were applied to commercial Modesto (Independence) and Tehama (Nonpareil) almond orchards. Both orchards are micro/mini-sprinkler irrigated on loam soils, but the Tehama soil is a gravely loam and the Modesto soil a sandy loam.

B. Objectives

Evaluate the impacts of delaying the beginning of seasonal irrigation on applied water savings, tree water status (stress) using stem water potential (SWP), yield, and nut quality at north (Tehama, CA) and mid (Modesto, CA) Central Valley commercial almond sites.

C. Annual Results and Discussion

At the Tehama site, trees in the delay treatment became drier than baseline SWP relatively quickly, and as a result there was only about one week between the start of irrigation in the controls and the start of irrigation in both delay treatments (Fig. 1, Tehama, top panel). The average SWP for both delay treatments reached -11 bars, which was about -3 bars drier than baseline (Fig. 1, Tehama, bottom panel). As a result, there was little difference (3.5 to 4") in applied water between the control and the delayed treatments for the season in Tehama. However, because the grower applied somewhat more water than calculated orchard water requirement (ET-rain) to the controls for most of the season, the water applied to all treatments substantially exceeded ET-rain, particularly in August (Fig. 1, Tehama, top panel). It is interesting to note that there was a significant treatment effect on SWP at the Tehama site during two periods: one during the delay, when the control had the highest (wettest) SWP compared to one or both delay treatments, and another in June/July, when the control had the lowest (driest) SWP (Fig. 1, Tehama, bottom panel, asterisks). The results in the first period are consistent with the fact that water was withheld from the delay treatments. The reasons for the reversal of the difference in the second period are not clear, but this reversal is consistent with the trend that was seen previously in walnuts. In walnuts, stress early in the season was associated with less stress later in the season. This may be due to improvements in root health and/or other ‘acclimation’ responses of the plant. Despite applying amounts of water that met or exceeded ET-rain in all treatments through August at the Tehama site (Fig. 1, Tehama, top panel), there were periods of serious (May) as well as severe (August) water stress experienced by trees in all treatments (Fig. 1, Tehama, bottom panel).

At the Stanislaus site, the first irrigation in the control sections of the orchard was on March 6, earlier than typical for this area. This was because the winter of 2019-20 was relatively dry with no rain at all during the month of February. Therefore many local growers irrigated during late February or early March to ensure the season started with a full soil profile. There was a substantial delay between the start of irrigation in the control (March 6) and in the delay treatments (April 20 and April 28). This was due to a sustained period of light rains during this time that satisfied ET requirements (Fig. 1, Stanislaus, top panel). SWP measurements indicated that delayed trees became stressed very quickly once rainfall stopped and the soil dried in April, going from about 3.4 bars drier than baseline to nine bars drier than baseline in just four days (April 24-28). Therefore the first irrigation in our most delayed treatment began at nine bars drier than baseline instead of our target of four. This rapid drop in SWP (increase in tree stress) may indicate that delaying the start of the irrigation season for even a few days too long may have season-long impacts on tree water stress.

The ability to account for the effects of infrequent or light rains may itself illustrate an important advantage of using SWP to schedule irrigation in the spring. Similar to the Tehama site, there was little difference (1.5 and 3 inches, or approximately 5-10% of the 33 inch seasonal total applied water) in the April 20 and April 28 start dates, respectively, between the control and the delayed treatments in Stanislaus. Unlike the Tehama site however, the water applied to all treatments at the Stanislaus site fell behind ET-rain, particularly in August (Fig. 1, Stanislaus, top panel). There were also more instances of statistically significant differences in SWP between control and delay treatments in Stanislaus than in Tehama.

In Stanislaus County, trees in areas where irrigation was delayed were consistently more water stressed during the first part of the season than trees that were irrigated in early March. In general, trees in the delayed irrigation treatments recovered immediately after each irrigation but became substantially drier (more water stressed) within just a few days (Fig. 1, Stanislaus, bottom panel, April/May). Trees that were not irrigated until April 28 (9 bars drier than baseline) did not recover to SWP levels similar to the earliest irrigated trees until late June, even though they were irrigated twice weekly matching ET. SWP in all irrigation treatments remained similar during July, August and September. However, trees in the most-delayed irrigation treatment again showed more water stress late in the season during the post-harvest period of November and December.

In all cases at the Stanislaus trial, it was always the control trees that were less stressed than the delay trees, unlike the reversal of this trend that occurred after the delay in Tehama. Similar to Tehama, the maximum level of water stress at Stanislaus occurred in August/September, associated with harvest, but the maximum stress level in Stanislaus (around -23 bars), was much less than in Tehama (note that the average value of around -35 bars, Fig. 1, lower panels, does not include values that couldn’t be recorded because the pressure chamber only read to -40 bars!). The milder levels of water stress in Stanislaus compared to Tehama late in the season, despite a much lower amount of applied water compared to ET-rain, suggests that the Stanislaus trees had more access to stored soil moisture than the Tehama trees, perhaps consistent with the more gravely soil in Tehama. However, during the April/May delay period, the Stanislaus trees in the delay treatment exhibited much higher levels of stress than did the delay trees in Tehama. This is a key observation, because it may indicate that 'soil available water' is not be a fixed quantity that only depends on the soil. Hence, trees may exhibit symptoms of having a low soil water availability at one time in the season (e.g., the Tehama soil in August/September, or the Stanislaus soil in April/May), and a high soil water availability at another time in the season. (e.g., the Tehama soil in April/May, or the Stanislaus soil in August/September). Further research will be needed to determine the reason for this change in apparent water availability over the season, but in the meantime it is clear that SWP monitoring is the appropriate tool to either identify periods of severe stress when irrigations are critical, or identify periods when irrigation can be safely withheld. An interesting example of the latter is a pilot test that was conducted at the Stanislaus site, to determine if the final irrigation in late October was necessary. At this site, the final irrigation was withheld from a row of guard trees. The guard row trees were monitored prior to the final irrigation and found to have the same SWP as the rest of the experimental trees prior to irrigation, but the guard row tree SWP clearly did not recover quickly as did the experimental trees following irrigation (Fig. 2). The guard trees did recover slowly over November/December however, reaching the same SWP as the Delay 2 treatment trees (Fig. 2). It is difficult to predict the overall effect of withholding the final irrigation from these trees, but if there is no lasting effect, then this may represent a savings of water in addition to the savings from delaying the start of irrigation. Previous research has demonstrated that stress during dormancy delays bloom, and it is also possible that a delay in bloom will have benefits if weather during normal bloom is unfavorable.

As expected, there was very little effect of delaying the start of irrigation on yield or any measure of nut quality at either site (Table 1) during the first year. The only statistical difference found was a greater level of NOW damage in the control treatment in Tehama, but the difference was small and there was no trend in the Stanislaus data (Table 1). It is interesting to note that the yields in Tehama were substantial (average of 3,560 kernel pounds/acre), despite the high level of water stress experienced by the trees at harvest. Previous research found a positive trend between crop load, the main determinate of yield, and mild to moderate mid-season stress in walnuts, so further research in this area is warranted in almonds.

D. Outreach Activities

A presentation of these results was given at the 2020 annual almond industry conference.

E. Materials and Methods

The orchard details for the Stanislaus Co. site were: 5 year old Independence on Atlas rootstock, 21' x 14' spacing, microsprinkler irrigated, on San Joaquin sandy loam soil. The orchard was irrigated approximately weekly early in the season, and approximately twice per week beginning in late May. For the Tehama Co. site, trees were 11 year old Nonpareil/Price/Peerless on Krymsk 86 rootstock. The spacing is 21.5' x 14', with R-10 minisprinklers. The Tehama Co. site is predominately Moda loam, secondarily Perkins gravelly loam/Hillgate loam soils. The experimental design in both locations was a randomized complete block with 4 blocks, each with a control (irrigation was started when trees were still exhibiting baseline SWP), and 2 levels of delay (irrigation was started only after SWP reached 2 or 4 bars drier than baseline). As mentioned above, SWP changed so rapidly in just a few days that the target of -4 bars was missed and the start of irrigation occurred at about nine bars drier than baseline in the Stanislaus trial. In Stanislaus, the experimental plots were 5 rows of 14-17 trees each, with the center three rows of each plot monitored for SWP and yield. One water meter in one control plot was used to measure applied water. In Tehama, the experimental plots were 3 rows x 19 trees, with the center row monitored for SWP and yield. A water meter was used to measure applied water in each treatment of each block. Baseline midday SWP was calculated using the nearest CIMIS station to each site.

F. Publications that emerged from this work

None to report.

Table 1. Summary of treatment mean yield, kernel weight, and percentage of kernels with naval orange worm (NOW) damage, kernel shrivel, or double kernels. Values followed by different letters are statistically different between treatments in the same site.

Site (variety)	Irrigation Treatment	Yield (kernel #/ac)	Kernel weight (g)	% NOW	% shrivel	% double
Stanislaus (Independence)	Control	2530	1.12	1.5	5.5	1
	Delay 1	2270	1.18	2.5	1	0
	Delay 2	2540	1.14	2	3	0
Tehama (Nonpareil)	Control	3750	1.13	1.8a	2.3	4
	Delay 1	3230	1.08	0b	0.5	4
	Delay 2	3690	1.08	0b	0.8	7

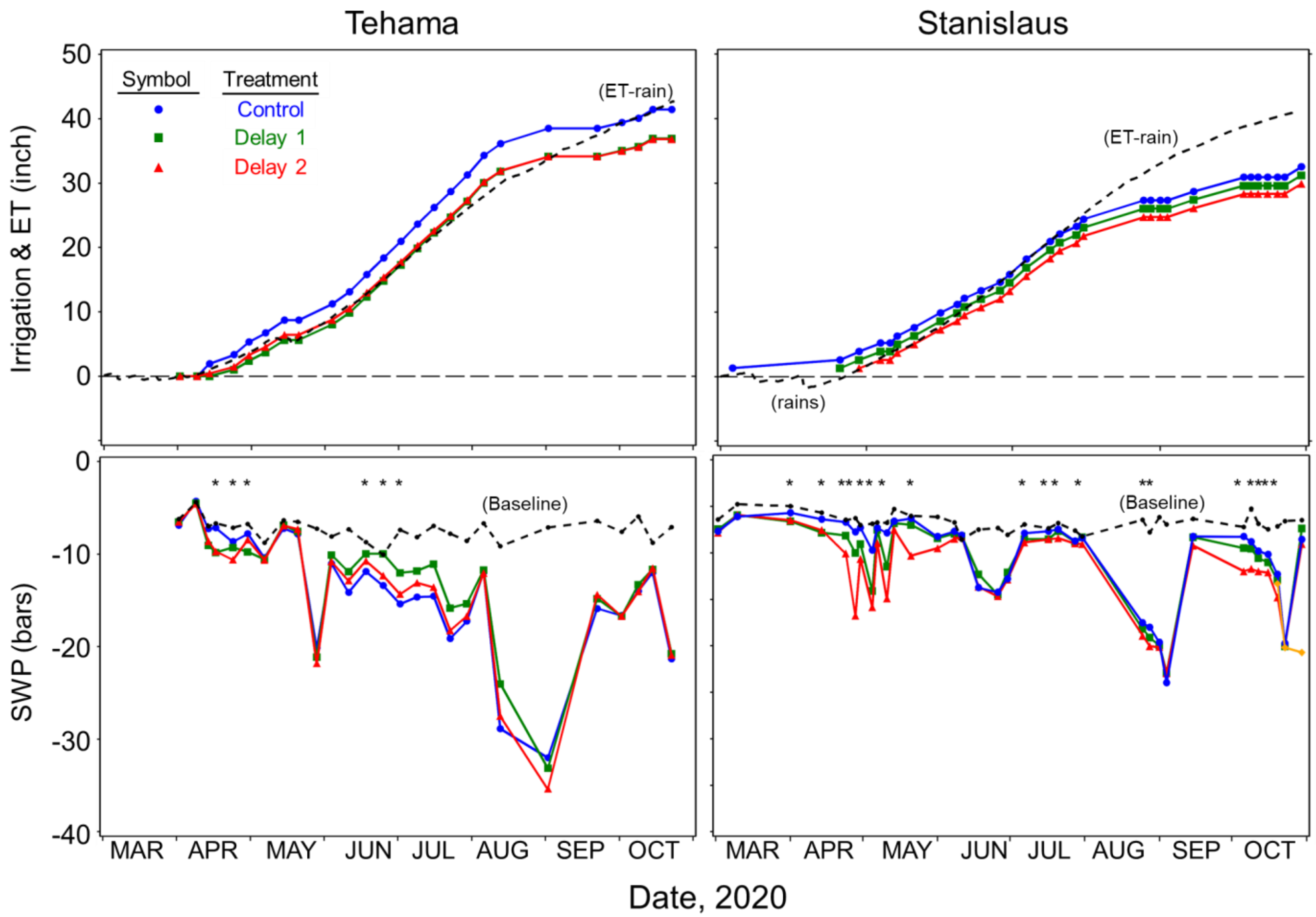

Figure 1. Cumulative applied irrigation (symbols) and calculated water requirement (ET-rain, dashed line), (top panels) and periodic orchard (symbols) and baseline (dashed line) SWP measurements (bottom panels) over the 2020 season at the Tehama and Stanislaus Co. sites. Because the calculated water requirement in the top panels (dashed line) subtracts rainfall from ET, when rainfall matches ET, the line is flat, and when rainfall exceeds ET then the value is negative (falls below 0). Asterisks in the bottom panels indicate the dates when there was a statistically significant difference between the control and either of the delay treatments.

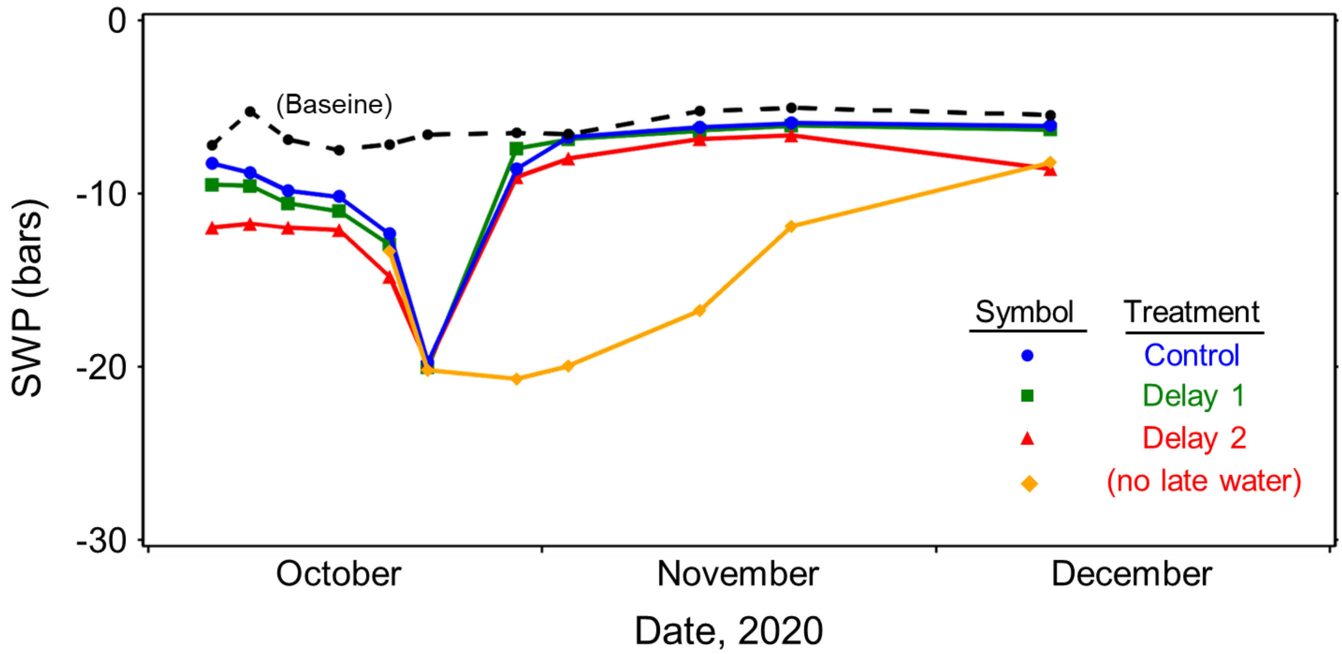

Figure 2. Detail of the SWP in all treatments at the Stanislaus site prior to and following the last irrigation in October.