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# Evaluation of Potential Pest Pressure Reduction for Early Off-ground Harvest

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## **A. Summary**

The Almond Board of California (ABC) is evaluating the option to transition the industry to early harvest to (1) reduce the severity of harvest water stress, enhance plant vigor and return bloom, which will improve long term yields and hence economic water use efficiency, and (2) reduce navel orange worm (NOW) and Hull Rot (HR) damage and therefore reduce dependence on pesticides. This report details preliminary research from two field sites in the Sacramento and San Joaquin Valleys during the 2020 growing season comparing early and standard harvest timings. The aim of this research is to evaluate early harvest practices on irrigation scheduling yield, pest and disease pressure. In this initial experiment, early harvest trees were shaken 21-28 days before standard harvest coinciding with 85 to 100% of all fruit showing some degree of nut split. Traditional harvest was at 100% hull split. We demonstrated that irrigation scheduling can generate a sufficient stress (-14 to -18 bars) to allow safe effective harvest of early harvest trees. Early harvest resulted in a significant reduction in HR incidence. Moisture content of almonds at harvest were greater for early harvest compared to standard harvest with no negative effect on almond yield. Data on NOW damage and shaker efficacy is being processed. We recommend further research on early harvest to better understand the impacts of early harvest on HR and NOW incidence, return bloom, and yield.

## B. Objectives

Research Goal 1 – Manage irrigation to induce a tree water stress two weeks before harvest to achieve a stem water potential (SWP) of -14 to -18 bars (*Irrigation SWP*) for trees under both early and standard harvest.

Outcome: In both early and standard harvest trees we 1) used biweekly SWP measurements to accurately establish and implement a two-week tree dry down period prior to early harvest and 2) successfully harvested almond trees 3-4 weeks prior to standard harvest at two sites.

Research Goal 2 –Measure kernel damage sustained from NOW (*NOW Kernel*) to estimate differences in marketable yield (*NOW Yield*) between early and standard harvest.

Outcome: For both early and standard harvest trees we: 1) collected individual tree yields; 2) measured nut moisture at harvest; 3) conducted preliminary assessment of almond kernels for NOW damage and 4) measured the number of almond mummies postharvest at the Denair site. The results of output 3 and 4 have not been finalized for reporting.

Research Goal 3 – Measure the incidence of hull rot at harvest (*Hull Rot Harvest*) and in winter 2021 contrasting early and standard harvest.

Outcome: At the Denair site only: 1) assessment of the number of hull rot strikes at harvest.

## C. Results and Discussion

Our goal for the early harvest treatment was to determine the effect of irrigation dry-down on tree response. To this end, we began reduction in irrigation to the early harvest trees on July 4<sup>th</sup> in Denair and on July 2<sup>nd</sup> in Davis, our goal was to achieve a stem water potential (SWP) values between -14 and -18 for a minimum of two weeks prior to harvest (Figure 1 a-d). At the Denair site, 7 days of a reduced irrigation of 0.12 acre-inches per day on the early harvest trees led to a drop in SWP from -15 to -22 bars. A slight increase in irrigation to 0.18 acre-inches per day raised the SWP back into the target range for the remainder of the time leading to early harvest. During this period standard harvest trees received 0.24 acre-inches of water per day and maintained a SWP of -13 to -15 bars. After August 6<sup>th</sup>, standard harvest trees were subjected to deficit irrigation, and responded with an SWP of -16 bars.

At the Davis site we followed the grower's normal irrigation schedule for standard harvest, reducing irrigation levels from a cumulative of 0.78 acre-inches to 1.65 acre-inches over two days, and maintaining the SWP of the early harvest trees between the target -14 to -18 bars for the 22 days leading up to the harvest date except for a single day above the -14 bars target due to environmental factors. Trees under standard harvest at the Davis site continued to receive 1.65 acre-inches of water twice weekly through July 22, at which point irrigation was cut off to dry the trees down in preparation for harvest and achieved SWP of -13 to -23 bars.

Each treatment tree was rated for hull split (suture >1 cm) prior to harvest, with an average of 85.6% hull split at early harvest and 99.3% at standard harvest in Denair (Table 1). At the

Davis site, 100% of almonds were at the >1 cm hull split stage during both early and standard harvests. Percentage moisture of the fruit at harvest was greater for early harvest compared to standard harvest at both study sites. Almond fruits contained 64.9 and 68.9% moisture at early harvest and 8.1 and 15.3% moisture at standard harvest for Davis and Denair, respectively. There were marked differences in the appearance of early harvest fruits Figures 2a-b).

Fresh weight collected from the field equaled 76.9 and 275 lb/tree for early harvest and 35.2 and 101 lb/tree for standard harvest in Davis and Denair, respectively (Table 1). Differences in moisture content translated to kernel yield of 7.2 and 22.7 lb/tree for early harvest and 6.6 and 24.9 lb/tree for standard harvest in Davis and Denair, respectively.

Hull rot strikes were tabulated before harvest for each treatment (Table 2). During early harvest, there was no incidence of hull rot on any of the trees. On August 14th, hull rot strikes were greater for the standard harvest trees, averaging 7.3 strikes per tree with a range of 2 to 12 compared to an average of 3.7 strikes per tree ranging from 1 to 6 for early harvest trees.

We are analyzing data for NOW damage and shaker efficacy to determine potential impacts of early almond harvest on NOW pressure and reinfestation. Furthermore, we will survey for hull rot strikes during winter 2021. These results are forthcoming.

#### **D. Outreach Activities**

We wrote a harvest season summary for the grower collaborator at the Denair site, Olam Group. The data obtained at their Denair site was circulated within the company. Olam Group operates almond orchards in multiple locations both in California and Australia.

#### **E. Materials and Methods**

##### *Field Sites*

The study sites used for this research are located in Davis, CA in Yolo County and Denair, CA in Stanislaus County. The Davis site is a 5<sup>th</sup> leaf orchard with a 22' x 16' spacing planted on Rincon silty clay loam with 0 to 2 percent slopes. The Denair site is a 12<sup>th</sup> leaf orchard with a 24' x 15' spacing soil planted on a mixture of Madera Sandy Loam with 0 to 2 percent slopes and a Rocklin Sandy Loam with 3 to 8 percent slopes. Both sites employed the same randomized complete block experimental design with four blocks and two treatments. The harvest dates were 7/24 for early harvest and 8/14 for standard harvest at the Denair site and 7/30 for early harvest and 8/26 for standard harvest at the Davis site. During the two to three months leading up to harvest, we took weekly or biweekly midday stem water potential (SWP) measurements on three trees per plot, totaling 24 trees. We used SWP data to determine an optimal irrigation schedule for almond tree dry down and harvest.

##### *Hull Split*

Visual hull split ratings were conducted for early and standard harvests for at both sites. Researchers inspected a subsample of 100 nuts per tree. Nuts with hull sutures ranging from less than 1 cm in diameter to drying and dried hulls were reported as 'split'.

### *Harvest*

Harvest was conducted using a mechanical shaker at the Denair site. Each treatment tree was shaken individually, and harvest-related data was collected on each tree separately. At the Davis site, the researchers manually harvested each treatment tree. They used polls to remove the total yield from each treatment tree, allowing the nuts to fall onto tarps. Harvest-related data was collected to determine yield on each tree separately. Upon drying, subsamples were hulled using a mechanical huller and shelled manually. Total kernel weights for the subsamples were used to determine the kernel dry weight for the yield from each tree. Percentage moisture was calculated on the yield from each tree for each site.

### *Pest assessments*

On August 14<sup>th</sup> 2020 during the standard harvest day in Denair, hull rot scouting commenced by identifying hull rot strikes on spurs from early and standard harvest trees. NOW damage ratings were conducted for both trial sites. Subsamples of nuts were collected at harvest from each data tree, totaling 1,000 nuts per plot. These nuts were subsequently cracked open and visually inspected for NOW damage. Researchers considered three distinct levels of NOW damage: 1-low damage, 2- moderate damage, and 3- severe damage. Data analysis for NOW is ongoing.

### *Shaker efficacy*

On October 19<sup>th</sup>, all 24 trees at the Denair site were shaken with a mechanical harvester to remove mummy nuts. Total nut weight for each tree was collected in the field, and a subsample of nuts were then dried to 3-5% moisture. Data analysis is ongoing.

## **F. Publications that emerged from this work**

Smith, EE, PH Brown, HM Andrews, BA Holtz, DJ Rivers, DR Haviland, KA Shackel and SDS Khalsa (*In Prep*) Early almond harvest as a sustainable pest management strategy, *HortScience*.

## Tables and Figures

Figure 1a. EH Irrigation & SWP, Denair

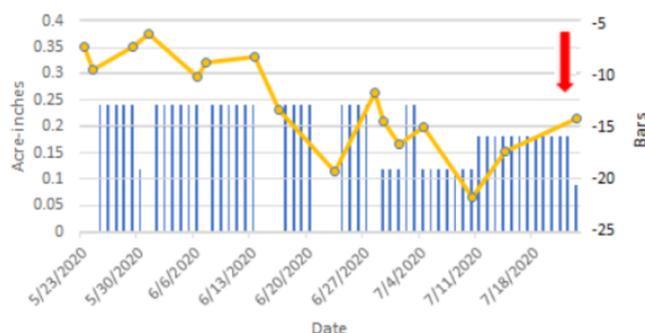


Figure 1c. EH Irrigation & SWP, Davis

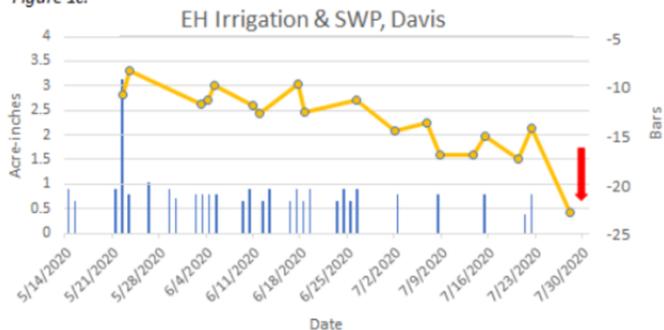


Figure 1b. SH Irrigation & SWP, Denair



Figure 1d. SH Irrigation & SWP, Davis



**Figures 1a-d.** Irrigation scheduling and stem water potential (SWP) values for early (EH) and standard harvest (SH) plots at the Denair and Davis sites. The blue columns represent daily applied irrigation (acre-inches) and orange dots represent the SWP (bars). The harvest dates were 7/24 for EH and 8/14 for SH at the Denair site and 7/30 for EH and 8/26 for SH at the Davis site. Red arrows are harvest dates and the MV label indicates missing data for irrigation.

**Table 1.** Hull rot strikes for early and standard harvest are shown at the Denair site.

Site	Treatment	Hull Rot Strikes	
		Mean	SE
Denair	Early Harvest	3.67	0.8
Denair	Standard Harvest	7.33	1.5

**Table 2.** Percentage hull split before harvest, percentage moisture at harvest, fresh nut weight and kernel yield for early and standard harvest are shown at the Denair and Davis sites.

Site	Treatment	Hull Split %		Moisture %		Fresh Weight (lb/tree)		Kernel Yield (lb/tree)	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Davis	Early Harvest	100	0.0	64.9	1.5	76.9	4.4	7.2	0.4
Davis	Standard Harvest	100	0.0	8.10	0.9	35.2	1.5	6.6	0.3
Denair	Early Harvest	85.6	7.5	68.9	1.5	275	23	22.7	1.8
Denair	Standard Harvest	99.3	1.0	15.3	3.9	101	7.3	24.9	2.0



*Figure 2a*



*Figure 2b*

**Figures 2a-b.** Almonds after shaking on the day of early harvest (a) compared to the typical appearance of almonds at standard harvest (b). The early harvest almonds were much greener with less pronounced hull split before shaking as compared to standard harvest.