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In This Issue

Navel Orangeworm

Management—2013

Almond Hull Rot—Cultural and Chemical Management

Alternaria Leaf Spot and Leaf Rust of Almond

Water Management for Almond—in-season, harvest and post-harvest

Pre-harvest Almond

Orchard Nutrition

Chris Greer

County Director

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Sacramento Valley Almond Newsletter

Navel Orangeworm Management - 2013

Joseph Connell and Richard P. Buchner

UCCE Farm Advisors, Butte and Tehama Counties.

Navel orange worm (NOW) monitoring begins in early April by hanging black egg traps baited with almond press cake mixed with 3-10% almond oil. Traps mimic old, moldy mummy nuts attractive to female NOW for egg laying and larval feeding. Because NOW populations are usually low in the Sacramento Valley, we typically do not observe egg laying on every trap, every year. Winter weather and good mummy nut removal (orchard sanitation) practiced in the Sacramento Valley reduce overwintering larvae and decrease worm pressure. Multiple traps are a good strategy to improve the probability of observing egg laying particularly when NOW populations are low. Four traps per location is a reasonable compromise between time and accuracy and reading NOW egg traps twice per week (Monday and Thursday) has worked well. Eggs will be white when first laid and turn orange as they mature. Remember, egg traps alone will not tell you if a spray is necessary, but if used in combination with Degree-Days (DD) it is possible to predict NOW activity and egg hatch.

Egg laying started about three weeks earlier this year compared to 2012 due to the warm dry spring. Hull split is also earlier than some years so it is important to pay attention and practice an early harvest to avoid as much worm damage as possible. A hull split spray can help reduce damage from this pest but that practice alone will not assure premium quality nuts. Figure 1 shows a comparison of 2012 and 2013 NOW egg laying in a Tehama County almond orchard.

NOW biofix is the beginning date of consistent egg laying. Notice that egg laying began much earlier this year in the Tehama county orchard (Fig.1). New crop nuts are a more nutritious food source which speeds up generation time after hull split. Generation time is 1056 DD on less nutritious mummy nuts and 723 DD on new crop nuts. Using that information we can predict second and third generation egg laying and egg hatch. The accuracy of the prediction improves as information is collected over the season. If egg hatch coincides with hull split on susceptible varieties, the chance of damage is increased.

Tehama County 2012 Navel Orangeworm Monitoring

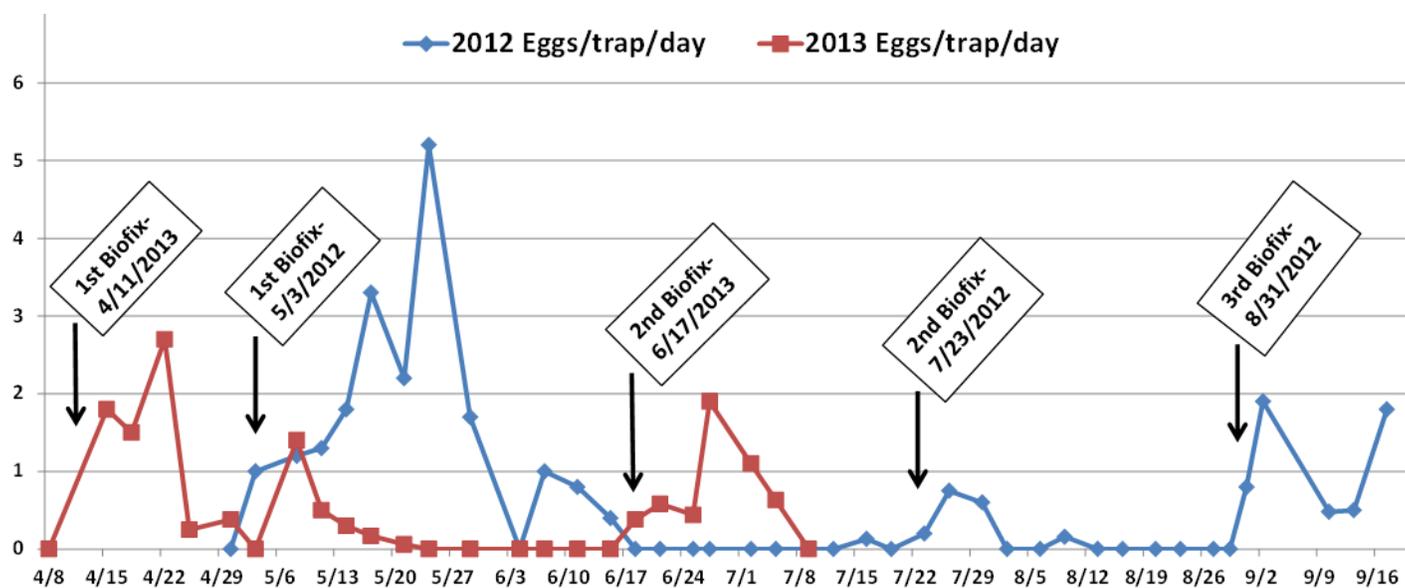


Figure 1. Navel Orangeworm egg laying activity in a single almond orchard in Tehama County. The first biofix marking the beginning of the first generation was 4/11/2013.

The navel orangeworm degree-day model predicted that second generation egg laying should be observed around June 24th. Egg trap counts increased however on June 17, about a week earlier than expected. With this second biofix occurring before hull split, the hatching worms must feed on mummy nuts remaining in the orchard. Third generation eggs are predicted to begin appearing on traps 1056 DD later occurring about August 4th to 5th this year.

Now that hull split is beginning (say July 11th), any eggs laid after this will only require 723 DD to complete the generation on new crop nuts. This cohort would mature and be predicted to begin laying third generation eggs about August 12th. Once laid, egg hatch normally takes 100 DD or about 5 days with typical degree-day accumulations during August.

Keeping an eye on egg traps will continue to allow adjustments or confirmation of these predictions as the season progresses. You can follow the Tehama information by going to <http://ceteama.ucdavis.edu> then click on orchard crops and click on insect update. Spring or hull split spray applications are two options for reducing damage but these options for 2013 have mostly passed. Spray timing and material choices are described in detail at the UC IPM website <http://www.ipm.ucdavis.edu>. Click on Ag Pests, Almond, then, navel orangeworm.

The navel orangeworm degree-day model can be accessed on the same UC IPM web page under the “Quick Links” on the left hand side of the page. Click on Weather, models, & degree-days, then, select your County, and click on the navel orangeworm model. Choose almonds and continue from there. At this point in the season, a rapid, early harvest is the best defense against worm damage and is an essential practice to preserve nut quality and optimum value.

Almond Hull Rot – Cultural and Chemical Management

David Doll¹ and Brent Holtz², UCCE Farm Advisors, Merced County¹ and San Joaquin County²

Hull Rot is an infection of the hulls caused by either *Rhizopus stolonifer* or *Monilinia fructicola*. Upon infection, the pathogens release toxins that are translocated into the fruiting wood, which kills the wood and causes crop loss. These pathogens are common throughout the environment and are, in this case, serving as opportunistic pathogens. Once the hull splits, the perfect micro-climate for fungi is created as the hull is full of nutrients and water. Since the spores of these fungi are found within the orchard environment, they invade the newly split tissue, infecting, and completing their life cycle. By making conditions less favourable for the fungi, the number of hull rot strikes can be reduced. Strategies include reducing the water and nutrient content of the hull.

Nitrogen and irrigation management can reduce hull rot incidence.

Hull rot often affects high vigour orchards. The highest incidence occurs on ‘Nonpareil’ with fewer strikes on other varieties (Table 1). Research conducted in 1990-2000 has shown that hull rot incidence can be reduced with adequate, but not excessive, nitrogen applications, and the application of a water deficit at the initiation of hull split.

Table 1: Almond varietal differences in hull rot occurrence

Variety	Strikes per tree	Susceptibility
Nonpareil	>500	Very High
Butte	>200	High
Winters	>200	High
Price	100-200	Medium
Sonora	100-200	Medium
Aldrich	10-100	Low
Wood Colony	10-100	Low
Mission	10-100	Low
Ruby	10-100	Low
Livingston	10-100	Low
Padre	10-100	Low
Fritz	0-10	Very Low
Carmel	0-10	Very Low
Monterey	0-10	Very Low

Excessive nitrogen within the tree increases susceptibility to hull rot infection. In two long term studies performed by University of California researchers, there was a positive linear relationship between nitrogen rates and hull rot incidence. In other words, the more nitrogen applied, the higher the incidence of hull rot. Trees with nitrogen application rates above 250 lbs/acre were the most severely affected, and hull rot strikes were higher in low crop years. In order to reduce hull rot, nitrogen rates should be modified based upon crop load to keep the trees sufficient. Analysis of leaf nitrogen content should be conducted to determine nitrogen status. If properly sampled, the critical value for mid-summer leaf nitrogen percentage is 2.2-2.5%.

Data suggest that summer nitrogen applications increases hull rot incidence. Nitrogen should not be applied after kernel development is completed. This is typically in late spring, but in abnormal years, it may extend into early summer. Applications made after this point will be directed to the hull, making the hull more conducive to infection. Nitrogen applications can resume in the post harvest period. Data suggests that nitrogen source does not influence hull rot.

Research by Teviotdale and colleagues (2001) has shown that a slight to moderate water stress at the onset of hull-split can reduce hull rot. Irrigation should occur when the average stem water potential is four bars more negative than baseline. This measurement is taken using a pressure chamber and is usually between -14 and -16 bars, depending on weather. The period of deficit irrigation should be carried out for two weeks. After the two weeks, full irrigation should resume until the harvest dry-down period. In managing the application of this stress, duration of the irrigation should be reduced, not the frequency. Typically, a 10-20% reduction in applied water will be needed, but this depends on the soil and irrigation system and will have to be determined on an orchard basis. A properly timed and applied deficit can reduce hull rot by 80-90%. Throughout the duration of the study, the application of this properly timed, regulated irrigation deficit did not affect yield or kernel size. It also appeared to have some effect of evening up hull split and subsequent harvest.

Stages of hull split and fungicide timing.

Work by Dr. Jim Adaskaveg (2010), UC Riverside, has found that *R. stolonifer* is only able to infect almond hulls during a brief period of nut development. Since the pathogen is not able to infect healthy tissues, it needs an injury in order to infect the hull. This wounding naturally occurs during the hull-split process. His studies elucidated that the highest incidence of infection occurred during the initiation of hull-split, when only a very small crack of the hull is present. This is classified as stage b2 (Figure 1) within the UC IPM manual. Later stages resulted in fewer infected fruit, and he concludes that the susceptibility differences of the stages are due to differences in hull moisture content.

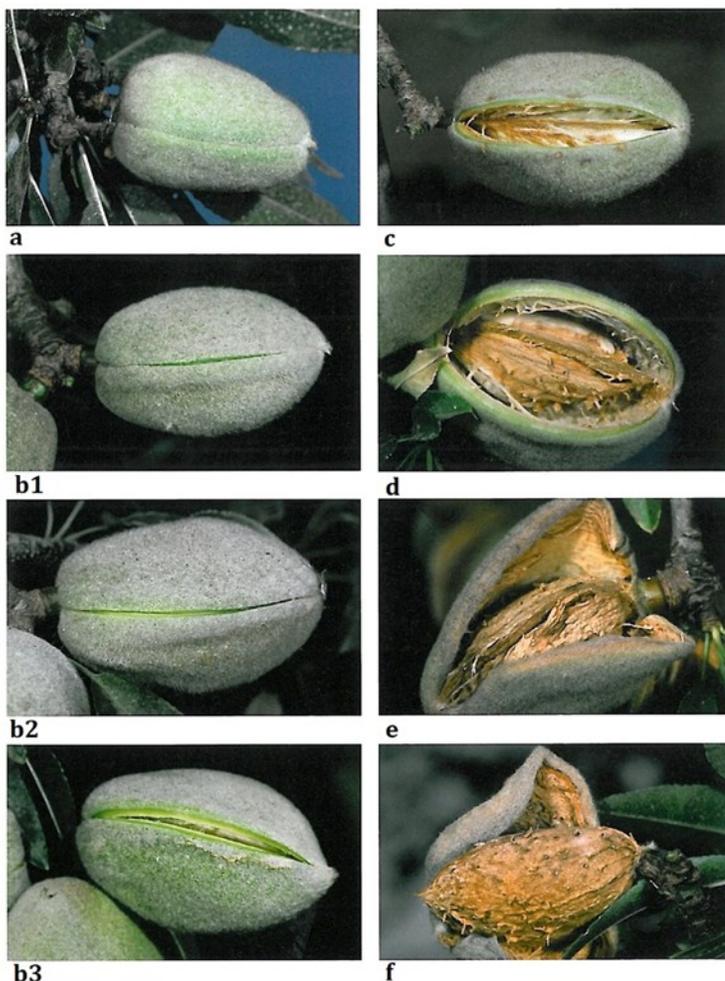


Figure 1: Stages of hull split.

- a. unsplit hull
- b1. initial separation
- b2. deep V split
- b3. deep V split, but nut pops when squeezed
- c. split, but less than 1 cm
- d. split, more than 1 cm
- e. initial drying stages
- f. completely dry

Further work by Dr. Adaskaveg has found that sprays timed to the b2 stage will decrease hull rot incidence. Due to the variability of hull-split progression within the field, fungicides should be applied at 10-20% of hull-split. Both DMIs (FRAC 3) and strobilurin (FRAC 11) fungicides are effective. These sprays are additive to the reductions shown by the cultural management practices of irrigation and nitrogen management. It is important to note that increased populations of other foliar fungi that occur at this hull split spray timing increases the risk of developing fungicide resistance, so fungicide sprays for hull rot should be used as a last resort. Fungicides applied at this time do not work on hull rot caused by *Monilinia fructicola*. Maximum residue levels (MRLs) of the fungicide chemistry used should be discussed with the processor/handler to determine the most up-to-date information, and pre-harvest intervals should be followed.

Hull rot management: bringing it all together.

Successful management of hull rot will rely on both cultural and chemical control strategies. Proper implementation of these practices must take in account the localized growing conditions. A late season rain may reduce the effectiveness of deficit irrigation or prevent the application of a fungicide spray. A late frost may lead to reduced crop load and an over-fertilized tree. Heavier and coarser soil types make the implementation of proper level of tree stress challenging; one requires a longer period of dry-down while the other may become dry too quickly. Even with varying environmental conditions, applications of the mentioned strategies have been shown to reduce hull rot in both field studies and grower's operations. Success and proper application will be dependent upon the monitoring of tree status through stem water potential readings, leaf tissue analysis, and observations of hull split timing.

Sources:

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Alternaria Leaf Spot and Leaf Rust of Almond

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Alternaria leaf spot and almond rust are fungal diseases of almond that are becoming more prevalent in the Sacramento Valley. Both diseases are favored by high humidity and leaf wetness. Often, additional fungicide treatments are necessary to minimize early defoliation. Recent extended wet springs and changes in cultural practices (higher density plantings and microsprinkler irrigation with longer, more frequent irrigations) are contributing to higher humidity, more accumulated leaf wetness hours (e.g., dew, rainfall, irrigation, etc.) resulting in higher disease incidence.

Alternaria leaf spot is a fungal disease caused by a complex of *Alternaria* species including *A. alternata*, *A. arborescens* and *A. tenuissima*. *Alternaria* leaf spot appears as up to half inch diameter brown spots (Fig.1) on leaves. Leaf spots turn black as the fungus produces spores. *Alternaria* leaf spot develops most rapidly in the hot summer months, and can almost completely defoliate trees by mid-summer.

Disease management. Relying entirely on fungicides to control this disease can be costly and increases the risk of resistance development. Consider an integrated approach including:

- Planting less susceptible cultivars. Varieties most susceptible include Carmel, Sonora, Monterey, Winters, and Butte.
- Select a planting design which allows for air circulation. Orchards planted with rows in an east/west direction typically have more severe disease than orchards with rows in a north/south orientation.
- Prune and train trees to allow air circulation and reduce dew formation.
- Practice good foliar disease and mite control to minimize stressed and injured leaf tissue.
- Irrigate less frequently with larger volumes of water to minimize relative humidity and subsequent leaf wetness.
- Manage the orchard floor to reduce relative humidity and the amount of senescing tissue colonized by *Alternaria* species.

Disease resistance against QoIs (strobilurins – FRAC group 11) and SDHIs (FRAC group 7) occurs in the Sacramento Valley. Late-spring/early-summer applications should alternate materials to manage resistance. New materials (Quash, Inspire Super - both containing FRAC group 3) and Ph-D (FRAC group 19) must be used in rotations and mixtures for resistance management. Newer SDHI fungicides (different sub-groups) such as Luna Sensation, Luna Experience, and Merivon (Fontelis should always be mixed with a DMI fungicide) are proving to be highly effective but the potential for resistance is also extremely high. Combination tank mixtures, pre-mixtures, and rotations will be required for preventing disease resistance to the newer SDHI compounds.

Rust is caused by the fungus *Tranzschelia discolor* and occurs sporadically throughout almond-growing areas in California. It appears as small, yellow, angular spots on the upper surface of leaves and rusty red pustules of spores on the lower surface (Fig. 2). The disease is favored by spring and early summer rains and is more likely to become serious in orchards near rivers or streams or other locations where spring and summer humidity is relatively high. Excessive levels of nitrogen are also known to increase a tree's susceptibility. The disease causes premature defoliation and will weaken trees, reducing the following year's bloom. The rust fungus overwinters in infected leaves that remain on the tree, spores contaminating buds and tree bark, and possibly infected twigs. Rust is frequently more severe in young vigorous trees, especially in second to fourth leaf orchards where fungicides have not been applied.

In orchards with a history of rust, treatments should be applied before symptoms appear: 5 weeks after petal fall and a second application 4 to 5 weeks later to control leaf infections. Monitoring can be done in April through May. Surveys by orchard block where 1% leaf infection occurs are at high risk if conducive environments persist. Two or three applications may be needed in orchards that have had severe rust problems.

A zinc nutritional spray (zinc sulfate 20-40 lbs./acre) applied in late October to early November resulting in defoliation may reduce overwintering rust inoculum.

Resistance management will be critical to maintain efficacy of currently available fungicides. Resistance development in *Alternaria* species to QoI fungicides was first detected in 2003/04. Field Disease resistance was found in Kern County in 2005 and in northern California in 2007. Field disease resistance to SDHI fungicides (group 7) was found in the northern and southern Central Valley in 2007. Consequently, Pristine® (groups 7/11 or QoI + SDHI) is not effective in some locations. For rust, resistance has not been detected and the potential for resistance against QoI (group 7 or QoI) and DMI (group 3) fungicides is considered low.

The following are general suggestions for fungicide resistance management:

- Rotate and mix fungicides that belong to different FRAC group numbers.
- Apply per acre label rates, **no every-other-row spraying** (upper label rates for QoIs).
- Limit a single mode of action fungicide class (e.g. FRAC Group) application to 1 or 2 per orchard per season.
- Start your fungicide program with a multi-site mode of action material (Captan, Bravo/Echo, Ziram, Rovral, sulfur). Sulfur can be used in combination with single-site mode of action fungicides such as QoI and DMI fungicides.

Fungicides effective for *Alternaria* leaf spot and rust can be found at www.ipm.ucdavis.edu Click on Agricultural Pests, then Almond, and then the individual diseases. Another resource is the 2012 Efficacy and Timing of Fungicides Publication at: <http://ipm.ucdavis.edu/PDF/PMG/fungicideefficacytiming.pdf>



Fig. 1. *Alternaria* Leaf Spot



Fig. 2. Almond Leaf Rust

Water Management for Almond: in-season, harvest and post-harvest

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Accurately imposing water stress for almond is challenging. Experience is one approach but more and more almond growers are using midday stem water potential (pressure chamber) to monitor actual tree water deficit. This article outlines an irrigation strategy using midday stem water potential as a monitoring tool. Low levels of tree water stress (-6 to -10 bars SWP) in almond are usually observed in the spring shortly after leafing when the days are shorter, weather is cooler, and rainfall is more abundant. As the season progresses, temperature and day length increase resulting in SWP levels in the low to mild range (-10 to -14 bars SWP) for fully irrigated, mature trees.

Excellent yields (over 4000 lbs/acre) are possible in the southern San Joaquin Valley when irrigation is managed to maintain tree water status in the low to mild SWP range for the entire season. This southern production region with warmer weather, less rainfall that favors pollination, and more intensive fertility management, appears to be more responsive to low tree stress. Concern exists about higher incidence of diseases, lower limb dieback, and shorter orchard life under this management regime. Irrigation managers also need to avoid saturated soils and poor aeration that compromise root health and tree performance. The decision to adopt intensive irrigation management to sustain low to mild stress involves an economic decision weighing the pros and cons of higher yielding orchards with potentially shorter life spans versus lesser but competitive yielding orchards with longer lives.

For locations where frost, pollination, disease, nutrition, or water scarcity result in more variability in cropping, a low tree stress management approach may not be the best management strategy. The use of SWP to impose timely and controlled levels of tree stress in almond may be the better choice. Controlled tree stress is referred to as “regulated deficit irrigation” or RDI. RDI involves withholding water at crop development stages where controlled levels of tree stress do not adversely affect crop yield or kernel quality and might improve tree performance. A possible RDI strategy would include irrigation management that sustains SWP at low to mild levels of stress (-6 to -14 bars SWP) from leaf out until just prior to hull split. Recent experiments in Glenn and Butte counties where salinity is not a management concern showed that SWP ranging from -14 to -18 bars (moderate stress) can be tolerated during hull split by almond without economic effects on kernel yield. A return to low to mild stress (-10 to -14 bars SWP) with the last irrigations prior to harvest will help prevent leaf loss during the harvest period. After harvest, sufficient post-harvest irrigation should be applied to recover tree stress to mild levels (-10 to -14 bars SWP). In some almond growing regions, particularly with later maturing almond varieties, rainfall may be adequate to supply post-harvest water needs.

Hull and foliar diseases are reduced with less free moisture and humidity in an orchard (moderate crop stress levels) and more uniform nut maturity and efficient harvest may be achieved with an RDI approach. Moderate tree stress during hull split has the potential to save water in comparison to a low stress irrigation strategy but implementing an RDI strategy does not always result in saving water. Almond orchards not currently monitored with a pressure chamber and SWP may already be under deficit irrigation at higher levels of tree stress than is prudent for RDI. If so, implementing RDI may result in applying more water to correct tree stress prior to onset of harvest operations.

High tree stress (-20 to -60 bars SWP) will result in increasing levels of defoliation and can reach a point of complete leaf loss. Kernel fill will be reduced causing more wrinkled nuts and lower kernel weights. Lower limb dieback has also been observed to increase 2 to 4 weeks following a high tree stress event (-20 bars). As tree stress increases, hull split is affected and a higher incidence of “stick tights”, where the hull adheres to the almonds, may result. Severe levels of tree stress will increase the impacts on shoot growth and bud formation impacting future bloom and tree fruitfulness. Almond has the ability to survive very high to severe tree stress levels, possibly as much as -60 bars SWP. The drawback of severe tree stress is severe reductions in crop yield and quality. In situations, where water supply is severely limited, almond may survive severe tree stress for a season, possibly longer, and then recover to near full production after sufficient irrigation is restored. Research suggests a recovery timeframe of two years or possibly longer.

Suggested guidelines for interpreting SWP measurements in almonds are shown in Table 1.

Table 1. Guidelines for interpreting Stem Water Potential measurements for almonds.

Pressure Chamber Reading or SWP measurement (bars)	Extent of Tree Stress and Types of Crop Responses Associated with Different SWP Levels in Almonds
0 to -6.0	Not commonly observed
-6.0 to -10.0	Low stress, fully irrigated conditions. These levels stimulate shoot growth, especially in developing orchards. Higher yield potential may be possible if these levels of crop stress are sustained over a season, barring no other limitations related to frost, pollination, diseases, or nutrition. Sustaining these levels may result in higher incidence of disease and reduced tree life span.
-10.0 to -14.0	Mild stress. Suitable in mid-June up to the onset of hull split (July) and still produce competitively. Recommended crop stress level after harvest. May reduce energy costs or help cope with drought conditions.
-14.0 to -18.0	Moderate stress. Will stop shoot growth in young orchards. Mature almonds can tolerate this level of crop stress during hull split (July/August) and still yield competitively. May help control diseases such as hull rot and <i>Alternaria</i> , if present. These levels may expedite hull split and lead to more uniform nut maturity. Also may help reduce energy costs and cope with drought conditions.
-18.0 to -20.0	Transitioning from moderate to higher crop stress levels, which should be avoided for extended periods. Likely to reduce yield potential and may contribute to lower limb dieback.
-20.0 to -30.0	High stress, wilting observed, some defoliation. Impacting yield potential.
-30.0 to -60.0	Very high to severe stress. Extensive or complete defoliation is common. Trees may survive despite severe defoliation and may be rejuvenated.
Less than -60.0 bars	Trees are likely to die.

Pre-Harvest Almond Orchard Nutrition

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Once hull split begins, orchard nutrient management may be less of a focus compared to other orchard activities, particularly pest management and harvest preparation. However, several nutrition related activities including leaf sampling and potassium (K) fertigation shouldn't be forgotten.

Leaf sampling is the key nutritional practice in July. While July leaf sampling is too late to help direct current season nutrient management, it is the most valid nutrition report card for the season based on leaf sampling at the proper time to compare with established standards. Take leaf samples in July; send them off to the lab and file the results in the "after harvest" file. Soon after harvest, review records of fertility practices and timings for the season and your yield results. Then, review the leaf sample results and plan for postharvest applications of needed nutrients or adjust your plans for in-season fertility management the following season.

When taking leaf samples, it is important to be consistent with previous practices, especially now with a new sampling protocol developed by researchers at UC Davis. Comparing lab results from one year to the next, when different protocols are used to sample leaves, may be less accurate than when the same protocol is used year in and year out. The major differences between the two protocols are 1) the new protocol requires collecting all the leaves from 5-8 well exposed, non-fruiting spurs per tree around the canopy located between 5 and 7 feet from the ground and 2) the trees should be at least 90 feet apart.

The traditional sampling collected fully expanded leaves from non-fruiting spurs at roughly 6 feet in height from trees across the planting that are representative of the majority of trees (same variety and rootstock) in the block. Don't sample in a corner of the field and call it "representative". Take a hike across the block and get a good sample. Approximately 100 leaves per sample, a few leaves per tree, are needed.

The new protocol from Dr. Patrick Brown's lab at UC Davis should be used for both April and July sampling if results from the two sampling times are to be compared. The following steps should be taken:

- Sample uniform, representative trees across the block.
- Sample trees must be at least 90 feet apart and to overcome typical tree to tree variability a truly representative sample must be collected from 18 to 28 trees.
- From each tree, sample all the leaves from 5-8 non-fruiting, well-exposed spurs.
- Combine all the leaves in a single sample bag.
- A minimum of 100 leaves per sample bag is required.

By taking the July samples with the new UC protocol and comparing it to the samples taken in April with the same protocol, you can start to evaluate the April sampling practice for your operation. If you plan to shift over to the new protocol on a regular basis, you might want to take two samples from several blocks this year – one by the old protocol and one by the new – to see how well they compare. This will be especially important if you track leaf analysis results over time.

The current UC leaf nutrient standards are in the following table. Use these numbers, along with visual evaluation of tree vigor and general appearance and yield data to determine orchard fertility programs on an orchard by orchard basis.

CRITICAL NUTRIENT LEVELS FOR ALMOND LEAVES* SAMPLED IN JULY.

NUTRIENT	ALMOND TREE NUTRIENT STATUS
Nitrogen	Deficient: below 2.0% Low: 2.0-2.2% Adequate: 2.2-2.5% High: 2.5-2.7% Excessive: more than 2.7%
Phosphorous	Adequate: 0.1-0.3%
Potassium	Deficient: less than 1.0% Adequate: more than 1.4%
Calcium	Adequate: over 2.0%
Magnesium	Adequate: over 0.25%
Sodium	Over 0.25% = excessive (potentially toxic)
Chloride	Over 0.3% = excessive (potentially toxic)
Boron	**Hull levels adequate over 80 ppm
Copper	Adequate: over 4 ppm
Manganese	Adequate: over 20 ppm
Zinc	Deficient: under 15 ppm

* Fully expanded leaves from non-bearing spurs sampled in July.

** Use analysis results of hulls sampled at harvest to best assess almond boron status.

Finally, this late in the season, will fertilizing with any nutrients benefit the crop? Steady potassium (K) uptake into almond nuts occurs for 180 days – roughly six months -- after full bloom. What about nitrogen? Nut N content increases very slowly between early June and harvest compared to the March through May period, so significant N fertilization in July isn't needed for the current crop. In addition, adding N after June 1 risks increasing hull rot incidence, as high N status is linked to elevated hull rot damage (see article on hull rot in this newsletter). Injection of K fertilizer through micro-irrigation, especially drip irrigation, is an effective way of rapidly getting K into trees. Growers with flood, solid set sprinklers, and wide-pattern micro-sprinklers should consider waiting until the fall to apply potassium band applications to the soil.