Sacramento Valley Almond News

Bloom, 2021

University of California
Agriculture and Natural Resources | Cooperative Extension

In This Issue

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Almond Orchard Management Considerations – Bloom through Early April

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IRRIGATION

This will be an interesting irrigation season. The initial US Bureau Rec surface water allocations have not yet been made, but given the current rain totals and reservoir levels, it is hard to imagine good news when they are released in February. The best way forward, as we see it, is to:

- Start the season with a full profile. Even if only moderate quality well water is available ahead of bloom, irrigate to fill the profile. Any further rain will leach and/or dilute rootzone salts from the groundwater. If needed, use several irrigations of less than 24 hours each, several days apart, to avoid extended soil saturation and *Phytophthora* infection. For more information on winter irrigation and leaching, see: growingthevalleypodcast.com/podcastfeed/leaching.
- Know what you are working with. Have lab analysis for root zone soil samples [salinity (EC), chloride and sodium (SAR)] from this winter and/or irrigation water source(s) on hand to help with irrigation decisions as the season progresses. More information on water quality in orchard crops at: sacvalleyorchards.com/walnuts/irrigation-walnuts/evaluating-water-supply-for-irrigating-nut-crops/.
- Ready your monitoring tools. Have plant water status (pressure chamber, etc.) and soil moisture sensor equipment ready to go for the season. New batteries or other equipment required?
- If not done already, check out your irrigation system ahead of bud swell and frost risk. Not all orchards can use water for frost protection, but an early checkup makes sense in a year where early irrigation may be needed. More information available at: sacvalleyorchards.com/almonds/irrigation/irrigation-system-maintenance.
- If you farm in Tehama, Butte, Colusa, Glenn, Shasta or Yolo counties you can apply for a free system evaluation from the Tehama Resource Conservation District Mobile Irrigation Lab. For more information, or to schedule a free evaluation, please contact: Kevin Greer (530) 727 – 1297, kevin@tehamacountyrcd.org.

- Review information on irrigation in drought years. Among other UC resources, a free UC ANR publication on drought management in almonds is available at: anrcatalog.ucanr.edu/pdf/8515.pdf.

NOW SANITATION

Sanitize for navel orangeworm!!! Don't ease up on navel orangeworm (NOW) management this year just because 2020 navel orangeworm damage was generally light. (Overall Nonpareil rejects for a major processor in the Sacramento Valley doubled from 2016 to 2017.) Overwintering NOW survival is much higher in drought years with dry winters. Target no more than 2 mummies/tree on average (less if possible) at bloom. In high pressure sites, the target is an average of 0.2 mummies per tree and 8 mummies on the ground under a tree.

- Talk with your neighbor. NOW can and will fly at least a quarter mile. If you sanitize and your neighbor doesn't, you can have higher pressure at hull split due to "fly in" NOW. It's high time to approach NOW from an area-wide perspective. Everybody needs to be doing this single most critical activity for reducing damage. You are ahead in NOW management with a sanitized orchard; you are really ahead if your neighbors sanitize, too.
- It's not too late. If you haven't sanitized before bud swell, there could still be time to cover some or all your orchards. An article by Wes Asai in the January, 2020 issue of West Coast Nut summarizes a 2-year trial examining the impact of late winter sanitation close to bloom. The trial showed no yield differences with winter shakes in early February (no open flowers) compared to early December. Some buds were removed, but mummies were removed and yield was not reduced.
- Finish the job by mowing by March 1. Make sure to blow/sweep downed mummies into middles/windrows and flail mow (or disc or shred) to ensure destruction of mummy nuts. Do this by March 1 to make sure NOW are still in the mummies when they are shredded. When flail mowing mummies, watch your mower speed and height setting; double-check a pass or two to ensure that nuts are being shredded.

WEED MANAGEMENT

- If not done already, talk with your PCA about a preemergence herbicide program for weed control in tree rows (strip sprays) before the "rainy season" ends. Some rain (up to an inch) is needed to incorporate preemergent herbicides within one to four weeks after application (check the label, with your PCA or the UC IPM website. Prepare for sprays by removing leaves or dead weed cover from strips. Applications made to clean soil will last longer and be more effective.
- Weed management can be particularly difficult in newly planted and young orchards, as weeds get plenty of sun, water, and fertilizer. Check with your PCA about pre-emergence programs for young orchards. There are a few materials labeled for use starting in first leaf. Pre-emergents are expensive, but so are repeated burndown (post-emergent) sprays which can damage trunks of young trees. See info on weed control in young orchards including a table listing materials and label restrictions for young trees at: sacvalleyorchards.com/manuals/young-orchard-handbook/weed-management-for-young-orchards.
- Trunk cartons can provide protection from herbicide injury for young trees; however, paint alone does NOT provide protection. Learn more at: ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=38701 and growingthevalleypodcast.com/podcastfeed/trunkprotection.

DISEASE MANAGEMENT

- Protect flowers during bloom with fungicides as needed, based on orchard history and weather conditions. The most current fungicide efficacy and treatment timings table for almond diseases are included in this newsletter.
- If bloom weather forecast is clear (little/no rain), a single fungicide application at 30% to 40% bloom is effective for disease control using locally systemic fungicide(s) [FRAC 3, 9, and/or 11].
- If bloom weather forecast indicates significant precipitation, apply two bloom fungicide sprays, one at pink bud (pink bud is not budswell) and one at full bloom.
    - If warm storms are forecast (temps in the low 60’s), include at least one fungicide active on anthracnose in each application (see efficacy tables in this newsletter).
    - If forecast is for cold storms, include at least one fungicide active on jacket rot (see efficacy tables in this newsletter). FRAC 3 fungicides are largely ineffective on jacket rot.
    - Freezing/wet bloom weather = elevated risk for flower damage from bacterial blast. Frost protection helps reduce blast damage (see bullet on frost control). Kasumin® antibiotic is the most consistently effective treatment in UC trials, but is **not yet registered in almonds**. A Section 18 emergency registration for 2021 has been requested (the 2020 Section 18 expired) but has not been approved to our knowledge. Biologicals such as Actinovate AG and Botector provided some reduction in blast damage in trials in cherry, but less than Kasumin®.
- Get your sprayer(s) ready before needed. Check your sprayer for worn or broken parts [nozzles, strainers, pressure gauge(s), etc.]. Calibrate the sprayer by measuring ground speed and spray flow. Target most of the spray volume towards the upper canopy as rainfall will redistribute the spray materials downwards. The general rule is at least 2/3rd of the spray volume (gallons per minute) should go out of the top half of the open nozzles. See the article on calibrating sprayers for bloom sprays in this newsletter.

HONEY BEE SAFETY

- Bee kind to bees in your orchard, you need them! Spray after pollen is gone from the orchard for the day and use only fungicide in the tank. (B.t. insecticide is bee safe and is the only exception to the “just fungicide” rule). See article in this newsletter for bloom pesticide activities, bee considerations, and the new BeeWhere program.

FROST PROTECTION

- Well before freezing conditions are predicted, close mow your orchard middles (vegetation should be < 2 inches tall). Once a freeze is forecast, irrigate to wet the top foot one to two days ahead of the event. Moist, firm, and bare/close mowed orchard floor stores and releases more heat through cold nights than orchards with taller vegetation or recent cultivation. Check your irrigation system to make sure it can function at bloom in case freezing temperatures are forecast.
- If sprinkler irrigation is available and a freeze is forecast, turn on irrigation before wet bulb temperatures reach the critical crop values; turn off water once the wet bulb temperature is above the critical values (or when all the ice melts). Critical values for many varieties and flower stages are listed at: sacvalleyorchards.com/blog/almonds-blog/low-temperatures-in-the-forecast.
- Drip irrigation provides no benefit when run during frost, but irrigating a day or two ahead of cold (especially with the greater wetting surface of double line drip) gives time for wet soil to warm with sunlight and store more heat to release on a frosty night. Re-irrigate the surface few inches of soil if

the surface dries out (a dry surface crust can prevent heat storage during the day and its release at night).

- National Weather Service has a web-based calculator that calculates wet-bulb temperature from dry bulb temperature and relative humidity. See it at: weather.gov/epz/wxcalc_rh. Assume 1013 millibars atmospheric pressure – that's the pressure used to develop tables reported in biomet.ucdavis.edu/frostprotection/Start&StopSprinklers/FP001.htm.

INSECT PESTS

- If peach twig borer (PTB) requires treatment, products containing only the active ingredient *Bacillus thuringiensis* (Bt) can be used at bloom with minimal impact on honey bees (when bee-safe application practices are followed). PTB can also be controlled with a delayed dormant spray or "May spray" (based on degree day timing), so bloom-timed B.t. application, while effective, is not essential. More information on PTB management is available at: ipm.ucdavis.edu/PMG/r3300211.html and sacvalleyorchards.com/almonds/insects-mites/when-is-peach-twig-borer-a-concern/.
- Hang San Jose scale and Oriental fruit moth traps by mid- to late-February; navel orangeworm and peach twig borer traps by mid-March. Begin accumulating degree days once biofix has been established. More detail at: ipm.ucanr.edu/agriculture/almond/ (select pest).
- If mating disruption is part of your IPM program for NOW, deploy dispensers by late March or early April. In areas where the wind blows from one predominant direction, disruptants should be placed so there is a higher density of traps on the windward (upwind) edge of the orchard. The NOW pheromone traps should be shut down (catching no male moths) with good dispenser placement, so make sure your monitoring includes egg and bait bag traps to follow NOW activity. More information at: ipm.ucanr.edu/agriculture/almond/navel-orangeworm/.
- Tell your almond, walnut, and pistachio neighbors if you are using mating disruption, as NOW pheromone trap catches may be affected in areas outside of the treated orchard. With NOW, the more effective your neighbors' management programs are, the better off you will be.

NUTRIENTS

- Cropload determines fertilizer need in mature orchards. The 2020 crop/acre in the Sacramento Valley was way up and experience suggests that 2021 crop may be lighter. That plus lower/uncertain nut prices makes conservative nutrient planning a reasonable approach for tree health and farm budget.
- Apply approximately 20% of the year's predicted nitrogen needs by late February or March.
- Start your K fertigation program in March or early April if dry fertilizer was not applied at all in the fall/winter.
- 1 to 2 lbs Solubor®/acre (equal to 0.2 to 0.4 lbs actual boron/acre) spray applied before bloom (no later than pink bud) can increase nut set and yield if a fall spray wasn't used and previous year hull samples showed low boron (B) levels. Spray late in the day to avoid direct spraying of any wandering bees.

Early Season Irrigation: Do We Know When to Start?

Allan Fulton, UCCE Irrigation and Water Resources Advisor Emeritus
Luke Milliron, UCCE Farm Advisor for Butte, Tehama, and Glenn Counties

Why does it Matter?

One of the motivations for making good water management decisions early in the growing season is to reduce risk of root and crown diseases that can eventually kill almond, walnut, prune, and other tree species. These diseases need three elements to infect and damage a tree: a susceptible host plant, a pathogen, and favorable environmental conditions. Early season water management influences the environment where roots grow by affecting soil temperature and aeration and can be pivotal in how much tree decline actually occurs. Trees are expensive. The money and effort spent to establish them is lost, more costs lie ahead to replace them, and production is lost.

Many Information Sources, but only one Direct Indicator

Each season you need to decide when to start irrigating. It can be difficult to choose the best time to start irrigation. There's a lot of different information sources you can use to make this decision. You can copy practices that you observe around you, evaluate soil moisture, consider the weather and evapotranspiration loss of the crop (ETc), or take a plant-based approach and in a sense "ask your trees" if they need to be irrigated. Utilizing multiple information sources for an important decision like this is highly recommended. Utilizing the plant-based monitoring approach of "stem water potential readings with a pressure chamber" has a distinct advantage over the others.

The pressure chamber (Figure 1) directly determines the water status experienced by the trees, while the other sources such as ET or soil moisture, although helpful are indirect. The pressure chamber gauges the amount of positive gas pressure (in pressure units, e.g. bars) required to balance the level of water tension in a plant sample (e.g. leaf). The level of water tension in a leaf expresses the degree of effort utilized to pull water all the way through the tree from the soil. Relying on an indirect information source, particularly an approach like beginning irrigation when your neighbor does, when the surface soil has dried out, or irrigating on the first hot day, could result in irrigating too soon.

To learn more about the pressure chamber, stem water potential, the fully watered baseline, how to go about getting equipment and taking measurements, check out our series at: [sacvalleyorchards.com/manuals.](sacvalleyorchards.com/manuals)

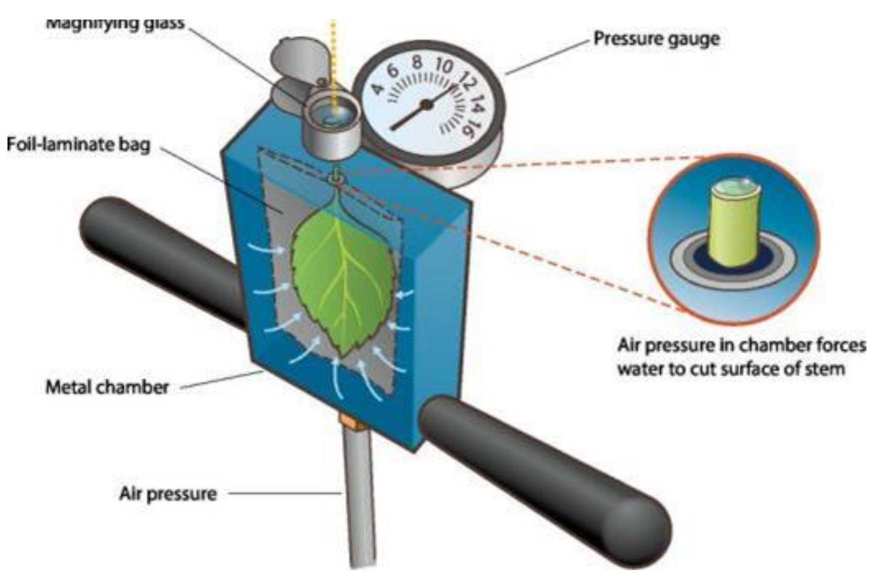

Figure 1. Schematic showing how water potential is measured in a severed leaf and stem (petiole) using a hand-held pump-up pressure chamber. Source: Adapted from Plant Moisture Stress (PMS) Instrument Company.

Flexibility to Delay the First Irrigation

Research in a walnut orchard in Tehama County has found that start of irrigation can be delayed by waiting for mild to moderate water status when measured with the pressure chamber. Some observed benefits have been a minimum 10 percent reduction in energy for pumping, less tree stress during harvest season, and edible kernel yield was equal or slightly better. A managed (informed) delay in start of irrigation may allow for deeper root activity late in the season. Possibly, an irrigation strategy that starts the irrigation season too early promotes a shallow root system at the expense of deeper root development. UC researchers are in the early stages of repeating this investigation in almonds in the Northern Sacramento Valley.

Before UC researchers have multiple years of results from this work in almond, it is best to be cautious in choosing a level of stem water potential with the pressure chamber to trigger the first irrigation of the season. From everything we currently understand, **waiting for a tree water status of 1 bar drier than the fully watered baseline before applying the first irrigation** represents a low-risk irrigation decision that could benefit long term tree and root health.

Monitoring Weather- Crop Evapotranspiration (ET)

If using the pressure chamber isn't appealing or a second source of information is desired, monitoring the weather and evapotranspiration crop losses is an option. This method is sometimes called a "water budget". It is analogous to budgeting money. Soil water storage in the crop root zone equates to a balance in a checking or savings account. ET equates to a debit from the account and significant rainfall or irrigation equates to a deposit or credit into the account. Water budgeting approximates the soil moisture level in the root zone rather than measuring it with soil moisture sensors. The goal is to avoid extreme imbalances.

Weekly ET reports are available during the irrigation season online at sacvalleyorchards.com/et-reports/ or can be delivered weekly by email. At that same website there is also a series of how-to videos on ET, which are available for self-study CURES credit at: curesworks.org/cecourses. ET is estimated based upon real-time weather measurements at eight regional CIMIS weather stations across the Sacramento Valley. Estimates are for trees with at least 50 percent canopy cover and need to be adjusted downward for smaller trees. Each report provides a real-time estimate of ET in inches for the past seven days and an estimate for the next seven days and keeps a running total for the season. Accumulations begin at leaf out for each crop which enables their use to help decide when to begin the irrigation season. It is important to know the hourly water application rate (inches/hour) of your irrigation system.

Using an example from the 2018 season, if we followed each weekly report from February 16 – May 3 for the Gerber South CIMIS weather station, it showed that cumulative ET for almonds was 7.51 inches while cumulative rainfall for the same period was 5.26 inches and resulted in a 2.25 inch soil moisture deficit. This assumed that all of the rainfall was effectively used in the orchard which is a site specific consideration that needs to be adjusted accordingly in the water budget. Dividing this 2.25 inch soil moisture deficit by a water application rate of 0.07 inch per hour (i.e. an almond orchard with 124 trees per acre with one 16 gph microsprinkler per tree) equates to 32 hours of irrigation or the equivalent of two 16 hour irrigation sets that suit PG&E off-peak rates. Choice of set length is site specific consideration depending on irrigation system and soil type, however it is best to minimize ponding conditions that can starve roots of oxygen and provide favorable disease conditions.

The previous example provides context of how this deficit relates to the irrigation system capacity. It is left to the irrigation manager's judgement to continue to delay the beginning of irrigation to protect tree and root health, begin irrigation by partially refilling the soil moisture deficit (i.e. one 16 hour irrigation set), or begin irrigation and fully replace the soil moisture deficit. If this information were paired with the pressure chamber measurements and the stem water potential measurements were still less than 1 bar drier than the fully irrigated baseline, the manager may have more peace of mind about continuing to delay the first irrigation.

Monitoring Soil Moisture Depletion

If neither the pressure chamber nor water budgeting appeal to you or you are looking for a backup to one or both of these methods, directly monitoring soil moisture is an option. Checking soil moisture by hand is a very basic method to evaluate soil moisture conditions. There are many online stores where soil augers can be purchased (try: JMC Backsaver, AMS samplers; Forestry Suppliers; and/or Ben Meadows). The USDA, NRCS also offers a nicely prepared publication with color pictures titled *Estimate soil moisture by feel and appearance:* nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf.

There are also a wide variety of soil moisture sensors that can also be used. Refer to the article *Soil moisture sensor selection is confusing* for more insight: sacvalleyorchards.com/blog/soil-moisture-sensor-selection-is-confusing/.

Hive Strength and Bee Health/Safety

Franz Niederholzer, UCCE Farm Advisor, Colusa and Sutter/Yuba Counties

Hive strength: For a successful harvest, start the season strong. A large crop at harvest requires good bee activity at bloom in the orchard. The current UC general recommendation for bee hive stocking rates is **1-3 strong hives per acre**. A strong hive contains at least **8 frames covered with bees**, an actively laying queen, and one to two frames of brood. Where cold, rainy and/or windy conditions limit bee flight (remember the 2019 bloom?), two to three strong hives may be needed to supply enough bees to set a decent crop when narrow windows of good bee weather open up. Less than two hives per acre may be sufficient to set a good crop in extended good bloom weather (2020 bloom). Good bee weather is at least 59°F, no rain and less than 10 mph wind speed. [In general, bees begin to forage when temperatures reach 55°F, winds less than 15 MPH and it's not raining.]

Hive strength makes a difference in pollination activity (see graph below). The more frames covered with bees in a hive means more foraging bees and more flowers pollinated. The best possible start to the season begins with strong hives in the orchard at the start of bloom.

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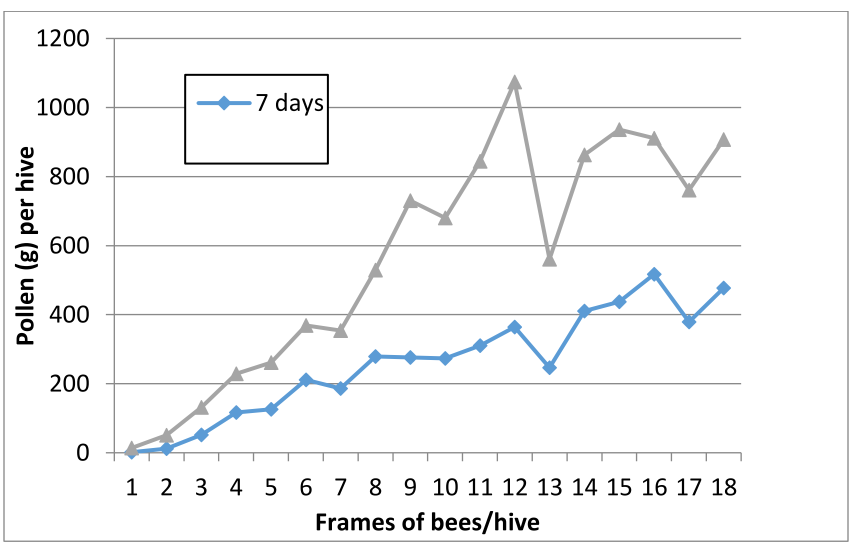
Average pollen collected per hive for a range of hive strengths based on frames of bees per hive over a 7 or 10 day period. Data from Sheesley and Bernard, Cal Ag, 1970



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To ensure strong hives in the orchard as bloom starts, pollination contracts should include 1) language stating hive strength and 2) an inspection clause stating that some fraction of the hives will be opened and frames inspected by a third party at or soon after delivery to confirm if the contracted hive strength was delivered. The hive strength check should happen at or close to delivery because, as almond flowers are an excellent food source for honeybees, a four-frame hive at delivery to the orchard can become stronger as the pollination season progresses. Assessing colony strength at the end or close to the end of pollination season is not an accurate measure of the pollination activity at the start of the season when strong hives are most needed.

Growers using lower bee stocking rates (1-2 hives/acre) in an effort to save money are the most in need of contract language stating hive strength and a hive inspection. **A single 8-frame hive collects 2.5x the pollen as a 4-frame hive**.

Hive health. Where hives are located and bees treated in an orchard can impact hive health and potentially pollination performance. Hive location, availability of clean water and spray programs (materials and timings) all should be considered by growers and communicated with beekeepers.

Hive placement plays a role in good bee activity across the orchard. Hives should be placed in locations where early morning sun will warm the hives and in groups in or around the orchard no more than a quarter of a mile apart.

Bees need water and will go find it (somewhere else) if not available in your orchard. Check-in with your beekeeper to decide on location and responsibility for providing watering stations for bees in your orchard. The water stations should be protected from pesticides by covering or moving the station or changing the water, or changing after spraying. Bees can't drink while flying and can drown trying to get to water if there is no landing site at the water source. A 5 gallon bucket with clean water and an old towel or piece of burlap draped over the bucket lip and into the water works as a bee watering site. The Almond Board of California's most recent Honey Bee Best Management Practices is available at almonds.com/sites/default/files/2020-12/BeeBPMs_12212020.pdf.

Bees can be harmed by pesticides. Certain pesticides and practices can be particularly harmful. In particular, all/any insecticides (except B.t. products such as Dipel) should not be used at bloom. Adjuvants, particularly organosilicones, can harm bees directly and/or increase the impact of pesticides on bees and should be left out of bloom sprays. Foliar nutrients may also harm bees. Protect your bee investment; put only fungicide(s) in the spray tank at bloom.

While both bees and fungicides are needed during bloom in Sacramento Valley almond orchards in most years, the best practices for bee health and crop set require dividing the day between time for bee activity and time for spray activity; a split shift for bees and sprayers (on spray days). This approach lets bees work and then flowers can be protected. Here's how that works.

The key to good hive health is keeping sprays off the daily pollen load that forager bees carry back to the hive and fed to the brood. Almond flowers release some pollen every morning as humidity drops after sunrise. This occurs for several days after the flower opens. In an orchard with good bee activity, pollen released that morning is stripped from flowers by early afternoon. Fungicide spraying shouldn't start until then; when pollen available for the day is gone (collected by bees and flown back to the hive). There are a couple of ways to check if the pollen is gone from flowers. If the pollen gathering bees (the ones with yellow lumps of pollen on their hind legs) are just doing touch-n-go landing on flowers, those flowers don't have pollen left and it's OK to spray. Another method is to rub the flower anthers (the spikey structures in the center of the flower) between your thumb and fingers and then check for yellow pollen on your hands.

If there is little to no pollen on your fingers, the bees have been there and gone. (Wash your "pollen-check" fingers before rubbing your eyes. Don't ask me how I know.)

Almond flowers provide pollen (and nectar) that build strong hives while providing pollination leading to nut set and a good harvest for growers. The continued success of this annual win/win relationship relies on consideration of the needs of both partners. Growers need strong hives at the beginning of bloom and beekeepers need strong hives at the end of bloom.

Finally, hives should be removed once 90% of the flowers in the last pollinizer variety have shed their pollen. By this time, the colonies have done their job in the orchard and most bees working the flowers will be foraging for nectar, not pollen. The majority of the pollen gathering bees will be foraging off-site and not providing pollination services to the grower who rented the hives.

Bloom Season Specific Sprayer Calibration Saves Money and Time

Franz Niederholzer, UCCE Advisor, Colusa and Sutter/Yuba Counties

If your sprayer can deliver good spray coverage at hull split, with a little work it can deliver good bloom spray coverage faster and cheaper. How is this possible? With no leaves in the canopy, air movement is less restricted at bloom than hull split. Also, there is less surface area to cover at bloom than hull split so volume needed to cover the susceptible tissue per acre (Gallons per acre, GPA) are less at bloom than hull split.

How could this work? Assuming your hull split spray set up is for 100 GPA (or more) and 2 miles per hour (MPH), at bloom you can increase ground speed, GPA and reduce power to the sprayer (less tractor engine or sprayer engine RPMs). All this means less time and diesel burned per acre and more acres per tank with no change in pest control. The exact settings should be worked out on the farm, but here are some general guidelines to use before bloom starts. [I am assuming that anyone trying this has a good knowledge of sprayer calibration. For the sake of space in the newsletter, I will not go into all the calibration details. Check the Almond Production Manual for details or call me at 530.218.2359. We do need an airblast sprayer extension publication.]

1. **Increase speed and reduce RPMs.** Reduce engine RPMs by 15-20% from full speed and shift up a gear or two so that tractor and sprayer speed is somewhere around 3-3.5 MPH. For a PTO sprayer delivering 540 PTO RPMs with engine RPM at 2200, the target is somewhere around 1800 RPM for the tractor engine. This is quickly checked with a GPS unit or a quick pass down a row in the orchard counting trees (2 MPH=176 ft/min, etc.).

If you spray every-other-row (EOR) at bloom, check air movement through the tree (next section) very carefully to make sure spray gets all the way through the tree or don't use the approach described in this article.

Every-other-row spraying delivers acceptable disease control at pink bud, but ineffective on the far side of the tree from the sprayer after 40% bloom. Every row spraying gives the best possible coverage. If you do spray EOR, do it carefully.

2. **Check that there will be enough upward air movement at this new speed. Readjust as necessary.** Put a length of PVC pipe with a 1.5-2' long length of flagging tape tied on the end up through the tree so that the top of the pole is roughly 3-4

feet above the top of the tree. Run the sprayer down the row with the fan on, water in the tank but nozzles turned off. Check how much the flagging tape moves as the sprayer goes by the tree? (I use the video function on my phone to capture the flag movement as the sprayer goes by.) If the tape flutters out to 45-90^{o} off the vertical, that is enough sprayer fan air movement to give good coverage. If the flagging kicks straight up, you can speed up more and try it again until the desired 45-90^{o} movement is reached.

3. **Figure out the flow rate you'll use based on your new speed and the product's recommended GPA.** Use your new tractor speed and row spacing to figure out the acres per minute you'll cover at that speed. Using the measured acres per minute and the gallons per acre you want to spray, calculate the gallons per minute (GPM) needed from the sprayer. If you are using an air shear/electrostatic sprayer (Lectroblast, Windmill, etc.) make sure the system pressure is set to that required by the manufacturer, set the flow rate on each side of the sprayer and you are ready to check the spray coverage. If you are using a standard airblast sprayer (Nelson Hardie, Rears, AirOFan, etc.) you will need to select and place the nozzles to deliver the needed GPM.

4. **Adjust your nozzles to favor upward movement at this new speed.** The general rule is that roughly 70% of the sprayer output (GPM) should come out of the top half of the open nozzles. Because of faster ground speed, larger nozzles will be needed and/or swirl plates changed (45's used instead of 25's). Large nozzles (D8-12) are a better choice in my opinion as the obvious nozzle exit hole difference between a D6 and a D8 make it easier to use the right nozzle for the right job if you are using rollover nozzle bodies (Rears or Nelson) or 2-3 nozzles/vane (AirOFan). In the table at the bottom of the page is an example of how a set up might go for a sprayer with two nozzle options per location on the spray boom.

   In the orchard, place the disc/cores on the nozzle bodies that point at the tree. You may need to skip a nozzle body or two along the spray boom to make sure the spray targets the tree. For example, the first (very top) nozzle body on many sprayers basically points straight up and the second body is inches away and slightly angled into the canopy. I usually skip the top one. Lower on the sprayer you may skip a nozzle site, turning off the nozzle body. The goal with fungicide spraying is to aim high; rainwater will recycle the fungicide down through the canopy if it's placed up high.

5. **Make sure your actual flow rate matches your desired flow rate.** Ground truth the sprayer output by filling it to overflowing with clean water, running it for a set amount of time (a minute or two minutes) and then refilling it with a hose attached to a flowmeter or buckets marked with gallons/quarts/pints. Calculate gallons per minute sprayed to use in the following equation to check your actual sprayer output and determine how much material to put in the spray tank:

$$Gallons\ per\ acre = \frac{gallons\ per\ minute}{acres\ per\ minute}$$

6. **Double-check your coverage in the canopy.** A final step in the calibration process is to check coverage with water sensitive paper either placed on poles or attached to the canopy.

   If you are interested in this bloom sprayer set up concept and want some help with the setup, please give me a call (218-2359).

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Example of nozzle selection and position on a standard airblast sprayer (Rears, AirOFan, Nelson, etc)

Nozzle top	Disc/core Bloom	GPM Bloom	Disc/core Hull split	GPM Hull split
1	8/25	0.97	6/45	1.15
2	8/25	0.97	6/45	1.15
3	8/25	0.97	6/45	1.15
4	8/25	0.97	6/45	1.15
5	4/25	0.45	4/25	0.45
6	4/25	0.45	4/25	0.45
7	4/25	0.45	4/25	0.45
8	4/25	0.45	4/25	0.45
bottom				
	target	calculated	target	calculated
GPA	70	73	150	143
MPH	3.5		2	
Estimated tractor rpm	1800		2200	

What New Research into Carbohydrates is Teaching us About California Orchards

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Orchards up and down the Central Valley sit bare and leafless during winter. But just because we can't see active growth with our eyes, doesn't mean the trees themselves aren't active. We refer to the winter stage of a deciduous tree's annual cycle as "winter dormancy", which comes from the old Latin word for sleeping. And similarly to how our bodies keep functioning while we sleep at night, the trees in the Central Valley's orchards are active all winter, too.

Recent years of research by the Zwieniecki lab (the Z Lab) at UC Davis, including the Carbohydrate Observatory, have been shedding light on what is happening in orchard trees during their yearly cycles, including during this dormant period, and how that interplays with how trees prepare for winter and emerge from dormancy in the spring, to bloom and leaf-out. This research has been used to better explain how trees may be counting winter chill and spring heat. In almond, this new knowledge has been used to create a bloom prediction tool. This is one of many promising avenues to start transitioning from establishing a baseline understanding of carbohydrate seasonal dynamics into finding lessons and creating tools that can be used to improve orchard health and yield.

What Are Non-Structural Carbohydrates?

Non-structural carbohydrates (NSC) are carbohydrates that are not part of structures like cell walls. NSC are utilized by the tree for energy, as building blocks for cell growth, as an osmolyte to influence water dynamics, and as signals for multiple physiological activities. By following the amounts of NSC in a plant over time, we can build a better understanding of how trees are using carbohydrates for current opportunities (vegetative and fruit growth) or future challenges (dormancy, defense against pathogens and other stressors).

NSC are either in the form of soluble carbohydrates (sucrose, hexose, fructose; henceforth simply referred to as "sugars") or starch. Sugars are the product of photosynthesis, and, roughly speaking, the building blocks of starch. Starch is the storage form of carbohydrates and can later be broken down to provide sugars. You can think about soluble sugars as 'cash' and starch as 'money in the bank'. Sugars are also an active part of biological cell activity and their level in cells are under strict control.

Different enzymes (catalysts) synthesize and break down starch. The enzymes that make starch are typically more active at higher temperatures, whereas temperatures don't have a big impact on the activity of the starch degrading enzymes. As a result, when it's warm, trees tend to turn sugars into starch, and when it's cold, trees turn starch into sugar. For trees to find their "sweet spot" to keep sugar levels in an optimum range, they adjust the concentration of these enzymes using gene expression machinery. Recent research is showing that the effort to maintain this sweet spot likely plays a role in how trees count winter chill and emerge from dormancy in the spring.

How Do Carbohydrates Vary Over the Year?

An intensive sampling was conducted of carbohydrates of almonds, pistachios and walnuts in the twig, branches and trunk over the course of a year.[1] As has been seen in other temperate trees, it was found that NSC varies with changing stages of growth or phenology, and concurrent climatic conditions. NSC decreases following bud break, reaches the lowest levels during the growing season, and then increases starting mid-to-late summer to reach maximum levels in fall or early winter (Figure 1, top, grey line). Data from the last three years[2] at the Carbohydrate Observatory have shown the same trend in twigs of almonds, pistachios, and walnuts throughout the Central Valley.

Carbohydrates Going into, During and Coming out of Dormancy

As trees move into the fall, NSC increases (Figure 1). Recent research by the Z lab has found that the increasing difference of above and below ground temperatures of fall conditions (cold canopy, warm roots) drives allocation of carbohydrates from canopy bark and branches into roots. Some starch storage is also maintained in the upper canopy.[3]

Over winter, trees use locally stored NSC for respiration to maintain baseline functions. Sugar is used for respiration, which decreases during dormancy as temperatures decrease, but certainly doesn't stop. Trees also use sugars as anti-freeze to protect cells and xylem (the tree's water pipes) from frost damage, as well as to scavenge for damaging free radicals, keep cell membranes stable, and to signal across cells.[4]

As trees wake up in the spring, they need carbohydrates to grow. Carbohydrates stored in the buds are not sufficient to support the vegetative and fruit growth that occurs before leaves start photosynthesizing to create new sugars. Recent research by the Z lab in walnuts has found that the sugars used for spring growth are imported from both near and far.[4] Girdling shoots 4 inches below buds delayed bud break by almost a week and significantly reduced bud size. Branch starch reserves closer to the trunk were drawn down even more than near the growing buds, as the starch was broken down into sugar to send up the shoot to support new growth.

This transport chain reaches all the way down to the roots, an important part of storage of over-winter NSC for use in the spring. The spring temperature differential of cold roots (from cold soil) and warm canopy drive allocation of carbohydrates from roots to canopy. Warm conditions drive starch-making enzymes to make starch in the canopy, thus reducing sugar availability, while cold conditions drive roots to turn stored starch into sugar, which is then circulated up through the xylem (which we usually think of as the water pipes, but in spring also send sugar up into the canopy).

Simply put, getting trees to emerge from dormancy is not just a matter of getting trees to bloom. A whole host of physiological functions need to fire up simultaneously. For synchronous bloom and budbreak within the tree, the whole tree needs to synchronize when it starts supplying buds with energy and water. If growing buds are not supplied with enough carbohydrates in the spring, growth can be delayed or decreased and flowers and nutlets can be aborted.

Carbohydrate Dynamics Predict Bloom

Exactly how trees break dormancy in the spring has remained somewhat mysterious. Winter chill and spring heat accumulation models have been used in combination to help predict bloom timing, but these models can't explain how trees are tracking the cold and warm temperatures they are experiencing. The Carbohydrate Observatory has found that in almonds, pistachios, and walnuts, shortly before bud break, there is a surge in starch and a dip in sugar concentration. Plants regulate sugar concentrations to maintain desirable metabolism and osmotic dynamics within their tissue. The Z Lab has used this knowledge, and the specific values and thresholds gleaned from the Carbohydrate Observatory to create a model for almond bloom timing, based on fall and winter carbohydrate and temperature dynamics.[5]

This bloom prediction model, the C-T model[6], integrates some important aspects about how plants balance sugar and starch concentrations. Recall that when it's warm, trees turn sugars into starch, and when it's cold, trees turn starch into sugar. For trees to keep sugar levels in an optimum range, they adjust the concentration of these enzymes. Because starch synthesis is very temperature sensitive, but starch degradation is not, trees can quickly respond to too *much* sugar at warm temperatures but can't respond as quickly to too *little* sugar.

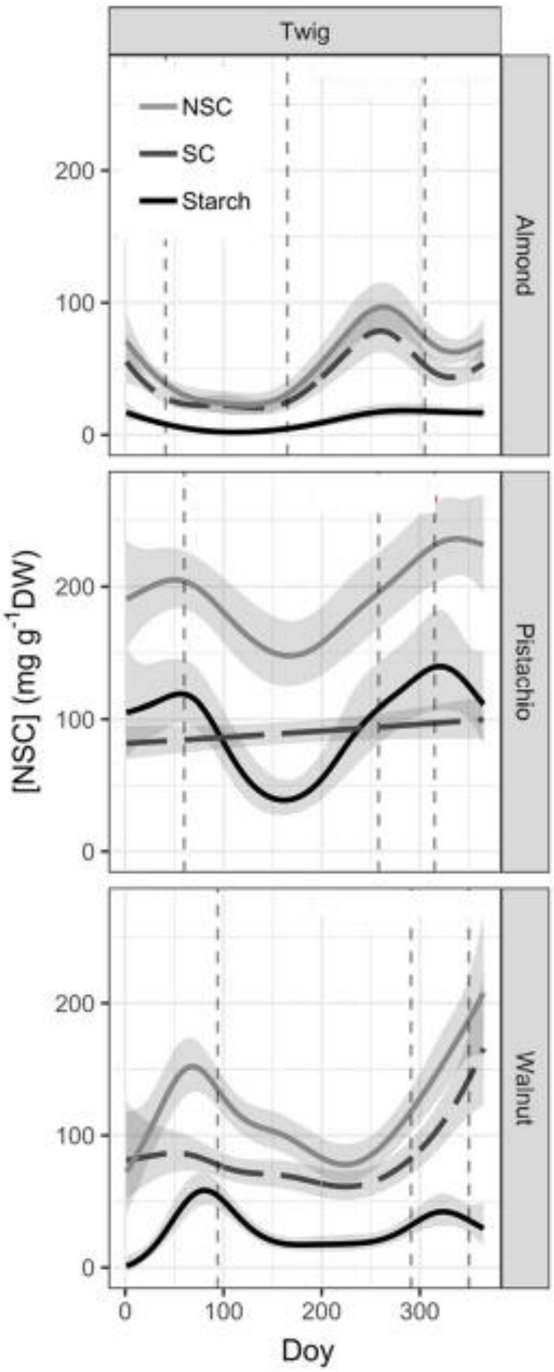
When conditions warm up in the spring, starch synthesis quickly takes off, pulling sugars out of circulation, resulting in a dip in sugar. This dip in sugar and upsurge in starch is predictive of (and may even trigger) bud break. This relationship may help explain the flash bloom we see after cold winters with a little spring heat, and the straggled bloom we see after warm winters.[7] Cold winters would amplify accumulation of starch synthesis enzymes, resulting in less warm time necessary in the spring to trigger a sharp sugar drop and bloom. Warmer winters would downregulate starch synthesis, requiring more warmth than normal in the spring to achieve low sugar levels.

By integrating this knowledge of the principles of carbohydrate dynamics and specific thresholds and ranges learned from the Carbohydrate Observatory, almond bloom timing was predicted in three locations in California over 24 years to within less than 5 days on average (RMSE = 4.7 days) (Figure 2). While this may not be accurate enough for management decisions, it's better than most bloom prediction models based on chill and heat accumulation alone, which supports integrating these carbohydrate dynamics into our understanding of how trees count the passing of winter and spring.

Many Carbohydrate Questions Remain Unanswered

Carbohydrates are the building blocks of vegetative growth as well as nuts, shells and hulls. The more we understand NSC dynamics, the better we can understand the potential and limitations for growth and yield in our orchards. Recent modeling also indicates that carbohydrates play a critical role in tracking the progress of winter and emerging from dormancy in the spring. We will be building on this baseline understanding to optimize the timing of dormancy breaking treatments in walnuts in the coming years.

The use of data from the Carbohydrate Observatory to build a bud break prediction model demonstrates the huge potential for the next stage of this project. Over the course of the last three years, volunteer growers, mangers, and PCAs have contributed samples to help develop a baseline understanding of the variability of NSC, starch, and sugar across seasons, years, locations and different nut crops. There is so much more that can be done from here. Now that these baseline dynamics are understood, researchers can dig deeper into which orchards perform above or below the baseline and why.



But more robust data sets are needed with collaborator assistance. A machine learning approach is in development to integrate climate and soils data, management metrics like irrigation, and carbohydrate dynamics to predict yield at the time of bloom. But we need collaborators who are willing to share records on yield, irrigation, and orchard health, to build a model that will yield good predictions. So far, the almond industry has been very supportive in providing these data, but we have not had as much luck with walnut collaboration. If you're interested in helping with this research, please reach out to Paula Guzman-Delgado at pguzmandelgado@ucdavis.edu.

Figure 1. Seasonal variation of NSC concentrations over the year for the different species. Total NSC (grey line), sugars (SC, dashed line) and starch (black line) concentration are modelled from data collected (shaded areas represents variability in the data). Phenological events - bud-break, fruit drop, and leaf abscission - are shown with dashed vertical lines. [1]

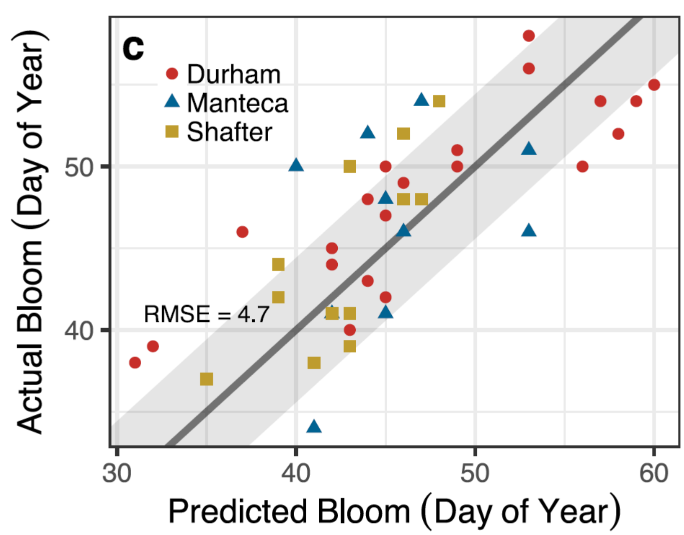


Figure 2. The C–T model projections of almond bloom time versus the actual bloom records from Durham (1984–2008, red circles), Manteca (1996–2008, blue triangles), and Shafter (1996–2008, orange squares). The 1:1 ratio is denoted by a black line and the root mean square error (RMSE=4.7 days) by a grey ribbon. [5]

[1] Tixier, A., Guzmán-Delgado, P., Sperling, O. *et al.* Comparison of phenological traits, growth patterns, and seasonal dynamics of non-structural carbohydrate in Mediterranean tree crop species. *Sci Rep* **10,** 347 (2020). https://doi.org/10.1038/s41598-019-57016-3

[2] Interact with Carbohydrate Observatory data at https://zlab-carb-observatory.herokuapp.com/

[3] Sperling, O., Silva, L.C.R., Tixier, A. *et al.* Temperature gradients assist carbohydrate allocation within trees. *Sci Rep* **7,** 3265 (2017). https://doi.org/10.1038/s41598-017-03608-w[5] Tixier 2019 Frontiers

[4] Tixier, A., Sperling, O., Orozco, J. *et al.* Spring bud growth depends on sugar delivery by xylem and water recirculation by phloem Münch flow in *Juglans regia* . *Planta* **246,** 495–508 (2017). https://doi.org/10.1007/s00425-017-2707-7

[5] Sperling, O., Kamai, T., Tixier, *et al.* Predicting bloom dates by temperature mediated kinetics of carbohydrate metabolism in deciduous trees. *Ag For Met* **276–277**, (2019) https://doi.org/10.1016/j.agrformet.2019.107643.

[6] Test out the C-T model for almond bloom prediction using your nearest CIMIS station at http://zlab-chill-heat-model.herokuapp.com/.

[7] Pope, K.S., Da Silva, D., Brown, P.H., DeJong, T.M. A biologically based approach to modeling spring phenology in temperate deciduous trees. *Ag For Met* **198,** 15–23 (2014). https://doi.org/10.1016/j.agrformet.2014.07.009.

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