Sacramento Valley Walnut News
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In This Issue

Submitted by:

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UCCE Virtual Walnut Series
February 16 and 17, 2021 | 9:00 AM-12:00 PM

Register at: ucanr.edu/walnutstatewide

Agenda – Tuesday, February 16

- **9:00 AM – Opening Remarks and Housekeeping** – *Kari Arnold, UCCE Area Orchard and Vineyard Systems, Stanislaus County*
- **9:05 AM – Early Season Water Management** – *Kari Arnold, UCCE Area Orchard and Vineyard Systems, Stanislaus County*
- **9:20 AM – An Overview of UC Walnut Varieties and the Walnut Improvement Program: Can we Surpass Chandler?** – *Pat Brown, Professor, UC Davis and Nut Crops Breeder*
- **9:55 AM – California Walnut Industry Update** – *Pam Graviet, Director, International Marketing | Jennifer Williams, Marketing Director, Domestic Advertising | Josh Rahm, Director, Technical and Regulatory Affairs, California Walnut Commission*
- **10:30 AM – Walnut Training Update** – *Bruce Lampinen, UCCE Orchard Management Specialist, UC Davis*
- **11:05 AM – The Four R's of Nitrogen Management** – *Katherine Jarvis-Shean, UCCE Orchard Systems Advisor, Capitol Corridor*
- **11:40 AM – Walnut Whole Orchard Recycling: Early Results** – *Luke Milliron, Orchard Systems Advisor, Glenn and Tehama Counties*

Agenda – Wednesday, February 17

- **9:00 AM – Opening Remarks and Housekeeping** – *Kari Arnold, UCCE Area Orchard and Vineyard Systems, Stanislaus County*
- **9:05 AM – Managing Rodent Pests in Walnuts – What's New?** – *Roger Baldwin, UCCE Specialist, UC Davis*
- **9:40 AM – Walnut Rootstocks and Diseases** – *Elizabeth Fichtner, UCCE Farm Advisor, Tulare County | Greg Browne, USDA Research Plant Pathologist*
- **10:40 AM – Blight Update** – *Jim Adaskaveg, Professor and Plant Pathologist, UC Riverside*
- **11:15 AM – Navel Orange Worm, Codling Moth and Pacific Flathead Borer Updates** – *Jhalendra Rijal, UCCE IPM Advisor, San Joaquin, Stanislaus, and Merced Counties*

Walnut Winter Management UCCE Resources

Luke Milliron, UCCE Orchard Advisor, Butte, Glenn, and Tehama Counties
Janine Hasey, UCCE Farm Advisor Emerita, Sutter, Yuba, Colusa Counties

Counting Winter Chill
Are you keeping track of chill? Chill accumulation is of increasing interest to growers, especially following the straggled leaf-out last year. Katherine Jarvis-Shean (UCCE Yolo) and others wrote an article that describes what drives the timing of leaf-out, the chill requirements of various walnut cultivars, and how to track and interpret chill accumulation. Article at: sacvalleyorchards.com/walnuts/horticulture-walnuts/counting-winter-chill. Katherine also discussed the potential challenges we will be facing in the future with chill requirements in walnuts and other orchard crops at: growingthevalleypodcast.com/podcastfeed/2018/9/22/chill-with-dr-katherine-jarvis-shean-wk76l

Tree Replanting Considerations in a Lean Price Year
Considering replanting missing tree spots in the orchard this winter? Make sure you're evaluating what the chances are that the replant will survive and follow all the best replanting practices. Learn more in the recent article: sacvalleyorchards.com/walnuts/cost-and-expense-considerations/replanting

Walnut Blight Bud Sampling
2020 was overall a low-pressure walnut blight season. However, if you don't have a good sense for the blight pressure in an orchard, it's easy to test the fruit buds for the bacteria. Knowing your blight inoculum level in addition to watching the weather during bloom helps inform how aggressively you need to control walnut blight this spring. Bud sampling and interpretation info at: sacvalleyorchards.com/walnuts/diseases/walnut-blight-bud-sampling

Nursery Products and Early Tree Training
Research and grower observation trials continue to show that trees left unheaded after planting grow as well or better than those headed back. Initially unheaded trees may grow more slowly but fewer problems like bending in the wind have been observed. On finished trees at planting, consider skipping the heading back step to save money, but not the painting step. For more information on the nursery products available and how to best handle them, visit: sacvalleyorchards.com/walnuts/orchard-development/walnut-trees-in-the-nursery-trade

The No Heading Tree Training Method
Numerous replicated trials have been conducted comparing the no heading training method to the minimum pruning training method. Advantages to not making heading cuts during the orchard development phase include early increased yield, the crop is distributed over more primary scaffolds, and there is less limb breakage. Disadvantages to pruning include labor costs to prune and dispose of prunings, the lower canopy shades more rapidly leading to quality problems, and more pruning wounds are exposed to *Botryosphaeria* infection. The only additional cost to the no heading method may be the need for stake extensions during the 2nd leaf growing season. For more information, visit: sacvalleyorchards.com/walnuts/horticulture-walnuts/training-young-walnut-trees-minimum-pruning-vs-no-pruning-compared

Evaluating Irrigation Equipment and Technology

With lean prices, it is essential to make informed purchasing decisions. Irrigation technology is rapidly evolving and can be overwhelming to sort through. Allan Fulton helps you navigate irrigation technology and avoid that sense of overload in this article: sacvalleyorchards.com/almonds/irrigation/navigating-irrigation-technology-overload. The pressure chamber continues to be the gold standard for knowing when to irrigate in walnut production. Growers and consultants who already use the pressure chamber indicate the cost to integrate it into their management ranges from about $10 to $20 per acre annually. Careful pressure chamber use can benefit walnut orchard health, as well as achieve water and energy savings. If you are interested in purchasing a pressure chamber, we have a guide at: sacvalleyorchards.com/manuals/stem-water-potential/purchasing-pressure-chamber-preparing-to-monitor. Finally, well before you need to think about the irrigation season, it's good to perform the system maintenance that underpins any improved irrigation management.

Pre-Season Airblast Sprayer Calibration

Well before you're scrambling to get out your first blight spray this spring, you should spend time on the maintenance and calibration of your airblast sprayers. A properly calibrated sprayer is needed for good pest and disease control. The need for excellent coverage is especially true for walnut blight, where – if it's not covered, it's not protected! sacvalleyorchards.com/almonds/foliar-diseases/pre-season-airblast-sprayer-calibration

Delayed Dormant Pest Management Cost-Saving Strategies

If an insect growth regulator insecticide was used for scale within the last two years, monitoring may indicate that a spray is not needed this year. See the article on winter pest management at sacvalleyorchards.com/walnuts/scale-pests-navel-orangeworm-and-flatheaded-borers.

Looking for Cost Savings Season-Long

For 2021, there are other cultural and pest management options to improving your profit margin. Check out sacvalleyorchards.com/walnuts/cost-and-expense-considerations during the year to see how to save on costs. You will find articles that focus on labor and cost cutting considerations appropriate to the season, while discussing those operations you should not scrimp on.

What new research into carbohydrates is teaching us about California orchards

Katherine Jarvis-Shean, UCCE Orchard Advisor, Sacramento, Solano and Yolo Counties
Maciej A. Zwieniecki, Dept Plant Sciences, UC Davis

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.

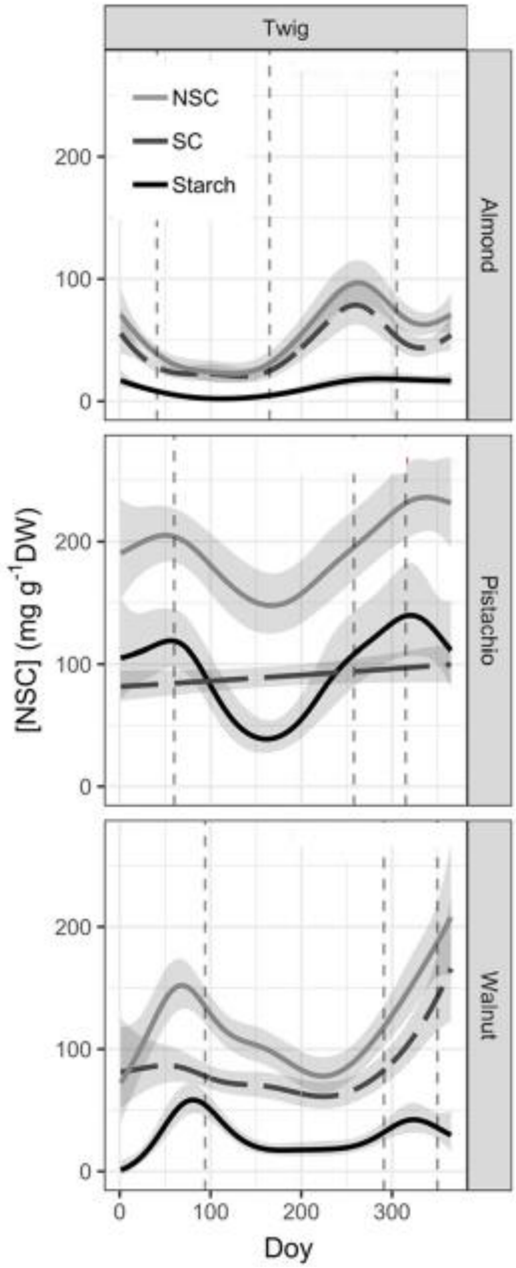

Figure 1. Seasonal variation of NSC concentrations over the year for the different species. Total NSC (grey line), sugars (SC, dashed line) and starch (black line) concentration are modelled from data collected (shaded areas represents variability in the data). Phenological events - bud-break, fruit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

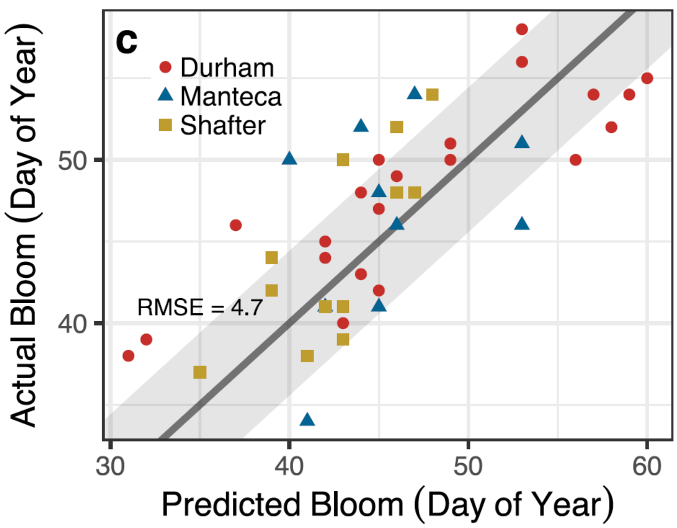

Figure 2. The C–T model projections of almond bloom time versus the actual bloom records from Durham (1984–2008, red circles), Manteca (1996–2008, blue triangles), and Shafter (1996–2008, orange squares). The 1:1 ratio is denoted by a black line and the root mean square error (RMSE=4.7 days) by a grey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