Almond Newsletter

Cooperative Extension Glenn County

UC CE | University of California Agriculture and Natural Resources

January 2020

In this issue:

Submitted by:

Glenn County UCCE
Office: 530-865-1107
Fax: 530-865-1109

View archived newsletter articles at:
sacvalleyorchards.com

Almond Orchard Management Considerations – Bloom through Early April

Emily J. Symmes, UCCE Area IPM Advisor, Sacramento Valley
Franz Niederholzer, UCCE Farm Advisor, Colusa and Sutter/Yuba Counties
Luke Milliron, UCCE Farm Advisor, Butte, Glenn, and Tehama Counties
Drew Wolter, UC Davis Graduate Student & Former UCCE Intern

NOW SANITATION

- *Sanitize for Navel Orangeworm*!!! Sacramento Valley Navel Orangeworm (NOW) damage was generally up in 2019. Growers who thought they could achieve low damage with additional sprays and little to no sanitation were largely unsuccessful. It's high time to approach NOW from an area-wide perspective. Everybody needs to be doing this single most critical activity for disrupting the life cycle and reducing damage. You will not maximize your return on investment with any other in-season management strategies unless you start with the lowest NOW population achievable through winter sanitation.

- A recent article by Wes Asai in the January 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 compared to early December, so get out and get it done if you haven't yet. There have been a few decent fog events in the Sacramento Valley so far, some precipitation, and orchard access has not been an obstacle yet. This should be a good year to improve our collective sanitation efforts and start to reset the region's NOW populations.

- Just knocking mummies out of the trees is no longer sufficient. Make sure to disc, shred, or flail the nuts once on the ground to ensure destruction of NOW habitat. This part of the process can occur as late as early March. When flail mowing mummies, watch your mower speed and height setting; double-check a pass or two to ensure that nuts are being sufficiently shredded.

ORCHARD FLOOR MANAGEMENT

- Weed management can be particularly difficult in newly planted and young orchards because their rapid growth is accelerated by frequent irrigation (necessary to establish trees), fertilizer, and the lack of canopy closure. For

information on weed management options in young orchards, read the article "*Young Orchard Weed Management*" in this newsletter.

- As the 2020 growing season approaches for California growers, PCAs and handlers will have new regulations to take into consideration. One of the main ones will be the new Environmental Protection Agency (EPA) restrictions on paraquat. More information regarding paraquat and the new EPA regulations are included in this newsletter.

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 and one at full bloom.

    - If forecast is for warm storms, include at least one fungicide active on anthracnose (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 has been requested. Biologicals such as Actinovate AG and Botector provided some reduction in blast damage in trials in cherry, but less than Kasumin®. Blast pathogen (*Pseudomonas syringe, pv syringe*) is resistant to copper in UC studies.

HONEY BEE SAFETY

- Bee kind to your bees, you need them! See article in this newsletter for bloom pesticide activities, bee considerations, and the new BeeWhere program.

- The fungicide efficacy and treatment timings table included in this newsletter do not include additional surfactants, some of which can be harmful to bees.

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 tall 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 values; turn off water once the wet bulb temperature is above the critical values (or when all the ice melts).

- 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 that heat to release on a frosty night. Re-irrigate the top foot of soil if the surface dries out (a dry surface crust can prevent the heat releasing at night).

- Critical values for many varieties/flower stages listed at: sacvalleyorchards.com/blog/almonds-blog/low-temperatures-in-the-forecast.

- 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). Applying any other insecticides at bloom risks hive health and is not an effective timing for any other insect pests in almonds. PTB can also be controlled with a "May spray" (based on degree day timing), so bloom Bt, 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. Make sure your monitoring includes egg and bait bag traps to follow NOW activity. More information at: ipm.ucanr.edu/agriculture/almond/navel-orangeworm/.

- Inform your almond, walnut, and pistachio neighbors about mating disruption use in the area, as NOW pheromone monitoring 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

- Apply approximately 20% of the year's predicted nitrogen needs by late February or March.
- Start your K fertilizer program with your first irrigation if you use in-season injection applications.
- 1 to 2 lbs Solubor®/acre (equal to 0.2 to 0.4 lbs actual boron/acre) at pink bud can increase nut set and yield if previous year hull samples showed low boron (B) levels and a fall B spray was not applied. Don't spray bees or open flowers. Bees may be harmed by B and open flowers sprayed with boron may set fewer nuts.

EQUIPMENT PREPARATION

- 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 bloom spray volume towards the upper canopy as rainfall will redistribute the fungicide downwards.

New EPA Paraquat Restrictions

Drew Wolter, UC Davis Graduate Student, Weed Science Program

As the 2020 growing season approaches, California growers, PCAs and handlers will have new regulations to take into consideration. The United States Environmental Protection Agency (EPA) recently announced the new requirements for handling paraquat (paraquat dichloride). The new EPA restrictions on paraquat aim to help protect Restricted Use Pesticide handlers, and others who may come into contact with these pesticides. However, these requirements will have a ripple effect on growers, distributors and the California agriculture community. Label changes emphasizing paraquat toxicity, restrictions and safe handling were completed November 2019. What changes did the EPA mandate?

Supplemental warning materials:
The containers of paraquat products will be required to include several supplemental warnings. These include a sticker with a, "one sip can kill", warning affixed near the dispensing valve and a product package safety requirements sticker affixed to the container. All of the supplemental warning materials will be in English, Spanish and pictogram format.

Restricting USE of all paraquat products to certified applicators. Two certifications will be required in order to use paraquat products:

A. Certified pesticide applicator's license/permit from your state or tribal authority.
   - ◊ There are three main types of applicator certifications in California: Qualified Applicator License (**QAL**), Qualified Applicator Certificate (**QAC**) and Private Applicator Certification (**PAC**).

B. Paraquat-specific training certificate in your name, obtained via online training at www.usparaquattraining.com, currently hosted by the National Pesticide Safety Education Center (NPSEC).

How is paraquat use defined?

"Use" includes pre-application activities involving mixing and loading paraquat. Use also includes applying paraquat, transporting or storing opened containers, cleaning equipment, and disposing of excess product, spray mix, equipment wash waters, empty pesticide containers, and other paraquat-containing materials. **Non-certified applicators will no longer be allowed to use (see "use" definition above) paraquat, even under the supervision of certified applicators.**

Will existing paraquat products need to be relabeled?

No, retailers will be allowed to sell the "old" labeled products until supplies are exhausted.

For more information on the changes to Paraquat labeling and restrictions visit:

ifca.com/files/syng_4386_2_3_National_Paraquat_QA_FINAL.pdf

Young Orchard Weed Management

Drew Wolter, UC Davis Graduate Student, Weed Science Program

Weeds in young orchards compete with trees for orchard resources such as sunlight, water and nutrients. This can lead to reductions in growth and future yields. If weed stands are allowed to mature, not only are they harder to control via chemical and mechanical methods, but they can also create cover for voles and gophers, which can then damage tree trunks, root systems and irrigation systems.

Weed management can be particularly difficult in newly planted and young orchards because rapid weed growth is accelerated by frequent irrigation, necessary to establish trees, fertilizer inputs to grow the trees, and the abundant sunshine due to small tree size. In addition, control is challenging because tree trunks may still be green and sensitive to contact and systemic herbicides, which can cause severe trunk damage and canopy stress. For these reasons, weed control can be one of the most obstructive facets of establishing a new orchard. While weeds are present in every

orchard, there is variation in the weed species composition and density from orchard to orchard, especially in young orchards. Scouting for weeds is the basis for a good Integrated Weed Management (IWM) plan. Post-harvest scouting should start early and be repeated once more before the start of the season in order to catch weeds when they are young. Herbicide applications targeting mature weeds are often minimally effective, resulting in a less successful program and increased management costs.

Post-emergent materials are often used for control of weeds in newly planted trees. Contact products (AKA burn-down herbicides) kill the leaves and green stems of plants that they come in contact with. Systemic herbicides enter the plant and move to the actively growing tips of the plants they come in contact with. Post-emergent herbicides require repeated treatment to control weeds throughout the season and careful timing of these short-lived products is necessary to control weeds in young orchards. Caution should be used when applying either form of post-emergent materials, because drift or direct spraying onto leaves or green tree trunks can lead to damage or even kill young trees (see figure 1). Crop safety is usually achieved by prudent application, being extra cautious with windy conditions, spray rig height, nozzle angles, and nozzle selection.

Figure. 1 Herbicide Damage in 2nd leaf almonds. Glufosinate + Glyphosate (1.5 + 2.75lbs/ac). Image on the left is trunk gummosis observed 5 weeks after treatment. Image on the right shows complete defoliation of the same tree 12 weeks after treatment.

Post-emergent Herbicides Registered for Young Orchards:

Herbicide	Example Trade Name	Notes from Labels
Carfentrazone	Shark	NOT OK on green bark
Clethodim	Select Max	Only for non-bearing
2, 4-D	Dri-Clean	OK to use after 1st leaf
Diquat	Diquat	Only for non-bearing
Fluazifop-p-butyl	Fusilade	
Glyphosate	RoundUp	NOT OK on green bark
Glufosinate	Rely 280	NOT OK on green bark
***Paraquat	Gramoxone	NOT OK on green bark
Pyraflufen	Venue	NOT OK on green bark
Saflufenacil	Treevix	
Sethoxydim	Poast	

**** NEW EPA RESTRICTIONS- See article in this newsletter titled "New EPA Paraquat Restrictions"*

A pro-active yet often overlooked method to manage weeds in young orchards is the application of **pre-emergent** products. Pre-emergent herbicides control weed seedlings as they germinate halting the development of seedling shoots and roots, ultimately preventing emergence. These herbicides can provide residual control throughout the year if properly timed and applied. Applications can be made once in the winter or early spring going into summer and again in the fall to target warm and cool season species, respectively. Pre's bind to organic matter and soil to limit leaching and mobility once applied to provide residual control. Clearing berms of leaf litter and skeletal remains of any resident vegetation from last season will help evenly distribute and incorporate the pre-emergent for optimal control. The majority of these products require between 0.25-0.75 inches of rain/irrigation for proper incorporation and effectiveness. Plantings that were made in fall can take advantage of winter and spring rains.

Pre-emergent Herbicides Registered for Young Orchards:

Herbicide	Ex. Trade name	Notes from Labels
EPTC	Eptam	Well-established
Flumioxazin	Chateau	Established for 1 season, needs carton
Indaziflam	Alion	Established for 1 season
Isoxaben	Trellis	
Norflurazon	Solicam	18 months
Oxyfluorfen	Goal	
Pendimethalin	Prowl	
Oryzalin	Surflan	
Penoxsulam	PindarGT	9 or 15 months (soil)
Rimsulfuron	Matrix	Established for 1 season

Cautionary note:

Many growers rely heavily on a single herbicide program on an annual basis. This might be because of affordability or the initial effectiveness of the program. However, by using the same products and mode of action to kill weeds, we are selecting for herbicide resistance. With the growing number of herbicide-resistant weeds in California orchards, control of escaped (resistant) weeds can considerably reduce the long-term cost of an annual orchard floor management program. For example, spot treating two acres of glyphosate-resistant palmer amaranth with a tank mix of glufosinate and paraquat is much more affordable than trying to control it over an entire 40-acre block. Remember to scout this winter so you can spot treat, rather than having an orchard full of herbicide-resistant weeds in the future.

For more information regarding the status of herbicide resistance in California visit:
ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=29069

More information regarding young orchard management can be found at:
UCCE/UCANR Young Orchard Handbook- ccfruitandnuts.ucanr.edu/files/238596.pdf
OR sacvalleyorchards.com/manuals/young-orchard-handbook/weed-management-for-young-orchards/

Honey bee colonies, pollination, bee safety, and beekeeper responsibilities

Joseph Connell, UCCE Farm Advisor Emeritus, Butte County and Emily J. Symmes, UCCE Area Integrated Pest Management Advisor, Sacramento Valley and Statewide IPM Program

Always be aware of honey bees when they're in your orchard to pollinate your crop. After all, you're paying good money for the bees to do a critical job! You can go a long way toward protecting the health of honey bee colonies by avoiding contamination of pollen and pollen foragers and by avoiding products with potential toxicity to honey bees or their larvae while bees are in your orchard. This is good husbandry and it's in the interest of both the grower and the beekeeper.

Honey bee pasture. Lack of blooming pasture while bees wait for almonds to bloom can weaken colonies. Although it's too late to plant a honey bee forage mix that will bloom before almonds this year, if you have an open field, new orchard, ditch banks, field margins, or a neighboring prune or walnut orchard where a winter cover would be beneficial, you might consider planting an early blooming forage mix containing mustard next fall. When planted in late summer or early next fall, it may provide flowers ahead of almond bloom in 2021 that can help with honey bee nutrition. Some cover crop seed providers have mixes particularly geared towards almond bloom timing. Almond flowers are so rich in rewards for bees that once almonds begin to bloom, flowers in cover crops are a minimal distraction for pollination.

For almond pollination a colony should have an active brood nest with uncapped worker brood at the start of almond bloom. Bees feed pollen to developing larvae so open brood cells indicate the hive has a demand for pollen. When pollen is in demand in the hive, more pollen foragers are sent into the field to collect pollen. Hives should be moved into orchards before the earliest blooming variety is at 5% bloom. Once 100% of flowers on the latest blooming variety have shed their pollen and are starting petal fall, hives should be moved out.

Honey bee colonies. The general recommendation is to have between 2 and 3 hives per acre for pollination with a minimum of 8 frames of bees per colony. Under adverse weather conditions weaker colonies may not field enough workers to provide adequate pollination. Beyond about 12 frames of bees, increased colony size doesn't seem to increase foraging. Dr. Robin Thorp at UC Davis developed a method that used cluster size observations to make a rapid honey bee colony strength evaluation. Five years of work comparing cluster observations with intensive frame by frame counts led to this quick evaluation system.

In self-fertile variety orchards there is speculation that fewer colonies will be needed to set an acceptable crop. Some have suggested that ½ to 1 hive per acre should be sufficient. Dr. Elina Niño, Apiculture Extension and Research at UC Davis, is beginning to study the number of colonies needed for optimum production in self-fertile orchards.

Plan ahead to make sure you have bees for pollination. You and your beekeeper should settle on a written contract so both parties know what is expected. It should include such things as when bees are moved into and out of the orchard, placement of colonies, minimum colony strength, and possibly price based on the number of frames of bees per colony. For the best bee health and successful crop pollination it's important that all beekeepers and almond growers talk to one another and work together for everyone's benefit.

Beekeeper requirements. California Food and Agriculture Code laws require that all beekeepers who move bees into the state or come into possession of an apiary must register with the appropriate County Agricultural Commissioner. Hives must be identified by displaying the owner's name, address, and phone number. Any apiary operator must notify the County Agricultural Commissioner if a colony of bees is relocated within the county. The County Agricultural Commissioner must be notified within 72 hours if a beekeeper relocates a colony of bees from one county to another.

A new program called BeeWhere is in place to help protect bees from pesticide applications. BeeWhere offers a dynamic, real-time GIS mapping system where beekeepers with a BeeWhere beekeeping ID can mark hives with a simple pin drop on a map. This program brings beekeepers and pesticide applicators together by tracking and safeguarding hive locations across California. All registered bee hive locations are stored securely within the California Agricultural Commissioners database system (CalAgPermits), and are not shared with anyone outside the California Agricultural

Commissioners staff.

BeeWhere integrates with crop management tools like Agrian and CDMS that are used by Pest Control Advisers (PCA), growers and licensed applicators in the state. These crop management tools interface with BeeWhere to access the general number of hives within a mile of a site when a PCA is considering a pesticide for crop management and allows applicators to contact beekeepers for notification purposes. Only verified growers and applicators get access to beekeeper contact information. Beekeepers choose the method of contact and have the option to remain anonymous. Check with your beekeeper and encourage them to use this new system to protect the safety of the almond pollinators you've paid dearly to see working in your orchard!

Bloom Sprays. Avoid insecticides when honey bee colonies are in the orchard. The only insect pest that could potentially be considered for treatment when honey bees are in the orchard is peach twig borer (PTB). The only viable option to manage PTB at bloom and petal fall is *Bacillus thuringiensis* (Bt), known to be non-toxic to honey bees. More detail on PTB management using Bt, and alternative treatment timings are available at: ipm.ucanr.edu/PMG/r3300211.html.

Fungicides. If the weather is dry and clear during bloom, conditions not conducive to disease development, UC pathologist Dr. Jim Adaskaveg suggests making a single delayed bloom application at 20 to 40% bloom. Under wet bloom conditions, multiple bloom fungicide applications are necessary. Treat only for pathogens that are a potential threat in your orchard and are best controlled during bloom. The online UC IPM guidelines (ipm.ucanr.edu/PMG/selectnewpest.almonds.html) provide details on monitoring and treatment timings for key almond diseases.

Adjuvants. According to the authors of the annual *Fungicides, Bactericides, And Biologicals for Deciduous Tree Fruit, Nut, Strawberry, And Vine Crops* (Adaskavag, Gubler, and Michailides 2017, ipm.ucanr.edu/PDF/PMG/fungicideefficacytiming.pdf), "most fungicides are formulated with adjuvants including wetting agents, spreaders, and stickers. Unless a material specifically indicates on the product label that an adjuvant should be added, the fungicide product does not need additional adjuvants mixed into the sprayer tank to improve performance. With few exceptions, adjuvants do not statistically improve the efficacy of fungicides for managing diseases of fruit and nut commodities."

All University of California efficacy trial results (+++'s in the efficacy table) are based on this premise and materials are tested without addition of adjuvants unless expressly indicated on the product label. Adjuvants may increase the potential toxicity of fungicides to honey bees. To save money and protect bees, only put what is absolutely necessary in the tank.

Choosing materials. Know the impacts of particular fungicides on honey bees by visiting the University of California IPM Program's "Bee Precaution Pesticide Ratings" at ipm.ucanr.edu/beeprecaution/. These precaution rankings (I, II, III) have been created based on all of the currently available scientific studies, including adult bee toxicity and effects on bee brood. Use the information contained here conservatively and always proceed with caution (err on the side of bee safety).

"Bee-safe" applications. Apply fungicides when available pollen is at the lowest possible level (late afternoon through very early the following morning). Pollen is released in the mornings when temperatures reach 55°F, and is often removed by foraging honey bees by mid-afternoon. The "bee-safest" time to apply fungicides is in the evening or at night when temperatures are less than 55°F.

Take precautions to never spray hives or bees directly with any material. Contaminated foraging worker bees carry the fungicide back to the hive where other worker bees clean them and contaminate the hive's food supply. Aside from these toxicity concerns, bee flight ability can be impacted from the weight of any spray droplets. Water application from sprays or rain can cause pollen grains to burst, damaging pollination.

2020 Sacramento Valley Winter Tree Crop Extension Meetings

Meeting	Location	Date	Topics	Organizer
UCCE Sacramento-Solano-Yolo Almond Meeting	UCCE Yolo Office 70 Cottonwood St, Woodland	**February 5** 8-Noon	Boron, Irrigation strategies, NOW, mites & beneficials, wood cankers diseases	Kat Jarvis-Shean

2020 Sacramento Valley Winter Walnut Extension Meetings

Meeting	Location	Date	Topics	Organizer
UCCE Tehama Walnut meeting	355 Gilmore Rd, Red Bluff	**February 7** 8-1 PM		Luke Milliron
UCCE Northern Sac Valley Prune meeting	355 Gilmore Rd, Red Bluff	**February 21** 8-1 PM		Luke Milliron
UCCE Sutter-Yuba Spray Workshop	LoMo Cold storage (N side)	**February 25** 8-3:30PM	Airblast sprayer calibration for tree crops	Franz Niederholzer
UCCE Sutter-Yuba-Colusa Walnut Day	Veterans Memorial Building, 1424 Veterans Memorial Circle, Yuba City	**February 26** Afternoon	Panel discussions Unpruned/unheaded Walnut training systems & clonal walnut rootstocks	Janine Hasey
UCCE Yolo-Solano-Sacramento Walnut Meeting	Woodland Community & Senior Center 2001 East St, Woodland	**March 4** 8-Noon		Kat Jarvis-Shean

2020 Sacramento Valley Winter Tree Crop Extension Meetings (other than almonds or walnuts)

Meeting	Location	Date	Topics	Organizer
UCCE Sacramento Valley Cling Peach Day	142 Garden Highway, Yuba City	**February 4** 8:30-Noon	Chill hours and other updates, laws and regs update, Industry updates, New Varieties and Rootstocks and Pest Management	Janine Hasey
UCCE Northern Sac Valley Prune meeting	355 Gilmore Rd, Red Bluff	**February 21** 8-1 PM		Luke Milliron
UCCE Sac Valley Pistachio Day	UCCE Yolo Office 70 Cottonwood St, Woodland	**February 28** 8-Noon		Kat Jarvis-Shean
UCCE Southern Sac Valley Prune meeting	142 Garden Hwy, Yuba City	**March 3** 8-Noon		Franz Niederholzer

The Sacramento Valley Extension Meetings are updated frequently.

Please visit: sacvalleyorchards.com/events/ to stay in the know!

Navigating Irrigation Technology Overload

Allan Fulton, UC Irrigation and Water Resources Farm Advisor

Technology vs Confusion

"Technology" has different meanings for different people (Figure 1). In irrigated agriculture we look towards technology to meet our changing needs and sustain our industry in the long run. However, with technology, "confusion" and a sense of overload can hinder our ability to learn and apply it. This article considers the abundance of irrigation technology and the challenges with its adoption. Some ideas are offered to cope with the sense of confusion and overload.

"TECHNOLOGY" –

"The application of scientific knowledge for practical purposes"

"Could be information, skills, techniques, machinery, or equipment"

"Sum of techniques, skills, methods, and processes to produce goods"

"**CONFUSION"**

Figure 1. Technology and confusion are often experienced together.

Why and Why Not Technology?

On one hand, there are many drivers that can cause us to look to technology for help with irrigation:

1. Acquiring sustainable irrigation water supply;
2. Uniformly distributing water and nutrients to the crop;
3. Proper timing and amount of irrigation for optimal production;
4. Irrigating with limited labor yet improving execution and precision;
5. Optimizing water and energy costs in relation to crop revenues; and

   Protecting groundwater and surface water from non-point source pollution.

On the other hand, there can be a variety of constraints to adopt irrigation technology:

1. Technology is available from many origins, in many forms and intensities. Because of this, it comes with a potentially steep learning curve to identify and understand whether a technology fits the need(s).
2. No two farms are the same. Each has its unique challenges depending upon the variables (size, crops, human resources, microclimate, soils, water source, etc.).

Where to Begin?

When considering new irrigation technology, it's probably best to start from the familiar "30,000 foot" perspective. An orchard irrigation system has multiple components (Figure 2) and it's necessary to determine what aspect may be the weakest link and provide the biggest return to investment in technology. It's helpful to recognize them all and not overlook something as you prioritize needs.

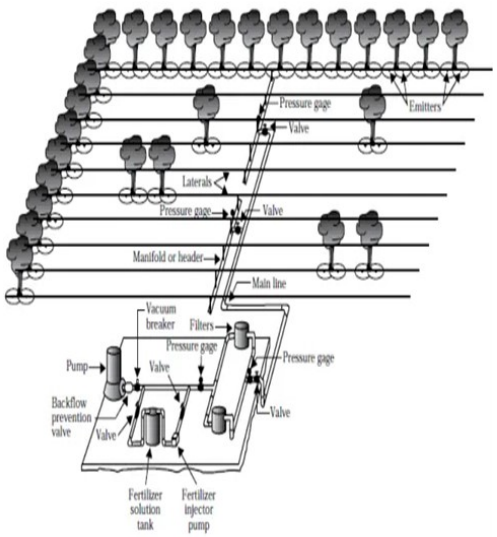

Figure 2. Schematic showing orchard irrigation system beginning with the well and pumping plant and extending out to the last lateral line and sprinkler or

Water Well Technology

Well design and construction choices affect how efficiently water enters the well from the aquifer. The less efficiently water enters into the well the deeper the pumping water level and the greater the yearly energy bill.

If you are developing and securing a new groundwater supply, seek information on different techniques of well drilling, well design, construction and development. This can lead to

a more reliable and affordable water supply and improve your understanding of the well you are buying. Some information resources include: 1) Water well design and construction, UC ANR Publication 8086 http://groundwater.ucdavis.edu/files/156563.pdf); and 2) Water well design, construction, and development: Important considerations before making the investment (https://ucanr.edu/sites/Tehama/files/20593.pdf).

Pumping Plant Technology

Overall pumping plant efficiency affects the cost of pumping water. The higher the efficiency the lower the cost of pumping an acre-foot of irrigation water. Efficiency and cost of pumping are affected by power demand, flow rate, irrigation system pressure, and fluctuating groundwater pumping levels. Flow meters to measure pump flow, pressure gauges or transducers that track irrigation system pressure, and well sounders or sensors to watch pumping levels are available to monitor pumping plant performance and costs. If used, they can notify the operator when the pumping plant performance is veering too far from optimal and in need of attention. They may also alert a manager of unexpected irrigation system failures such as a pump not turning on or off or a valve not opening or closing as expected. Other technologies such as solar arrays and variable frequency drives (VFD) are also becoming more common to manage the costs of pumping water. A solar system provides an alternative, renewable power source and a variable frequency drive (VFD) regulates the power to an electric motor to optimize demand and pumping plant performance. This is particularly valuable to manage irrigation sets of different sizes and flow needs. A VFD can also improve consistency of flow and pressure to an irrigation system during pump start-ups, back flushing, and when pumping water levels fluctuate.

Figure 3. Magnetic flow meter (upper left), pressure transducer (upper right), acoustic groundwater level sensor (lower left), and VFD digital control panel (lower right).

Irrigation system technology

A wide range of technology is available and all aim to grow uniform orchards that produce efficiently and at a high level for many years. This includes orchard site preparation schemes, choices among water filters, pressure regulators, drip emitters, microsprinklers, or minisprinklers, and tools to help monitor and maintain irrigation systems.

Figure 4. Layered orchard soil considered for soil modification and/or zone irrigation management.

Land assessments using backhoe pits (Figure 4) to guide soil modification with excavators or other deep tillage equipment is one technique used prior to planting trees and installing an irrigation system. Another approach uses non-invasive techniques to map and geo-reference the soil variability. This information is used to precisely design irrigation systems so that soils with distinctly different water infiltration and water holding characteristics can be irrigated in separate sets. This approach is referred to as variable rate irrigation (VRI) or zone irrigation. Refer to UC ANR Publication 3507, Prune Production Manual, Chapter 8 (https://www.youtube.com/watch?v=rz_ER49fZEA) and zone irrigation management articles found on the Sacramento Valley Orchard Source. (http://www.sacvalleyorchards.com/?s=zone+irrigation).

Figure 5. Pressure transducer on irrigation line (top) and flow meter on injection pump (bottom).

Pressure gauges or transducers (Figure 5) can be installed in drip or microsprinkler lines intermittently across an irrigation system to verify the system is operating as designed and according to schedule. Small flow me-

ters can be installed on injection pumps to verify chemigation and fertilization efforts are going as planned. It is becoming easier to collect and analyze pressure and flow data from an irrigation system. This allows a quick response, if needed, or the option to save the historical data for management consideration at a later time.

Irrigation scheduling technology

Decisions on when to begin irrigating, how frequent and long to irrigate, and when to stop irrigating an orchard is often based on experience. However, there is growing interest in information and technology that enables a manager to adjust to site specific weather, soil, and crop conditions (Figure 6). The technology varies considerably ranging from manually operated, partially automated, or fully automated. The delivery of information can range from infrequent snapshots in time to hourly or more frequent delivery so that trends in crop water balances, soil moisture, or tree water status can be observed, evaluated, and used to guide the next irrigation scheduling decision.

Figure 6. Irrigation scheduling technology. ET station (top left), plant water status sensor (top right), and soil moisture sensor (bottom).

Remote data and information acquisition

Remote implies "from afar" and not actually being there in person. Data acquisition is a process of collecting signals from various sensors that measure real-world physical conditions. "Telemetry" (Figure 7) is the means of gathering and transmitting the data to a collection point. After the signals are received they are then converted to useful numerical values that can be analyzed on a computer and interpreted to answer questions and guide management decisions.

Being able to collect quantitative data and information and respond based upon it while reducing labor and management time spurs interest in irrigation technology. It represents opportunity and hope as we strive to irrigate orchards as efficiently and productively as possible.

Figure 7. Parts of a telemetry system. Cell tower and gateway next to pump controls (top left), gateway connection to internet (bottom left), orchard cell tower connected to sensors in the field (top right); and node connection to field sensors (bottom right).

Find your place on the technology continuum

Irrigation technology is best viewed as a "continuum" … something that changes constantly but gradually without clear dividing points. It will continue to have a level of uncertainty and choosing to pursue technology is not always necessary, rather it is contingent on need.

When considering irrigation technology, it's probably best to step back and try to view the irrigation system in its entirety. By doing this, it will provide an opportunity to appreciate the improvements that have already been made and identify those parts of the system that are in greatest need of attention in the future. This should help ensure investments are focused on improvements with less risk and the largest opportunity for return.

Once some needs have been identified and prioritized, it may make sense to try the technology on a partial scale or even manually to establish proof of concept, robustness, and effectiveness on the way towards automation and broader adoption.

ALMOND: **FUNGICIDE EFFICACY – Conventional Chemistry**

Fungicide[4]	Resistance risk (FRAC)[1]	Brown rot	Jacket rot	Anthrac-nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot [3]	PM-like[5]	Hull rot[16]
Bumper,Tilt,Propicure, Propiconazole	high (3)	++++	+/-	++++	++	++	+++	ND	++	+++	++
Fontelis[4]	high (7)	++++	++++	++	++++	+++	+++	ND	+++	ND	----
Kenja[4]	high (7)	++++	++++	++	++++	+++	'----	ND	+++	ND	----
Indar	high (3)	++++	+/-	+++	++	++	NL	ND	+	ND	----
Inspire	high (3)	++++	+	+++	++	+++	+++	ND	+++	ND	+++
Inspire Super[4]	medium (3/9)	++++	++++	ND	+++	+++	+++	ND	+++	ND	+++
Fervent	medium (3/7)	++++	+++	++++	+++	++++	++++	ND	++++	+++	+++
Luna Experience[3]	medium (3/7)	++++	+++	++++	+++	++++	++++	ND	++++	+++	+++
Luna Sensation[3,7]	medium (7/11)	++++	++++	++++	++++	++++	++++	ND	++++	+++	+++
Merivon[3,7]	medium (7/11)	++++	++++	++++	++++	++++	+++	ND	++++	++++	+++
Pristine[3,7]	medium (7/11)	++++	++++	++++	++++	++++	+++	ND	+++	+++	+++
Custodia[3]	medium (3/11)	++++	NL	++++	+++	++++	++++	ND	+++	+++	+++
Quadris Top[3]	medium (3/11)	++++	NL	++++	+++	++++	++++	ND	+++	+++	+++
Quilt Xcel,Avaris 2XS[3]	medium (3/11)	++++	+++	++++	+++	++++	++++	ND	+++	+++	+++
Cevya	high (3)	++++	++	++++	+++	+++	+++	ND	++++	+++	+++
Quash[4]	high (3)	++++	++	++++	+++	+++	++++	ND	++++	+++	+++
Rovral + oil[8, 9]	low (2)	++++	++++	----	+++	+/-	++	ND	+++	ND	----
Scala[3, 7]	high (9)	++++	++++	ND	++	----	ND	ND	+	----	----
Tebucon,Toledo (Elite**,Tebuzol**)	high (3)	++++	+/-	+++	++	++	+++	ND	+	ND	++
Topsin-M,T-Methyl, Incognito,Cercobin[2,6,7,8]	high (1)	++++	++++	----	----	+++	+	+++	----	++	----
Vangard[3, 7,9]	high (9)	++++	++++	ND	++	----	ND	ND	+	----	----
Viathon	medium (3/33)	++++	+/-	+++	++	++	+++	ND	+	ND	++
Abound[3,4,7,10]	high (11)	+++	----	++++	+++	++++	++++	+++	+++	+++	+++
CaptEvate*	low (M4/17)	+++	+++	+++	+++	+++	----	+++	+	----	----
Elevate[7]	high (17)	+++	++++	----	+	ND	ND	ND	ND	ND	----
Gem[3,4, 7, 10]	high (11)	+++	----	++++	+++	++++	++++	+++	+++	+++	+++
Laredo	high (3)	+++	----	++	++	----	+	+++	----	+++	----
Luna Privilege	high (7)	+++	++	++	++	+++	+++	ND	+++	++	++
Rovral,Iprodione, Nevado[9]	low (2)	+++	+++	----	+++	----	----	ND	++	----	----
Rally[13]	high (3)	+++	----	++	+/-	----	+	+++	----	+++	----
Rhyme	high (3)	+++	+/-	ND	+	++	ND	ND	++	ND	ND
Bravo,Chloro-thalonil,Echo,Equus[11, 12, 15]	low (M5)	++	NL	+++	+++	+++	++++	NL	NL	----	----
Captan[4, 6, 12]	low (M4)	++	++	+++	+++	++	----	+++	+	----	----
Mancozeb	low (M3)	++	++	+++	+++	++	+++	+++	+	----	----
Ph-D	medium (19)	++	+++	----	++	+++	+++	ND	++++	ND	+++
Ziram	low (M3)	++	+	+++	+++	+++	----	++	+	----	----
Syllit	medium (U12)	+	----	ND	+++	++++	ND	ND	+	ND	----
Copper[14,15]	low (M1)	+/-	+/-	----	+	+	----	----	ND	----	----
Lime sulfur[12,15]	low (M2)	+/-	NL	----	+/-	++	++	NL	NL	----	----
Sulfur[4,12]	low (M2)	+/-	+/-	----	----	++	++	----	----	+++	----
PlantShield[17]	low	----	----	----	----	----	----	----	----	----	----
Copper + oil[14,15]	low (M1)	ND	ND	----	+	+++	----	----	ND	----	----

Rating: ++++ = excellent and consistent, +++ = good and reliable, ++ = moderate and variable, + = limited and/or erratic, +/- = minimal and often ineffective, ---- = ineffective, NL = not on label, and ND = no data

*** Registration pending in California.**

****Not registered, label withdrawn or inactive in California.**

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than

one application of fungicides with mode-of-action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action Group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action Group number.

[2] Strains of the brown rot fungi *Monilinia laxa* and *M. fructicola* resistant to Topsin-M and T-Methyl have been found in some California almond orchards. MBC-resistant strains of the jacket rot fungus, *Botrytis cinerea* and powdery mildew fungi, have been reported in California on crops

other than almond and stone fruits and may have the potential to develop in almonds with overuse of fungicides with similar chemistry. MBC-resistant strains of the scab fungus, *Fusicladium* (*Cladosporium*) *carpophilum*, have been found in California.

[3] Field resistance of *Alternaria* sp. and *Fusicladium carpophilum* to QoI and SDHI fungicides has been detected in almond orchards. AP-resistant populations of *Monilinia* spp. have been found on other stone fruit crops in California.

[4] Of the materials listed, only sulfur, Abound, Gem, and some of the DMI fungicides (FRAC Group No. 3) are registered for use in late spring and early summer when treatment is recommended. See specific fungicide label for PHI. Some fungicides are now prohibited in some markets (e.g., iprodione and propiconazole in the EU) and should not be used due to potential residues on the harvested crop regardless of the PHI.

[5] PM-like refers to a powdery mildew-like disease on almond fruit that is managed with fungicides. Recent information suggests an *Acremonium* species is involved.

[6] Excellent control obtained when combinations of Topsin-M or T-Methyl and Captan are used.

[7] To reduce the risk of resistance development, start treatments with a fungicide with a multi-site mode of action; rotate or mix fungicides with different mode of action FRAC numbers for subsequent applications, use labeled rates (preferably the upper range), and limit the total number of applications/season.

[8] Oils recommended include "light" summer oil, 1-2% volume/volume.

[9] Not registered for use later than 5 weeks after petal fall.

[10] Efficacy reduced at high temperatures and relative humidity; experimental for Alternaria.

[11] Bravo Ultrex, Bravo WeatherStik, Echo, Echo Ultimate, and Chlorothalonil are currently registered.

[12] Do not use in combination with or shortly before or after oil treatment.

[13] Efficacy is better in concentrate (80-100 gal/acre) than in dilute sprays.

[14] The low rates necessary to avoid phytotoxicity in spring reduce the efficacy of copper.

[15] "Burns out" scab twig lesions when applied at delayed dormant. (Chlorothalonil can be applied with dormant oil during tree dormancy).

[16] Hull rot ratings are for the disease caused by *Rhizopus stolonifer*. Ratings for the disease caused by *Monilinia* spp. will be provided in the future.

ALMOND: **FUNGICIDE EFFICACY – Soft Chemistry (Biological and Natural Products)**

Fungicide[4]	Resistance risk (FRAC)[1]	Brown rot	Jacket rot	Anthrac-nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot [3]	PM-like[5]	Hull rot[16]
Dart	low	+++	++	----	----	----	----	----	----	----	----
EcoSwing	low	+++	++	----	----	----	----	----	----	----	----
Fracture	low	+++	++	----	----	----	----	----	----	----	----
PlantShield[1]	low	----	----	----	----	----	----	----	----	----	----
Regalia	low	++	+	----	----	----	----	----	----	----	----
Serenade	low	++	+	----	----	----	----	----	----	----	----

[1] Plantshield is best used for wood-exposing wounds to prevent silverleaf and wood decay.

ALMOND: TREATMENT TIMING

Note: Not all indicated timings may be necessary for disease control.

Disease	Dormant	Bloom			Spring[1]		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	++	+++	+++
Anthracnose[2]	----	++	+++	+++	+++	+++	+++	++
Bacterial spot	+	----	++	+++	+++	++	+	----
Brown rot	----	++	+++	+	----	----	----	----
Green fruit rot	----	----	+++	++	----	----	----	----
Hull rot[7]	----	----	----	----	----	----	----	+++
Leaf blight	----	----	+++	++	+	----	----	----
Rust	----	----	----	----	----	+++	+++	+[6]
Scab[3]	++	---	---	++	+++	+++	+	---
Shot hole[4]	+[5]	+	++	+++	+++	++	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

[1] Two and five weeks after petal fall are general timings to represent early postbloom and the latest time that most fungicides can be applied. The exact timing is not critical but depends on the occurrence of rainfall.

[2] If anthracnose was damaging in previous years and temperatures are moderate (63°F or higher) during bloom, make the first application at pink bud. Otherwise treatment can begin at or shortly after petal fall. In all cases, application should be repeated at 7- to 10-day intervals when rains occur during periods of moderate temperatures. Treatment should, if possible, precede any late spring and early summer rains. Rotate fungicides, using different fungicide classes, as a resistance management strategy.

[3] Early treatments (during bloom) have minimal effect on scab; the 5-week treatment usually is most effective. Treatments after 5 weeks are useful in northern areas where late spring and early summer rains occur. Dormant treatment with liquid lime sulfur improves efficacy of spring control programs.

[4] If pathogen spores were found during fall leaf monitoring, apply a shot hole fungicide during bloom, preferably at petal fall or when young leaves first appear. Reapply when spores are found on new leaves or if heavy, persistent spring rains occur. If pathogen spores were not present the previous fall, shot hole control may be delayed until spores are seen on new leaves in spring.

[5] Dormant copper treatment seldom reduces shot hole infection but may be useful in severely affected orchards and must be followed by a good spring program.

[6] Treatment in June is important only if late spring and early summer rains occur.

[7] Make application at 1 to 5% hull split to manage hull rot caused by *Rhizopus stolonifer*.

ALMOND: SUGGESTED DISEASE MANAGEMENT PROGRAMS BY FUNGICIDE FRAC[1] GROUPS

Note: Not all indicated timings may be necessary for disease control (*see* Treatment Timing Table). If treatments are needed based on host phenology, weather monitoring, inoculum models, or environmental-disease forecasting models, suggested fungicide groups are listed for each timing.

How to use this table:

1) Identify the disease(s) that need(s) to be managed. Know the disease history of the orchard, especially from the previous season.
2) Select one of the suggested fungicide groups. *Numbers separated by slashes are pre-mixtures, whereas numbers grouped by pluses are tank mixtures.* If several diseases need to be managed, select a group that is effective against all diseases. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group. Group numbers are listed in numerical order within the suggested disease management program.
3) Rotate groups for each application within a season and, if possible, use each group only once per season, except for multi-site mode-of-action materials (e.g., M2) or natural products/biological controls (NP/BC).

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Alternaria	----	----	----	----	----	2	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11, 19	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11, 19
Anthracnose	----	3, 3/7, 3/9, 3/11, 3/33, 7	3, 3/7, 3/9, 3/11, 3/33, 7, 7/11, 11	3, 3/9, 3/7, 3/11 3/33, 11, M3, M4	3, 3/9, 3/11, 3/7, 3/33, 7, 7/11, 11, M3, M4	3, 3/7, 3/9, 3/11, 3/33 7, 7/11, 11 M3 M4	3, 3/7, 3/9, 3/11, 3/33 7, 7/11 11 M3 M4	3, 3/7, 3/9, 3/11, 3/33 7, 7/11 11 M3 M4
Bacterial spot	M1, M1+M3	----	M1, M1+M3	M1, M1+M3	M1, M1+M3	M1, M1+M3	M1	'----
Brown rot	----	1[2] 2 +oil 3, 3/7, 3/9, 3/11, 3/33 9	1[2] 2 +oil 3, 3/7, 3/9, 3/11 3/33, 7, 7/11, 9, 11, 19	1[2] 2 +oil 3/11, 3/33 7, 7/11, 9, 19	----	----	----	----

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Green fruit rot	----	----	1[2] 2 +oil 3/7, 3/9, 3/11, 7, 7/11, 9 19	1[2] 2 +oil 3/7, 3/9, 3/11, 7, 7/11, 9 19	----	----	----	----
Leaf blight	----	----	1[2] 2 3, 3/7, 3/9, 3/11 3/33, 11	1[2] 2 3, 3/7, 3/9, 3/11 3/33, 11 M3 M4	3, 3/7, 3/9, 3/11, 3/33 11 M3 M4	----	----	----
Rust	----	----	----	----	----	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19 M3	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19
Scab[4]	M1+oil, M2[3], M5+oil	----	----	1[2], 3/7, 3/9, 3/11, 3/33, 7, 7/11[2] 11[2] M3 M4, M5	1[2], 3/7, 3/9, 3/11, 3/33, 7, 7/11[2] 11[2] M3 M4, M5	3, 3/7, 3/9, 3/11 3/33, 7, 7/11[2], 11[2] M2[3] M3, M4	M2[3] M4	----
Shot hole	M1	2 3, 3/7, 3/9, 3/11, 7, 9, 11	2 3, 3/7, 3/9, 3/11 7, 7/11 9, 11, 19	2 3, 3/7, 3/9, 3/11 7, 7/11 9 11, 19	7, 7/11 11, 19 M3 M4 M5	7, 7/11 11, 19 M3 M4 M5	----	----

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://www.frac.info/). Group numbers are listed in numerical order within the suggested disease management program. Fungicides with a different group number are suitable to alternate in a resistance management program. Refer to the fungicide efficacy table for fungicides belonging to each FRAC group.

[2] Strains of *Monilinia fructicola* and *M. laxa* resistant to Topsin-M, and T-Methyl are present in some California almond orchards. Resistant strains of the jacket rot fungus, *Botrytis cinerea*, and powdery mildew fungi have been reported in California on crops other than almond and stone fruits and may have the potential to develop in almond with overuse of fungicides with similar chemistry.

[3] Use liquid lime sulfur in dormant applications and wettable sulfur at and after pre-bloom.

[4] Apply petal-fall treatments based on twig-infection sporulation model.