Sacramento Valley Walnut News
Issue 38 Winter, 2020

University of California
Agriculture and Natural Resources | Cooperative Extension

In This Issue

Submitted by:

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2020 Sacramento Valley Winter Walnut Extension Meetings

Meeting	Location	Date	Topics
UCCE Tehama Walnut meeting	355 Gilmore Rd Red Bluff	February 7 8-1 PM	Laws & Regs, Phytophthora, Botryosphaeria, and Navel Orangeworm
UCCE Sutter-Yuba Spray Workshop		February 25	
UCCE Sutter-Yuba-Colusa Walnut Day	Veterans Memorial Bldg 1424 Veterans Memorial Cir. Yuba City	February 26 12:30-4:30 pm	Panel discussions Unpruned/unheaded Walnut training systems & clonal walnut rootstocks
UCCE Yolo-Solano-Sac Walnut Meeting	Woodland Community Ctr 2001 East St Woodland	March 4 8-Noon	
You can find meeting updates and agendas at: sacvalleyorchards.com/events			

Winter Pest & Weed Management Considerations

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

Pest Management:

- **Clean operation:** Navel orangeworm (NOW) infestation levels were high in some Sacramento Valley walnut harvests in 2019. Sanitize orchards as part of your NOW management program by shaking/hand poling, blowing berms, and then flail mowing mummies prior to next season. 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. Make sure to pay attention to areas in and around your operation where nuts and orchard debris may accumulate, and destroy those mummies as well. There may be more mummy nuts in trees and on the ground this year, particularly if you had high levels of diseased nuts in 2019.

- **2020 Codling Moth & Navel Orangeworm Mating Disruption:** If you use mating disruption for codling moth – stay the course. If not, consider adding it to your IPM program, particularly in light of the phase out of particular broad-spectrum materials. Codling moth mating disruption is a proven effective strategy for reducing populations and damage, with return on investment maximized over multiple years of use. Good codling moth management can also mitigate NOW infestation. If both codling moth and NOW are big factors in harvest damage, there is a mating disruption product that targets both pests. Talk with your PCA about options. Get mating disruptants ordered in advance and hung before typical spring biofix in your orchards. Remember that you will need to use monitoring approaches that evaluate female activity as well as male activity in mating disruption orchards. More information at: sacvalleyorchards.com/walnuts/insects-mites-walnuts/monitoring-codling-moth-in-and-near-mating-disruption-orchards/. BE KIND to your neighbors and let them know if you are using mating disruption, as traps in nearby orchards can be impacted.
- **Scale Pests:** Delayed-dormant is one of the effective pesticide application timings for managing scale pests. Scales often do not need treatment every year. Learn more at: sacvalleyorchards.com/walnuts/cost-and-expense-considerations/scale-pests-navel-orangeworm-and-flatheaded-borers/.
- **Sprayer Prep:** 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 (see article in this newsletter).
- **Pocket Gophers:** Late fall through winter is a great time to manage pocket gopher populations. Population levels are typically low and more manageable and yet mounding activity is high. Heading out to set traps in the tunnel networks connected to those fresh mounds is an incredibly effective management approach. For information on trap types, as well as the possibility of pairing other management options such as baiting with trapping for increased control see: sacvalleyorchards.com/blog/almonds-blog/options-for-gopher-management/
- **Ground Squirrels:** Unlike pocket gophers, ground squirrels are only effectively managed at certain times of the year. From mid-January through mid-May burrow fumigants are the most effective control measure. Always follow the label safety precautions and obtain the correct permits from your county agriculture commissioner's office. You can learn about management at: groundsquirrelbmp.com/management-cgs.html

Weed Management:

- Weed management can be particularly difficult in newly planted and young orchards because their rapid growth is accelerated by frequent irrigation to establish trees, fertilizer, and excellent sunlight exposure. For information on weed control options in young orchards read the article on "*Young Orchard Weed Management*" in this newsletter.

As the 2020 growing season approaches, 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. For more information regarding paraquat and the new EPA regulations read the article in this newsletter.

Preparing for Extreme Events: Flood and Drought

Luke Milliron, UCCE Farm Advisor for Butte, Tehama, & Glenn Counties
Janine Hasey, UCCE Farm Advisor Emeritus, Sutter-Yuba & Colusa Counties
Allan Fulton, UCCE Irrigation and Water Resources Advisor in Tehama, Shasta, Glenn, & Colusa Counties

In the 2019 postharvest issue of the Sacramento Valley Walnut Newsletter we wrote the first part of the preparing for extreme events series, which was focused on freeze and fire. Hopefully, you have not had to contend with either of those extremes this past autumn. If you missed this issue but want to learn more about preparing for freeze and fire, please see: sacvalleyorchards.com /walnuts/year-round-management-walnuts/preparing-for-extremes-freeze-fire/

In part two of this series we discuss preparing for flood and drought. Although neither may confront you in 2020, it's best to be prepared for these inevitable extremes!

Flooding. How can damage be reduced?

Flooding from unprecedented flows of the Sacramento and Feather Rivers in early 2017 through spring, resulted in extensive orchard damage. Although there is little you can do to prepare against the most extreme flooding, some practices can help to reduce damage. For more information on flood damage and recovery, go to: sacvalleyorchards.com/walnuts/flooding/

- Moving water is key to trees surviving because it is oxygenated. Standing water can lead to extensive damage from waterlogging induced root-death. Furthermore, saturated soils favor *Phytophthora* infection. Keep ditches clear to keep water moving away from the orchard. If water is still not moving off the orchard, pump the water out if possible or dig trenches. Anything you can do to prevent stagnant water should be considered.
- Although it's too late for this season, in some circumstances planting cover crops in the orchard can improve infiltration. Roots from vegetation cover may help hold the soil and reduce erosion. The UC ANR publication "*Cover Crops for Walnut Orchards*" is an excellent guide to deciding whether cover crops fit into your operation, how to choose a cover crop, and how to manage it. Please see: anrcatalog.ucanr.edu/pdf/21627e.pdf
- Resident vegetation (weeds) in row-middles and along orchard edges can offer similar benefits by increasing infiltration, reducing erosion, and allowing equipment back in the orchard sooner. A bare orchard floor, and especially recently cultivated ground is the most susceptible to erosion.
- Just as with fire and freeze in part one, trees that have been damaged from flooding should not be quickly removed. Wait until mid-summer after you have had time to see if adventitious (dormant) buds break and provide vegetative growth that will eventually establish a new tree canopy. In addition, keeping damaged trees standing can allow for insurance and recovery program evaluation.
- Flood damage can have long-term impacts on tree productivity. The effects from 2017 long-term flooding reduced productivity in some orchards through 2019.

Drought. Monitoring and responding to conditions:

So, where do we currently stand? Statewide:

A CA Department of Water Resources (DWR) network of electronic readings from 130 stations throughout the state averaged 90% of average snowpack on January 2nd. Manual measurements taken at Phillips Station (south of Lake Tahoe) were above the statewide network average, at 97% of average as of January 2nd. The statewide totals for rainfall up to this early January date were less encouraging, at 74% of average precipitation.

The full report is at: water.ca.gov/News/News-Releases/2020/January-2020-Snow-Survey

Sacramento Valley Precipitation Totals:

We have periodically reported the status of winter precipitation in recent years. The dormant winter season is a time when evapotranspiration (ET) is low and it is an opportunity to refill the soil profile in your orchards prior to the next season. Some benefits include:

- Moist soils tend to be warmer and reduce the risk of winter kill from severe cold snaps.
- A full profile before leaf-out should delay the need for the first crop irrigation (except for frost protection) and provide better aeration to discourage diseases as the trees grow.
- Banking water for use later in the season may help lessen summer pumping. It is particularly important in orchard soils that have very slow infiltration (silt and clay soils).

By tracking rainfall, it's possible to substitute irrigation for a rainfall shortage on a monthly basis beginning in December. All is well when enough rainfall in combination with irrigation is received to refill the soil profile at least three feet deep. Tables 1-4 demonstrate the idea of tracking rainfall to help gauge if and how much winter irrigation might be needed. The tables show average monthly rainfall and total rainfall for four different areas in the Sacramento Valley and they compare rainfall measured in the four most recent fall and winter seasons at four area CIMIS weather stations. Of course, not all rainfall is effectively stored in the soil profile as it depends upon the soil conditions and intensity of the storm. As a rule of thumb, on average only 50 to 60 percent of actual rainfall will likely be effectively stored in the soil profile.

Tables 1-4 show total rainfall in 2017/18 generally lagged well behind average rainfall amounts from October through March. As a result, winter irrigation was a fairly common practice in 2017/18. The rainy season was slow in getting started in the fall of 2018 and 2019, which was a big part of the story for both the Camp Fire in 2018 and cautionary electricity shutoffs in 2019. Rain did finally arrive in mid-to late-November in both years. In 2018 following a dry October, late November rains brought that month's total closer to (or above) the historical average. In 2019 despite some areas receiving rain in November, rainfall totals for October through December have been well below-average. A notable exception was above average rainfall at the Williams CIMIS station in December (although there were some values flagged for being moderately or far out of the normal range on a heavy rainfall day). Rainfall totals in December of 2018 were also below average, but an above average January and a very wet (generally 2-2.5x the historical average) February made up for the low December levels.

Rainfall totals to-date in January have also been below average, although there is additional rain in many short-term forecasts. Time will tell whether we can make up for a slow start to the rainy season. The DWR

2020 News Release on the previous pages reminds us that about ¾ of California's rain falls in December, January, and February, so there's still some time to make-up for a slow start to the rainy season. So far, the 2019/2020 rainfall season is tracking closer to the below average 2017/2018 rainfall totals, with some orchards receiving winter irrigation already. DWR also has an 8-station index report of Northern Sierra precipitation, the index was only at 64% of average as of January 22. You can see where the index is now and how this season is tracking against historical highs and lows at: cdec.water.ca.gov/cgi-progs/products/PLOT_ESI.pdf

As always, using site specific rain gauges rather than depending upon regional weather stations some distance away will improve accuracy in assessing your specific situation. Soil moisture sensors or ground truthing with an auger will give you the best indication of how much the soil-profile has refilled. Checking soil moisture by hand is a very basic method that allows you to evaluate storage of rainfall and winter irrigation in different orchard soils. There are many online stores where soil augers can be purchased (try: JMC Backsaver, AMS samplers; Forestry Suppliers; and/or Ben Meadows). Choosing equipment that allows you to easily and rapidly evaluate soil moisture depletion by feel is critical to making this practice part of your routine. The USDA NRCS publication *Estimate soil moisture by feel and appearance* can help you hone this skill*:* nrcs.usda.gov//Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Table 1. Red Bluff (Gerber CIMIS #222) Winter Rainfall (In)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Avg. Monthly	**1.2**	**2.8**	**4.2**	**5.0**	**4.1**	**3.2**	**20.5**
2016/2017	3.2	2.9	3.0	4.6	3.9	2.1	19.7
2017/2018	0.2	2.2	0.0	3.1	0.1	2.4	8.1
2018/2019	0.5	2.4	2.8	5.5	8.7	4.6	24.5
2019/2020	0.0	0.1	2.7	0.6*	?	?	3.5*

Table 2. Chico (Durham CIMIS #12) Winter Rainfall (In)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Avg. Monthly	**1.4**	**3.3**	**4.6**	**4.8**	**4.4**	**4.3**	**22.8**
2016/2017	4.2	3.2	4.7	6.9	6.5	3.2	28.6
2017/2018	0.5	4.0	0.1	3.5	0.3	3.4	11.8
2018/2019	0.7	6.4	2.9	5.4	11.3	3.7	30.5
2019/2020	0.0	0.9	5.0	0.6*	?	?	6.5*

Table 3. Williams (CIMIS #250) Winter Rainfall (In)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Avg. Monthly	**0.8**	**2.4**	**2.9**	**3.3**	**2.6**	**1.8**	**13.8**
2016/2017	2.1	1.6	1.8	7.1	6.4	1.3	20.3
2017/2018	0.2	0.1	0.0	2.3	0.1	1.9	4.6
2018/2019	0.5	2.0	0.8	3.5	7.0	2.8	16.5
2019/2020	0.0	1.1	3.5 (K)	0.4*	?	?	5.1*

Table 4. Woodland (CIMIS #226) Winter Rainfall (In)							
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Avg. Monthly	**1.1**	**2.4**	**3.7**	**4.5**	**4.1**	**3.0**	**18.7**
2016/2017	1.9	1.0	2.2	9.0	5.8	2.0	21.9
2017/2018	0.7	1.4	0.0	3.5	0.3	2.9	8.8
2018/2019	0.9	3.1	1.7	5.2	8.0	4.4	23.3
2019/2020	0.0	0.0	0.5 (K)	0.8*	?	?	1.3*

K = One or more daily values flagged. In the case of Williams in December, this was due to values being moderately or far out of the normal range for several hours during a high rainfall day. In the case of Woodland in December it was a single hour of missing data on a day without any other rainfall reported.

* = Precipitation total as of January 17, 2020

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 (Time of first use)
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/

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

Pre-Season Airblast Sprayer Calibration

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

Prep your sprayer for bloom (blight) sprays. If you use stainless steel nozzles, toss out last year's and buy new ones. If you are using ceramic nozzles, check them for wear. Ceramic nozzles do wear out, eventually. Once you are happy with your nozzles, check pump and system strainers as well as those at the nozzle. Replace any that need it (screen holes, clogging, poor/damaged end seals, etc.). Pull off all nozzles/strainers and run clean water through the system to blow out any solids that could collect at the nozzle screens and slow/clog flow. Check the pressure gauge, too. Does the pressure it reads match up with the flow rate from the sprayer based on the manufacturer specs? If you are using Spray Systems nozzles, the TeeJet catalog 51A is available as a free download from teejet.it/media/461405/cat51a_us.pdf or as a hardcopy from your local dealer. Look for leaks and fix where found. Now calibrate the sprayer to deliver the GPA you want.

- Set a ground speed that allows sprayer air [and the pesticide carried by it] to reach just above the tops of the trees. Use flagging in the tree tops to see if sprayer air is moving through the canopy. The speed you decide on should be faster than that used for summer sprays (mites, worms, etc.) so the application is more cost-effective and still effective – assuming you are happy with the results of your summer sprays Measure speed in ft/minute in the field over a distance of at least 100'. [Don't trust the MPH on the tractor tach] For use later in the process, calculate acres per minute (APM) sprayed by multiplying ground speed in feet/minute by the row spacing. [For example, if the sprayer travels 176 ft in a minute down a tree row that is 28 feet wide, it will spray an area of 4,928 sq ft/min. Divide that number by 43560 sq ft/acre to get 0.11 acres/minute.]
- Gallons per acre = gallons/minute divided by acres/minute. With a certain gallons per acre (GPA) in mind and working from the nozzle manufacturer's catalog, select the number and sizes of nozzles to deliver the needed gallons per minute. Set up the nozzles on the sprayer so that most of the spray (~70-80% of flow) targets the upper tree canopy. Rain will recycle the upper deposits, washing the blight materials downwards onto green tissue below. [The more material high in the tree, the longer the protection will last in the upper tree, plus there is a bigger reservoir to wash down and protect the lower tissues as the lower residues are removed by rainwater.]
- Check actual sprayer GPA by filling the sprayer to overflowing, running it at field settings (rpms, system pressure, etc.) for 2-3 minutes, making sure to note exactly how long the nozzles were open. Refill the tank just to overflowing with a flow meter on a hose or calibrated buckets. Divide the total gallons replaced into the sprayer by minutes of run time and you have the actual gallons per minute (GPM) put out by the sprayer. Divide gal/minute by acres/minute to get actual GPA sprayed. Repeat at least once more to make sure you have it right. Now you can add pesticides to the tank with confidence that the intended rate per acre is being delivered.
- Double check calibration throughout the spray job by checking trees/minute at different times and knowing the number of rows or trees per tank at the particular GPA.
- Recalibrate the sprayer for summer work once the early leaves are fully expanded (May?). The target will be larger (more GPA) and the canopy more dense (slower ground speed needed at that time and a good bloom calibration will not deliver the needed coverage.

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"**

- "Lack of understanding, uncertainty
- "Bewildered or unclear in one's mind"

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
6. 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 all of the components and not overlook something as you prioritize needs.

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 groundwater.ucdavis.edu/files/156563.pdf); and 2) Water well design, construction, and development: Important considerations before making the investment (ucanr.edu/sites/Tehama/files/20593.pdf).

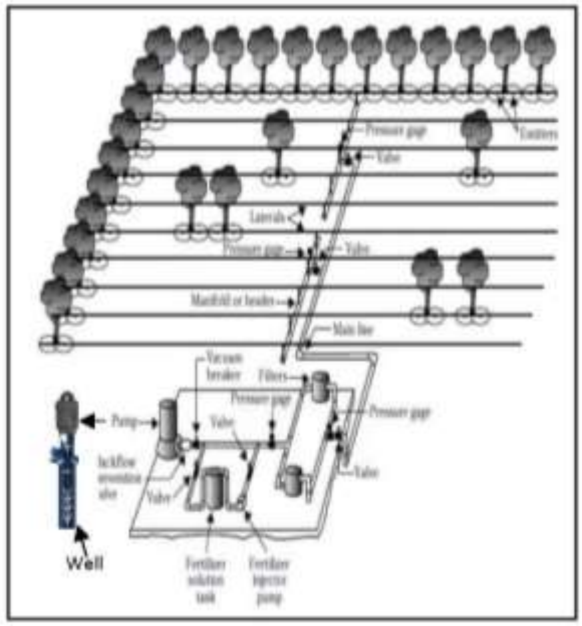

Figure 2. Schematic showing orchard irrigation system beginning with the well and pumping plant and extending out to the last lateral line and sprinkler or dripper.

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 (Figure 3). If used, they can notify the operator when the pumping plant performance is veering too far from optimal and is 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 (Figure 3). This is particularly valuable to manage irrigation sets of different sizes and flow needs. VFD's 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, Pr une Production Manual, Chapter 8 (anrcatalog.ucanr.edu/Details.aspx?itemNo=3507) and zone irrigation management articles found on the Sacramento Valley Orchard Source (sacvalleyorchards.com/?s=zone+irrigation).

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

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

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.

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

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

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).