Sacramento Valley Walnut Newsletter

UC CE | UNIVERSITY OF CALIFORNIA Agriculture and Natural Resources | Cooperative Extension

Winter, 2026

In This Issue

Submitted by:

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Upcoming Meetings!

Program	Date	Location
Sutter-Yuba Walnut Day	Mar 4, 2026	Veteran's Hall
North Sac Valley Walnut Day	Mar 5, 2026	Elks Lodge, Red Bluff
2026 Principles of Fruit & Nut Tree Growth, Cropping, and Management	March 9-13, 2026	Davis, CA
Nickels Soil Lab Field Day	May 19, 2026	Arbuckle, CA

Walnut Winter Management UCCE Resources

Jaime Ott, UCCE Tehama, Shasta, Glenn, and Butte Counties

With walnut prices modestly up, this is a good time to look at your orchard operation, grade sheets, and pest/disease challenges in the last few years and make a plan for 2025 and beyond. Consider how the 5% rule might apply, where small improvements across multiple aspects of an operation can yield large returns.

Chill accumulation has been low-to-moderate so far this winter, depending on how you count and where you grow. If you're worried about inadequate chill in your orchard, this could be a year to explore dormancy breaking treatments. See more in this newsletter for the latest research.

Mating disruption is an effective method for reducing codling moth damage, which also helps to reduce NOW infestations. If you opt to use mating disruption, hang mating disruptants before the typical spring biofix in your orchard. Remember that these products can affect trap catches in pheromone traps in nearby orchards, so be kind to your neighbors and let them know that you are using mating disruption.

Any sanitation is better than none for NOW control. If you situation doesn't justify the Cadillac treatment (shaking/hand poling, blowing berms, and destroying mummies by flail mowing), consider doing what you can to protect your 2025 crop.

Delayed-dormant is a good time to spray for scale pests If you have used an insect growth regulator in the last two years, monitor to see if you can skip a scale spray this year.

Take the time to maintain and calibrate your airblast sprayers. A properly calibrated sprayer is needed for good pest and disease control. Full coverage is especially necessary for walnut blight– if it's not covered, it's not protected! Check your sprayer for worn or broken parts (nozzles, strainers, pressure gauge(s), etc.). Calibrate the sprayer by measuring ground speed and spray flow. The general rule is at least 2/3rd of the spray volume (gallons per minute) through the top half of open nozzles.

Perform irrigation system maintenance before you start things up in the spring. Contact your local Resource Conservation District Mobile Irrigation Lab for free system evaluations:

- Tehama, Butte, Glenn, and Shasta Counties- Kevin Greer, kevin@tehamacountyrcd.org or 530-727-1297

- Yolo, Colusa, Sutter, and Yuba Counties- Conor Higgins, higgins@yolorcd.org or 530-661-1688 ext. 4
- Solano County- 707-678-1655 ext. 123
- Sacramento County- Chris Timmer, chris@sloughhousercd.org or (916) 628-0369

Consider using a pressure chamber to inform irrigation start timing this spring. Careful pressure chamber use can benefit walnut orchard health, as well as achieve water and energy savings.

Follow these best practices for replanting. If more than half of the replant spot is shaded at midday, a replant is unlikely to succeed.

Look for cost savings throughout the year with these articles focusing on labor and cost cutting considerations appropriate to each season.

Check out your regional UCCE meeting this winter for the latest production research and best practices. See the calendar in this newsletter or visit the Events page on SacValleyOrchards.com.

Updated fungicide and bactericide efficacies and timing for 2025 are available now at UC IPM. Walnut-specific tables are included in this newsletter.

Managing flatheaded borer in Sacramento Valley walnut orchards

Sudan Gyawaly, Area IPM Advisor, Northern Sacramento Valley

Background and pest biology

Over the past few years, Sacramento Valley Orchard Advisors have received several calls about flatheaded borer damage concerns in walnut orchards. While most of those farm visits were found to be unrelated to flatheaded borer, it certainly underscored the need for awareness and accurate diagnosis of flatheaded borer and other problems.

Pacific flatheaded borer is an important wood-boring beetle pest of walnuts. This beetle belongs to the family *Buprestidae* and is also called a jewel beetle because of its shiny, metallic appearance in adults. The name "flatheaded borer" comes from its larval stage, which appears to have a greatly enlarged and flattened head (Figure 1).

Flatheaded borer typically has one generation per year in the Central Valley. Adults emerge from late spring through summer, leaving a D-shaped exit hole. Females lay eggs on the trunk and branches, often in bark cracks and crevices. After hatching, larvae feed just under the bark in the cambium layer, creating tunnels that are often filled with sawdust-like frass, and may bore deeper into the wood as they mature. The insect survives the winter as mature larvae within young trunks and branches before turning into pupae in early spring and emerges as an adult beetle.

Figure 1. Flatheaded borer larva

Flatheaded borers, like other wood-boring beetles, are usually associated with stressed trees. Stress can result from drought, sunburn, soil issues, or other factors. However, once populations become high, borers may also infest healthy trees, leading to orchard decline.

Identifying flatheaded borer damage and activity

Flatheaded borer infestations often go unnoticed until damage is severe. Injury can be confused with other causes of tree stress or decline, which may delay timely response. Prompt identification of beetle infestations is critical to prevent this pest from becoming a serious problem.

Common signs of infestation include flagged or dead branches, most often in the upper canopy where weakened limbs may break. Other indicators include cracked or rough bark (Figure 2, left) and oozing sap at infestation sites (Figure 2, right). When bark is peeled back, feeding tunnels filled with fine sawdust (frass) may be visible, and cream colored flatheaded larvae may be present within the tunnels.

Figure 2. Flatheaded borer feeding damage showing cracked or rough bark (left) and oozing sap at infestation site (right)

Commercial traps are not yet available for this pest in walnuts. Several years of UC research in the northern San Joaquin Valley have found that custom-made yellow triangular traps can effectively attract adult flatheaded borers. These traps are four feet tall, ground-installed, and have a sticky substance applied to their exterior surfaces (Figure 3). They can be constructed from corrugated plastic panels and used as a detection tool in orchards. Instructions for making and deploying these traps is available here.

Figure 3. Custom-made, yellow triangular trap for flatheaded borer detection

Management strategies

Flatheaded borer is difficult to manage once established in an orchard, and control options are limited. In mature orchards, pruning out and destroying infested branches can help reduce population buildup and limit reinfestation. Maintaining tree health and reducing stress are key to preventing infestations, as borers are primarily attracted to stressed trees.

For newly planted trees, protecting the trunk from sunburn is critical, so paint from just below the soil line upward with interior white latex paint to protect exposed bark. Extending the paint slightly below the soil surface helps maintain protection if soil settles or erodes. In frost-prone areas, trunk painting can be adjusted to minimize potential effects on bud break.

Currently, no insecticides are specifically recommended for managing flatheaded borers in walnuts. However, studies in the northern San Joaquin Valley suggest that summer applications (late June with a follow-up application approximately three weeks later) of certain insecticides, including diamides and acetamiprid, may help reduce damage in some cases, but results have been modest, and no consistently effective insecticide program has been identified to date. For now, the best approach remains maintaining tree health, watching for early symptoms, and pruning and destroying infested branches. Growers with flatheaded borer infestation concerns can contact their local UC Cooperative Extension farm advisor for guidance and support.

Cost drivers of walnut production in the Sacramento Valley

Domena A. Agyeman, UCCE Ag and Natural Resources Economic Advisor; Butte, Glenn, and Tehama Counties

Walnut production costs remain elevated, and overall profitability continues to hinge on how well growers can manage key cost drivers. With margins still tight, understanding where costs have increased over time could benefit growers in identifying areas where savings may be possible.

Figure 1 shows walnut production costs per acre in the Sacramento Valley, expressed in 2025 dollars to allow fair comparison across years. This adjustment removes general inflation, so differences between years reflect real changes in production costs. Total costs, consisting of operating, cash overhead and non-cash overhead costs increased steadily from $4,805 per acre in 2007 to $8,081 per acre in 2022, representing a 68% increase. Non-cash overhead costs experienced the largest increase (89%), followed by operating costs (62%) and cash overhead costs (19%).

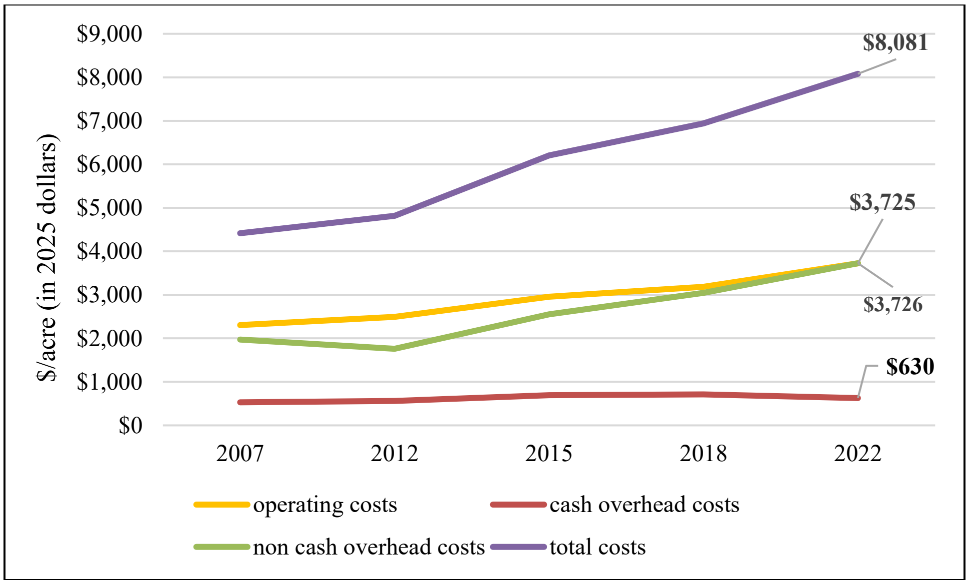


Figure 1. Per-acre costs of walnut production in the Sacramento Valley (adjusted to 2025 dollars using GDP price deflator). Source: *UC ANR cost and return studies.*

Operating costs include annual production costs such as labor, fertilizer, harvest, and interest on operating loans. Cash overhead costs are whole farm expenses paid in cash that are not tied to a specific operation, such as office expenses, field sanitation, equipment repairs, or property taxes. Non-cash overhead costs are ownership expenses, representing annual depreciation and interest on farm investments like wells, irrigation systems, land, and orchard establishment costs.

Cost changes between 2018 and 2022 are the most recent available from UC ANR and are therefore the most relevant for guiding current management decisions. Over this period, total production costs increased 25%, driven primarily by operating costs (up 26%) and non-cash overhead costs (up 32%). Within non-cash overhead, establishment costs were the main contributor, doubling between 2018 and 2022 and increasing their share of non-cash overhead from 29% to 44%, largely due to rising interest rates. Land costs rose about 10% over the same period and remained the largest component of non-cash overhead, accounting for 47% in 2022, a decline from 57% in 2018.

A closer look at operating cost components between 2018 and 2022 shows that much of the cost increase was concentrated in fertilizer, irrigation, machinery, operating loan interests, and labor costs. Fertilizer costs and the cost of pumping irrigation water doubled, while expenses for operating machinery, including gasoline, diesel, lubricants, and repairs increased by 95%. Interest paid on operating capital increased by 72% following the rise in operating loan interest rates. Labor costs also increased by 35%, adding further pressure to operating margins.

Together, irrigation, fertilizer, and labor costs accounted for 22% of total operating costs in 2018 rising to 33% in 2022. In contrast, pest management costs (herbicide, fungicide, bactericide, insecticide, and rodenticide) declined from 25% to

20% of operating costs. This shift can be attributed to several key factors. Supply disruptions following the COVID-19 outbreak, combined with the rise in U.S. natural gas prices between 2020 and 2021, significantly increased the cost of nitrogen production in the U.S., as natural gas is a key component in nitrogen fertilizer production. In addition, drought conditions between 2020 and 2022 reduced surface water deliveries and increased irrigation water pumping costs. Decrease in the overtime threshold for agricultural workers, along with the steady increase in the minimum wage (from $11 per hour in 2018 to $14 per hour in 2022), contributed to rising labor expenses. Irrigation and labor expenses are likely to continue growing as a share of operating costs in the coming years, driven by stricter groundwater management policies and labor regulations that raise labor costs. For reference, California's minimum wage is $16.90 per hour as of January 2026, with agricultural workers entitled to 1.5 times the regular rate for overtime. Harvest costs rose about 11% between 2018 and 2022, though their share of operating costs declined from 38% to 34% over the same period.

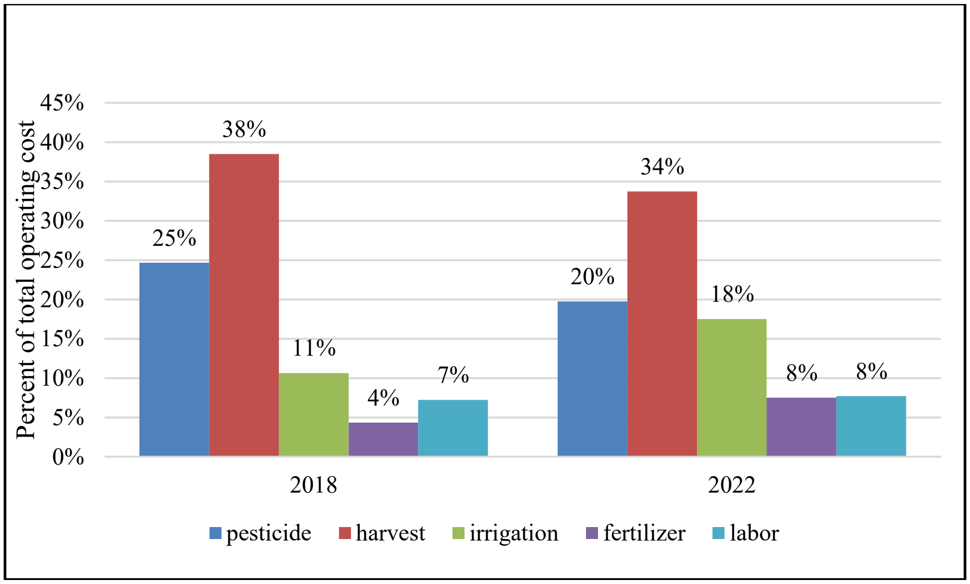


Figure 2: Percentage of total operating costs by cost category for walnut production in the Sacramento Valley 2018 and 2022. Source: UC ANR cost and return studies

In addition to depressed walnut prices, recent cost trends underscore that walnut profitability is increasingly shaped by rising production costs. Although growers have limited control over factors such as market prices, interest rates, and irrigation water costs, understanding which cost categories are rising most rapidly can help identify areas where management adjustments may improve profitability. Optimizing irrigation efficiency, nutrient management, and labor allocation as part of annual budgeting and planning decisions may offer opportunities to reduce operating costs in the current environment. Growers can use the UC ANR cost studies, including a downloadable spreadsheet to track their expenses and identify where management adjustments are most needed. Moreover, with interest rates remaining elevated relative to historical levels, careful consideration of orchard establishment timing and financing structure has become increasingly important. This handout from Morrisson provides key financial metrics that can help growers improve access to credit and secure more favorable financing opportunities.

As production costs rise and market prices remain uncertain, your walnut profitability will increasingly depend on how well you adapt your management practices, control costs you can influence, and make sound investment decisions for your orchard.

Phytophthora sampling in the Stockton East Water District

Jaime Ott, UC Extension Tehama, Shasta, Glenn, and Butte Counties
This work was partially funded by the Stockton East Water District

Crown rot and root rot caused by *Phytophthora* species are diseases of great concern for walnut growers. Many people believe that irrigating with surface water puts your trees at risk of *Phytophthora*, and that irrigating with groundwater is the best way to prevent these diseases. However, a recent study of *Phytophthora* in irrigation water and orchard soils tells a different story.

The Bottom Line:
Irrigation management is *Phytophthora* management. This study showed that *Phytophthora* is common in orchard soils. Regardless of whether they are irrigated with surface water or groundwater, over 30% of tested orchard soils were positive for *Phytophthora*. Since water (either standing water or saturated soil) allows *Phytophthora* to cause disease, good irrigation management is crucial to prevention, no matter what your water source.

- Reduce ponding: irrigation application rate should not exceed soil infiltration rate
- Reduce length of soil saturation: run shorter sets (24 hrs max) more frequently
- Avoid water on the trunk of the tree and avoid soil saturation at the trunk: plant on berms, use stream splitters, choose microsprinkler wetting patterns that avoid the trunk, move drip emitters away from the trunk

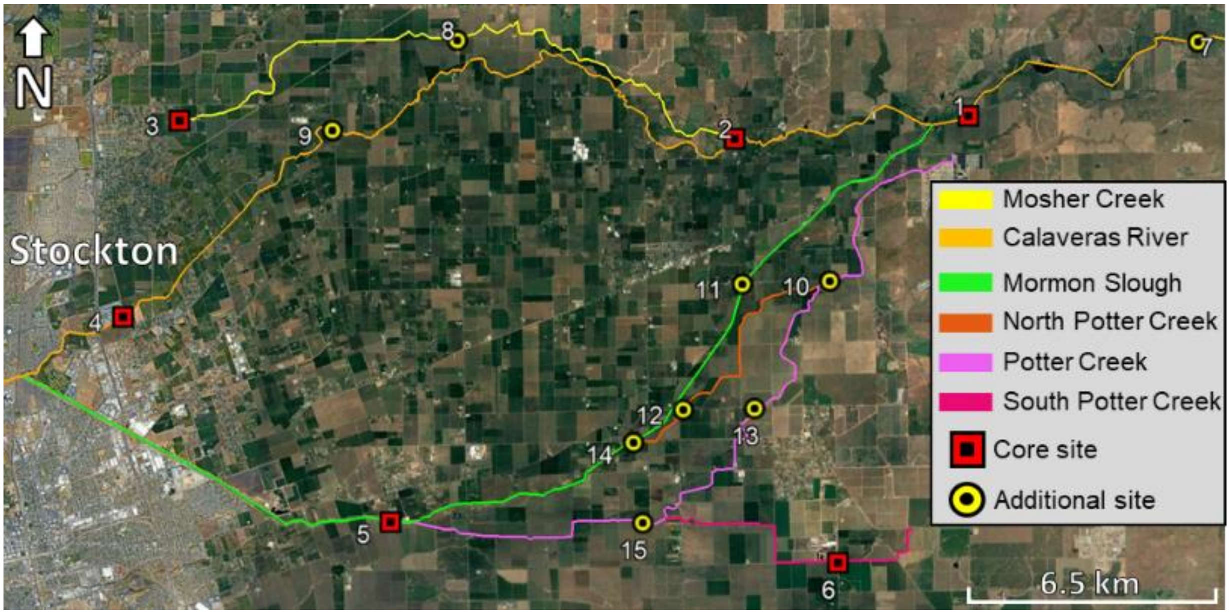
Using a resistant rootstock is an excellent tool to help limit Phytophthora disease if you are planting a new orchard or putting in replants. RX1 is a great option with proven resistance to Phytophthora. Even with a resistant rootstock, good irrigation management is crucial because no rootstock is immune.

The Details:
Phytophthora is a genus of fungus-like organisms which contains over 200 different species. Many of these species are important pathogens of orchards, causing root rot or crown rot (for example *Phytophthora cinnamomi*, *Phytophthora cactorum*, and *Phytophthora mediterranea*) or pruning wound cankers (mainly *Phytophthora syringae*). Many previous studies have shown that *Phytophthora* species are common in surface sources of irrigation water, such as rivers, canals, and sloughs. *Phytophthora* has not been found in groundwater from wells, unless that well has been contaminated with surface water. From this, people have assumed that irrigating with surface water puts an orchard at risk of Phytophthora root or crown rot, and that irrigating with groundwater is ”safe.” However, biology is rarely that simple: in my experience, orchards irrigated with groundwater can struggle with *Phytophthora*, and many orchards irrigated with surface water do not show symptoms of Phytophthora disease.

In 2021 and 2022, collaborators and I conducted a study to look at the effects of *Phytophthora* in irrigation water from a broader perspective. This study took place in the Stockton East Water District (SEWD), a local water agency that manages both groundwater and surface water use by agricultural producers east of Stockton, CA. The study had three objectives:

1. Test SEWD surface water for *Phytophthora* during the irrigation season
2. Test for live *Phytophthora* coming through irrigation emitters
3. Test orchard soils for *Phytophthora*, comparing orchards irrigated with surface water vs groundwater

Objective 1. Test SEWD surface water for *Phytophthora* during the irrigation season
During the 2021 irrigation season, we sampled water from surface water irrigation sources throughout the SEWD. Some locations (core sites) were sampled monthly from June through October, and some locations (additional sites) were sampled twice during the season, in July and October. Samples were taken back to the lab and tested for *Phytophthora* using DNA sequencing.



Overview of the Stockton East Water District (SEWD) with water sampling sites marked.

We found that *Phytophthora* species were common in SEWD waterways. Over the course of sampling, we found 39 *Phytophthora* species, 10 of which are known pathogens of orchards crops grown in the SEWD. Many of these species were found throughout the irrigation season. We did find that different waterways had different *Phytophthora* species, and some waterways had more orchard pathogens than others. However, every waterway, and nearly every site, had at least one *Phytophthora* species of concern to orchards. These results are consistent with many previous studies, which have determined that *Phytophthora* species are common in surface sources of irrigation water.

Phytophthora species detected in Stockton East Water District waterways throughout the irrigation season

Species	Can cause disease on	Calaveras River	Mosher Creek	Mormon Slough	Potter Creek	South Potter Creek
P. cactorum	W, **C**, **A**	+	+	.	+	+
P. acerina	**A**	+	.	.	.	.
P. pini (formerly *P. citricola*)	**W**, A	+	+	+	+	.
P. rosacearum	C	+	.	.	.	.
P. chlamydospora	C, A	+	+	+	+	.
P. gonapodyides	W	+	+	+	+	.
P. taxon walnut	W, A, **P**	+	+	.	+	.
P. xcambivora	**C**, A	+	.	.	.	.
P. niederhauserii	**A**, **P**	+	+	.	.	.
P. mediterranea	**A**, **P**	+	+	+	+	.

The *Phytophthora* species listed in this table are reported to cause disease on walnut (W), cherry I, almond (A), or pistachio (P). If the crop is **bold**, the *Phytophthora* species is particularly aggressive on that crop. A plus (+) indicates that the *Phytophthora* species was detected at least once in that waterway. A period (.) indicates that the species was not detected in that waterway. Nineteen other *Phytophthora* species (not listed) were detected, but these are not known to cause disease on orchard crops.

Objective 2. Test for live *Phytophthora* coming through irrigation emitters

In objective 1 we determined that *Phytophthora* is common in the SEWD waterways. However, very few studies have looked at whether *Phytophthora* in a waterway can get into an orchard through the irrigation system. This is especially true of drip irrigation systems, which require substantial filtration of surface water to keep emitters from plugging.

During the 2021 and 2022 irrigation seasons, we collected water directly from irrigation emitters during a normal irrigation and tested this water for the presence of live *Phytophthora*. This was done in three surface-water-irrigated orchards, two with drip emitters and one with sprinklers, as well as two groundwater-irrigated orchards, one with drip emitters and one with sprinklers.

Orchard sampling stations used to detect live *Phytophthora* in water from **A**, sprinklers and **B**, drip emitters.

We found that *Phytophthora* commonly survives the journey from surface water sources into the orchard, and that the irrigation system type did not seem to matter. Also, the presence of a sand media filter did not seem to affect how regularly we detected live *Phytophthora* coming through irrigation emitters.

Summary of *Phytophthora* detections in water collected from irrigation emitters

Site	Irrigation water type	Water source	Emitter type	Emitter specifications	Sampling date	Sand media filter	*Phytophthora* detected
1	Surface	Calaveras River	Sprinkler	Nelson R2000 5/64” nozzle	9/27/21	No	**Yes**
					7/6/22	Yes	**Yes**
					9/13/22	Yes	No
					10/3/22	Yes	No
3	Surface	Calaveras River	Drip	Toro 2GPH	9/13/22	Yes	**Yes**
					10/3/22	Yes	**Yes**
4	Surface	Potter Creek	Drip	Jain 0.5GPH	9/30/22	No	**Yes**
					10/5/22	No	**Yes**
5	Ground	Well	Drip	Jain 0.5GPH	10/11/22	Yes	No
2	Ground	Well	Sprinkler	Nelson R2000 5/64” nozzle	7/6/22	No	No
					9/17/22	No	No

Objective 3. Test orchard soils for *Phytophthora*, compare orchards irrigated with surface water vs groundwater

In objectives 1 and 2 we determined that *Phytophthora* is common in SEWD waterways and that it can survive the trip through an irrigation system and into the orchard. However, in most cases *Phytophthora* must survive in the soil to infect the orchard when conditions are right. Even though we knew that irrigation with surface water is bringing *Phytophthora* into orchards, we didn't know if this affects the incidence of *Phytophthora* in orchard soils.

In 2021, we collected soil from 20 SEWD orchards exclusively irrigated with groundwater for at least 60 years and from 20 SEWD orchards irrigated with surface water over the same timeframe. This soil was tested for the presence of *Phytophthora* species using both the DNA sequencing from objective 1 and the live detection methods from objective 2.

We found that *Phytophthora* is common in orchard soils, with 32.5% of sampled orchards (13 out of 40) testing positive. We also found that the source of irrigation water did not affect the chances of finding *Phytophthora* in the soil: groundwater irrigated orchards were as likely to have *Phytophthora* as orchards irrigated with surface water. This indicates that irrigation with surface water was not the main factor determining whether *Phytophthora* was present in orchard soils and that irrigation with surface water may not increase risk of Phytophthora disease in orchards.

Summary of total *Phytophthora* detections from orchard soils

	Groundwater	Surface Water
Number of orchards sampled:	20	20
Number of orchards positive for *Phytophthora*:	7	6
Phytophthora species found:	***P. cinnamomi*** ***P. pini*** ***P. cactorum*** *P. rosacearum* *P. nicotianae*	***P. 9innamomic*** ***P. pini*** ***P. cactorum***

Phytophthora species in **bold** are particularly aggressive on orchard crops

The results from this study confirm that *Phytophthora* is common in surface water but show that irrigating with surface water was not the main factor determining whether *Phytophthora* was present in an orchard. Where is the *Phytophthora* coming from? It is hard to know, but historical flooding may play a role. We also know that *Phytophthora* can be moved into an orchard on planting material and in soil on equipment. Where does this leave us in terms of management? This study shows that *Phytophthora* is very common in orchard soils, regardless of the source of irrigation water. Since over 30% of tested orchards were positive for *Phytophthora*, it would be prudent to assume you have *Phytophthora* in your orchard. Saturated soil allows *Phytophthora* to infect and cause disease, so good irrigation management is crucial to prevention. By "good irrigation management", I mean that you want to reduce the length of time that orchard soils are fully saturated and avoid having standing water. This can be done by using irrigation emitters with output volumes suited for your soil infiltration rate and by irrigating more frequently for a shorter duration (24 hrs maximum). In addition, you want to apply irrigation water in the root zone but away from the trunk to reduce the opportunity for infection of the trunk or major roots. This can be done using stream splitters with sprinklers to protect the trunk, choosing a microsprinkler wetting pattern that avoids the tree trunk, or moving drip emitters away from the trunk of the tree. At planting, consider using a resistant rootstock, like RX1, and plant on berms. Note that even if you are using a resistant rootstock, good irrigation management is crucial because no rootstock is immune.

I want to leave you with this thought: **irrigating well is much more important for preventing *Phytophthora* than the source of your irrigation water**. I have been to many surface-water-irrigated orchards with no symptoms of *Phytophthora*. Some of the worst orchards I have seen, in terms of Phytophthora disease, were irrigated with groundwater with the driplines right against the trunk on 3rd leaf trees. Irrigation management is *Phytophthora* management.

Thank you to my collaborators on this project, Greg Browne (USDA-ARS) and Mohamed Nouri (UCCE San Joaquin County). Special thanks to Justin Hopkins with the SEWD for his help planning and executing this project. Thank you also to the SEWD growers who welcomed me into their orchards for sampling. This work was partially funded by the Stockton East Water District.

Selecting the Best Walnut Rootstock for Your Situation – an Update on Commercial and New Clonal Walnut Rootstocks (2026)

Janine Hasey, UCCE Tree Crops Advisor Emerita, Sutter-Yuba, Colusa Counties
Luke Milliron, UCCE Orchards Advisor Butte, Glenn, Tehama Counties
Clarissa Reyes, UCCE Orchards Advisor Sutter-Yuba, Butte, Placer Counties
Greg Browne, USDA-ARS Crops Pathology and Genetics Research Unit (Retired)
Ali McClean, USDA-ARS, Crops Pathology and Genetics Research Unit, Davis
Andreas Westphal, UC Riverside, Department of Nematology

A lot of factors impact the planting decision. Once a site is selected, the three critical decisions in establishing a new walnut orchard are variety selection, rootstock selection, and tree/row spacing. The spacing should be determined after the variety and rootstock are chosen because that combination will determine the ultimate size of the tree, along with the soil type and orchard management. Rootstocks are the foundation of a walnut orchard. Selecting one that tolerates or resists site problems, while providing vigor for optimum tree performance, is key to orchard productivity, health, and longevity. As pesticide and fumigant options become more limited and restrictive, rootstocks that resist or tolerate soilborne pathogens offer a pathway to long-term management.

Commercially available Paradox clonal rootstocks include Vlach, VX211, RX1, and most recently, Grizzly. Vlach has been available since 1999 and came from a vigorous Paradox tree in Stanislaus County. Originally identified as superior seedlings from the Walnut Improvement Program's statewide Paradox diversity trial in the 1990's and then cloned, VX211 and RX1 were released by UC and USDA in 2007 and patented in 2010 after years of evaluation for vigor and soil pathogen resistance. Commercial nurseries developed efficient and reliable clonal propagation methods, and nursery production continues to shift from seedlings to clonal walnut rootstocks.

In 2012, an extensive team including UC, USDA-ARS, UCCE, nurseries, and growers with funding from the CA Walnut Board and Commission and USDA's National Institute of Food and Agriculture, embarked on developing new walnut rootstocks with resistance to the major soilborne pathogens. The targeted pathogens were *Agrobacterium tumefacien*s (crown gall), *Phytophthora* spp. (Phytophthora root/crown rot), and *Pratylenchus vulnus* (root lesion nematode). This article provides updates focused on commercial clonal rootstocks and a summary of the completed and ongoing statewide rootstock trials with experimental clones. First however, is a summary of available seedling walnut rootstocks, although limited, that were the mainstay of the walnut industry before clones. Following are definitions to clarify the terminology used in this article.

The first definition below refers to resistance ratings to disease pathogens; the next two are in reference to rootstock nematode ratings.

Disease resistance in rootstocks refers to their ability to defend against pathogens, such as *Phytophthora* and the bacterium causing crown gall, through various mechanisms that reduce pathogen growth and damage.

Tolerance: Nematodes can reproduce on the rootstock, but the tree can grow and flourish despite their presence. The opposite is intolerant or sensitive.

Resistance: Nematodes are unable to reproduce on the rootstock, but tree growth may be affected unless the trees also carry some tolerance.

Seedling walnut rootstock attributes

Northern California black walnut: This was the rootstock of choice in the early walnut industry. Its main desirable attribute is having the most tolerance to salinity, compared to Paradox seedling and Paradox clonal rootstocks. Vigor of black walnut seedling rootstock is only moderate, and in UC trials, yields were always lower compared to trees on Paradox rootstocks. Traditionally Northern California black seedling rootstock was planted and grew well in deep loamy alluvial soils near rivers. Trees on Northern California black often have stunted growth when planted on more marginal soil. It has lower susceptibility to crown gall vs. seedling Paradox but is very susceptible to *Phytophthora* and to lesion nematode. Clonal Paradox rootstocks are recommended where any of these problems exist (Table 1). Black walnut rootstocks should be considered where there are salt problems like chloride and only where soils are loamy and well-draining.

Paradox hybrid seedling: This rootstock gained popularity in the 1950s because of its vigor and tolerance to Phytophthora and lesion nematode relative to black walnut rootstock. However, Paradox seedling rootstocks are very susceptible to crown gall disease and do not possess as much resistance as RX1 clonal rootstock to Phytophthora species. There are seed sources that have lower crown gall incidence and certain nursery practices that prevent infection by the bacterium during the seed collection phase which can alleviate crown gall from developing. However, clonal Paradox rootstocks typically have much lower crown gall infection than Paradox seedling rootstocks across numerous trials statewide and have the other specific advantages shown in Table 1. Paradox seedlings also exhibit genetic variability, so tree size differences are more common than in clonal rootstock orchards.

Commercial clonal Paradox walnut rootstock attributes update (2026)

What we now refer to as “standard clones”, i.e., Paradox rootstocks Vlach, VX211, and RX1, have been subjected to ~25 years of screening, field research trials, and observations in growers’ orchards for confidence in the attributes listed below. These three standards are comparatives for new genotypes in UC/UCCE/USDA walnut rootstock trials.

Vlach: Available since 1999, Vlach was the first clonal Paradox rootstock to be widely planted. Parentage is Northern California black (*Juglans hindsii*) x English walnut (*Juglans regia*). Trees on Vlach typically have high growth rates and yields in trials. Although it usually develops much lower crown gall incidence than seedling Paradox, Vlach consistently developed higher incidence of crown gall and larger galls, compared to the other standard clonal rootstocks discussed here. Vlach is susceptible and sensitive to root lesion nematode and is more susceptible to *Phytophthora* species than the other standard clones.

VX211: Parentage of VX211 is Northern California black x English walnut. Trees on VX211 typically have high growth rates and yields in trials. Its main attribute of rootstock interest is its tolerance to root lesion nematode. The nematode reproduces on this rootstock, but in most instances, VX211 can tolerate higher levels of it than the other standard rootstocks. It is recommended for where there are nematode problems or as replant trees in existing orchards because of the root lesion nematode tolerance advantage paired with vigor. However, VX211 can be damaged by root-knot nematode, a group that is rarely encountered in walnut growing areas. VX211 has notably less crown gall than seedling Paradox and consistently less crown gall than Vlach in field trials. It is more resistant than Vlach but less resistant than RX1 to Phytophthora. You can find more replant considerations at: sacvalleyorchards.com/walnuts/cost-and-expense-considerations/replanting

RX1: The genetics for RX1 are different than for Vlach or VX211. RX1 parentage is Texas black (*Juglans microcarpa*) x English walnut. The *J. microcarpa* seems to instill resistance to Phytophthora and potentially to crown gall disease and therefore has been used extensively to breed the new rootstock genotypes we’re testing and reporting on in statewide field trials. As a rootstock, it has moderate vigor, but grafted trees on RX1 often have equal or more vigor compared to trees on VX211, and they yield well at most sites.

RX1 has moderate to high resistance to Phytophthora, depending on the pathogen species (Table 1), making it the preferred rootstock for any site with *Phytophthora*. Consistent in our greenhouse screening and often in statewide field trials, RX1 has the least crown gall of the three standard clones. RX1 may handle drier conditions in terms of irrigation scheduling and still be vigorous and productive but this needs further research. RX1 appears to show lower salinity tolerance (leaf scorch) than the other standard clonal rootstocks. Consider using a different rootstock in situations with soil or water salinity concerns.

Vlach, VX211, RX1 disease rating: The updated problem situation table below reflects results of newly completed statewide rootstock research trials. None of these three clonal rootstocks have high resistance to *A. tumefaciens* (cause of crown gall). In two studies, potted trees on RX1 rootstock were compared to field grown one-year-old bare root June budded trees on RX1 for crown gall infection. After seven years, potted trees that had been grown in sterile media before planting in the orchard had zero to very low crown gall incidence whereas the field grown June buds had a higher incidence. Perhaps delayed exposure to *A. tumefaciens* in potted trees resulted in the lower crown gall infection.

Table 1. Disease rating of standard commercial clonal Paradox rootstocks for problem situations

Clonal Paradox Rootstock	Rootstock Vigor†	*Pathogen Challenges*		
		Crown Gall Resistance	**Lesion Nematode** Tolerance	***Phytophthora*** Resistance
RX1	Medium	Medium	Intolerant	Medium to high**
Vlach	Medium high	Low to very low	Intolerant	Low
VX211	High	Medium to low	Medium tolerance*	Low to medium**

†Based on rootstock vigor only. Once grafted or budded to an English walnut variety, all these rootstocks can support vigorous tree growth depending on the site.

*Nematode tolerance due to a post-infection mechanism.

**Based on data with *P. cinnamomi* and *P. citricola* (now called *P. pini*), the two most aggressive species affecting California walnuts.

Grizzly: The most recent commercially available clonal Paradox rootstock, Grizzly is patented by a grower and a nurseryman. Grizzly parentage is Northern California black x English walnut. It was propagated from a mother tree in a second-generation commercial orchard planting with very sandy soil and lesion nematodes. Over 20 years, this tree had twice the size and production of surrounding trees that declined much earlier. There was one replicated trial in Lake County planted in 2016 and another planted in Sutter County in 2022 on Grizzly rootstock, but there is currently insufficient trial data to assign crown gall and Phytophthora resistance ratings for Grizzly. In 4 to 6-year-old orchards with Grizzly rootstock and on some older trees, crown gall has only been seen on a handful of trees to date.
Grizzly is highly susceptible to root lesion and root-knot nematodes but appears to have high levels of tolerance. This means that trees on Grizzly can grow well even though nematodes reproduce heavily on its roots. Trees on Grizzly have demonstrated vigor in difficult growing conditions. Grizzly rootstock is often planted in orchards with tougher, coarse soil or for replant situations.

Clonal walnut rootstock field trials

Since 2015, several replicated rootstock trials statewide have compared new experimental rootstocks to the standard clonal walnut rootstocks (RX1, Vlach, VX211) with differing soil and disease challenges. They are listed in Table 2 below and this article summarizes the most important results of the completed trials. For detailed data and results, refer to *Pacific Nut Producer, December 2025,* Volume 31/No.12, pp. 6-12 https://pacificnutproducer.com/2025/12/01/read-december-2025-issue/#read-december-2025-issue/6/ .

Table 2. Statewide clonal walnut rootstock trials comparing new genotypes to standard clones.

Rootstock Trial Years	County or Location	Site Problems/Target Pathogen[2]
d gen)	UC Davis	PHY, CG (inoculated)
2016 - 2022 (2nd gen)	Glenn	Replant disease, RLN, PHY, CG
	Sutter	Marginal soil, Chloride in water
	Tulare	PHY, RLN
	Lake[1]	Armillaria, NEM, CG
d gen)	Kearney Agricultural Research and Extension Center	Replant, NEM
2nd gen)	Nickels Soil Lab	Replant, NEM
2022 - ongoing (3rd gen)	Butte	NEM
	Sutter	NEM
	San Joaquin	PHY
	Stanislaus	CG
	UC Davis	PHY, CG, NEM (inoculated)
3rd gen)	UC Davis	PHY, CG, NEM (inoculated)

[1] Very different environmental conditions compared to the three valley trial sites.

[2] CG=crown gall, NEM=nematode, PHY=Phytophthora, RLN=root lesion nematode.

2015-2020 trial at UC Davis: Four new 2nd generation clonal rootstocks include: **K3** (*J. microcarpa*) and **11-991** (*J. microcarpa* × *J. regia*), with supposed resistance to crown gall (*A. tumefaciens*), and **STJM4** and **29JM 8** (both *J. microcarpa* × *J. regia*), with supposed resistance to *Phytophthora* spp. Potted clonal trees of these new genotypes and standard clones **VX211**, **RX1**, and **Vlach** were planted spring 2015 and patch-budded to Chandler in September. In May 2017, trees were inoculated with either *Phytophthora cinnamomi and Phytophthora citricola* or *A. tumefaciens.* In fall 2020*,* crown gall incidence and gall size were rated and excavated root systems sampled to assess crown and root rot incidence.

For Phytophthora crown rot, there was no incidence in RX1 and 11-991, confirming our ratings in Table 1 for RX1 and resistance to Phytophthora and in some of the new genotypes. For crown gall, experimental rootstocks K3 and 29JM 8 developed minimal disease symptoms. Crown gall symptoms on RX1 were intermediate between symptoms observed on rootstocks K3 and 29JM 8 and other industry standards Vlach and VX211. All four of the new genotypes had less crown gall severity than both Vlach and VX211, suggesting some resistance to *A. tumefaciens*.

2016-2022 trials: The four new genotypes listed above along with standard clones and seedling Paradox rootstocks were compared for survival, growth, yield, nut quality, sucker counts, and crown gall incidence in four counties (Table 2). The sites were not fumigated prior to planting. One-year-old Chandler June budded trees on the eight rootstocks were planted in winter or spring 2016 and left unheaded. We concluded the trials after the 2022 season although some data collection continued at two locations.

Rootstock performance varied by location. Standard clonal rootstocks VX211, RX1, and Vlach continued to perform well overall having no (VX211) to very low (RX1 and Vlach) mortality and good trunk growth in the valley sites.

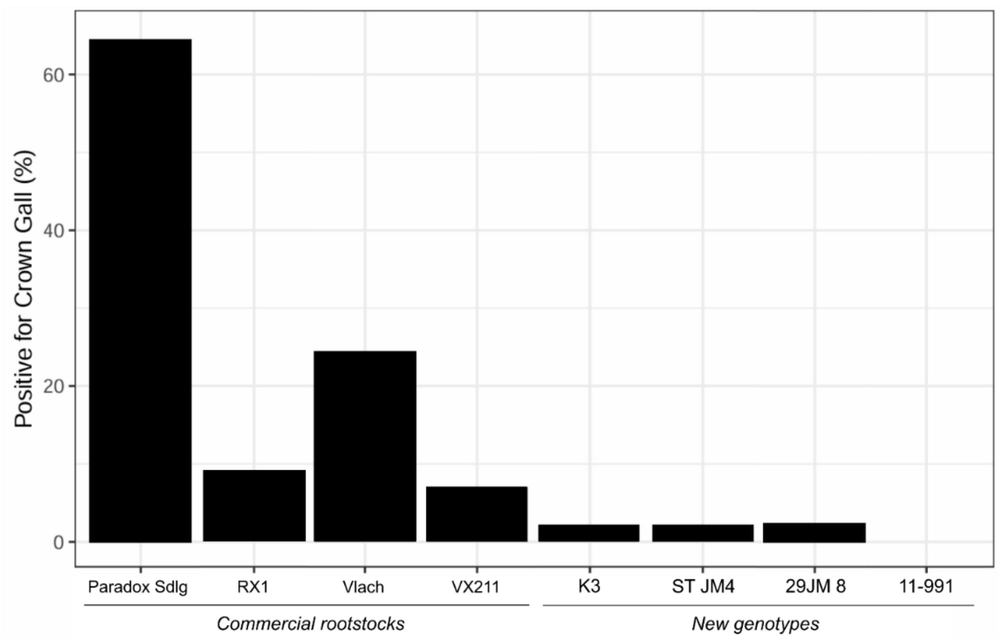
Trunk growth: The clonal standards and experimental K3 had the same trunk growth in Sutter and Glenn Counties; in Tulare County, all new genotypes had the same trunk growth as VX211. Tree trunks on K3 tended to lean in the early years only in Sutter (see Figure 1) and Glenn Counties but many trunks straightened with maturity. Suckers were observed on K3 in Tulare County, whereas in Lake County most suckers were found on RX1 followed by K3. Sucker growth was not a problem in Glenn or Sutter Counties.

Figure 1. In Sutter Co. trial above (fall 2024), note trees 4 and 5 with a slight lean on K3 (see arrow). Tree trunks in foreground are straight. (Photo credit- Clarissa Reyes)

Yield: Cumulative yields varied between the four trial sites. Only the Tulare trial had no significant yield differences between rootstocks. Chandler on Vlach yielded well at each trial site, and trees on RX1 yielded well at the valley trial sites while nut yields on seedling Paradox had the lowest yields at Glenn and Sutter locations. Chandler yields on the new genotype K3 were also good, being equivalent to those on VX211 at the valley sites and were also not significantly different from yields on RX1 and Vlach at Glenn and Sutter locations.

Crown Gall: In annual crown gall surveys from 2018 through 2022, crown gall incidence below the graft union was only reported in the first year observed. Across all trial locations, clonal Paradox rootstocks had substantially lower crown gall incidence at ground level compared to the highly susceptible seedling Paradox rootstock (Figure 1). Paradox seedling crown gall incidence ranged from 43% (Lake Co.) to 95% (Sutter Co.). The new genotypes had much lower or no (11-991) crown gall incidence compared to the standard clones. Vlach had the most crown gall of the standard clones consistent with other statewide long-term rootstock field trials (Figure 2).

Figure 2. Cumulative crown gall (%) at ground level combined from all trial locations



Crown galls at ground level appeared early on young Paradox seedling rooted trees. Conversely crown gall generally first appeared on older trees on RX1, Vlach, and the new genotypes. Ground level incidence of crown gall significantly reduced Chandler trunk growth on Paradox seedling. The rapid onset of crown gall in the first three survey years compared to that on the clonal rootstocks contributed to this reduction in Paradox seedling trunk growth. Previous research shows it is critical to reduce crown gall disease in the first four years of an orchard to avoid severe tree stunting and cumulative yield losses.

2018/2019 trials: 2nd generation experimental clonal rootstocks were compared to standard clones for nematode resistance and tolerance. Experimental K3 appears to have moderate resistance and moderate levels of tolerance to root lesion nematode, meaning trees grow well even though nematodes are present in the soil. It also appears to handle the replant problem – caused by an undescribed microbial complex – better than the three standard clonal rootstocks.

2022/2023 - Current trials: There are over 20 new 3rd generation rootstock genotypes being tested in four locations against the target pathogens (Table 2). The UC Davis trials have been inoculated with these three soilborne pathogens and are measured for growth and survival only (Table 2). Results will be shared in the next couple of years.

Looking for grower cooperators

Rootstock development is a long-term investment. The many experimental rootstocks identified that appear to cope effectively with soil-borne diseases need more field testing to confirm their usefulness. From our trials on 2nd generation experimental genotypes, K3 emerged as a rootstock in the valley trials that merits further testing in grower orchards. Compared to the standard clonal rootstocks, it had equivalent yields and growth, lower and delayed crown gall infection, and showed superior growth under non-fumigated nematode-infested replant conditions. K3 has not exhibited as much resistance to Phytophthora species as RX1. Other concerns noted at two trial sites include its propensity for some trees to lean, especially in early years, and for potential suckering. We are especially interested in testing experimental K3 in orchards with replant situations, non-fumigated borders, sandy soil, or any other situation in which we expect nematode or crown gall pressure to be high. Growers interested in obtaining trees should contact your local UC Cooperative Extension Farm Advisor who will facilitate this process.

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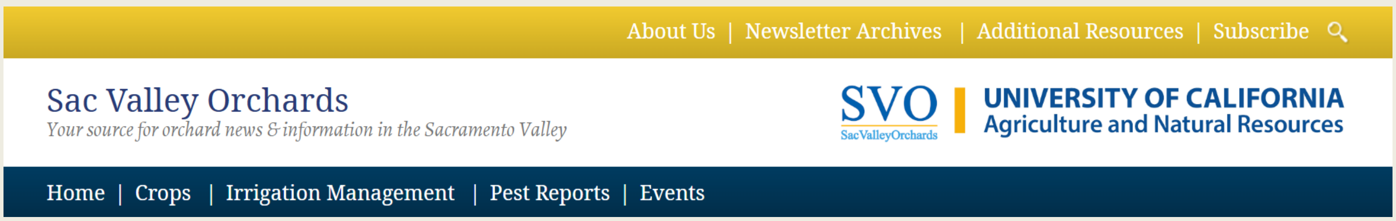
These newsletter articles, and the latest orchard announcements, events, and resources are available at our website



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