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# 2021 Pistachio Irrigation: Mitigation Strategies for Drought

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The San Joaquin Valley is in the midst of another drought and pistachio growers are bracing for another hot, dry growing season. Areas on the west side of San Joaquin Valley, got as little as 4 inches of precipitation from fall 2020 until April 2021. With such low moisture reserves, many growers may be seeing signs of stress early. In Westland's Irrigation District, some managers are reporting water delivery costs higher than $1200 per acre foot. For those using groundwater on the west side, pumping costs can range between $200-500 per acre foot depending on production of the well and water levels. Additionally, drought conditions lower canal levels and increase the salt concentration of what is normally high-quality water. Decreasing flowrates, and changes to the chemical and biological characteristics of the water may impact the actual application rate and distribution uniformity of microirrigation systems.

Limited water supplies and increasing costs will lead to tough decisions about when is the most beneficial time to irrigate. Pistachios are known for their ability to withstand drought, but the severity and length of a dry spell can result in high percentages of blanks, low shell splitting percentages, and reductions in overall yield. These negative impacts can be partially mitigated through good water budgeting strategies, monitoring tree water stress levels, and implementing drought management techniques such as proportional decreases in water application throughout the season or regulated deficit irrigation at different stages in crop development.

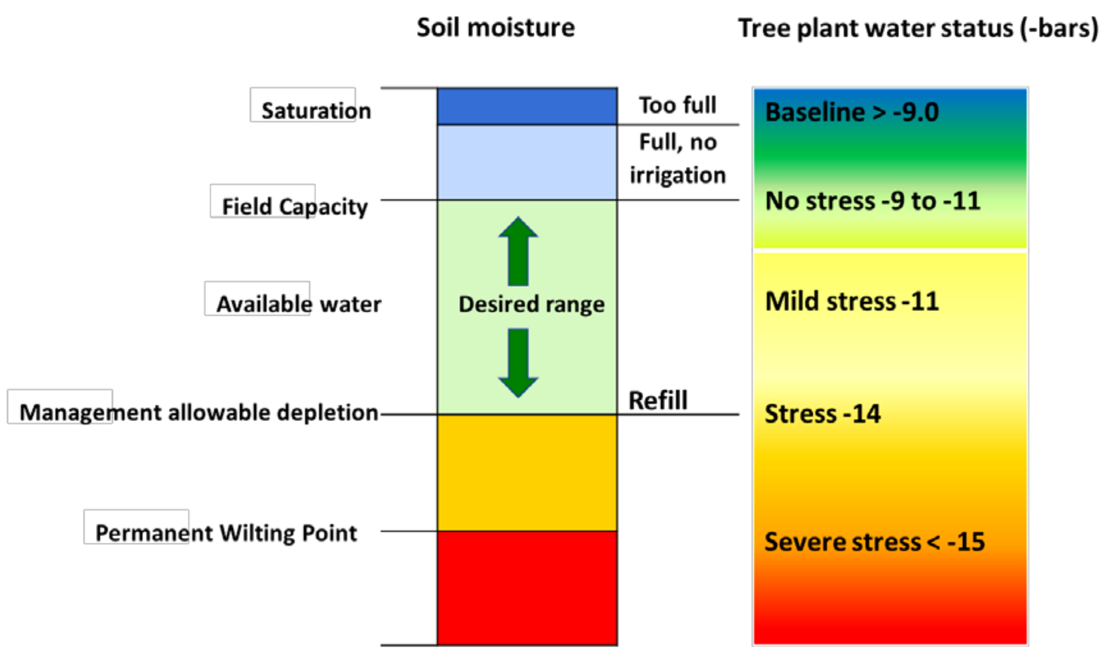


**Figure 1. Relationship between different levels of soil moisture availability and plant water stress. Water budgeting techniques aim to maintain soil moisture in the desired range between field capacity and ~50% total soil available water. Severe drought limitations may require moisture just above the threshold of management allowable depletion.**

Water budgeting plus soil moisture monitoring is an irrigation management strategy that is useful during normal precipitation years and during drought to minimize water stress damage to tree health, growth, and nut crop quality. A water budget considers the amount of irrigation needed to replace water losses from transpiration by trees and vegetative cover and evaporation from the soil surface, known in combination as evapotranspiration (ET). Irrigation is needed when estimated or actual ET exceed water inputs, and soil moisture storage. The goal of the water budget is to apply the correct amount of water, at the right timing and frequency to maintain soil 'available water' between field capacity, and 'overdraft' stress levels below management allowable depletion (MAD) that will adversely impact the crop (Figure 1). In drought conditions, managers may attempt to proportionally decrease water applications to maintain soil moisture levels just above the MAD threshold for crop limiting water stress. For fruit and nut trees, the MAD value is estimated to be 50% of total available water.

Developing an efficient irrigation schedule requires knowledge of the soil characteristics of the site. The depth of soil considered for a water budget changes dependent on the 'effective rooting depth', the portion of soil from which trees extract most of their soil moisture and nutrients. For pistachios grown with microirrigation, this is generally the top 3 feet of soil. Available water holding capacity within the 'effective rooting depth' is an important consideration for water budget irrigation scheduling. The amount of 'available water' to the plant, is commonly shown as the inches of soil moisture per foot of soil (inches/foot). Inches of available moisture varies dependent soil texture (Table 1). Sandy loam soils, for example, hold less water (1.5 inches/foot) than clay loam soils (2.2 inches/foot), and will require a shorter time interval between irrigation sets to maintain soil moisture levels in the desired range (above the MAD) to avoid severe tree stress. Applying more water than the soil can hold or at a faster rate than it can infiltrate may lead to leaching, water logging, runoff from berms, and increase water loss from evaporation.

**Table 1. Average available water-holding capacity ($W_a$) for various soil textures. Adopted from the UC ANR Drought tips "Field Irrigation water management in a nutshell" https://anrcatalog.ucanr.edu/pdf/8571.pdf**

| Soil | | $W_a$ (inches of water per foot of soil) |
|---|---|---|
| General description | Texture class | |
| light, sandy | coarse sand | 0.5 |
| | fine sand | 0.9 |
| | sandy loam | 1.2 |
| medium, loamy | fine, sandy loam | 1.5 |
| | loam | 1.8 |
| | silt loam | 2.0 |
| heavy, clay | clay loam | 2.2 |
| | clay | 2.4 |
| | peat/muck | 6.0 |

*Source:* Modified from U.S. Bureau of Reclamation, Agrimet Irrigation Guide website, (https://www.usbr.gov/pn/agrimet/irrigation.html).

In addition to texture, soil structure, sodicity and salinity levels, the presence of restrictive layers in the subsoil, the soil rock content, soil organic matter content, and spatial variability of these characteristics across the orchard also influence available soil water. Knowledge of these characteristics for a particular orchard site is important to accurately schedule irrigations. Locations with high levels of spatial variability of soil properties may have uneven soil moisture availability. These sites can be managed by adjusting the frequency and depth of water applied for individual designated zones to maximize water use efficiency and productivity across the orchard. A site-specific soil analysis for the effective rooting zone (top 3') will provide the most accurate information, but online resources can also provide a useful broad characterization of the location. The UC Davis California Soil Resource Lab "Soilweb" application provides general soil texture with an interactive Google map https://casoilresource.lawr.ucdavis.edu/gmap/.

## Online Water Budgeting and Irrigation Scheduling Resources

There are several online resources available to make the water budgeting and irrigation scheduling decision making much easier. CropManage is an online decision support and management tool that can be customized to site-specific conditions of an individual orchard and can track fertilizer and irrigation applications throughout the year. Forecast $ET_o$ (FRET) National Weather Service is another useful tool that anticipates the coming week's atmospheric water demand, helping growers to adapt to week-to-week weather variability. Another option developed through a cooperation between the Department of Water Resources (DWR) and UCCE provides weekly ETc reports for a variety of orchard trees and other major crops. The reports deliver the previous weeks ETc and the projected ET for the following week based on historical records from CIMIS weather stations throughout the Central Valley. Contact your local UCCE farm advisor for more information about how to access the DWR-UCCE weekly ET reports.

## Monitoring tree stress levels

Irrigating according to a water budget and soil moisture monitoring does not provide information about how orchard trees respond to the applied water schedule. Pressure chambers and other newly available automated technologies offer a plant-based approach to understand if plant stress is within acceptable levels. These tools deliver a measure of the negative pressure of water in the tree, known as mid-day stem water potential (SWP), which is compared to known values for water stress. At high soil water content, tree roots easily extract soil moisture. As the soil dries moisture becomes increasingly difficult to extract, increasing plant stress.

The range of tension measurements for pistachio is generally between -6.0 and -20.0 bars, where a more negative value indicates increasing water stress. At field capacity, pistachios in moist soil may have tree mid-day SWP values between -9 and -11 bars. As the soil dries, mild stress develops between -11 and -14 bars. Values more negative than -15 bars point to growth and yield reducing levels of moisture stress (Figure 1). However, research suggests the threshold for stress tolerance under deficit irrigation management may be lower (more negative) at different stages of crop development (see next section).

When measured just prior to watering, mid-day SWP can be used to determine if soil moisture storage from the previous irrigation was sufficient to carry the trees through to the next irrigation set without reaching potentially detrimental stress levels. After watering, they can also confirm whether the prescribed irrigation adequately relieved stress. When used to fine tune irrigation scheduling in multiple regulated deficit irrigation studies in different regions and varieties of pistachio, pressure chamber measurements allowed decreasing water applications by 18-23% without a reduction in nut yield or quality. More information about the pressure chamber and its operation can be found in UC ANR publication 8503 https://anrcatalog.ucanr.edu/pdf/8503.pdf

## Regulated deficit Irrigation

Throughout the growing season, different stages of crop development are more or less sensitive to water stress. Multiple studies have found controlled deficit irrigation during shell hardening (Stage II) from the middle of May until the end of June, and during the post-harvest period had little or no negative impact on production. The right level of deficit will vary depending on many factors, but in general about 50% of ETc (the maximum crop ET with no water limitation for a well- drained soil) with mid-day SWP values between -15 and -18 bars during this time could result in significant water savings without adverse yield impacts. Water stress should be minimized during the shell expansion (Stage I), which occur during the first two weeks of May, and the nut filling (Stage III) phase of crop development beginning around late June. Severe stress from late June through mid-September will likely reduce harvestability and can also decrease shell splitting. More information can be found on the UC Drought Management webpage:
http://ucmanagedrought.ucdavis.edu/Agriculture/Crop_Irrigation_Strategies/Pistachios/

**Saline locations**

Pistachio trees are known for their salt tolerance and much of the acreage they are grown on have naturally high salt levels. However, these trees do have salt tolerance limits. Irrigation water exceeding 4.5-7 dS/m EC is probably not sustainable for the long term, especially if salinity challenges are coupled with poor soil drainage. Shifting water quality and limited supply in a drought year can intensify salinity problems. Recent UC research found salt affected soil resulted in lower yields but also lower water use. When salinity levels are very high, trees are subjected to osmotic stress, meaning they are working harder to take up and transpire water. As salt concentrations increase around the roots there is less solute differential between the root sap and the soil water, which reduces the ability of the root to pull in water by osmosis. More information about understanding soil and water reports and managing salinity can be found here: http://www.wcngg.com/2020/08/06/choosing-amendments-for-effective-salinity-management/

Saline-sodic conditions reduced average daily actual ET ($ET_a$) by about 33% in a salt affected site compared to non-saline orchards. However, the differences in water use were not constant throughout the growing season. Salt-affected trees had the same $ET_a$ as non-saline sites earlier in the season through shell hardening (Stage II), but then the water use per unit of canopy cover decreased during kernel fill through the postharvest season. Despite the potentially lower water requirements during the growing season, salt affected orchards will require additional water to leach salts from the rootzone during dormancy. Therefore, the overall amount of water needed to produce a crop in salt-affected areas needs to account for the necessary leaching fraction.

**Irrigation System Evaluation and Maintenance**

Commonly used in pistachio plantings, microirrigation systems allow for careful management and timing of water and nutrient applications. Although highly efficient, there are almost always varying levels of distribution uniformity (DU) in different areas across an orchard block. The small openings of micro-emitters make these irrigation systems highly susceptible to clogging and require routine maintenance. Changes in water sources during drought years can result in unexpected problems stemming from poor water quality. Annual water tests are recommended to make informed decision on water treatment to keep irrigation systems performing adequately. Irrigation system evaluations are mainly advised to determine the actual application rate (in/hr) and DU for accurate irrigation scheduling and water applications. Doing so will also enable managers to address small problems in a timely manner and ensure the best water use efficiency possible.
http://micromaintain.ucanr.edu/

**Summary**

Pistachios are known for their ability to withstand drought, but severe water shortages during critical stages of crop development can result in high percentages of blanks, low shell splitting percentages, and reductions in overall yield. Regulated deficit irrigation targeted at different stages in crop development may significantly reduce water use and mitigate detrimental water stress impacts to the crop. Much of pistachio growing acreage is located on salty ground. Saline sites have recently been shown to reduce water use by one-third relative to the amount used by pistachios growing on non-saline ground. Irrigation managers should consider site specific information about salt levels and soil texture when creating an irrigation schedule. Water budgeting, soil moisture and tree water stress monitoring techniques, irrigation system evaluations and routine maintenance should be implemented to increase irrigation scheduling precision. There are free online resources available to schedule and track irrigation applications throughout the year. Contact your local UCCE farm advisor for more resources to implement water-saving techniques during drought.

# Large Bug Control in Pistachio

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Summer is a critical time for controlling large bugs in pistachio: they can cause economic damage in fruit, this damage does not show external signs past a certain point in the year, and adults are not always easy to find. There are a handful of species that attack pistachio fruit. All belong to the insect order Hemiptera, which are also known as "true bugs," and this order includes other pierce-suck feeding insects such as aphids, leafhoppers, planthoppers, and bed bugs. Most feed on plants, but some, such as the minute pirate bug and the rough stink bug, are beneficial insects.

**Image 1**: Large stink bug populations can lead to significant feeding damage on nut crops, such as these green stink bugs (*Chinavia hilaris*) on almonds.

Anecdotally, UC personnel have heard reports of increased presence of bug species in orchards, possibly because pyrethroid use to control NOW has decreased over the past decade. Over the past few years, we have personally visited a handful of almond orchards that have been heavily hit by stink bugs; one almond orchard I visited was devastated by this pest (Image 1). We do not advocate preventative pyrethroid use to try to keep these insects down. There are very few registered insecticides that control large and small plant bugs and losing them because of evolved resistance from overuse could be devastating. Additionally, using these products can lead to issues with other pests, so it is best to use them only when needed. However, it is important to keep an eye on your orchards to stop these pests once they do appear.

*Large Plant Bugs*

Leaffooted plant bugs and stink bugs are the two groups of potentially damaging large plant bugs you may find in your pistachio orchard.

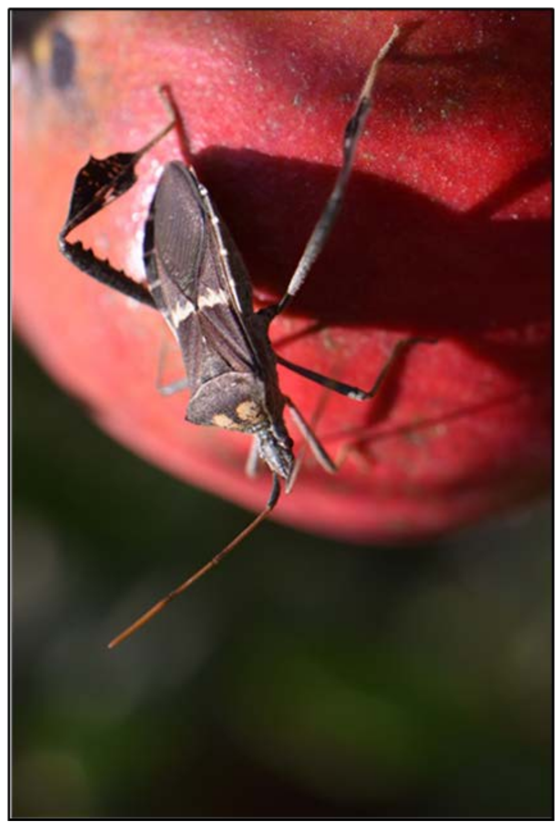

**Image 2**: Leaffooted plant bug, specifically *Leptoglossus zonatus.* Note the wide, leaf-like structures on the hind legs. Photo: Kent Daane

There are three species of leaffooted plant bugs (Image 2) that can be found in pistachio orchards, though *Leptoglossus zonatus* is the most common species. All appear similar in shape and coloration and have an enlarged area on their hind legs resembling a leaf. There are also several different species of stink bug (Image 3); all have a common shield-like shape to their bodies, though they will differ in coloration. We recommend making an effort to identify stink bugs before treatment, as the rough stink bug is an insect predator that can commonly be found in pistachio orchards.

Leaffooted bugs (LFB) and stink bugs, due to their larger stature, have larger, stronger mouth parts and can damage developing pistachio nuts after shell hardening as well as before. Research on "hidden damage," or feeding damage to the kernel that does not result in an obvious lesion on the pistachio hull, showed that external signs of feeding damage is significantly reduced during mid-June (Daane et al., 2005). Feeding can still occur after the fruit stops showing external damage; in the previously cited research trial, kernel necrosis increased starting in May and peaked in August. While bugs were feeding on pistachio nuts before May, those nuts were most likely aborted.

Large bug damage before shell hardening is similar in appearance to small plant bug damage: blackened and/or dropped nuts with white netting on the inside of the hull and shell. External signs of damage appear quickly, as soon as 48 hours after feeding. Similar to small plant bugs, large plant bug feeding during this time may not result in economic injury, however populations should be closely monitored due to the more severe damage that can occur once shell hardening is in progress.

LFB and stink bug damage after shell hardening differs from early season damage. These nuts do not drop from the rachis, and the only external indication of feeding is a small brown pinpoint on the hull, however with later season damage this external sign usually will not appear. If you cut into the fruit, you will find a darkened nut


**Image 3**: Left: Redshouldered stink bug (*Thyanta custator acerra*), green stink bug (*Chinavia hilaris*), and consperse stink bug are some of the large bug pests you may find in your pistachio orchard. Right: Rough stink bug (*Brochymena quadripustulata*), which is a beneficial insect.

that may be sunken near the feeding area, and the nut will have an off flavor. Large bugs, particularly LFB, can continue to feed on the nut long after shell hardening if they feed near the fruit peduncle, or the "stem" that connects the fruit to the rest of the cluster. The shell is weaker in that area and less able to protect the fruit; feeding attempts in other areas of the fruit during the late season are less likely to result in fruit damage. Large plant bugs can also transmit two diseases to pistachios: Botryosphaeria panicle and shoot blight and stigmatomycosis in the kernel (Image 4).

**Image 4:** *Stigmatomycosus* in pistachios, due to large bug feeding.

Monitoring for large plant bugs during the summer is best done by looking at fruit. Leaffooted bugs adults are highly mobile and you're more likely to see them flying away than capturing them in beat trays or sweep nets. They also will try to hide behind foliage; I will sometimes see them scooting around behind leaves or nuts when I try to move in for a closer look. Another monitoring method is to look for eggs; LFB and stink bug eggs are easy to identify once found (Image 5). LFB eggs are cylindrical in appearance and laid in straight rows, stink bug eggs are barrel-shaped and laid in clusters. In mid-June onward, if you see the presence of stink bugs and LFB when walking your orchards, look for kernel damage to confirm feeding rather than for epicarp lesions, because these external lesions often don't appear for up to two weeks after feeding damage (Daane et al., 2005).

**Image 5:** Leaffooted bug eggs (K. Tollerup) and stink bug eggs from which nymphs have already emerged.

*Treatment and treatment considerations*

The insecticides registered to control large plant bugs are all pyrethroids (e.g. permethrin, bifenthrin, lambda-cyhalothrin). In the past, pyrethroid sprays for NOW would also have the side benefit of controlling bug populations, but the use of these chemicals to control NOW is declining, and we are getting more reports of bug damage to almonds and pistachios. For more information, you can visit the UCIPM guidelines for:
Stink bugs: https://www2.ipm.ucanr.edu/agriculture/pistachio/Stink-Bugs/
Leaffooted Plant Bugs: https://www2.ipm.ucanr.edu/agriculture/pistachio/Leaffooted-Bugs/
and Small Plant Bugs: https://www2.ipm.ucanr.edu/agriculture/pistachio/Small-Plant-Bugs/

*Brown Marmorated Stink Bug*

Preliminary research by Kent Daane and Judith Stahl shows that brown marmorated stink bug is able to complete its life cycle when feeding only on pistachio, but it is not as good as a host as peach. While there is still much to be learned about this invasive insect, at this point it we are not very concerned that it may cause severe economic damage in areas dominated by pistachio unless there are more favorable nearby hosts.

## Fall 2020 Caused Cold Injury on Walnut Throughout California

*Elizabeth J. Fichtner, Farm Advisor, UCCE Tulare and Kings Counties*

Freeze damage was reported in commercial walnut orchards throughout California during the winter of 2020. Although comprising the southern tier of the state's walnut-growing area, Tulare and Kings County orchards were not exempt from freeze damage. The damage caused by freezing temperatures in the fall are not perceptible until budbreak and leaf out the following spring. As a result, the extent of winter freeze damage is often not fully realized until well into the following season.

Walnuts are most susceptible to freeze occurring in late fall and early winter, prior to onset of full dormancy. Freeze damage may be caused by either an abrupt or rapid decrease in temperatures or a large fluctuation between day and night temperatures. Both the probability and extent of freeze damage are mitigated by climatic conditions that allow for a gradual acclimatization of the trees to colder temperatures as they enter dormancy. Prior to complete dormancy, low temperatures of 22°F to 28°F may induce freeze damage; however, fully dormant trees may withstand lower temperatures (below 20°F) without sustaining damage (Sibbett, et al., 1998). Tree health and soil-water status may also influence the occurrence of freeze damage (Sibbett, et al., 1998). For example, during the winter of 2020-2021, dryland farmed mature walnut trees in Lake County were killed by freezing temperatures, whereas irrigated trees in the region did not sustain the same damage (Elkins, R. June 2021).

Freeze damage identified in young Tulare County orchards was likely caused by freezing temperatures in late November and early December 2020 (Figure 1). For seven consecutive days (11/26-12/2) temperatures plunged

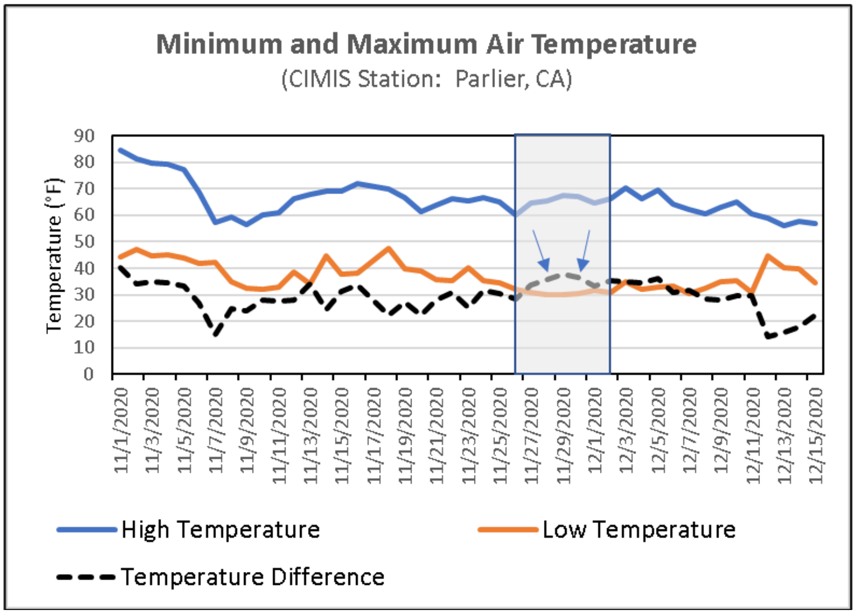


**Figure 1**. Minimum and maximum air temperatures acquired from a CIMIS station (Parlier, CA). The difference between high and low temperatures was also calculated and graphed.

below freezing. This timeframe was also characterized by a large difference between high and low air temperatures, as indicated by the arrows in Figure 1. Greater differences between high and low temperatures are associated with an increased likelihood of freeze damage.

Diagnosing freeze damage is largely based upon the distribution of the symptomatic trees in the orchard as well as the distribution of tissue damage on individual trees. Freeze damage may appear in low areas of the orchard where cold pockets of air settle (Figure 2A). Affected trees may be adjacent to unaffected trees (Figure 2B). The outermost branches may die back but buds closer to the ground may survive and push in the spring (Figure 2C). Rootstocks are often less suscept to freeze injury due to the re-radiation of heat from the ground; however, excessively cold temperatures or cold air trapped by an inversion may offset the benefit of radiated heat from the soil surface. To diagnose freeze damage on a given tree or tissue, expose the cambium below the bark and look for darkened tissue. Growers may consider the potential to retrain scaffolds from surviving buds and shoots. The decision to retrain vs. replant may be based upon several factors including tree availability in the nursery trade, number of viable buds remaining, and overall extent of damage in the orchard.

Several methods have been suggested for preventing freeze damage in walnut orchards (Jarvis-Shean, 2016). Limiting nitrogen application and irrigation in September and during the post-harvest time will reduce the production of succulent shoot growth that may be more susceptible to cold damage as temperatures drop. Additionally, research studies conducted by Bruce Lampinen, CE Specialist, UC Davis, demonstrate that painting the trunks and shoots with dilute (50%) white interior latex paint after leaf fall will reduce the extent of temperature fluctuations at the plant surface, particularly on the southwest side of the tree. Studies conducted by Wilbur Reil, Farm Advisor Emeritus, demonstrated that application of the paint after a freeze event can still mitigate the damage.

**References**

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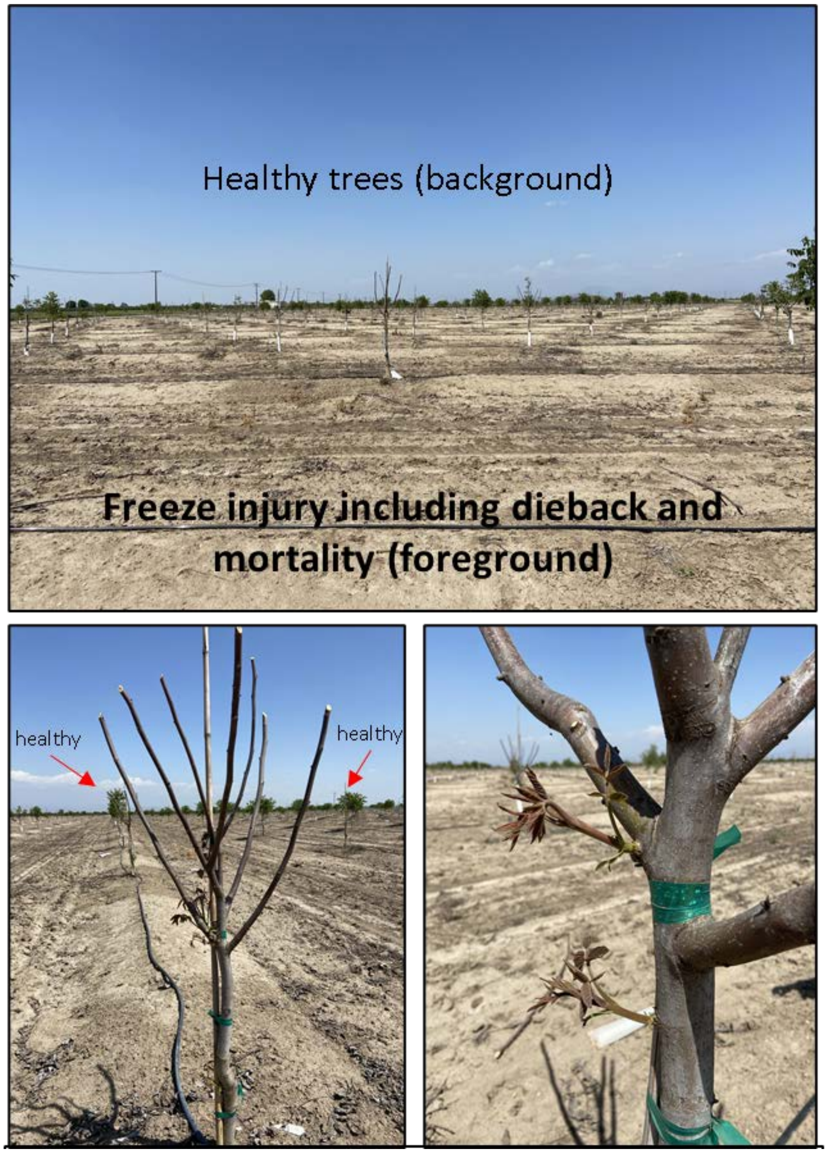


**Figure 2**. Cold damage may be limited to low-lying pockets n an orchard where cold air may settle. As a result, affected trees may be in discreet areas of the orchard and not evenly distributed throughout the site (A). Affected trees may be adjacent to healthy trees (B). Lower buds may survive (C) and push in the spring, and can be used to re-select scaffolds, if desired.

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