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Kern Pistachio Notes

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Winter Juvenile Tree Dieback (WJTD) – a Problem in Pistachio in the San Joaquin Valley

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Introduction

This winter, as was the case the two previous winters, juvenile pistachio trees (i.e. trees 1 to 6 years old), demonstrated considerable blackening of the trunk, gumming, early leaf-out and dieback in a large number of orchards in the southern San Joaquin Valley. The purpose of this newsletter is share some of the current thinking is on the cause of the problem and what might be effective in reducing the incidence in the future.

Description of the Problem

Juvenile pistachio trees appear to be in excellent health as they go into fall dormancy. Initial winter juvenile tree dieback occurs sometime during the period between early November and spring leaf out in trees one to six years old. Leaves on branches affected before the trees begin to defoliate in the fall remain attached to the branch delaying leaf drop. Black mold may grow on damaged bark, especially on the trunk between the lower portions of the scaffold branches and the graft union. The rootstock does not usually demonstrate mold growth. These moldy areas will appear wet. Often white beads or small ribbons of dried sap, apparently originating fairly shallowly in the bark, are visible on the outside of the tree in the moldy areas. Initially, in the moldy areas of the tree, there appears to be little if any damage to the bark and cambium layer below the outer skin of the bark. Trees showing mold growth and gumming may leaf out earlier than unaffected trees. Later, in early spring, more severe dieback of the branches becomes apparent beginning at the branch tips and affected areas of the scion and rootstock. In some years, these early symptoms are not obvious, and the extent of the dieback is not apparent until spring leaf out usually in May after the first run of warm to hot spring temperatures. In these trees, the only new leaves may push from the lower scion or rootstock wood and this growth occurs later than in unaffected trees. Some affected trees show minimal dieback, while many trees in the worst affected blocks die back to the rootstock, and the entire tree is killed. Kerman, Peters, Kalehghouchi and Golden Hills cultivars growing on UCB1, UCB1-clonal material, and PGI rootstocks have been affected. Reported incidences of WJTD increase greatly soon after extended freeze events.

Additional Observations of WJTD are as follows:

a) trees go into dormancy apparently vigorous and healthy;
b) topographically low-elevation orchards have most, but by no means all, of the WJTD, but damaged trees are often not in the lowest areas of a given orchard;
c) rootstock starch concentrations are much higher during early spring at leaf out in WJTD trees than in unaffected trees;

d) high sodium levels in the soil and water, and soil characteristics such as presence of hardpans, appear to increase WJTD;
e) sodium concentration is highly elevated, when measured in mid-May, in the scion and rootstock bark of WJTD-affected trees growing in salt-impacted soils;
f) the scion is usually more adversely affected than the rootstock, but the entire tree may be killed;
g) A tree with WJTD is often immediately adjacent to an unaffected tree, although typically, affected trees appear in clumps.
h) Trees uninjured the previous year may be injured the subsequent year.
i) juvenile trees are much more susceptible to WJTD than are bearing trees, and usually third, fourth, and fifth leaf trees appear most at risk;
j) The most vigorous rootstocks, cultivars and growth stages of the pistachio tree appear most susceptible to WJTD.

Frost damaged trees.

Top – tree shortly after freeze event. Note dead leaves still attached.

Middle – light gumming, blackening and extrusion of white gum from WJTD tree.

Bottom – Earlier leaf out of frozen tree in spring.

Probable Cause

The cause of WJTD is probably freeze damage, although freeze damage has not been proven and the extreme variability in symptoms within an orchard remains puzzling. Since considerable debate remains about the cause of the WJTD, and how much of the problem may be related to salinity or disease, I will discuss what I think is happening and what the grower might do if contemplating planting new pistachios or managing existing juvenile pistachio trees, especially at a low-elevation location where cold drainage may be more of a problem. This hypothesis is based on many discussions and research results involving a number of crop consultants, growers, and my coworkers in UCCE, with special involvement of Blake Sanden, Irrigation and Soils Farm Advisor in Kern County, and crop consultants Carl Gwilliams, Mike Harvey, and Alan Scroggs. I would like to stress that many of whom would likely disagree with some to many of my deductions. Discovering the cause of WJTD remains a work in progress. The following discussion is provided with the important caveat that future research may change the exact cause and corrective recommendations considerably.

Juvenile tree at leaf out in spring. Note extent of dieback of branches.

Current Hypothesis and Reasoning of the UCCE Pistachio Pomology Farm Advisor in Kern County

Winter juvenile tree dieback is not new to the San Joaquin Valley. In the past, we have called this problem freeze damage. What is new is the extent of the problem. I believe the problem has become bigger because more pistachio trees are being planted in low-elevation areas of the San Joaquin Valley at the same time that we have had several low-rainfall years. Cold air drains into low elevation areas, and low rainfall translates into reduced fog. The absence of fog means drier air with low dew point temperatures. Dry air means temperatures get colder faster in the evening, resulting in lower lows and longer durations of cold temperatures, with much more potential to damage vigorously growing young trees. The most obvious cause of the dieback during the winter is freeze damage. Reports of WJTD always spikes shortly after a major early freeze event. Investigations of WJTD affected trees for disease and the soil for harmful levels of heavy metals, have found nothing suggesting these are causal factors. Juvenile trees die at both low elevations and high elevations, as long as freezing temperatures are present.

I believe a large part of the WJTD problem is associated with the rootstocks currently used in the pistachio industry, specifically, the *P. integerrima* component. This observation does not mean that we need to throw these rootstocks out! The discovery by University of California researchers that *Pistacia integerrima* was resistant to Verticillium Wilt disease was of tremendous importance to the California pistachio industry. The lack of resistance to Verticillium Wilt disease in the existing rootstocks of the time, was allowing Verticillium Wilt to destroy the industry. Trees are still dying from Verticillium Wilt in San Joaquin Valley orchards planted to *P. atlantica* and what is called *P. terebinthus* in California. Rootstocks with *Pistacia integerrima* have been and will continue to be a critical component of the California pistachio industry. However, *P. integerrima* is not a perfect match for the San Joaquin Valley, which is to be expected, since this species of pistachio is adapted to a relatively high elevation, subtropical area of the Indian subcontinent. Juvenile *P. Vera* scions (i.e. the commercial nut bearing portion of the tree) such as 'Kerman' grafted onto rootstocks having *P. integerrima* heritage, do not appear well-suited to pick up environmental cues that winter is approaching. These cues include shorter

day length and reduced night-time temperatures. If water is available, these trees continue to grow vigorously into the fall and winter, since temperatures remain warm throughout the fall. In fact, trees on our commonly used rootstocks, no matter which one, do not appear to go fully dormant until the end of December. In general, we have observed in orchards planted to various rootstocks, that the greater the amount of *P. integerrima* heritage, the greater the susceptibility to frost damage.

Note picture of a single pistachio tree on a *P. integerrima* rootstock taken Dec. 10, 2010. The tree was watered well until this date. Note that the scion leaves have dried indicating some degree of dormancy, whereas the rootstock leaves remain green and succulent. What is happening at the graft union?

Some qualitative starch analysis of the rootstock of unaffected and trees with WJTD conducted after leaf-out in 2011, demonstrated that unaffected trees contained almost no starch below the graft union either in the trunk or roots, while severely impacted trees were loaded with starch. This suggests that all of the trees in the orchard were healthy going into the winter, and had stored large amounts of starch in the scion trunk, roots and above ground portions of the rootstock. The trees not damaged by frost were able to mobilize these starch reserves in the spring and use them to produce a new leaf canopy. Starch stored in trees that had died back, and now had too few unfrozen growing points left, remained stored in the rootstock instead of being used to make a new leaf canopy. In some frost-damaged trees, there was a clear line of demarcation between no starch in the scion directly above the graft union and a large concentration of starch in the rootstock directly below the graft union.

Note the well marked line of demarcation in the wood below the bark at the graft union in the WJTD-affected tree in May. The dark stain below the graft union indicates presence of starch in the rootstock, with little starch remaining above the union in the scion.

Note that starch appears to be completely absent in the unaffected tree, indicating that the tree, apparently, was able to mobilize starch reserves in the rootstock for new canopy growth in May.

The clear line of demarcation at the graft union also suggests that the graft union, the place where *P. integerrima* melds with *P. vera*, is a weak point with respect to frost tolerance. In Montana and Minnesota, where the temperatures get very cold, it is very difficult for any grafted landscape plants to survive the winters. In cold climates, the graft union is a point of weakness in susceptibility to frost. The xylem (i.e. the water conducting tissues) are the most susceptible structures in the trunk to frost damage and the xylem vessels most at risk appear in the tree appear to be those at the graft. In freeze-damaged orchards, it is not uncommon to see rootstocks regrowing, minus the scion, which has died. As part of my research efforts in the past, I have been involved in a number of seedling breeding plots, where *P. vera* are grown on their own roots. I have not seen a *P. vera* tree on its own roots affected by frost damage.

Note gumming from graft union.

Note UCB-1 rootstocks growing absent the scion. When the scion dies as a result of WJTD, the rootstock often regrows vigorously, suggesting the grafted tree is more frost sensitive than the rootstock alone.

When the low temperatures occur in the fall appears to dictate symptoms. For vigorously growing young trees, temperatures just below freezing in late October or mid-November appear to be sufficient to freeze small-diameter shoots and branches, and if low enough, to freeze and kill the tree. If the freeze occurs before leaf drop, the leaves of frozen branches remain on the tree and are very distinctive after the leaves of unfrozen branches lose their leaves. If the freeze is not too severe in late October or early November, only the smaller branches are affected and new branches regrow quickly from the upper scaffolds in the spring. If cold temperatures occur later, for example in late November to mid-December, the small-diameter, outer canopy branches appear undamaged, but black mold, bark wetness and white gum can be found on the lower scaffold branches and trunk above the graft union. These symptoms appear shortly after the freeze event. For this damage to occur in December, low temperatures below 24˚F appear to be necessary, with a duration of five or more hours below freezing. Trees showing the grey-black mold growth, bark wetness, and gumming often leaf-out and flower, if old enough, earlier than unaffected trees in the spring. However, with the first string of hot days in May, frequently dieback, unable to keep up with the transpirational requirements as a result of damage to the vascular tissue. On some WJTD-affected trees in late November or December, attached leaves, mold growth and gumming are not visible after the freeze event or events. These trees not showing the symptoms of mold and gumming are, usually, even more heavily damaged than those showing symptoms, and may only leaf-out from the lower scion and rootstock of the trunk in the spring, well after the unaffected trees have produced leaves. The reason for differences seen in freeze-related symptoms appears to be related to the stages a tree goes though in becoming dormant. Dormancy should be thought of as a time of reduced metabolic activity not as a time of no metabolic activity. Most

trees from colder climates become dormant beginning at the outer periphery of the tree and then sequentially toward the trunk. In late October or early November, no part of the tree is dormant, and freeze damage is dependent on the diameter of the wood. By late November to mid-December, the outer branches have begun to go dormant, so do not appear to be damaged by extended low temperatures as much as the scaffold branches and trunk, which have not yet begun dormancy. Generally, then, the cause of the dieback is damage to the water-conducting vessels, as a result of cold temperatures. Basically, the tree dies back due to dehydration, or inability to supply water for maintenance and growth of the tree.

In many plants, when a plant part is damaged or wounded by something like frost, mechanical damage, an herbivore, or insect infestation; ethylene (a plant growth regulator) is released by damaged cells. Ethylene induces a stress response in the plant, which results in cells adjacent to the wound site sealing of the damaged area. For example, parenchyma cells associated with the xylem create tyloses, which affectively seal off the xylem, preventing excessive loss of water by the plant. Interestingly, applying ethephon to the canopy and trunk of a pistachio tree at concentrations greater than 500 ppm before it is dormant, appears to mimic the symptoms of gumming and early leaf out seen in frozen pistachio trees. If a tree is frozen, but not so bad that the upper canopy is destroyed, we would expect to see early leaf-out as a symptom as leaf and flower buds are affected by the ethylene gas being released by damage cells.

The tree in these pictures was treated with 1000 ppm of ethephon on November 10.

Top left – Damaged shoot with dead flower buds in spring.

Top right – Trunk showing gumming.

Bottom left – Earlier leaf out than neighboring unsprayed trees.

As mentioned above, excessive tree vigor going into fall, appears to have a strong association with WJTD. Trees older than seven or eight years appear to be largely immune from the problem, but, of course, if temperatures get cold enough, anything can freeze. Perhaps bearing large yields of nuts or prolific amounts of pollen reduces tree vigor, or something about the rhythmicity of the bearing cycle once fully established, allows trees to become dormant earlier.

The Kalehghouchi variety is probably the most vigorously growing cultivar out there. We noticed this season at a couple of sites, that this cultivar appears to be slightly more freeze susceptible than other cultivars growing adjacent to it. Also, we have noticed that trees that are fully irrigated late into the season, appear to be more at risk of WJTD. Relatedly, areas of the orchard with poor infiltration or shallow hard pans can hold water later into the season, allowing more vigorous growth later into the season. Juvenile pistachio trees show very little sign of slowing down on their own if sufficient water is available. In the San Joaquin Valley, there is often very little transition in temperature in the fall. Temperatures can easily be in excess of 80˚F in October and early November and suddenly crash to below freezing. The variability of the degree of WJTD in an orchard may reflect differences in individual tree vigor within the orchard.

High soil salinity, especially in association with low-soil calcium appears to be associated with WJTD. However, soils do not have to be saline for WJTD to occur. Separating the effects of salinity from late-season soil-water storage is difficult. Areas with high salinity are usually associated with silty, poorly draining soils and shallow hardpan or high water tables. Wetter areas of the field, also tend to be saline, since it is more difficult to leach salts in these areas. Low calcium in plants has been associated in the literature with increased sensitivity to frost for a number of plant species including trees. Differences in calcium concentration between affected and unaffected plant parts has been found in our testing, but this may simply be the result of sodium being higher in poorly drained areas of the field where greater damage is found. Since pistachio excludes salts from its cells, we have been unable to establish much difference in plant sodium concentration between plant parts of affected and unaffected trees shortly after a freeze event when the trees begin showing the first symptoms. The concentration of sodium is much higher in the bark and outer wood near the cambium of the trunk of WJTD trees in May after leaf out. However, bark sodium concentration does not appear to be higher shortly after the freeze event. This suggests that sodium is leaking out of the frozen xylem vessels in the trunk and into the wood and bark as the flow in the xylem responds to the increased transpirational demand on the tree in the spring, and is not higher in these tissues prior to the freeze event.

What the Grower Might Be Able to Do to Reduce the Incidence of WJTD

Reduce tree vigor through reduced late season irrigation

Reducing the vigor of the trees by making sure that the root zone is dry prior to the arrival of freezing temperature appears to be an effective counter measures to WJTD. On deeper, heavier soils, the last irrigation should probably occur about the third week of August. On shallower, lighter soils the grower can probably wait longer and may want to reduce water more slowly. Cutting off the water will reduce late-season growth, but not as much as some fear. Don't try to make up for a late planting or budding by pushing the trees into the fall, especially in a low-elevation area. Not getting the tree up the stake the first season is not the end of the world. Cutting of the irrigation water really means cutting off the water. Since pistachio trees, on the existing rootstocks, do not appear go become anything like fully dormant until the end of December, do not irrigate until January, once you shut off the water in August. In saline areas, wait until the new year to begin leaching salt. Current observations suggest the tree is more in danger of frost, than salt. Of course, in a high rainfall year, cutting off irrigation will be less effective, since the orchard may remain wet. Additionally, as was the case for the 2011 crop year which was harvested late, reducing irrigation too much too early could reduce the split nut percentage in 5th leaf trees and older that are in their early nut-bearing years.

The reason that first and second-leaf trees appear less at risk from WJTD than slightly older trees is that their root systems are not that well established yet under drip systems, and the tree may be able to be put into drought quicker.

Reduced tree vigor through nitrogen management

Do not over apply nitrogen to young trees. Test the soil to see how much nitrogen is present and then add just enough so that little N remains in the soil at the end of the season. Pistachio is an effective scavenger of nitrogen due to its extensive root system. Cut off nitrogen applications in late June or early July.

Choice of rootstock

Rootstocks that by heritage contain 50% *P. integerrima* and 50% *P. atlantica* heritage appear to be more frost tolerant. These rootstocks would include UCB1 seedlings, Duarte® clones, and Pioneer Platinum® clones. However, choice of rootstock is not enough. All of these rootstocks are vigorous and additional measures will be required.

Leaf canopy defoliation

Early defoliation with foliar zinc sulfate sprays or by some other means has been suggested as a means of encouraging dormancy for many years. However, trying to find scientific research supporting this practice in pistachio has not been easy. It does make sense that defoliating the tree should send a message to the tree to slow down. Since freeze events can occur, especially at low elevations at the end of October, trees should probably be defoliated in mid-October. Defoliation should be done in conjunction with soil drying. We don't want to defoliate too early, as the leaves may regrow, which may reinvigorate the tree, creating a condition that we are trying to avoid. We have be experimenting with defoliating trees, but have not yet found optimum conditions to determine how well defoliation works on its own, separate from the effects of soil drying. Having a dry root zone and a defoliated canopy should take the vigor out of even the most stubborn tree.

Tree Wraps?

Research conducted last year demonstrated that tree wraps may have some use in protecting the portion of the tree covered by the wrap. Tree wraps composed of ¾ inch, closed cell, black foam, tightly fit to the trunk with black Gorilla® tape kept the trunk approximately 4˚F warmer, 12 inches above ground level than the outside temperature.

What to do if the trees freeze?

Previous experience has shown that the trunks, including the rootstock and scion, of frozen trees, may sunburn in the spring, after the loss of the shading canopy. Whitewash the trunk, especially on the south and west sides of the tree, to prevent sunburn.

Do not try to prune the tree during the winter or early spring. Damaged trees will likely continue to die back during the hotter temperatures of May and June. By late May or June, you should have a pretty good idea if a tree is worth saving.

If the tree has died back to the lower trunk, it is probably best to replace the tree or rebud on a sucker originating from below ground level. Often the trunks are severely damaged, and a stronger tree will likely result if no old scar tissue exists between the producing canopy and the roots.