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Kern Pistachio Notes

January 2016

Second Call for STATEWIDE PISTACHIO DAY 2016!

Wednesday, January 20, 2016
Location, Visalia Convention Center 303 E. Acequia Ave., Visalia, CA 93291

Pre-Registration Fees
$40 thru Jan. 6, 2016
$60 after Jan. 6
$80 onsite

For pre-registration see: http://ucanr.edu/sites/pistachioday/Registration/
For agenda see: http://ucanr.edu/sites/pistachioday/Agenda/

Pistachio Chilling Accumulation on Right Path in Kern County

Obviously, we have a lot to learn about what constitutes good or adequate fall and winter chill accumulation in pistachio, but no matter what method or model that you use, chill accumulation is looking good this fall and winter in Kern County. The chill-accumulation 'clicker' is working overtime from the high desert east of the Sierras, over to the hill country along the east side of the San Joaquin Valley, through the old lake beds and up into the hills on the west side. Even the number of chill-interrupting warm-winter temperatures is much smaller this year compared to the last couple of seasons. The rain, although somewhat disappointing to date in relation to some of the El Nino publicity, should produce fog to further enhance chilling into January and February. Hopefully, there will be some opportunities to get back into the fields to get all the necessary berm blowing, herbicide spraying, juvenile tree training, mature tree pruning and mummy poling done before buds start pushing in March.

At a recent California Pistachio Research Board meeting, a well-known pistachio guru shared an observation he had made that the female flower buds have looked 'skinny' the last couple of seasons, especially were yields have been particularly disappointing. After he mentioned this, I realized, but had not properly mentally processed at the time, that I had seen the same thing in a number of blocks that I had examined last season when looking for a location for an experimental winter-oil trial. At that time, I was looking for a site with plenty of yield potential, as reflected in large numbers of flower buds. The site I finally chose had plenty of flower buds, but, on reflection, they were small, thin, and sometimes, difficult to separate from adjacent vegetative buds. This season, I see plenty of 'fat', round flower buds on the female trees. The presence of fat flower buds might be a good sign. Trees, in orchards having sufficient irrigation and nutrition to keep photosynthesis operating efficiently, should be loaded with starch (in roots, trunks and branches). This assumption is based on the observation that the disappointing crops that have been harvested the past two seasons in many Kern County orchards did not make much of a demand on starch storage in the trees. Good chilling this fall and winter should get the message to the flower buds to produce nuts. Activated flower buds, good starch storage in the tree from the 2014 and 2015 seasons, in combination with the carbohydrate that will be produced in the 2016 season, suggests a branch-busting crop should be in the offing this fall for many Kern County growers.

Basic Pistachio Nutrition with Tips for Southern San Joaquin Valley (SJV) Growers

Fertilization is the process of supplementing elemental nutrients present in the soil and water for the purpose of maintaining tree health and productivity. The elemental macro nutrients required in relatively large quantities by plants are nitrogen (N), phosphorous (P) and potassium (K). The micronutrients are those required, by comparison, in small to vanishingly small quantities and include: boron (B), copper (Cu), chloride (Cl), iron (Fe), manganese (Mn), molybdenum (Mo), and nickel (Ni). The demand for the secondary nutrients, calcium (Ca), magnesium (Mg) and sulfur (S), is somewhere in between the macro and micro elements. Carbon (C), oxygen (O) and hydrogen (H) are also required in large quantities. These later elements diffuse into the plant in molecules (carbon dioxide, oxygen and water) and are made available for plant growth through photosynthesis and respiration.

Although we refer to fertilization as 'feeding' or 'pumping up' the plant, these terms are misleading. No matter how diligently fertilizers are applied, a plant cannot be 'fattened up' with nutrients. Plants feed themselves through the process of photosynthesis, where energy generated by light captured by chlorophyll is used to turn carbon dioxide in the air into carbohydrate. Carbohydrate is the food that, eventually, is used to provide energy for the plant. Nutrients are necessary to allow the plant to utilize the energy in carbohydrate to maintain the photosynthetic and respiration systems, grow the plant, and produce reproductive structures (such as the nuts we eat). In the final analysis, there is no point in providing more fertilizer than is necessary for the crop to maintain optimal light interception, and its eventual conversion into energy by the leaf canopy, per unit of ground area.

Applying nutrients to annual plants, like cotton, wheat or tomatoes, is relatively straight forward with recommended fertilizer timing and amounts having been studied in detail. At the end of the season, annual plants are harvested or die and the process starts all over with planting next season. A perennial tree crop may be more forgiving with respect to timing and amounts of fertilization than is the case with annual crops, since the tree has the ability to 'store' many required nutrients in the leaves, twigs, branches, trunk and roots, for later retrieval. The ability of pistachio to store nutrients, especially the more mobile nutrients such as N, in combination with its massive root system that is able to 'mine' a large are of the soil profile, may reduce the need for exact amount and timing of fertilizer applications. However, the southern San Joaquin Valley (SJV) is a desert and the ability of roots to absorb nutrients is often limited to the volume of soil that is wetted by low-volume irrigation systems, and further challenged by the alkaline (i.e. high pH) and salty nature of the soil and irrigation water. The ability to fertigate (i.e. apply fertilizer nutrients through low-volume irrigation systems) is a valuable asset under these conditions. Fertilization should be balanced with water availability. There is no point in fertilizing for maximum yields, if water quality or quantity is insufficient for optimum photosynthesis necessary to maximize nut yield. Similarly, if nutrients are present in the soil, and irrigation is in excess, these nutrients may be leached below the root zone. Pistachio adds an additional fertilizing challenge due to its alternate bearing habit, where a heavy crop of nuts, often, is followed by a much lighter crop.

The effective application of fertilizers to the soil is a function of soil chemistry while effective foliar application is a function of leaf and bud absorption. Obviously, tree size and reproductive status will influence the amount of applied fertilizers. Commonly, a given nutrient may not need to be added as fertilizer. A nutrient may already be present in the soil or water in sufficient or excessive quantities. If in excess in the soil, it can be absorbed into the tree in excess, resulting in toxicity symptoms in leaves or buds. Just because fertilizers are applied, does not mean that plants will absorb them. Sometimes deficiency symptoms of one nutrient element can result from an excess of another nutrient element of similar chemistry (called antagonism) or an element in excess may combine chemically with another rendering both unavailable for plant uptake. For example, excessive potassium may result in magnesium deficiency or excessive phosphorous can result in zinc, copper and manganese deficiencies. Soil pH (excessive acidity or alkalinity) can influence nutrient availability as can soil physical and chemical properties. Insufficient or excessive irrigation can interfere with root uptake of nutrients, as can poor root health resulting from pests, disease, and other causes.

Leaves may help diagnose nutrient deficiencies and toxicities. Nutrient deficiencies or toxicities may be expressed as foliar-leaf symptoms and leaf-tissue samples can be used to confirm leaf symptoms or discover problems before visual symptoms occur.

By following the protocol below, a meaningful leaflet sample can collected from pistachio:

- collect the sample from late July through mid-August
- sample female trees only.
- sample non-fruiting branches, 6 ft. from the ground
- choose fully-expanded sub-terminal leaflets on newer shoots. Calcium, Mg, B, Cu, and Mn concentrations vary markedly depending on leaf age. If all of these elements are low in the leaf it suggests that the leaves sampled were not yet fully expanded and the tree may not be as deficient in these elements as the tissue samples would suggest.
- collect 4 - 10 leaflets per tree from different quadrants of the canopy
- sample 10 - 20 trees/orchard block
- foliar sprays cloud results. Do not include leaflets that have received in-season foliar nutrient sprays
- deliver the sample to the lab within 24 hours.

Suggested levels of some nutrients, on a leaf dry-weight basis, appear in Table 1. Visual leaf deficiency or toxicity symptoms should not be ignored, even it leaf-tissue samples appear to indicate adequate levels for a given nutrient. This is especially true for some of the micronutrients, such as copper and zinc, where the difference between adequate and severely deficient levels are a few parts per million and where nutrient availability may be highly variable across an orchard. Leaf tissue analysis conducted on nutrients in leaves that were subject to foliar sprays containing these same nutrients, generally, have little meaning, as most of the nutrient showing up in the sample were not fully absorbed into the leaf, but merely reside in or on the outer surfaces.

Table 1. Suggested ranges and deficiency thresholds for selected nutrients necessary for pistachio production.		
Nutrient Element	Probably deficient if less than:	Suggested Range (dry weight basis)
Nitrogen (N)	1.8%	2.2 -2.5%
Phosphorus (P)	0.14%	0.14-0.17%
Potassium (K)	1.6%	1.8 - 2.0 %
Calcium (Ca)	?	1.3-4.0%
Magnesium (Mg)	?	0.4-1.2%
Sodium (Na)	?	(?)
Chlorine (Cl)	?	0.1-0.3%
Manganese (Mn)	30 ppm	30-80 ppm
Boron (B)	90 ppm	150-250 ppm
Zinc (Zn)	7 ppm	10-15 ppm
Copper (Cu)	4 ppm	6-10 ppm

In my experience as a U.C. Farm Advisor in the southern SJV, only a few of the nutrient elements required for pistachio plant growth have engendered the majority of the concerns related to deficiency or toxicity symptoms. These 'problematic' nutrients include nitrogen, zinc, copper, boron and, under certain circumstance, manganese. Chloride (Cl), is an ever-increasing toxicity problem as pistachio becomes increasingly grown in salty soils, but warrants, along with sodium, an article of its own.

Nitrogen (N)

A substantial weight of nitrogen is removed from the orchard in the nuts at harvest. Nitrogen is the nutrient element usually requiring the greatest weight of supplemental fertilization. Approximately 28 lbs. of N is present in 1000 lbs. (dry weight basis) of harvested nuts dried to 5% moisture (this includes the N in the hulls). For a 3000 lb. per acre nut yield, replacing the amount of N removed from the tree in harvested nuts is not as simple as adding 90 or so lbs. of N as fertilizer. Not only will next-year's developing nuts require N, but so will new leaves and shoots. Nitrogen applied to the soil is not absorbed by the tree at anything close to 100% efficiency. Nitrogen may be 'tied up' in organic matter', lost through the soil rooting profile (especially when salty soils are leached to remove salts), denitrified (gassed off) by soil-borne organisms and exit the orchard in surface run-off. If we progressively fail to replace fertilizer elements removed at harvest, used in tree growth, and otherwise lost during crop production, then the soil is being depleted and is becoming less productive.

Nitrogen can be gained to the plant and soil in ways other than through fertilization. Molecules containing nitrogen can be released into the atmosphere as a result of vehicle exhaust and other human-related activities and produced as a result of atmospheric electrical storms. These molecules may be washed out of the atmosphere in rain and serve as N fertilizer. Also, N and other nutrients, may be present in irrigation water which can be subtracted from the annual N application fertilizer requirement on a pound for pound basis. Nitrogen is removed from the tree during pruning and in falling leaves, but may return to the soil, and eventually the tree, if prunings are shredded and allowed to decay within the orchard.

Generally, to reduce N pollution, the goal is to fertilize with sufficient N to produce the maximum crop possible under the existing environmental limitations, with little residual N remaining in the soil after leaf drop in the fall. This goal is especially important in salty soils where extensive salt leaching will occur during the winter or in areas with high winter and spring rainfall. Soil should be tested in spring to assist in estimating how much N is available in the soil rooting profile for the upcoming season, and a portion of this can be counted toward the annual N fertilizer requirement. High leaf-N in August leaf samples usually indicates, besides high N storage in the tree, high residual N in the soil. Both of these conditions suggest that N fertilization rates can probably be reduced significantly the following year without danger of reducing yields. Good record keeping can greatly assist the grower in adjusting current N applications based on historical N fertilization, leaf and soil N levels, and crop yields. If post-harvest soil-N levels are increasing year over year, and yields are optimal, N fertilization rates can probably be reduced. See http://fruitsandnuts.ucdavis.edu/files/165545.pdf for a model developed by Drs. Brown and Siddiqui for estimating and adjusting in-season N and K fertilization requirements for pistachio.

The alternate-bearing habit of pistachio further complicates efficient application of N. A high yielding 'on-year' is typically, but not always, followed by a lower-yielding 'off-year'. The question is if the N application should increase during the 'on-year' and be reduced during the 'off-year'. Research, such as that presented in Table 2, suggests that fertilizing the pistachio crop on a two-year basis, as opposed to a single-year basis, may have merit. In this study, the total N demand of the trees was very similar between the on and off-year. In this same study, the authors determined that during the on-year 85% of the total N uptake went to the nuts, while during the off-year 67% of the N went to the canopy. These data suggest that in the off-year, the tree is growing the leaf canopy for light capture and associated carbohydrate production and storing N that is utilized for nut production during the on-year. The application of similar quantities of N during the on and off-years, in combination with maintaining more manageable tree size through pruning, may help mitigate large swings in alternate bearing. The mobility of N within the tree makes N storage possible. In contrast, potassium due to its relative lack of mobility within the plant, probably, requires that potassium fertilization be conducted on an annual basis with adjustments for expected yield, with application timing within the season more critical.

Table 2. Estimate of soil nitrogen demand over the alternate bearing cycle for Kerman on *P. atlantica* rootstock (after Weinbaum, Brown and Rosecrance)

Cropping status	Spring Flush (Apr. – May)	Nut Fill Period (June – Aug.	Post-Harvest (Sept. – Dec.)	Total nitrogen
	---------------------------- lbs. N per acre --			
On-year	46	103	*	150
Off-year	60	76	*	136

Mature bearing pistachio trees, in orchards not challenged with excessive sodium, chloride or boron, with sufficient water to meet the full evapotranspiration requirement, and assuming no N in the irrigation water and minimal residual N in the soil profile, will require approximately 150 to 200 pounds of N fertilizer annually. This annual estimate also assumes that the fertilizer is applied efficiently, at intervals, usually beginning prior to bud-break in mid-March using low-volume irrigation systems, and deep leaching of irrigation water is kept to a minimum during the growing season. Annual leaf tissue and post-harvest soil sampling is a good check on how the fertilizer program is working.

Nitrogen applications to juvenile trees in low elevation areas should not continue beyond early August to reduce late season vigor and encourage dormancy. Recommended N leaf-tissue levels for bearing trees in late July and early August appear in Table 1. Typical visual N leaf-deficiency symptoms appear in Figure 1. Note the reddish veins. Since N is mobile in the plant, new leaves commonly are able to obtain N from older leaves. Yellowing and drop of older leaves may signal some level of N deficiency.

Figure 1. Nitrogen deficient shoot on young pistachio tree. Photo by Craig Kallsen.

Zinc (Zn) and Copper (Cu) Deficiency

In the southern San Joaquin Valley, zinc and copper deficiency symptoms are not unusual, and frequently occur together. When present, these deficiencies are most commonly seen in juvenile trees or trees just coming into bearing. Young trees may be more susceptible as a result of their vigorous juvenile growth and reduced rooting area. Both zinc and copper are not very mobile in the plant, and older leaves remain normal in appearance as younger leaves show deficiency symptoms. Zinc deficiencies may show up earlier in the season, while, copper deficiency symptoms, typically, do not appear until mid-summer. Mild Zn deficiency symptoms include interveinal chlorosis and reduced internode length in the terminal portion of developing shoots. As symptoms worsen, small branches in the outer canopy will terminate in a rosette of small, yellowish (chlorotic) leaves and the shoots may die back. In more severe Zn deficiency, vegetative and flower buds will push later in the spring and the new shoots will dieback. Bearing zinc deficient trees will produce clusters with small, reddish, blank nuts, not unlike chill-deficient trees. High soil manganese levels (300 ppm in the leaf, 40 ppm plant available zinc in the soil) appears to have induced zinc deficiency in sandy soils in the California high desert east of the Sierras and in Arizona. Foliar zinc and copper sprays may restore normal leaf growth in new leaves, but will not correct leaves showing deficiency symptoms.

Copper deficient leaves fail to expand normally and may appear 'clover shaped' and scorched. If symptoms are noticed early, and copper foliar treatments made, correction can occur rapidly in new growth. However, if not corrected early, the terminals of new shoots dieback and some may curl downward. Shoot symptoms often progress so rapidly in juvenile trees, that a year's growth can be lost in a few weeks. Nuts of bearing trees will shrivel if excessively copper deficient. Trees with a probable combination of zinc and copper deficiencies are shown in Figure 2.

Soils with an alkaline pH, and elevated phosphorous, salinity and organic matter can reduce availability of zinc and copper to pistachio. Sandy soils, as a result of low cation exchange capacity, can also have a problem delivering copper (and zinc). Shallow hardpans can make this situation worse since they limit root growth. San Joaquin sandy loam (which holds the honor of being the official soil of the State of California, probably because it is a common soil type on the east side of the Central Valley), appears to be especially at risk from both zinc, copper and boron deficiency. Trees on this soil type are often potassium deficient, even if K fertilizers are applied, as a result of its chemical composition which 'fixes' potassium within its structure, making it unavailable to roots.

An effective time to correct zinc and copper deficiency is in early May, with the expansion of the new leaf canopy. In alkaline soils in the San Joaquin Valley, juvenile and bearing trees should both be treated with zinc and copper foliar sprays annually, or more often, depending upon the specific orchard conditions.

Figure 2. Copper and zinc deficient pistachio shoots in late August Photo by Louise Ferguson.

Manganese (Mn) Deficiency

Manganese leaf deficiency symptoms in pistachio have come to the attention of this U.C. farm advisor only once in the past 20 years and only in an area of the SJV treated with a unique soil amendment. Unusual leaf symptoms (see Figure 3) began appearing in the spring in an area of many hundreds of acres treated with large tonnages of treated municipal organic material a number of years before pistachio was planted. This material was very high in N and phosphorous (P). In *P. vera* (i.e. the nut producing part of the tree in this case Kerman) leaf tissues, zinc and copper appeared to be borderline in sufficiency, but Mn was very low, with values as low as 7 ppm. Leaves on rootstocks, such as UCB-1 and pure *P. integerrima*, did not demonstrate leaf symptoms. Leaf symptoms were not present until the *P. vera* scion was present after field budding. Manganese, Zn and Cu deficiencies would be expected in that this soil is high in organic matter, is very salty, has a high pH and is high in P. Trees demonstrating the symptoms appearing in Figure 3 stopped growing and shed leaves. Shortly after Mn fertilizers were applied (foliar Mn and fertigated chelated Mn) the trees produced a new flush of growth. However, the leaves on this initial new growth showed distinct N deficiency symptoms, which, at first look, was surprising considering that the amount of available N in the soil was in the hundreds of pounds per acre. However, Mn is an essential element in plant N metabolism and no matter how much N is in the soil solution, it cannot be utilized by the plant if Mn is deficient. The N deficiency symptoms were short-lived and appeared to be caused by a transitory deficiency of Mn resulting from a lag in leaf and root uptake. By mid-summer most Mn and N deficiency leaf symptoms were no longer present and the trees appeared to be growing normally, despite the difficult soil conditions. With this soil, maintaining adequate Mn levels remains a challenge. Acidifying the soil to reduce alkalinity appears to be a limited option based on the concern that acidification would release even more phosphorous into soil solution, further reducing uptake of available Mn, Cu and Zn by the roots.

Figure 3. Third-leaf pistachio trees showing symptoms, primarily, of manganese (Mn) deficiency June 23, 2014. Photo by Craig Kallsen.

Boron (B) Deficiency and Toxicity

In the SJV, B has the distinction of being a common serious problem to pistachio growth and yield in deficiency and excess. Pistachio, compared to most nut and tree crops, has a high B requirement. Unless B is present naturally in the soil and water in significant quantities, B fertilization is likely to be required. The element is essential for functional bloom, pollen viability, and nut set but deficiencies also effect vegetative growth. Boron deficiency may appear early in the season. When B is very deficient, new shoots produce leaves that are thickened, with stout, elevated midribs and veins; and with twisted, crinkled and upwardly curling blades. If the deficiency persists, growing points die followed by shoot dieback. The shoots themselves can become dark, corky and old-looking. Terminal buds may remain dormant while lateral buds push growth with short internodes, giving the tree a stunted, bushy appearance. Borderline deficiencies are difficult to diagnose visually even if twisted and deformed leaves are present. Leaves produced on trees growing in windy and/or salty areas or subject to heavy, early flower thrips infestations can become similarly deformed leaves as well. Fortunately, leaf tissue sampling can provide a useful early warning as boron concentration in the leaves falls below 90 ppm. Along the east side of the SJV, B tends to be deficient in acidic soils irrigated with pure surface irrigation water. Boron is required in large enough quantities that it may be difficult to provide enough in foliar applications alone. Soil applied B can be very effective in assisting the tree in meeting the B requirement even in difficult soils. Generally, B is high in well water available to growers on the west side of the San Joaquin Valley and is often in excess. However some orchards, in the area around Goose Slough in Kern County for example, may become boron deficient since little B (but plenty of sodium and chloride) is present in well water or in better-quality water from the California Aqueduct. Assumptions about the presence of B in well water should not be based on EC values alone. Irrigation water should be specifically tested for B.

On the west side of the southern SJV, excessive B is more likely to be a problem than deficient B. The most obvious symptom of excessive B in the orchard is marginal necrosis of the leaves, usually beginning in late July as appears in Figure 4. Excessive sodium and chloride can cause similar symptoms to B toxicity, but usually only at soil and water concentrations much in excess of what occurs where pistachio is grown in the SJV. If enough B is present, leaf B concentration can exceed 2000 ppm and the trees may defoliate in August before harvest. In some areas, plant available B may be less than 0.5 ppm in the soil water extract and in the irrigation water, but leaves may show marginal burn and tissue samples can exceed 900 ppm. The source of B in these orchards appears to be high concentrations of what would be normally unavailable-B in the soil. Total soil B, as differentiated from available soil B present in the saturated soil extract, may exceed 70 ppm or more. The determination of total B in the soil is not commonly done by laboratories and this test usually requires a separate analysis. The high B values in the leaves of these orchards may indicate that some of this normally unavailable B may be slowly released to the trees with acidifying soil amendments and fertilizers. Trees can readily tolerate leaf tissue concentrations of 750 ppm but values higher than this are probably cause for concern over the long-term and efforts should be made to reduce B availability in the orchard. As long as some necessary micronutrients are applied foliarly, caution should be used in attempting to drop pH levels below 8.5 with acidifying treatments where total soil B is high but largely unavailable to the trees at higher pH. Leaching is a corrective strategy for soil B, especially if B is low in irrigation water.

Unfortunately, in some areas, a significant percentage of the total soil B present is readily-available. Some evidence now suggests that where readily-available B is high in the soil and water, the long-term health of the trees may be compromised, even with careful attention to leaching. As the industry gains experience in growing pistachio with high levels of B, meaningful thresholds where damage is likely or where yield is seriously impacted, will be established.

Figure 4. Pistachio leaves showing burn (necrosis) at leaf margins typical of boron toxicity. Photo by Louise Ferguson.

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