Topics in Subtropics Newsletter
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News from the Subtropical Tree Crop Farm Advisors in California

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Editor's Note:

Please let us know if your mailing address has changed, or you would like to add someone else to the mailing list. Call or e-mail the farm advisor in the county where you live. Phone numbers and e-mail addresses can be found in the right column.

Please also let us know if there are specific topics that you would like addressed in subtropical crop production. Copies of Topics in Subtropics may also be downloaded from the county Cooperative Extension websites of the Farm Advisors listed below.

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Boron Is High In Many Southern San Joaquin Valley Citrus Trees

Craig Kallsen
UC Cooperative Extension Farm Advisor, Kern County

Many citrus trees in the southern end of the San Joaquin Valley are grown on moderately calcareous soils and frequently have high levels of boron in the leaf tissue. Citrus is sensitive to boron. Boron, when excessive, may cause defoliation and significant yield loss. At high, but nontoxic concentrations, leaf symptoms are similar to those caused by excessive salt, deficient potassium, heat stress, or biuret toxicity from urea foliar sprays. Therefore a leaf tissue analysis is important for delineating causes.

Excessive levels of boron produce a yellowing of the tip of leaves and yellow spotting of the leaf surface. Death of the leaf tissue may occur along the margins. Higher levels of boron may cause brownish, resinous gum spots on undersides of leaves but this symptom is not always present. Leaf symptoms are most severe on the "hot" south side of the tree. Boron accumulates in the leaves as they age so symptoms usually appear on older leaves first. Older leaves with high concentrations of boron are relatively short lived compared to trees that have boron at optimum concentrations. Often excessive boron and sodium appear together in leaf tissue analyses. Boron is associated with a decreased distance between leaf nodes. Trees with high leaf tissue boron concentrations appear to be less vigorous with shorter branches, probably as a result of the association of boron with decreased distance between leaf nodes.

Discussion of levels of boron which would be considered excessive in September-sampled spring-flush leaf tissue may be misleading because the particular leaves that are selected for the sample can greatly influence results. If only leaves with the most severe symptoms are sampled, such as leaves that are mostly yellow with dead margins, concentrations of boron can reach into the thousands of parts per million (ppm). A truer picture of the boron status of the grove can be gained by pulling leaves with 'average' symptoms. Using this sampling technique, the highest level of boron in orange leaves seen in this office over the past eight years has been 600 ppm from an isolated and particular calcareous part of an orchard located near the town of Edison in Kern County.

Standards from citrus in Florida for the concentration of boron in leaf tissue (4-6 month old leaves on nonfruiting terminals) correlate well with observations made in the San Joaquin Valley as follows:

Deficient	<20
Low	21-35
Optimum	36 - 100
High	100 - 200
Excess	> 250

Leaf boron concentrations greater than 250 ppm are excessive, but in older orange, lemon and grapefruit trees visible leaf symptoms are not usually manifested until leaf-tissue boron concentrations exceed 300 ppm. A range of 300 to 400 ppm show little outward sign of boron toxicity except for some slight tip yellowing and some reduction in vigor. Excessive defoliation does not usually begin in most citrus until concentrations of approximately 450 ppm are reached. Trees at 450 ppm and greater will, generally, exhibit a thin-canopied, unthrifty, somewhat stunted appearance. The yield of the tree does not appear to be affected nearly as rapidly as the appearance of the canopy. At least one large lemon grove in Kern County, that characteristically produces excellent yields of early-maturing, good quality fruit, has elevated leaf-boron levels. Moderate levels of leaf boron, in the 300 to 400 ppm range in this orchard appear to reduce tree growth, reducing the need to prune, while yield remains relatively unaffected.

Leaf boron concentrations greater than 300 ppm probably warrant further investigation as to the source of the boron. Orange leaf tissue samples taken from trees planted in the 1960's or early 1970's in Kern County routinely show levels of 300 to 400 ppm. Young trees appear to increase in boron concentration rapidly but at about 300 to 400 ppm the concentration tends to plateau. Why boron levels tend to plateau is not known. Chandler pummelos appear to be the most sensitive to excess boron, followed by lemons, grapefruits and oranges. Leaf boron concentrations of 400 ppm in Chandler pummelos appear to have caused severe stunting of the trees in several orchards in Kern County, while similar levels in Melogold (a pummelo x grapefruit hybrid) resulted in only some tip burn.

There are actions the grower can take to reduce the amount of boron in the tree. First the source of the boron should be determined if possible. If boron levels are increasing in the leaf tissue, analyze both surface water and well water. Avoid using water with greater than 0.5 ppm of boron for irrigation of citrus. Levels of boron that are beneficial to cotton or pistachio can cause severe problems with citrus. Surface water comes from diverse sources in Kern County. Surface delivered water may have started out as well water, or in some instances as diluted oil-field waste water which may contain relatively high concentrations of boron. Water districts will know if oil-field waste water is being diluted in irrigation water. Use of oil-field waste water can be seasonal and irrigation derived in part from oilfields may fluctuate in boron concentration. If boron is in the water even at slightly elevated levels, avoid spraying it directly on the trees when treating for insect pests or when applying foliar fertilizers. Fertilizers are foliarly applied because of the quick uptake of dissolved minerals through the leaves. If boron is in the spray solution, it will be absorbed quickly by the tree along with the potassium, zinc, manganese, nitrogen and other foliar nutrients. Organic matter, manure, composted materials, and mulches on the ground have been shown to reduce boron uptake by the plant from irrigation water with high concentrations of this element.

In the southern San Joaquin Valley, soils should be tested before citrus is planted. Areas of soil with high boron are found in the most unexpected places. Boron may have accumulated on some properties when high-boron well water was used before the advent of easier access to water from Sierra snow melt.

If leaf-tissue boron is high and the water or soil is not, check the foliar fertilizer blends being used. Often, boron is included in many micronutrient mixes because boron can be deficient in acid soils. Determine how much boron soil amendments may contain. Pit gypsum can have varying quantities of boron in it. A ton of this gypsum may contain as much as 20 pounds of boron.

Discovering the cause of high boron in citrus leaves may require an extra soil test in addition to the typical saturated pest extract. Soil tests for ‘available’ boron using a saturated pest extract can be deceiving. In many instances where the concentration of boron in a ‘typical’ leaf averaged greater than 300 ppm, plant-available boron in the soil and water frequently averaged less than 0.25 ppm. However, total soil boron in these same orchards was at very high levels. Total soil boron estimates both available and unavailable boron. To help determine where the boron in the trees originates, both readily available and total soil boron should be sampled. This disparity between plant-available and total boron suggests that boron moves between the relatively small plant-available pool in the soil and the much larger ‘unavailable’ pool tied up in these calcareous soils. Soil acidifying agents and acid-forming fertilizers probably increase the availability of boron to citrus trees by making boron that is relatively unavailable to the trees at high pH, more available at lower pH. At any given time, plant-available boron may be relatively low but its constant replacement from the unavailable pool keeps the boron concentration in trees relatively high. In orchards where total soil boron is elevated; soil pH should probably be kept as high as tree health permits. Where the total amount of soil boron is moderate and soils are relatively well-drained and topography is flat, acidifying and leaching is probably the preferred option for reducing boron levels. Acidifying the soil and not supplying sufficient water to leach the boron from the root zone can compound the problem by making more boron readily available to the tree.

If boron is not found in the upper soil profile, but is found or suspected to exist deeper, irrigations could be scheduled that are more frequent but of shorter duration so that most of the citrus roots remain in the upper, lower-boron portion of the soil profile.

Actively growing, vigorous trees may dilute the concentration of boron in the leaf tissue through the production of a thick canopy. Old leaves tend to accumulate boron and drop. Adequate nitrogen ensures that enough nitrogen is present for production of new leaves. Increasing the nitrogen fertilization rate can encourage vegetative production and enhance this effect, but too much nitrogen may be associated with adverse fruit quality characteristics like regreening of Valencias, later maturity of early navels or higher yields of smaller fruit. Keeping other nutrients in the leaf in balance is important if boron is present at excessive concentrations. Maintaining high concentrations of phosphorous and calcium in the leaves through an appropriate fertilization program should be beneficial as these nutrients have been shown to reduce absorption of boron.

Armillaria Root Rot

Ben Faber, Farm Advisor, Ventura County

There have been a lot of new avocado orchards planted during the last few years. These often have been in old ‘Valencia’ orchards or lemons that had poor production. In order to save money, growers have just cut the trees at ground level and replanted the avocados near the stumps. Avocados have recognition of being resistant to Armillaria, but in this environment of high disease pressure, they can fail.

Armillaria root rot is common, yet is an infrequently identified and poorly understood disease. It is capable of attacking most species of trees and other woody plants growing in California. It is sometimes called "shoestring root rot" and the causal fungus is often referred to as the "honey mushroom." Because oak is one of the preferred hosts, it is also called "oak root fungus."

If a tree undergoes a slow to rapid decline without any obvious reason, suspect Armillaria as the cause. Certain areas, such as drainage areas from chaparral or woodlands are likely areas for this disease. Old roots left underground provide a food base for continued fungal growth and survival.

General symptoms of Armillaria resemble those of other root disorders. These symptoms are disrupted growth, yellow foliage, branch dieback, and resin or gum exudates at the root collar. Trees may die rather abruptly without showing any decline symptoms. Avocados typically have a rather protracted death, but in citrus it can be rapid.

Only rarely can the disease be diagnosed without examining the larger buttress roots and root collar of the tree. After carefully removing the soil, examine for the presence of:

1) Rhizomorphs, or fungal 'shoestrings' attached to the wood under the bark. These may occur beneath the bark for some distance above the soil line in advanced cases, rarely they may radiate from the wood into the soil. Rhizomorphs may also grow out from the larger roots, resembling feeder roots in appearance. They are about the diameter of pencil lead and vary in color from black to reddish brown. The interior consists of white mycelial tissue.
2) Decayed areas of wood at the root collar or on the crown roots. Armillaria causes a white rot and the wood develops a stringy texture. Roots in advanced stages of decay may be soft, yellowish and wet.
3) Veined, white mycelial fans between the bark and wood where the cambium has been killed. Sometimes this fan (or fans) extends quite far above the soil line beneath the bark.
4) Soil remaining attached to the roots.
5) Characteristic mushrooms on the lower trunk or on the ground near the infected roots. These short-lived annual fruiting structures of the disease-causing fungus may develop during the fall or winter rainy season and may occur in small clusters or in large numbers. The stalk is typically yellow and 3 inches or more long. Usually a ring is connected to the stalk just below the cap. The cap is 2-5 inches across and often honey-yellow. It may be dotted with dark brown scales. The underside is covered with loosely spaced white or yellow gills radiating from the stem.

After the disease has been identified, the grower should study the situation to determine the role Armillaria root rot has played in causing the decline or death of the tree. Frequently the fungus is only involved in a secondary manner by invading and destroying roots after the tree has been exposed to stress of some form, such as severe drought, water logging, or soil fill over the roots. The fungus can also act as a saprophyte feeding on dead wood. It is frequently involved in the decay of old tree stumps and roots.

Many oaks are lightly infected with the disease for years with no resultant damage except for isolated pockets of buttress root rot which are walled off by the tree and have no ill effects. Other infected trees show no damage until subjected to stress. Accumulating evidence suggests the type of root exudate that is produced influences the susceptibility of the tree. Certain forms of stress cause a shift in exudates that promote rapid development of the fungus and may hasten tree invasion and decay.

Spores are produced by the mushroom fruiting structures (mushrooms) and disseminated by air currents and introduced into new area. Once the fungus enters the cambium and bark tissues, mycelial fans develop during the parasitic phase of the attack. Subsequently, mycelium invades and decays the woody tissue of the roots and sometimes also the base of the trunk. Under proper conditions the fruiting structures form at or near the base of the infected tree, completing the life cycle.

Direct control of the fungus in a diseased tree is not possible with present technology. However, in many instances the fungus is incapable of causing severe damage unless the tree is first subjected to substantial stress. Thus, keeping the tree healthy and avoiding severe stress is one important approach in preventing loss of trees to Armillaria.

Drought and leaf defoliation are two major forms of stress that favor Armillaria. In dry years it is advisable, as in all years, to make sure irrigation scheduling is appropriate. Stresses such as defoliation from persea mite, soil compaction and physical injury can exacerbate the disease. Nutrient management may minimize Armillaria effects, although little research information exists on this subject.

The second most important means of minimizing Armillaria damage is to avoid or eliminate the fungus inoculum before planting. Trees planted in former orchards will quite possibly be exposed. Since these sites cannot be avoided, here is a suggestion that will be helpful: remove stumps and old roots from the old orchard to the greatest extent possible.

Figure 1. Mycelial plaques under the bark

Figure 2. Armillaria mushrooms (Courtesy University of Illinois)

Soil Test Kits

Ben Faber and Jim Downer, Farm Advisors, Ventura County

Leaf analysis is the preferred method of guiding a fertilizer program for fruit tree crops. Soil testing is less important, since the tree has the capacity to store nutrients in its various parts – roots, trunk, stems and leaves. However, soil testing is a component of a plant nutrient management program and has been standard practice for growers to aid in adjusting fertilizer applications. Soil testing is performed not only to improve plant growth, but also to reduce over-application of fertilizers that may lead to nutrient toxicities, excessive leaching and consequent economic losses.

For maximum accuracy and benefit, soil testing must be conducted using reliable methods on correctly-sampled soils (if the user is not trained in obtaining representative soil samples, test results even from the same soil can vary greatly). Test results must also be properly interpreted for a specific crop. Interpretative guidelines are readily obtainable for many agronomic and horticultural crops, as well as landscape trees. Cost for laboratory analysis for pH, NO_3-N, P_2O_5 (Olsen), and extractable K_2O are typically under $20 per analysis, but frequently results take from 1-4 weeks to get back to the grower.

By contrast, many retail garden centers offer commercial test kits, ranging in cost from $10 to $50 for multiple tests, so that the cost per test can be relatively low. These commercial kits are also advantageous because results can be obtained within one to two days. Commercial kits typically use a colorimetric method for indicating macronutrient and pH levels. Soil is measured into a sample container, extractant is added, and after a specified time for the reaction, the user compares the color obtained to a color card corresponding to categorical nutrient and pH levels.

We have always wondered how well these kits performed, so we purchased five commercially-available test kits and compared their results to standard laboratory analysis of NO_3-N, P_2O_5 (Olsen), extractable K_2O and pH from the same soil type with three distinct cropping histories (Soils 1, 2, and 3). The objectives were to identify differences in accuracy, if any, among test kits and to suggest a kit that most closely corresponds to analytical lab results.

Four of the kits, "La Motte Soil Test Kit" (La Motte Co., Chesteron, MD); "Rapitest®" (Luster Leaf Products, Woodstock, IL); "Quick Soiltest" (Hanna,Woonsocket, RI); and "NittyGritty" (La Motte Co. Chesteron, MD) measured nitrate-N, P_2O_5, K_2O and pH. "Soil Kit" (La

Motte Co., Chesteron, MD) measured only nitrate-N, P_2O_5 and K_2O. The kit results for macronutrients were categorical (high, medium, and low); pH results were numeric, rounding to half pH units for the Rapitest® and one pH unit for the other three kits. The manufacturers' instructions for each kit were followed for soil testing.

Results show that pH measures from LaMotte Soil Test Kit and Rapitest consistently matched lab results. Soils 1 and 3 proved to be in the pH 6.5 range, but the pH of Soil 2 was 7.8, technically beyond the capacity of Rapitest (pH 4.5-7.5). NittyGritty did not match lab results at all. Quick SoiltTest generally indicated lower pH values than the analytical lab. Results from LaMotte Soil Test Kit, Rapitest, and Quick Soiltest consistently matched the analytical lab results for nitrate-N and P_2O_5, while Soil Kit and NittyGritty did not. Soil Kit and NittyGritty analyzed K_2O content with greater accuracy than for the other nutrients; the commercial tests in total corresponded with the analytical lab 82% of the time for this test. For Soil 3; all the commercial test results matched the analytical lab results 100%.

Precautionary measures for these commercial kits may increase their accuracy. For Soil Kit and Nitty Gritty, the extracting powders that came with the kits dissolved poorly; these kits generally yielded inaccurate results, but pulverizing the tablets or powders may increase extraction potential. Interpretation of color development should be made only within the time specified by the kit instructions because color intensity could vary within minutes. Also, interpretation can occasionally vary depending on the user. In this study, the observers independently interpreted the same result for 91% of the tests; this would probably be an acceptable proportion for a home gardener or farmer individually conducting tests, but occasional independent interpretation by another source may change the result.

La Motte Soil Test Kit results corresponded to those from the analytical lab for pH and all nutrients (86% of the tests matched). This kit is suitable for growers because it proved to be very accurate even over a range of pH values and is housed in a hard-sided, padded container. Rapitest yielded accurate results 92% of the time for all nutrients and pH less than 7.5, and was comparatively easy to use and interpret. Quick Soiltest matched the analytical lab results only 64% of the time because pH and K_2O values were inaccurate. Interpretation of values from this kit may have resulted in application of potassium in excess of the needs of Soils 1 and 2.

An important limitation of all commercial test kits is the approximate or categorical value of nutrient content (i.e., low, medium, high). Analytical labs must be used when precise values are required. Nevertheless, commercially-available kits such as Rapitest and La Motte Soil Test Kit have shown to provide accurate, fast, and economical results and can help growers improve nutrient management.

Using Evapotranspiration (ETo) for Scheduling Irrigations
An Improvement on "Guessing"?

Gary S. Bender, Farm Advisor, San Diego County

In a recent citrus meeting in San Diego County we asked how many growers were using soil moisture monitoring equipment to help schedule their irrigations. Only 3 people out of 40 indicated that they were using some sort of equipment to monitor soil moisture. We didn't ask how many were using California Irrigation Management Information System (CIMIS) to figure out how much water their trees were using on a daily basis, but we imagine that we might have had even a worse response.

Quite frankly, in a county where water is costing $700 to $1000 per acre foot, we though this practice would have been a common practice. Added to this is the increasing pressure to reduce nitrate leaching into creeks and ground water, where there is a serious problem developing. The natural response when water prices are high is to reduce water use, but we have seen groves where even a 10% reduction in water reduces the yield by 50%, and we have also seen quite a few growers irrigating too much with the belief that a couple of extra feet of water per acre will more than pay the cost of water in increased yield. Clearly we need to apply enough water to make the trees produce a profitable yield, How does a farmer accomplish this?

I believe every grower should be using tensiometers or some other kind of soil moisture monitoring equipment to determine ***when*** to water, and using CIMIS to determine ***how much to water***. There, just simply, is no an easier, or a better method.

Some growers said that tensiometers don't work. Well, they work just fine if they are installed correctly and serviced periodically. If the soil gets too dry (the reading goes above 80 cb) the device breaks suction from the soil, and they don't work until they are removed, filled, pumped and re-installed. As for gypsum blocks, they work just fine also, but are not very accurate under wet conditions. Both work a lot better than just guessing. There are newer electronic devices that work very well if calibrated with the soil moisture, but they don't work very well in rocky soil (rocks don't hold water).

Using CIMIS

This assignment is to help you figure out the water use in your grove. The following is a step by step procedure that is not difficult. Several of our grove managers use this on a weekly basis to calculate the water requirement in each of their groves. We have one grower who has this task assigned to his child in the third grade…***Really, this is not that difficult!***

This assignment will demonstrate how to use CIMIS to calculate the irrigation requirement for an avocado grove in Escondido. ETo is called the reference evapotranspiration (defined as the water use for eight inch tall grass), and all crops in California are related to this water use by adjusting ETo with a "crop coefficient". In this example you will see that the crop coefficient for avocado in November is 0.55. ETo data is gathered from the automated weather stations that are part of the CIMIS network in California. The irrigation calculator you will be using multiplies the ETo number by the crop coefficient and gives you ETc, the water use by the crop in question. This comes from the station in "inches" of water loss, and the calculator changes this into gallons per tree per day. The calculator then tells you how much water to apply to the avocados to replace the water they used during the last seven days.

Go the website **www.avocado.org**
Click on California Industry (on the top right side of the page)
Click on Growers
Click on Water
Click on Irrigation Calculator

Start with Evapotranspiration (ETo).
Click on Go To CIMIS
Use the drop down box and Click on San Diego
Click on Submit
Choose Escondido
Click on Daily Data

1. "Select a Time Period", in this example we will select the previous week; select November 15 through November 21
2. In "Select Variables", leave everything selected with the green checkmark.
3. Leave "English Units" selected.
4. Click "Retrieve Data"

Write down ETo for the last week. In this case it will be: 0.12, 0.11, 0.11, 0.10, 0.12, 0.12 and 0.10.

Add these up, and you get 0.78 (this is your ETo for the past week). Minimize this window.

You are now back to the Irrigation Calculator on the Avocado website.

1. Evapotranspiration, delete the 0.22 and fill in your 0.78
2. Under "Crop Coefficient", just click on November in the drop down box.
3. Leave "Distribution Uniformity" at 0.85.
4. Leave trees at 109 per acre.
5. Leave sprinkler output at 17 gal/hr. (of course, you can change this to match your sprinkler output, but for the sake of this example, leave this at 17).
6. Click on Calculate.

You should get 138 gallons (this is the amount of water used by one tree in the last seven days) <u>and</u> a watering run time of 8 hrs and 8 minutes.

As I mentioned earlier, you should have tensiometers (soil moisture meters) set at the 8 inch depth (avocado) or 12 inch depth (citrus) to tell you "when" to water. In avocados, I like to irrigate when the shallow tensiometer reads 20-25 cb, and in citrus when the tensiometer reads 35 – 40 cb. You cannot rely on irrigating every seven days because the tensiometer may tell you the soil is getting dry by the fourth day. This often happens in the summer.

To review, CIMIS tells you how <u>**much**</u> to water, the tensiometer tells you <u>**when**</u> to water. Now, in actual use, you may find that, in a windy area or on the south side of a slope, your trees may need more water. Merely add a 10% increase to the run time, and keep making minor adjustments until you get this right for your grove. Or, if you have root rot, you may want to water 10% to 30% less water.

By the way, if you are using this calculator for citrus, merely put 0.65 into the crop coefficient for each month, and you can use the same calculator. Some people believe the crop coefficient in the avocado calculator might be too low. Both Ben Faber and I believe the coefficient should be 0.80, but we don't exactly have good data to support this…just experience. At any rate, the calculator will put you in the ballpark…and it is a lot better than "guessing".

Give this a try, and ***Good Luck!***

Irrigation Calculator developed by Reuben Hofshi, Shanti Hofshi and Ben Faber.

Subtropical Crops Program Coverage in Riverside County

The subtropical crops program in Riverside County is being covered by the staff research associate Tom Shea until further notice. His contact information is:

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