Topics in Subtropics Newsletter

University of California Cooperative Extension

Fresno, Kern, Madera, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, & Ventura Counties

News from the Subtropical Tree Crop Farm Advisors in California

Volume 19, Spring 2019

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Topics in Subtropics –Spring 2019 – Published Quarterly
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Introducing your new information source for CDFA grants, Kern County and Ventura County

Shulamit Shroder and Alli Rowe are two of the newest members to UC Cooperative Extension. Shulamit is based out of Kern County and serves Kern, Tulare, and King Counties. Alli is based out of and serves Ventura County. Both specialize in the climate smart agriculture initiatives from the California Department of Food and Agriculture. They provide technical assistance for the SWEEP, AMMP, and Healthy Soils grant programs.

- The State Water Efficiency and Enhancement Program (SWEEP) encourages farmers to install more efficient irrigation systems that decrease their water consumption as well as their greenhouse gas emissions. You can apply for a SWEEP grant for up to $100,000.
- The Alternative Manure Management Program (AMMP) awards funds - up to $750,000 - to livestock producers who decrease their methane emissions by changing the way that they manage manure.
- The Healthy Soils Program incentivizes the implementation of conservation agriculture techniques that decrease erosion and greenhouse gas emissions, like cover cropping, compost, crop rotation, and mulching. For this grant, there is $75,000 available per project.

Keep an eye out for future announcements about grant deadlines - they have all passed but should reopen within the next year, pending further funding.

For more information about these programs and for help applying for these grants, please contact Shulamit or Alli at:

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Spotlight on SWEEP in Citrus

Shulamit Shroder, UCCE climate smart agriculture specialist - Kern County

In 2014, Bruce Kelsey in Kern County received a grant through the California Department of Food and Agriculture's State Water Efficiency and Enhancement Program (SWEEP). He used the funds to set up 8-foot-wide plastic weed mats underneath his mature organic citrus trees. He also decreased his electrical consumption by about 30% and installed soil moisture sensors, a water flow meter, and a pressure-sustaining device.

Benefits
Labor: The installation of the weed mat was a labor-intensive process, but it ended up paying off in the long term. It diminished weed populations so that he no longer has to weed under his citrus trees. Now he only mows with a small mower in the lanes between his trees.
Water usage: His overall water usage decreased by about 10%. The weed mat decreased evaporation and weed pressure while the other devices allowed him to better manage and schedule his irrigation.
Drawbacks
Pests: Bruce experienced an increase in earwigs in the weed mat orchard. The plastic covering provided the perfect humid environment for the insects.
Organic certification: The weed mats will eventually start to disintegrate, which could contaminate his soil. To maintain his organic certification, he will have to rip them up once they start to break down. Smaller, younger trees do not protect the plastic from the sun, which quickly destroys the plastic. For this reason, he recommended against using weed mat in immature orchards.

Figure 1. Weed mat in place.

Low Pressure Guide to Low-Flow Irrigation Scheduling

Allison Rowe, UC Community Education Specialist and
Ben Faber, Soils/water/subtropical crops advisor for Ventura and Santa Barbara Counties

How to irrigate is probably the most common question in irrigated agriculture, even with 10,000???? years of cultivation knowledge to guide us. The complexities of irrigation and the unique situation for each grower makes this question so difficult. Not enough water and plants have diminished growth or the propensity for disease and disorder [1]. Too much water leads to root disease and nutrient problems [2]. So, it can't be too much or too little, but just right. There are times when citrus can handle a little more water stress than other times, which can lead to water savings [3], especially in a drought year or in areas where water costs are crucial. Salinity further compounds the question of irrigation where striking a balance determines the health of your tree. Staying in tune with your orchard and using appropriate methods to measure water need, water use, environmental water demand, and soil water-holding capacity will help inform irrigation management decisions.

There are all kinds of ways of estimating tree water need [4], a valuable piece of information for irrigation decision making. An inexpensive and often overlooked method of estimating tree water requirements is grower observation in the orchard to assess leaf color, leaf size, the look of the leaves, and canopy fullness. Pure observation and knowledge of your trees yields a lot of valuable information regarding irrigation management. Beyond observation, a direct measure of the tree with a porometer, pressure gauge (bomb), sap flow meter, dendrometer or other device gives an absolute or relative number of tree performance. Technological advances, such as telemetry and imaging with drones or satellites, holds promise, but are still being perfected for general irrigation use. In general, technological devices yield informative data, but tend to be expensive, delicate, and require manual monitoring to account for tree-to-tree variation in the orchard.

Soil moisture sensors can be an effective method of evaluating water use by the tree. The most basic way to measure soil moisture is with a human powered shovel or soil tube [5]. While it requires an operator who knows what they are doing, the technique is easily learned and repeatable. A human and shovel can move around an orchard checking out different suspicious spots that are not easily done with fixed-in-place sensors. Installation of soil moisture sensors systems range in cost and capabilities, yet provide specific data on water use. Integrating certain systems into communication relay systems allow for the monitoring of multiple sites at once. Some sensors can measure soil salinity, as well as soil moisture, to give a sense of whether the water in the soil will be useable by the tree. If soil moisture sensors are used, correct placement of where roots are taking up water is imperative to get an accurate assessment of water uptake. Overall, it is critical to keep the entire orchard in mind and understand that fixed sensors only take a specific location's reading.

Another great technique to inform irrigation scheduling is an estimate of the demand that drives water use. An evapotranspiration estimate either by CIMIS, a private weather station with evapotranspiration (ET) calculation or atmometer gives not only an amount to apply but also when to apply that amount based on the water holding capacity of the soil and the rooting depth of the crop. Soil moisture holding volume can be complicated, but can be estimated from the National Resource Conservation Service (NRCS) table in the previous paragraph[5] or from tables in the Web Soil Survey [7].

Simply running an irrigation system for a specific amount of time and probing for depth of water penetration and extent of wetted area is the best way to get an estimate of soil moisture holding capacity. This knowledge is needed in order to decide whether the active rooting volume is getting wetted sufficiently or too much is being applied. Emitters are rated by gallons per hour (gph), but that 1 gph, 5 gph, 20 gph emitter output might differ according to water pressure that can vary over an irrigation period. On the flip side, monitoring soil moisture depletion over time can give an approximation of how depletion compares to ET estimates. Soil moisture depletion can be measured by soil moisture sensors or by shovel and feel. This estimate of applied water compared to output and ET only needs to be done once at a given growth stage of the orchard. If the orchards is young, it will need to be done each year as the trees fill out. An estimate of canopy growth can also be used to better approximate young orchard ET.

All of these methods suppose that a grower has the capability to irrigate when, where and for how long they need to. If water delivery is on a fixed schedule and the amount of water can be controlled it is valuable to understand specific water needs. Knowing the rated applied amount of an emitter is important, but that amount should not be assumed, especially considering natural wear and tear, damage from harvest, poor filtration, clogging, or damage by wildlife. Maintenance to insure good distribution uniformity is critical to the operation and the correct application of water to trees and for the maintenance of tree health. Low-pressure systems are wonderful but they should be evaluated on a yearly basis and tuned up in preparation for every irrigation season. Many growing areas have mobile irrigation labs that will evaluate system performance and make recommendations for improvement.

All said, knowing the orchard and evaluating tree health will inform irrigation management decisions. Applying technology where technology is appropriate will help. Using it to help advise irrigation decisions is valuable, but new tools will not always be the answer.
It's important to know what is being applied.

Trust but verify.
Links:

[1]https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=20381
[2]https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=24319
[3] http://www.citrusresearch.org/wp-content/uploads/2008-Craig-Kallsen-Irrigation-Stress-on-Early-Navels.pdf
[4]https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=6806
[5]https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf
[6]https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=18384
[7]https://websoilsurvey.nrcs.usda.gov/app/
Drought Tips & Video: https://www.youtube.com/watch?v=LKSQRuHAnYA ;
https://anrcatalog.ucanr.edu/pdf/8549.pdf

The So-Called "Leaf Fleck" Virus Diseases of Citrus

Robert R Krueger, USDA-ARS National Clonal Germplasm Repository for Citrus & Dates Riverside, California

Huanglongbing has recently emerged as an existential threat to California citrus production. Although thus far it has been apparently confined to Southern California residential citrus plantings and has not yet been detected in Central or Northern California, its potential for destruction has resulted in most of the attention paid to citrus diseases (as well as most of the research funding) being focused on Huanglongbing. However, other citrus diseases have historically been deleterious to citrus production and their elimination is required in registration and certification programs. It is therefore important to remain knowledgeable regarding these diseases.

One such group of diseases is sometimes referred to as the "leaf fleck" diseases. This is a reference to the symptoms produced in indicator plants in bio-indexing. Bio-indexing was, until relatively recently, the only manner of detecting these diseases, which have quite different effects from each other in commercial orchards. Recent advances in understanding these diseases were presented at the XXI Conference of the International Organization of Citrus Virologists (IOCV) held in Riverside March 09 – 12, 2019. A brief over-view of these findings and their historical context will be presented in this communication.

The diseases to be discussed include Concave gum (CG), Cristacortis, Impietratura, and the newly described Citrus virus-A. These diseases for the most part have historically been associated with the Mediterranean area. CG has historically been present in California, apparently introduced with a varietal introduction before stringent guidelines were in place. CG, Cristacortis, and Impietratura all cause the so-called “oak leaf pattern” in young, tender spring flushes of sweet oranges and mandarins when temperatures are mild. However, other symptoms and the economic effects of these three diseases are different.

Concave gum causes the formation of “concavities” in the trunk and larger limbs of infected trees (Fig 1). These concavities are depressions or pits that may be up to several square inches in size. In the initial stages of concavity formation, the bark cracks and exudes gum. Gum may also be present on the exterior of long-established concavities and within the trunk under the concavities. A portion of the xylem is plugged with these gummy exudates. The overall effect on the tree is generally not death but rather a general debilitation. Higher levels of concavities are associated with a larger degree of tree debilitation and decreased yield and fruit quality (Wallace, 1978).

Cristacortis (Fig 2) also results in pits on the trunks and main branches of infected trees. However, the pits are smaller, deeper, and sharper and occur in both the scion and rootstock. As with CG, the effect is a general debilitation of the tree and decreased economic performance. Impietratura (Fig 3) differs from CG and Cristacortis in that there are no vegetative symptoms. Infected trees have large numbers of small, hard fruits. Gum deposits are present on the albedo at the stem-end of the fruit and in the stem near the fruit. In some fruits, there is surface browning with gum present beneath the surface (Wallace, 1978).
What these three diseases have in common is the “oak leaf pattern” of leaf clearing seen in the leaves of sweet orange and mandarin under appropriate conditions (Fig 4). These symptoms can often be seen in the field and this led to the development of a biological index for this pattern (Roistacher, 1995). This consists of the use of ‘Dweet’ tangor as an indicator, held under cool (65 – 75 ºF) temperatures in the greenhouse. ‘Dweet’ proved to be a more sensitive indicator than other mandarins or sweet oranges. A problem is that the patterns in the indicator leaves are so similar that differentiation is difficult or impossible. Isolates are maintained based on the identification of the source trees in the field. Other diseases, notably psorosis, produce similar symptoms in indicators but the symptoms differ from the oak leaf pattern (Fig 4). This led to the association of these diseases and some others as part of a “psorosis complex” for many years. Since for most of these diseases, a causal agent had not been definitively established, disconnecting of the oak leaf pattern-forming presumed viruses was done based upon transmissibility, ability to cross protect, epidemiology, etc (Timmer and Beñatena, 1977; Wallace, 1978).

Recently, the di Serio group in Italy (Navarro et al, 2018a, b) and Vives in Spain (presentation at IOCV, 2019) have identified viruses associated with some of the leaf-flecking diseases and have developed laboratory assays for them. Navarro et al (2018a) identified a CG-infected tree by bio-indexing and excluded psorosis by molecular methods. Next-generation seque3ncing (NGS) identified an apparently new negatively stranded RNA virus, Citrus concave gum associated virus (CCGaV). CCGaV was originally said to be a member of the genus *Phlebovirus*, previously only reported in insects (Navarro et al, 2018a). However, further phylogenetic studies led to a proposal to create a new genus *Coguvirus* to accommodate CCGaV. A second virus from the proposed new genus *Coguvirus* was isolated and identified as Citrus Virus A (CiVA). A field survey in Southern Italy encompassing 71 trees showed 15 trees with CiVA present and 5 trees infected with both CCGA and CiVA. Ten of the trees were infected by CiVA and not CCGaV and were asymptomatic. CiVA did not produce symptoms in inoculated plants of 'Dweet' tangor, 'Madame Vinous' sweet orange, or other potential indicator plants (Navarro et al, 2018b).

At the IOCV conference, Vives reported Phlebo-like viruses associated with CG, Cristacortis, and Impietratura. A CG isolate (CG-24, originally from California) and an Impietratura isolate I-501 showed homology with CiVA, whereas Cristacrotis isolate C-601 (from Corsica) showed homology with CCGaV, based upon the sequences published by the de Serio group. At the same meeting, several other possibly-related viruses were discussed. Park from Texas presented an oak-leaf inducing virus that acted similar to a CG isolate CG-301 but grouped with CiVA was dubbed Citrus oak leaf associated virus (COLaV). Bester from South Africa described field trees that had psorosis-like trunk and limb symptoms but were negative for psorosis. Some apparent viruses were sequenced, some more like CCGaV and some more like CiVA. Cao from China described five new viruses that would also be related to CCGaV and CiVA that, converse to the South African report, produced leaf symptoms but no trunk symptoms.

These new developments are starting to shed some light on these previously mysterious diseases, but are also opening up new questions. Of particular interest in California is what we are calling CG isolates may in fact be CiVA isolates. This is confusing because the trees producing these isolates were those identified as CG trees based upon the field observations. Some of these trees are still maintained as field trees in Riverside. It is possible that the CG tree used by Navarro et al (2018a) to identify CCGaV had symptoms similar to our California CG trees but actually were caused by a different causal agent. However, our California CG isolates consistently produce symptoms in the 'Dweet' indicator whereas CiVA did not (Navarro et al, 2018b). In any case, the new NGS methods have revealed interesting new insights into these interesting old diseases.

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Figure 1. Concave gum symptoms in sweet orange tree in Riverside.

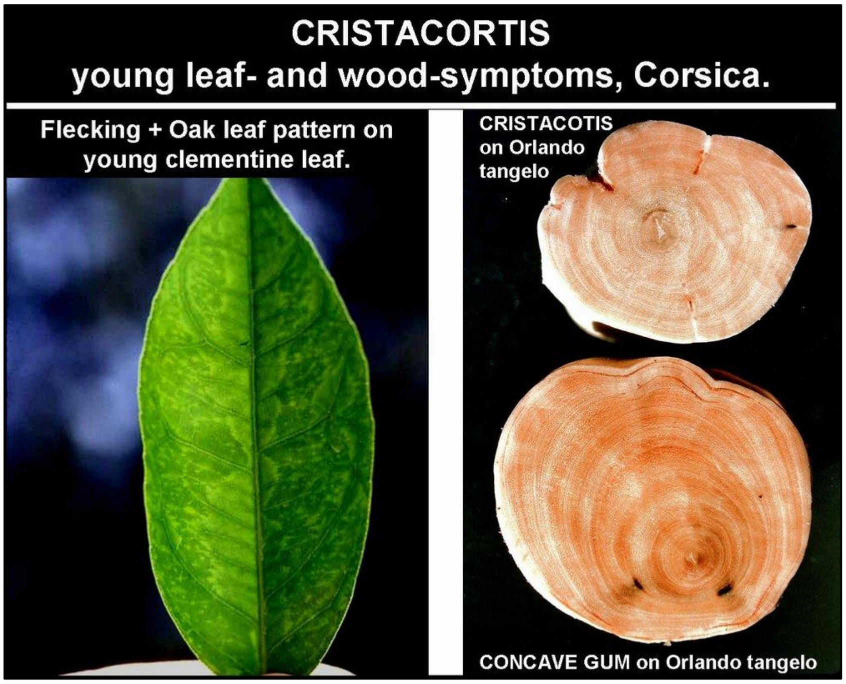

Figure 2. Cristacortis symptoms (source: iocv.org).

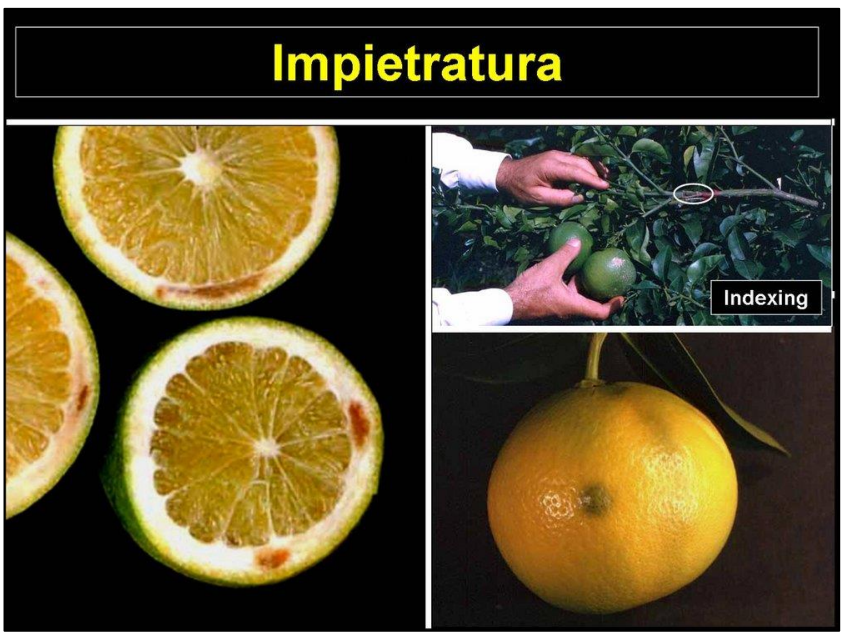

Figure 3. Impietratura symptoms (source: iocv.org).

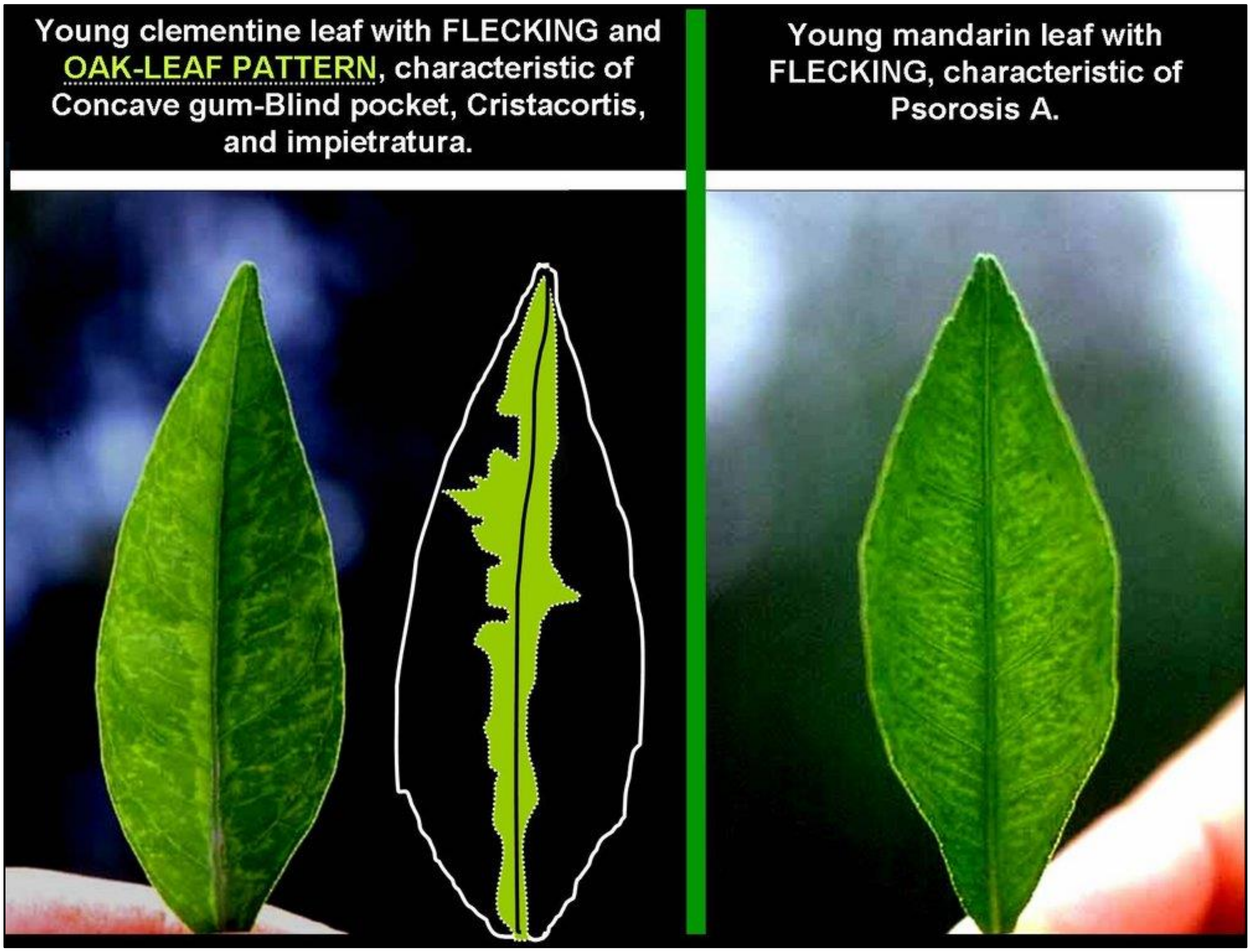

Figure 4. Oak leaf pattern associated with concave gum compared with leaf flecking associated with psorosis.

Replanting Trees in Mature Citrus Groves

By Craig Kallsen, UC Cooperative Extension Advisor, Kern County

While citrus groves are long-lived, the individual trees that compose the grove are not necessarily so. Inevitably, for many reasons, some mature trees will eventually die and be replaced with baby trees from the nursery. The process of growing these replants into productive trees can be a slow process and frequently hazardous to the health of the replant.

When considering replanting dead or dying trees, the first relevant decision, and generally outside the scope of this article, is the economic viability of the grove. If many replants are required, perhaps the soil or location is unsuitable for citrus. It may well make more economic sense to push the grove out and switch to a different crop.

Before replanting a given tree, the grower should try to determine why the original tree or trees died. If it was a stubborn-infected tree, neighboring host weeds, if present, such as the mustards or Russian thistle, may require control. If the original tree died from a root rot, the irrigation system may need replacement and water application efficiency or drainage may need to be addressed. Vertebrate pests, insect pests, fungal diseases or nematodes may need to be treated. A wide variety of rootstocks are available to the grower, and changing the rootstock of the replants from what currently exists in the field might be a viable option for improving the health and productivity of the new trees in response to disease, incompatibility issues, frost hazard or pH related nutrient-absorption problems in the grove.

After deciding to replant missing or sick trees, select the best possible replants from the nursery. Equal, if not more, care should occur in selecting replants as occurred in buying the original trees for the orchard. There is a tendency for "left-over" trees to end up as replants. Trees should be large, but not root bound or J-rooted, vigorous, with healthy, green foliation and free from insect, mite and snail pests.

An unexpected hurdle in some older orchards is choosing the variety to replant. Citrus is long-lived tree and the navel orange is a good case in point. For example, some navel varieties planted decades ago are no longer available. Some groves have changed hands so many times growers are not sure what selection of navel they have in their grove. In fact, navels were being planted so fast in the 1960's that it's doubtful that even the original owners were sure which rootstock or variety they were getting. Replacing a Frost Nucellar with a Parent Washington is of little consequence; however, real differences in maturity become apparent between a Newhall versus Washington navel. When many blocks of citrus are replanted at the same time, special care should be taken to insure that the Valencia replants end up in the Valencia groves and not in the navel groves and vice versa. Putting different varieties on the same trailer for planting is asking for a mix-up.

The environment for the replant in a mature grove is very different from that which young trees in a newly planted grove experience. The growth rate of the replant will be slower, simply because of shading from large, full-grown neighbors, and this is tough to mitigate. However, the grower is able to adjust the flow of water, nutrients and pesticides to the size of the replants compared to the mature trees. The water requirement of the newly replanted tree is probably $1/50^{th}$ of that of the mature tree (i.e. the newly planted tree may only transpire about one gallon of water per day during the summer). Water to the replant may be decreased by the use of emitters having a much reduced flow-rate (which have to be monitored closely, as the smaller orifices are more likely to plug) or through the use of devices such as pulsators which interrupt the flow of water at intervals reducing the total flow rate per unit time. If fertilizer or amendments are injected through low-volume irrigation systems, decreasing the flow of water to the trees through smaller emitter orifices will concomitantly decrease the flow of nutrients. Reducing the level of fertilization is critical for good replant growth, since for example, the nitrogen requirement of the young tree is only a fraction of that for the mature tree.

Figure 1. Replants are subject to many vicissitudes. This replant appears to be the victim of crows looking for something to eat in the tree wrap (photo by Craig Kallsen).

Controlling weeds adjacent to replanted citrus avoids excessive competition for light, nutrients, and water. Weeds can become especially thick around replants because of the more open, less-shaded ground around them as compared to the limited area now adjacent to mature trees. When the herbicide applicator encounters these weedy areas, the tendency is to give the replant space an especially heavy application. On young trees this can be especially damaging as the chance for both foliar and root uptake of the pre-emergent herbicides, and foliar uptake and burn from post-emergent herbicides, increases. In heavily replanted groves, the use of only carefully applied post-emergent herbicides may be beneficial until the replants achieve sufficient size to tolerate the pre-emergent materials. Many groves have sufficient residual pre-emergent herbicides to carry them through a year or so of replant establishment without a substantial increase in weed pressure. The hoe is a surprisingly effective tool for keeping weeds under control around replants and provides an opportunity for scheduled inspection of the replants for other possible problems. Gophers quickly find weedy areas and, experience suggests, consider citrus roots just as appetizing as the roots of weeds.

Some pre-emergent herbicides are registered for new citrus plantings and some may be injected through the irrigation system. Because of their increased cost, growers may be reluctant to use these potentially less-phytotoxic chemicals. The grower should be aware that most label directions for many of the less-expensive pre-emergent, and thus commonly used, herbicides are much different for young trees as opposed to mature trees. For example, pre-emergent herbicides containing simazine and diuron, should not be used on citrus that has been in the ground for less than a year, and some herbicides containing both diuron and bromacil, are not labeled for use if the citrus is less than three years old. The use of these herbicides in mature groves can greatly affect the growth of new replants, especially, if used in groves with coarse soils low in organic matter. Some applicators are cautioned to turn off their machines before spraying some pre-emergent materials adjacent to a replant, but the grower should be aware that some herbicides travel down-slope with surface-drainage water.

Inspection of replants should be an active part of the pest control procedure of any grove. The pests of mature trees are rarely the same as for the juvenile replants. Several species of ants are capable of establishing hives in the wraps of young replants, which can result in trunk girdling. Heavy feeding of the false chinch bug, which does not damage mature citrus, can result in the rapid death of a replant, while pests like the brown garden snail, California orangedog (http://ipm.ucanr.edu/PMG/r107302311.html) or Fuller rose beetle can set the tree back seriously. Ground squirrels, meadow mice and rabbits can strip the bark and leaves or girdle the trunk killing the replant.

Young trees planted in mature groves appear to be more at risk from freezing than do trees of equal age in new grove establishments. This may be partly due to the increased shading of the ground by large trees and tree litter inside mature groves, which allows for less absorption of heat for radiation back to the trees at night, or the generally, poorer health of replant trees. Replants in cold areas definitely need to have the trunk tree-covered or trunk wrapped with an insulating material. If possible, avoid tying the wrap to the tree as lower wind speeds within a mature grove makes tying less necessary. If not checked, as replants commonly are not, these ties may eventually girdle the tree.

Producing mature, productive trees from replants requires extra effort and expense. To make matters worse, the pay-off can be a number of years down the road. However, actively growing vigorous replants, in older blocks with many missing trees, may eventually determine the difference between profit and loss. Big, healthy replants can help sell an older orchard; an important consideration when owners' thoughts of getting up in the middle of Christmas or New Year's Eve, to start wind machines begins to lose its appeal.

What about Planting Lemons in Kern County?

By Craig Kallsen, UC Cooperative Extension Advisor, Kern County

Kern County is located at the southern end of the San Joaquin Valley of California. Over the past couple of years, I, as the citrus Farm Advisor for the University of California Cooperative Extension in Kern County, have received an increasing number of enquiries about the feasibility of growing lemons here. The answer is “yes” we can grow lemons here and according to the latest Kern County Agricultural Commissioner’s Report (2017) we have 4010 acres of bearing and 10 acres of non-bearing lemons in the county. Those 10 acres of non-bearing lemons indicate that fairly recently someone decided lemons were the way to go.

These enquiries as to the feasibility of growing lemons are understandable. The price and demand for lemons in the U.S. and worldwide is increasing. Depending upon where you get your statistics the retail prices of lemons was something like $1.50 per pound from 2011- 2013 to something like $2 a pound from 2015 – 2017. The statistics show 2018 was even a better year for selling lemons. Consumption of lemons in the U.S. was less than 1 million metric tons in 2011 to about 1.25 million metric tons in 2017. Worldwide consumption has increased from about 4.5 million metric tons in 2011 to 5.5 million metric tons in 2017. If you add in other factors such as a heat wave, which, for example, hit Ventura County production hard in July 2018, or extreme winter freeze events, and sometimes-erratic supplies from other lemon producing areas of the world, prices can skyrocket 40% or more in a month. Being able to sell a carton of lemons for excess of $55 can be very attractive to prospective growers. Not surprisingly, if you compare the cost and returns of growing lemons with those of oranges, a person might wonder why anybody would choose producing navels over lemons (see https://coststudies.ucdavis.edu/).

Planting lemons is riskier. In the San Joaquin Valley, the major consideration is the greater frost sensitivity of lemons as compared most other citrus crops. Not only do lemons freeze at a higher temperature, so do its branches. A freeze, which can spoil orange or mandarin production for a year, can devastate lemon production for three years due to increased damage to the lemon canopy and the older branches of that canopy. If your tree freezes back to the major scaffold branches, you are out of business for a while. An important question is how often does it cold enough to destroy my lemon production capacity for three years or more? Industry wide, for the last 30 years we have had three freezes where lemon leaf canopies, even in the warmer areas of Kern County, were severely damaged – December 1990- January 1991, December 1998, and January 2007. Not to be an alarmist but, in looking at these dates, it would appear that we may be overdue for an extreme freeze. We flirted with one in early December of 2013. Over the years, I have noticed that as the time interval increases from the previous frost event, citrus orchards move further and further down onto the valley floor, only to retreat to higher ground after the next severe event.

Well, what about global warming? Shouldn't Kern County be getting to be a safer place to grow lemons? In answer, predictions can be difficult, and according to baseball legend Yogi Berra, this is especially so if they are about the future. Winter air temperatures have been climbing over the past 30 years in the southern San Joaquin Valley. With our Mediterranean climate in the SJV, most of our rain falls during the fall and winter. Drought years, which means drought winters, have become more common. The higher winter temperatures are good news for citrus growers, but the droughts have been bad news in that dry air in not conducive for fog formation. Fog, historically, is our winter blanket, that holds temperatures above freezing when conditions are ripe for rapid drops in temperature associated with clear, windless nights following cold fronts that move into the valley from Alaska and other points north.

The risk in growing lemons can be mitigated. As with any real estate endeavor, the three most important factors governing the value of a prospective lemon property are location, location and location. When we are talking about cold temperatures, we are talking about nighttime low air temperatures. Daytime winter temperatures, once we get into mid-morning, usually, are more than warm enough to keep lemons from freezing. The major mitigation factor under human control is to plant lemons in the areas of Kern County that have the warmest nighttime temperatures. These areas tend to be on the lower slopes of the foothills on the eastern and southern areas of the SJV. Cold air is much heavier than warm air and runs like a river downslope. Good cold drainage is necessary. If lemons are planted too far out onto the valley floor, they end up at the bottom of a lake of cold air during late fall and winter freeze events. The area where citrus is grown, often, is referred to as a belt along the lower foothills of the SJV. Not only is this belt characterized by more fog than higher up in the foothills, but also it is close to the atmospheric inversion layer that forms in the SJV during the winter. The SJV is at the bottom of a large deep bowl formed by surrounding mountain ranges, and the depth of this bowl makes the air more difficult to disturb by wind. This still air, on cold, clear nights during the winter, allows heat radiating into the sky from the ground to warm a layer of air, usually located from 500 to 1000 feet above the valley floor. The idea of using wind machines successfully is to move this layer of warm air down to the trees on the ground. If you are down on the valley floor, on most nights the warmer air is way too high up to bring it down to the ground with wind machines. If an orchard is 500 feet above the valley floor on the side of a foothill, you might already be in the inversion layer and won't even need to start your wind machines, or at worst, the inversion layer is close enough to bring that warm air down to the trees with wind machines. Unfortunately, the amount of land winter-warm enough for growing lemons in the foothills is very limited, and, currently, is occupied by other crops, probably citrus. We cannot grow lemons too high up in the foothills, because these areas are above the inversion layer and winter temperatures there will always be too cold for lemons. Kern County, in general, appears to be colder than its neighbor Tulare County to the north, and usually suffers more in terms of fruit and tree losses during extreme frost events.

Those bold enough to grow lemons appear to have more choices on which lemon to grow now than in the past. Some newer seedless or lower-seeded lemon varieties are available (https://citrusvariety.ucr.edu/). The Lisbon lemons, of which there are several selections, is an old Kern County standby, and appears to have better frost tolerance than the Eureka, commonly grown in the central and southern coastal areas. The Improved Meyer lemon is a hybrid, apparently, with citron, mandarin and pummelo heritage, and has excellent frost tolerance. However, the fruit does not hold up well on the tree, in storage or ship very well, and few commercial groves exist. It remains a very popular and successful backyard tree for homeowners.

With the threat of the Asian Citrus Psyllid (ACP) and the Huanglongbing disease it spreads, the feasibility of growing citrus under protective screens (CUPS) is under investigation. These protective screens, in addition to keeping ACP out, would likely provide additional frost protection as well.

The other obvious concern related to the number of enquiries I have received, is that even if lemons are not widely grown in Kern County now, worldwide demand suggests that there are likely many new acres of lemons in the ground now or in advanced planning stages in other locations in California, Arizona and the world. In the past, we have seen the acreage of a number of crop commodities rise and fall with the laws of supply and demand. We have planted and then pulled lemons in Kern County before based on market conditions. At some point, even unfrozen lemons will not sell if there are too many out there.

Figure 1. Frozen mature lemon trees in photo background, after the 1998 freeze in the Edison area of Kern County. Juvenile, undamaged navel orange trees in foreground (photo by Craig Kallsen).

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