CENTRAL VALLEY POSTHARVEST NEWSLETTER

COOPERATIVE EXTENSION ● University of California
Kearney Agricultural Center
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KAC FRESH FRUIT POSTHARVEST HANDLING DAY – FEBRUARY 15, 2007

Excellent research on disease epidemiology and control has been carried out by Adaskaveg and Michailides teams during the last four years, and now it is time to put this investment to work.

A full day program focused mainly on decay control for tree fruit and table grapes will be carried out at the Kearney Agricultural Center on Thursday, February 15, 2007. This program will include lectures and demonstrations on decay identification, preharvest-postharvest fungicide management, equipment-packingline sanitation, new potential alternatives or complements to conventional control, and other related topics. Hands-on demonstrations on how to apply fungicides, and how to identify diseases; corky spot, etc. will be part of the program. Experts in this research area such as Jim Adaskaveg, Harry Andris, Carlos H. Crisosto, Kevin Day, Joe Smilanick, Themis Michailides and others will be part of the program.

For more information please contact Carlos H. Crisosto by phone at (559) 646-6596 or email carlos@uckac.edu.

SCHOLAR'S MENTOR GETS AN EMERGENCY REGISTRATION TO HELP MANAGE SOUR ROT OF STONE FRUIT IN CALIFORNIA

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The new postharvest fungicide Mentor 45WP from Syngenta Crop Protection received a Section 18 Emergency registration in California for managing sour rot, a decay of summer stone fruit. This is the first postharvest registration of this fungicide on any crop. The California Grape and Tree Fruit League made the request and made every effort to obtain the registration that was approved on August 1, 2006. The fungicide is highly active against the fungal pathogen *Geotrichum candidum* and should provide some relief for growers, packers, and shippers that have been facing the disease that has been on the increase in the last several years. With higher fruit quality demands by consumers, riper and better tasting fruit that are ready to consume are being delivered upon arrival to markets around the world. Ripe fruit, however, promotes decay problems like sour rot in addition to the usual set of decays, namely brown rot, gray mold, and Rhizopus rot.

The pathogen of sour rot, *G. candidum,* is causing both pre- and postharvest sour rot of ripening fruit. Symptoms include a watery, soft decay with a thin layer of white mycelial growth on the fruit surface. Rotted fruit have a characteristic yeasty to vinegary odor, but other odors may develop with bacterial contamination that commonly develops in the watery decay. The fungus is a wound pathogen that decays fruit after spores are deposited into injuries. The organism is commonly found in soil and is carried on dust or dirt onto fruit surfaces. Other yeasts have also been reported to cause decays of ripe fruit similar to sour rot. These decays (i.e., yeast rots), however, are generally of minor importance and should not be confused with sour rot.

Sour rot has become a major decay problem this summer in the production of fresh market stone fruit – peaches, plums, and nectarines in California. With the protracted bloom season this past spring, many varieties are not ripening evenly, resulting in a range of fruit firmness and stages of fruit maturity at harvest. Furthermore, high spring rainfall and high summer temperatures have resulted in numerous fruit with split pits and heat- injured epicarps (peels) that are ideal injuries for decay fungi including sour rot. These extreme weather conditions have also increased the incidence of some other yeast species. All these factors have potentially increased pathogen populations and increased fruit susceptibility to sour rot. Generally, first harvests of an orchard block are not a problem but by the second and third harvest, an increase in sour rot incidence occurs. In a recent evaluation of a second harvest of a white peach and a nectarine variety, 3% and 5%, respectively, of the fruit had sour rot upon arrival at the packinghouse after a morning harvest despite a preharvest fungicide program. Still, crop losses are generally low when the disease develops prior to harvest, but losses can be very high during storage, transport, and market display. This summer, crop losses of 20 to 30% for fruit in storage and transit have been commonly reported for selected varieties. Thus, the pathogen is being brought in on decayed or injured fruit and then the packingline is being contaminated. This results in the inoculation of healthy fruit bound for packaging and further handling, transportation, and final market display.

Help is on the way.

For the past several years, the California Tree Fruit Agreement (CTFA) has supported research of two labs (Adaskaveg and Michailides) at the University of California to improve our understanding of the pathogen and the disease, as well as to develop new management programs for reducing sour rot. Our research identified a series of strategies to combat the disease and include identification of susceptible varieties, orchard sanitation and dust control, fruit firmness and maturity levels, and postharvest sanitation methods for fruit and equipment (see below). Stone fruit varieties vary widely in their susceptibility to sour rot and thus, management programs should be developed specifically for each variety.

One of the most effective strategies is the identification of a fungicide that can be used postharvest. After screening most pre- and postharvest fungicides registered or planned for registration on stone fruit, propiconazole was identified as one of the most effective fungicides against sour rot. Yeast rots are not managed with this fungicide. Propiconazole was already registered as Orbit 3.6EC for preharvest use for managing brown rot and powdery mildew of stone fruit crops in the United States. Thus, the product name Mentor is appropriate because it is a fungicide developed before fludioxonil (Scholar). The emulsified concentrate formulation works well for decay control, but it is very odoriferous for postharvest use in an enclosed area. Thanks to Syngenta's cooperation, we evaluated several new formulations, and the wettable powder (WP) formulation fit the bill. The final mixture with water is odorless and mixes well with aqueous dilutions of postharvest fruit coatings and other postharvest fungicides that manage postharvest decays not controlled by propiconazole. Thus, Mentor 45WP is specifically formulated for postharvest use and is highly effective against sour rot. The mixture of Mentor 45WP with Scholar 50WP (fludioxonil) will provide the broadest activity spectrum against decays of stone fruit ever developed. Both materials can be used in 4 oz/6 oz or 4 oz/8 oz ratios (Mentor/Scholar) per 200,000 lb of fruit. These rates may appear low but both fungicides are extremely active at low rates and low residues on fruit. The label for Mentor will include the same low- and high-volume application methods as Scholar including controlled droplet (CDA, 8-25 gals/200,000 lb of fruit) and high volume (e.g., Dips, Drenches, or T-Jet nozzles set for 100 gals/200,000 lb of fruit) applications. The fungicide with the final approved label will be available by mid-August and will be sold in 8-oz packages. The Section 18 is valid from August 1 to September 30, 2006 and any unused material will need to be returned to the registrant. Four counties, Fresno, Tulare, Kings, and Kern, are included in the Emergency registration.

For this year, postharvest treatments with Mentor are to be made only on fruit that have <u>not</u> received preharvest cover sprays with Orbit 3.6EC except for bloom treatments. Preharvest fruit applications with other fungicides are acceptable. The goal is to stay well below the maximum residue limit (MRL) or tolerance of 1 ppm (1 mg propiconazole per 1 Kg of fruit) for the pre- or postharvest use. To prevent fungicide-resistant pathogen populations from developing to propiconazole, mixing Mentor with Scholar will minimize the risk for *Monilinia* spp. to become insensitive to propiconazole. Scholar is not registered for preharvest use and belongs to a different class with a different mode of action. The mixture provides complementary high activity against brown rot. Mentor is effective against brown rot, sour rot, and partially effective against Rhizopus rot, whereas Scholar is highly effective against brown rot, gray mold, and Rhizopus rot.

Preharvest strategies for sour rot and brown rot management.

Previously registered pre- and postharvest fungicides were not effective against sour rot. As discussed above, propiconazole was the most effective fungicide evaluated. Tebuconazole (Elite 45WP) is somewhat effective against the pathogen, but much less than propiconazole. Preharvest applications of these fungicides help but are not stand-alone treatments in reducing the incidence of sour rot. Again, remember, if postharvest use of Mentor is planned, propiconazole containing fungicides (Orbit, Bumper, etc.) cannot be used as preharvest fruit cover treatments this year and other fungicides will have to be selected if a preharvest fungicide program is needed. If sour rot is not a problem or no postharvest applications of Mentor are planned, then propiconazole-containing fungicides can be used.

For brown rot management, two to three applications of Indar (fenbuconazole), Elite (tebuconazole), or other fungal demethylation inhibitor (DMI) fungicides are suggested for application within two to three weeks of harvest and ideally at 7- and 1-day preharvest intervals (PHI). An excellent rotation fungicide for brown rot control is Pristine (pyraclostrobin and boscalid). As an example, a DMI fungicide could be followed by Pristine for the first harvest of a block and then a rotation back to a DMI fungicide for the second harvest of that same block would be an excellent program. Pristine followed by two DMI fungicides would also be acceptable but would be a higher risk for selecting for resistance to the DMI fungicides. Use of the anilinopyrimidines fungicides (e.g., Vangard, Scala) as rotational materials instead of Pristine would also be very good, provided temperatures and humidity are at moderate levels. As always, follow label directions and limitations of all these fungicides.

Epidemiology of sour rot and integrated management programs.

The sour rot pathogen is widespread on organic material in the soil. In the field, spores of the fungus may be spread by vinegar flies and dust deposited in cracks or bruises in healthy fruit. The spores may also be spread in picking boxes and handling equipment. During harvest micro-wounds occur on the fruit and these may function as infection sites. Fruit should not be picked up from the orchard floor, and dust control of orchard floors and roadways is an important practice and should start with the first color pick and continue as fruit mature. Fruit handling methods that minimize injuries are critical. Highly susceptible varieties should be picked and transported in small containers to minimize rubbing and bruising injuries that may occur in bins. All fruit should be carefully sorted at the packingline. Care in handling should be taken to prevent injuries. When the fruit are washed, the wash water may carry spores of the fungus into fruit wounds. Thus, fruit should be washed using a disinfectant with a surfactant such as chlorinated water mixed with neutral cleaner. To be effective, chlorinated washes need to be monitored and maintained at 50-100 ppm free chlorine (hypochlorous acid) at a pH of 7.5-8. Equipment should be surface disinfested with chlorinated water or quaternary ammonium products at recommended dilutions and then rinsed with potable water after every fruit lot.

Furthermore, the decay can be managed with proper temperature management guidelines of maintaining fruit at 32-35ºF. The minimum temperature for spore germination, growth, and infection of the fungus is about 36ºF (2ºC), the optimum is 77-80ºF (25-27ºC), and the maximum is 101ºF (38ºC). At above 60ºF (15.5ºC), the rot spreads very rapidly in ripe peaches. Decay will essentially stop developing if fruit is maintained below 41ºF (5ºC); however, if the fruit was already inoculated, decay develops quickly once the fruit are stored at higher temperatures. Thus, rapid cooling of the fruit and refrigeration at low temperature will reduce losses from sour rot.

Several aspects of sour rot make it potentially a serious decay problem:

- Incipient or early infections cannot be easily observed and infected fruit may become packed with healthy fruit into the same box.
- Sour rot may be misidentified resulting in claims concerning the ineffectiveness of postharvest treatments with Scholar.

- Sour rot spreads rapidly at temperatures above 41ºF (5ºC).
- Only a single currently registered fungicide (i.e., propiconazole) is very active against sour rot. Preharvest applications with Orbit 3.6EC will reduce the incidence of sour rot, but postharvest treatments with Mentor 45WP will be much more effective if 100% coverage and uniform dosage is provided.
- Integrated management programs have to be followed that include proper harvesting and handling of fruit to minimize wounds and soil contamination. Additionally, sanitation rinses that prevent spread of inoculum and new inoculations of fruit during postharvest cleaning and low-temperature storage (<41ºF or 5ºC) are required for effective control.

FRUIT BLEMISHES (CORKING AND SPOTTING)

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Along with many other problems, fruit corking and spotting marred the 1998 season. The condition appears at or near harvest as dark sunken spots on the surface of the fruit. The fruit sides and blossom end are most greatly affected; symptoms are rarely observed on the shoulders. Internally, the flesh turns brown, dry, and corky, and sometimes the lesser-affected areas of the flesh take on a reddish-white coloration. Although it has been seen many times in the past – I first encountered the problem in 1985 – this year's problem was particularly severe with losses approaching 100% in some orchards. Mostly mid-season and some late-season varieties were affected. Both yellow and white-fleshed fruit were afflicted. Fruit from a range of soil types and tree ages were also harmed by this problem. Curiously, after causing severe damage, the problem lessened and virtually went away as the season progressed.

Early (c. 1930s) stone fruit reference materials cite a similar condition called "blossom-end breakdown" or "Sims Spot" after the variety of cling peach on which it was first discovered. This disorder is described as first developing as "small round light colored blister-like areas that always occur on the blossom end" and progressing to flesh symptoms similar to those described above. The biggest difference in symptomology between these references and what was observed in 1998 is that the recent problem was not limited exclusively to the blossom end of the fruit.

In the past when I have observed this problem it has almost always been on young (3rd or 4th leaf), vigorously growing, lightly cropped trees. Additionally, the problem was most severe when the season was cooler than normal. The problem was always restricted to mid-season or later varieties – I have never seen it occur on a variety ripening earlier than 'Elegant Lady'. I have seen the problem on a diverse enough range of varieties to be assured that no one particular nursery or plant breeder can be implicated in the problem.

The biggest question remains "What is the cause of the problem?" The safest answer is that we do not know. Many answers have been given, the most frequently cited being calcium deficiency. Based on what is known about calcium deficiency in apples (the problem is most severe in cool seasons, on lightly cropped vigorous trees), this appears to be sound. However, this does not explain why so many older, fully cropped orchards were afflicted in 1998. It also stands that if calcium were the sole cause of the problem, the condition would not have gone completely away as the season progressed.

The condition remains somewhat baffling and difficult to characterize. However, the following portion of this paper will attempt to discuss how several factors may influence fruit cork spot and flesh breakdown of stone fruits.

NUTRITION

Calcium

Outside of experimental sand culture, there has never been a documented case of calcium deficiency on trees. By that I mean conditions where leaf deficiency symptoms occur and plant growth is affected. There are, however, calcium related disorders that can occur despite plants having what appears to be sufficient concentrations of calcium in leaves and other plant tissues. The most common and well-known of these conditions includes bitter pit of apples.

There are two major calcium related disorders affecting apples, bitter pit and cork spot. The visual symptoms are similar – dark spots on the fruit surface and dry corky breakdown of the flesh of the fruit. Bitter pit, however, is a storage-related condition that only appears after fruit have been harvested and stored. Corking is a field-related problem affecting fruit on the tree. It is made worse under conditions of low calcium, but is not caused by low calcium. Corking is also variety sensitive and is worse under conditions of high vigor and moisture stress.

Calcium is one of the most widely studied elements in plant nutrition. Studies throughout the world have focused on the beneficial affect of calcium on fruit quality. In apple production it is common to include calcium with nearly every in-season spray application. Results of studies with stone fruit have been inconclusive. Most research performed with stone fruit indicates that it is exceedingly difficult to get calcium into the fruit. Several reasons may account for this including rates, timing, application method, and material formulation. Evidence exists that summer pruning may help improve calcium concentration in fruit since the removal of vigorous shoots reduces fruit competition for available calcium. While helpful as part of an overall program, summer pruning by itself is not adequate to control severe calcium related problems.

Boron

Boron deficiency is a potential problem in stone fruit production. We usually think of boron as affecting flowering and fruit set. However, the fruit symptoms of boron deficiency include internal and external corking accompanied by dry pithy lesions in the fruit. This description is very similar to what we experienced in 1998. In apples it is known that if boron deficiency does not become severe until late in the fruit developmental period, the main symptom may be internal cork formation. This condition is worsened under conditions of heat and/or water stress. (See below for a full discussion of this issue.) It is also known that boron deficiency in apple is often confused with cork spot (cork spot is calcium related). In peach, boron deficiency of this type causes fruit to develop brown, dry corky areas in the flesh. Additionally, boron is readily leached by heavy rain and deficiencies are common under conditions where there is poor root activity – wet cold springs for instance. Based on this information what we experienced in 1998 may have been boron related rather than calcium related.

Nutritional Balance

Both Ca and B deficiencies are made worse when trees are out of balance. This is usually interpreted to mean vigorously growing trees that have been pushed with excessive nitrogen. In 1998 it is well known that trees grew exceptionally well. Also, the spring rains and storms provided much free N.

Furthermore, boron is an element that is readily leached. The heavy winter and spring rains may have leached boron during the critical periods of fruit development as cited above. Additionally the cold wet soils early in the year did little to help root growth and this also likely impeded the uptake of both boron and calcium.

Plant Analysis

Plant analysis can be helpful for diagnosing either of these deficiencies. Boron deficiencies are easily detected by leaf analysis. In the case of calcium, leaf samples are unlikely to uncover deficiencies. Because of this, in apples – where calcium nutrition is so important – it is common to test fruit tissue calcium concentrations in both the flesh and peel. We do not know what critical levels may be for such tests of stone fruit. In the past we have analyzed peach and nectarine fruit affected with corking. Affected areas have sometimes been low in calcium, but these tissues are essentially diseased and so would naturally test low.

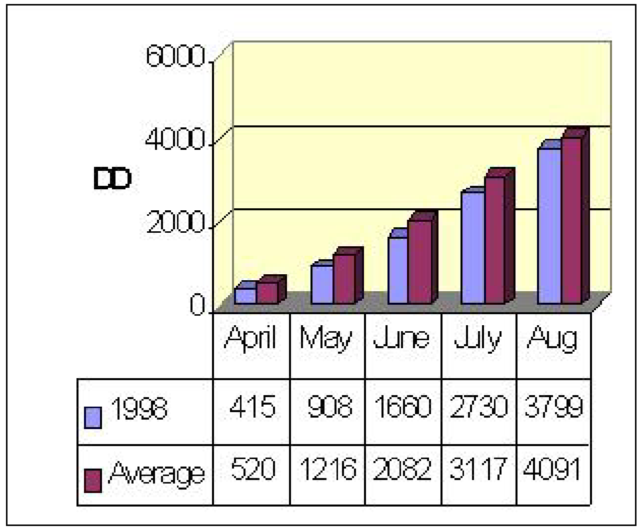
The best current recommendations can only be made to continue practicing good nutritional programs in all orchards. This includes adequate soil and tissue testing to maintain proper tree nutritional status. Excessive use of nitrogen especially should be avoided as it can cause both calcium and boron to be reduced in plant tissues.

ENVIRONMENTAL CONDITIONS

Seasonal Temperature Patterns

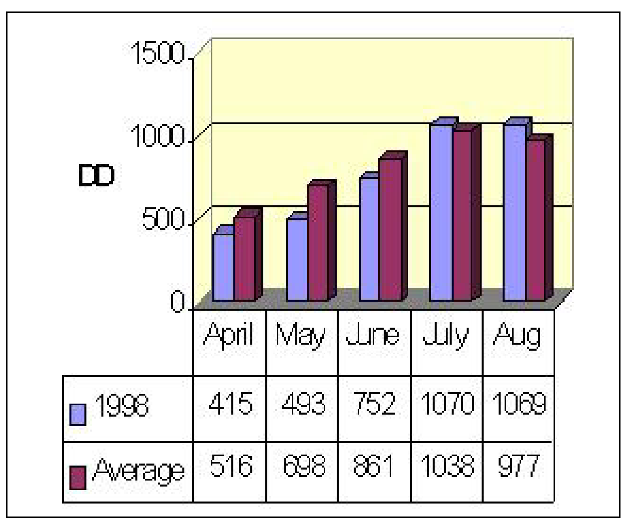
The 1998 season was considered to be a "cool" year, with fruit harvest running as much as several weeks later than "normal". The data shown in Figure 1 give a graphic representation of the heat unit accumulation that occurred during the season as compared to a 16-year average. Indeed, 1998 was the coldest season during the 16-year period available for analysis.

Figure 1. Seasonal total heat unit accumulation: 1998 vs. 16-year average.



A better understanding of the season can be gathered by looking below at Figure 2. During the 16 year period studied, the coldest April, May, and June each occurred in 1998. August was hotter in 1998 than any of the other years. July 1998 was warmer than average, and it was the 5th hottest July of the 16-year period, with most of the heat accumulated after the middle of the month.

Figure 2. Monthly heat unit accumulation: 1998 vs. 16-year average.



From the temperature data presented, it is clear that 1998 was unique in several respects. The season was characterized as one of the coolest springs in history – this of course explains the lateness of the year. On the other hand, August was the warmest in recent history. The second half of July was abnormally warm as well. Fruits that ripened in late July and early August were subjected to both an abnormally rapid warm-up and great amounts of heat. These environmental conditions undoubtedly contributed to the problem of fruit corking. Fruit that entered the final ripening process after this abnormal warm-up seemed to develop and ripen properly without the corking problem being manifested.

Environmental Stress

Cool spring temperatures have been implicated in contributing to low calcium and boron concentrations in plants. Furthermore, boron accumulation is particularly sensitive to drought conditions. During periods of high water demand even well irrigated trees can undergo significant amounts of stress.
During July of 1998 it is likely that the high heat and water demand, after transitioning from an abnormally cool spring and early summer, may have caused some type of imbalance to occur in developing fruits. This stress might have affected both boron and calcium accumulation as well as many other physiological processes. Orchards that were stressed during this time may have been those that were most affected. This may help explain several of the discrepancies I noted this year such as adjacent or nearby blocks of the same varieties showing the problem in one location and not the other.

CONCLUSION

My personal opinion – deduced from observation rather than empirical controlled study data – is that the corking we observed in 1998 was as much caused by environmental stress as either boron or calcium deficiency. I believe that it is critical to remember that the problem occurred only after the severe warm-up of mid-July and then affected varieties that ripened just after that. The problem then progressively lessened and eventually went away.

I do not think that calcium is as likely to be involved as boron. This is supported by evidence that orchards growing in high lime soils were just as likely to have the problem as those growing in other soils. Boron may indeed be related to this problem because we know that it is readily leached during high rainfall years and that it is inherently low in many of our soils. Those with available records from 1998 should check to see that boron concentrations are in the proper range. If not, boron applications may be warranted.

FUTURE DATES

Friday, September 8, 2006 – Variety Display and Research Update Seminar at the Kearney Agricultural Center, 9240 S. Riverbend Avenue, Parlier, CA. Sponsored by University of California Cooperative Extension and the Kearney Agricultural Center.

8:00 – 9:00 a.m. Variety display by stone fruit nurseries, breeders and the USDA
9:00 – 10:00 a.m. Soil Fumigation Considerations (research update and discussion in the field)

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Wednesday, December 6, 2006 – Winter Tree Fruit Meeting in Dinuba.

Other upcoming events posted on the Postharvest Calendar at the ANR website can be found at:
http://ucce.ucdavis.edu/calendar/calmain.cfm?calowner=5423&group=w5423&keyword=&ranger=3650&calcat=0&specific=&waste=yes

UC Davis Postharvest Technology Research & Information Center
Short Courses & Workshops

- 11th Annual **Fresh-Cut Products: Maintaining Quality & Safety Workshop**
  Tuesday-Thursday, September 19-21, 2006
  at the Alumni Center, UC Davis
  Link to our 2006 brochure.

- 13th Annual **Management of Fruit Ripening**
  at the Buehler Alumni Center, UC Davis
  Tuesday, May 21, 2007.

- 2nd Annual **Methods of Measuring Fruit and Vegetable Quality: Color & Texture**
  at the Buehler Alumni Center, UC Davis
  Wednesday & Thursday, May 22 - 23, 2007.

- The 29th Annual **Postharvest Technology Short Course**
  will be held at UC Davis
  June 18 - June 29, 2007
  Link to 2006 Lecture Handouts.

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