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Editor

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POOR SANITATION OF FRUIT AND NEW HANDLING PRACTICES MAY INCREASE SOUR ROT INCIDENCE OF PEACH, PLUM, AND NECTARINE

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Sour rot of peach, caused by *Geotrichum candidum* (sexual stage: *Galactomyces geotrichum*), has only been infrequently reported to cause problems of traditionally handled and marketed fruit. Sour rot-like infections may also be caused by other yeasts and possibly other organisms that have not been well characterized. Although the following discussion specifically deals with decay caused by *G. candidum*, decays by these other organisms may have similar requirements. Postharvest handling and marketing practices that minimize injuries and utilize sanitation and immediate cold temperature management of harvested fruit (32ºF, 0ºC) generally eliminate the occurrence of the disease. In fruit lots that reach the market and develop the disease, the incidence of sour rot is usually less than 3%.

Occasionally, fruit decay can also occur during transportation if temperatures are above 36ºF (>2ºC). Sour rot is associated with fruit injuries or bruises and fruit with split pits. Furthermore, the disease mainly occurs on ripe fruit but may also occur on severely injured immature fruit. Symptoms include a dark-brown, watery, soft decay with a thin layer of white mycelial growth on the fruit surface. The decay may reach the pit and consume the entire fruit. Rotted fruit have a characteristic yeasty to vinegary odor; however, other odors may develop with bacterial contamination that commonly occurs in the watery decay.

In recent years, pre-conditioning or pre-ripening of fruit has become a more widely used practice to improve the quality of fruit bound for distant markets. Specifically, pre-conditioning of fruit reduces internal breakdown from chilling injury. Internal breakdown results in dry, mealy textured fruit with pit cavity browning and mesocarp translucency, as well as loss in fruit flavor. The pre-conditioning process involves a 48-hour storage treatment of harvested fruit at 68ºF (20ºC) prior to cold temperature storage at 32ºF (0ºC). Senescent fruit are very susceptible to decay. Laboratory treatments that block wound healing and lead to fruit senescence increase the incidence of the disease. Pre-conditioned fruit are closer to senescence and thus, more prone to fungal decays, including sour rot, because of the ripening of fruit. Postharvest fungicides can effectively control all the major stone fruit decays such as brown rot, gray mold, and Rhizopus rot. No fungicide, however, has ever been developed or registered for postharvest use on stone fruit that is effective against sour rot. Thus, increases in the incidence of sour rot in recent years have been associated with changes in temperature management (i.e., pre-conditioning) and poor sanitation, as well as harvest and postharvest handling practices that lead to fruit injuries or bruises.

Epidemiology and management practices

Geotrichum candidum is a wound pathogen that decays fruit after spores are deposited into injuries. The organism is widespread on organic material in the soil and is commonly found in dust or dirt on fruit surfaces. Spores of the fungus may be spread by vinegar flies from decayed fruits to cracks or bruises in healthy fruit. The spores may also be disseminated in picking boxes and handling equipment. During harvest micro-wounds occur on the fruit and these injuries may function as infection sites. When the fruit is washed, the wash water may carry the spores of the fungus into the wounds.

The minimum temperature for spore germination, growth of the fungus, and infection is about 36°F (2ºC), the optimum 77-80ºF (25-27ºC), and the maximum 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 infected the decay develops quickly once the fruit are marketed at higher temperatures. Rapid cooling of the fruit and refrigeration at low temperature will reduce losses from sour rot. If fruit are pre-conditioned, then fruit must be stored at 32ºF (0ºC) to arrest any incipient decay and maintain fruit quality.

Proper sanitation practices are critical for effective decay control. Fruit should not be picked up from the orchard floor, and should be carefully sorted at the packingline to remove fruit with obvious injuries**.** Care in handling should be taken to prevent injuries and fruit should be washed using a disinfectant such as chlorinated water and all equipment should be periodically sanitized. To be effective, chlorinated washes need to be monitored and maintained at 50-100 ppm free chlorine (hypochlorous acid + hypochlorite ion) at a pH of 7.5-8. For sanitizing equipment, quaternary ammonia compounds are among the most

effective treatments. In studies where *G. candidum* spores were directly exposed to selected sanitizers, a complete kill of the spores was obtained with 10-ppm solutions of chlorine or quaternary ammonia during 60-sec or 30-sec exposures, respectively. On contaminated fruit, however, not all decay propagules could be removed using 100-ppm solutions of chlorine but approximately 80% reduction was obtained. In addition, chlorine washes were more effective when a neutral detergent was added to the wash solution and when washing times were for at least 30 sec. Furthermore, the decay can be managed with proper temperature management after harvest. If pre-conditioning is used, then sanitation practices to remove injured fruit and to sanitize wash water and fruit surfaces are essential to prevent sour rot from developing. Furthermore, all fruit handling equipment should be cleaned thoroughly after each day. Quaternary ammonia and chlorinated wash water are EPA-approved materials for sanitizing equipment used in food handling. Bin dumps, brush beds, and other equipment not in contact with sanitizing washes of fruit should also be cleaned more frequently based on usage. Labels of specific products should be followed for rates, contact time, and water rinse duration. If chlorinated water is used to clean equipment, higher rates can be used as compared to rates used for sanitizing fruit but higher concentrations of chlorine (higher oxidation potential) may be more harmful to equipment.

Previously, registered pre- and postharvest fungicides were not effective against the sour rot pathogen. The fungicides tebuconazole (e.g., Elite 45WP) and propiconazole (e.g., Break 3.6EC or Orbit 3.6EC), however, are somewhat effective, but they are registered only for preharvest and not for postharvest use on stone fruit crops. Preharvest applications of these fungicides probably are effective in reducing the incidence of sour rot. Although specific usage of these fungicides for management of this decay on stone fruit has not been well studied and they currently are not labeled for this disease, these fungicides have been shown to be effective against sour rot of other fruit crops by the senior author of this article. Tebuconazole was submitted to the United States EPA through the IR-4 program (J. E. Adaskaveg, *unpublished data*) as a postharvest fungicide of stone fruit crops, but the registration has been postponed until EPA completes a further review of SBI-triazoles.

Five aspects of sour rot that need to be considered for proper management of the disease include:

- Incipient infections cannot be easily observed by graders and infected fruit are often packed with healthy fruit.
- Sour rot spreads rapidly at temperatures above 41°F (5°C).
- The disease is not controlled by any registered postharvest fungicide and requires proper harvesting and handling practices to minimize wounds and soil contamination. Additionally, sanitation washes, preferably with a neutral detergent, that prevent further spread of inoculum and inoculation of fruit during postharvest cleaning and low-temperature storage (<41°F or 5°C) are required for effective control. Pre-conditioned fruit should ideally be stored at 32°F (0°C) with a practical range of 32°F to 36°F (0 to 2°C) and should not be held above 36°F (2°C).
- Equipment should be regularly disinfected with sanitizing solutions such as quaternary ammonia or chlorinated washes. Treatments should be done regularly, especially between fruit lots from orchards with a history of the disease.
- Fruit planned for pre-conditioning should be pre-harvest treated with a SBI fungicide such as propiconazole (e.g., Break 3.6EC or Orbit 3.6EC) or tebuconazole (e.g., Elite 45WP). Two pre-harvest applications within 14 days of harvest may help to reduce the incidence of postharvest sour rot but proper sanitation and temperature management should be used in an integrated approach.

ABSTRACTS

'Princess' Table Grape Berry Browning Related to Harvest Maturity

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'Princess' table grapes are known to develop skin browning (SB) and flesh browning (FB) during cold storage. To study this problem, we harvested grapes at low, moderate, and high maturity from three vineyards located in Parlier, Delano and Arvin, California during the 2002 season. Individual clusters were labeled and analyzed for soluble solids concentration (SSC), titratable acidity (TA), and browning potential and then stored at 0ºC and 85% R.H. for seven weeks.

A high incidence of SB was observed after 3 weeks of cold storage, but little FB even after 7 weeks. SB was strongly related to vineyard location, and then maturity within the vineyard. For all locations, SB rapidly increased when berries were harvested at a TA $\leq$ 0.60% and/or SSC > 16.0%.

Total phenol (browning potential) of skin tissue extracts of 'Princess' table grapes was measured by spectral analysis at 320 nm and 280 nm. Although absorbance values were lower at 320 nm than 280 nm, there was a strong correlation between the two measures ($p<0.0001$, $R^2=0.84$). Neither measure of browning potential was highly correlated to berry surface browning (OD_{320} $p=0.059$, $R^2=0.21$; OD_{280} $p=0.062$, $R^2=0.20$). 'Princess' table grape berry surface browning may be more related to the absence of antioxidants/organic acids, oxidative enzyme activity or tissue senescence.

An "in-store" taste test was performed to determine the relationship between 'Princess' grape SSC and consumer acceptance. For this, 100 American consumers tasted monadically three individual half-berry samples with SSC ranging from 13.0 to 20.5%. More than 79% of respondents liked grapes with SSC between 14.5-15.9%, while only 64% liked grapes with SSC between 13.0-14.4%.

Based on this work, we recommend harvesting 'Princess' table grapes between 15.0 to 17.0% SSC. This should satisfy most consumers and reduce the development of berry browning during cold storage.

The Use of Molecular Genetics to Improve Peach and Nectarine Post-Storage Quality

C.P. Peace, C.H. Crisosto, A.M. Dandekar, and T.M. Gradziel

Internal breakdown (IB), also known as chilling injury, is the collective term for various disorders that occur during prolonged cold storage and/or after subsequent ripening of stone fruit. Symptoms include mealiness, flesh browning, loss of flavor, and red pigmentation (bleeding). The symptoms are usually not noticed until fruit reaches consumers, and therefore affects consumer consumption. Certain pectin-degrading enzymes appear to play a role in the development of mealiness. To date, our program had evaluated approximately 133 peach and nectarine varieties for their susceptibility to IB. Some cultivars tend to be more susceptible than others, indicating that the trait has a genetic component. However, the genetic mechanisms by which low susceptibility genotypes avoid IB symptoms are not clear. Using two related and genetically variable populations of peach, we have undertaken a classical and molecular genetics approach to gain a better understanding of the genetic control of IB and lay the foundation for marker-assisted selection (MAS) for these traits. A partial genetic linkage map was constructed, based on random SSR and RAF markers, candidate gene markers, and gene-targeted SRAP markers. Segregating morphological markers were also

mapped, including the *Freestone* (*F*), Melting flesh (*M*), and *Flesh color* (*Y*) loci. QTL analysis was performed on the linkage groups, using phenotypic data collected for three seasons. QTLs for flesh mealiness, browning, and bleeding were located. Candidate gene analysis identified that a gene encoding the cell wall degrading enzyme endopolygalacturonase pleiotropically controls the *F* and *M* loci. A large genetic effect on mealiness was detected for this locus, reflecting the observation that mealiness occurred only in freestone melting flesh progeny (though not all such progeny) and was entirely absent in clingstone non-melting flesh progeny. The use of MAS in breeding for low susceptibility to internal breakdown symptoms appears to be an achievable goal for peach and nectarine.

Developing Tree Fruit Quality Indexes Based on Consumer Acceptance and Market Life

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In recent years, we have been developing stone fruit quality indexes based on consumer acceptance and fruit market life with the main goal of increasing fruit consumption. To reach this goal we have taken the following steps: First, we evaluated market life potential based on internal breakdown susceptibility for the most important peach, nectarine and plum cultivars in the California industry. Second, we conducted soluble solids concentration (SSC) and titratable acidity (TA) surveys, which indicated the potential fruit quality range for these cultivars within the industry. Third, we investigated the potential role of pre-harvest factors on these quality attributes. Fourth, we studied the relationship between sensory attributes such as sweetness, sourness, aroma, texture, and overall fruit flavor intensity and the measurements of firmness, SSC, TA and sugar-to-acid ratio (SSC:TA) using a trained taste panel. And finally, we used the above data to design large "in store" consumer tests for the different stone fruit cultivars. After completion of these steps, our industry will have enough solid information to propose a high quality fruit standard if necessary.

Relation between Destructive and Nondestructive Bench Top Firmness Measurements on Peaches, Nectarines and Plums

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Fruit firmness changes are related to the texture changes during fruit ripening and softening. Thus, destructive and non-destructive firmness measurements can be used to identify stage of ripeness and potential susceptibility to bruising during post harvest changes. Relationship between "bench top" fruit tester destructible firmness (UCF) measurements and non-destructive measurements (Sinclair iQ firmness bench top) was significant but low for commercial applications (R^2 = 0.46-0.71). These results suggest that iQ is not measuring the same fruit physical properties changes as the UCP. However, iQ measurements were consistent on segregating fruit into two categories (hard versus soft) by using a discrimination analysis. The thresholds between "hard" and "soft" categories were chosen according to differing ripening stages and bruising susceptibility during postharvest handling. As bench top iQ non-destructive measurements were not highly related to destructive measurements but they were

consistently segregated according to their ripening stage (soft/hard), further work is recommended to improve this bench model performance and to evaluate this technology under a commercial packing line situation.

Increasing 'Blackamber' Plum (*Prunus salicina* Lindell) Consumer Acceptance

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'Blackamber' plum (*Prunus salicina* Lindell) consumer acceptance and market life were highly dependent on harvest date. For fruit within the most common industry ripe soluble solids concentration (RSSC) range (10.0-11.9%), ripe titratable acidity (RTA) played a significant role in consumer acceptance. Plums within this RSSC range combined with low RTA (≤0.60%) were disliked by 18% of consumers, while plums with RTA ≥ 1.00% were disliked by 60% of consumers. Plums with RSSC ≥12.0% had ~ 75% consumer acceptance, regardless of RTA. Fruit harvested between 35.6-17.8 N had high consumer acceptance because of lower RTA and higher RSSC than earlier harvested fruit. Ripening plums before consumption decreased TA by approximately 30% from the TA measured at harvest. In some cases, this decrease in TA during ripening may increase the acceptability of plums that would otherwise be unacceptable.

Development of chilling injury symptoms limited market life of fruit harvested early (44.5-35.6 N) and late (17.8-13.3 N). Late harvested fruit were more likely to develop flesh translucency (overripeness) when stored at 5ºC, whereas early harvested fruit had low consumer acceptance and were more prone to develop flesh bleeding/browning during storage at 0 or 5ºC.

Based on this work, 'Blackamber' plums are well adapted to late harvest but proper postharvest temperature management, including ripening, and marketing within its market life potential are necessary to avoid the onset of storage disorders and maintain flavor.

ESTABLISHING A QUALITY CONTROL SYSTEM

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In recent years, the production and marketing of fresh stone fruits has increased rapidly, but consumption remains low at approximately 5.9 pounds per capita per year for nectarines and peaches, and 1.3 for fresh plums and prunes. Surveys (Bruin, 1991) to explain this low consumption indicate that consumers object to hard fruit and lack of flavor (Table 1). As the volume of shipments is still increasing, greater attention must be given to the production and delivery of high quality stone fruits.

Table 1. Consumer satisfaction with peach purchases.

Consumer complaint	%
Little flavor	30
Too hard	21
Too soft	5
Mealy	13

Preliminary and limited studies associated high soluble solids concentration (SSC) with higher consumer acceptance. Unfortunately, there are more factors involved such as acidity, phenolics, volatiles, etc. in consumer acceptance than just the simple SSC value. Thus, since we do not know enough about consumer acceptance and stone fruit chemical

composition during maturation/ripening, we are not able to propose any quality standards. Furthermore, the variability of the SSC among fruit from different orchards and within the tree is so large that it is impossible to set any minimum maturity standard.

The best way to assure high quality produce is by using the right cultivars, training systems, pruning, thinning, good irrigation and fertilization practices, etc., in combination with late harvesting.

It also is essential to evaluate production processes by establishing a quality control system. It will help to identify, segregate and keep records of fruit quality. Also, it will help to evaluate the effect of changes in cultural practices on fruit quality and to identify cultivars with high SSC levels. Correct handling of the information will benefit growers and the California fruit industry's reputation.

MEASUREMENT OF PH AND TITRATABLE ACIDITY

D. Garner, C.H. Crisosto, P. Wiley, and G.M. Crisosto

I. Materials
   A. Required: pH meter or phenolphthalen, burette, burette clamp and stand, gram scale, graduated cylinder, beakers, 0.1N NaOH solution
   B. Optional: magnetic stirrer & stir bar, automatic titrator

II. Procedure
   A. Obtain at least 50 ml of clear juice by one of the following methods:
      1. Cut fruit, press with a hand press, and filter through cheesecloth, or
      2. Cut fruit into a blender, homogenize, centrifuge slurry, and pour off clear liquid for analysis.

      ** Sugar levels often vary within the fruit, being higher at the stem-end and lower at the calyx-end. For this reason, it is important to use longitudinal slices of fruit (from end to end) when sampling.
   B. Make sure samples are at room temperature before taking measurements.
   C. Measure the pH of the samples with a pH meter and record the value.
   D. For each sample, weigh out 6 grams of juice into a 100 ml beaker.
   E. To each sample, add 50 ml of water.
   F. Titrate each sample with 0.1 N NaOH to an end point of 8.2 (measured with the pH meter or phenolphthalen indicator) and record the milliliters (ml) of NaOH used.
   G. Calculate the titratable acidity using the following formula:

% acid = [ml NaOH used] x [0.1 N NaOH] x [milliequivalent factor] x [100] / grams of sample

Commodity	Predominant Acid	Milliequivalent Factor
Stone fruit, apples, kiwifruit	Malic Acid	0.067
Citrus	Citric Acid	0.064
Grapes	Tartaric Acid	0.075

MEASUREMENT OF FRUIT FIRMNESS

D. Garner, C.H. Crisosto, P. Wiley, and G.M. Crisosto

I. Materials
   A. Effegi penetrometer or Magness-Taylor pressure tester, either hand-held or mounted on a stand for consistency.

II. Procedure
   A. Make sure all fruits tested are comparable in temperature since warm fruits are usually softer than cold fruits.
   B. Make two puncture tests per fruit, one on each of the opposite cheeks,

midway between the stem-end and calyx-end.

C. Remove a disc (about 2 cm in diameter) of the skin with a stainless steel vegetable peeler or sharp knife.
D. Use an appropriate tip (plunger) size for each commodity (5/16" for stone fruit and kiwifruit, D'Anjou pears, Bosc pears, Comice pears, Bartlett pears, and Winter Nellis pears; 7/16" for most apples).
E. All determinations for a given lot should be made by one person to minimize variability.
F. Hold the fruit against a stationary hard surface and force the tip into the fruit at a uniform speed (take 2 seconds).
G. Depth of penetration should be consistent to the inscribed line on the tip.
H. Record reading to the nearest 0.5 lb or 0.25 kg.
    1. The unit should be written as poundforce (lbf) or kilogram (kgf) in order to avoid confusion with the units of mass.

III. Maintenance
    A. Before use on a given day, work the plunger in and out about 10 times to loosen up the springs inside the instrument.
    B. Clean the tips after use to prevent clogging with fruit juice.

IV. Calibration:
    A. Hold the firmness tester in a vertical position and place the tip onto the pan of an accurate scale.
        1. Press down slowly on the firmness tester until the scale registers a given weight, then read the firmness tester. Repeat this comparison three to five times. If you find that the instrument is properly calibrated, it is ready to use.
    B. If the instrument reading is not in agreement with the scale reading, find out the magnitude and direction of the difference and proceed as follows:
        1. Effegi fruit penetrometer:
            a) Unscrew the chrome guide nut to remove the plunger assembly.
            b) To make the instrument read lower, insert washers between the spring and the stationary brass guide.
            c) To make the instrument read higher, insert washers between the chrome guide nut and the stationary brass guide on the plunger shaft.
            d) Reassemble and recheck for calibration.
        2. Magness-Taylor Pressure Tester:
            a) Remove the plunger assembly from the barrel of the instrument and remove the bolt and washers from the end of the plunger assembly.
            b) Pull the plunger and spring out of the metal cylinder, then shake the washers out of the cylinder.
            c) To make the instrument read lower, move washers from inside to outside the metal cylinder.
            d) To make the instrument read higher, move washers from outside to inside the metal cylinder.
            e) Reassemble and recheck for calibration.
    C. If the indicator needle does not stop or does not release properly, clean the case in the area of the release button, remove the plunger assembly, and then lubricate the inside of the instrument with an aerosol lubricant.

MEASUREMENT OF SOLUBLE SOLIDS CONTENT

D. Garner, C.H. Crisosto, P. Wiley, and G.M. Crisosto

I. Theory
   A. Sugars are the major soluble solids in fruit juice. Other soluble materials include organic and amino acids, soluble pectins, etc. Soluble solids concentration (SSC%, °Brix) can be determined in a small sample of fruit juice using a hand held refractometer. This instrument measures the refractive index, which indicates how much a light beam is "bent" when it passes through the fruit juice.
   B. Temperature of the juice is a very important factor in the accuracy of reading. All materials expand when heated and become less dense. For a sugar solution, the change is about 0.5% sugar for every 10°F. Good quality refractometers have a temperature compensation capability.

II. Materials
   A. 0-32% Brix temperature compensating refractometer, distilled water, Kimwipes, 5 or 10% sugar solution.

III. Procedure
   A. Extract clear juice from fruit to be sampled.
      1. Sugar levels often vary within the fruit, being higher at the stem-end and lower at the calyx-end. For this reason, it is important to use longitudinal slices of fruit (from end to end) when sampling.
   B. Place a drop of juice on refractometer prism.
   C. Lower cover plate and read.
      2. In juice samples with a high starch content, like unripe kiwi, it may be difficult to read the refractometer because the starch settles out on the prism. To remedy this, put your thumb on the cover plate, turn the refractometer upside down, and re-read. This way the starch settles out on the cover plate and does not blur the reading.
   D. Rinse prism between samples with distilled water and dry with a soft, lint-free tissue (Kimwipe).

IV. Refractometer maintenance and calibration
   A. Clean the instrument after each use with distilled water. Dry with a soft tissue (Kimwipe).
   B. Calibrate with a drop of distilled water. Adjust reading to 0°Brix if necessary with the small set-screw on the back. Verify accuracy with a drop of 5 or 10% sucrose solution (5 grams sugar in 100 ml of distilled water).
   C. Do not submerge the refractometer when cleaning. If water gets into the instrument it will need to be sent out for repair and resealing.

STARCH-IODINE TEST

D. Garner, C.H. Crisosto, P. Wiley, and G.M. Crisosto

I. Materials required
   A. Iodine-potassium iodide solution
      1. Dissolve 10 grams (about 1 teaspoon) of potassium iodide crystals in 1⅛ cups clean water in a 1-quart container.
      2. Swirl until crystals dissolve.
      3. Add 2.5 grams (about ¼ teaspoon) iodine and swirl until all iodine dissolves.
      4. Dilute the solution with water to make one quart.
      5. Protect the solution from light to prevent the chemicals from degrading i.e., put in an opaque container or wrap the container with aluminum foil, or store in a dark cabinet. A fresh solution should be made each season.

II. Procedure
   A. Cut the fruit in half at the equator – midway between and perpendicular to the axis passing through the calyx-end and the stem-end of the apple.
   B. Dip one of the cut surfaces in the iodine-potassium iodide solutions and soak for 30 seconds.
   C. Rinse for 5 seconds in tap water.
   D. Evaluate according to the following scale developed for Granny Smith:

      0 = 25% of the area within the core line is white, all of the cortex is blue.
      1 = 50% of the area within the core line is white, all of the cortex is blue.
      2 = 100% of the area within the core line is white, all of the cortex is blue.
      3 = 100% of the area within the core line is white, 25% of the cortex area is white (usually patchy).
      4 = 100% of the area within the core line is white, 50% of the cortex area is white (usually patchy).
      5 = 100% of the area within the core line is white, 75% of the cortex area is white (usually patchy).
      6 = 100% of the surface is white.

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9:00 – 10:00 a.m. Research Update and discussion in the field

- Friday, June 25 Research Update – Tree Fruit Nutrient Management
- Friday, July 30 Research Update – To be announced
- Friday, August 27 Research Update – Late Season Irrigation Management

***For more information call*:**

Scott Johnson (559) 646-6547; Kevin Day (559) 685-3309, Ext. 211;
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