CENTRAL VALLEY POSTHARVEST NEWSLETTER

COOPERATIVE EXTENSION **UNIVERSITY OF CALIFORNIA**
Kearney Agricultural Center, 9240 South Riverbend Avenue, Parlier, CA 93648

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INTRODUCTION

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This is a new newsletter designed especially to address the postharvest concerns of fruit growers, packers and shippers in the California San Joaquin Valley. It is planned to release two issues each year, with one emphasizing stone fruits and the other covering apple, kiwifruit, tablegrape, Asian pear, citrus and other subtropicals. In initiating this newsletter, Dr. Carlos Crisosto, a Postharvest Pomologist, University of California, Davis located at the Kearney Agricultural Center, and Dr. Mary Lu Arpaia, a Subtropical Horticulturist at the University of California at Riverside, hope to better reach the fresh fruit industries with current postharvest information, drawing on work done here and elsewhere.

This newsletter is only part of an expanded effort by the University of California to better meet the postharvest horticulture needs in the San Joaquin Valley. Dr. Crisosto was the first UC Postharvest Research and Extension appointment at the Kearney Agricultural Center. The first phase of a major postharvest horticulture laboratory is currently under construction through the generosity of a UC benefactor. When this is operational we will have the capability of a world-class laboratory in the center of the fruit growing area. As the UC budget allows we hope to see more personnel assigned to this program. The first two of what we hope will be many postharvest meetings were held at the Kearney Agricultural Center this spring, one on stone fruits and one on refrigeration.

I am personally delighted to see this program underway. I have seen this as a long-term need. In recent years it has become more important for us to have this capability at the Kearney Agricultural Center as the fresh fruit industry has been growing, especially in the San Joaquin Valley, as the importance of fresh fruit in the diet has increased consumption, and as opportunities for export shipments are expanding. With these changes we have challenges to extend the market life while reducing losses, and to maintain or improve fruit quality, including flavor, nutritional value and safety. This postharvest horticulture center located in the heart of the fresh fruit industry can help us to meet these challenges.

STATUS OF DICLORAN (BOTRAN, DCNA) IN THE UNITED STATES

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Brief History of Dicloran and Current Post-harvest Fungicide Treatments in Stone Fruits:

In 1959, dicloran (Botran, DCNA) was introduced by the English company Shering AG. as a broad spectrum fungicide. It is currently manufactured by and licensed in the United States to Nor-Am Chemical co., Wilmington, Delaware. The compound, a chlorinated nitro-aniline, is used on a wide range of fruits and vegetables as a protective treatment against fungal pathogens including species of *Botrytis, Monilinia, Rhizopus, Sclerotinia*, and *Sclerotium*. In the stone fruit industry, the fungicide is used mostly in post-harvest treatments to control *Rhizopus stolonifer*. In 1989, through our research, iprodione was registered for post-harvest use on nectarines, peaches, plums, and sweet cherries (Federal Register - PR-3092, 3093, 2809, PP 8E3619, and PP8L3545). Currently, dicloran (Botran 75 WP) is combined with iprodione (Rovral 50 WP) as a tank mix to control decay causing organisms. Dicloran is used to control Rhizopus rot (*R. stolonifer*); while iprodione controls brown rot (*Monilinia fructicola, M. laxa*), Botrytis rot (*B. cinerea*), Penicillium rot (*P. expansum*), and Alternaria rot (*A. alternata*). Iprodione provides some control of Rhizopus rot but its efficacy is significantly less than that of dicloran. No alternative fungicides to dicloran are available for effective control of Rhizopus rot. The disease can be controlled, however, by continuous cold storage of fruit at approximately 40°F or below. Other fungicides previously used in combination with dicloran include benzimidazoles (benomyl, thiophanate methyl) and dicarboximides (Iprodione).

Current Status of Dicloran (Botran)

In September 1991, Nor-Am announced that the company would not pursue efforts to re-register dicloran for use in the United States. In accordance with Section 6(f)(I) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, a pesticide registrant may, at any time, request to voluntarily cancel registration of products containing dicloran (Botran 8% Dust, Botran 6% Dust, Botran 75 W, Botran 12% Dust Fungicide, Botran 15% Dust Fungicide, Botran 10% Dust, Botran 4% Dust Fungicide, Botran Technical, and Botec Peanut Seed Protectant). The Environmental Protection Agency (EPA) following FIFRA regulations, published this request in the Federal Register, 4 March 1992. If Nor-Am or any other company does not withdraw the request by 2 June 1992 (90 days from publication of cancellation notice), orders will be issued by EPA to cancel all registrations of this material. The effective cancellation date will be 4 March 1992, and orders effecting the requested cancellation will permit the sale and distribution of existing stocks of the canceled products for 1 year (4 March 1993) after the effective date. Existing stocks already in the hands of dealers and users can be distributed, sold, or used legally until they are exhausted in compliance with federal and state regulations. Thus, companies that specialize in post-harvest treatments can continue to use products containing dicloran until their stocks are used.

Future Post-Harvest Treatments for Control of *R. stolonifer* in Stone Fruits

In the fall of 1991, preliminary research conducted in our laboratory on fresh market peaches and fresh market tomatoes suggests that the effectiveness of Rovral 50 WP (iprodione) for control of decays caused by *R. stolonifer* and *A. alternata* can be substantially increased with specific additives. Currently, we are conducting research jointly funded by commodity groups and chemical industries to improve the efficacy of iprodione, and to test new formulations and materials for control of fruit decays caused by *R. stolonifer* and other major decay pathogens.

OPTIMUM FRUIT COOLING TEMPERATURE MANAGEMENT

Carlos H. Crisosto
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Storage temperature and delay of cooling are important issues in the development of temperature management policies for your postharvest fruit handling operations. Storage temperatures should be kept within 1°C (2°F) of the optimal temperature for the commodity being stored. In general, for commodities not sensitive to chilling injury, temperatures should be kept very close to the freezing point. Of course, this will depend of your ability to control temperature in your storage facilities. If temperatures drop below the optimum range for a given commodity, freezing injury or chilling damage may result while elevated temperatures will shorten storage life. Wide temperature fluctuations during storage can result in both water condensation (on the product) as well as more rapid water loss.

The lapse of time between harvest and fruit cooling has a very important effect on fruit quality, storage, and market performance. In general, a delay in cooling increases the rates of fruit softening and ripening, CO_2 and ethylene production, water loss, and the onset and severity of physiological disorders and decay. There are some benefits in some cases to delaying cooling and packing warm fruit. One of these is a reduction in the incidence of bruising--which is one of the main causes of fruit losses in stone fruit--in cherries, peaches, plums, and nectarines. Thus, an understanding of the relationship between cooling delay sensitivity, fruit bruising, and temperature can be used to decrease bruising incidence without significantly increasing postharvest deterioration. Unfortunately, the effects of cooling delays on deterioration often differ from species to species, sometimes between varieties, and may even vary depending upon the physiological maturity of the individual fruit. Thus, specific information for each variety needs to be made available in order to develop an optimum temperature management program for your packing operation and to assure that fruit of high quality reaches the consumers.

<u>Cherries</u>: Recommendations to reduce fruit deterioration in 'Bing' cherry indicated that fruit flesh should be cooled to the storage temperature 0°C (32°F) within 4-6 hrs after harvest (Overholser, 1932; Micke et al., 1965). Delays in cooling induce fruit deterioration in the form of softening, shrivelling, stem browning, and fruit decay thereby shortening postharvest life. As new cherry varieties ('Brook', 'King' and 'Tulare') developed for Central Valley area had almost double the respiration rate of 'Bing' at 20°C (68°F), they should be cooled to storage temperatures within a time period even shorter than 4-6 hrs after harvest to reduce fruit deterioration and maximize potential market life. Impact bruising damage was greater in cherries when flesh temperature was lower than 10°C (51°F), although sensitivity to vibration bruising was not significantly influenced by temperature. This suggests that 'Bing', 'Brooks', 'Tulare' and 'King' cherries should be handled during the packing operation at temperatures between 10 to 20°C.

Based upon this information, the way in which cherries are handled becomes a function of how long of a delay there is until packing. It would be best to pack them warm 10-20°C (51-68°F), cool to the storage temperature with an in-line hydrocooler, and then carefully package them. Forced-air cooling after the fruit is packaged is also an option if flesh temperatures can be lowered to the storage temperatures rapidly enough. If this entire process cannot be carried out within 4-6 hours of the harvest, however, the fruit should be immediately cooled to the storage temperature to await processing in order to minimize postharvest losses associated with cooling delays. Before these fruit are packed, they should be allowed to rewarm to 10-20°C (51-68°F) in order to minimize bruising. Although hydrocooling is able to drop cherry flesh temperatures to their storage temperature within 6 minutes, I am concerned with the potential increase in fruit pitting by using this method. This relationship has been reported in areas with pitting problems. The incidence of pitting in California is lower than in other cherry production areas, but its relationship with the hydrocooling operation has not been studied.

<u>Stonefruit</u>: The accumulating evidence with California grown stone fruits is that cooling should start within a few hours of harvest and that the fruit should be at storage temperature within 18-24 hrs of harvest. To achieve this, fruit must be transported from the orchard to the cooler several times per day. In California, the harvesting and packing operations are usually separated, and it is common to pack fruit on the day following harvest. Good results have been obtained by cooling to 5-10°C (41-51°F) soon after picking, with cooling completed to near 0°C (32°) immediately following packing. If packing is to be delayed beyond the next day, then deterioration factors discussed earlier dictate that fruit should be cooled soon after picking to near 0°C (32°F) (while waiting to be packed). If packing is to be done on the day of harvest, then careful supervision is needed to coordinate fruit flow through the two operations. Fruit should be packed as soon as possible after harvest, then immediately cooled. Fruit should never remain warm overnight for next day packing. Occasionally, it is possible to pass fruit through a hydrocooler for partial cooling before it moves over the packing line. In most packing operations, the cooling process must be completed after the fruit has been placed into the shipping container.

Peach and nectarine fruit harvested soft (flesh firmness = 9-10 pounds) and with high soluble solids content require cooling very soon after harvest to minimize further flesh softening. Even an 8 hour cooling delay advances the rate of flesh softening. In plum ('Blackamber', 'Friar', 'Angeleno'), flesh softening appeared unaffected by a 24 hr cooling delay.

Storage temperatures of -0.6 to 0°C (31-32°F), with 90-95% RH, are recommended for stone fruits. In general, delay on internal breakdown development is attained by storing fruit susceptible to internal breakdown at -1.1°C (30°F). However, to store fruit at this low temperature, high soluble solids content and excellent thermostatic control are necessary in order to avoid freeze damage storage.

MANAGEMENT OF STONE FRUIT HARVEST AND FIELD OPERATIONS

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The goal of fruit harvesting should be to:

1) Pick fruit at optimum maturity.
2) Transport fruit to the packing facility with no deterioration in fruit quality.

To do this requires proper coordination between human resources, fruit maturity, environmental factors, and technical resources and equipment. An understanding of these factors and their relationship is essential to making the proper management decisions for a given orchard situation.

Harvest Operations

Fruit maturity can be measured by a number of different methods. Unfortunately, many of these methods are destructive, and therefore are of little value in field situations. Fruit background color is a useful, nondestructive method of estimating fruit maturity, and is most easily employed and understood by field workers. Since the proper background color for estimating optimum harvest maturity varies by variety, experience with a particular variety is helpful in making the correct decision.

At the start of a block or variety, accurate, easily understood directions for estimating maturity should be given to the workers. By selecting a few fruit of varying maturity, and demonstrating what maturity level is acceptable or unacceptable, many mistakes can be eliminated. It is good to leave these samples with the crew boss as a reference throughout the day. The value of a good crew boss cannot be overemphasized. This person should be considered essential and integral in the harvesting process. He should be instructed to continually monitor the fruit being picked, as well as the fruit remaining on the tree, to determine if the correct balance is achieved.

Orchard managers should involve the crew boss in all stages of the decision-making process when determining optimum harvest maturity. Doing so will give him greater understanding and experience in the process. More importantly, it will solidify in his mind the importance of his role in harvesting fruit at the proper maturity.

A number of factors can affect how quickly fruits ripen. Trees tend to ripen from top to bottom. This is probably related to the amount of sun they receive. Consequently, fruit on weak trees tend to ripen earlier than on strong trees, as does fruit on summer pruned trees. Fruit on girdled trees ripen earlier than fruit on ungirdled trees. These fruit also tend to ripen more uniformly within the tree from top to bottom. A skillful manager will consider these factors, as well as others, and judge when an orchard should be harvested, and how much fruit can be removed in any one picking.

Because of the complexity of these factors, there is no substitute for experience in making these decisions. This process involves as much art as it does science. Strategies that are effective for one grower may be entirely incorrect for another due to different organizational and marketing situations and tactics. An example of differing strategies is demonstrated by the grower who prefers to harvest five to eight times for each variety, with each harvest 2 to 3 days apart. This is in contrast to the grower who prefers to pick only two or three times, with a longer interval in between. The first grower may decide that he doesn't mind spending the extra money on increased labor because he is getting greater packouts. The second grower may not mind throwing away greater amounts of fruit because he is saving so much on labor.

Most stone fruit operations use picking bags and bins in their harvest operations. There are still a number of growers who pack directly from buckets or field boxes. These growers feel that they can more easily handle fruit of higher maturity through this method. Regardless of the system used, a number of precautions should be taken with any harvest operation.

Pickers should be instructed to treat the fruit as gently as possible at every stage of the harvest process. When emptying bags into the transport bins, care should be taken to ensure that the fruit are not dumped into the bin from a high height. Again, this is where the crew boss is helpful in reducing problems. Picking bags and buckets should be kept clean. There appears to be a relationship between "ink staining," dirt, and surface abrasion. Washing picking bags at regular intervals may be helpful in reducing this problem.

After harvest, but while still in the field, fruit should be protected from heat and direct sunlight. Insulated bin covers are the most helpful, but any type of shading is beneficial. Some growers use cloth coverings to protect the fruit. On very hot days, cloth coverings should be supported above the fruit because direct contact can allow enough heat to pass through to cause fruit scald.

Transport Operations

Tractor drivers should be instructed to drive slowly and smoothly. Severe fruit damage can result from poor driving practices, especially on turns and starts. It appears to be beneficial to use "suspension-type" bin trailers instead of solid axle trailers. These trailers tend to ride more smoothly. Similar results can be obtained to a lesser degree by lowering tire air pressure. Both of these procedures are probably more helpful for road transport conditions than for field transport.

Unloading of trailers should also be performed as gently as possible. Care should be taken to educate workers as to the importance of this process. It is helpful if the unloading area is smooth and spacious to eliminate bumping and jarring.

After harvest, fruit should be transported to a cooling facility as quickly as possible. If there is a delay in transportation, fruit should be stored in a cool, shaded area. Temporary structures near the harvest location are often constructed from shade cloth material. Care should be taken while the harvested fruit is being loaded for transport to the packing facility. Forklift drivers should be informed of the importance of treating fruit gently when loading and unloading.

During transport, drivers should do everything possible to reduce and eliminate jarring and bouncing. By choosing proper routes, and avoiding rough, bumpy roads, transportation injury can be better controlled. Position of fruit on the trailer is also important. Vibration levels within the bin are highest at the front of the trailer, intermediate in the rear, and lowest in the middle of the trailer. The addition of air-suspension systems to trailers has been shown to be of tremendous value in reducing this type of fruit damage. Plastic bin liners and padded bin covers have also been demonstrated to reduce transport injury. Research has shown that thick bubble padding is more beneficial than thin, and that larger bubbles are preferred to small.

There are three types of damage which can occur during harvest and transport: impact bruising, compression bruising, and abrasion/vibration bruising. Impact bruising is the result of dropping, bouncing, or jarring. Compression bruising occurs primarily when bins are overfilled and stacked, and fruit is "crushed" against each other. Abrasion bruising results from fruit rubbing against each other or against container surfaces. Proper fruit handling and transport will reduce these types of injury, and contribute to the production of a high-quality final product.

Suggested practices

The results discussed above coupled with other work and observations have led to the following suggestions:

1. Avoid extended forklift movement of bins through the field from point of harvest to loading site.

2. Supervise truck or trailer loading to avoid rough handling or dropping of bins or lugs.

3. Grade farm roads to eliminate ruts, potholes, and bumps.

4. Where necessary, route truck movement to avoid public roads that are in poor conditions.

5. Restrict transport speeds to a level that will avoid free movement of fruit. This may require different speed limits on different roads.

6. Use suspension systems on all transport equipment. Consider installing air suspension systems on all axles of transport equipment--tests have shown that this reduces damaging motion as well as fruit damage by more than 50 percent.

7. Reduce tire air pressure on transport vehicles to reduce motion transmittal to the fruit.

8. Install plastic liners inside the bin. Bottom liners are not needed. Plastic bubble liner material, fastened to bin sides with bubbles facing the fruit, performs well. Side vents can be cut in the liners to match those on the bin sides.

9. In difficult situations, such as long-distance transport, top bin pads can further reduce damage. These are pieces of light (3/8 inch or 10 mm) plywood cut to fit inside the bin, faced with a double layer of 1/2-inch (13-mm) thick bubble liner, and held against the fruit by short rubber trucker straps.

RESEARCH UPDATES

Project Title:
Selecting and handling high quality stone fruit for fresh market

Project Leader:
F. Gordon Mitchell

Summary:
The 1991 portion of this study helped us to understand the relatively high level of visual bruising that can occur when high maturity peaches and nectarines are handled through commercial harvest and packing operations. With the variability in flesh firmness that was encountered, it appears that fruit averaging less than 9 or 10 pounds-force (lbf) would show excessive damage in typical commercial handling operations. This would still allow fruit to mature beyond the level of normal commercial harvest to accommodate special marketing opportunities for high maturity fruit.

The work of Saenz completed the evaluation of the effect of fruit position in the tree canopy. It documented the large position effect on fruit color, flesh firmness and soluble solids concentration (SSC). However, it also showed only minor effects of position on the postharvest performance of the fruit, including respiratory characteristics, susceptibility of injuries and susceptibility to internal breakdown, including internal browning and textural changes. Thus, any fruit on the tree that meets maturity and quality standards should perform approximately equal during subsequent handling and marketing.

The work of Slaughter showed a high correlation between the use of near-infrared light to nondestructively measure SSC in intact fruit and the use of the standard destructive refractometer measurement. Further work is needed to attempt to develop this procedure for high speed packing line use. Since past work has shown SSC to be a critical factor in segregating flavor quality of these stone fruits, such a development would facilitate the marketing of a uniformly high quality product.

From this three year study we can now present a general picture of the fruit characteristics and handling requirements for marketing high quality stone fruits:

1. Varieties can be selected that have high soluble solid concentration level (SSC), relatively low susceptibility to impact bruising, and with relatively slow ripening (flesh softening) characteristics.

2. Taste or acceptance of these stone fruit increases as SSC levels increase, especially when they exceed 11% for peaches and nectarines.

3. Fruit of the same variety from different growing locations showed differences in SSC level.

4. Impact bruise susceptibility does not increase until fruit soften to the 6-8 lbf level.

5. In commercial packing facilities fruit in the 6-8 lbf range show a fairly high level of bruising.

6. With a flesh firmness standard deviation of 2-2.5 lbf for peaches and nectarines, these fruits would need to average 9-10 lbf to avoid excessive damage.

7. There is a substantial range in flesh firmness among fruit on the tree at any harvest date, and this is usually greater than differences due to harvest date.

8. While the level of physiological activity was higher with advancing maturity, several of the test varieties showed only a minor rise with delayed harvest.

9. Peach and nectarine fruit harvested at lower flesh firmnesses require cooling very soon after harvest to minimize further flesh softening (even an 8 hour cooling delay advanced the rate of flesh softening).

10. Plum softening (for the varieties tested) appeared unaffected by a 24-hour cooling delay.

11. Fruit quality characteristics varied greatly among the major populations in the tree canopy (top, outside and inside fruit).

12. Fruit performance characteristics appeared little affected by position in the tree canopy, so that handling practices do not need to be modified to account for performance differences.

13. Top fruit in the tree canopy showed considerably higher levels of SSC and best color of any fruit on the tree. This fruit would be most desirable for any high quality pack.

14. Characteristics of outside fruit on the tree were often close to those of top fruit.

15. Inside fruit had levels of SSC that were often considerably lower than other fruit populations, and inside fruit are characteristically lower in color.

16. Procedures such as the use of near-infrared light measurement to nondestructively measure SSC of the fruit could have significant value in

segregating high quality fruit if high speed packing line applications could be developed.

17. By evaluating various characteristics as outlined in these studies, and including data on fruit diameter, weight changes, and the rate of fruit drop from the trees, it was possible to project optimum harvest times for test varieties.