Management of Postharvest Decay of Avocado Fruit

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Background and rationale

Avocado handling recommendations are stated in foreign publications, but the validity of their conclusions under California conditions has not been established, and magnitude of the impact of some practices on the management of actual fruit losses has not been quantified.

Postharvest thermal conditioning. Thermal conditioning of harvested avocado fruit is a promising technique to minimize postharvest decay. In preliminary tests, Arpaia and Sievert (unpublished) observed that storing 'Hass' avocados at 5°C for relatively long periods (weeks) followed by ethylene treatment (100 ppm for 24 h) and ripening at 20°C very substantially reduced subsequent stem end rot and body rot incidence in the ripe fruit. This regime did not cause chilling injury or other harm to the fruit. Other workers have noted that temperature of storage can greatly influence decay in ripe avocado fruit. Most recommendations for avocado ripening are 20°C or higher. In 1957, Newsom reported that cold-hardy avocados could be ripened at about 15°C and anthracnose would be "practically eliminated" although ripening was very slow compared to ripening at higher temperatures. Bezuidenhout (1983) reported temperature was a major factor in determining the extent of anthracnose development. Fitzell and Muirhead (1988) reported that reducing ripening temperature from 24°C to 17°C reduced subsequent anthracnose incidence. Spalding and Reeder (1975) reported anthracnose on 'Fuchs' and 'Waldin' avocados was reduced by storage at 4.4°C for 3-4 weeks before ripening compared 7.2 or 10°C, although chilling injury occurred on these varieties at these temperatures. Johnson et al (1990) recommended storage of avocados at 7°C before ripening reduced at 16-20°C to reduce stem end rot caused primarily by *Dothiorella*, based on research originally done with mangos to control this pathogen.

Method of harvest. In 1998, Arpaia and Hofshi reported that among Hass avocados from San Diego County, California, the incidence of stem-end rot (SER) after storage and ripening among 'snap' harvested avocados was 15.0% while that among 'clip' harvested avocados was 38.3%. They reported the primary advantage of "snap" harvest was a decrease in labor of about 30% to pick fruit and that snap harvested fruit had the same quality as 'clip' harvested fruit. Other workers reported SER incidence was reduced when avocados were 'snap' harvested (Johnson and Kotze, 1994; Darvas et al, 1990). Arpaia and Hofshi found ripening rate did not differ among 'clip' and 'snap' harvested Hass avocados, which differed from the earlier workers' findings that removal of the stem increased the rate ripening of Hass avocados (Tingwa and Young 1975) and slowed ripening of Fuerte avocados (Darvas et al, 1990). Slower ripening was associated with elevated anthracnose (*Colletotrichum*) incidence (Johnson, G. L., and Kotze). Harvest during rainy periods is not recommended (Johnson, G. L., and Kotze), and may impact results when testing 'snap' or 'clip' harvest (Alan Wolf, personal communication).

Fungi associated with postharvest decay. Among 'clip' harvested avocados from many sources that were not part of harvest experiments (n=609), the most important fungi *Dothiorella*, *Colletotrichum*, and *Alternaria* were isolated from SER lesions on 37%, 22%, and 17% of the diseased fruit, respectively.

Beginning in 1999, we isolated fungi from 247 avocados with SER, primarily 'Hass' cultivar, from ripe avocados that had been harvested by the 'snap' or 'clip' methods from eight groves in southern California in collaboration with M. L. Arpaia and J. R. Seivert. SER lesion size in avocados was classified as 1 (minor), 2 (moderate), or 3 (severe). SER lesions were smaller on 'clip' harvested avocados than 'snap' harvested fruit. Fungi responsible for SER differed between 'clip' and 'snap' harvested fruit. *Phomopsis, Dothiorella,* and *Alternaria* spp. were isolated from 30, 41, and 10%, respectively, of the 'clip' harvested avocados (n=116) with SER. *Phomopsis, Dothiorella,* and *Alternaria* spp. were isolated from 10, 12, and 27%, respectively, of the 'snap' harvested avocados (n=131). Aggressive pathogens, capable of making large SER lesions, were isolated from 71% of the 'clip' harvested fruit with SER, while they were isolated from only 22% of the 'snap' harvested fruit. Most SER lesions on 'snap' harvested fruit contained weakly parasitic fungi and saprophytes that do not make large SER lesions.

We hypothesize the reason the distribution of fungi isolated and SER severity differs between 'clip' and 'snap' harvest is that a large proportion of the aggressive pathogens, such as *Dothiorella* and *Phomopsis*, were eliminated from the fruit that were snapped from the tree during harvest. These fungi are associated with colonization of woody twigs where they can occur as endophytes in stem tissue (Johnson and Kotze, 1994), that are spread by splashing water and not as air-borne spores. They remained associated with the stem left attached to the tree when the avocados are 'snap' harvested, while they remained with the fruit when the avocados were 'clip' harvested. Although the inoculum of the aggressive pathogens is greatly reduced by 'snap' harvest, the relatively unprotected avocado flesh (mesocarp) exposed when fruit are harvested in this fashion is vulnerable to colonization by air-borne spores of weakly parasitic and saprophytic fungi, or by rain-splashed spores of very aggressive *Colletotrichum* spp. if harvest is after or during a rainy period. The limited colonization of the flesh of the stem-end by these fungi causes minor, but still objectionable, SER symptoms. We noted particularly *Alternaria* spp., although only capable of colonizing 2 to 3 mm into soft, ripe avocado flesh, caused vascular bundles throughout the fruit to darken objectionably.

We evaluated 'snap' and 'clip' harvest in January 2001, and found fruit harvested after a 3-day long rainy period had *much more* stem-end rot than those clip harvested, and the pathogen causing most of this rot was *Colletotrichum.* Apparently, rain greatly facilitated the production of spores of this pathogen and they exploited the exposed flesh of the 'snap'-harvested fruit. During harvest under dry conditions, we think the opposite will be true and stem end rot incidence would be reduced by 'snap' harvest, as it was in others' work.

This preliminary work has yet to support the use of 'snap' harvest to manage postharvest SER, as was reported SER by other workers, but we anticipate the practice may be sound if done in other than rainy periods. We did not see the negative consequence of 'snap' harvest reported by others that it delayed ripening, seen with Fuerte avocados(Johnson and Kotze, 1994 Darvas et al 1990), where the delayed ripening was associated with increased postharvest side rot losses by *Colletotrichum* (Johnson and Kotze, 1994). Our results agree with those of Arpaia and Hofshi (1998), where California 'snap' harvested Hass fruit ripened at the same rate as 'clip' harvested fruit. Because ripening occurs at its normal rate, the side rot incidence in California would probably not be influenced by harvest method.

This work also shows which types of fungi are associated with SER under these two harvest methods; this information impacts the disease control methods employed to reduce SER. For example, for 'clip' harvested fruit, fungicides or other techniques employed for preharvest or postharvest management of SER should focus on *Phomopsis* and *Dothiorella* control, while on 'snap' harvested fruit, control of other fungi, such as *Alternaria,* becomes important. Methods to protect fruit from air-borne spores are presumably very important for 'snap' harvested fruit, because the fruit flesh is exposed and vulnerable to attack by air-borne spores of even weak pathogens and saprophytes. The woody stem of 'clip' harvested fruit resists postharvest infections from air-borne spores and may not require rigorous protection from contamination, although the stem itself often harbors quiescent SER infections of the very aggressive *Phomopsis* and *Dothiorella* fungi. During rainy periods, *Colletotrichum* incidence becomes very high, and management of this pathogen becomes important.

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2001 Experimental

Hypothesis: That harvest and handling methods, such as snap or clip harvest, sanitation in the grove and packinghouse, ethylene degreening, and postharvest thermal conditioning treatments, can be optimized to minimize postharvest decay of avocados.

In early 2001, we conducted a large test to evaluate the impact of harvest and handling on the incidence and pathogens causing postharvest rot of avocadoes, and propose to conduct tests of similar design in the future. Harvested fruit were placed in 5°C storage for 7 or 21 days before ripening. This cold storage period was shown in prior tests by Mary Lu Arpaia and coworkers to dramatically reduce the incidence of postharvest decay, and we observed the phenomena again in this test. Two methods of harvest were evaluated, “snap” or “clip” removal of the fruit from the tree. This was done to see if the labor-saving “snap” harvest, shown in prior tests to influence the number of decayed fruit and kind of pathogens isolated, would continue to show significant advantages over the current practice of “clip” harvest. Two methods of postharvest handling were evaluated, the fruit were either packed into clean boxes in the grove, or they were transported and packed normally in a packinghouse after proceeding down a packingline. This was done to determine if the conventional handling influenced the incidence of postharvest rot.

In this first series of tests, we sampled fruit in three commercial “Hass” groves near Fallbrook on January 16, 2001. Approximately 2.5 inches of rain had fallen over the prior 2 days. Fruit were harvested from three groves by either the "snap" or "clip" method. Fruit from each type of harvest were: 1) packed in the grove into clean boxes minutes after picking; or 2) packed in clean boxes after transport of the fruit from the grove in field bins to the packinghouse and after normal passage down the packingline. In the case of packinghouse samples both “clipped” and “snapped” fruit were mixed together in the same field bin. The same packinghouse was used for all the fruit. All were ripened in ethylene (40 ppm for 30 hours) two days after harvest. Additional boxes of packinghouse-packed “clip” harvested fruit were placed in 5°C storage for 7 or 21 days before ripening. When the fruit had softened to about 1.5 lbs firmness or less, the incidence of side- and stem-end rot was recorded, isolations from decay lesions from every fruit with stem-end rot was made, and the fungi present were identified. A partial summary of the results of this test follows.

Cold temperature conditioning after harvest dramatically reduced the incidence of postharvest rot among fruit from three groves sampled (Fig. 1). The impact of storage at 5°C after harvest on postharvest body rot was evident on fruit stored 7 days, although the additional storage to 21 days affected a further reduction in body rot, particularly at

Location 3. Stem-end rot was equally reduced by 7 or 21 days storage. These results are similar to the results observed by Mary Lu Arpaia and coworkers in prior tests. No chilling injury was observed on any fruit.

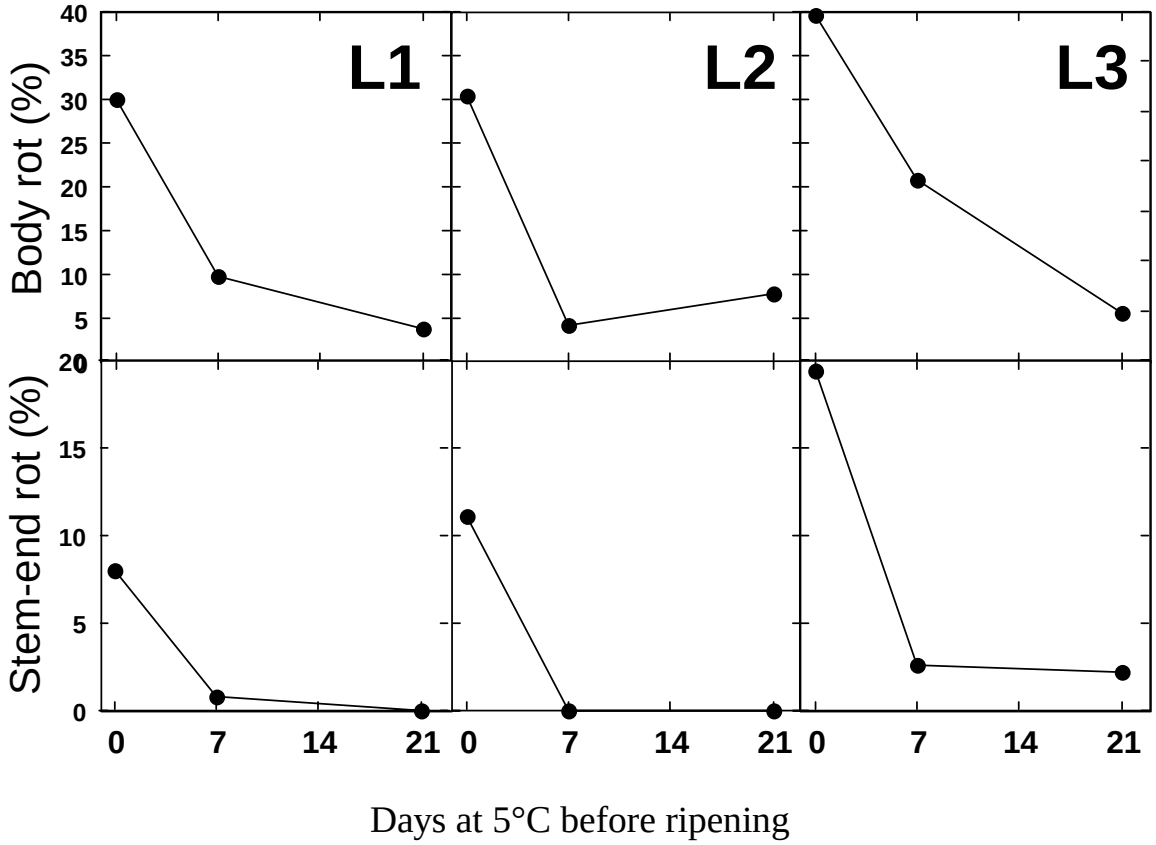

Figure 1. Incidence of body rot (top) and stem-end rot (bottom) and on "Hass" avocados ripened to 1.5 lbs firmness or less after harvest from three groves (L1, L2, or L3). The fruit were ripened with ethylene within 2 days of harvest (0 days), or after 7 or 21 days of storage at 5°C. The fruit were detached from the trees by clipping the pedicels with metal clippers (clip). The fruit were picked and placed in field bins, transported to a packinghouse, passed down the packingline, and packed in boxes. Each column is the mean of 2 or 3 boxes of 48 to 60 fruit each.

Stem-end rot was more prevalent among snap-harvested fruit than clip-harvested fruit (Fig. 2). The exposed avocado flesh in the stem scar was more susceptible to infection than the cut surface of pedicel, and during the wet conditions of this harvest the water-dispersed conidia of common avocado pathogens *Colletotrichum* and *Dothiorella* were presumably abundant. Fruit transported to and packed commercially in the packinghouse had slightly more stem end rot than those packed in the grove, indicating some additional decay resulted from inoculation or injuries that occurred during this additional handling.

Colletotrichum predominated in isolations from in infections among snap-harvested avocados. Among clip-harvested avocados with stem-end rot (n=138), *Dothiorella, Colletotrichum*, and *Alternaria* were isolated from 19%, 17%, and 10% of the diseased fruit, respectively. Among snap-harvested avocados with stem-end rot (n=312), *Dothiorella, Colletotrichum*, and *Alternaria* were isolated from 10%, 73%, and 3% of the diseased fruit, respectively.

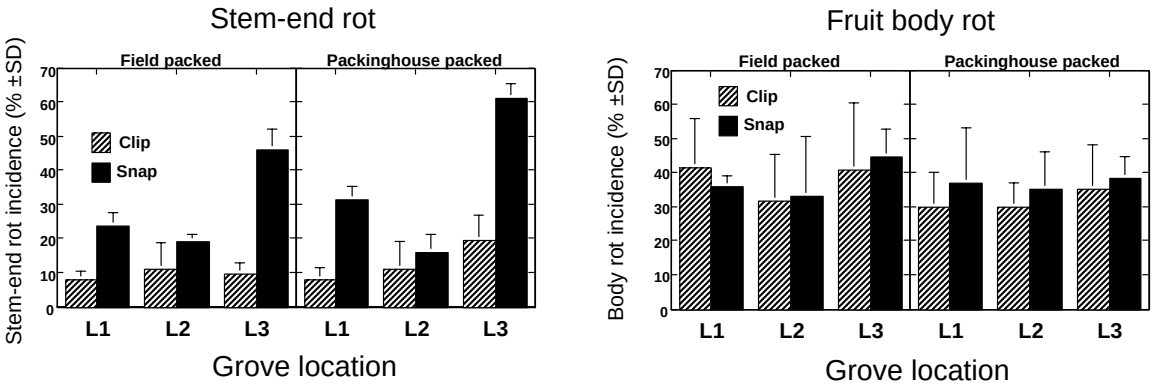

Figure 2. Incidence of stem-end rot (left) and body rot (right) on "Hass" avocados ripened to 1.5 lbs firmness or less after harvest from three groves (L1, L2, or L3). The fruit were detached from the trees by clipping the pedicels with metal clippers (clip) or pulled from the tree leaving the pedicel behind (snap). The fruit were packed in boxes in the grove, or transported to a packinghouse, passed down the packing line, and packed in boxes. Each column is the mean of 3 boxes of 48 to 60 fruit each.

Body rot incidence was high at all locations and not influenced by method of fruit harvest or the transport and packing process. This suggests infections responsible for these infections were already present at harvest.

These results suggest snap harvest during rainy periods early in the season increase, rather than decrease, the incidence of stem end rot, and that snap harvest should be avoided during rainy periods. These results differ from those of Mary Lu Arpaia and coworkers in prior tests and some published reports. Prior results in California and elsewhere showed snap harvest reduced stem end rot, but we believe this conclusion was derived from tests done during fruit harvest under dry conditions. Transport to the packinghouse and packingline handling did not increase body rot and only slightly increased stem-end rot. Modification of the handling practices or packingline equipment to improve sanitation or reduce handling injuries is perhaps of only very modest benefit in the management of postharvest decay.

This test was preliminary and was repeated with late-season avocados in July and August of 2001 and analysis and identification of the isolated fungi is in progress. We suspect the maturity of the fruit and the weather conditions at harvest could impact postharvest decay significantly and perhaps lead to different results.