POST-HARVEST ROTS OF AVOCADOS AND THEIR CONTROL

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SUMMARY

The principal post-harvest diseases of avocado fruits are anthracnose, caused by *Colletotrichum* spp., and stem-end rots, caused by species of *Botryosphaeria*, *Fusicoccum*, and *Phomopsis*. These diseases were controlled through a combination of tree hygiene; pre-harvest sprays with copper-based fungicides, or of copper plus benomyl; and post-harvest dipping in prochloraz.

Keywords: avocados, post-harvest rots, control, fungicides, tree hygiene

INTRODUCTION

Fruit of avocado (*Persea americana* Miller) cv. Hass, take c. 14 months to mature in the Bay of Plenty. Some fall prematurely during the first 5-6 months after flowering, the remainder rarely show any symptoms of disease while on the tree. The fruits do not ripen until after harvesting and it is at this stage rots appear. There is evidence that some, at least, of these rots arise from latent infections in the maturing fruits (Binyamini and Schiffmann-Nadel 1972). Thus protection to control the rots needs to start some time before harvest. In some countries, e.g. Australia, copper-based fungicide sprays are recommended during the growing season (Peterson and Inch 1980) although frequent use of such sprays can lead to the presence of highly visible deposits on ripened fruit.

In this paper the pathogens associated with post-harvest rots in New Zealand avocados are identified and trials on control methods are reviewed.

METHODS

Isolations

Potato dextrose agar (Difco) plus 50 ppm streptomycin was used for isolating fungi and the cultures grown in diffuse light at ambient temperature c. 23 °C. Other media (e.g. oatmeal agar), and fluorescent plus near-UV lighting were used occasionally to assist in identification of pathogens.

Pre-harvest sprays

The use of pre-harvest sprays is being tested in two on-going trials in an orchard in Tauranga; one evaluating the use of copper hydroxide (Kocide 101, 150 g/100 litres), the other the use of benomyl (Benlate 50 DF, 50 g/100 litres). The trials were designed to determine if these treatments have seasonal or cumulative effects on disease control. All sprays were applied to run-off (15-35 litres/tree, according to size) using a hand lance at 2800 kPa.

i. Copper hydroxide spray trial

The trial commenced on 28 September 1988. The treatments under test are:

- no spray (control)
- four sprays per season (September, November, February, April)
- sprays every month
- monthly sprays from April to October; 2-weekly from November to March (18 sprays/year)

Each treatment was replicated four times, each plot consisting of a pair of trees. All dead branches and twigs were pruned from one tree of each pair at 3-4 month intervals. In the 1991 harvest 50 fruits per tree were packed into boxes. Further samples of 50 fruits were taken from unpruned trees and dipped for 2 minutes in 250 ppm prochloraz,

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air dried, and then packed. It was not possible to include every combination of treatments because there were not enough resources to assess the extent of the rots in the harvested fruits, and to identify the pathogens present.

ii. Benomyl spray trial

An ongoing trial was started in 1989 to test the use of three applications of benomyl (in November, December and January) as an alternative treatment to copper-based fungicides.

In 1990 a further treatment, copper hydroxide applied monthly, May to October, followed by the three benomyl applications, was added to the trial as the results from the 1990 harvest indicated that benomyl alone was not controlling anthracnose.

In the 1991 harvest, 80 fruits were picked from each tree. Half were dipped in prochloraz and the other half left undipped.

Post-harvest dipping

Freshly harvested fruits were dipped in fungicides (1-2 minutes) or disinfectants (10-20 minutes). Fruits were intermittently agitated while in the dip. They were then air dried before being packed in boxes or paper bags. The fungicides tested in dipping trials included prochloraz, propiconazole, bitertanol, flusilazol, guazatine, benomyl and thiabendazole. The disinfectants tested included sodium hypochlorite, benzalkonium chloride, and potassium permanganate. The effect of post-harvest delays in dipping of between 2 and 24 h was investigated using 250 ppm prochloraz (Sportak 45 EC).

Disease assessment

The harvested fruits were returned to the DSIR Plant Protection laboratories, Auckland and ripened at ambient temperature (c. 23 °C). Every 1-2 days the fruits were examined for post-harvest rots and those with external rots removed and any fungi present isolated. When ripe, the remaining fruits were halved and assessed for internal rots. The extent of rotting in each fruit was estimated as follows:

- nil = no rots
- trace = shallow (c. 1 mm deep) rot only
- marginal = rots confined to a small segment (less than one quarter) of the fruit
- rotten = rots spreading well beyond initial infection site

A rot severity index was obtained by multiplying the number of fruits in each category by an arbitrary factor, related to the extent of rot found in that category, and then combining these values and converting the sum to a percentage of the maximum severity possible.

Rot severity index (%) =

$$\frac{[(\text{number trace}) + (4 \times \text{number marginal}) + (10 \times \text{number rotten})] \times 100}{10 \times \text{total fruits in sample}}$$

RESULTS AND DISCUSSION

The pathogens

A list of fungal pathogens isolated from avocado fruits is given in Table 1 (Hartill, in press). The anthracnose and stem-end rot pathogens also commonly occur on dead twigs and branches within the tree canopy. The list differs somewhat from the pathogens listed by other authorities (e.g. Snowden 1990; Ohr *et al* 1991). In New Zealand *Colletotrichum acutatum* is as important as *C. gloeosporioides* as a cause of anthracnose. *Botryosphaeria* spp. and *Fusicoccum luteum* are major pathogens in stem-end rots, not *Dothiorella* spp. or *B. ribis* as described elsewhere (e.g. Snowden 1990). These differences are probably due to differences in taxonomic interpretation rather than to the presence of different pathogens.

It may be significant that the fungi found in stem-end rots of avocado are identical to those found in ripe rots of kiwifruit (Pennycook 1985). The two crops are often grown adjacent to each other and share shelter belts from where the pathogens can also be isolated.

Pre-harvest sprays

The results of the copper hydroxide trial are presented in Table 2. The sprays were very effective in reducing the severity of post-harvest rots ($P < 0.001$). There was a

TABLE 1: Pathogens isolated from post-harvest rots.

Anthracnose:	<i>Colletotrichum acutatum</i> Simmonds ex Simmonds <i>C. gloeosporioides</i> (Penzig) Penzig & Saccardo
Stem end (neck) rots:	<i>Botryosphaeria parva</i> Pennycook & Samuels <i>B. dothidea</i> (Mougeot ex Fries) Cesati & de Notaris <i>Fusicoccum luteum</i> Pennycook & Samuels <i>Phomopsis</i> spp. (at least 2 species)
Others (rare):	<i>Fusarium</i> spp. (4 species) <i>Botrytis cinerea</i> Persoon <i>Rhizopus stolonifera</i> (Ehrenberg) Vuillemin <i>Trichothecium roseum</i> (Persoon) Link

TABLE 2: The severity of post-harvest rots and the incidence of pathogens in avocado fruits after use of different disease management strategies (copper hydroxide sprays, dead wood removal, and post-harvest dipping).

Treatment			Healthy fruits (%)	Rot severity (%)	% fruits with		Ripening time (days)
copper sprays	dead wood	dipped in prochloraz			<i>Colletotrichum</i> spp.	<i>Botryosphaeria/Phomopsis</i> spp.	
		S.E.	± 9.5	± 6.5			
none	no	no	32	51.0	30	52	11.2
	no	yes	54	29.8	21	36	13.2
	yes	no	33	47.3	36	47	11.6
4/year	no	no	50	31.2	36	22	11.0
	no	yes	66	16.4	17	21	11.4
	yes	no	69	16.4	20	13	10.7
12/year	no	no	70	19.8	14	15	11.6
	no	yes	82	10.3	8	9	14.3
	yes	no	81	9.5	14	7	12.5
18/year	no	no	79	11.2	11	11	11.0
	yes	no	92	4.9	3	6	12.4

progressive reduction in disease severity with increasing frequency of spray application. The post-harvest dip in prochloraz significantly reduced disease severity ($P < 0.001$) in all sub-samples of fruits on which it was tested.

Removal of dead wood from the trees had no effect on disease levels when the trees were unsprayed but caused a marked reduction in disease severity ($P < 0.001$) where copper hydroxide had been applied to the trees.

The different treatments affected fungal development in different ways. The application of copper hydroxide sprays led to a reduction in both the incidence of anthracnose and of stem-end rots. Periodically removing the dead wood from the trees had a greater effect on the incidence of the stem-end rot pathogens, *Botryosphaeria* and *Phomopsis* spp. than on anthracnose: dipping post-harvest in prochloraz had the opposite effect. The treatments are therefore complementary. It seems probable that the copper hydroxide sprays, together with removal of the dead wood, controlled the pathogens residing on dead wood and twigs within the tree canopy and reduced the amount of inoculum available for fruit infection. The post-harvest dip in prochloraz led to a significant ($P = < 0.05$) delay of 1.6 days in ripening, an effect noted in previous dipping trials (Table 2).

Both benomyl alone and with copper hydroxide reduced the severity of post-harvest rots (Table 3); the winter copper hydroxide + summer benomyl treatment being particularly effective ($P < 0.001$). The severity of post-harvest rots was further reduced when the field sprays were followed by a post-harvest dip in prochloraz. When the winter copper hydroxide + summer benomyl treatment was supplemented with the prochloraz dip the percentage of fruits remaining healthy after ripening was increased from 49% (untreated fruit) to 91%.

TABLE 3: The severity of post-harvest rots, and incidence of pathogens, in avocado fruits sprayed with either benomyl alone or copper hydroxide and benomyl.

Treatment	Healthy fruits (%)	Rot index (%)	% fruits with <i>Colletotrichum</i> spp. <i>Botryosphaeria/Phomopsis</i> spp.		Ripening time (days)
S.E.	± 8.9	± 7.3	± 3.6	± 2.5	
unsprayed					
undipped	49	34	13.5	9.3	11.6
dipped	72	15	4.0	6.5	12.0
summer benomyl					
undipped	65	20	9.7	6.0	11.8
dipped	75	10	5.0	5.0	12.1
winter copper + summer benomyl					
undipped	72	11	5.3	6.3	12.0
dipped	91	4	1.3	2.5	12.3

Post-harvest dipping

None of the treatments proved to be more effective than prochloraz, the currently recommended fungicide (Hartill *et al* 1986; Hartill 1988, 1989a, 1989b; Hartill and Sale 1989, 1990, 1991), though the use of sodium hypochlorite or benomyl would be practical in relation to markets where tolerances for prochloraz have not been set.

The efficacy of a 250 ppm prochloraz dip decreased with increasing delay between harvesting and dipping (Table 4). Fruit dipped 24 h after harvest had significantly more rots ($P < 0.05$) than fruits dipped immediately afterwards but had significantly less rots ($P < 0.001$) than undipped fruits.

The results of these trials indicate that the severity of post-harvest rots in New Zealand avocados can be controlled, but a combination of orchard hygiene, pre-harvest sprays, and post-harvest dipping are required to give the optimum quality.

TABLE 4: Effect of delaying dipping of avocado fruits in prochloraz after harvest on the severity of post-harvest rots and incidence of fungal pathogens.

Dipping time (hours after picking)	Rot severity index (%)	% fruits with <i>Colletotrichum</i> spp. <i>Botryosphaeria/Phomopsis</i> spp.	
S.E.	± 5.9	± 2.1	± 2.1
immediately	25	3.7	5.7
2	29	4.3	5.3
4	32	4.7	7.0
12	31	3.0	9.6
24	38	5.0	8.3
not dipped	65	10.7	13.7

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