

ORCHARD SURVEY: EFFECT OF PREHARVEST FACTORS ON POSTHARVEST ROTS.

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ABSTRACT

A survey has been carried out covering 3 seasons (1998-1999, 1999-2000, and 2000-2001) to look at the effect of various orchard factors on postharvest rots. In the first two surveys it was found that fungicide application and nutrition were important. In the 2000-2001 season there was a dramatic improvement of quality of New Zealand fruit in the USA marketplace. A further survey was carried out to find out if the decrease in rots in the marketplace was due to improved postharvest or orchard management practices or to a generally lower level of rots. Rots were less prevalent in the 2000-2001 season than in the previous two seasons (27.4% for 2001, 46.3% for 1999 and 35.8% for 2000). However, rot incidence was not low enough to account solely for the difference in fruit quality compared to the previous two years. The improvement in fruit quality this year appears to be due to a combination of both improved postharvest and orchard practices and to a reduced prevalence of rots. The relationship between nutrition and rots was not significant in this orchard survey. When compared with the results of the previous season, it was apparent that all orchards were using more calcium, and that calcium levels were above the 'threshold' determined in the previous survey. There was a stronger relationship between number of fungicide sprays and rots ($R^2=82.1\%$) than previously, probably because calcium was no longer influencing rots, and because an improved assessment method was used. Fruit harvested from the bottom half of trees tended to have more rots than those from the tops of trees, although this was not statistically significant. Body rots were significantly more severe from fruit from the bottoms of trees but there was no difference in stem-end rots. Rots were significantly reduced in fruit after 4 weeks coolstorage. The relationship between coolstored and non-coolstored fruit was stronger ($R^2=96.5\%$) for stem-end rots than for body rots ($R^2=49.8\%$).

Keywords: calcium, fungicides, coolstorage

INTRODUCTION

Out-turn monitoring of New Zealand fruit in the USA market has shown that fruit quality in the 2000-2001 season was significantly better than in the previous two seasons. A number of changes were made to procedures for harvesting, packing and transporting fruit this season (AIC USA Best Practice Manual, July 2000). Historical data of the rot levels in New Zealand fruit is available (Everett 1999a, Everett 2000). Orchards were surveyed to determine the amount of rots

in New Zealand fruit compared to the previous two seasons to clarify whether these changes were responsible for the improvement in fruit quality, or whether there were simply fewer rots in fruit this year.

Inoculum in the orchard as identified by necrotic patches on dead leaves is noticeably concentrated on the lower leaves in the avocado canopy. If the avocado postharvest rot fungi were water dispersed, spores would be dispersed upwards from the dead leaves and twigs in the mulch by rain splash and downwards from dead leaves and twigs in the canopy by dripping down the tree. Potentially fruit at the bottom of the tree will therefore have more rots than fruit at the top.

Numbers of rots in fruit in library trays treated according to AIC Avocado Assessment Manual (4 weeks at 5.5°C, then ripened at 20°C) were few, and thus comparisons between orchards were difficult. In contrast, large differences in quality of fruit between orchards were found using the methods of the orchard rot survey (Everett 1999a, Everett 2000). This suggests a requirement for standardising the postharvest treatment of fruit to enable comparisons of research results with industry results. A comparison between the industry standard (4 weeks at 5.5°C followed by ripening at 20°C) and the orchard rot surveys methodology (ripening and storage at 20°C) will enable a modifying formula to be derived to convert past results to commercially relevant results. It will also provide a basis for the development of a standardised methodology for use in future survey work.

A strong relationship was observed between the ratio of calcium and magnesium to potassium and fruit body rots in the previous orchard rot survey. Comparison between nutrition and fungicide application showed that nutrition was the more important factor in determining fruit quality. The validity of these relationships was investigated as part of the current survey.

MATERIALS AND METHODS

Over January 10th-16th 2001, 200 fruit were harvested from each of eight avocado orchards. Methods used were the same as those described in Everett (2000) except half the fruit was harvested from the top of the trees (approximately 5m above ground) and half from the bottom of trees (approximately 0-2m above ground). From each orchard 10 trays of 10 fruit each were stored and ripened at 20°C in a controlled temperature room. The remaining 10 trays were placed in a coolstore at 5.5°C for 28 days, and then placed at 20°C for ripening. There was a maximum delay of 48 hours between picking fruit and placement in the coolstore. Avocados were cut when ripe as determined by hand firmness testing. Cut fruit were assessed for rot, and pathogens from rots were isolated and identified using methods described previously (Everett, 1999a). Body rots were also assessed using the methods described in the AIC Avocado Assessment Manual.

RESULTS

Number of rots

Overall, rot incidence for the eight orchards sampled in each of the three surveys was lower this season than in the previous two seasons (Table 1). In the January 2000 season, body rots were more common than in January 1999 and January 2001. Stem-end rots were more common in the January 1999 season than in the following two seasons.

Table 1: Means of rot incidence in non-coolstored fruit for the 8 orchards sampled in January 2001 compared with these orchards in previous years. Error values are standard deviations.

Year sampled	Body rots	Stem-end rots	Total rots	Average no. of fungicide applications
January 1999 ¹	14.5 ± 8.8	41.0 ± 19.1	48.2 ± 19.8	3.9 ± 4.0
January 2000 ¹	21.3 ± 11.4	16.3 ± 8.4	33.9 ± 14.3	8.1 ± 5.9
January 2001	6.5 ± 4.6	23.4 ± 16.2	27.4 ± 16.7	11.6 ± 6.74

¹. Means were calculated using data from all 23 orchards sampled in 1999 and 2000.

Number of fungicides applied has steadily increased over the three seasons surveyed (Table 2), which resulted in a decrease in the numbers of rots in fruit. There was a dramatic decrease in rots in fruit from orchard 23 this season, concurrent with an increase in numbers of fungicides applied from 0 in the preceding two seasons to 14 this season. The fruit from orchards 5, 6 and 20 has improved in quality every year. Fruit from orchard number 8 has been consistently good every year. Fruit from orchard number 4 had a high number of stem-end rots this season, and rots in fruit from this orchard this season were above the mean, whereas in the previous two seasons rot levels were below the mean.

Table 2: Incidence of total rots and number of fungicide applications for the 8 orchards surveyed during 1999, 2000 and 2001.

Orchard Number	Incidence of total rots			Number of fungicide applications		
	1999	2000	2001	1999	2000	2001
8	11	14.5	8	11	12	17
4	15	24	48	8	10	16
20	34	19	12	5	5	13
6	43	26	20	3	12	14
14	64	53	45	0	0	0
23	64	57	13	0	0	14
2	65	55	46	0	4	2

	5	74	37	27	0	5	17
mean±standa rd deviation	46.3±24.3 ²	35.5±17.2 ²	27.4±16.7	3.4±4.27 ²	6.0±4.87 ²	11.6±6.74	

² These means are calculated from data from these 8 orchards only, in contrast to the means in Table 1.

Coolstorage

There was a strong relationship between incidence of stem-end rots in coolstored and non-coolstored fruit ($R^2=96.5\%$, $P<0.0001$) (Fig. 1), with coolstorage consistently reducing the incidence of rots by about half. The relationship for body rots, although significant was not as strong ($R^2=49.8\%$, $P=0.05$). Overall, there were fewer rots in fruit that had been coolstored for 28 days compared with non-coolstored fruit. There was no relationship between coolstored and non-coolstored fruit when severity was analysed separately.

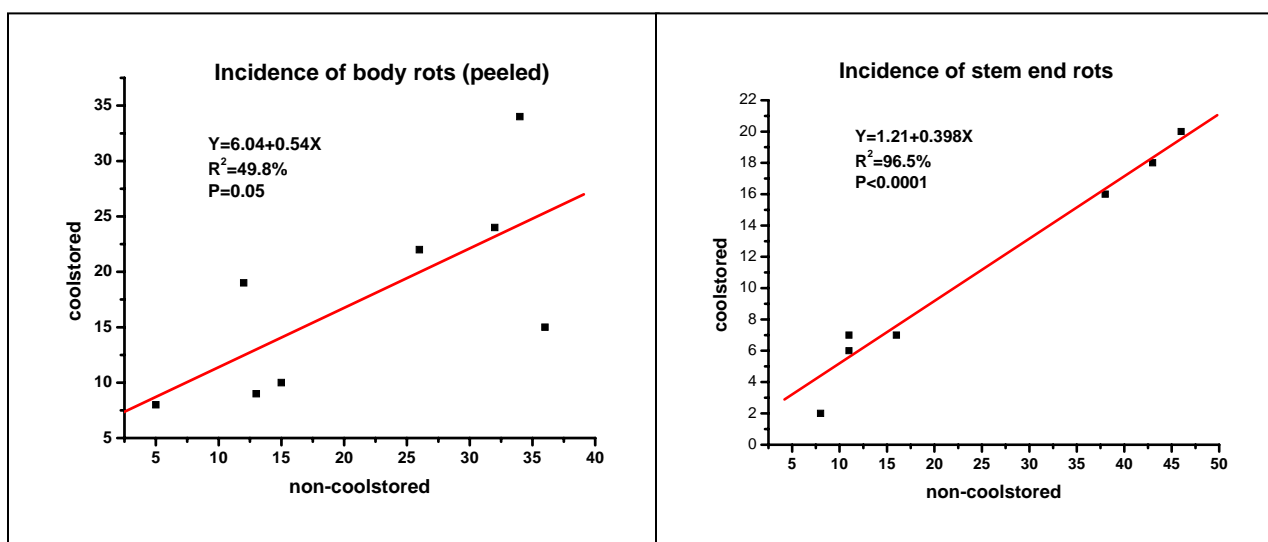


Figure 1: Comparison of incidence of body rots and stem-end rots when fruit were coolstored for 28 days at 5.5°C followed by ripening at 20°C (coolstored), and fruit stored at 20°C (non-coolstored).

Position

When orchards were used as replicates, rot incidence tended to be higher in fruit from the bottom half of the tree, although this difference was not significant. Overall, stem-end rot severity did not differ significantly in fruit from the tops or the bottoms of trees, although they did tend to be more common in the lower half of the tree. However, body rots assessed by peeling were significantly worse in fruit from the bottom of the tree (Table 3).

Table 3: Incidence (%) and severity of body rots and stem end rots at the tops and bottoms of trees.

	Incidence		Severity	
	Body rots (peeled)	Stem-end rots	Body rots (peeled)	Stem-end rots
Top	10.00±4.38	8.88±8.13	4.92±1.80	0.52±0.31
Bottom	12.25±7.56	14.13±9.16	8.60±4.37	0.51±0.34
P	n.s.	n.s.	0.045	n.s.

Values are means ± standard deviations. P= probability of differences not being due to chance. n.s. = not significant.

Fruit Nutrition

The relationship between fruit nutrition and mean severity of body rots was not significant. The apparent trend in the data showed that the higher the ratio between Ca+Mg/K, then the less severe were the rots (Fig. 2). However, examination of the raw data shows that this effect was due to one data point (x=0.065, y=0.16). Once the ratio exceeded 0.07, there was effectively no change in fruit quality. There was no obvious relationship between stem-end rots and nutrition.

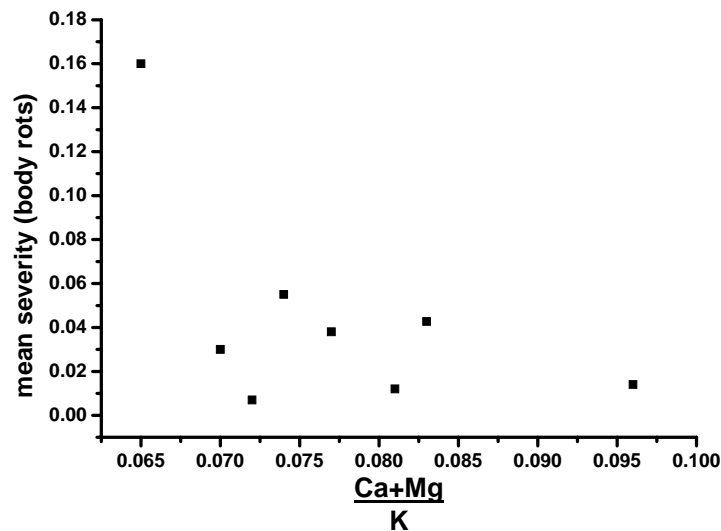


Figure 2: The relationship between Ca+Mg/K and mean severity of body rots.

Fungicide sprays

There was a highly significant relationship between number of fungicide sprays applied and incidence of fruit with rots that had not been coolstored ($R^2=82.1\%$, $P=0.002$), when assessed following peeling (Fig. 3).

Fungal isolations from rots

The most prevalent fungus isolated from stem-end rots was *Colletotrichum acutatum*, and from body rots was *Botryosphaeria parva*, followed closely by isolations of *Colletotrichum acutatum* (Fig. 4).

When orchards were divided to those north and south of Auckland (Fig. 4), there were more isolations of *Colletotrichum acutatum* from orchards north of Auckland than from southern orchards.

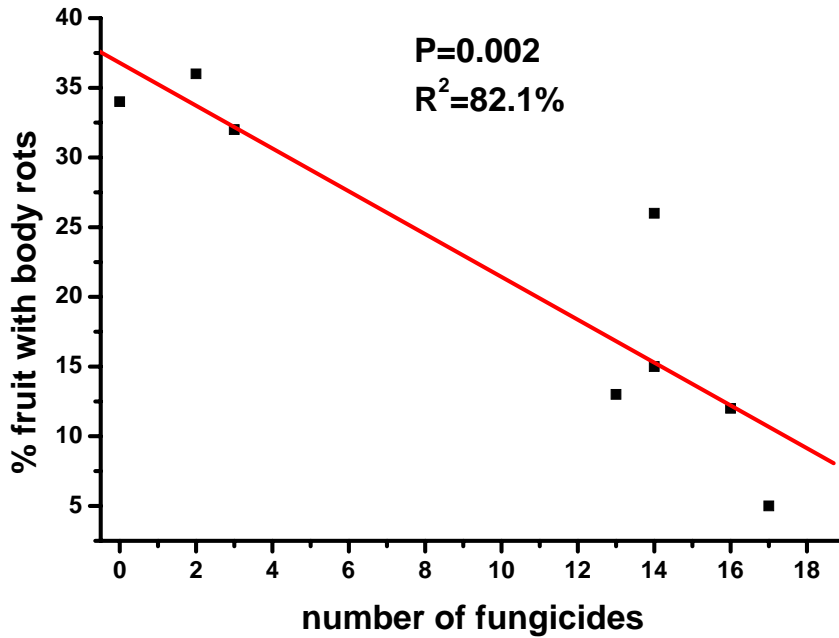
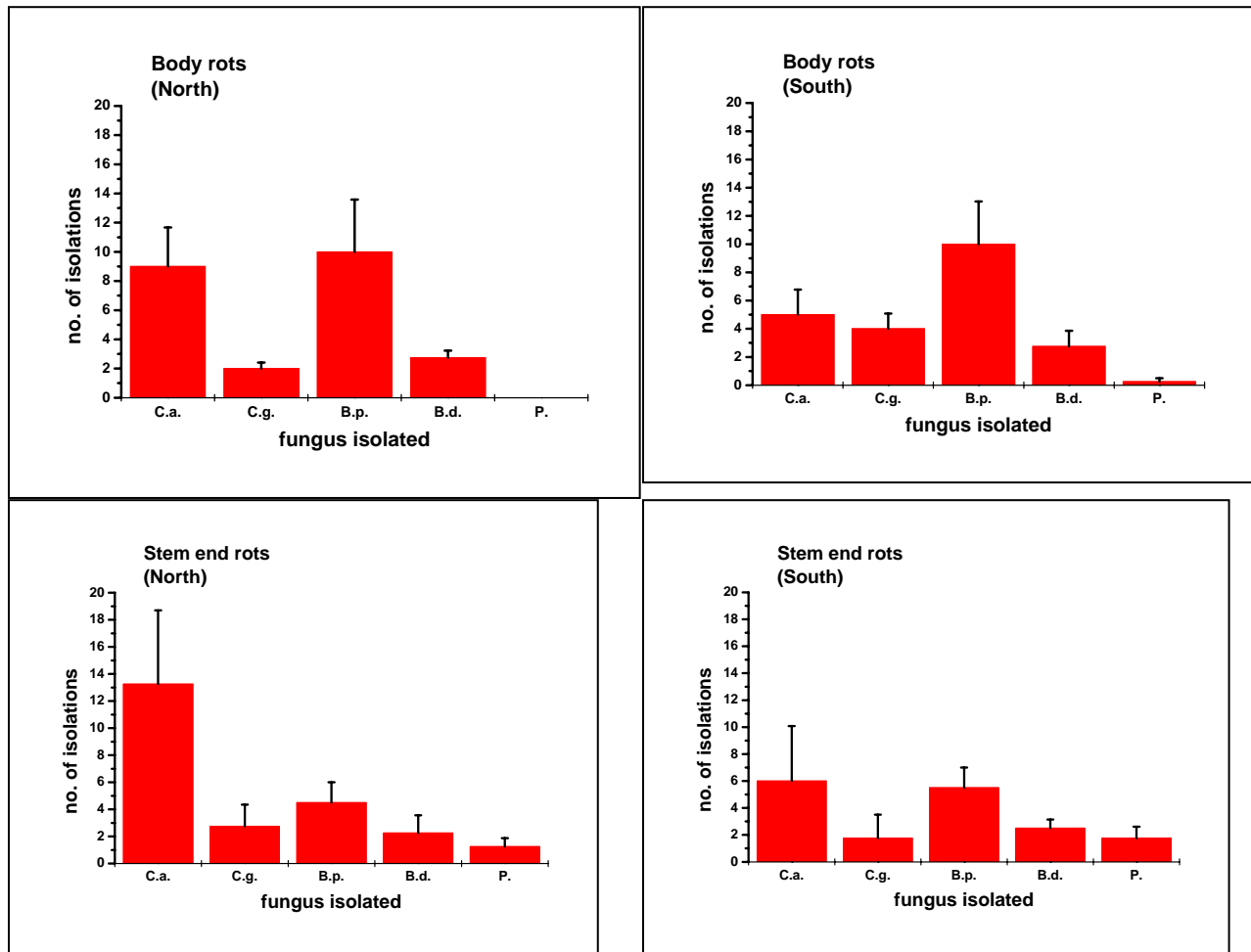


Figure 3: Incidence of body rots from 100 fruit (non-coolstored) from each of eight orchards plotted against number of fungicide applications.

Figure 4: Mean number of isolations of fungi from body rots and stem-end rots out of 100 fruit from each of 8 orchards from two major avocado growing regions categorized as North (north of Auckland) and South (south of Auckland). C.a. = *Colletotrichum acutatum*, C.g. = *Colletotrichum gloeosporioides*, B.p. = *Botryosphaeria parva*, B.d. = *Botryosphaeria dothidea*, and P. = *Phomopsis*. Values are means \pm standard errors.



DISCUSSION

During the three years of the orchard rot survey, there has been a steady improvement in the quality of the fruit. There has also been a steady increase in the number of fungicide applications, and this year compared to last year an increase in the amount of calcium in fruit. Some orchards changed practice significantly after the results of the first year, with a consequent improvement in quality.

Those orchards that received fewer than five fungicide applications a season did not achieve acceptable control of fruit rots. Reasonably good control was achieved on those orchards where fungicide was applied at least five times a year.

In the January 2000 season, body rots were twice as common as in January 1999 and January 2001, which was reflected in the marketplace. In both USA and Australia there was a severe problem with body rots in January 2000. In spite of the differences in rot assessment methodology the results of the orchard rot survey appear to reflect the problems in the marketplace. The orchard survey data does indicate that in the 2000-2001 season there was still considerable disease pressure, with the potential for major quality issues if fruit had been poorly handled. The extent to which weather has impacted on these results will be clearer after comparison of climatic and library tray data from the current season. Regarding the differences in assessment methodology between the historical survey data and the industry standard it was clear that for body rot assessments fruit peeling gave more accurate data than that collected in the previous two surveys.

The amount of rot in fruit ripened at 20°C overall was greater than in fruit coolstored for 4 weeks prior to ripening at 20°C. This is in contrast to the results of other workers (Hopkirk et al. 1994). There was no obvious difference in the severity of rots in coolstorage compared to those of fruit stored at 20°C. Storing fruit at 20°C was a very good predictor of the amount of stem-end rot that developed in coolstore, with rot incidence consistently reduced by about half in the coolstored fruit.

However, the relationship between numbers of body rots in fruit stored at 20°C compared with coolstored fruit was not strong, accounting for only 50% of the variation in the data. This could be due to the fact that body rots are caused both by direct penetration by spores through lenticels and by latent infections by appressoria (Kim et al. 1999). It is unlikely that stem-end rots are caused by latent infections, as all stem-end rots are observed to progress through the stem, which is a new wound site. Appressoria require 24- 48 hours to form (Ogle et al. 1990). In this trial fruit were placed in the coolstore a maximum of 48 hours after picking. It is known that appressoria do not form below 12°C (Everett 1998), and that 50% of spores are killed after 14 days at 5°C. It is also known that the temperatures used to coolstore avocado fruit did not affect survival of appressoria of *Colletotrichum gloeosporioides* (Everett 1999b). Therefore, some of the variation in the relationship between body rots in coolstored and non-coolstored fruit may be caused by inoculum that is impervious to damage by coolstorage.

In this study the relationship between body rots and nutrition was not significant. Examination of the raw data generated from the previous survey (Everett 2000) shows that for values of Ca+Mg/K above 0.065, there is no further reduction of body rots due to increased calcium. In the current study, fruit from all orchards sampled had a ratio higher than 0.065. It appears that orchardists in this survey have improved their nutrition programme so that insufficient calcium is no longer a factor limiting fruit quality. These results indicate that orchardists need to maintain a Ca+Mg/K ratio above 0.07 for best fruit quality, but that any further increase in the ratio does not confer any further improvement in fruit quality.

There was a very strong relationship between number of fungicides and body rots. This relationship is stronger than in both previous orchard rot surveys (30% in 1999, 23% in 2000, 82% this study). This strong relationship is probably due to two factors: (1) more accurate assessment of body rots by peeling fruit and (2) removal of the effect of nutrition on rots. There may also be a seasonal effect.

Colletotrichum acutatum and *Botryosphaeria parva* were the most common pathogens isolated from body rots this year, but *Colletotrichum acutatum* was the most common fungus isolated from stem-end rots. In the previous two orchard rot surveys (Everett 1999a, Everett 2000), *Botryosphaeria parva* has been the most common pathogen isolated from both body rots and stem-end rots except for orchards North of Auckland in 1999. During the three years of the orchard rot survey, the most important pathogens overall have been *Botryosphaeria parva* and *Colletotrichum acutatum*.

CONCLUSIONS

The improvement in fruit quality this season appears to be a combination of both preharvest and postharvest factors. In this survey, calcium did not appear to limit fruit quality in the orchards sampled. The number of times fungicides were applied was strongly negatively correlated with incidence of postharvest rots. There tended to be more rots in fruit from the bottom of trees compared to the tops of trees. Fruit coolstored at 5.5°C for 28 days has fewer rots than non-coolstored fruit.

Orchardists should aim to achieve a Ca+Mg/K ratio in fruit of at least 0.07 to assist with protection from rots. The industry recommendation of 8 sprays per season provided good control in this survey. Coolstoring fruit for an extended period up to 28 days reduces the amount of rot which develops on the fruit. Fruit ripened at 20°C may be a useful method to predict the amount of stem-end rots that develop in coolstored fruit.

ACKNOWLEDGEMENTS

Many thanks to Lisa Benson for technical assistance, and to the growers who participated in the survey. I would also like to acknowledge Pauline Mooney for editorial assistance.

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