FUNGICIDE TIMING FOR CONTROL OF SUMMER ROTS OF APPLES

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ABSTRACT

Control of pre-harvest summer rot in cv. Royal Gala apple in the Waikato district during the 2006/2007 growing season was evaluated. There were six treatments and an unsprayed control. Three treatments investigated the effect of timing by applying tolyfluanid, mancozeb, captan and copper sequentially at 10-14 day intervals in October and early November (spring), November and December (early summer) or January and February (late summer). The fourth treatment was two applications of carbendazim in early October (flowering) and there were two biological control treatments, *Bacillus subtilis* QST713 and *Serratia marcescens* HR42, applied at 10-14 day intervals from flowering (October) to harvest (February). Compared with the unsprayed treatment, the most effective control was achieved by fungicide applications during either November/December or January/February. Due to large variation in the data, differences were not statistically significant, but mean lesion diameter at final assessment for these treatments was 29% and 35% of controls, respectively. The other treatments did not control rots.

Keywords: apple summer rots, *Colletotrichum acutatum*, *Botryosphaeria dothidea*, timing, biological control, HR42, Serenade®.

INTRODUCTION

Apple summer rots are characterised by small dark spots, ca 1-2 mm in diameter, which appear on fruit surfaces in January-February. These lesions can increase in size to cover most of the fruit surface by harvest in late February and March. Affected fruit are unmarketable. Summer rots can be caused by *Colletotrichum acutatum*, *Colletotrichum gloeosporioides* (teleomorph *Glomerella cingulata*) and by *Botryosphaeria dothidea* (Dingley 1969; Jones & Aldwinckle 1990; Lardner et al. 1999; Cunnington et al. 2007). In the case of the two *Colletotrichum* species, lesions can become covered with circular rings of pink to orange spores. Rots caused by these fungi are also characterised by the 'v' shaped lesion in cross section under the circular spots. Those caused by *B. dothidea* have cup-shaped lesions in section.

At the beginning of this study summer rots were not being adequately controlled by the routine fungicide spray applications, which may have been due to inappropriate timing of the fungicides in relation to the infection periods of the causative fungi. Anecdotal evidence suggested that spraying carbendazim during flowering was controlling summer rots. This paper reports a study of the timing of fungicide applications on the efficacy of these treatments for control of summer rots of apples. In addition, the effectiveness of carbendazim application during flowering and two biological control agents applied throughout the season were tested for control of these rots.

METHODS

Fungicide application

The fungicides used and their respective application rates are detailed in Table 1. The trial had six treatments and an unsprayed control. The first three treatments tested the effect of timing of fungicide application on rot control by applying the same fungicides, tolyfluanid, mancozeb, captan and copper sequentially at 10-14 day intervals, in three different periods. These fungicides were selected because of known efficacy against summer rots and all are registered for use on apples (Young 2007). The order of application was to comply with withholding periods for export (M.R. Butcher, pers. comm.). The three spray periods were spring (October/early November), early summer (November/December) or late summer (January/February) (Table 2). There were two biological control agent treatments, *Bacillus subtilis* QST 713 and *Serratia marcescens* HR42, which were applied at 7-14 day intervals throughout the season on 12, 18, 26 October, 1, 7, 21 November, 5, 20 December, 11, 22 January and 9 and 19 February. The sixth treatment was carbendazim, which was applied twice only, during flowering and early fruit set, on 12 and 18 October. All treatments were compared with an unsprayed control. The trial location was at the Blands Research Orchard in Waikato and cv. Royal Gala apple trees were used. Each spray treatment was applied to six replicate trees using a random block design. Products were applied to run-off using a pressurised hand gun sprayer.

Disease assessment

Disease was assessed by labelling five randomly selected branches per tree and recording the number of infected fruit and lesion sizes at weekly intervals from 11 January–1 March 2007, giving eight assessments. If there were several lesions on a fruit, then the lesion diameter was summed to give a total surface area affected by summer rots.

Isolations

Isolations were made from a randomly selected sub-sample of 10 fruit (1-2 lesions per fruit) showing symptoms of summer rots from the Blands Research Orchard to identify the fungal pathogens. The surface of each diseased apple fruit was wiped with 70% ethanol, the skin cut and peeled back, and a portion of the exposed rotted tissue excised and placed on Difco® potato dextrose agar. After 3-6 weeks under UV/daylight fluorescent lights on a 12:12 h light:dark cycle, any resultant fungi were identified by culture and spore morphology. In addition, isolations were also made from eight fruit showing symptoms of summer rots in an adjacent commercial orchard from which *C. acutatum* had been isolated for the previous two seasons (K.R. Everett, unpubl. data), and eight from the packhouse both orchards used, to determine if the climatic conditions that year had affected the causal organism of summer rots in the Waikato district.

TABLE 1: Products used and rates of active ingredients applied to six trees per treatment of cv. Royal Gala apple trees in a field trial.

Product	Active ingredient (a.i.)	Rate (a.i./100 litres)
Euparen® Multi	tolyfluanid	50 g
Manzate® 200DF	mancozeb	150 g
Captan 80W	captan	100 g
Kocide 2000	copper hydroxide	66.5 g
Goldazim® 500 SC	carbendazim	12.5 g
Serenade®	*Bacillus subtilis* QST 713	5×10^8 cfu/ml
HR42[1]	*Serratia marcescens* HR42	1×10^8 cfu/ml

[1]Experimental HortResearch product.

TABLE 2: Timing of fungicides applied to cv. Royal Gala apple trees in Blands Research Orchard, Waikato (2006/2007). For each time period the four fungicides were applied sequentially.

	Timing of application		
Date	Spring	Early summer	Late summer
12 Oct	tolyfluanid		
18 Oct	mancozeb		
26 Oct	captan		
1 Nov	copper hydroxide		
7 Nov		tolyfluanid	
21 Nov		mancozeb	
5 Dec		captan	
20 Dec		copper hydroxide	
11 Jan			tolyfluanid
22 Jan			mancozeb
9 Feb			captan
19 Feb			copper hydroxide

Statistical analysis

SAS® (version 8.2) and Excel® were used for data analysis. Tree is the experimental unit. Tree means at each week were calculated by averaging the lesion diameter measurements over all the fruit. Treatment means and their standard errors were calculated using the tree means weighted by number of fruit per tree. Each individual tree mean was calculated from the mean of the fruit on the five assessed branches, and treatment tree means from the mean of the six replicate trees. There were unequal numbers of fruit per branch. Dropouts were handled by Last Observation Carry Forward (LOCF), which is a method for imputation of missing values (Powers et al. 2007). The last remaining observation is carried through to remaining time points. It is assumed that dropout is due to fruit missing at random. Statistical differences were calculated by generating P values using a one-tailed paired t test of the final point response.

RESULTS

Treatment means and their standard errors are plotted in Figure 1. Results of t tests provided weak evidence that fungicide applications in early and late summer reduced lesion size compared to untreated controls (P=0.16 and 0.18 respectively). Mean lesion diameter of these two treatments (0.5 and 0.6 mm) was 29% and 35% respectively of untreated controls (1.7 mm). These differences were not statistically significant due to large variability between trees. The other treatment P values were ≥ 0.39 and were not significant.

The differences between treatments of fruit that dropped from the trees during the treatments were small (Fig. 2) and fruit retention was not consistently related to disease control confirming the assumption that dropout is due to fruit missing at random.

Botryosphaeria dothidea was isolated from all 12 of the small dark lesions on the 10 fruit from the Blands Research Orchard. *Colletotrichum acutatum* was isolated from all similar lesions from 12 fruit from an adjacent commercial orchard, and from rejected fruit at its packhouse.

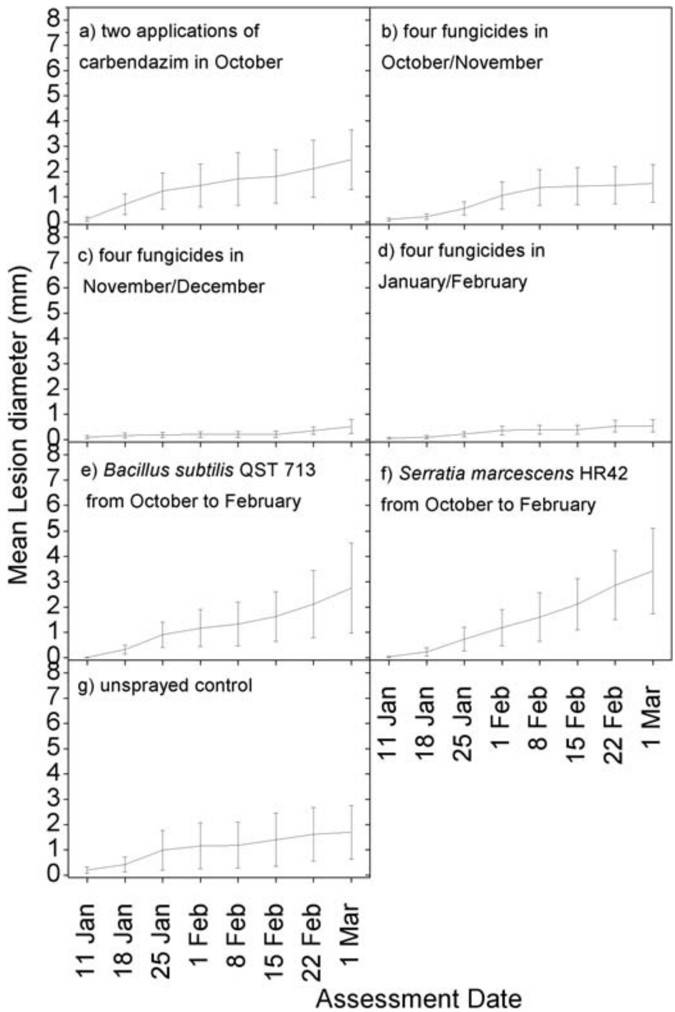

FIGURE 1: Mean diameters per fruit (mm) of lesions caused by *Botryosphaeria dothidea* at eight weekly assessments. Bars are standard errors of the means. (a) two applications of carbendazim in October, (b) four fungicides in October/November, (c) four fungicides in November/ December, (d) four fungicides in January/February, (e) *Bacillus subtilis* QST 713 from October to February, (f) *Serratia marcescens* HR42 from October to February and (g) unsprayed control.

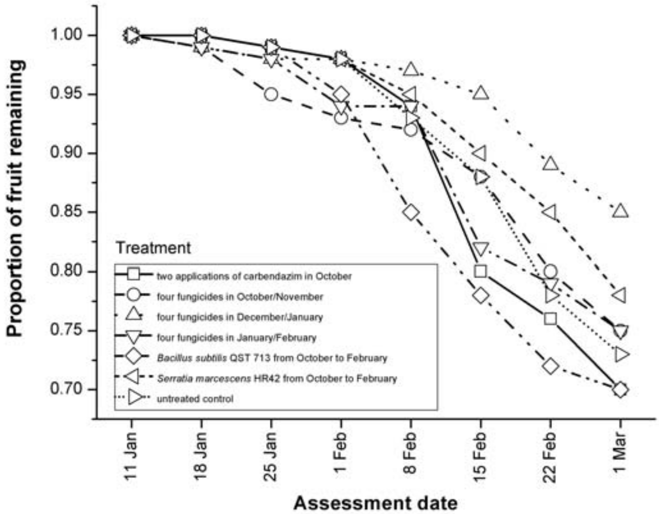

FIGURE 2: The relative proportion of fruit remaining on trees during the summer, for each of the seven treatments. (a) two applications of carbendazim in October, (b) four fungicides in October/November, (c) four fungicides in November/December, (d) four fungicides in January/February, (e) *Bacillus subtilis* QST 713 from October to February, (f) *Serratia marcescens* HR42 from October to February and (g) unsprayed control.

DISCUSSION

Best control of summer rot disease of apples was achieved by applying one application each of tolyfluanid, mancozeb, captan and copper sequentially at 10-14 day intervals during either early or late summer (November/December or January/February). However, this result was not statistically significant due to high variability between trees. A larger sample size is recommended to reduce variability for future trials. In studies on timing of application of ergosterol biosynthesis-inhibiting fungicides, Kim & Uhm (2002) found that applications were most effective in mid to late summer for control of summer rots of apples caused by *B. dothidea* in Korea. Although different fungicides were used, the most effective control was obtained when fungicide applications were applied at an equivalent time in the season to the time best control was achieved in the present study.

In New Zealand, *B. dothidea* is occasionally isolated from summer rots, but its incidence is low. For instance, in 1999 46% of isolations from fruit rots from 13 orchards in the Waikato district by ENZA yielded *C. acutatum*, and *B. dothidea* was not found. In the same survey *G. cingulata* was not isolated (M.R. Butcher, pers. comm.). In contrast, the summer rots on the Blands Research Orchard were caused by *B. dothidea*. Because lesions from fruit from adjacent orchards yielded *C. acutatum* seasonal weather patterns are not likely to be the reason for this difference.

The Blands Research Orchard was selected on the basis of its likelihood to have high disease pressure because it was not managed using standard commercial practices. Thus, it is an unusual orchard, and not typical of other orchards in the Waikato. These results suggest that regular spray programmes on commercial orchards control rots caused by *B. dothidea*.

Over 30 years ago, control of summer rots caused by *Glomerella cingulata* was achieved by applying captafol sprays four times at 13-15 day intervals in spring (September/October) and in early summer (November/December) (Brook 1977). However, captafol is no longer available, and more recent studies have shown that the disease is now most commonly caused by *C. acutatum* (M.A. Manning, pers. comm.). The present results suggest that 30 years later summer rots are better controlled by fungicide applications in early and late summer. However, this needs confirmation by testing on an orchard with a high incidence of summer rots caused by *C. acutatum*.

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