POSTHARVEST FRUIT ROTS OF AVOCADO ARE REDUCED BY BENOMYL APPLICATIONS DURING FLOWERING

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ABSTRACT

Spray trials were carried out on avocado trees at two sites in the Bay of Plenty. At each site, trees received either two applications of benomyl during flowering or were left unsprayed. Several stem end rot pathogens (*Phomopsis* sp., *Botryosphaeria* sp. and *Colletotrichum* sp.) were isolated from flowers. Stem end rots were reduced in fruit harvested 10 months after fruit set from trees which had been sprayed with benomyl during flowering. Fewer isolations of *Phomopsis* sp. were made from flowers sprayed with benomyl and from stem end rots from fruit of sprayed trees compared with fruit from unsprayed trees. These results suggest that *Phomopsis* sp. may gain entry to avocado fruit at flowering and subsequently cause postharvest stem end rots.

Keywords: avocado, benomyl, *Phomopsis* sp., flowers, stem end rots.

INTRODUCTION

After harvesting, avocado (*Persea americana*) fruit develop both stem end and body rots. Fungi isolated most commonly from stem end rots include *Colletotrichum acutatum* Simmonds ex Simmonds, *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. (teleomorph *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk), *Botryosphaeria parva* Pennycook & Samuels, *Botryosphaeria dothidea* (Mougeot ex Fries) Cesati & de Notaris, and *Phomopsis* sp. (Hartill 1991). The infection pathway for stem end rot fungi is not well understood, but infection may occur at harvest, as endophytes (Johnson *et al.* 1992), or by infection of dying flower parts.

Benomyl is a broad spectrum systemic fungicide with both protective and curative action and has activity against a wide range of fungi, including species of *Phomopsis*, *Botrytis*, *Botryosphaeria*, *Cladosporium*, *Fusarium* and *Colletotrichum* (Foot 1997). The active ingredient is absorbed through the leaves and roots and translocation is principally acropetal. Benomyl is registered for use on avocado and is also recommended for application during flowering on other crops, so neither phytotoxicity nor deleterious effects on bees are expected.

This study examines the effects of a benomyl spray programme during avocado flowering on fungi isolated from flowers, and subsequent development of stem end rots in fruit harvested 10 months later.

METHODS

Trials were carried out in two orchards in the Bay of Plenty (Te Puke and Katikati). Fungal populations from trees sprayed with benomyl (500 g/litre, Benlate) and from unsprayed trees were compared. Benomyl was applied to single tree plots at a rate of 50g/100 litre, on 30/10/97 and 4/12/97 (flowering). At both sites, benomyl was applied to 10 replicate trees using a randomised block design. Spray was applied to run-off using a hand-gun from a motorized sprayer. Unsprayed trees were included in the trial as experimental controls.

Flower samples for fungal isolations were collected one day before the first spray application (pre-spray) and one day after the second application (post-spray). Four flower panicles were removed from as near as possible to north, south, east and west sectors of each of 10 trees per treatment. Isolations were made from a flower selected randomly from each of these four flower panicles. Flowers were surface-sterilised, then dissected under a binocular microscope in a laminar flow cabinet. Stamens, carpels, petals and stalks were then individually placed onto Difco potato dextrose agar (PDA). Fungal colonies were identified after 3-6 weeks growth at c. 20°C under diffuse light.

Fruit were harvested on 29/10/98 from Te Puke and 19/11/98 from Katikati, (10 fruit per tree per treatment). However, as fruit set on a few trees at Katikati was low, all available fruit were harvested from these trees. Fruit were placed in a temperature controlled room (20°C), and assessed for rots when 'ready to eat'. To determine when fruit were 'ready to eat', fruit were gently hand-squeezed and categorised on a 0-10 scale (0=hard, 5= ready to eat, 10=soft) which relates to a firmometer reading of firm 70-85, ready to eat 85-100, and soft 100+ (White *et al.* 1997). Fruit were visually assessed internally for both stem end rots and body rots using a 0-10 scale (0=healthy and 10 indicating entire fruit decay (Korsten *et al.* 1995). Treatments were compared using analysis of variance (ANOVA) and Fisher's protected least significant difference test. Percentages were angular transformed before analysis but untransformed percentages are presented in all Tables.

RESULTS

Fungal colonies were isolated from 1755 of 2560 dissected flower parts (Table 1). A total of 29 fungal genera were isolated, but only those 10 isolated from >1% of flowers are shown. Of those 10, the incidence of the following eight fungal genera was further analysed; *Phomopsis* sp., *Colletotrichum* sp., *Botryosphaeria* sp., *Epicoccum* sp., *Chaetomium* sp., *Alternaria* sp., *Botrytis* sp. and *Cladosporium* sp. These eight fungi were chosen because *Phomopsis* sp., *Colletotrichum acutatum*, *C. gloeosporioides*, *Botryosphaeria parva* and *B. dothidea* can cause stem end rots of avocado fruit. *Epicoccum* sp., *Chaetomium* sp., *Alternaria* sp., *Botrytis* sp. and *Cladosporium* sp. can cause disease on other hosts, or were present in sufficient numbers to be considered important. The other fungi isolated were either saprophytes or were not present in sufficient numbers of isolations to be considered important. Of the eight fungi chosen for analysis, number of isolations of *Phomopsis* (P=0.092) and *Botrytis* (P=0.006) was reduced by applications of benomyl (Table 2).

When isolations from each dissected flower part were examined to determine if any of the treatments affected fungi present in specific flower parts, no differences (P>0.05) were detected.

TABLE 1: Fungi isolated at frequencies >1% from both Te Puke and Katikati orchards and on two occasions (pre- and post spray) from a total of 2560 dissected flowers from 'Hass' avocado.

Fungal genera	No. of times isolated	% of total isolations
<i>Epicoccum</i> sp.	678	38.5
<i>Alternaria</i> sp.	235	13.4
<i>Phomopsis</i> sp.	198	11.3
<i>Colletotrichum</i> sp.	88	5.0
<i>Botryosphaeria</i> sp.	85	4.8
<i>Chaetomium</i> sp.	80	4.5
<i>Mucor</i> sp.	63	3.6
<i>Cladosporium</i> sp.	62	3.5
<i>Fusicladium</i> sp.	56	3.2
<i>Botrytis</i> sp.	21	1.2

TABLE 2: Mean numbers¹ of isolations of *Phomopsis* sp. and *Botrytis* sp. isolated per flower part before and after trees were treated with benomyl over the flowering period.

Orchard	Treatment	<i>Phomopsis</i>		<i>Botrytis</i>	
		Pre-spray	Post-spray	Pre-spray	Post-spray
Te Puke	benomyl	0.17	0.04 b	0.006	0.00
	unsprayed	0.17	0.11 a	0.00	0.02
Katikati	benomyl	0.01	0.03	0.00	0.00 b
	unsprayed	0.01	0.06	0.00	0.04 a

¹Numbers in columns followed by different letters were different ($P < 0.05$), Fisher's protected LSD test.

Stem end rots were reduced by two applications of benomyl over flowering (Table 3). There was no effect on fruit body rots (data not shown). The numbers of isolations of *Phomopsis* sp. and the two *Botryosphaeria* spp. were less from stem end rots from fruit from trees that had been sprayed with benomyl than on fruit from unsprayed trees (Table 4). The mean severity of rots caused by *Phomopsis* sp. was less ($P < 0.001$) in fruit from trees sprayed with benomyl at flowering than in fruit from unsprayed trees (Table 5).

TABLE 3: Mean severity¹ of stem end rots in fruit from trees sprayed with benomyl during flowering and from fruit from unsprayed trees.

Orchard	Treatment		Significance ²
	Benomyl	Unsprayed	
Te Puke	0.33	0.66	0.044
Katikati	0.09	0.32	0.005

¹ Mean severity = (proportion of total fruit with stem end rots x severity of rots scored visually on a 0-10 scale, 0 = no rots, 10 = totally rotten).

²ANOVA P value.

TABLE 4: Percentage of fruit yielding fungi from stem end rots from trees sprayed with benomyl during flowering and from unsprayed trees.

Fungus isolated	Te Puke		Katikati	
	Benomyl	Unsprayed	Benomyl	Unsprayed
<i>Colletotrichum acutatum</i>	3 ¹	7	4	4
<i>C. gloeosporioides</i>	2	1	0	4
<i>Botryosphaeria parva</i>	6	13	2	4
<i>B. dothidea</i>	2	5	1	0
<i>Phomopsis</i> sp.	5	9	1	12
Total number of fruit	99	100	86	91

DISCUSSION

In three studies of fungal populations of 'Fuerte' avocado flowers in South Africa, the predominant fungal genera isolated were *Cladosporium* sp., *Alternaria* sp., *Fusarium oxysporum*, *Pithomyces graminicola* and *Colletotrichum* sp. (Thomas *et al.* 1994; Smith and Korsten 1996; Eicker *et al.* 1998). The predominant fungi isolated in this present study were, in decreasing order of occurrence, *Epicoccum* sp., *Alternaria* sp., *Phomopsis* sp., *Colletotrichum* sp. and *Botryosphaeria* sp.

TABLE 5: Mean severity¹ of stem end rots caused by *Phomopsis* from fruit sprayed with benomyl during flowering and from fruit from unsprayed trees.

	Te Puke	Katikati	Both ²
Unsprayed	0.14	0.20	0.17
Benomyl	0.04	0.002	0.02
P (ANOVA)	0.078	0.002	0.001
Total number of fruit	200	177	377

¹mean severity=(proportion of total fruit with stem end rots x severity of rots scored visually on a 0-10 scale, 0 = no rots, 10= totally rotten).

²Results from both orchards pooled as no difference between orchards was detected (P=0.825)

Of the fungi which were most frequently isolated in our study, *Epicoccum* sp. and *Chaetomium* sp. are unlikely to be present as pathogens. *Alternaria* sp. can be present as a saprophyte only. However, Thomas *et al.* (1994) showed that the application of spores of five fungi (*Alternaria alternata*, *Cladosporium cladosporioides*, *Fusarium oxysporum*, *Pithomyces graminicola* and *Nigrospora oryza*) resulted in greater abscission of flowers than in uninoculated controls. *Alternaria* sp. and *Cladosporium* sp. were isolated frequently from avocado flowers in our study. The effect of these fungi on flower abscission in New Zealand is not known, but application of benomyl over flowering did not increase fruit set in our study (data not shown). Although benomyl application reduced the infection of flowers by *Botrytis* sp. the presence of *Botrytis* sp., is unlikely to have been of any importance because this fungus does not cause postharvest rots of avocado fruit in New Zealand.

Little is known about the infection pathway of avocado stem end rot pathogens. In mango, stem end rot pathogens are thought to infect fruit endophytically by systemic invasion through petioles (Johnson *et al.* 1992). In the present study the stem end rot fungus *Phomopsis* sp. was isolated from flowers, and application of benomyl reduced *Phomopsis* sp. populations on senescent flower parts and stem end rots caused by *Phomopsis* sp. Therefore, it appears that this fungus may gain entry to avocado fruit following infection of senescent floral parts. *Botryosphaeria* may have a similar mode of entry, but this requires verification.

REFERENCES

- Eiker, A., Thomas, T.V. and Robbertse, P.J., 1998. The occurrence, identity and possible role of endophytic fungi in pistils of avocado flowers. *J. S. Afr. Soc. Hort. Sci.* 8: 85-87.
- Foot, D. (Ed.) 1997. New Zealand Agrichemical Manual. Wham Chemsafe, Wellington.
- Hartill, W.F.T., 1991. Post-harvest disease of avocado fruits in New Zealand. *N.Z. J. Crop Hort. Sci.* 19: 297-305.
- Johnson, G.I., Mead, A.J., Cooke, A.W. and Dean, J.R., 1992. Mango stem end rot pathogens- Fruit infection by endophytic colonisation of the inflorescence and pedicel. *Ann. Appl. Biol.* 120: 225-234.
- Korsten, L., De Jager, E.S., De Villiers, E.E., Kotze, J.M. and Wehner, F.C., 1995. Evaluation of bacterial epiphytes isolated from avocado leaf and fruit surfaces for biocontrol of avocado postharvest diseases. *Plant Dis.* 79: 1149-1156.
- Smith, J. and Korsten, L., 1996. Microbes associated with the avocado flower and fruit: the good, the bad and the ugly. *SAAGA Yearbook* 19: 39-40.
- Thomas, T.V., Eicker, A. and Robbertse, P.J., 1994. Possible role of fungi in negatively affecting fruit-set in avocados. *S. Afr. J. Botany* 60: 251-256.
- White, A., Woolf, A. McLeod, D. and Burdon, J., 1997. The electronic firmometer. Pp. 69-75 In: Proceedings of the 1997 Australia and New Zealand Inaugural Avocado Conference. Australian Avocado Growers' Federation and NZ Avocado Growers Association.