FIELD TESTING ALTERNATIVES TO COPPER FOR CONTROLLING AVOCADO FRUIT ROTS*

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ABSTRACT

Six fungicides: boscalid, boscalid/pyraclostrobin, two formulations of copper hydroxide (Kocide Opti and Champ DP), dithianon and fluazinam and one biological product (Biostart™ Target) were applied to avocado fruit in an orchard in Whangarei. Products were applied as sprays on 13 February, 23 March, 20 April, 18 June, 19 July, 21 August, 27 September and 23 October 2007. There were five replicate trees for each treatment in a completely random block design. At harvest, on 2 November, 20 fruit per tree were placed in a box, transported to the Mt Albert Research Centre within 24 hours, and stored at 5.5°C for 28 days. Fruit were then placed at 20°C and assessed for rots when ripe. There were too few stem-end rots for the differences between treatments to be statistically significant, but 4 of the fungicides significantly reduced numbers of body rots compared with the unsprayed control. These were fluazinam, boscalid/pyraclostrobin, Kocide Opti and Champ DP.

Keywords: *Spray trial, fungicides, stem end rots, body rots*

INTRODUCTION

Copper use in New Zealand orchards has been of concern because of its possible detrimental effect on earthworms and microbial activity in the soil (Merrington *et al.*, 2002; Zwieten *et al.*, 2004) and on non-target beneficial micro-organisms and insects in the canopy (Lo and Blank 1992b; Stirling *et al.,* 1999). Holland and Solomona (1999) surveyed the amount of copper in soil from 19 orchards in the Bay of Plenty, Gisborne, Hawke's Bay, Nelson and Otago. Of these regions, the Bay of Plenty is where avocados are grown in commercially important quantities. In the Bay of Plenty, the amount of copper in soil ranged from 80 to 210 parts per million (ppm). Severe effects of copper are expected at greater than 500ppm copper in soil . In order to prevent the build up of copper in soils of avocado orchards to these levels, a 3-year study to find alternatives to copper fungicides was instigated. The outcomes of two strategies to achieve this aim are reported here: the first is to find alternate fungicides that are as effective as copper, the second is to find formulations of copper that are effective at lesser rates.

During June 2006 to July 2007 several fungicides were tested *in vitro* for effectiveness against spore germination and mycelial growth of the 5 fungi that most commonly cause avocado fruit rots (Everett and Timudo-Torrevilla, 2007), and previously several other fungicides were similarly tested (Everett *et al.*, 2005). The five most common fungi that cause postharvest rots on avocados are *Colletotrichum acutatum*, *C. gloeosporioides*, *Botryosphaeria parva*, *B. dothidea* and *Phomopsis* sp. (Hartill and Everett, 2002; Everett *et al.*, 2007). A fruit test was conducted to test biological products for effectiveness against these five fungi (Everett and Timudo-Torrevilla, 2006).

*This paper was first published as: Everett, K.R.,O.E. Timudo-Torrevilla, G.N. Hill and T.E. Dawson. Field testing alternatives to copper for controlling avocado fruit rots. NZ Plant Protection 61: 65-69.

On the basis of those results, six fungicides (boscalid, boscalid/pyraclostrobin, Champ DP, Kocide Opti (previously named Kocide 3000), dithianon and fluazinam in combination with di-1-p-methene) and a biological product (Biostart Target) were selected for testing on an orchard.

MATERIALS AND METHODS

Fungicide application

The trial was on an avocado orchard block in Whatitiri Road, Whangarei, Northland, New Zealand. Seven products were tested, viz. boscalid, boscalid/pyraclostrobin, Champ DP, Kocide Opti (previously named Kocide 3000), dithianon, fluazinam in combination with di-1-p-methene and the biological product Biostart Target (Table 1). Controls were unsprayed trees. Each spray treatment was applied to 5 replicate trees using a randomised block design. Sprays were applied at recommended rates (Table 1) at monthly intervals, a total of 8 applications on 13 February, 23 March, 20 April, 18 June, 19 July, 21 August, 27 September and 23 October 2007. Products were applied using a pressurised hand gun sprayer, at approximately 8 litres/tree. Fruit were harvested on 2 November 2007,with 20 fruit being randomly selected from each of the 5 replicate trees, giving a total of 100 fruit/treatment.

Fruit assessment

After harvest, fruit were placed in a coolstore at the Mt Albert Research Centre of HortResearch at 5.5°C for 28 days. After that time, fruit were placed at 20°C and evaluated daily until ripe. When fruit were ripe as judged by gentle hand squeezing, they were cut in quarters, peeled and rots were assessed according to the procedures in the Avocado Industry Council assessment manual (Dixon, 2003).

Statistical analysis

Results were analysed using the General Linear Model (analysis of variance) of MINITAB (version 15.0), and means were separated using Tukey's LSD (α=0.05). The results presented are the mean severity values = [(incidence x severity) /100] (Fig. 1). The ORIGIN (version 7.5) graphical package was used for drawing graphs.

Table 1. Application rates of products tested as spray applications for control of avocado fruit rots.

Fungicide product[1] g ai /100 litres	Active ingredient	Chemical group	Rate applied
BAS 510F	boscalid	carboxamide	30 g
Pristine®	boscalid/ pyraclostrobin	carboxamide/ strobilurin	15.2/7.7 g
Champ™ DP	copper hydroxide	copper	52.5 g
Kocide® Opti	copper hydroxide	copper	27 g
Delan® 700 WG	dithianon	quinones	12.6 g
Shirlan®	fluazinam	pyridinamine	50 ml
Nufilm-17®	di-1-p-methene	terpene polymer	115.2 ml
Biostart™ Target	biological activators	ND[2]	1000 ml

[1]Champ is a trademark of Nufarm Americas Inc., Kocide is a trademark of Dupont, Delan and Pristine are trademarks of BASF, Shirlan is a trademark of Syngenta Group Company, Nufilm-17 is a trademark of Miller Chemical and Fertilizer Corporation, USA, and Biostart is a trademark of Biostart Limited.
2ND = not disclosed.

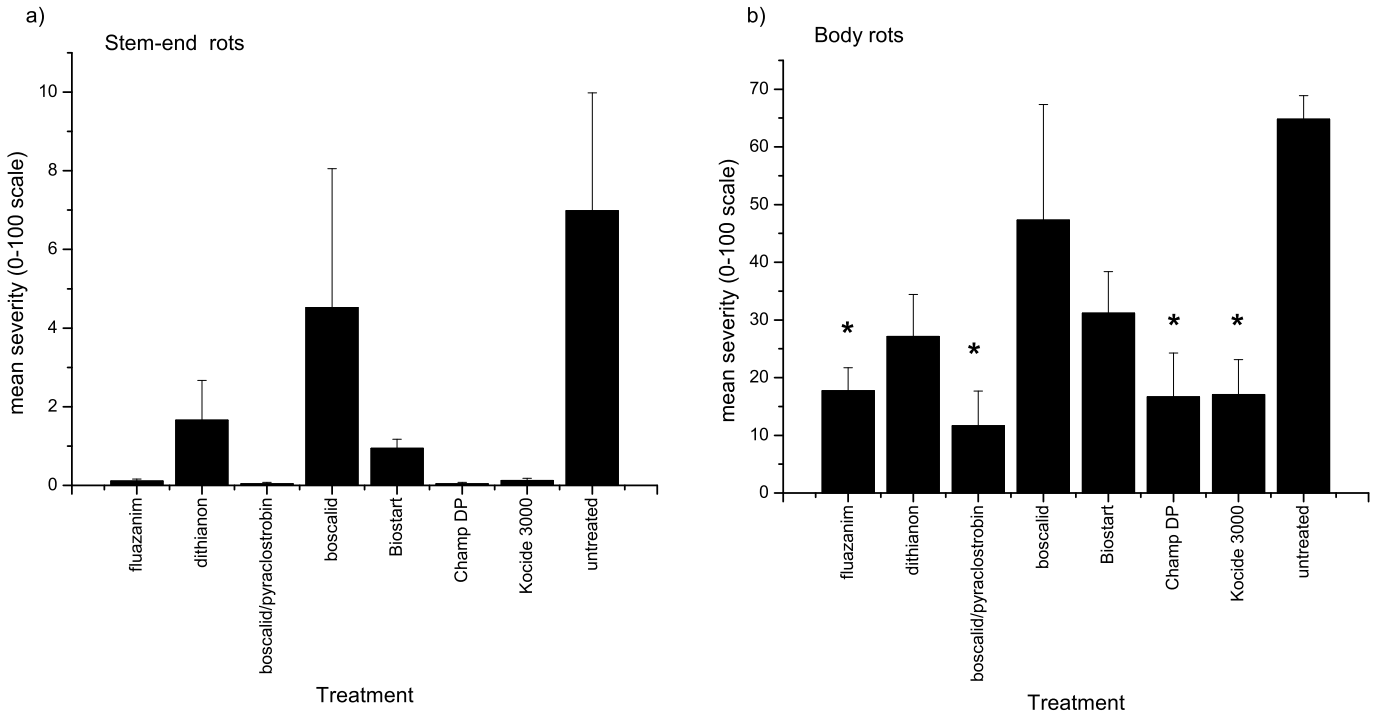

Figure 1. Mean severity (%) of (a) stem-end rots and (b) avocado body rots following 9 field sprays at monthly intervals with test products. Fruit were harvested on 2 November 2007, coolstored for 28 days at 5.5°C and assessed after placing at 20°C when ripe. Values are means ± standard errors, and asterisks denote a significant difference from unsprayed controls (analysis of variance followed by Tukey's LSD (α=0.05**).**

RESULTS

There were no statistically significant differences between treatments for stem-end rots (Figure 1a). Four treatments significantly reduced body rots compared with levels in the untreated control (Figure 1b). These were fluazinam, boscalid/pyraclostrobin, Champ™ DP and Kocide®Opti.

The total metallic copper applied for nine applications, assuming 1500 litres/ha spray solution, was 140 g/100 litres (52.5 g ai/100 litres) = 7.1 kg/ha per season for Champ DP and 90 g/100 litres (27 g ai/100 litres) = 3.64 kg/ha per season for Kocide Opti.

DISCUSSION

In this trial, two fungicides, fluazinam and pyraclostrobin/boscalid, were as effective as copper at controlling avocado rots. A formulation of copper, Kocide Opti, was as effective as Champ DP against avocado rot fungi, at almost half the rate of elemental copper. Chemical company results (data not shown) on other crops suggest that Champ DP may also be effective at a lower rate, but this was not tested in this trial.

Thus the trial has achieved the aims of identifying alternate fungicides that were as effective as copper, and identifying copper formulations that could control avocado rots in the field using lower quantities of elemental copper.

When applied in combination with di-1-p-methene, fluazinam was an effective fungicide. This fungicide has previously shown very good efficacy in laboratory tests (Everett *et al.*, 2005) but did not control rots when applied as an on-orchard spray. One possibility was that the formulation was damaging the skin and for this reason fluazinam was applied with di-1-p-methene as a skin protectant in this trial.

Fluazinam is a broad spectrum fungicide with a multi-site mode of action (Komyoji *et al.*, 1995). This means that resistance is unlikely to develop in the fungal population following repeated use. There are no maximum residue limits for avocados, and residue testing now needs to be carried out before this fungicide can be registered.

Pristine is a combination fungicide of a carboxamide (boscalid) and a strobilurin (pyraclostrobin). Pyraclostrobin has a single-site mode of action, so there is a risk of resistance developing in fungal populations following repeated use. Boscalid has a different single-site mode of action and in combination with pyraclostrobin there is less chance of resistance developing than if either fungicide was applied alone (Hauke *et al.*, 2004). When applied by itself, boscalid did not significantly reduce rots.

Although there are no maximum residue limits for avocados to pyraclostrobin or to boscalid, there is a maximum residue limit for azoxystrobin, which is also a strobilurin fungicide, for avocados in Australia. Azoxystrobin (Amistar®) has been tested on avocados in a field trial in New Zealand, and was as effective a fungicide as copper (Everett *et al.*, 2005).

The effect of these fungicides on beneficial insects has not been investigated on avocado, but on citrus in Queensland, Australia, pyraclostrobin was reported to be less toxic to the predatory mite *Amblyseius victoriensis* Womersley (Acarina: Phytoseiidae) than the industry standard products (Miles *et al.*, 2004). Industry standard fungicide applications included mancozeb, which has known toxicity to predators. Boscalid was non-toxic to the predacious mite *Anystis baccarum* Linnaeus (Acari: Anystidae) on apples in Canada (Laurin and Bostanian 2007). Fluazinam in combination with metalaxyl-M was slightly harmful to the beneficial arthropod *Adalia bipunctata* Linnaeus (Coleoptera: Coccinellidae), but had no effects on *Aphidius rhopalosiphi* De Stefani Perez (Hymenoptera: Braconidae) and *Episyrphus balteatus* De Geer (Diptera: Syrphidae). In contrast, copper has been observed to disrupt predation by ladybirds on citrus in New Zealand (Lo and Blank 1992a). Overseas reports are variable, and often copper is recommended as a suitable fungicide in integrated pest management programmes (Hassan *et al.*, 1991), but it has also been recorded as having a slightly adverse effect on the beneficial insect *Cheilomenes sexmaculata* Fabricius (Coleoptera: Coccinellidae) (Krishnamoorthy *et al.*, 2004). The effect of copper and any new fungicides on beneficial insects in avocado orchards needs to be investigated in New Zealand.

Kocide Opti has recently been registered for use on avocados in New Zealand and is available for application to orchards, to reduce the amount of elemental copper that is applied to control postharvest rots of avocados.

ACKNOWLEDGEMENTS

This study was supported by a grant from the MAF Sustainable Farming Fund, New Zealand Avocado Industry Council, BASF, Biostart, Dupont and Nufarm. We are extremely thankful to the participating growers.

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