FUNGICIDE SPRAY TRIAL IN THREE AVOCADO GROWING REGIONS IN NEW ZEALAND

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ABSTRACT

Three fungicides were tested as spray applications to 12 orchards, four in each of the three major avocado growing regions of New Zealand (Far North, Whangarei and Bay of Plenty). Pristine® and Shirlan® were as effective as copper in controlling avocado rots, but Shirlan® applied in combination with Nufilm™ damaged leaves. Two additional fungicides were tested on one orchard in Whangarei. The biological control agent Serenade® Max did not control avocado rots when applied 11 times throughout the season as an orchard spray. Propiconazole was as effective as copper, but damaged avocado leaves. Leaf isolations of *C. gloeosporioides* from orchards in Whangarei and the Bay of Plenty provided a good indication of the persistence of fungicides. Copper and Pristine® persisted for four months in the Bay of Plenty, and for three months and two and a half months, respectively, in Whangarei. Pristine® and Shirlan® are suitable alternatives to field applications of copper fungicides for controlling avocado fruit rots, at least until November. Pristine® would need to be used judiciously to prevent build up of resistance in fungal populations. Because Pristine® was very effective against *Colletotrichum acutatum,* it would be useful to apply this fungicide in the stage of the disease cycle likely to control this fungus most effectively, probably during spring. Shirlan® and propiconazole would be most useful applied during winter when there is least risk of damaging leaves. Copper could still be applied but in combination with these fungicides, thus reducing the numbers of applications of copper and therefore the impact of this fungicide on the environment.

Keywords: fluazinam, boscalid/pyraclostrobin, propiconazole, *Bacillus subtilis* QST 713, body rots, stem-end rots.

INTRODUCTION

Despite efforts to diversify the fungicides used for control of postharvest rots of avocado, reviewed in Everett (2002), copper remains the most common fungicide used in avocado orchards. Trials have shown that at least eight applications per season are required for effective control, and some growers apply copper sprays 15 times in a season (Everett *et al.,* 2007b). Industry concerns regarding the long term effect of frequent copper applications on the environment have led to this three-year research project to investigate methods to reduce copper use in avocado orchards. In the first year of the project, 2006/07, several fungicides were screened in the laboratory against the five most common fungi that cause postharvest rots in avocado (Everett and Timudo-Torrevilla, 2006; 2007). In the second year, 2007/08, the most promising of these fungicides were tested pre- and postharvest in preliminary evaluation trials (Everett *et al.,* 2007c; Everett *et al.,* 2007a; Everett *et al.,* 2008a) and two fungicides selected for further evaluation (fluazinam; Shirlan® and boscalid/pyraclostrobin; Pristine®). This year 2008/09, the final year of the programme, these fungicides were field-tested on four orchards in each of the three major avocado growing regions: Far North, Whangarei and Bay of Plenty. In addition,one other fungicide, propiconazole, and a biological control agent *(Bacillus subtilis* QST 713; Serenade® Max) were field tested on one site in Whangarei.

Figure 1. Speckling and holes on leaves sprayed with Shirlan + Nufilm.

METHODS

Alternatives to copper

Twelve orchards were selected from the three main avocado growing regions, four each from the Far North, Whangarei and from the Bay of Plenty (two in the eastern Bay of Plenty and two in the western Bay of Plenty). On each orchard, 20 trees that were about 5 years old in a discrete block were marked. Four treatments were applied to trees in a completely randomised block design with five tree replicates.

The four treatments were:

1. unsprayed control
2. copper hydroxide (Kocide® Opti)
3. fluazinam (Shirlan®) + Nufilm™
4. pyraclostrobin + boscalid (Pristine®)

Details of the fungicides and the surfactant used are shown in Table 1.

All products were applied to the point of run off (approximately 8 litres/tree) using a pressurised hand gun sprayer. Each spray treatment was applied to five replicate trees using a randomised block design at rates described in Table 1. As far as possible, the sprays were applied on fine calm days to minimise spray drift between treatments (Table 2). In the Bay of Plenty, Nufilm™ was discontinued for the October application because of damage (yellow speckling, deformation and holes; Figure 1) to new leaves in the Shirlan® + Nufilm™ treatment. Fruit were harvested on 3 and 4 November (Far North), 11 and 12 November (Whangarei) and 18 and 19 November 2008 (Bay of Plenty), 100 fruit per treatment per orchard, a total of 4800 fruit. Harvested fruit were placed in avocado trays (20 fruit per tray), then placed in the coolstore at 5°C for 28 days, and evaluated following ripening at 20C.

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

Fungicide product[1, 2]	Active ingredient	Chemical group	Rate applied Product/100 L	Rate applied g ai/100L
Pristine®	boscalid/ pyraclostrobin	carboxamide/ strobilurin	60 g	15.2/7.7 g2
Kocide® Opti	copper hydroxide	copper	90 g	27 g
Champ™ DP1	copper hydroxide	copper	140 g	52.5 g
Serenade® Max	Bacillus subtilis QST 713	n/a	400 g	58.4 g2
Shirlan®	fluazinam	pyridinamine	100 mL	50 ml
Tilt™EC	propiconazole	triazole	500 mL	125 ml
Nufilm™-17	di-1-p-methene	terpene polymer	120 mL	115.2 ml

[1]Kocide is a trademark of Dupont, Shirlan is a trademark of a Syngenta Group Company, Nufilm is a trademark of Miller Chemical and Fertiliser Corporation USA, Tilt and Shirlan are trademarks of a Syngenta Group Company, and Pristine is a trademark of BASF, [2]Refer to label for recommended rate.

Table 2. Dates on which treatments were applied to avocado trees in the copper alternatives trial in the Far North, Whangarei and Bay of Plenty 2008.

Application number	Far North	Whangarei	Bay of Plenty
1	18/03/2008	17/03/2008	06/03/2008
2	12/04/2008	10/04/2008	08/04/2008
3	24/04/2008	05/06/2008	07/05/2008
4	20/06/2008	19/06/2008	10/06/2008
5	28/07/2008	30/07/2008	08/07/2008
6	02/09/2008	29/08/2008	21/08/2008
7	29/09/2008	01/10/2008	17/09/2008
8	29/10/2008	28/10/2008	14/10/2008

Table 3. Dates on which spray treatments were applied to the avocado trees in the copper compatibility and propiconazole trial.

Application Number	Dates
1	20/12/2007
2	29/01/2008
3	06/03/2008
4	28/03/2008
5	24/04/2008
6	04/06/2008
7	30/07/2008
8	29/08/2008
9	01/10/2008
10	28/10/2008

Copper compatibility and propiconazole

The trial was on an avocado block in Whatitiri Road, Whangarei, Northland, New Zealand. Three products were tested, Serenade® Max, propiconazole and copper (Champ™ DP, Table 1). The copper and Serenade® Max were tested in combination and separately. Controls were unsprayed trees. Each of the five treatments was assigned to five replicate trees using a randomised block design. The dates of application of the fungicides are shown in Table 3. Sprays were applied on fine calm days as much as possible, to minimise spray drift between treatments and were applied to the point of run off using a pressurised hand gun sprayer, approximately 8 litres/tree.

Fruit were harvested on 11 and 12 November 2008, placed in the coolstore at 5^{0}C for 28 days, and evaluated following ripening at 20^{0}C. A total of 500 fruit were harvested.

Leaf sampling

Approximately a month after the last spray application, leaves were sampled from the copper- and Pristine®-treated trees to determine the persistence of fungicides at concentrations inhibitory to fungal growth. Leaves were sampled from eight orchards, four in Whangarei and four in Bay of Plenty. Four leaves were collected from four equidistant quadrants on the tree giving a total of 16 leaves from each tree. Leaves were also collected from unsprayed control trees from the same eight orchards. Two leaf discs 1 cm in diameter were removed from each leaf, and surface-sterilised, then placed on a fungal isolation medium. After 10 days, fungi growing from leaf discs were identified and counted. Leaves were sampled weekly for two months, then fortnightly, then monthly until May 2009 (Table 4).

Table 4. Sampling dates for avocado leaf fungal isolations.

Region		Whangarei	Bay of Plenty
Final spray applications		18/10/2008	14/10/2008
Leaf sampling		11/11/2008	
		21/11/2008	18/11/2008
		27/11/2008	28/11/2008
		04/12/2008	05/12/2008
		12/12/2008	13/12/2008
		09/01/2009	09/01/2009
		22/01/2009	23/01/2009
		05/02/2009	05/02/2009
		19/02/2009	19/02/2009
		19/03/2009	19/03/2009
		21/40/2009	21/04/2009
		18/05/2009	18/05/2009

Statistical analysis

Results were analysed using the General Linear Model Analysis of Variance of the MINITAB version 15.0 statistical software and means were separated using Dunnett's one-tailed t test ($P<0.05$). The results presented are the [(incidence x severity)/100], or mean severity values. The ORIGIN (version 7.5) graphical package was used for drawing graphs.

Table 5. The effect of fungicides on mean severity of body rots in avocado fruit.

		Treatments						
Region	**Orchard**	**Pristine®**	***P***	**Shirlan®**	***P***	**Copper**	***P***	**Untreated**
Far North	1	2.51±0.86	*[1]	8.39±1.71	NS[2]	7.51±1.63	NS	10.84±1.85
	2	0.18±0.08	*	0.62±0.20	*	1.32±0.48	*	12.18±2.55
	3	0.51±0.19	*	0.94±0.46	*	1.90±0.41	*	5.92±1.26
	4	2.03±0.92	*	4.52±1.07	NS	3.18±0.77	*	6.80±1.33
Whangarei	5	2.12±0.56	*	7.21±1.14	*	2.02±0.50	*	11.48±1.64
	6	1.59±0.55	*	2.88±0.91	*	4.19±0.79	*	17.50±2.26
	7	1.48±0.41	*	6.10±1.08	*	6.62±1.13	*	18.56±2.43
	8	1.46±0.49	*	3.18±1.01	*	4.33±1.02	*	14.81±2.35
Bay of Plenty	9	1.42±0.41	*	0.53±0.17	*	2.88±0.81	*	3.01±0.41
	10	1.07±0.37	*	0.86±0.23	*	1.38±0.37	*	5.71±1.29
	11	3.17±0.58	*	2.82±0.45	*	4.50±1.20	*	15.76±2.02
	12	2.79±0.65	*	8.10±1.60	*	4.44±0.82	*	21.61±2.75

[1]*Values are significantly less than untreated controls according to Dunnett's one-tailed test (P<0.05), [2]NS Values were not significantly less than untreated controls.

Table 6. The effect of fungicides on mean severity of stem-end rots of avocado fruit.

		Treatments						
Region	**Orchard**	**Pristine®**	***P***	**Shirlan®**	***P***	**Copper**	***P***	**Untreated**
Far North	1	1.51+0.83	NS[1]	4.50+1.06	**[3]	2.57+0.90	NS	2.64+0.89
	2	2.35+1.17	NS	4.40+1.62	NS	1.23+0.54	NS	5.16+1.52
	3	0.31+0.12	NS	4.96+1.74	NS	1.37+1.01	NS	1.45+0.82
	4	3.13+1.51	NS	2.89+1.02	NS	1.06+0.33	NS	1.31+0.44
Whangarei	5	1.01+0.33	NS	3.01+0.93	NS	1.44+0.71	NS	2.16+0.58
	6	2.08+0.41	*[2]	1.99+0.58	*	4.62+1.11	NS	6.45+1.36
	7	4.33+1.43	*	3.64+0.89	*	4.73+1.04	*	11.19+2.07
	8	1.30+0.44	NS	2.50+1.08	NS	3.26+0.69	NS	2.21+0.44
Bay of Plenty	9	2.44+0.99	NS	2.16+0.55	NS	2.11+0.46	NS	2.36+0.54
	10	1.92+0.52	NS	1.39+0.43	NS	1.77+0.38	NS	1.70+0.58
	11	2.81+0.57	*	1.82+0.70	*	2.47+0.55	*	5.36+0.91
	12	1.51+0.83	*	2.64+0.89	*	2.57+0.90	*	4.50+1.06

[1]NS Values were not significantly less than untreated controls, [2]*Values are significantly less than untreated controls according to Dunnett's one-tailed test (P<0.05), [3]**Values are significantly greater than untreated controls according to Dunnett's one-tailed test (P<0.05).

RESULTS

In general, Pristine® and Shirlan® controlled body rots as well as copper did (Table 5). However, on two orchards in the Far North, Shirlan® did not control body rots, and on one of these orchards neither did copper. Significant control of body rots was achieved by Pristine®, copper and Shirlan® on all other orchards.

Stem-end rots were not as prevalent as body rots. Only on four orchards, two in Whangarei and two in Bay of Plenty, were these rots controlled by fungicides. On each of these four orchards, stem-end rots were controlled by Pristine® and Shirlan®, and on three of the four, one in Whangarei and two in Bay of Plenty, stem-end rots were controlled by copper (Table 5). On one Far North orchard (orchard no. 3), fruit treated with Shirlan® had

Table 7. The effect of fungicides on mean severity of avocado diffuse flesh discolouration.

		Treatments						
Region	**Orchard**	**Pristine®**	***P***	**Shirlan®**	***P***	**Copper**	***P***	**Untreated**
Far North	1	0.43+0.24	NS[1]	0.30+0.22	NS	0.00+0.00	NS	0.10+0.10
	2	0.90+0.57	NS	1.60+0.72	NS	1.00+0.59	NS	1.02+0.44
	3	1.10+0.40	NS	1.80+0.74	NS	0.95+0.38	*	2.90+0.87
	4	2.72+1.25	NS	3.10+1.14	NS	0.30+0.22	NS	1.25+0.52
Whangarei	5	0.00+0.00	NS	0.30+0.22	NS	0.25+0.21	NS	0.65+0.51
	6	8.75+2.04	**	2.85+1.19	NS	7.55+2.11	**	3.66+1.07
	7	6.75+1.70	NS	6.40+1.79	NS	8.79+2.09	NS	3.60+1.41
	8	6.10+1.76	NS	4.05+1.42	NS	3.40+1.22	NS	7.50+2.06
Bay of	9	5.31+1.33	NS	7.60+1.81	NS	9.25+1.94	NS	4.40+1.37
Plenty	10	12.50+2.36	*[2]	8.70+1.80	*	13.90+2.62	NS	22.70+5.05
	11	3.90+1.52	NS	1.54+0.83	NS	0.80+0.80	NS	2.30+1.06
	12	9.38+1.79	NS	13.19+2.87	NS	10.88+2.56	NS	6.75+2.04

[1]NS Values were not significantly less than untreated controls, [2]*Values are significantly less than untreated controls according to Dunnett's one-tailed test ($P<0.05$), [3]**Values are significantly greater than untreated controls according to Dunnett's one-tailed test ($P<0.05$).

Table 8. The effect of fungicides on mean severity of avocado bruising.

		Treatments						
Region	**Orchard**	**Pristine®**	***P***	**Shirlan®**	***P***	**Copper**	***P***	**Untreated**
Far North	1	3.70+0.54	**[3]	1.20+0.34	NS	1.45+0.39	NS	1.90+0.44
	2	2.95+0.66	**	1.50+0.50	**	1.90+0.51	**	0.40+0.40
	3	4.30+0.68	NS[1]	1.75+0.40	*[2]	3.65+0.65	NS	3.50+0.65
	4	2.01+0.50	NS	2.83+0.51	NS	2.37+0.62	NS	2.92+0.98
Whangarei	5	0.15+0.11	NS	0.05+0.05	NS	0.00+0.00	NS	0.30+0.30
	6	0.70+0.26	NS	0.80+0.57	NS	0.70+0.33	NS	0.10+0.10
	7	0.65+0.27	NS	0.20+0.12	NS	0.25+0.21	NS	0.10+0.10
	8	0.55+0.26	NS	0.65+0.47	NS	0.34+0.17	NS	0.10+0.10
Bay of	9	0.30+0.22	NS	0.5+0.5	NS	0.1+0.1	NS	0
Plenty	10	0	NS	0	NS	0	NS	0.10+0.10
	11	0	NS	0	NS	0	NS	0
	12	0	NS	0	NS	0.38+0.28	NS	0

[1]NS Values were not significantly less than untreated controls, [2]*Values are significantly less than untreated controls according to Dunnett's one-tailed test ($P<0.05$), [3]**Values are significantly greater than untreated controls according to Dunnett's one-tailed test ($P<0.05$).

significantly more stem-end rots than untreated controls (Table 6).

There were two symptoms that were not typical of rots. Isolations were made from each of these two symptom types. These symptoms were similar to those previously described as diffuse flesh discolouration and bruising (White *et al.*, 2001; Dixon, 2003). No fungi were isolated from these fruit. There was less diffuse flesh discolouration observed on fruit from fungicide-treated trees on two orchards, by copper on a Far North orchard and by Pristine® and Shirlan®on a Te Puke orchard (Table 7). On one occasion, the incidence of bruising was less in fruit from trees treated with Shirlan® (Far North), and on two occasions was greater in fruit from trees treated with fungicide treatments (Far North) (Table 8).

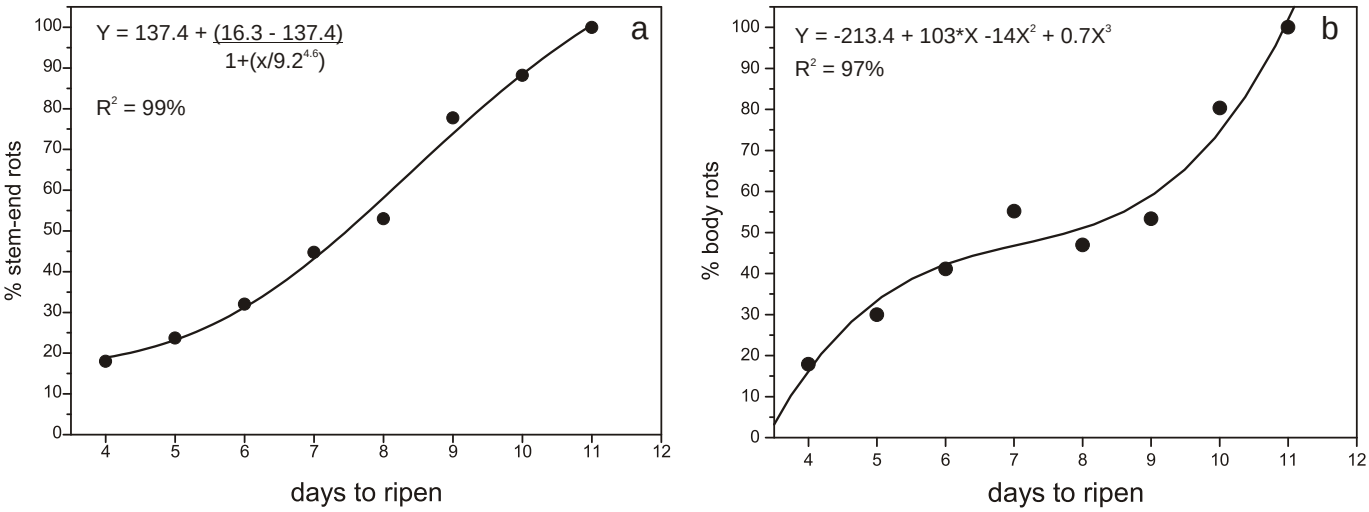

Figure 2. Effect of time to ripen on expression of avocado stem-end rots (a) and body rots (b).

When all stem-end rots and body rots were averaged for all treatments and all orchards then plotted against days to ripen, a logistic curve was the best fit for stem end rots (Figure 2a) and a polynomial curve was the best fit for body rots (Figure 2b). Fewer rots expressed in fruit that ripened quickly.

Application of Serenade® Max alone resulted in significantly more body rots and stem-end rots than in untreated control fruit (Table 9). When Serenade® Max was applied in combination with copper, body rots were significantly reduced compared with untreated controls, but there was no improvement in control of body rots compared with when copper was applied alone. Propiconazole also significantly controlled body rots. There was no control of stem-end rots by any treatment, but these rots were few. There was no effect of any treatment on diffuse flesh discolouration or bruising.

There was some wrinkling of young leaves following spraying with propiconazole during October (Figure 3).

Table 9. Effect of fungicide treatments on rots and disorders of avocado in the copper compatibility and propiconazole trial.

	Mean severity of disease or disorder							
Treatment	body rots	*P*	stem-end rots	*P*	diffuse flesh discolouration	*P*	bruising	*P*
Serenade® Max	22.3+3.2	**[3]	14.6+3.0	**	0.5+0.4	NS[1]	0.0+0.0	NS
Serenade® Max + copper	1.1+0.5	*[2]	0.5+0.2	NS	0.2+0.2	NS	0.1+0.1	NS
copper	0.4+0.1	*	0.7+0.6	NS	0.3+0.2	NS	0.2+0.1	NS
propiconazole	4.6+1.6	*	1.2+0.3	NS	0.1+0.1	NS	0.5+0.4	NS
untreated	11.5+2.5	*	2.2+0.6	NS	0.7+0.6	NS	0.3+0.3	NS

[1]NS Values were not significantly less than untreated controls, [2]*Values are significantly less than untreated controls according to Dunnett's one-tailed test ($P<0.05$), [3]**Values are significantly greater than untreated controls according to Dunnett's one-tailed test ($P<0.05$).

Figure 3. Symptoms associated with applying propiconazole to avocado trees as a spray.

In both the Bay of Plenty and Whangarei, *Colletotrichum gloeosporioides* was isolated less frequently from both copper- and Pristine®-treated leaves than from untreated leaves until 12 January 2009 (Figure 4). This fungus was suppressed by both fungicides for at least two months after application. This suggests that Pristine® can be applied at the same spray intervals as copper with equal effect, as was also shown by the results of fruit assessments.

The frequency of isolation of *C. acutatum* from copper treated leaves exceeded that from untreated leaves after 15 December 2008 in the Bay of Plenty (Figure 4). In Whangarei, the number of times *C. acutatum* was isolated from copper-treated leaves exceeded those from untreated leaves after 20 April 2009. In both regions, the number of times *C. acutatum* was isolated from Pristine®-treated leaves remained fewer than from untreated leaves until 20 April 2009. In Whangarei, the number of isolations from Pristine®-treated leaves were fewer than from both untreated controls and copper-treated leaves throughout the sampling period, until 18 May 2009.

It was difficult to compare the frequency of isolation of *Botryosphaeria* spp. between treatments, as this fungus was isolated in very low numbers from leaves.

DISCUSSION

During the 2008/09 season both Pristine® and Shirlan® were as effective as copper for controlling avocado rots when applied eight times to four orchards in each of the three major avocado growing regions in New Zealand (Far North, Whangarei and Bay of Plenty). All fruit in these trials were harvested in November 2009. During

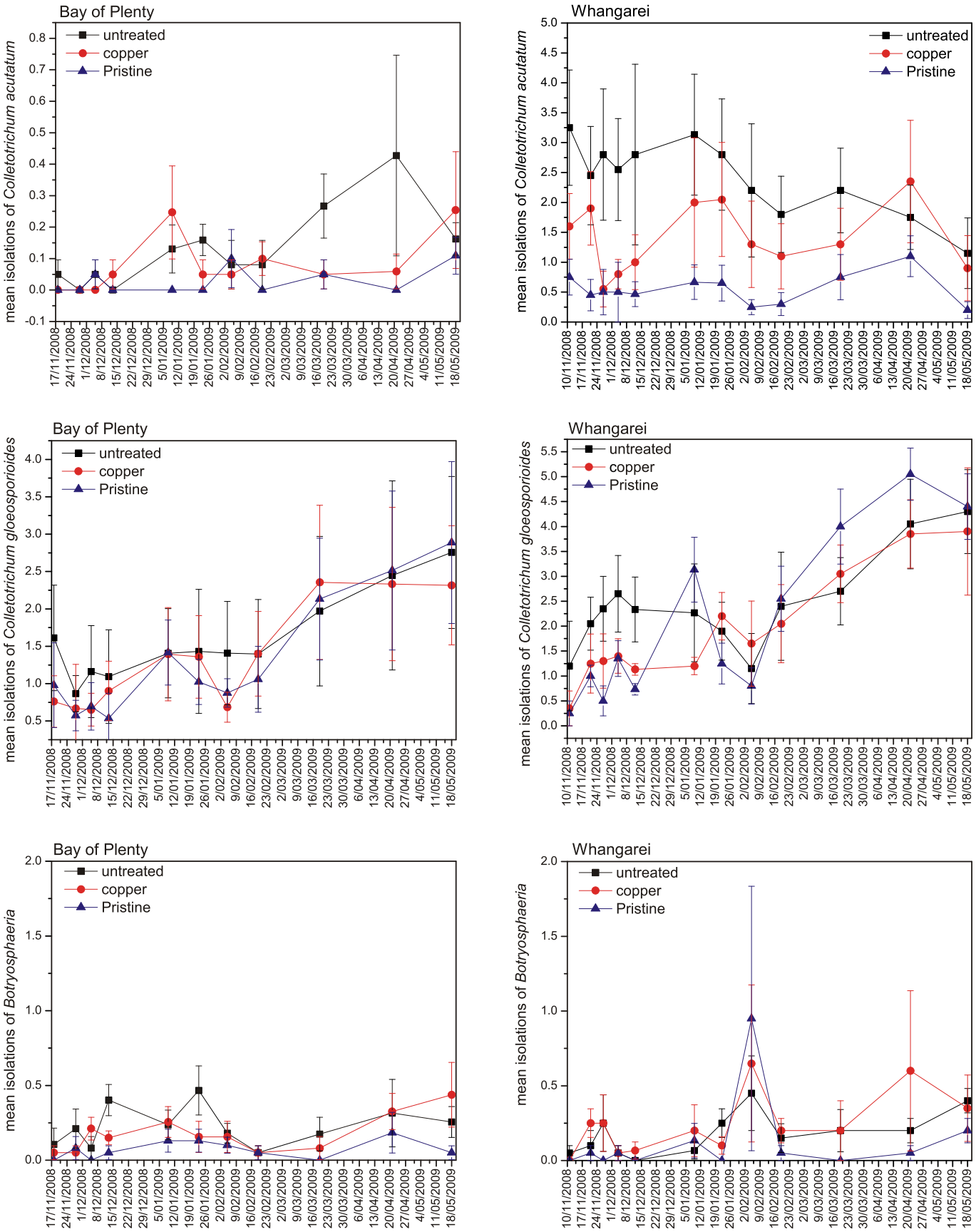

Figure 4. Results of isolations of *Colletotrichum acutatum, C. gloeosporioides* and *Botryosphaeria* spp. from avocado leaf discs from trees that were untreated, sprayed with copper or with Pristine® in the Bay of Plenty and Whangarei.

the preliminary evaluations in the 2007/08 season it was reported that Shirlan® in combination with Nufilm™ damaged leaves (Everett *et al.,* 2008c). During the 2007/08 season, applications of Shirlan® and Pristine® significantly controlled bodyrots when fruit were harvested in November 2007. However, neither Shirlan® nor Pristine® provided significant control of rots when fruit were harvested in February 2008 (Everett *et al.,* 2008c), but copper hydroxide in the form of Champ DP continued to provide significant rot control. Therefore, copper fungicides need to be applied between November and February to provide good rot control. This year a harvest in November only was possible, because most of the growers in the trial harvested before Christmas. Spraying newly developing leaves by Shirlan® during spring should be avoided to prevent damage. Both Shirlan® and Pristine® are more bio-degradable alternatives for rot control in avocado orchards than copper (Everett *et al.,* 2008b).

When days to ripen were plotted against rot incidence the results showed that there might be two infection periods for body rots, one at harvest and the other in the orchard. This was indicated by the best fit to the data being achieved by the polynomial model.

There were two physiological disorders affecting fruit in the spray trial, diffuse flesh discolouration and bruising. These two symptoms were not seen in a previous study of fruit from 23 orchards throughout New Zealand harvested in January, but not coolstored (Everett *et al.,* 2007b). Last year (2008) these symptoms were first seen in fruit harvested in November 2007, and also in fruit harvested in March 2008. All these later fruit were coolstored for 28 days followed by ripening at 20°C. Because these symptoms were not seen in fruit that had not been coolstored, it is possible that the symptoms are a result of cold damage. The attribution of these symptoms to cold damage has been reported by Dixon *et al.* (2003).

Isolations from leaves were useful for determining the persistence of the fungicides tested. Pristine® reduced populations of *Colletotrichum gloeosporioides* for four months in Bay of Plenty and for two and half months in Whangarei. Copper reduced populations of *C. gloeosporioides* for three months in Whangarei and for four months in Bay of Plenty. *C. acutatum* and *Botryosphaeria* spp. were isolated in numbers that were too few to determine trends in the Bay of Plenty. In Whangarei, populations of *C. acutatum* were reduced for the duration of the sampling period by Pristine®. Populations of this fungus in leaves treated with copper were fewer than in untreated controls until six months after final application. This suggests that *C. acutatum* is more sensitive to these fungicides than is *C. gloeosporioides,* and that because fungicides are used more rigorously in Te Puke than in Whangarei, the fungal population on leaves may have been shifted to be predominantly *C. gloeosporioides* in this region. This is supported by the results of isolations from Whangarei; treatment with Pristine® appears to have resulted in permanent suppression of the population of *C. acutatum* on leaves, which has been replaced by *C. gloeosporioides.* However, it is also possible that there is some other unknown factor that has reduced the population of *C. acutatum* on leaves in Bay of Plenty.

Although propiconazole and Shirlan® + Nufilm™ reduced rots of avocados, there was some damage to leaves. It is not known what effect, if any, this leaf damage will have on productivity. As there are no recommended rates for use on avocados, it is possible that lower rates may reduce damage and have no effect on rot control. Applying Shirlan® with lower rates of Nufilm™ or alone may not damage leaves.

When the copper compatibility spray trial was set up, there were no recommendations for application rates of Serenade® Max for avocados. The subsequent recommended rate is lower than was used in this trial. It is possible that lowering the rates will improve control, but further assessments are required beforeany recommendations can be made. Results from this trial show that there was no improvement of rot control when Serenade®

Max was applied in combination with copper, and there was no rot control when Serenade® Max was applied alone. From these results, Serenade® Max cannot be recommended to control avocado rots when applied as an orchard spray.

CONCLUSIONS

Pristine® and Shirlan® are both potentially suitable alternatives to field applications of copper fungicides for controlling avocado fruit rots, at least until November. Although not as extensively field tested, propiconazole also provided good rot control, but damaged leaves. Currently these fungicides are not registered for use on avocados. Until they are registered for avocados their use cannot be recommended. Leaf isolations of *C. gloeosporioides* provided a good indication of the persistence of fungicides in the orchard. Nufilm™ was removed from sprays applied in the Bay of Plenty in October because of grower concern, with a consequent reduction in leaf damage. However, a replicated spray trial would need to be carried out to investigate if application of Shirlan® by itself provides effective rot control and does not damage leaves. Shirlan® would be most useful applied during winter when there was least risk of damaging leaves. Pristine® would need to be used judiciously to prevent build up of resistance in fungal populations, and there are instructions on the label for avoiding resistance in an apple spray programme. Copper could still be applied but in combination with these fungicides, thus reducing the numbers of applications of copper and therefore the impact of this fungicide on the environment.

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