FIELD EVALUATION OF FUNGICIDES FOR CONTROL OF PEACH LEAF CURL (*TAPHRINA DEFORMANS*)

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SUMMARY

Several long-established fungicides were evaluated for control of leaf curl on nectarines and peaches in 3 years of field trials at Hawkes Bay Research Centre. Two sprays at proprietors recommended rates were applied in the leafbud-movement period prior to green tip. Order of effectiveness was the same under conditions of high (1991 and 1992) or moderate (1993) disease pressure. Ziram, captafol and thiram were the most effective, followed by dodine, captan and chlorothalonil. Maneb, mancozeb, dithianon, cupric hydroxide and copper oxychloride were generally ineffective. Difenconazole when applied twice over bloom showed eradicated activity and was as effective as chlorothalonil.

Keywords: *Taphrina deformans*, leaf curl, fungicides, peach, nectarine.

INTRODUCTION

Leaf curl of peaches and nectarines, caused by the fungus *Taphrina deformans*, is potentially devastating to both crop yields and tree longevity. Commercial control in New Zealand in recent years has been based on copper products and chlorothalonil, with two sprays applied during the bud movement period. Recently growers in Hawkes Bay have encountered problems achieving adequate control with copper sprays, and this was shown to be caused by decreased sensitivity in *T. deformans* (Cheah *et al.* 1993). This development stimulated further evaluation of fungicides with potential activity against *T. deformans*, and 3 years of field trials in Hawkes Bay are reported here.

METHODS

All trials were conducted on plantings of fresh nectarine or peach varieties situated at the Hawkes Bay Research Centre, near Hastings, using randomised block designs of six replicates in 1991 and 1992 and seven in 1993. Two drenching fungicide sprays were applied during leafbud-movement each season (Table 1) by hand-operated knapsack sprayers with solid-cone nozzles.

Weather factors (leaf wetness duration, mean wet period air temperature and total rainfall) were logged at an automatic weather station situated within 120 m of each trial and used in a computerized 'infection monitor' to identify the timing of infection periods. The criteria for infection were 1) green tip or later; 2) a prolonged (>10 h), cool (8-12 °C) wet weather event with significant rain (>5 mm) and 3) symptoms appearing within 10-16 days. Wet periods that met these criteria were designated as probable infection periods (Tate *et al.* 1987).

After development of symptoms, disease incidence on 100 lateral shoots (laterals) and 100 terminal shoots (terminals) observed sequentially upwards from the tree base, were recorded. In 1993 on 1 year-old trees only 30 terminals were recorded. Disease severity on terminals was rated as follows, using a 1-5 scale.

Nil disease	= 1 all leaves healthy
Trace severity	= 2 only one leaf with one small spot of disease
Slight	= 3 one or two leaves (= 50% of one mature leaf) diseased
Moderate	= 4 about half of all leaf surface diseased
High severity	= 5 most (>70%) of leaf surface diseased

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Incidence and severity were analysed using the general linear model procedure of the Statistical Analysis Systems computer programme. Incidence percentages in Tables 2-4 were derived by back-transforming the fitted values of the logit models.

The 1991 trial was conducted on 6 year-old Fantasia and Red Gold nectarine trees spaced at 3 x 2.8 m. The trees were inoculated with *T. deformans* on 13 August 1991, with a cell suspension of 1×10^6 cells per ml from yeast-stage cultures. Fungicides tested, at proprietors' recommended rates, are listed in Table 2. Unsprayed 'control' trees were included. Disease incidence was assessed on 2 and 9 October, and disease severity on 17 October.

The 1992 trial was conducted on uninoculated, 7 year-old Flavourtop and Firebrite nectarine trees spaced at 3 x 2.8 m. Fungicides tested (Table 3) included thiram and dithianon, not included in 1992, and new formulations of cupric hydroxide and ziram. Unsprayed controls were included. Disease was assessed from 12-16 October.

The 1993 trial was conducted on uninoculated, 1 year-old Zeelady peach trees, spaced at 5 x 1.7 m. The fungicides applied (Table 4) included two not previously tested, mancozeb and difenoconazole. Difenoconazole was applied on 21 and 29 September as a blossom blight fungicide (respectively 25% and 75% open bloom). No untreated plots were included. Disease was assessed on 26 November.

RESULTS AND DISCUSSION

Spray timing in relation to growth stage, weather and disease development for each trial, is shown in Table 1. In 1991, infection occurred a week after leafbud-break commenced and symptoms appeared relatively early. In 1992, leafbud-break was abnormally early but the occurrence of infection in late bloom meant that disease appearance was also delayed. In 1993, the 1 year-old trees had recently been planted and bud-break and bloom were delayed. The infection period of 19-21 September therefore occurred at early bloom, and the difenoconazole sprays acted eradically. Overall, spray timing was from 8 to 40 days prior to infection.

TABLE 1: Dates of growth stages, spray timing, weather and disease development in each trial.

Trial Year	Leaf bud movement	Spray timing	Leafbud-break from:	Probable infection periods	Symptoms visible from:
1991	15-25 Aug	14 & 20 Aug	20 Aug	28 Aug, 4 Sep	mid Sep
1992	8-31 Aug	6 & 9 Aug	8 Aug	18 & 24 Sep	early Oct
1993	20 Aug-8 Sep	24 & 30 Aug 21 & 29 Sep ¹	8 Sep	19-21 Sep	mid Oct

¹ Difenoconazole

In the 1991 trial (Table 2), unsprayed trees had 90% of terminals diseased with a high mean severity rating. Ziram, captafol and thiram gave 10-20% incidence with mean severity ratings between trace and slight. Dodine, chlorothalonil, captan and cupric hydroxide gave 34-35% incidence with slight severity. Copper oxychloride and maneb gave 51-81% incidence with moderate severity. Disease incidence on sprayed trees was generally lower on laterals than on terminals.

In the 1992 trial (Table 3), unsprayed trees had 98% of terminals diseased with mean severity ratings between moderate and severe. Ziram reduced this to 17% with trace severity, captan (240 g), thiram (160 g) and dodine (80 G) to 33-43%; chlorothalonil, captan (160 g), dodine (48-64 g), thiram (240 g) to 50-68% (higher than slight severity), and dithianon and cupric hydroxide (all rates) to 83-87% (moderate severity). Disease incidence on sprayed trees was generally lower on laterals than terminals.

TABLE 2: Effect of leafbud-movement fungicide sprays on incidence (percent diseased shoots) and severity (mean severity category) of leaf curl of nectarines in October 1991.

Fungicide treatment	Product/formulation	g ai/100 litres (two sprays)	% Diseased shoots ¹		Severity ratings ²
			Terminals	Laterals	
untreated	-	-	90*	98*	4.6*
maneb	80 WP	200/200	+81*	+81*	4.3*
copper oxychloride	50 WP	300/150	+51*	+32*	+3.5*
cupric hydroxide	Kocide 101	125/75	+35	+27*	+3.0*
captan	80 WP	160/160	+34	+21*	+3.3
chlorothalonil	Bravo 500F	150/125	+35	+17	+2.7
dodine	40 FL	48/40	+35	+ 9	+2.5
thiram	80 WP	160/160	+20*	+12	+2.7
captafol	Difolatan 5F	150/100	+17*	+ 5	+2.1*
ziram	Ziram 81WP	379/228	+10*	+ 4	+1.5*

¹ * = significantly different to chlorothalonil at P = 0.05

+ = significantly different to untreated at P = 0.05

² 1 = nil disease, 2 = trace, 3 = slight, 4 = moderate, 5 = high severity

TABLE 3: Effect of leafbud-movement fungicide sprays on incidence and severity of leaf curl of nectarines in October 1992.

Fungicide treatment	Product/formulation	g ai/100 litres (two sprays)	% Diseased shoots ¹		Severity rating ²
			Terminals	Laterals	
untreated	-	-	98*	99*	4.6*
cupric hydroxide	Kocide DF	100/60	+87*	+55*	+4.2*
cupric hydroxide	Kocide DF	200/120	+87*	+45*	+3.9*
dithianon	Delan	12/12	+84*	+62*	+4.2*
dithianon	Delan	25/25	+83*	+61*	+3.9*
dodine	Syllit Plus	48/48	+68	+16	+3.4
thiram	Thiram 40F	240/240	+57	+37*	+3.1
dodine	Syllit Plus	64/64	+56	+11	+3.2
captan	80 WP	160/160	+51	+13	+3.5
chlorothalonil	Bravo 500F	150/150	+50	+13	+3.3
dodine	Syllit Plus	80/80	+43*	+ 7	+3.0*
thiram	40 F	160/160	+34*	+15	+2.8*
captan	80 WP	240/240	+33*	+ 6	+2.8*
ziram	Mizar Granuflo	342/228	+17*	+ 4*	+2.3*

¹ * = significantly different to chlorothalonil at P = 0.05

+ = significantly different to untreated at P = 0.05

² 1 = no disease, 2 = trace, 3 = slight, 4 = moderate, 5 = high severity

In the 1993 trial (Table 4), ziram reduced the number of diseased terminals to less than 1% with a slight disease severity rating. Incidence was 9-13% for thiram, 18-21% for dodine and 29% for chlorothalonil, all with a disease severity rating of slight to moderate. Mancozeb had a 46% incidence with moderate disease severity. Thiram (160 g) sprayed at bud-movement combined with difenoconazole in early bloom (right

after the infection period) and late bloom, reduced diseased terminals to 3% with slight disease severity, and difenoconazole used alone in early and late bloom, to 15% with slight disease severity. Disease incidence was again lower on laterals than on terminals.

In a commercial orcharding situation, greater than 5% diseased terminals is considered unacceptable because of its adverse effect on yield and tree health and the secondary inoculum from diseased shoots. Similarly, a disease severity rating greater than slight is unacceptable due to the loss of productive leaf surface area. However, a higher incidence of low-severity diseased terminals may be tolerable, particularly if sporulation does not occur. Thus while terminal leaf curl incidence (Table 2) was quite high for many treatments, including the standard for comparison (chlorothalonil), disease severity was below the damaging threshold. Incidence of diseased laterals is of no concern as laterals are easier to protect with fungicides than terminals (Tables 2-4).

The three trials, two conducted under extremely high disease pressure and using proprietors' recommended rates of application, showed ziram to be the only fungicide currently capable of matching the previous efficacy of captafol, withdrawn in the mid-1980's. This supports Californian data (English 1958). The third trial showed that under reduced disease pressure ziram can almost completely eliminate leaf curl.

TABLE 4: Effect of leafbud-movement fungicide sprays on incidence and severity of leaf curl of peaches in November 1993.

Fungicide treatment	Product	g ai/ 100 litres (two sprays)	% Diseased shoots ¹		Severity rating ²
			Terminals	Laterals	
mancozeb	80 WP	160/160	+46	+4	+4.0*
chlorothalonil	Bravo 500F	150/150	+29	+3	+3.7
dodine	Syllit Plus	40/40	+21	+5	3.4
dodine	Syllit Plus	60/60	+19	+4	3.9
dodine	Syllit Plus	80/80	+18	2	3.5
difenoconazole ³	Score 10WP	10/10	+15	1	3.4
thiram	Thiram 40F	240/240	+13*	1	3.3
thiram	Thiram 40F	160/160	+ 9*	1*	3.6
thiram and	Thiram 40F and	160/160			
difenoconazole ³	Score 10WP	10/10	3*	<1*	3.3
ziram	Mizar Granuflo	342/228	<1*	<1*	3.0*

¹ * = significantly different to chlorothalonil at P = 0.05

+ = significantly different to ziram at P = 0.05

² 1 = no disease, 2 = trace, 3 = slight, 4 = moderate, 5 = high severity

³ Difenoconazole was sprayed eradically on 21 and 29 September

Thiram was less effective than captafol but more effective than chlorothalonil, the only replacement available for captafol at the time. The reason for thiram giving consistently better control at the lower rate used is unknown. Matthee and Kriegler (1975) showed that one application of thiram at budswell was highly effective in conjunction with autumn copper sprays, but one application was not effective on its own. Our approach was to use two applications at bud-movement. Captan was only more effective than chlorothalonil at high application rates.

Dodine at 80 g under high disease pressure also showed promise, being at least as effective as chlorothalonil at higher rates, but both were considered marginal in efficacy, while fixed coppers, maneb, mancozeb and dithianon generally failed to control leaf curl at the rates used. The ineffectiveness of even high rates of copper-

based sprays (Table 3) supports the opinion that reduced sensitivity to copper fungicides has developed in *T. deformans* in Hawkes Bay (Cheah *et al.* 1993).

Difenoconazole, a systemic triazole fungicide normally used during blossom, adds a further dimension to leaf curl control. It appeared to complement thiram bud-movement sprays and by itself was a useful curative at lower disease pressure when applied right after the infection period. Effective control was obtained by Follas and Welsh (1993), but it is unclear if curative action occurred in their trials.

To date none of our observations or data support the view that infections occur beneath the bud scales during the bud movement period as suggested by MacSwan and Dooley (1986). Rather, our experience supports the conclusion of FitzPatrick (1934), that infections usually occur when leaves are unfolding, often as late as the end of blossom.

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