CONTROL OF LEAF SPOT IN STRAWBERRIES

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SUMMARY

Trials in 1981 and 1982 investigated control of leaf spot (*Mycosphaerella fragariae*) on the susceptible strawberry (*Fragaria ananassa*) cultivar 'Tioga'. In trials at Pukekohe and Waitakere 5-7 prochloraz or bitertanol sprays applied fortnightly, early in the growing season, were most effective at controlling the disease and improving yields on first year plants. Triforine, fenarimol, imazalil, and captan appeared less effective and benomyl was ineffective. At Rukuhia six bitertanol or benomyl plus captan sprays applied in the mid-growing season gave very effective control of leaf spot in the first and second years of production and plant vigour was noticeably increased. Triforine was less effective in controlling leaf spot. The half lives of bitertanol, fenarimol and prochloraz on the fruit were 3.6 to 6.5 days.

INTRODUCTION

Mycosphaerella fragariae which induces leaf spot, sometimes known as frog-eye, in strawberries has become an important pathogen in New Zealand crops. The 'Tioga' cultivar, now widely grown, particularly in the Auckland district, is susceptible. Copper fungicides were formerly recommended to control the pathogen but were later replaced by captan and maneb. Beever (1973) tested a number of fungicides and found benomyl and, to a lesser extent, captan gave good disease control and increased fruit production. Benzimidazole fungicides are also very effective in the control of *Mycosphaerella* ringspot diseases of brassicas (Hartill 1977). However, in recent years growers have claimed that benomyl is now less effective and triforine is widely used, at least in the period before flowering. A number of new azole-based fungicides have recently become available which act by inhibiting ergosterol synthesis. Their high activity which combines protective and eradicant action make them promising disease control agents (Brandes *et al* 1979).

This paper reports a number of independently conducted trials to find effective treatments for the disease. Residue measurements were also made for the newer materials tested to assist in setting withholding periods and to enable residue tolerance petitions to be made.

METHODS

First year plants of the 'Tioga' cultivar were used in trials at DSIR Research Station, Pukekohe (WTH) in 1981 and 1982; at Rukuhia Horticultural Research Block, MAF, Hamilton (PTH) in 1981 and at Waitakere, Auckland (MAE) in 1982. The trial at Rukuhia was continued in 1982 on the same planting. The runners used at Pukekohe and Rukuhia were selected from local stocks infected with leaf spot. All trials were planted out in June on black polythene covered raised beds with row plots 3-4 m in length. Randomised block designs were used with 4 or 5 replicates.

Fungicides were applied to run-off by means of pressure knapsack sprayer. Some treatments included 0.5% summer spraying oil as indicated in the tables. Wettable powder formulations were applied with 10 ml/100 litres of wetting agent where oil was not used. Details of the treatments and number of applications for the individual trials are in the tables.

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Disease severity was assessed by counting the number of lesions present on 30 mature leaves selected at random from plants in each plot. Either total number of spots were recorded or a simple ranking was recorded on the following scale: 0 = no spots; 1 = 1-5; 2 = 6-25; 3 = >25 spots/leaf. The ranking scores were converted to a percentage infection index following McKinney (1923) using the formula

$$\text{Infection Index (\%)} = \frac{100}{3 \times \text{No. leaves sampled}} \times \sum_{i=1}^3 (i \times \text{No. leaves in rank } i)$$

Fruit yields were determined by picking all ripe fruit at intervals during the main production season (PTH, MAE) or from a 2 weeks period during the main flush (WTH). In some trials mean berry weights were determined and plant vigour assessed by estimating the radius of each plant.

Pesticide residues on harvested fruit were determined by standard methods involving solvent extraction and gas chromatography or high performance liquid chromatography (Specht and Tilkes 1980; Holland and McGhie 1983).

RESULTS AND DISCUSSIONS

Both prochloraz and bitertanol gave outstanding control of leaf spot (Tables 1 and 5). In the 1981 trial at Pukekohe fenarimol gave a similar high degree of control (Table 1) but this result was not repeated in 1982 (Table 2 and 5). Imazalil, triforine, and captafol gave moderate control of leaf spot but were inferior to the above materials. Benomyl with oil was ineffective at Pukekohe but at Rukuhia benomyl plus captan was as effective as bitertanol in 1981 (Table 3) and more effective in 1982 (Table 4).

TABLE 1: Screening of fungicides for strawberry leaf spot control, Pukekohe 1981.

Treatment	g ai/100 litres	Infection index (%)	Fruit yield kg/plot	Mean berry wgt (g)
Untreated		90 a	0.71 bc	8.8 c
benomyl + 0.5% oil*	25	62 ab	0.54 c	9.1 bc
triforine + 0.5% oil	30	38 bcd	0.94 ab	10.7 abc
prochloraz	30	19 d	1.22 ab	12.1 a
imazalil	30	49 bc	1.26 a	11.6 abc
bitertanol + 0.5% oil	15	17 d	1.25 a	13.4 a
fenarimol	5	23 cd	1.01 ab	12.1 a

Seven sprays applied at fortnightly intervals starting 13 July.

Disease assessed 5 October.

*Universal Spraying Oil

NOTE: Values in the same column having no letter in common differ significantly ($P < 0.05$, Tukey Studentised Range Test).

In contrast to the Rukuhia results the degree of leaf spot on the untreated plants at Waitakere decreased as the season progressed. This was attributed to loss of heavily infected older leaves. In the Rukuhia trials spraying was commenced some 2 months later in the season than at the other two sites. However, the relatively high infections at the first assessment (Tables 3 and 4) were markedly reduced at subsequent assessments by the benomyl/captan and bitertanol treatments.

The existence of substantial benzimidazole resistance at Pukekohe is confirmed by *in vitro* tests on isolates of the pathogen (W. Hartill unpublished). As the 1971 trial of Beaver (1973) showed captan alone to be nearly as effective as benomyl it is possible that captan rather than benomyl provided the leaf spot control in the Rukuhia trials.

TABLE 2: Efficacy of prochloraz, bitertanol and fenarimol in control of strawberry leaf spot, Pukekohe 1982.

Treatment	g ai/100 litres	Infection index (%)		Vigour (plant radius cm)
		actual	fitted	
untreated		92	93	5.8
prochloraz	10	28	32	7.3
+ 0.5% oil	20	29	25	9.0
	30	22	21	8.8
bitertanol	5	36	35	6.3
+ 0.5% oil	10	31	27	7.0
	15	20	23	7.0
fenarimol	5	69	69	6.3
	10	68	64	7.0
	15	57	62	7.5

Five sprays applied at fortnightly intervals starting 13 July.

Infection estimated on 26 October, vigour on 8 November.

For comparisons of infection indexes between chemicals at a given rate S.E.D. is approximately 5%.

The infection indexes obtained in the 1982 Pukekohe trial (Table 2) fall on a single curve. From the fitted values it was found that doubling the concentration of any of the fungicides reduced the infection index by 8% ($\pm$ S.E. = 2.0%) at 50% infection level or by 6.5% ($\pm$ S.E. = 1.8%) at the 20% infection level. Plant size measurements in one trial (Table 2) show the beneficial effect of controlling leaf spot on plant vigour. Visual observations of all the trials noted the marked stunting of the plants that occurs with severe leaf spot infections.

TABLE 3: Screening of fungicides for strawberry leaf spot, Rukuhia, 1981.

Treatment	g ai/100 litres	Infection Index (%)		
		Nov. 12	Nov. 23	Dec. 8
untreated		65.8	67.5	94.7
benomyl + captan	12.5 + 80	40.6	27.5	12.8
triforine	20	44.4	39.4	33.1
bitertanol	12.5	39.2	25.0	6.4
SED 5%		5.0	4.6	3.1

Six sprays from 9 October at 10-14 day intervals.

At Pukekohe in 1981 the trend in fruit yields was the inverse of that in the infection index. Benomyl gave the lowest yield and imazalil, prochloraz and bitertanol the highest. The increase in yield with the later fungicides was approximately 100% over the less effective treatments. At Pukekohe in 1982 yields were not significantly different from each other due to low and erratic cropping resulting from poor growing conditions and bird damage. At Waitakere the prochloraz, bitertanol, and captafol treatments gave approximately a 40% yield increase over unsprayed controls (Table 5). At Rukuhia yields were not measured in 1981 but in the second year the fungicide treatments gave a 40-50% yield increase with triforine not significantly inferior to benomyl/captan or bitertanol (Table 4). The increased yields at Rukuhia were principally due to an increased number of fruit produced whereas at Pukekohe there was also an increase in

mean berry weight (Table 1). This difference may be due to the first versus second year nature of the two crops. Prochloraz treated fruit had an unacceptable taint similar to that reported on treated blackcurrants (McLaughton and Litchfield 1982).

Fruit from the Pukekohe and Rukuhia trials were analysed for fenarimol, prochloraz, and bitertanol residues. The results were fitted to a simple first order decay model and are expressed in Table 6 as estimated initial deposit and half life values. The three materials decay rapidly with half lives in the range of 3.6 - 6.5 days. The multiple spray programmes used give initial residues in the low mg/kg range. Estimates of the time for residues to decay to 0.1 mg/kg can be calculated from the model to be 20 - 44 days (Table 6). As most of the data were for up to 15 days following spraying these extrapolations must be treated with caution. However, one measurement on fruit from the 1982 Rukuhia trial gave a residue for bitertanol of 0.17 mg/kg at 20 days post spray. Also fruit from the Waitakere trial collected 9 weeks following the last sprays had non-detectable residues of prochloraz or bitertanol (less than 0.05 mg/kg). Thus the estimates in Table 6 appear reasonable.

TABLE 4: Screening of fungicides for strawberry leafspot, Rukuhia, 1982.

Treatment	g ai/100 litres	Infection index (%)			Fruit yield kg/plot	Mean berry wgt g
		Oct. 10	Nov. 9	Dec. 16		
untreated		23.3	52.2	75.3	4.05	9.9
benomyl + captan	12 + 80	16.4	8.6	13.6	6.08	10.1
triforine	20	15.3	36.9	39.2	5.54	9.6
bitertanol	12.5	15.0	23.0	21.4	5.60	10.7
SED 5%		3.6	2.1	2.6	0.53	0.36

Five sprays from 7 October at 14-21 day intervals.

TABLE 5: Screening of fungicides for strawberry leaf spot control, Waitakere 1982.

Treatment	g ai/100 litres	Infection (spots/leaf)		Fruit yield kg/plot
		Sept. 3	Nov. 8	
untreated		16.4	7.7	2.6
triforine	40	9.3	17.2	3.2
prochloraz + 0.5% oil	15	0.8	3.0	3.6
bitertanol + 0.5% oil	12	1.5	2.9	3.8
fenarimol	5	7.0	10.3	3.4
captafol	80	10.7	10.8	3.6
SED 5%		2.7	2.3	0.4

Six sprays applied at fortnightly intervals starting 6 July.

Excellent control of strawberry leaf spot can be obtained by two weekly sprays of prochloraz or bitertanol over the early growing season. Residues of these materials should be non detectable for export purposes if withholding periods of 7 and 4 weeks respectively were observed. For prochloraz pre-flowering use only may be necessary to remove the risk of fruit taint.

Benomyl/captan is still an effective fungicide combination at least in some areas. Benomyl and captan have the advantages of having residue tolerances in export markets, allowing use later into the season and also of controlling botrytis, particularly where benzimidazole resistance is low.

TABLE 6: Pesticide residue decay on strawberries.

	Initial Deposit		Half-life		Time for residue to read 0.1 mg/kg (days)
	mg/kg	SE	(days)	SE	
fenarimol ¹	3.2	0.33	5.0	0.9	24
prochloraz ¹	1.3	0.53	6.5	2.7	44
bitertanol ¹	4.8	1.20	3.6	0.8	20
bitertanol ²	2.1	0.42	4.6	0.7	20
bitertanol ³	1.7	0.32	5.5	0.5	22

¹ Pukekohe 1981, Table 1.² Rukuhia 1981, Table 2.³ Rukuhia 1982, Table 3.

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Chemicals and Formulations used.

prochloraz	Sportak 40 WP, 50 WP
bitertanol	Baycor 25 WP, 50 WP
benomyl	Benlate 50 WP
fenarimol	Rubigan 12 EC
triforine	Saproc 19 EC
imazalil	
captafol	